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THE IMPACT OF HUMAN FACTORS ON
DECISION MAKING IN COMBAT

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The Impact of Human Factors on
Decision Making in Combat

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ABSTRACT

This thesis identifies those human factors which impact on a commander's decision in a tactical combat environment. Various models for categorization are discussed. The study argues that in order to establish clear casual/effect relationships between human factors and battle outcome, concentration of analytical research must focus on first order effects. Two categorical judgment surveys in the form of questionnaires are developed. Results from the surveys are transformed to interval scales. The first survey is exploratory in nature and allows respondents to apply 27 endogenous factors within a generic tactical context. The second survey presents four specific tactical scenarios in which the top seven factors identified in the first survey can be applied. Respondent selection for the first survey represented the four military services while respondent selection for the second survey was limited to Army officers. The study concludes that the top seven factors are: Leadership, Training/Experience, Initiative, Discipline, Cohesion, Morale, and Will/Motivation. The rank order and scaled magnitudes of these factors are found to be scenario dependent.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

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DISCLAIMER

The views expressed in this thesis are those of the authors and do not reflect the official policy or position of the Department of Defense or the United States Government.

The reader is cautioned that computer programs utilized/developed in this research may not have been exercised for all cases of interest. While every effort was made, within the time available, to ensure that the programs are free of computational and logic errors, they cannot be considered validated. Any application of these programs without additional verification is at the risk of the user.

Unless otherwise stated, whenever the masculine or feminine gender is used, both men and women are included.

I. INTRODUCTION

"Convincing people to fight and getting them to do it well, is one of the more essential and less obvious aspects of maintaining an armed force. Illusions must be created, and maintained, often unto death. Few individuals, once aware what combat is all about, want to spend any time at it." [Ref. 1: p. 291]

Throughout the history of military organizations, commanders have attempted to maximize the utility of the individual soldier. By altering organizations, battlefield formations, orders of battle, and styles of warfare, commanders directly determine the fate of their subordinates.

Indeed, the importance of considering all aspects of the soldier, accounting for every human factor, shines through in the analysis of the 1973 Arab-Israeli War where "human factors were found to be the major determinants of the outcome of battles [Ref. 2: p.14]." Due to a higher level of complexity, advances in technology increase the attention paid to human interface planning and man-machine interaction considerations. A recent example of how human dimension aspects directly affected a commander's decision-making ability occurred during fighting in the Persian Gulf.

On 3 July 1988, the Aegis cruiser U.S.S. Vincennes was patrolling the dangerous waters of the Persian Gulf. While the Vincennes was engaged in a surface gunbattle with Iranian Revolutionary Guards Corps gunboats, a mix of unsubstantiated reports coupled with intense stress and task fixation contributed to the launching of two surface-to-air missiles against a target thought to be an attacking Iranian F-14 fighter. As a result, the commercial flight Iran Air 655 with 290 passengers on board was shot down. Human error certainly contributed to this tragedy [Ref. 3: pp. 108-111]. Additionally, a series of tactical command and control (C^2) decisions were made which, at the time, fully justified the launch given the information available to the decision-maker.

On 20 December 1989, the United States invaded Panama. The objectives were the security of the Panama canal, the restoration of a democratic government, and the capture of deposed Panamanian dictator Manuel Noriega. Fierce fighting ensued from the start of the operation through the first three days and innumerable acts of heroism and bravery occurred, but one of the greatest psychological factors (which persisted for several weeks after the invasion) was the presence of Panamanian snipers. The potential for being killed or wounded by this seemingly indiscriminate fire increased perceived stress and fear levels far beyond those experienced from force-on-force firefights [Ref. 4]. It is the individual makeup of each soldier operating as part of the larger group which will directly or indirectly impact the commander's decision.

Two endeavors which are at the leading edge of research in ensuring adequate attention is paid to human factors integration are the Manpower and Integration (MANPRINT) Program and the More Operational Realism in Modeling of Combat (MORIMOC) effort. MORIMOC represents a substantial effort by the Military Operations Research Society (MORS) to integrate human factors and human performance data where needed in existing and future combat models. To date, MORIMOC has made progress toward the identification and integration of the varied professional fields which must interface if this multidisciplinary effort is to succeed. MANPRINT is a Department of the Army ODCSPER (Office of the Deputy Chief of Staff, Personnel) sponsored program whose effort is to "reduce the dependence of system performance upon extraordinary, unsustainable levels of soldier performance and human resources, and to alleviate human performance problems [Ref. 5: p. 9-1]." Under this program, consideration to human factors must be given throughout all aspects of engineering design, system integration, and organizational development.

The fundamental question of the human factors integration issue is simply stated: Given that human factors are important, how can the effects of human factors be qualitatively defined to determine which human factors matter?

The primary goal of this study was to develop and demonstrate a research methodology that isolates those human factors which are important relative to a command and control (C^2) decision. The study addressed four major objectives:

1. To develop a list of human factors which are considered relevant to command and control decisions and to show possible categorization techniques;
2. To conceptually develop some of the second, third, and higher order relationships that must be considered and which will require further exploration;
3. To demonstrate statistical methods necessary to quantify, rank, and more importantly, provide an interval scale of the human factors;
4. Finally, to determine if the relevant human factors are scenario or context-dependent. In other words, given another set of input variables depicting a scenario, do the scaled values or the rankings of the human factors significantly differ?

Based on the premise that human factors research currently underway will continue, a systematic, building block approach was used in answering the objectives of this study. As a result, the thesis presents a dynamic, yet straightforward approach that produces a final output of quantified human factors. The research was initiated through the identification of the human factors which are relevant to C^2 decisions. With a defined list of human factors, several methods of categorizing the factors were reviewed with three deemed appropriate for inclusion in this study. The first method classifies the factors based on when each factor is seen to impact on a battle. The second method focuses on whether or not the factor is affected by internal or external stimuli, while the third focuses on the change in combat potential/combat power resulting from stimuli on factors related to either the individual soldier or to a group of soldiers.

Human factors research is best conducted using human beings as the research subject [Ref. 6: p. 20]. As such, the approach selected drew research subjects from an 'expert' pool of knowledgeable personnel. The selected experts were personnel who had previously commanded or held leadership positions within a military organization. These experts judged the relative importance of the selected human factors based on the conscious or subconscious application these factors within their personal leadership experiences. A questionnaire, in the form of a

categorical judgment survey, was designed as an exploratory tool and was administered to a sample population of experienced commanders. The results from this first survey (termed the *Initial Survey* or *Survey I*) were quantified, placed on a common scale, and ranked. The top seven factors identified during Survey I were used as input for the second survey. The second survey (termed the *Follow-On Survey* or *Survey II*) focussed on determining whether the context or scenario to which the factors were applied would make a significant difference in the relative importance of the factors. With the results from both surveys in hand, a potential roadmap for future research endeavors was developed in order to provide continuity and to allow this study to be used as a base document for follow-on human factors research.

II. NATURE OF THE PROBLEM

Imagine, for the moment, a world devoid of the peculiarities and individualities of the human -- a society where all beings think, talk, walk, look, feel, decide, and act the same. The actions or reactions of a 'person' in this society are reasonably predictable. There is an existing set of variables or 'things' which are present when the person acts in a certain manner. Some of these variables are internal to the individual person, while other variables are external to the person and exist in the environment. Some of the variables are present only within the individual while others are apparent only in group interaction. In order to realistically predict the behavior of a member of this society, all possible combinations of variables must be tested. At the point where every variable combination has been tested and the results have been verified, a clear cause and effect relationship pattern exists. The cause, in this case, is the input variables while the outcome is represented by the event outcome -- the observable behavior. The input variables **cause** an action to occur. Since there is no variability from one person to the next, standardization of the results is not required. The observed or quantified value for each of the variables *is* the norm.

The domain of human factors is elusive and difficult to capture, both conceptually and physically. Even within the 'carbon copy' society described above, all variable combinations must be tested if one wanted to positively establish that a certain variable combination will produce a specified result. How would this experiment be designed? Indeed, are the factors even quantifiable? If they are, do the appropriate tools exist to measure varying levels of these factors?

The details to this problem are infinite. Even though the example presented above is relatively simple, its purpose has been well served if the reader takes away but one point -- the extreme difficulty involved in any attempt to ***quantitatively*** structure a ***qualitative*** factor.

The focus of this section of the thesis is to define how human factors and the C^2 environment are intertwined. Following a definition of command and control, human factors are defined, described, and delineated. This is followed by a description of the overall (big picture) integration of human factors which includes arguments supporting the lowest level that should be considered, a discussion on causal/effect relationships, and the impact of human factors research.

Command and control is re-visited with particular attention on how and where human factors impact on the decision cycle as described within current C^2 models. For completeness, one section presents a cursory discussion of factor aggregation. Finally, several models for classifying the factors are described in detail.

A. COMMAND AND CONTROL

In order to understand how human factors affect C^2 decision-making, it is necessary to understand some unique terms associated with commanding soldiers within a military organization.

1. Command and Control Defined

The definitions presented in this section represent the currently accepted meanings. The primary function within this study is **command**. Command, as defined in Joint Chiefs of Staff Publication 1 (JCS Pub 1), is:

> "The authority which a commander in the military service lawfully exercises over subordinates by virtue of rank or assignment. Command includes the authority and responsibility for planning the employment of, organizing, directing, coordinating, and controlling military forces for the accomplishment of assigned missions. It also includes responsibility for health, welfare, morale, and discipline of assigned personnel." [Ref. 7: p. 74]

This definition implies action by the commander -- organizing forces for optimal performance, directing force actions to accomplish a mission, coordinating force action to achieve synchronization, and controlling the force to assure conservation of effort.

The commander is the individual who exercises command. He does so through a process referred to as **command and control**. As defined, command and control is:

> "The exercise of authority and direction by properly designated commander over assigned forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures which are employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of the mission." [Ref. 7: p. 74]

Command is the function of the commander. Command and control is the process the commander uses to exercise command. Command and control decisions are those decisions which enable the commander to impose or express his will to his subordinates.

2. The Nature of Combat

As part of defining command and control, one must determine the type of environment in which a C^2 system must be capable of functioning. The environment can range from deterministic to totally indeterminate. Different types of systems must be considered and applied to the requirements of the command and the demands of the environment. In this respect, the *nature* of combat must be taken into account when devising a system to function within a combat environment. There are four principal types of systems or environments.

Deterministic systems are those in which a certain stimulus results in a known reaction. An example of this is pulling a trigger on a rifle. Assuming that the rifle is functional and loaded, then a pull on the trigger will result in a round being fired. Except for the purely technical and mechanical aspects of combat, this type of command and control system is not found on the battlefield.

Moderately stochastic systems are those in which a certain stimulus may result in one of several outcomes with known probability distribution. The likelihood of a gunner hitting his target under constant conditions is an example of this type of system. Most facets of modern combat can hardly be considered within this category.

Severely stochastic systems are those in which a single condition can result in many different outcomes through a more complicated probability network. A decision to fire a weapon at a target at a certain time could be an example of this system. Severely stochastic systems abound on the battlefield.

Indeterminate or ***chaotic systems*** are those systems in which no outcome can be predicted from a certain condition or set of conditions with any probability. Most aspects of combat can be placed within this category. [Ref. 8: pp. 52-54].

3. The Importance of Command and Control

Hypothetically, if two forces are engaged in combat with all other things being equal, the force with more effective C^2 should have the upper hand. For the purposes of this study, a commander's decision (also referred to as a C^2 decision) represents his judgment or determination as to the best course of action. The influence a commander can generate through a C^2 decision is for the most part immeasurable, primarily due to the stochastic and somewhat chaotic nature of modern combat. Combat situations with exactly the same parameters lack reproducibility and, as a result, one has to rely on post-battle analysis to postulate the outcome that a different decision might have caused. In his book *Command In War*, Van Crevald addresses the force multiplier effect of command by stating that: "Napoleon's presence on the battlefield was said by some of his enemies...to be worth a corps of forty thousand men." [Ref. 9: p. 8]

Just as command can serve as a force multiplier, it can most assuredly become the Achilles' heel. Poor command decisions have done as much to decide the outcomes of battles as have the great decisions. Some poor decisions were based on poor or inadequate information; other decisions, one could postulate, have been made by commanders who were incapable of making a reasonable decision given the duress under which they acted.

Although the actions of some of the greatest commanders have been well documented, it would be infeasible to model patterns for future commanders in

their footsteps. These 'great captains' represent only a small fraction of all commanders.

Finally, since almost all battlefield systems are severely stochastic or indeterminate [Ref. 8: p. 53], the C^2 system must be capable of functioning within these types of environments. To handle severely stochastic environments, the command and control system must be capable of reacting to quick-response or reduced-time situations. Part of this capability, especially at the lower levels of command, rests personally within the commander's responsibility of establishing a viable C^2 system with which to implement a prescribed C^2 process. Before detailing the command and control process and describing how human factors are conceptually interwoven into the process, a definition of human factors is appropriate.

B. HUMAN FACTORS DEFINED

The world of human factors comes in many different flavors but can be seen to be primarily based on the interaction between the human-machine-environment. For those who feel more comfortable with a strict definition, consider the following:

> "Human factors discovers and applies information about human behavior, abilities, limitations, and other characteristics to the design of tools, machines, systems, tasks, jobs, and environments for productive, safe, comfortable, and effective human use." [ref. 10: p. 2]

As is easily discernible from this definition, the human factors arena is rather large and can be applied anytime the situation has a human-in-the-loop.

Modification to the formal definition of human factors allows for consideration of only those factors that specifically impact on C^2 decisions. Therefore, for the purpose of this study, ***human factors are those factors that can psychologically or physiologically affect a soldier's will to fight in a combat environment.***

1. Physiological and Psychological Factors

Two fundamental schools of thought exist within the relatively large empirical science of human factors: engineering-based and cognitive-based. Engineering-based human factors comprise the ***physical*** interface of the human with the system or environment. These factors are physiological in nature. A 'system', as described here, is simply an entity that exists to carry out some purpose. Engineering-based factors are typically the first things that come to mind when one thinks of human factors and are characterized by some type of quantifiable base from which to work. Hand sizes, subject height, muscular strength, eye-hand coordination, and manual dexterity are all applicable descriptors for this category [Ref. 6: pp. 12-13]. Sometimes called *anthropometrics*, this science is defined as "the study of human body measurements, especially in comparison with the layout of a system." [Ref. 11: p. 51]

A 'system approach' bridges the gap between engineering-based and cognitive-based factors.

> "The concept of a system implies that we recognize a purpose; we carefully analyze the purpose; we understand what is required to achieve the purpose; we design the system's parts to accomplish the requirements; and we fashion a well-coordinated system that effectively meets our purpose." [Ref. 12: p. 192]

Since the human is a functional entity within the system, interaction between humans, machines, and other entities within the environment should be considered in system design.

The cognitive-based human factors account for man's input into the system. Cognitive factors account for factors which provide the ***psychological*** input into the system. Factors within this category are generally less quantifiable than their physical counterparts. Thought processes, such as decision-making, are representative factors within this classification.

2. The Starting List

Developing a list of applicable factors for consideration at the beginning of this research study was critical. In order to ensure that the potentially important factors were identified early in the research phase, an extensive literature search was conducted through professional journals, research reports, and published books. This search provided an initial working list of human factors. After several sensing sessions with professors at the Naval Postgraduate School (NPS) who have conducted human factors research and a verbal query of NPS student officers, the working list was refined and considered sufficiently comprehensive to continue. An alphabetic listing of all of the human factors initially considered is delineated below. Definitions of these came from a variety of sources. The factors, as defined for this study, are listed in Appendix B.

HUMAN FACTORS CONSIDERED

Altitude
Attitude
Boredom
Cognitive Factor
Cohesion
Comradeship
Confinement
Coordination
Cowardliness
Crowding
Culture
Darkness
Decision-making
Dedication
Depression
Discipline
Drive
Education level
Emotion
Endurance
Energy
Esprit de Corps
Excitement
Experience
Fear
Fire
Frustration
Honor
Ideology
Initiative
Intuition
Isolation
Jet Lag
Leadership
Mental Fatigue
Momentum
Morale
National Characteristics
National Ethos
Noise
Obedience
Physical Aptitude
Physical Conditioning
Physical Fatigue
Primary Group
Propaganda
Sleep Loss
Social Motivation
Soldier Load
Strength
Stress
Suppression
Surprise
Terrain
Toxicity
Training/
Experience Level
Uncertainty
Values
Visibility
Weather
Will/Motivation

C. THE IMPACT OF HUMAN FACTORS RESEARCH

Human factors research has had a profound effect on almost every human being. From automobile display designs which attempt to optimize the cognitive capabilities of the 'average' person to the design of a chair in an effort to provide comfort and to minimize back stress [Ref. 6: pp. 5-12]. In the military context, consideration of the human dimension has revolutionized the way that many design, organizational, and procedural problems are approached. Service sponsored programs, such as the Army's MANPRINT, strive to consider the human as an integral part of the overall system design. This research effort intends to add to an already large foundation of human factors research. The focus is to identify which factors a tactical commander perceives as the important factors and whether or not the order of importance is situationally dependent.

How do the physiological and psychological aspects of human factors appear to the commander in combat? Since combat is fundamentally stochastic in nature with both forces motivated towards attaining specified objectives, the outcome of a certain battle or phase of a battle is uncertain and can be thought of as a probability distribution of outcomes. Commanding combat is somewhat analogous to a two-player chess game; each player is trying to optimize his own position while attempting to frustrate the opponent's attempts. Inherent in combat are vulnerability, lethality, and the ability to spatially reposition one's forces. Embedded in this philosophy of combat

> **"...is that combat is more than the actual physical clash of forces, also having a psychological dimension. This psychological dimension can be exploited by aiming to achieve a power distribution that gives the opponent the idea of being lost, and through causing mental paralysis and friction presenting to the opponent a problem that changes more rapidly than he can respond." [Ref. 13: p. 63]**

Research within the human factors discipline has potential for far-reaching effects. Two of these will be addressed within this section: combat modeling and training/doctrine.

1. Combat Modeling

Two basic premises which provide the underpinnings for development of a discussion on human factors integration into combat models are:

1. Models are abstractions of reality;
2. Combat is a human venture.

If models are to adequately reflect combat, they must have the inherent capability to adequately represent man. Strictly defined, "a model is a simplified representation of the entity it imitates or simulates." [Ref. 14: p. 1] Models can be prescriptive, predictive, or descriptive.

- Prescriptive models are generally used to specify a course of action. These models are characterized by solving problems and by telling the decision-maker what to do or what course of action to pursue. Examples are linear programs, dynamic programs, and game theory.
- Once models are found to adequately describe existing phenomena, they can be used as predictive models to process other input data and arrive at a predicted solution for a given situation.
- A descriptive model reproduces essential processes of the phenomenon that it models. An example of this type of model is a combat simulation which serves to emulate portions of a battle.

The key operative with respect to combat models is the word 'describe'. If these models are expected to adequately describe what transpires in combat, the variability caused by man must be determined, quantified, and factored into the description. [Ref. 14: pp. 5-6]

Not only is the type of model important, but also the model's purpose. Implementation of human dimensions within these combat models is heavily based on the intended use of the model. Schroth, after an extensive literature search, concluded that:

> "Before human factors can be incorporated into models, the model must be well understood. This includes the model's purpose and structure. The purpose is one of four types: technical evaluation, force structure analysis, doctrinal analysis, and training. The structure is often quite complex. The structure includes treatments of time and probability, the level of aggregation, the processes, and the environment represented." [Ref. 15: p. 51]

Why haven't human factors been fully integrated into combat models already? The answer, simply stated, is that human factors are much more difficult to comprehend and much less tangible than other processes. Consider, for instance, a firing engagement where System A is firing at System B. Theoretically, it is much easier for an experienced combat modeler to model the ballistics of a fired round, the probability of a hit, or the probability of a kill than it is to attempt to model how much lead the 'average' user of System A will apply based on the level of cohesion within his unit. Most people have a natural tendency to focus on the 'things' which are understandable -- things that can be touched or felt or diagrammed. As a result, human factors are generally avoided.

a. Establishing the Level

One of the primary components in establishing a valid 'set of rules' concerning human factors integration is the development of a hierarchical tree. This hierarchy tree should reflect measurable factors and should allow for the systematic construction of models which can be validated. In other words, start with a small, understandable phenomenon and build from that point, maintaining an understanding as to how each piece affects the overall model. Additionally, the hierarchy should provide logical representations of both physical processes (e.g., target acquisition or firing accuracy) and cognitive processes (e.g., C^2 decision-making). [Ref. 16: pp. 337-338] For the purposes of this study, these processes are primarily exhibited at the levels of abstraction indicated below:

Level of Abstraction	Processes Involved
Item	Physical
Squad	Physical
Platoon	Physical
Company	Physical/Cognitive
Battalion	Cognitive

Two arguments exist from selecting the company as the first observable level of command and control. The first argument is that the company-level is too high and C^2 decision-making occurs at the platoon (and possibly the squad) level. Current U.S. Army doctrine addresses combat actions fought at the squad/platoon level as a series of combat drills. These drills, more commonly referred to as *Battle Drills*, provide a well-documented delineation of the standards for the successful completion of combat actions in the face of an enemy force.

> "These drills allow small units to link individual and leader tasks into coordinated, efficient and effective group action. Drills provide the vital, standardized plays which...units will use in combat." [ref. 17: p.4].

Rote, pre-rehearsed actions, the repetitive training of battle drills increases both proficiency and cohesion. Battle drills are explicitly defined for combat arms units.

As will be described in detail later, the C^2 process *can* be applied when viewed from a one-person perspective (i.e., the individual 'commands and controls' himself). While this may be true, the fact remains that the individual soldier drills on specified individual tasks until proficient. The individual skills are doctrinally integrated to form squad and platoon drills; the platoons then become ***maneuver*** elements for the commander to apply at the critical place and time.

A second argument for refuting the company-level as the C^2 decision start point is that company-level is too low and that <u>real</u> C^2 decisions occur only at higher echelons. The performance of front-line soldiers in the heat of battle can collectively determine the effectiveness of higher echelon units. Therefore, it can be argued that a brigade or division's effectiveness depends on the fighting ability at the company level. Within the context of AirLand Battle doctrine, leadership at battalion-level and higher is generally displayed through the mastery of maneuvering forces and synchronizing the battlefield, much as a musical conductor orchestrates a symphony. Alternatively, at the company-level and below, soldiers are motivated by their leaders. A company commander, if he is performing his duties, should know every soldier within his command. In fact, "it

is at the company-level and below that human factors play an important role in determining how well a soldier fights." [Ref. 18: p. 7]

In retrospect, any position can be argued as to the level where command and control is initiated. For the purposes of this study, command and control will begin at the company level.

b. Establishing Cause and Effect Relationships

"If we are to work within the sphere and spirit of science, we must aim to describe the phenomenon of combat in such a way that cause and effect can be related." [Ref. 19: p. 0-3] Consider a combat action which occurs over specified amount of time. Over the course of the battle, decisions are made by commanders on both sides which, in turn, cause other events or actions to occur. The overall outcome of the battle is now driven by **more than one** decision. In fact, many decisions decide the final outcome as depicted in Figure 1.

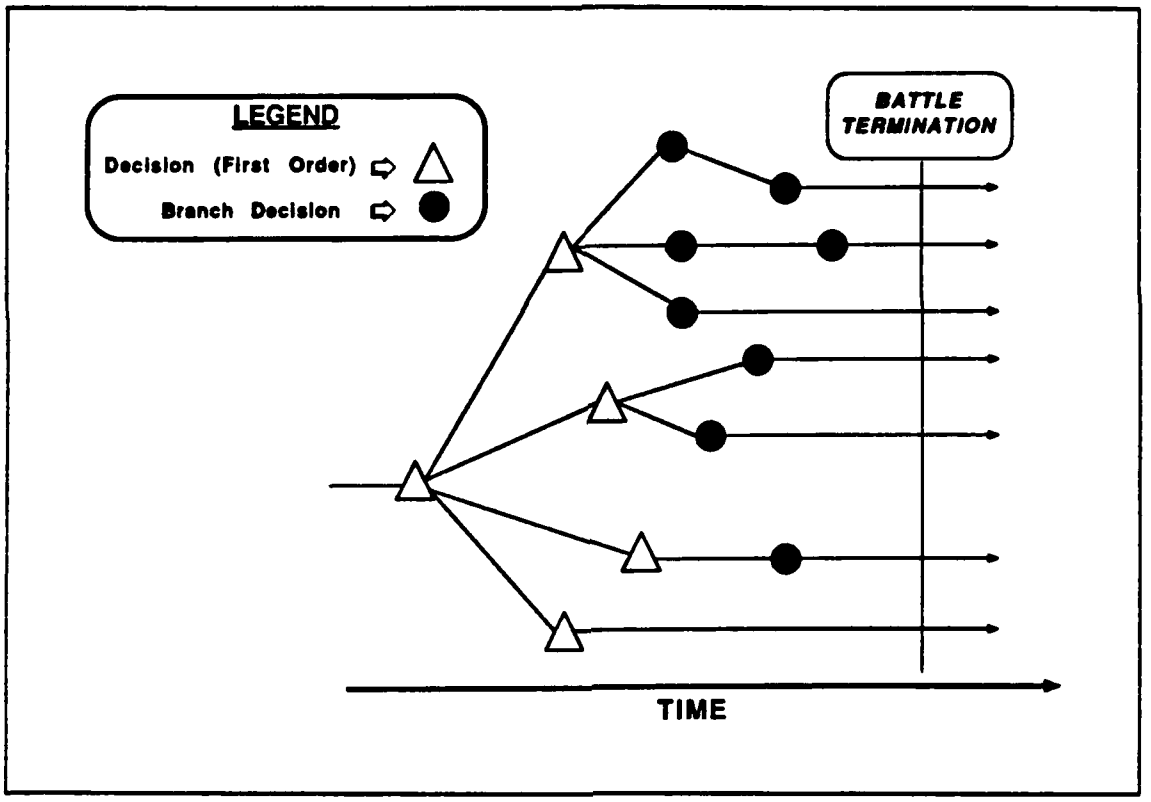

Figure 1. Cause and Effect Audit Trails

The *effect* is the battle outcome. Through the use of a computer-driven combat simulation model, it is possible to stop the battle after a certain amount of time (Δt) and gather data representing the 'state' of the battle (e.g., forces remaining, ground gained or lost, killer-victim scoreboards) at this time. This data is frequently numerical, although graphical displays to depict relative unit positions at battle termination are useful. Given numerical output, the effect is in a form that is overt and measurable.

The *cause* is a command and control decision. Under normal circumstances, more decisions are possible given a larger Δt. As shown, the audit trail from the first C^2 decision out to battle termination can have several branches. If these branches and their relationships are not understood, cause and effect is difficult to establish.

Given the opportunity to simulate the same battle twice, what is the effect on battle outcome if the commander is replaced? Likewise, if a Measure of Effectiveness (MOE) is defined, to what extent does the MOE change due to the change in the decision-maker? In essence, replacing the commander changes the human factors composition of the individual making the decision. As a result, one could postulate that a new decision-maker might consider different 'things' when making a decision. It is conceivable for two commanders to make the same decision even though different variables were considered. Similarly, it is possible for two different commanders considering different variables and making different decisions to produce the same value for the MOE at battle termination. In part, the difficulty in attempting to isolate the effects of 'good' or 'bad' command and control lies in the chaotic and stochastic nature of the battlefield.

c. Over the Obstacles

Given that the interaction of human factors is multifaceted and affects every phase of a force-on-force confrontation, the weighting and/or consideration of human factors can be broken down to two primary issues. First, one must ***identify the pertinent human factors*** which most affect the commander in his formulation of a C^2 decision. Since the commander is part of the overall environment, the human factors which the commander possesses (those which are inherent), are also displayed to varying degrees by the soldiers under his command. This is one of the primary assumptions of this study and, as such, will be re-addressed periodically throughout. For the moment, consider two human factors: fatigue and stress. Although the commander personally shoulders the responsibility of command, his measurable level of these factors should not differ significantly from those of his soldiers, assuming that he has been commanding his soldiers as a leader (as opposed to a manager). For factors like training, he has individually undergone much more in-depth and enriched leadership training and, as a result, one would expect any measurable capability with regards to leadership knowledge to be higher.

Second, and more importantly, once the pertinent factors have been identified, one must devise ***reasonable techniques for measuring the inherent levels possessed by individuals*** if the effects of human factors are to be determined. Another hurdle which is related to measurement includes the isolation of the factors, the determination as to which factors interact, and the methodology for how that interaction occurs. Shortcomings in measuring these human factors occur for one of several reasons:

- **Practicality** - it may be that the factor which has been identified as 'important' is impractical to measure. A conceptual measurement tool may not exist which allows for economical attainment of an answer once an experiment is conducted. This is a cost-effectiveness issue that poses the question -- Can enough information be gained to make the expenditure of resources worthwhile? Another potential shortcoming occurs due to technical limitations -- How do we measure fear? In many cases our societal values prohibit the use of human guinea pigs to attain information that may be useful for ***future*** combat effectiveness.
- **Technological Restrictions** - the primary question here is: Is the instrumentation available to capture what you want? The current technological base may limit our understanding of the chemical/electrical interworkings of the brain and, as a result, will only allow us to give a 'best guess' with respect to how the human mind functions.

Innumerable tests have been conducted in the past in an attempt to quantify human factors. The secrecy of these tests was, in part, derived from a concern for national security. This shroud of secrecy has also allowed for avoiding public scrutiny with 'what' was being tested and 'how' the tests were being conducted. Peter Watson, who produced a comprehensive study on the psychology of war, addresses one of the side-effects of secrecy being that studies:

> **"...do not always conform to the accepted scientific standards. In 1962, for example, Mitchell Berkun, working at the Human Resources Research Office, conducted a series of experiments aimed at exploring whether troops could be battleproofed by making their training so stressful that they would enter battle inured to any fears. In one experiment men flew in an aircraft which 'developed' an 'engine fault'. In another, men were 'accidentally' led into a 'shelling zone'." [Ref. 20: p. 30]**

d. Integration of Human Factors - An Approach

What methodology can be used to integrate human factors into combat models? Currently, there is no patented solution to this dilemma. There are, however, many potential theories for the 'best' approach. Regardless of the methodology followed, the results must satisfy the analytical community, the behavioral science community, and the military-user community. One possible approach is depicted in Figure 2.

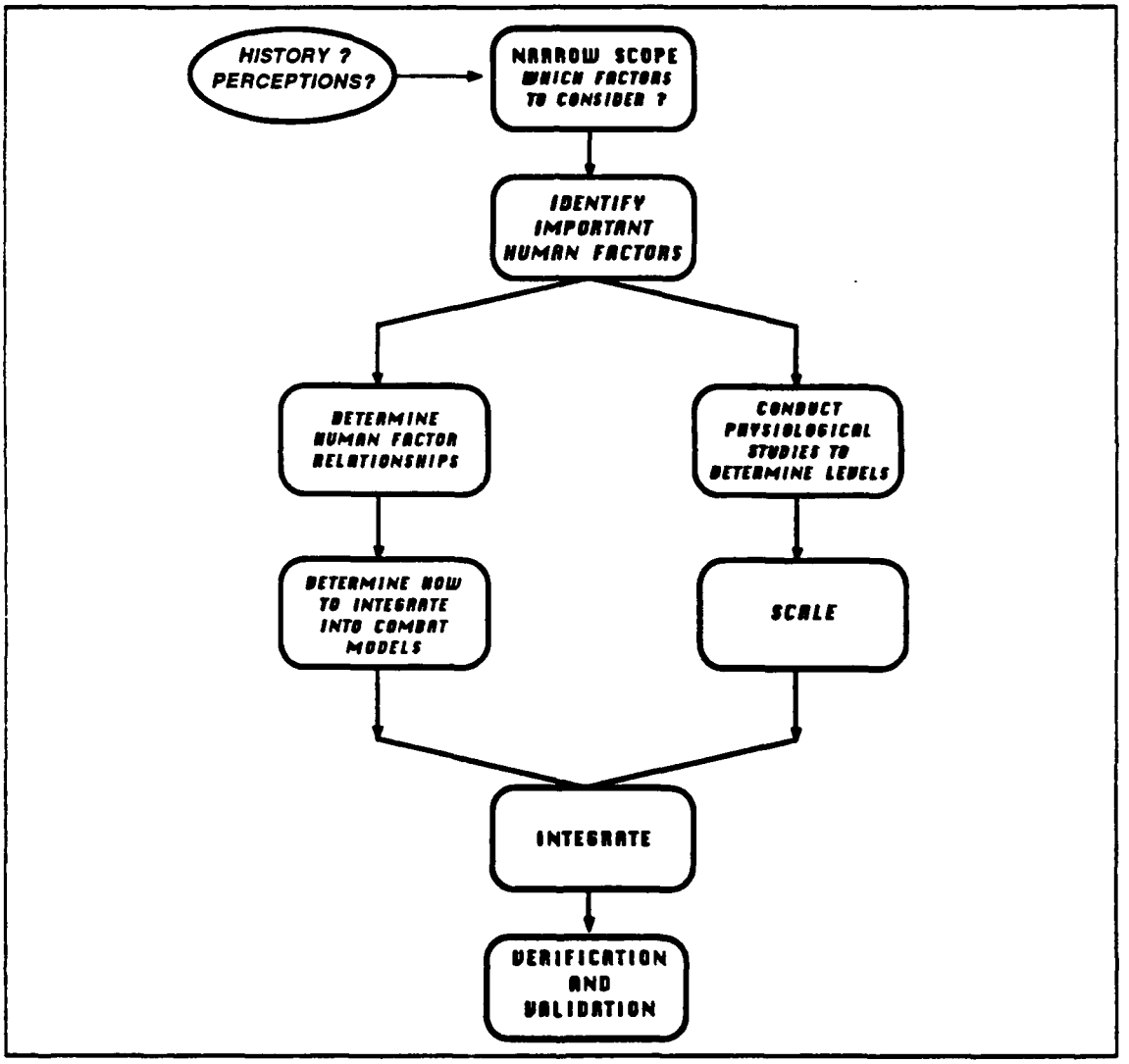

Figure 2. Approach to Human Factors Integration

2. Training and Doctrine

Given recent events in Europe and the perceived reduction of the threat posed by the Warsaw Pact, United States force reductions are inevitable. Likewise, deployments and actual 'field training' days will also be reduced due to fiscal constraints. The mere expense of one battalion-level rotation at the National Training Center (NTC), ranging from S4 million to S6 million [Ref. 21: p. 2], will become less tolerable, forcing a shift in training philosophy to a more economical solution. One way to lessen the effects of reduced funding is through ***realistic*** simulation devices.

Simulation devices cover the spectrum from reduced caliber firing devices/ranges to computer-driven combat models. Whatever the means, these training devices must be as realistic as possible from a user's perspective. Again, in order to attain realism, the human dimension must be heavily considered during model development.

As technological advancements increase the level of sophistication in modern weaponry, doctrine will change to maximize the utility of weapon systems. Just as it would make no sense to develop a weapon system without considering human interface, it makes no sense to develop doctrine without considering man's role and capabilities within the proposed doctrinal environment. If, given better prediction tools, human behavior can be adequately simulated, applications to optimize the doctrinal man-machine-environment mix are theoretically possible.

D. THE COMMAND AND CONTROL PROCESS

The command and control process provides a contextual basis for the application of human factors. As such, it will serve as a focal point for understanding the impact of human factors. A representative model which demonstrates the C^2 process was selected for analysis within this study. Again, given that models emulate real-world phenomena, the focus of the study is **not** the functional design of the model, but rather how and where human factors impact on the model.

1. Lawson Command and Control Process Model

A simplified approach to diagrammatically representing the C^2 process is a model attributed to Dr. Joel S. Lawson, Sr. In his report entitled "The State Variables of a Command and Control System" [Ref. 22: pp. 93-99], he defines five basic functions of the process along with external interfaces. This model, sometimes called the 'Lawson Loop', is as depicted in Figure 3.

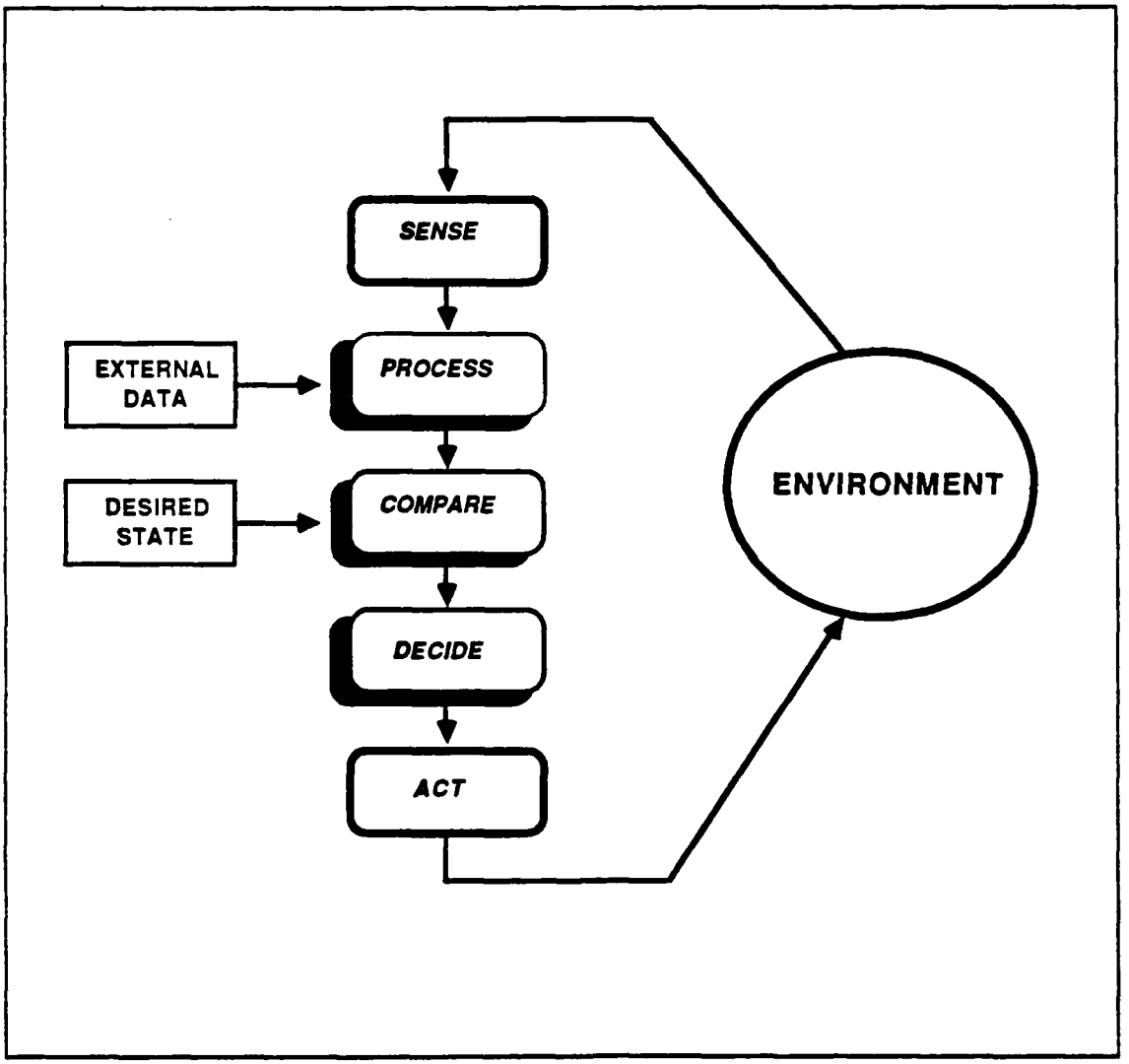

Figure 3. Lawson Loop

a. Defining the Model

The Lawson C^2 model is applicable to the highest levels of resolution. Consider, for instance, a person in a dark hallway who is trying to find a doorway (assume that no light switch is available). He knows that the door is on his right so he lets his hand touch the right side wall as he senses (tactile) for the opening that represents the doorway. As he moves down the hallway, the raw data from his senses is processed and is then compared to what he expects to find (depending on whether the door is open or closed). After comparing the processed information, he decides whether he has reached the doorway. If the decision is ***no***, he acts by continuing down the hallway, and as a result, re-enters at the top of the Lawson loop. If the answer is *yes*, then the "Desired State" changes; he must now determine whether the door is open or closed. As a result, the Lawson loop is re-entered with the new desired state variables.

This example shows the Lawson model used in a discrete, stepwise manner -- sense, process, compare, decide, act. Two inherent facets of the model are that it is both continuous and recursive. The model represents a ***continuous*** process in that each function occurs and is succeeded by the following step. It should be noted that any or all of the functions can be ongoing at any instant. Second, from a military organizational standpoint, the Lawson loop is ***recursive*** in the sense that each level of command within a military organization is engaged in its own C^2 process. If these C^2 processes were represented by a series of cogs, the higher echelon commands (i.e. corps or division-level) could be represented by comparatively large cogs which turn slowly in comparison to the speed of revolutions at the lower levels (i.e. company-level).

Returning to the model itself, each of the functions represents a certain type of activity being performed. This study focuses primarily on tactical C^2 decision-making and, as such, the functions along with a description and tactical application examples are as indicated in Table 1.

Table 1. COMMAND AND CONTROL FUNCTIONS

Function	Description	Example
SENSE	• *Corresponds to all data-gathering activities* • *Extracts signals from data*	• *Soldier with a set of binoculars and a radio (FO)*
PROCESS	• *Acts upon signals to extract meaning from them* • *Transposes 'raw' data to usable information*	• *The 'human brain'* • *Database development at higher echelons*
COMPARE	• *Compares current state (or actual) of the environment to the desired state*	• *The 'human brain'* • *Graphics displays*
DECIDE	• *Determines what should be done to move actual state to desired state*	• *The commander's primary role*
ACT	• *Executes the decision*	• *Subordinate units*

b. Applying Human Factors

Consider human factors within the context of the previously given definition: those factors that can psychologically or physiologically affect a soldier's will to fight in combat. In developing the discussion within this section, the focus is on the 'generic' human factors and not on specific factors.

Each function within the Lawson C^2 process model is affected by human factors. The ***SENSE*** function, since it really represents how the sensor *perceives* a given stimulus, is susceptible to all factors, particularly psychological factors. The perceived truth (how something is perceived) can be exactly opposite from the ground truth (how it really exists). The ***PROCESS*** function receives the raw data from the sensors and then compiles, de-conflicts, and synthesizes

meaningful information which has meaning. Since this study concentrates on human factors, assume that the processing is being done by people. Manual processing allows for the full range of human errors. A great potential exists for the processors to gloss over a seemingly insignificant part of a sensed report which, in fact, was critically important to the commander. Likewise, personal bias of the individual or group performing the processing may cause them to focus on a small point which is irrelevant to the information required. If a commander is lucky, mistakes made during both the sense and process functions will cancel each other rather than cascade.

As part of the ***COMPARE*** function, the information which has been processed, representing the current state of the environment is compared to the desired state. In a tactical environment, the desired state is derived through a combination of:

- Specified missions from higher;
- Implied missions from higher;
- Next higher commander's intent;
- Internal analysis of the situation (via sensed data);
- Analysis of warfighting doctrine.

All of these things considered, the commander determines how he would like the environment to exist and expresses his desire to subordinates through missions, orders, and intent. Here again, perception plays a major role. One could hypothesize that as a commander attains seniority and is promoted to higher levels of command, most of the variability in interpreting/creating the desired state washes out due, if nothing else, to increased experience. Of course, at the lower levels of command (i.e., company-level) the commander must, by the nature of his position, personally process and compare the state of the environment with the desired state.

The commander, and only the commander, shoulders the responsibility to ***DECIDE*** the next course of action. The decision-making process involves weighting alternative options to determine which is most likely to succeed given the circumstances.

Integral to this process is an analysis and weighting of some of the more tangible entities that the commander must perform: he is here and he thinks that the enemy force is there; his force size is X and he thinks the enemy's force size is Y; the sun rises at 0530 hours and will set at 1900 hours. In many situations, uncertainty of specific aspects of the operation cause the decision-maker to hesitate. A subtle difference should be noted between **uncertainty** and **ignorance**. With ignorance, the information is available to the decision-maker but is not used. With uncertainty, the information is not available *or if it is*, there is considerable uncertainty as to its quality.

The factors listed above represent some factors that the commander might consider important and which he might consider in the formulation of a decision. Somewhere, in the formulation of his decision, human factors enter into the final decision equation, perhaps as a subconscious contributor. The decision then becomes a function of the conscious weighting of tangible factors and the subconscious weighting of human factors. This is a "black and white" approach to how human factors are really considered; human factors might be part of both the conscious and subconscious considerations.

At the lower echelons of command, the compare and decide functions are probably combined into a three step process:

1. Determine the desired state;
2. Identify and evaluate various alternative ways to reach this desired state;
3. Select one of the alternative ways.

Particularly at the company level, this combination of steps is done out of necessity since the company commander, who is tasked with the most immediate responsibility, is organized without a formal staff.

The ***ACT*** function serves to implement the decision. This function is initiated by the dissemination of orders from the commander. The function may be served by adjusting the desired state in this loop or it may initiate or adjust C^2 processes at subordinate leader levels. One of the key facets of this function is the responsiveness of the individual or unit taking the action.

2. Beware the Shortcomings

Prior to attempting to universally apply the Lawson C^2 model, one must account for the shortfalls inherent in the model. For instance, what about the commander's ability to process information? The ability to process information varies from individual to individual. This capability also varies within the individual. Many studies within the area of information processing have been performed. Many studies have been conducted to determine the individual's ability to process information. Of notable mention is an article by George Miller which places the number of negotiable variables of judgment at seven plus or minus two:

> "There is a clear and definite limit to the accuracy with which we can identify absolutely the magnitude of a unidimensional stimulus variable. I would propose to call this limit the *span of absolute judgment*, and I maintain that for unidimensional judgment this span is usually somewhere in the neighborhood of seven." [Ref. 23: p. 90]

Miller's focus on unidimensional stimuli must be expanded for use in a tactical military context. Combat decisions rely on the commander's ability to sort through a deluge of multivariate, multidimensional information. A research effort that focuses on information processing and C^2 decision-making diverges outside the bounds of this study, however it is addressed here as another consideration for variability among decision-makers.

Probably the greatest deficiency of the Lawson C^2 model as described above is the absence of the *enemy* command and control process. This omission tends to make the model appear one-sided. For the model to adequately describe the C^2 process, both the friendly and enemy command and control processes must be simultaneously considered. This problem is addressed in subsequent derivations of the model. Known as the *Lawson-Moose* C^2 model, this model ensures that both forces operate within the same conceptual environment.

E. AGGREGATION

Within the course of topic development, the authors have attempted to stay relatively within the bounds of scientific methodology. For the purposes of the discussion within the forthcoming section, the authors have taken literary license to recognize (but not solve!) an extremely complex issue.

Strictly defined, **aggregation** is "the entire number, sum, mass, or quantity of something." [Ref. 24: p. 53] For the purposes of this study, 'aggregation of factors' will be defined as the combination of several individual human factors. The terms 'combination' and 'congregation' of factors are considered synonymous. The term 'sum' as used here is a misnomer for two reasons. First, the contributing factors *may* not be consumed in the formation of the higher order effect. Second, the contributing factors not only add to the higher order factor, but one could postulate that there is an interaction or synergistic effect which makes the whole greater than the sum of the individual parts.

Aggregation accounts for the first, second, and higher order effects of factors, consider the factors β_1, β_2, β_3, and β_4. Each of these factors is individually inherent within the individual or independently exerts a certain level of 'force' on the individual. These will be called 'first order effects'. Higher order effects are the result of two or more of the factors combining to contribute an aggregate effect. This concept is depicted in Figure 4.

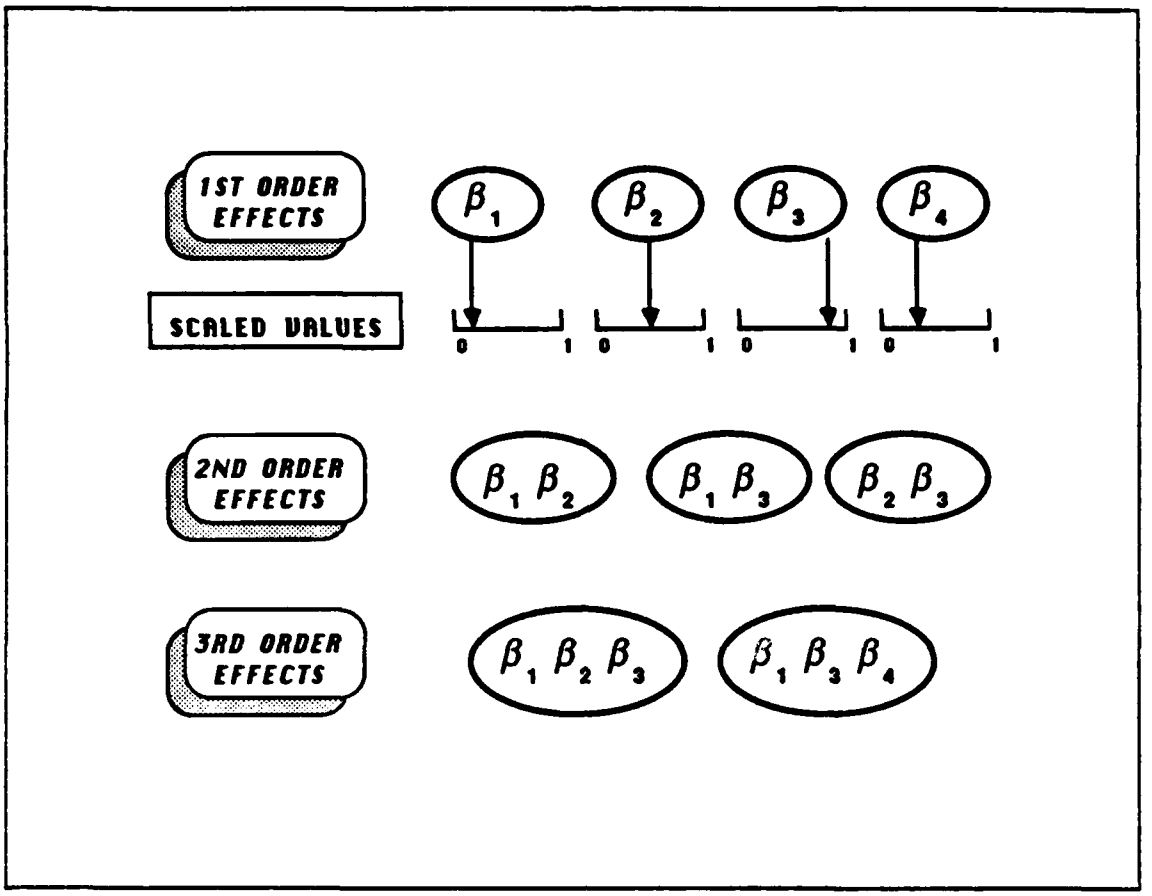

Figure 4. Higher Order Effects

Under the concept of aggregation, the individual first order effects may contribute to a higher order factor, albeit the contributor may not be consumed in the process. For example, a factor such as stress can be affected by a number of other individual factors. This concept is as depicted in Figure 5.

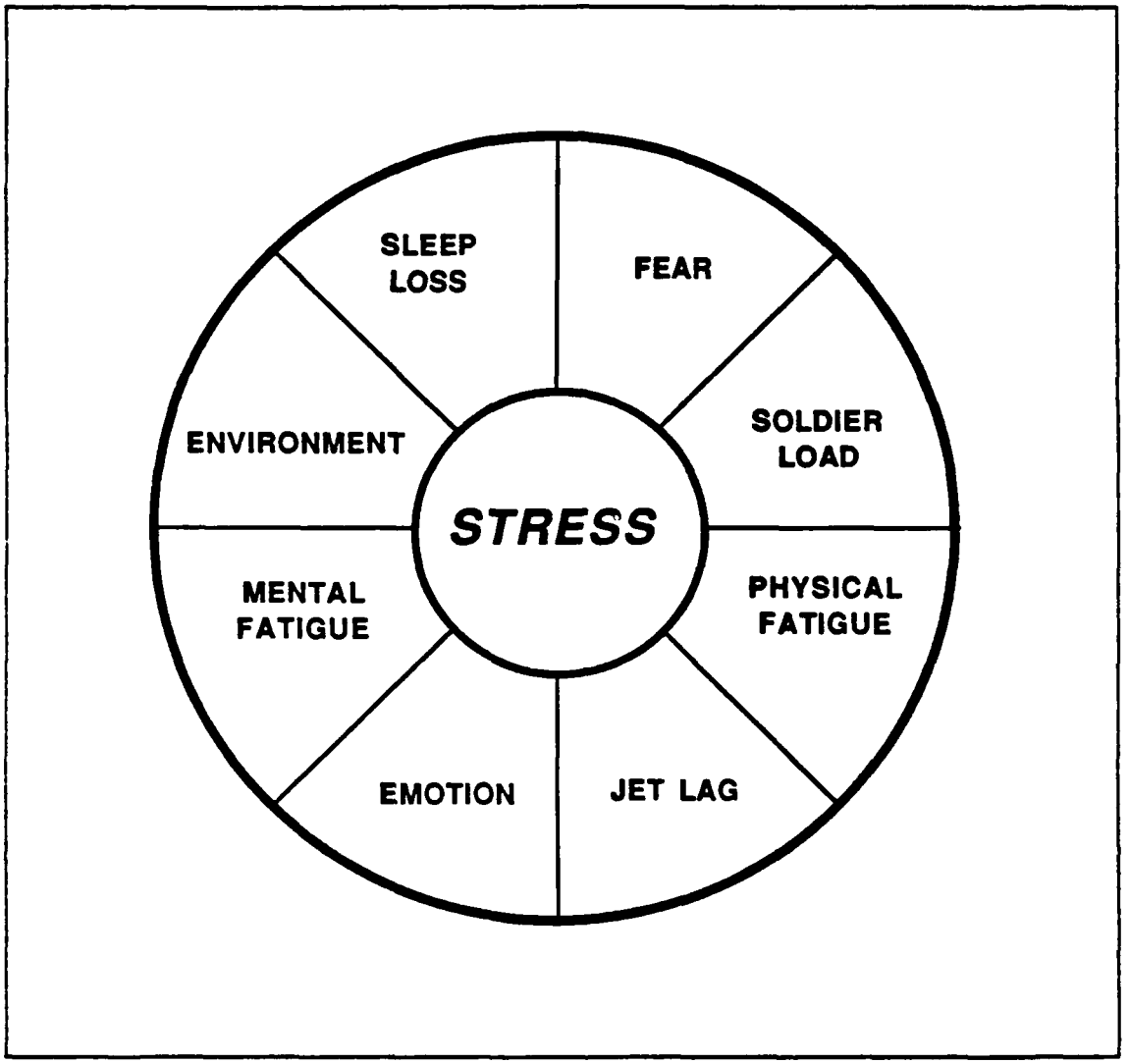

Figure 5. Contributing Factors

The multivariate combination of factors that impinge on other factors can be invoked either separately or simultaneously. An experimental technique which attempts to derive these interrelationships must ensure that the overlapping of factors is controlled in order to predict outcome (effect) from the related human factors (cause).

F. HUMAN FACTORS MODELS

To establish a baseline from which to focus the research effort, an extensive search was conducted to find potential models which categorized human factors. Three models were analyzed in depth and were found to offer slightly different approaches to categorizing human factors.

The first model categorizes human factors with respect to where (temporally) the factor surfaced as a major player or 'big swinger' during a battle. The second model classifies the factors based on whether the impact on performance is due to changes inside or outside the soldier *and* the extent of change over a relative period of time. Finally, the third model focuses on whom the factors affect and the effect on combat potential/combat power. It should be noted that these models were created for different reasons and will be used as 'potential' ways to categorize the factors identified within this study. Each model explains a separate phenomenon.

1. Classified by Time

One method for classification of factors was developed by Schroth in a study which has served as a primer for the incorporation of human factors into combat models. After identifying candidate human factors through an extensive literature search, the factors were divided into two broad areas of influence upon man. The 'areas of influence' represented the time, relative to a battle, that the factors would be most influential. The two categories are:

- Before/After the battle;
- During the battle.

The selected factors can be depicted over time as shown in Figure 6.

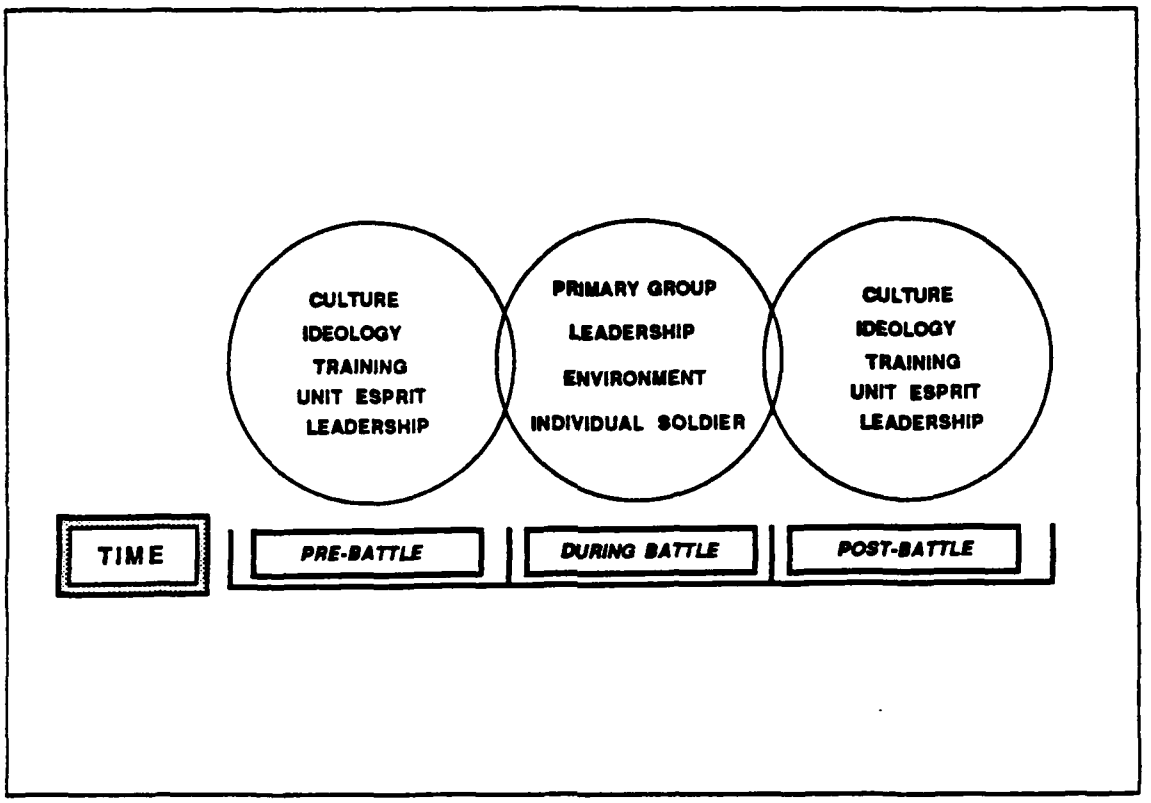

Figure 6. Factors Applied Over Time in a Battle

The human factors chosen are those defined herein as aggregate factors. For instance, within the factor of 'Training' are the following contributing factors:

- Cohesion
- Tactical expertise
- Technical expertise
- Discipline
- Confidence
- Obedience

Since the factors are not isolated down to the individual factor as defined in the current study, direct application to combat models will pose immediate loss of a cause and effect audit trail. This does not discard this classification

technique as a valid model; the individual factors listed in the current study can be categorized using this method.

2. Classified by Location and Endurance

In a study entitled "Soldier Dimensions in Combat Models" [Ref. 25: pp. 1-23], Dr Phillip L. Vandivier discusses and recommends techniques for inputting soldier dimensions (human factors) information into computer models. By integrating human factors, the models are expected to better reflect the real-world situations through adjustment in light of the expected degradation due to soldier performance. A background research effort identified 23 different soldier dimensions which showed a relationship with soldier performance during continuous operations. Of the 23 selected for initial consideration, 19 factors were isolated for use in the study. In the course of the research effort, a conceptual model was developed which classified the factors with respect to their ***location*** relative to the soldier (internal or external to the soldier) and their ***endurance*** (length of time that the factor will prevail). The following terms were used to characterize the factors:

ENDOGENOUS - describes activities and events that occur within the soldier

EXOGENOUS - describes activities and events in the environment that effect the soldier

TRANSITORY - the factor exists for a relatively short duration, is transient, or is short lived

ENDURING - the factor exists for a relatively long time or has a lasting duration

Using these location and endurance descriptors, there are four resultant combinations:

- Endogenous/Transitory
- Endogenous/Enduring
- Exogenous/Transitory
- Exogenous/Enduring

The conceptual model that depicts the classification of the factors considered by Vandivier is depicted in Figure 7.

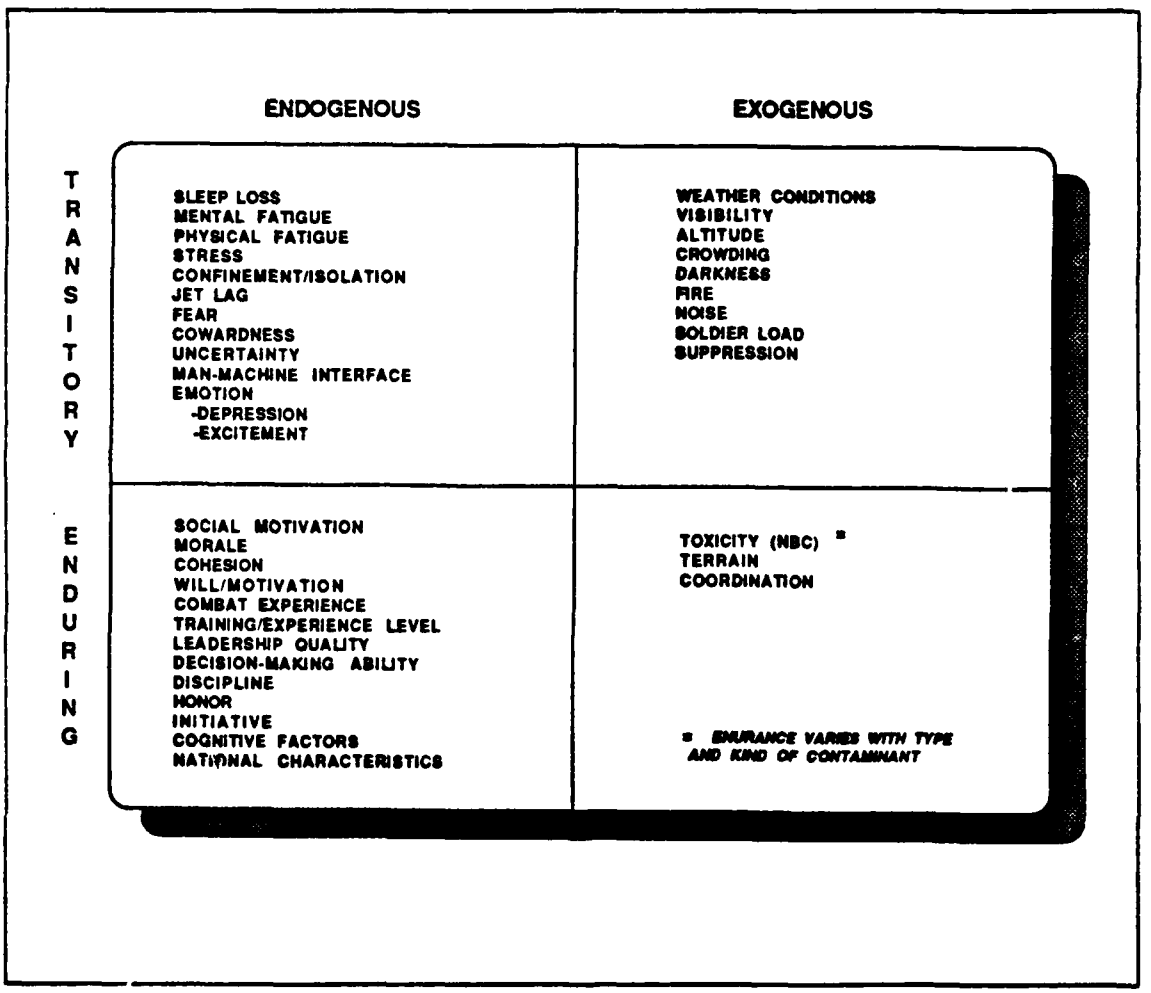

Figure 7. Factors Applied by Source Location and Endurance

One of the obvious advantages to this method of classification is the inherent discrete nature of the model. Discrete, as used here, indicates that the human factors can be categorized with respect to their source location (internal/external) and their endurance (relatively long or short duration). It would be difficult to find many examples that straddle between categories.

3. Classified by Change in Unit Effectiveness

The final model selected for consideration was developed through a series of discussions between the authors and Wayne P. Hughes (Capt, USN, Ret), currently an operations analysis professor at the Naval Postgraduate School. The foundation for this model is the categorization of human factors based on effects resulting from changes in the factors. The effects, in this case, represent a change in what Hughes opts to call 'combat potential' or 'combat power'. In order to fully appreciate the contribution of this model, a basic understanding of the underlying theory of combat potential and power is important.

The theory of combat in this section was developed by The Military Conflict Institute and expanded by Hughes in his paper "Command and Control Within the Theory of Combat" [Ref. 26: pp. 1-53]. The basic premise of the theory is that combat is a complex interaction of force-on-force activities. ***Combat potential*** is the capacity of a given force to engage successfully in combat against an enemy. Combat potential is one of two types: designed or available. Designed combat potential is the result of optimal training, equipment, motivation, organization, and leadership, whereas available combat potential results from the unit's *current capacity* given the unit's state of training, equipment, motivation, organization, and leadership. ***Combat power*** is the lethal effectiveness delivered by forces as result of those forces being activated against an enemy. This is a result of forces engaging enemy forces at a given time and location

Paramount to understanding this theory of combat is the awareness that combat potential is transformed to combat power through the commander's activation of his forces utilizing the C^2 process. As described earlier, human factors can have a profound effect on the command and control process. Within the

context of Hughes' theory of combat, factors which cause changes to human factors are generated from one of four categories:

- External origin generated by nature;
- External origin generated by the enemy;
- External psychological origin generated by friendly forces;
- External psychological origin generated by enemy forces.

These factors can effect the individual or unit (or both) in one of three ways. From the individual soldier perspective, the effects manifest themselves through:

- **Physical changes** - caused by factors internal to the soldier which effect his physical abilities. Examples are a soldier's load, fatigue, and physical conditioning.
- **Psychological changes** - caused by external factors which effect the soldier's cognitive processes and abilities. For instance, increased training is designed to build the soldier's mental confidence in his personal abilities.
- **Spiritual changes** - caused by external factors, these pertain to the immaterial nature of man and are normally considered as part of the 'soul' or inner man. An example of this category of factors can be represented by descriptors such as the "will to win".

With these definitions, the model as proposed by Hughes is depicted in Figure 8.

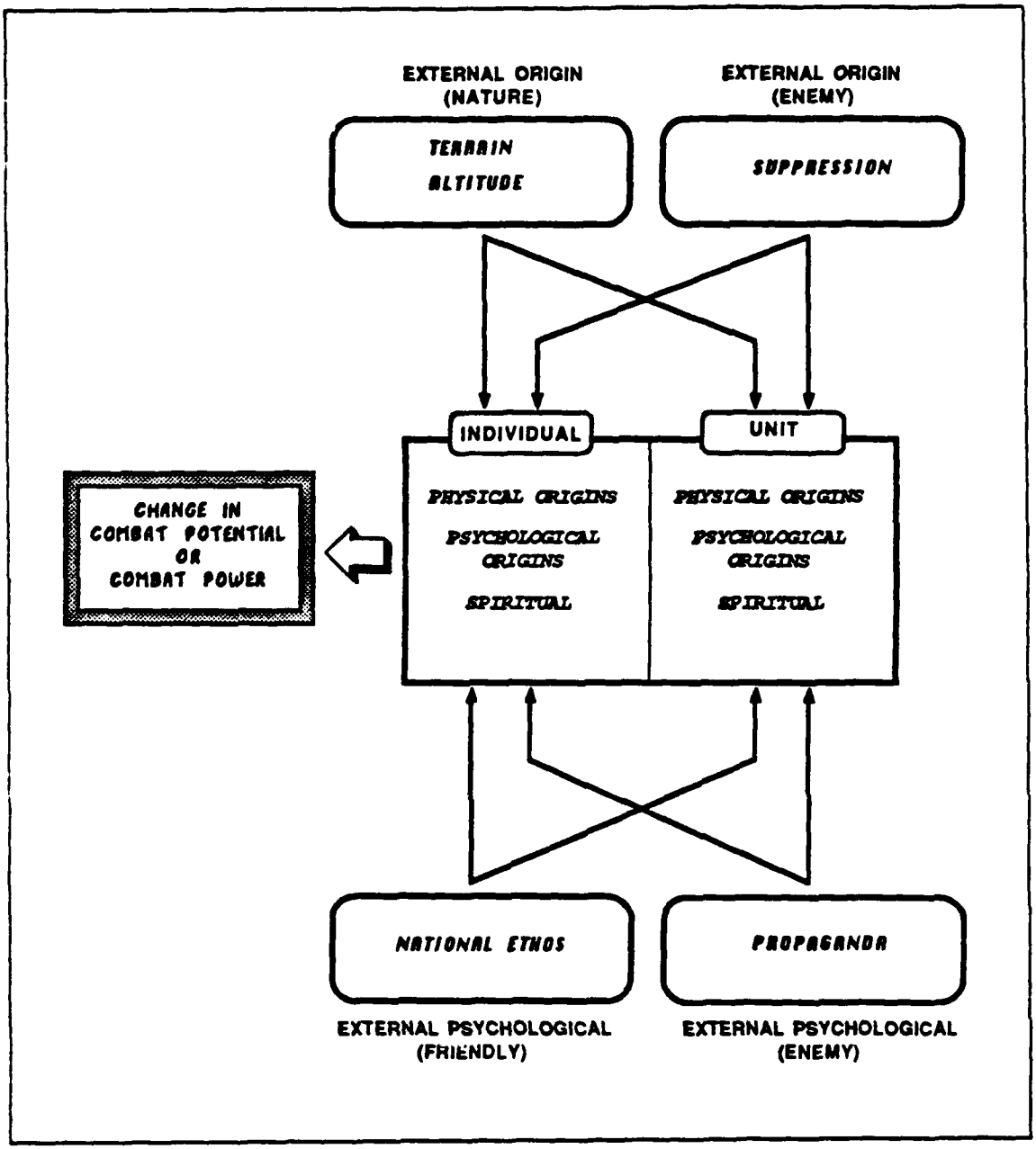

Figure 8. Factors Applied by Effect on the Individual or Unit

G. REVIEW OF ISSUES

A summary of the background information presented is in order prior to delineating the experimental design. Therefore, the following represent the cogent points of this section:

- The C^2 process within an indeterminate or chaotic environment provides the scenario backdrop for the purposes of this study.
- Human factors, as defined, are of two basic types: physiological and psychological.
- Combat models emulate the combat environment. As such, combat models should adequately reflect the human dimension.
- The command and control process is comprised of five functions: sense, process, compare, decide, and act. At lower echelons of command, the compare and decide functions are normally personally performed by the commander.
- Aggregation of factors should be avoided at the onset of experimentation if clear cause and effect audit trails are to be established.
- There are a multitude of models available to classify or categorize human factors. Of these, the three reviewed were:
  - Classified by when the factor most impacted on a battle;
  - Classified by whether the change occurs internal or external to the human and based on the endurance of the factor;
  - Classified by the effect on the unit or individual with the subsequent impact on the unit's combat effectiveness.

These developmental points provide the basis for the experimental design. As such, each was partially implemented in defining the method for determining those factors affecting a commander's decision in a tactical environment.

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III. EXPERIMENTAL DESIGN

The common thread which provides the substance of this study is the determination of those human factors that impact on the commander as a decision-maker. The experimental design and process used to determine those factors is the subject of this section. There are several candidate methodologies which might be used to address this issue. After discussion of their advantages and disadvantages, this section provides an in-depth examination of the approach used in this research.

A. DATA COLLECTION METHODS

As previously stated, quantifying a qualitative entity is difficult. In selecting an approach within the bounds of scientific methodology, the primary question with respect to this study is: What are the options available to isolate the *important* human factors? The answer is that there are three primary methods, all bearing their own degree of merit. Each of the research techniques described here was considered as a viable research option. A brief explanation along with the advantages and disadvantages are presented.

1. Historical Combat Accounts

Probably the most prolific source of literature involving human factors in combat has resulted from the work of historians, behavioral scientists, and soldiers gathering data from combatants after a battle/combat action or reflecting on historical accounts of combat action. Examples can be attained through examining the research efforts and works of authors such as S.L.A. Marshall[1] and Trevor Dupuy. There is no doubt that the efforts of these authors have revolu-

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1 S.L.A. Marshall (BG, USAR, Retired), served as a combat historian in World War II, Korea, and Vietnam. His books include *The River and the Gauntlet* and *Pork Chop Hill.* Probably his most recognized work was *Men Against Fire* which examined and emphasized the importance of the often forgotten and misunderstood figure: the American combat soldier. His research techniques focussed on interviewing combatants fresh from battle.

tionized current thinking with respect to the attention paid to the human aspects of combat systems, processes, and organizations. In fact, in a paper addressing the modeling of human behavior in combat, Dupuy states:

> "...to study human reaction in a battlefield environment we have no choice but to go on the battlefield, not the laboratory, not the proving ground, not the training reservation. But because of the nature of the very characteristics of combat which we want to study, we can't study them during the battle. We can only do so retrospectively." [Ref. 27: p. 3]

There are some potential detriments to acquiring data from historical incidents. The first potential shortcoming is in the perishability of the data. Marshall (and others) attempted to capture the information while it was still 'fresh' by interviewing soldiers immediately after a battle. One can postulate that as the time from event conclusion to interview increased, the clarity of the account of *how* the action occurred decreased -- that is human nature. Additionally, talk among soldiers may further confuscate the recollection. The second potential shortcoming is the individual who is providing the account. The soldiers who ***survived*** the battle are the subjects. What of those who did not survive? What were they doing right or wrong? What factors might have been involved or to what degree did they possess certain attributes that may have caused them to place themselves in danger?

Of final consequence is that data obtained from combat is real but rough. That is due, in part, to the multivariate and chaotic nature of combat. With respect to obtaining data from combat, Hughes (et al.) states:

> "The existence of combat data should not lead to an overestimation of its precision and value. Wartime analysts emphasized the need for personal presence and observation to understand not only the nature of the data but the nature of the operation. Morse and Kimball's famous 'hemibel thinking,' the search for a threefold difference between postulated and observed results, was based in part on the coarseness of the data, in part on a compelling desire to find areas of big improvement." [Ref. 14: p. 26]

2. Training Exercises

Field exercises or training exercises have the potential to provide a wealth of useful data. In planning these exercises, commanders attempt to emulate conditions which might confront their soldiers in combat. In doing so, many of the battlefield processes (i.e., force maneuver, fire planning, C^2) are stressed. With respect to the current study, there are two major drawbacks to using training exercises for determining the most important factors affecting a commander's decision:

1. The lack of **experimental robustness**, and
2. The isolation from the **mental terror** experienced under actual combat conditions.

Field exercises under similar conditions can be partially reproduced, but the resource expense significantly increases with the size of participating units. As a result, collection of data is usually a by-product and not the main focus of most field training exercises. Missions are infrequently repeated which narrows the range of conditions over which causal/effect relationships can be surmised. This, in turn, lessens the range of conditions to which any findings can be applied and decreases the utility or robustness of a derived model.

A second drawback is that 'actual battlefield conditions' are essentially irreproducible. The cumulative stress or fatigue associated with continuous **combat** operations; the adrenalin 'high' and its related physiological impacts; the mental anguish experienced from treating wounded or dying comrades; the devastating effects of modern weaponry -- these aspects cannot be experienced in a peacetime training environment. Even with the addition and integration of direct fire training systems such as MILES (Multiple Integrated Laser Engagement System), a soldier's mental frame of mind is likely to be such that if he is killed, unlike the unforgiving nature of actual combat, he can be revived and allowed to fight another day.

3. Subjective Methods

In designing qualitative research, there are two fundamental techniques which provide the core of data collection: personal observation and in-depth interviewing. These techniques are used in collecting data in both combat and exercise environments and are supplemented by more specific techniques characterized by:

1. Questionnaires and surveys
2. Films, photographs, and videotapes
3. Projective techniques and psychological testing

For the most part, these supplemental techniques range the spectrum of subjectivity. Subjective influence may be interjected early in the data collection process (as seen in surveys) or later (as demonstrated in the subjective analysis of psychological tests). Although potential research avenues with respect to human factors exist in all of the supplemental techniques, the scope is narrowed to consider the questionnaire or survey as the instrument of choice. [Ref. 28: pp. 79-87]

Questionnaires and surveys allow the researcher to make inferences about a large number of people from data which is drawn from a relatively small number of individuals from that group. In fact, a survey "is the preferred method if the researcher wished to obtain a small amount of information from a large number of subjects [Ref. 28: p. 84]." As such, the survey serves its basic aim by statistically describing and explaining the variability of certain facets or dimensions of the population. Surveys have several basic strengths including their:

> "...accuracy, generalizability, and convenience. Accuracy in measurement is enhanced by quantification, replicability, and control over observer effects. Survey results can be generalized to a larger population within known limits of error. Surveys are amenable to rapid statistical analysis and comparatively easy to administer and manage." [Ref. 28: p. 85].

There are also inherent weaknesses in survey instruments. With respect to human factors research, a survey would strive to provide the basis of inference encompassing those factors that commanders *think* are important. In essence, the

fallability of surveys are that they require humans to judge which factors they *perceive* to be important.

B. THE RESEARCH APPROACH

Given the advantages and disadvantages of each of the techniques described above, a subjective approach using surveys as the research instrument was determined as the most appropriate. As such, the thrust of the experimental design was twofold. First, isolate those factors which might affect a commander's decision. By 'affect', consideration is given to those factors which would impact on a commander's decision -- those which the commander consciously or subconsciously considers in the formulation of his decision. Second, of the most important factors identified in the exploratory experiment, determine whether the tactical situation or context changes the relative order of significance.

The sample population for the survey was drawn from students at the Naval Postgraduate School. Using these officers provided a wide variety of military background and experience. As with any survey, the honesty and accuracy of the respondents' replies must be depended upon in order to infer population characteristics from the sample responses.

The steps taken to answer the research questions comprise the remainder of this section and are summarized in the following outline.

1. A categorization model was chosen from those presented in the previous of the thesis. The selected model enabled the factors to be categorized by source location and endurance [Ref. 25]. Using this model as a base, the research effort was focussed solely on endogenous factors which reduced the initial 61 factors (Appendix B) to a more manageable quantity of 27 factors.
2. Next, since ***survey design*** and ***required output*** from the survey are inseparable, the potential methods for quantifying the qualitative nature of the survey data were explored. Of the four techniques considered, the *Categorical Judgment Technique* was judged as the most appropriate technique. The output of the technique provides an interval scale.

3. Survey design was critical to establishing the validity of the research effort. As eluded to in the Introduction of the study, there were two primary surveys used.
   - Survey I or the Initial Survey focussed on determining which of the factors would impact on the commander as the decision-maker. With the exception that the 'decision' was specified as a reduced-time command and control decision, the scenario in which to apply the human factors was essentially generic or dimensionless.
   - Survey II or the Follow-On Survey was designed to determine whether the scenario in which the factors were considered would alter the relative order of the factors.
4. As a final explanatory step to the research method, a numerical 'walk-through' of the categorical judgment technique is provided at the end of this section. Since a majority of the calculations were performed through the use of computer algorithms, this example will serve to assist the reader in understanding how the interval scales were constructed.

C. NARROWING THE SCOPE

Reducing the quantity of variables involved in an experiment is critical when a large number of variables are involved. Coupled with reduction is categorization. Of the models reviewed in the previous of this study, the model developed by Dr. Phillip Vandivier [Ref. 25: pp. 1- 23] was selected for use in this study. This model offered the simplest approach to discrete categorization of the factors. As such, the initial 61 human factors can be classified in one of four categories:

- Endogenous/Transitory
- Endogenous/Enduring
- Exogenous/Transitory
- Exogenous/Enduring

With the factors categorized, the guideline of considering only those factors which are endogenous was invoked. Why only endogenous factors? Besides allowing for an immediate reduction in variables, the primary reason for this restriction is that these factors are *internal* to the human or are only apparent

within groups. As such, the endogenous factors are not as understandable as external variables, yielding wide latitude in the research approaches used to isolate the important variables.

Factors organic to an exogenous source tend to affect a soldiers with respect to a change in *time* required to perform a specified task. For instance, consider two units operating within two distinct external environments: one in a non-chemically contaminated environment, the other in a fully contaminated chemical environment. With all other things being equal, if the unit within the chemical environment has been properly trained to withstand the physiological and psychological rigor associated with that type of environment, one could expect that unit's performance to nearly parallel the unit operating in uncontaminated conditions. Proper advance planning by commanders and prior training of the unit can serve to diminish and compensate for the difficulties experienced by a change of environmental or exogenous factors.

The other reason for steering clear of exogenous factors is that, in many cases, these can be considered as dependent variables. That is, these factors are sometimes considered as the ***cause*** for a change in the level of internal attributes. For instance, increasing a soldier's load or a change in altitude elicits other physiological and psychological responses.

Given this narrowed scope, the factors which can be categorized into either endogenous/transitory or endogenous/enduring are as depicted in Figure 9. This list of 27 human factors provided the base used in developing the Initial Survey.

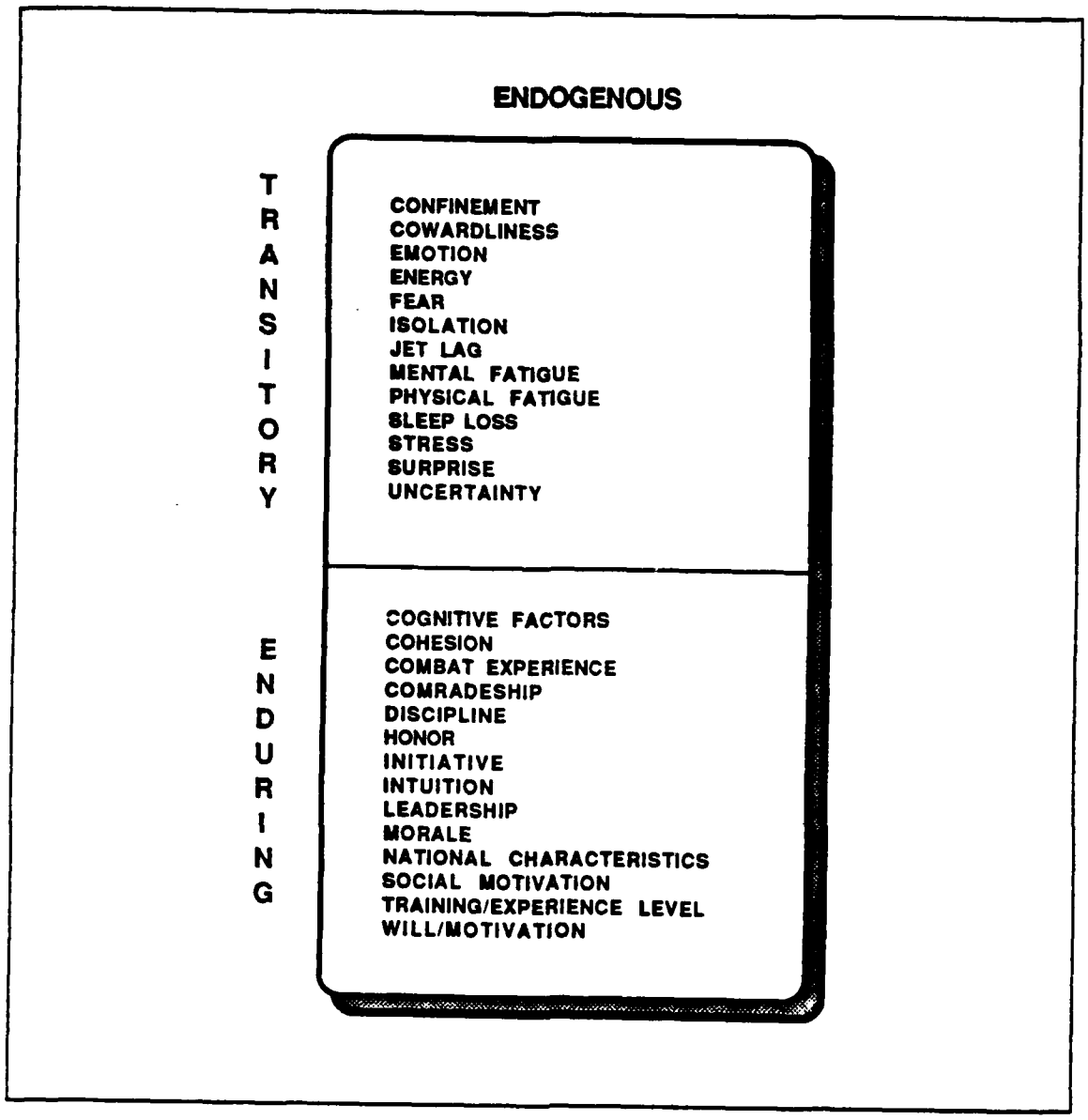

Figure 9. Factors Impacting on Command and Control Decisions

D. QUANTITATIVE METHODS

In designing the survey instruments, the available methods for reduction and quantization of subjective responses were reviewed. The purpose of this review was to find the technique which would provide, as its output, an interval scale. An interval scale was preferred to an ordinal ranking since the interval scale provides a spatial distribution along with the relative order of the factors. During the process of determining the most effective technique for quantifying the factors, four methods were considered: a continuous response scale, the paired comparison test, ordinal judgments, and categorical judgments. Each is briefly discussed below.

1. Continuous Response Scale

A Continuous Response Scale allows subjects to rank instances (human factors) on a scale from 0 to 100. This ranking is based on the feelings of the subjects making the ranking. This approach is analogous to a one-way classification in the Analysis of Variance (ANOVA) which is often used to determine interrelationships. However, subjects may find it extremely hard to make a judgment on a continuous scale. Additionally, intervals between the ranks could not be established and, as a result, this method was not used. [Ref. 29: p. 46]

2. Paired Comparison Test

The method of Paired Comparisons asks subjects to compare two instances or human factors and determine which possess the greater value. To use this method each instance is paired with another instance. Thus, given n instances, there are $\frac{n(n-1)}{2}$ possible pairings. For the Initial Survey, designed to determine the most important of 27 human factors, this technique would require the subject to compare $\frac{27(27-1)}{2} = 351$ instances. For such a large number of instances it would be infeasible to accurately make useful comparisons. Therefore, this method was not selected. [Ref. 29: pp. 166-168]

3. Ordinal Judgments

The Ordinal Scale method asks subjects to rank or order instances based on their feelings. There are no assumptions made, however, regarding the distance or spatial distribution between the instances. Due to the number of instances included in the Initial Survey (27), a subject may not be able to distinguish between two instances. For one reason or another, some subjects may not rank all of the instances thereby creating an invalid ranking. As a result, this method was determined to be less than desirable. [Ref. 29: p. 19]

4. Categorical Judgments

Categorical judgments require respondents of questionnaires to select the category they deem as best representing an instance. This method is a scaling technique which uses the categorical ratings of the respondents and constructs an interval scale. This scale includes both the instances and the bounds or intervals between the categories. As such, the categorical bounds are discretely defined on the final scale. The categories are understood to be a mutually exclusive set of successive intervals. Also these categories are listed in such a manner that the categories are placed in ascending order. One example of categorical judgments is the method by which students rate instructors as poor, fair, average, excellent, or outstanding. In this example, the possible rating levels are the categories and the instructors are the instances. Another example of a categorical judgment is the ranking of military officers on fitness reports. [Ref. 30: p. 1]

E. SURVEY I DEVELOPMENT

The initial focus of the experimental procedure was to determine which of the human factors would impact on a commander making a C^2 decision. To establish the rank order of importance for the categorized human factors, a judgmental questionnaire (Initial Survey or Survey I) was designed to be distributed to officers attending advanced study curricula at the Naval Postgraduate School (NPS). The designed intent of the survey was the identification of the most important factors for use as input in the Follow-On Survey.

Officers from each of the four services (Army, Air Force, Marine Corps, Navy) were queried through the Initial Survey. This 'joint' approach was used solely to determine whether responses or order varied by service. Even though the vast majority of the respondents were non-combat veterans, the sample population reflected a wide variety of background experience with expertise in both staff and command positions. Distribution included all assigned officers in the Army, Air Force, and Marine Corps, while one of every four naval officers was randomly selected for participation based on the disproportionate number of naval officers attending NPS.

1. Survey Design

The Initial Survey was designed to allow respondents to logically categorize the human factors in the simplest manner possible. The survey consisted of three parts:

Part I - Demographics/Special Instructions

Part II - Questionnaire

Part III - Open Statement/Respondent Comments

In addition, a cover letter was included which provided an explanation of the purpose of the study and the intended use of the findings. A description of each part of the survey is outlined below, while a sample copy of the actual survey is included in Appendix C.

a. Demographics/Special Instructions

The first part of the survey consisted of two parts: demographics and special instructions. The demographic information was requested in order to establish the background characteristics of the sample population. The basic demographic information consisted of the respondents' service, pay grade, branch of service, time spent in command, and time spent as a staff officer. Additionally, each respondent was queried as to his combat experience; this was included to determine if a large enough sample was available to detect a difference between the responses of combat and non-combat veterans. Since less than one percent of the respondents had served in a combat environment, this information was not used in further analysis.

The special instructions were intended to ensure that all respondents began the survey with the same basic understanding of *how to categorize* the listed human factors. The scenario or context was intentionally left open-ended, allowing the respondent to apply the human factors in accordance with his personal experience. In addition, this 'dimensionless' environment ensured that no branch or service bias was introduced into the survey.

The driving point of the special instructions was that the human factors were to be categorized based on a **reduced-time, operational command and control decision**. The terminology of 'reduced-time' was used to distinguish this type of combat decision from a planning or organizational decision -- a decision that must be made within seconds or minutes as opposed to a decision where time is of little or no consequence. In many cases, the amount of time that a commander has to consider a course of action may influence *how* he will make that decision.

Ensuring that the decision-maker is confronted by this type of 'critical' decision also assists in isolating the way that a first order human factor is perceived. For example, consider the factor ***cohesion***. As depicted in Figure 10, the level of cohesion that a unit possesses varies with time. Theoretically, a

reduction in the amount of time given the decision-maker should reduce the variance of an inherent factor level such that the factor can be specified instantaneously at a certain level.

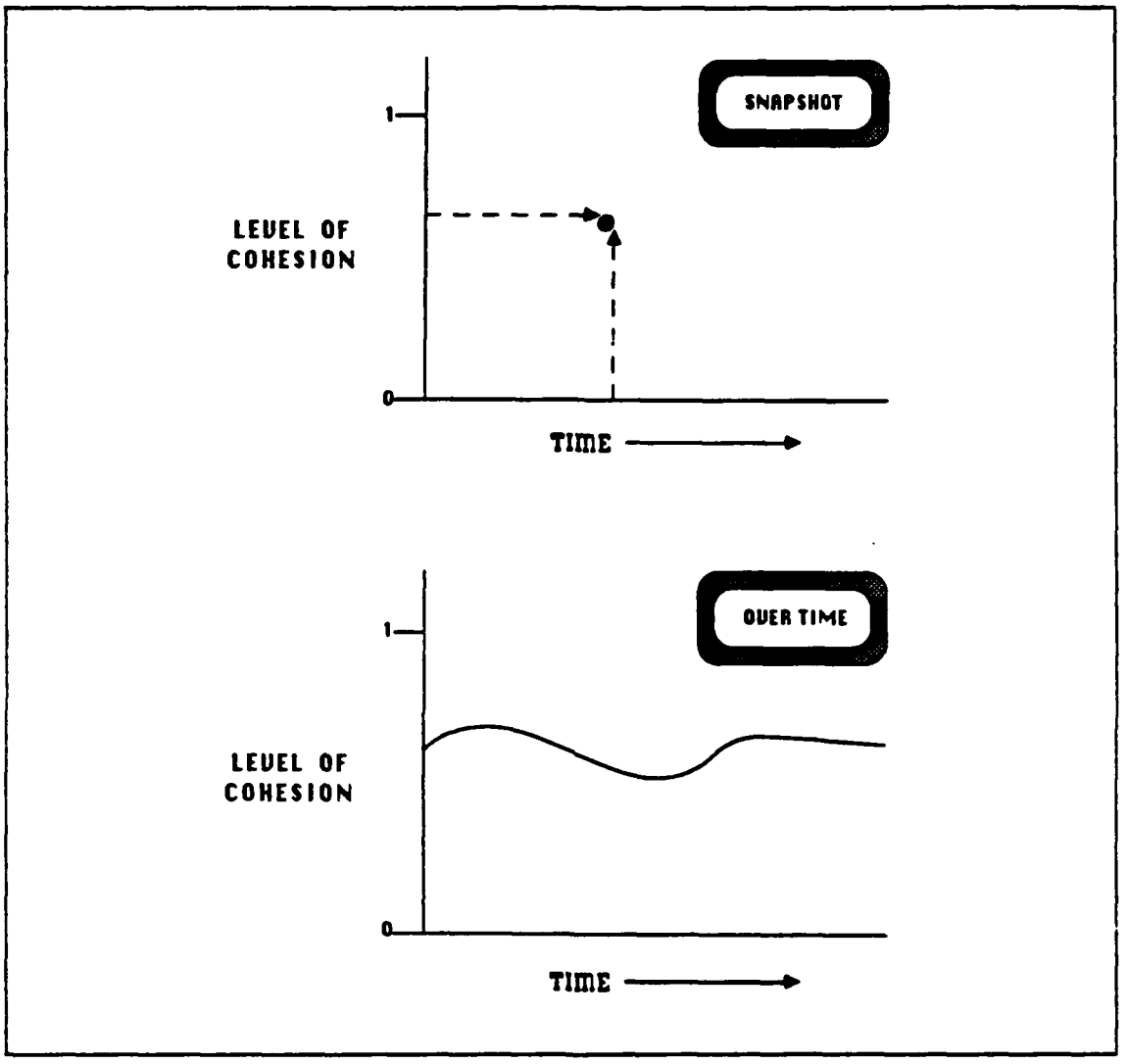

Figure 10. Level of Factor - Instantaneous versus Over Time

b. Questionnaire

The questionnaire portion of the survey consisted of the research question, the judgment categories, and the 27 human factors under consideration. Since the judgment category descriptors and the research question are so intimately correlated, extensive care was taken to word the question in a manner that elicited a logical response. The research question for Survey I was:

> How important is each of these Human Factors (as possessed by the unit or individuals within the unit) to a commander in his formulation of a reduced-time operational command and control decision?

Since the categorical judgment technique was chosen as the analysis tool, the descriptors allowed for each factor to be scaled independently in one of four categories:

- Very Important
- Important
- Not Important
- Very Unimportant

In addition to providing discrete, mutually exclusive categories, the chosen descriptors were selected such that the parallel wording ensured that the response categories were one standard deviation apart (based on normality of responses). In most cases of categorical judgments, five categories are presented giving respondents a category of 'neutrality'. The neutral category was intentionally omitted from the Initial Survey to force respondents to commit to the fact that a given factor either **is** important or **is not** important, thereby alleviating the potential for 'middle-of-the-road' responses. [Ref. 31: p. 84]

Each human factor was listed in the main body of the questionnaire along with its definition. The definition was included to clarify the intended meaning of the factor, thereby establishing a common basis of understanding. Alphabetical ordering was used to avoid any potential for bias at the onset.

As with any categorical judgment survey, validity of the output is highly dependent on the quality of the initial research question. Therefore, it is necessary for the respondents to have a clear understanding of the research question from the start [Ref. 28: p. 104]. As a result, the question is stated twice early in the questionnaire and is reiterated at the beginning of each page.

c. Open Statement

Since this survey represents an exploratory 'pilot' research approach, respondents were asked to list any additional human factors which they felt would affect a commander in making a C^2 decision. This provided an open-ended environment where respondents could express their personal thoughts on human factors in command and control decision-making. The results from this portion were used to tailor the Follow-On Survey.

F. SURVEY II DEVELOPMENT

With the relative order of the factors affecting a commander's C^2 decision-making process delineated, the next logical step was to determine whether the scenario or context to which the factors were applied would have a significant impact. Recall in Survey I that the factors were applied in a 'dimensionless' environment. The methodology supporting the Follow-On Survey was to time-step the respondent through a sequence of scenarios, invoking (out of necessity) some of the exogenous factors purposely deleted from the Initial Survey.

Two versions of the survey were designed based on the experience and background of the authors. The first scenario, called the ***Infantry Scenario***, focussed on C^2 decisions that an infantry company commander might be required to make in a combat environment. The second scenario, called the ***Artillery Scenario*** concentrated on the C^2 decisions that might confront an Artillery battery commander

in combat. The primary reason for scenario variation was the added determination as to whether the service branch (i.e., Infantry versus Field Artillery) and, as a result, the decisions facing that type commander would significantly affect the relative order of significance of the human factors. Both of these branches are considered *combat arms*, generally operating in chaotic environments where reduced-time decisions normally impact on the immediate outcome of a battle. This two-pronged variation to the development and implementation of the Follow-On Survey is as depicted in Figure 11.

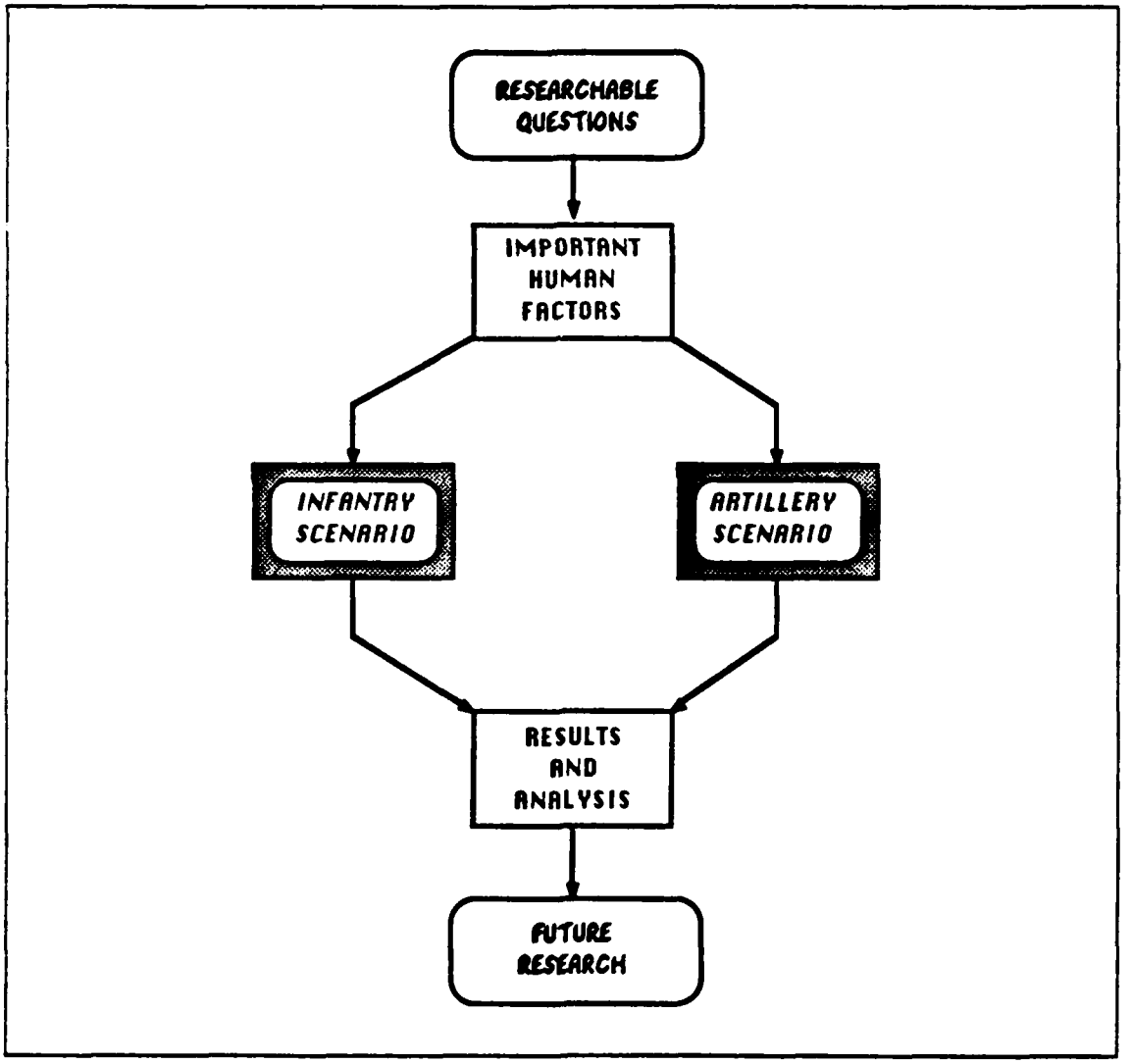

Figure 11. Follow-On Survey Methodology

Respondent selection for participants in Survey II was limited to Army students assigned to advanced study curricula at the Naval Postgraduate School (NPS). This restriction was installed due to the fact that the respondents for this particular survey should have some basic working knowledge of Army field operations. The participants were divided such that Infantry-branched officers completed the Infantry scenario, Artillery-branched officers completed the Artillery scenario, with the remaining officers randomly split to ensure equal branch representation to both scenarios.

The human factors which the respondents were to categorize consisted of the seven most important factors as determined from the Initial Survey. The reason for selecting only seven factors was (as will be seen in the *Results* section) that these factors were the top seven for all services independent of the rank order.

1. Survey Design

As with the Initial Survey, the Follow-On Survey was designed to allow respondents to logically categorize the human factors in the simplest manner possible. The survey consisted of four parts:

Part I - Background

Part II - Task Force Scenario

Part III - Unit Situation/Sub-cases

Part IV - Special Information

As in the Initial Survey, a cover letter provided respondents the purpose of the study and the intended use of the findings. A description of each part of the survey is outlined below while sample copies of the surveys are included in Appendix D.

a. Background

The survey background information was intended to provide respondents with a base from which to complete the survey. The background information emphasized the following points:

- Perceived truth was assumed to be ground truth. In other words, the friendly and enemy information provided in the survey is exactly how it exists on the ground. This was included to emphasize to respondents not to unnecessarily 'wargame' the decision based on how they might perceive the presented information.
- Since the scenario was written within a ground European theater context, respondents were directed to assume that (for whatever reason) hostilities between NATO and the Warsaw Pact were imminent.
- Probably the most important point of consideration, respondents were informed that the authors realized that applying a list of human factors is not normally done by decision-makers in a reduced-time environment. As previously stated, this is probably part of a subconscious weighting. As such, respondents were directed to apply each factor individually.
- Since the scenario was designed as a time-step sequence, respondents were directed not to change an answer once made.
- The overall general Brigade mission to which the respondent was assigned was delineated.

In designing this survey, one self-imposed restriction was to try to keep each sub-case on one sheet of paper. Since the emphasis was in portraying an adequate decision context in which to apply the human factors, most of the available page space was used for that purpose. As such, definitions of the human factors under consideration were included as the last section of the background information.

b. Task Force Scenario

The task force scenario was intended to provide the respondents with the basic 'tactical picture'. Included as part of this section are:

- Designation of the Battalion Task Force as well as the company/battery of which the respondent is the commander.
- Information on the enemy to include current activity, potential, and probable courses of action.
- The Task Force Commander's intent, expectations, and Mission Oriented Protective Posture (MOPP) guidance.
- Environmental considerations to include the terrain and weather within the area of operation.

c. Unit Situation/Sub-Cases

The unit situation was designed to place the respondent within a parametrically specified environment. The term *unit*, as used here, refers to either an Infantry company or an Artillery battery. Specific items addressed as part of the unit situation include:

- Specific unit organization
- General unit location in relation to the Inter-German Border
- Assigned unit mission, contingency mission, and current disposition (defensive posture)
- General unit level of training with respect to the assigned and contingency missions
- Initial unit readiness states (personnel and equipment).

In addition, respondents were asked to disregard the success or failure of the Non-combatant Evacuation Operation (NEO) plan.[2] This restriction was foreseen as necessary in order to isolate the respondents' thoughts specifically on the tactical context and avoid unnecessary bias by those who feel that unit performance would decrease if the NEO plan fails.

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2 The Non-combatant Evacuation Operation (NEO) plan is designed to provide non-combatants (in particular, families accompanying service members in overseas locations) with a plan for evacuation from a hostile or potentially hostile region.

Another potential bias which was intentionally omitted was what the authors have chosen to call 'map bias'. Given the same six or eight digit coordinate and a topographic map which contains those coordinates, each individual interprets the coordinates in a slightly different manner; many times people 'see' different things when looking at the same terrain feature on a map. As a result, general descriptions of tactical situations were preferred over specific map dispositions.

The sub-cases or sub-scenarios (referred to herein as cases) comprised the questionnaire portion of the survey. These cases represented four separate and distinct scenarios that were presented in a time-stepped sequence, leading the respondent through a series of tactical contexts. The four cases were essentially parallel for both Infantry and Artillery scenarios. The Infantry cases are outlined below.

Case Number 1 - The unit commander is required to quickly decide how to modify his intended plan to secure two sites. The modification is necessary due to the fact that his Executive Officer, who was going to supervise the security of one of the sites (with the commander at the other) was medically evacuated.

Case Number 2 - One of the two platoons protecting the site where the commander is located starts receiving heavy ground fire. The commander must make the decision whether to deploy the reaction force in support of that platoon.

Case Number 3 - Two large rockets land 3 kilometers upwind from the commander's location. Since the unit is currently in a reduced Mission Oriented Protective Posture (MOPP), the commander must decide whether or not to go to full MOPP and accept a degradation in defensive preparations.

Case Number 4 - A sister unit's defensive position sustained a direct hit with a non-persistent nerve agent resulting in an estimated 110-115 casualties. The battalion commander has directed the company commander to send one of the platoon's from his current position to the sister unit's position to re-establish the defense and assess/evacuate casualties. The battalion commander has also told the company commander that he is to personally remain with the current site security mission.

As in Survey I, the judgment categories and the research question were intimately correlated, therefore extreme care was taken to word the question in a manner that elicited a logical response given the judgment categories. The research question for Survey II was:

> **How important is each of these human factors listed below (as possessed by the unit or individuals within the unit) to you, as the commander, in the formulation of this reduced-time decision?**

Since the categorical judgment technique was the method chosen for analysis, the category descriptors allowed for each factor to be scaled independently in one of five categories:

- Very important
- Important
- Neutral
- Unimportant
- Very unimportant

The seven factors used in the Follow-On Survey were the most important factors identified by respondents of the Initial Survey. The factors were presented to the respondents in alphabetical order. The seven factors used in Survey II were:

- Cohesion
- Discipline
- Initiative
- Leadership
- Morale
- Training/Experience
- Will/Motivation

As previously stated, the validity of output for this type of survey instrument is highly dependent on the research question. Respondents must be able to clearly identify the research question and, as such, the question is stated twice (in the cover letter and in each sub-case) prior to the first required response.

d. Special Information

The special information consisted of two parts: demographics and survey effectiveness. The demographics information was the same as that requested for Survey I. The survey effectiveness portions asked respondents to subjectively state their opinions as to the quality of the survey. Respondents were asked to respond to the following questions:

- Were the situations presented understandable?
- Would you say that the situations presented were realistic?
- What assumptions did you have to make in order to complete this survey?

The information derived from the effectiveness questions was requested to facilitate improvements in future generations of this survey.

G. THE TECHNIQUE OF CHOICE: CATEGORICAL JUDGMENTS

The categorical technique is a method that has been used in previous research efforts conducted at the Naval Postgraduate School. After careful consideration of the requirement to have an interval scale as an end product, this technique was deemed as the most suitable method for the transformation of the judgmental responses. Four APL (A Programming Language) programs were used to accomplish the quantitative manipulation task. These programs (Appendix D) were developed by Professor Glenn F. Lindsay, an operations research instructor at the Naval Postgraduate School.

The procedure to derive the interval scale from judgmental responses will be discussed in the next section. There are four assumptions which must be considered in using this technique:

1. A respondent's 'feelings' about the scale value of an instance (human factor) i is a normally distributed random variable with mean μ_i and variance σ_i^2.
2. Respondents view the continuum of values for instances as being broken into successive intervals called categories.
3. A respondent's feeling about a category upper bound is a normally distributed random variable so that for category j, the upper bound would be normally distributed with mean μ_j and variance σ_j^2.
4. All category bounds have the same variance, so that for all j, $\sigma_j^2 = c$. [Ref. 30: pp. 6-7]

1. Step-by-step interval scale development

The mathematical procedure used to establish an interval scale is thoroughly and clearly described, along with examples, in Professor Lindsay's paper [Ref. 30]. The following is a brief outline of the steps involved in the procedure.

1. Arrange the raw frequency data in a table where the rows are instances (human factors) and the columns the categories. Columns should be in rank order, with Column 1, the leftmost column, representing the least favorable category and the most favorable category in the rightmost column.

2. Compute relative cumulative frequencies for each row, and record these in a new table. This table is referred to as the P array and all values of $p_{ij} > 0.98$ and $p_{ij} < 0.02$ are removed to avoid undue influence by a small number of respondents. This creates a n by (m-k) array, where k is the number of columns removed.

3. Treating these values as leftward areas under a Normal (0,1) curve, go to a table of the Normal distribution and find the z values for these areas. Record these in a new n by (m-k) table. This is the z_{ij} array for the computations which follow.

4. For each row i in the z_{ij} array, compute the row average, $\bar{z}_i$.

5. For each column j in the z_{ij} array, compute the column average. Call these column averages b_j, and note that b_j is the value of the upper bound of category j on the scale.

6. Compute a grand average of all the values in the z_{ij} array. This is readily done by simply averaging the column averages. Call the grand average $\bar{b}$.

7. Compute the sum of squares of the differences between the grand average, $\bar{b}$, and the column averages, b_j using the equation:

$$B = \sum_{j=1}^{m-k} (b_j - \bar{b})^2$$

8. Compute the sum of squares of the differences between the normalized row averages, $\bar{z}_i$, and the individual normalized array values, z_{ij} using the equation:

$$A_i = \sum_{j=1}^{m-k} (z_{ij} - \bar{z}_i)^2$$

9. For each row, compute $\sqrt{B/A_i}$, an estimate of the standard deviation:

$$\sqrt{\sigma_i^2 + c}$$

10. Finally, compute each row (instance) scale value using the equation:

$$S_i = \bar{b} - \bar{z}_i \sqrt{B/A_i}$$

The final product of this outlined procedure are the scaled values of the instances which are on the same interval scale as the category bounds b_j. With this scale established, a linear transformation may be performed using the general formula:

$$y = \alpha + \beta x, \beta > 0$$

which will adjust the scale as desired. When performing the linear transformation it is critical to adjust ***both*** the instance values and the category bounds. [Ref. 30: pp. 14-15]

The categorical APL programs combine several of these steps possibly making the concept difficult to understand. Thus, an example will be presented to ensure understanding of the entire procedure and what the programs are doing. Also, part of the requirements for using this technique is to develop an appropriate survey to categorize instances, which has already been discussed.

2. Incomplete Arrays

The categorical method does have a flaw in that the computational procedure should not be applied to an incomplete z_{ij} array. Therefore in order to use this method one must re-do the scaling problem in a way to obtain complete z_{ij} arrays. Due to the fact the z_{ij} array corresponds to the cumulative relative frequencies, missing z_{ij} values are always found in one or more of the outermost columns which involve the highest ranked categories, the lowest ranked categories, or both.

The approach used (as incomplete arrays occur within this study) was to separate the z_{ij} array into smaller arrays and apply the previously discussed method. The smaller grouped arrays are then scaled separately from the complete z_{ij} array. Hence, one must cleverly divide the original array in such a way that the resulting set of scales have two or more points in common. The two or

more points in common will come from the upper category bounds so that appropriate linear transformations will place all instances (human factors) and upper category bounds on the same scale. [Ref. 30: pp. 18-19]

If by chance the smaller array contains only the two higher order categories or the two lower order categories then one must take a different approach; this will be referred to as the 'Special Transformation Case'. The scaled values will be determined using the previously discussed method, however the linear transformation method will differ slightly. In this case, since only one point or upper category bound exists in common between any two arrays, a regression technique must be applied to the scaled values. This regression technique uses the established lower bound (0) from the original (or complete) z_{ij} array and the $\bar{b}$ (or grand average) of the smaller array as the scaled value to coincide with the appropriate established upper bound (100). The regression procedure requires three points to be used, therefore the slope of the line between the scaled values and the bounds must be determined. Once the slope equation is determined then any transformed value from the other scales may be used to determine the third value. When the scaled values are regressed against the transformed values, then all instances are placed on the same linear transformed scale.

3. Walk-Through of Interval Scale Construction

Before demonstrating the technique, it must be emphasized that the results for this demonstration will differ from the actual survey results. This difference is due to the fact that the final boundaries and interval scale determined through this technique are ***relative*** to the factors used in deriving the boundaries. Since the intent of this walk-through is to illustrate the steps taken to determine the scale, a reduced number of factors are used. The actual results from the surveys will be presented in the next section of the study.

Once the raw data is collected, a matrix is formed with the instances being the rows and the categories being the columns. An individual cell will be referred to as p_{ij} with the i representing the row number and the j the column number. For this example, ten of the actual human factors from the Initial Survey were

selected to represent the instances. The collected raw frequencies have been arranged in the matrix to coincide with the appropriate instance and category. The categories, as stated earlier, must be listed in ascending order with the least desirable category in the leftmost column. Table 2 illustrates a sample matrix with actual raw data taken from the first survey.

Table 2. INITIAL SURVEY RESULTS - ARMY TOTAL (SAMPLE)

Human Factor	Very Unimportant	Not Important	Important	Very Important
Jet Lag	*7*	*48*	*43*	*3*
Cowardliness	*3*	*26*	*52*	*20*
Fear	*2*	*22*	*65*	*12*
Honor	*2*	*17*	*55*	*27*
Intuition	*0*	*14*	*51*	*36*
Stress	*0*	*2*	*64*	*35*
Sleep Loss	*0*	*3*	*49*	*49*
Leadership	*0*	*0*	*6*	*95*
Morale	*0*	*0*	*35*	*66*
Training/Experience	*0*	*0*	*19*	*82*

The relative frequencies will be computed by dividing each cell in a row by the row total or the total number of respondents. For this example, a total of 101 respondents were used resulting in the relative frequencies shown in Table 3.

Table 3. RELATIVE FREQUENCIES - ARMY TOTAL (SAMPLE)

Human Factor	Very Unimportant	Not Important	Important	Very Important
Jet Lag	*0.069*	*0.475*	*0.426*	*0.030*
Cowardliness	*0.030*	*0.257*	*0.515*	*0.198*
Fear	*0.020*	*0.218*	*0.644*	*0.118*
Honor	*0.020*	*0.168*	*0.545*	*0.267*
Intuition	*0*	*0.139*	*0.505*	*0.356*
Stress	*0*	*0.020*	*0.634*	*0.346*
Sleep Loss	*0*	*0.030*	*0.485*	*0.485*
Leadership	*0*	*0*	*0.059*	*0.941*
Morale	*0*	*0*	*0.347*	*0.653*
Training/Experience	*0*	*0*	*0.188*	*0.812*

The cumulative frequency, referred to as the 'P' array, is shown in Table 4. These values are attained by summing across a row (from left to right). Since the probability of all responses within a category must sum to 1, the **Very Important** category will always have a value of 1.

Table 4. CUMULATIVE FREQUENCIES - ARMY TOTAL (SAMPLE)

Human Factor	Very Unimportant	Not Important	Important	Very Important
Jet Lag	*0.069*	*0.544*	*0.970*	*1*
Cowardliness	*0.030*	*0.287*	*0.802*	*1*
Fear	*0.020*	*0.238*	*0.882*	*1*
Honor	*0.020*	*0.188*	*0.733*	*1*
Intuition	*0*	*0.139*	*0.644*	*1*
Stress	*0*	*0.020*	*0.654*	*1*
Sleep Loss	*0*	*0.030*	*0.515*	*1*
Leadership	*0*	*0*	*0.059*	*1*
Morale	*0*	*0*	*0.347*	*1*
Training/Experience	*0*	*0*	*0.188*	*1*

Now that the P array has been formed, all cells that contain values of p_{ij} > 0.98 and p_{ij} < 0.02 must be removed. Once these cells are removed an incomplete array exists due to the fact that not all the rows have the same number of cells. As a result, the z_{ij} array must be separated. With the removal of the appropriate z_{ij} cells, three arrays now exist which will be respectively called Scales 1, 2 and 3.

- **Scale 1** - treated as a three-category problem with the upper bounds of *Very Important*, *Not Important*, and *Important*.
- **Scale 2** - treated as a two-category problem with the upper bounds of *Not Important* and *Important*.
- **Scale 3** - treated as a single-category problem with the upper bound of *Important*.

Tables 5 and 6 illustrate Scales 1 and 2 using the common upper bounds of **Not Important** and **Important**. Table 7 has only the **Important** upper bound in common with either of the other two scales therefore it falls into the special transformation case.

Table 5. REMOVE P_{ij} > 0.98 AND P_{ij} < 0.02 - SCALE 1 (SAMPLE)

Human Factor	Very Unimportant	Not Important	Important
Jet Lag	*0.069*	*0.544*	*0.970*
Cowardliness	*0.030*	*0.287*	*0.802*
Fear	*0.020*	*0.238*	*0.882*
Honor	*0.020*	*0.188*	*0.733*

Table 6. REMOVE P_{ij} > 0.98 AND P_{ij} < 0.02 - SCALE 2 (SAMPLE)

Human Factor	Not Important	Important
Intuition	*0.139*	*0.644*
Stress	*0.020*	*0.654*
Sleep Loss	*0.030*	*0.515*

Table 7. REMOVE P_{ij} > 0.98 AND P_{ij} < 0.02 - SCALE 3 (SAMPLE)

Human Factor	Important
Leadership	*0.059*
Morale	*0.347*
Training/Experience	*0.188*

Since the p_{ij}'s represent the probability density from a Normal (0,1) distribution, the z values were obtained from a Normal distribution table. The z values are recorded in new arrays with Tables 8, 9, and 10 representing the normalized values.

Table 8. NORMALIZE - SCALE 1 (SAMPLE)

Human Factor	Very Unimportant	Not Important	Important
Jet Lag	*-1.485*	*0.115*	*1.890*
Cowardliness	*-1.883*	*-0.560*	*0.850*
Fear	*-2.055*	*-0.710*	*1.185*
Honor	*-2.055*	*-0.885*	*0.625*

Table 9. NORMALIZE - SCALE 2 (SAMPLE)

Human Factor	Not Important	Important
Intuition	*-1.085*	*0.370*
Stress	*-2.055*	*0.395*
Sleep Loss	*-1.883*	*0.045*

Table 10. NORMALIZE - SCALE 3 (SAMPLE)

Human Factor	Important
Leadership	*-1.560*
Morale	*-0.400*
Training/Experience	*-.885*

Next, column values are summed and divided by the numbers of rows or instances to obtain a column average. The column average, denoted b_j , is the value of the upper bound of category j on the interval scale. The row values follow the same procedure so that the row average, denoted $\bar{z}_i$, is computed for each instance. The row averages are summed and divided by the total number of rows to obtain the "grand average", denoted as $\bar{b}$. The numerical manipulation to attain $\bar{b}$ is as depicted in Tables 11, 12, and 13.

Table 11. GRAND AVERAGE - SCALE 1 (SAMPLE)

Human Factor	Very Unimportant	Not Important	Important	Row Total	Row Average ($\bar{z}_i$)
Jet Lag	*-1.485*	*0.115*	*1.890*	*0.520*	*0.173*
Cowardliness	*-1.883*	*-0.560*	*0.850*	*-1.593*	*-0.531*
Fear	*-2.055*	*-0.710*	*1.185*	*-1.580*	*-0.527*
Honor	*-2.055*	*-0.885*	*0.625*	*-2.315*	*-0.772*
Column Totals	*-7.478*	*-2.040*	*4.550*	*Grand Average: $\bar{b}$ = -1.242*	
Column Averages: b_j	*-1.869*	*-0.510*	*1.138*		

Table 12. GRAND AVERAGE - SCALE 2 (SAMPLE)

Human Factor	Not Important	Important	Row Total	Row Average ($\bar{z}_i$)
Intuition	*-1.085*	*0.370*	*-0.715*	*-0.358*
Stress	*-2.055*	*0.395*	*-1.66*	*-0.830*
Sleep Loss	*-1.883*	*0.045*	*-1.838*	*-0.919*
Column Totals	*-5.023*	*0.810*	*Grand Average: $\bar{b}$ = -1.404*	
Column Averages: b_j	*-1.674*	*0.270*		

Table 13. GRAND AVERAGE - SCALE 3 (SAMPLE)

Human Factor	Important	Row Total	Row Average ($\bar{z}_i$)
Leadership	*-1.560*	*-1.560*	*-1.56*
Morale	*-0.400*	*-0.400*	*-0.400*
Training/Experience	*-0.885*	*-0.885*	*-0.885*
Column Totals	*-2.845*	*Grand Average:* $\bar{b} = -0.948$	
Column Averages: b_j	*-0.948*		

The column averages for all three scales (Table 14) represent the ***scaled upper bounds*** of the categories. These scaled values will be used during the transformation procedure.

Table 14. UPPER BOUNDS - COLUMN AVERAGES (SAMPLE)

	Very Unimportant	Not Important	Important
Scale 1	*-1.869*	*-0.5100*	*1.130*
Scale 2	*NA*	*-1.674*	*0.270*
Scale 3	*NA*	*NA*	*-0.948*

The sum of squares for the column differences are computed with the following equation:

$$B = \sum_{j=1}^{m-k} (b_j - \bar{b})^2.$$

Since this equation applies to scales with more than one column, the sum of the squares for the column differences for Scales 1 and 2 are:

$$\begin{aligned} B(Scale\ 1) &= \sum_{j=1}^{m-k} (b_j - \bar{b})^2 \\ &= (-1.869 - (-1.242))^2 + (-0.510 - (-1.242))^2 \\ &\quad + (1.138 - (-1.242))^2 \\ &= \mathbf{6.593} \end{aligned}$$

$$\begin{aligned} B(Scale\ 2) &= \sum_{j=1}^{m-k} (b_j - \bar{b})^2 \\ &= (-1.674 - (-1.404))^2 + (0.270 - (-1.404))^2 \\ &= \mathbf{2.875} \end{aligned}$$

As seen in Tables 15 and 16 the sum of squares of the individual differences of Scales 1 and 2 are computed using the equation:

$$A_i = \sum_{j=1}^{m-k} (z_{ij} - \bar{z}_i)^2$$

Table 15. SUM OF SQUARE DIFFERENCES - SCALE 1 (SAMPLE)

$A_{ij} = (z_{ij} - \bar{z}_j)^2$				$A_i = \sum A_{ij}$
Human Factor	Very Unimportant	Not Important	Important	
Jet Lag	*2.749*	*0.003*	*2.948*	*5.700*
Cowardliness	*1.828*	*0.001*	*1.907*	*3.736*
Fear	*2.335*	*0.033*	*2.931*	*5.299*
Honor	*1.646*	*0.013*	*1.952*	*3.611*

Table 16. SUM OF SQUARE DIFFERENCES - SCALE 2 (SAMPLE)

$A_{ij} = (z_{ij} - \bar{z}_j)^2$			$A_i = \sum A_{ij}$
Human Factor	Not Important	Important	
Intuition	*0.529*	*0.530*	*1.059*
Stress	*1.500*	*1.500*	*3.000*
Sleep Loss	*0.929*	*0.929*	*1.859*

The estimate of the standard deviation $\sqrt{\sigma_i^2 + c}$ for each row is computed by using $\sqrt{B/A_i}$. The scaled values of the instances can now be computed using the equation:

$$S_i = \bar{b} - \bar{z}_i \sqrt{B/A_i} \ .$$

Scale 3 has no B or A_i value. The scaled value is computed using the equation:

$$S_i = \bar{b} - \bar{z}_i.$$

The S_i values are on the same interval scale as the category bounds b_j. With these results recorded in Tables 17, 18, and 19 any linear transformation may now be performed to move or reposition the scale where needed.

Table 17. SCALED VALUES - SCALE 1 (SAMPLE)

Human Factor	$\bar{b} - \bar{z}_N\sqrt{B/A_i}$	S_i
Jet Lag	$-1.242 - (0.173\sqrt{6.593/5.700})$	*-1.428*
Cowardliness	$-1.242 - (-0.531\sqrt{6.593/3.736})$	*-0.537*
Fear	$-1.242 - (-0.527\sqrt{6.593/5.299})$	*-0.654*
Honor	$-1.242 - (-0.772\sqrt{6.593/3.611})$	*-0.199*

Table 18. SCALED VALUES - SCALE 2 (SAMPLE)

Human Factor	$\bar{b} - \bar{z}_N\sqrt{B/A_i}$	S_i
Intuition	$-1.404 - (-0.357\sqrt{2.875/1.059})$	*-0.815*
Stress	$-1.404 - (-0.830\sqrt{2.875/3.000})$	*-0.592*
Sleep Loss	$-1.404 - (-0.919\sqrt{2.875/1.859})$	*-0.261*

Table 19. SCALED VALUES - SCALE 3 (SAMPLE)

Human Factor	$\bar{b} - \bar{z}_i$	S_i
Leadership	$-0.948 - (-1.560)$	*0.612*
Morale	$-0.948 - (-0.400)$	*-0.548*
Training/Experience	$-0.948 - (-0.885)$	*-0.063*

A linear transformation will now be performed to move both instance values and the category bounds to the same scale. For this example, an arbitrary value of zero (0) was selected as the upper bound on category **Very Unimportant** and a value of 100 as the upper value of category **Important**.

By using the linear transformation equation, $y = \alpha + \beta x$, where $\beta > 0$, the unknowns can be determined by solving simultaneous equations. Also, a desired value can be assigned as the middle bound and a statistical program such as Minitab can be used to determine the three unknowns. By establishing this linear transformation equation and letting x represent the raw or scaled data and y represent the transformed data, Tables 20 and 21 can be formed for the transformed values. The simultaneous equations for Scale 1 are:

$$100 = \alpha + \beta(1.138)$$

$$0 = \alpha + \beta(-1.869)$$

and transformed values are given in Table 20.

Table 20. TRANSFORMED DATA - SCALE 1 (SAMPLE)

Human Factor	x Value	y Value
Jet Lag	*-1.428*	*14.700*
Cowardliness	*-0.537*	*44.400*
Fear	*-0.654*	*40.500*
Honor	*-0.199*	*55.670*
Upper Bound	1.138	100
Middle Bound	-0.510	45.300
Lower Bound	-1.869	0

The simultaneous equations for Scale 2 are:

$$100 = \alpha + \beta(0.270)$$

$$0 = \alpha + \beta(-1.670)$$

and transformed values are given in Table 21.

Table 21. TRANSFORMED DATA - SCALE 2 (SAMPLE)

Human Factor	x Value	y Value
Intuition	*-0.815*	*69.860*
Stress	*-0.592*	*76.056*
Sleep Loss	*-0.873*	*68.247*
Upper Bound	0.270	100
Lower Bound	-1.670	45.300

Values determined using the regression technique on the Special Transformation Case are shown in Table 22. The third value (shown as the rescaled value below) was drawn from Scale 2.

Table 22. TRANSFORMED DATA - SCALE 3 (SAMPLE)

Human Factor	x Value	y Value
Leadership	*0.612*	*269.169*
Morale	*-0.548*	*142.747*
Training, Experience	*-0.063*	*195.604*
Upper Bound	-0.948	100
Rescaled Value	-1.150	76.056
Lower Bound	-1.869	0

The transformed data along with the ranking of each of the human factors in the sample are shown in Table 23. From this table, one can see how the categorical judgment technique obtains a numerical value and, as a result, a ranking structure for each factor. Analysis of this data is reserved for discussion in the *Results* section of the thesis. It should be noted here that the rankings and transformed values of the factors used in this example are ***relative*** to the other factors. Under most circumstances, addition or deletion of factors from the calculations will change the transformed data values. Since the data values and rankings results (as shown in the next section) for the Initial Survey were calculated using 27 human factors, the ***actual*** transformed values are different than those shown in this walk-through example.

Table 23. RANKING SCALES 1-3 (SAMPLE)

Human Factor	Transformed Data	Ranking
Jet Lag	*14.700*	*10*
Cowardliness	*44.400*	*8*
Fear	*40.500*	*9*
Honor	*55.670*	*7*
Intuition	*69.860*	*6*
Stress	*76.056*	*5*
Sleep Loss	*82.250*	*4*
Leadership	*269.169*	*1*
Morale	*142.747*	*3*
Training/Experience	*195.604*	*2*

Finally, an interval scale can be constructed with the transformed values of both the category upper bounds and the scaled values of the instances. The interval scale for the procedural walk-through example is depicted in Figure 12. The eloquence of this procedure results from the fact that both relative order and relative spatial distribution between factors is produced. This allows the user not only to identify *which* factors are important, but also the relative degree of *how much more* important some factors are in light of others.

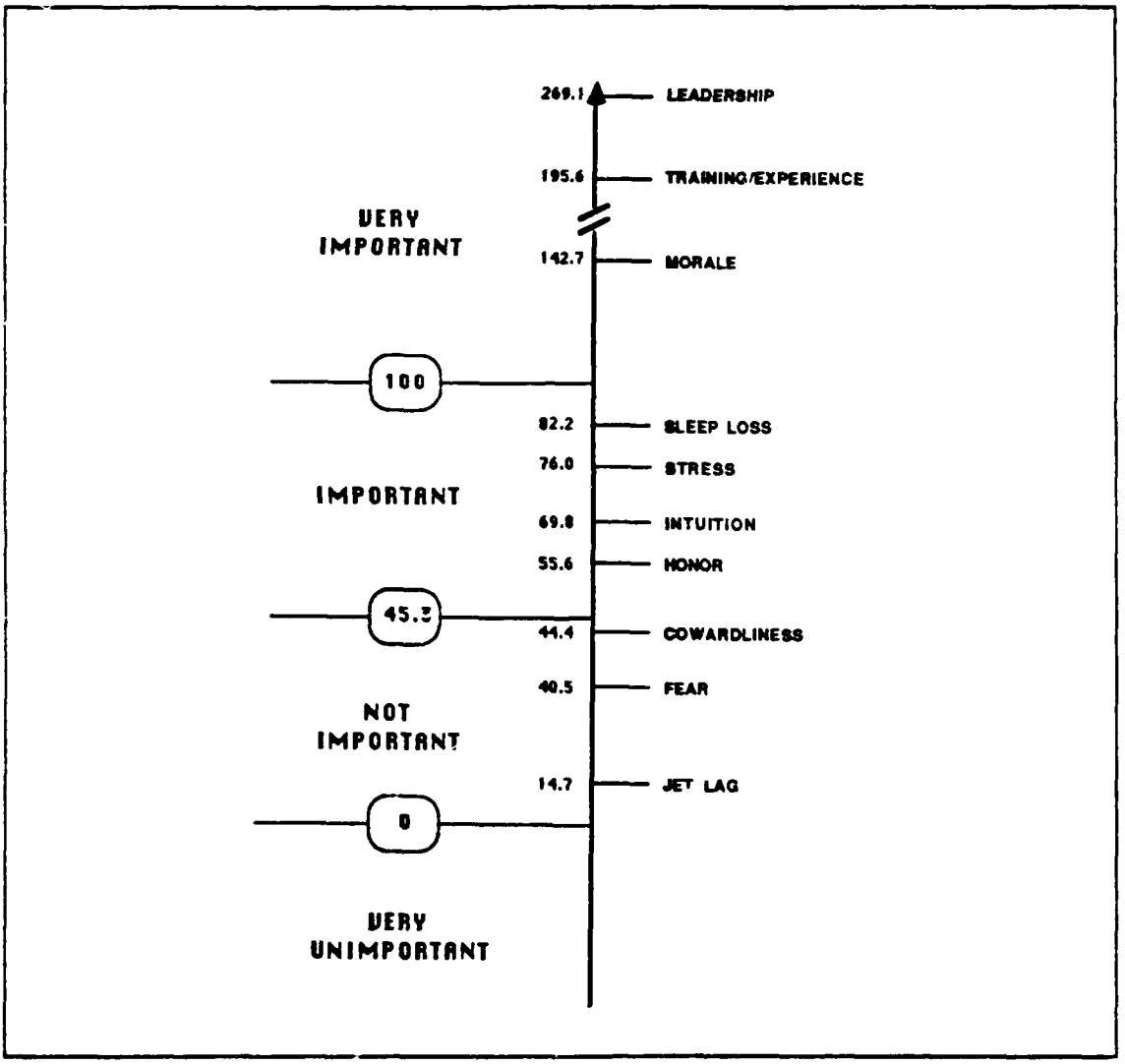

Figure 12. Interval Scale - Example

H. REVIEW OF EXPERIMENTAL DESIGN

Before proceeding to an analysis of the results of the experiment, a review of the points addressed in this section is in order.

- As a method of determining the most important factors affecting a commander's decision, surveys allow the researcher to make inferences about a large number of people from data drawn from a relatively small sample of that group.
- The categorical judgment technique provides the user the ability to quantify judgments described within specific categories.
- By considering only endogenous factors, the scope of consideration is narrowed to a more manageable quantity.
- The research design delineates two surveys. The Initial Survey was designed to identify the most important of 27 human factors. The Follow-On Survey was designed to determine whether context or scenario would vary the relative importance of the top seven factors.

Given the experimental design and techniques described in this section and responses to distributed surveys, the results along with the appropriate analysis are presented in the following section.

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IV. RESULTS

The preceding section explained the techniques used to determine the rank order and magnitude of survey responses within the context of categorical judgments. Through the administration of the Initial and Follow-On Surveys and the application of these numerical techniques, raw results were attained and transformed to interval scales. These scales provide the foundation for determining the factors perceived to be important to a commander in a decision-making environment. This section provides a summary of results, with a complete listing of both raw and transformed results included in Appendix E.

A. SURVEY I

Since the officers queried for this survey represented all four Armed Services (Army, Air Force, Marine Corps, Navy), a side-by-side comparison is possible based on the final rank order of the human factors. The rankings were performed for the six respondent groups as listed below:

- *Army Total* - includes all Army respondents
- *Combat Arms* - includes Army respondents from any one of the combat arms branches (Air Defense, Armor, Artillery, Aviation, Infantry)
- *Non-Combat Arms* - includes Army respondents from any one of the combat support or combat service support branches (Adjutant General, Chemical, Engineer, Finance, Medical Service, Military Intelligence, Quartermaster, Ordnance, Signal)
- *Air Force* - includes all Air Force respondents
- *Marine Corps* - includes all Marine Corps respondents
- *Navy* - includes all Navy respondents.

The final rank order positions obtained from the categorical judgment technique are as detailed in Table 24.

Table 24. SURVEY I RESULTS - INTERSERVICE RANK COMPARISON

HUMAN FACTOR	Army			Air Force	Navy	Marine Corps
	Total	Combat Arms	Non-Combat Arms			
Leadership	1	1	1	4	1	4
Training/Experience	2	2	3.5	7	7	7
Initiative	3	3	2	3	2	1
Discipline	4	4	3.5	6	3	2
Cohesion	5	6	5	1	4	5
Morale	6	5	7	5	6	6
Will/Motivation	7	7	6	2	5	3
Energy	8	9	8	8	9	9
Mental Fatigue	9	8	9	13	11	10
Sleep Loss	10	10	10	15	16	14
Stress	11	11	12	16	13	13
Surprise	12	13	13	10	14	11
Intuition	13	12	14	9	8	8
Physical Fatigue	14	14	11	11	10	12
Combat Experience	15	15	17	12	15	15
Honor	16	17	15	19	12	16
Comradeship	17	16	19	20	20	20
Emotion	18	19	18	14	17	17
Social Motivation	19	24	16	17	18	22
Cowardliness	20	21	20	21	21	21
Uncertainty	21	18	22	22	24	19
Cognitive Factor	22	22	21	18	19	23
Fear	23	20	24	24	23	18
Isolation	24	23	23	23	25	24
National Characteristics	25	25	25	26	22	25
Jet Lag	26	26	26	25	26	26
Confinement	27	27	27	27	27	27

There are two predominant points from an interservice perspective. First, considering only the four service groups, ***relative rankings*** are fairly consistent for all services. The greatest variation occurs with the factors of:

- Honor - range in ranking from 12 ⇒ 19
- Sleep loss - range in ranking from 10 ⇒ 16
- Fear - range in ranking from 18 ⇒ 24

In fact, the range most frequently varied between 5 and 6 positions. Range of the factors includes the endpoints. For instance, the factor Confinement has a range of *1* since all four service groups ranked this factor as the 27th most important factor. The range of rankings was distributed as follows:

Table 25. SURVEY I - RANGE OF RANKINGS

Range	1	2	3	4	5	6	7	8
Number of Factors	*1*	*4*	*2*	*3*	*7*	*7*	*2*	*1*

The second important point is that the seven factors identified as **most important** by all of the services were the same, albeit the order in which they were ranked varied by service. These human factors, listed in alphabetical order, are:

- Cohesion
- Discipline
- Initiative
- Leadership
- Morale
- Training/Experience
- Will/Motivation

As previously mentioned, the interval scale was preferred because it depicts both magnitude and relative rank order of the factors. Given scaled value results for Survey I (Appendix E), an interval scale for each of the six respondent groups is possible. However, since Survey II encompassed only Army respondents, interval scales depicting the three Army respondent groups (Total, Combat Arms, Non-Combat Arms) were selected for presentation. The scales for these groups are presented in Figures 13, 14, and 15, respectively.

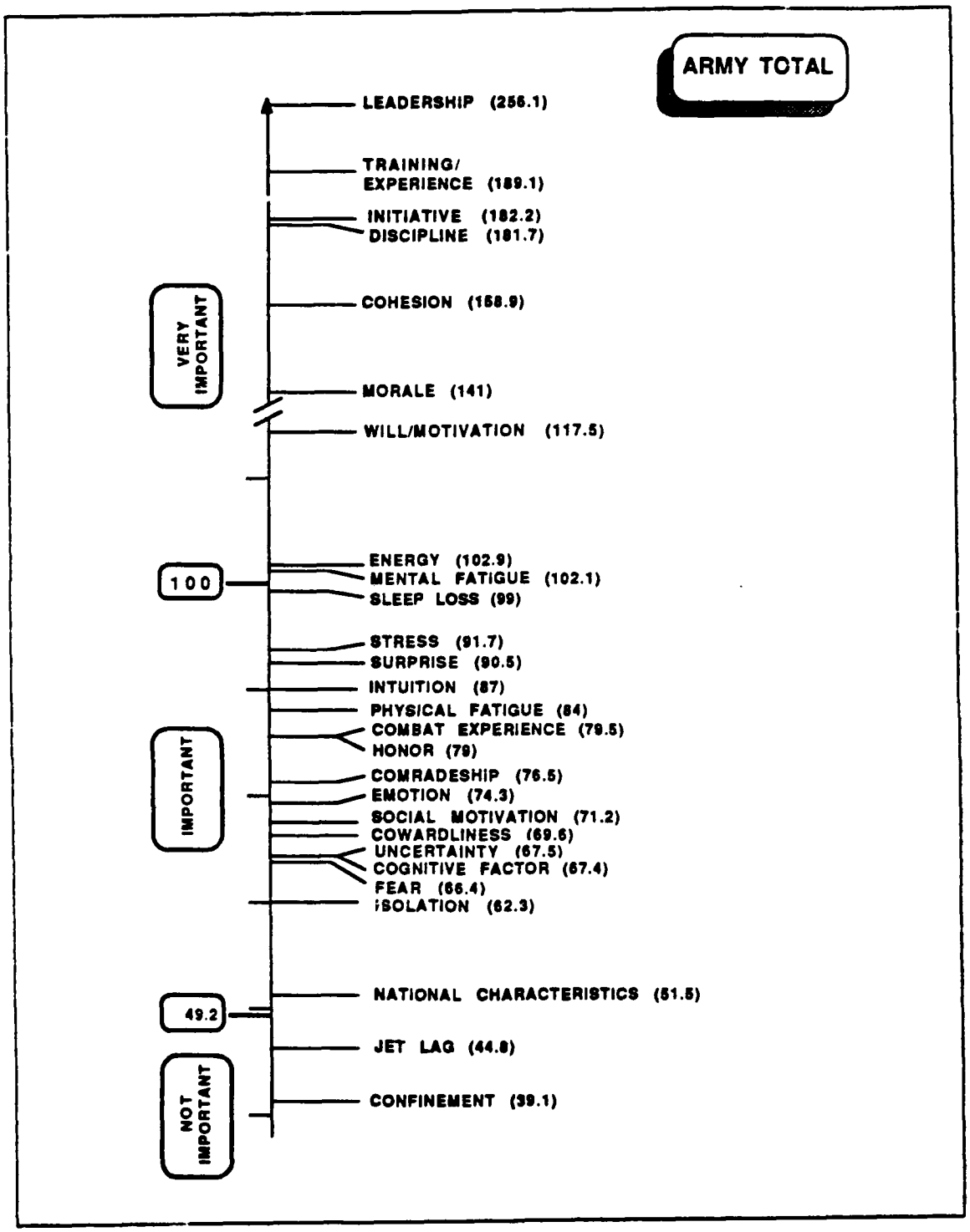

Figure 13. Survey I Interval Scale (Army Total)

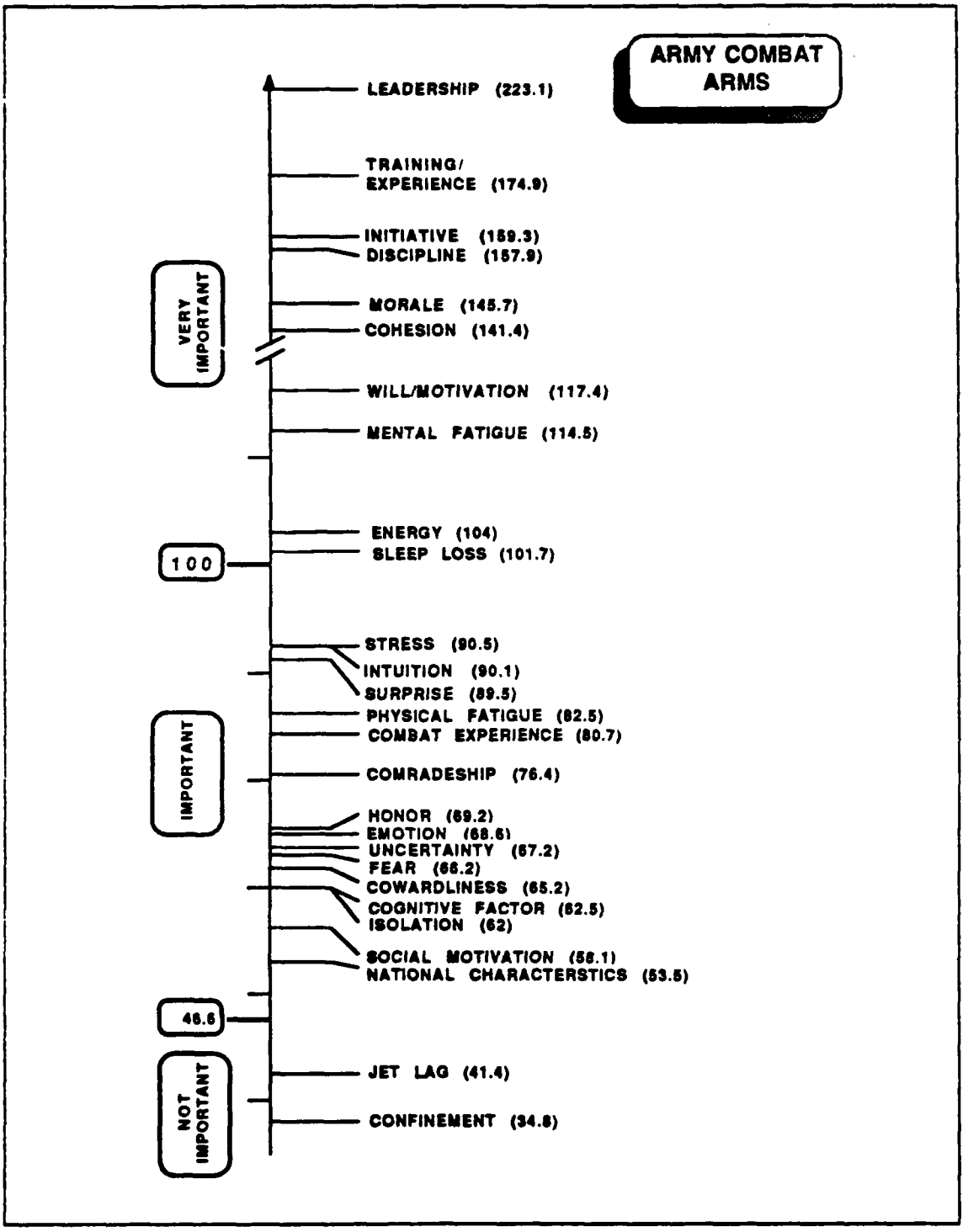

Figure 14. Survey I Interval Scale (Army Combat Arms)

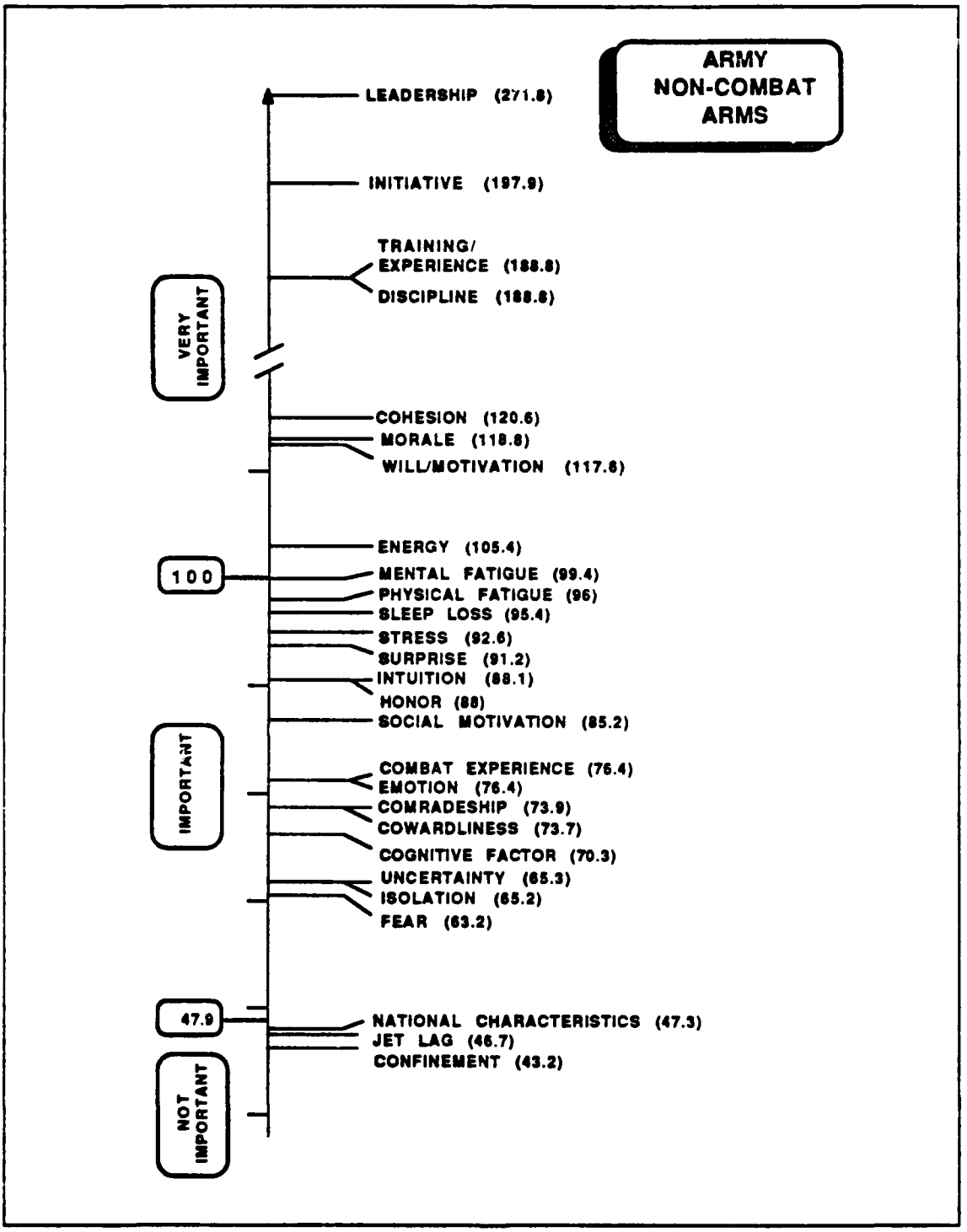

Figure 15. Survey I Interval Scale (Army Non-Combat Arms)

Comparison of Combat Arms and Non-Combat Arms scales provides several key insights:

- None of the factors listed resulted in **Very Unimportant** scaled values.
- The bounded categories contained the same factors, albeit in a different sequence, with the following exceptions:
  - Sleep Loss and Mental Fatigue - viewed as **Very Important** by Combat Arms and as **Important** by Non-Combat Arms.
  - National Characteristics - viewed as **Important** by Combat Arms and **Not Important** by Non-Combat Arms.
- Leadership was, by far, the most important factor selected by both groups, ranging 48.2 ⇒ 73.9 units higher than the second most important factor.
- Non-Combat Arms results within the **Very Important** category are characterized by three distinctly separate groups of human factors while the Combat Arms results for the same category are slightly less pronounced.

For the purpose of comparison with the results attained in the subsequent surveys, the rank order of the factors determined from the Army Total group will be used as a baseline. Again, this is primarily due to the fact that only Army officers attending advanced study programs at the Naval Postgraduate School (NPS) were queried in the Follow-On Survey. Since all services generally agreed on the top seven factors, the focus for the Follow-On Survey was on those factors. The rank order of the top seven human factors as determined by the Army Total respondents for the Initial Survey was:

1. Leadership
2. Training/Experience
3. Initiative
4. Discipline
5. Cohesion
6. Morale
7. Will/Motivation

B. SURVEY II

Recall that this survey was designed in two basic versions - Infantry and Field Artillery. Both versions have parallel design and ask respondents to apply the factors given the same general scenario context. Survey subjects were divided such that Infantry-branched officers completed the Infantry scenario, Artillery-branched officers completed the Artillery scenario, with the remaining officers randomly split to ensure equal branch representation to both scenarios.

The results from these surveys will be presented from two perspectives. First, a comparison of the similarities found through examining *intra-scenario* results (i.e., Infantry versus Non-Infantry) is presented. Second, total results for both surveys will be compared with the top seven factors identified in the Initial Survey. This comparison formulates conclusions as to whether the application of a scenario varied the *relative* importance of the human factors.

1. Infantry Scenario

The questionnaire portion of this scenario was developed within a specified context. The cases for the Infantry scenario are outlined below.

Case Number 1 - The unit commander is required to quickly decide how to modify his intended plan to secure two sites. The modification is necessary due to the fact that his Executive Officer, who was going to supervise the security of one of the sites (with the commander at the other) was medically evacuated.

Case Number 2 - One of the two platoons protecting the site where the commander is located starts receiving heavy ground fire. The commander must make the decision whether to deploy the reaction force in support of that platoon.

Case Number 3 - Two large rockets land 3 kilometers upwind from the commander's location. Since the unit is currently in a reduced Mission Oriented Protective Posture (MOPP), the commander must decide whether or not to go to full MOPP and accept a degradation in defensive preparations.

Case Number 4 - A sister unit's defensive position sustained a direct hit with a non-persistent nerve agent resulting in an estimated 110-115 casualties. The battalion commander has directed the company commander to send one of the platoon's from his current position to the sister unit's position to re-establish the defense and assess/evacuate casualties. The battalion commander has also told the company commander that he is to personally remain with the current site security mission.

Since all respondents were Army officers, results have been grouped in the following categories:

- ***Total*** - includes all survey respondents
- ***Infantry*** - includes all respondents whose basic branch is Infantry
- ***Non-Infantry*** - includes all respondents whose basic branch is other than Infantry.

The groupings (Infantry/Non-Infantry) were used to determine if familiarity with the subject branch made a significant difference in the order or magnitude of the human factors. The Total respondents group was used for a side-by-side comparison with the Artillery scenario counterpart in light of the top seven factors identified in Survey I.

a. Interval Scales

The interval scaled results from the Infantry version are depicted in Figures 16, 17, 18, and 19. These diagram each case of the scenario and are presented in a manner that allows for comparison between Infantry and Non-Infantry respondents.

For all of the interval scales developed for Survey II, the lower bound of the highest category (**Very Important**) was always set at 100. The other bound used was set at zero (0), designating the upper bound of the **Neutral**, **Unimportant**, or **Very Unimportant** category depending on the nature of the data. The interval scales, as drawn, depict categorical bounds to the left of the scale while scaled factors are presented to right of each scale. The numerical bounds of the categories are also on the left and are characterized by a number within a box. Only those categories which contain factors are depicted.

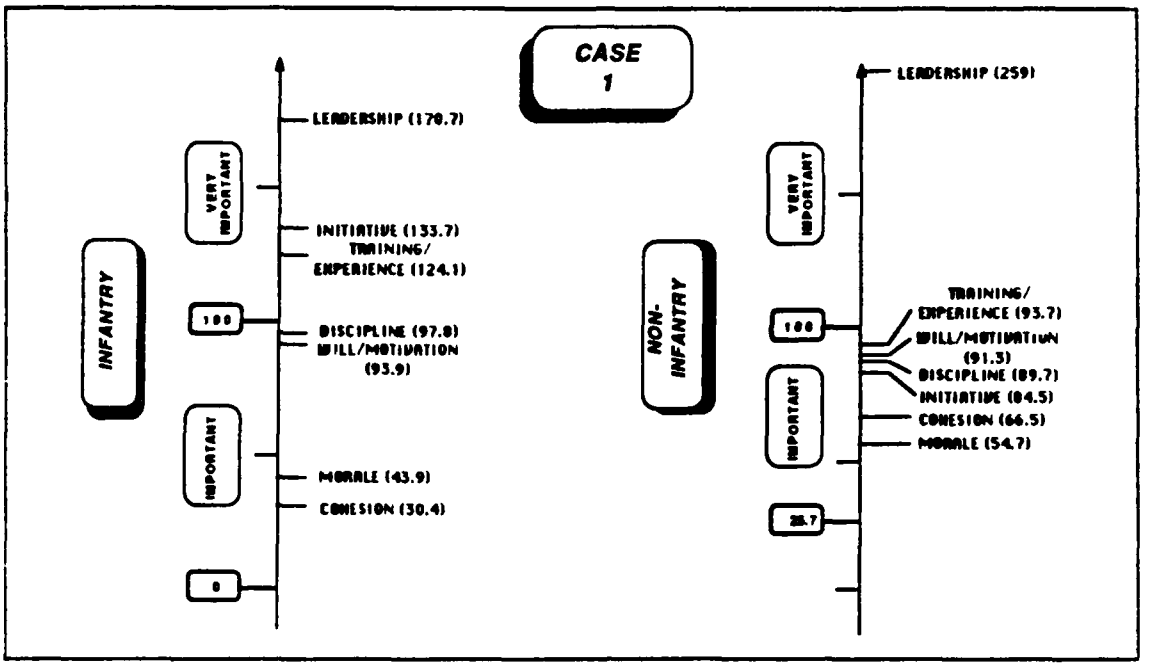

Figure 16. Infantry Version - Case 1 (Infantry versus Non-Infantry)

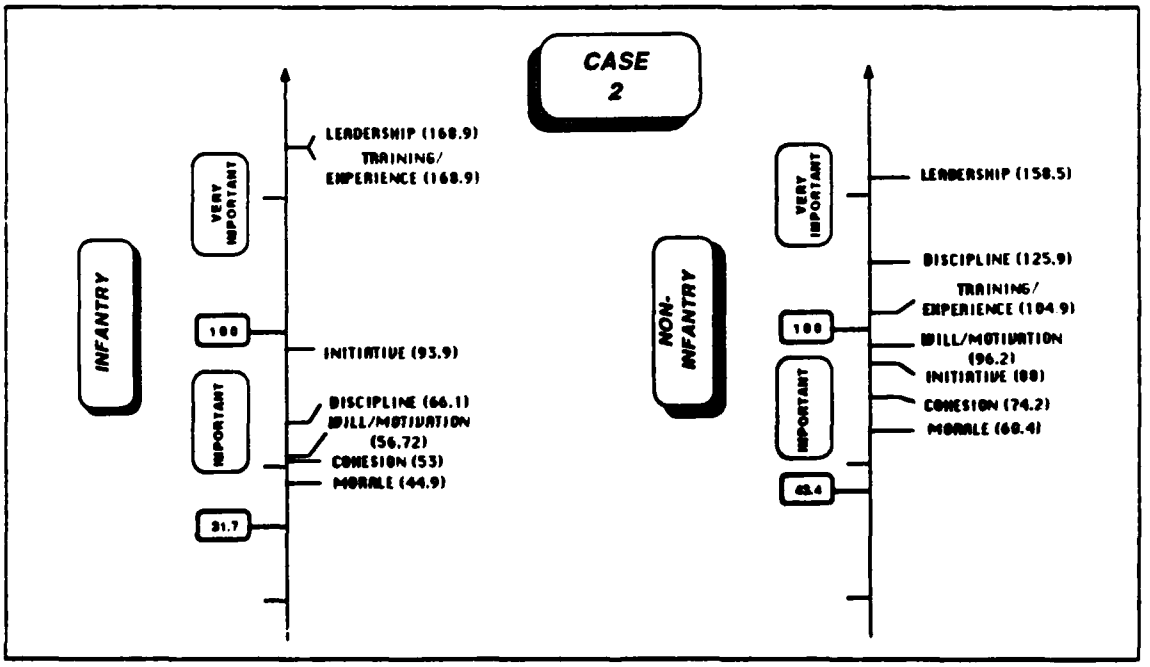

Figure 17. Infantry Version - Case 2 (Infantry versus Non-Infantry)

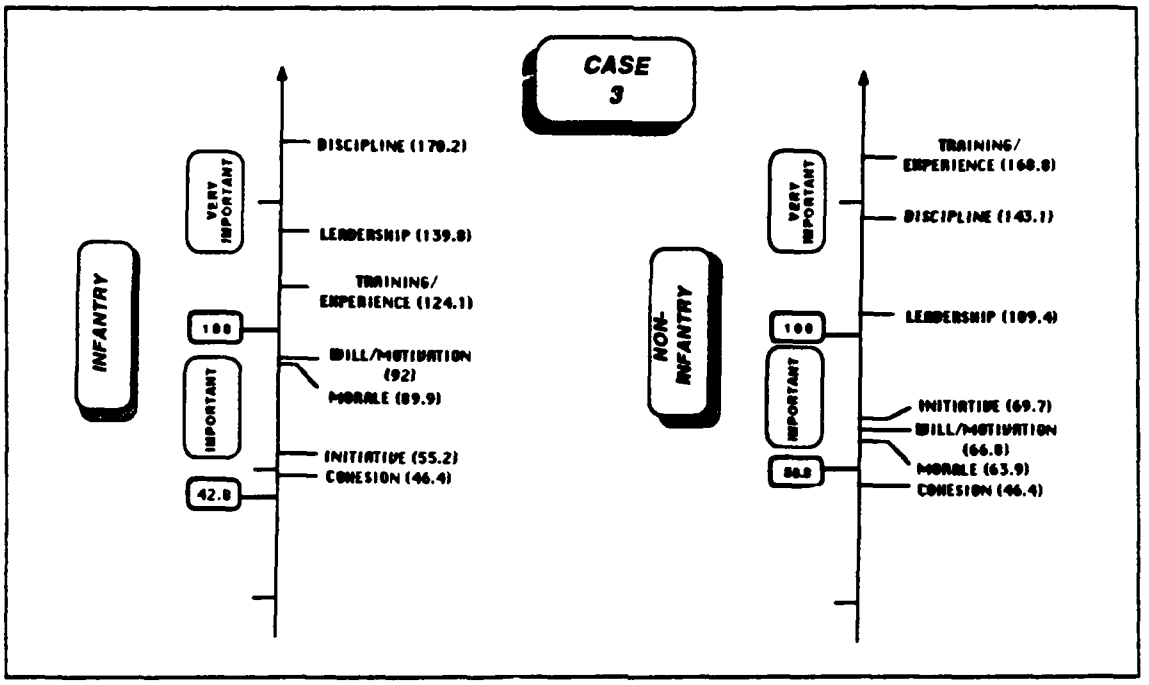

Figure 18. Infantry Version - Case 3 (Infantry versus Non-Infantry)

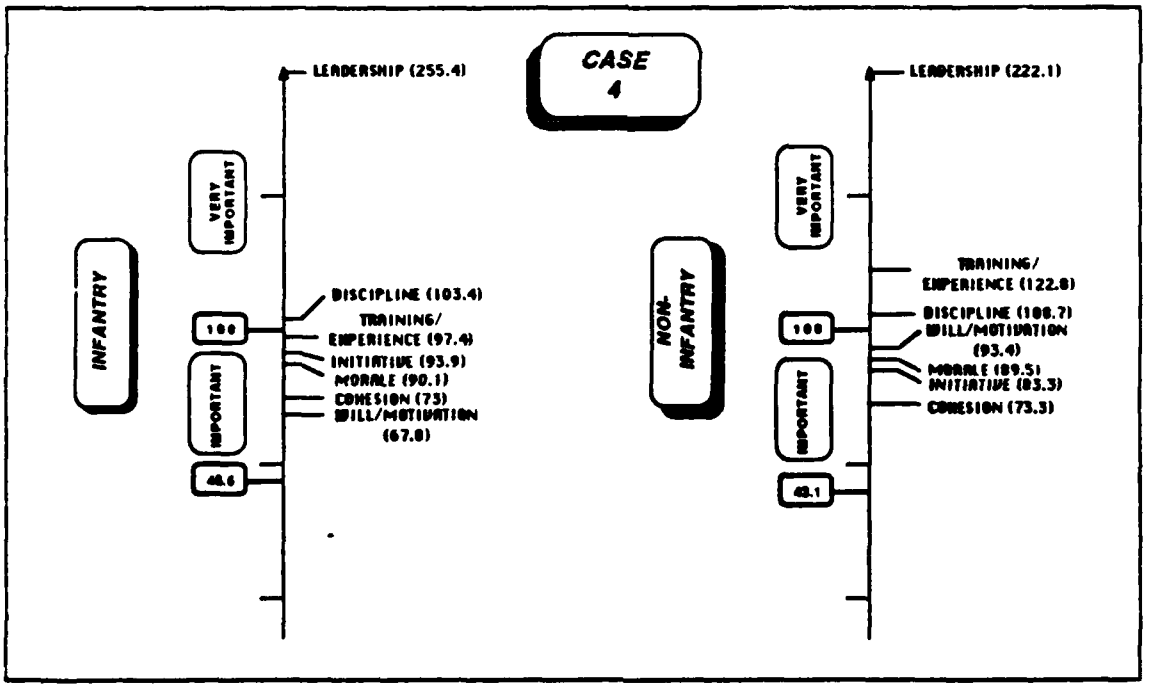

Figure 19. Infantry Version - Case 4 (Infantry versus Non-Infantry)

b. Infantry versus Non-Infantry Comparison

There are several points which can be derived by comparing the interval scaled values for the four Infantry scenario cases.

- In a case-to-case comparison, none of the rankings were exactly the same between the four cases.
- Leadership was ranked as the most important factor by both groups of respondents in three of the four cases.
- In all cases, the factors of Cohesion and Morale tended toward the bottom of the scale.
- With respect to Case 3, Discipline was viewed by Infantry respondents as the most important factor, however Training/Experience was the most important factor as determined by Non-Infantry respondents. Additionally, Cohesion was identified as the least significant factor for both respondent groups, dropping into the **Neutral** category for Non-Infantry respondents.
- In Case 4, Leadership is prominently identified as the top factor while the other six factors are grouped and appear much more compact when compared to the other three cases.

Other than the differences delineated above, no other significant differences were detected between Infantry and Non-Infantry respondents. As a result, it was determined that the branch of the respondent had no significant impact with respect to the results attained from the Infantry scenario.

2. Artillery Scenario

The Artillery version of the Follow-On Survey paralleled the design of its Infantry counterpart. The four cases for the Artillery scenario are outlined below.

Case Number 1 - The unit commander is required to quickly decide which platoon to deploy forward to support an element of the Task Force that is guarding an Ammunition Supply Point (ASP). A decision is necessary since the deployed platoon will have to act as an independent firing element. Both platoon leaders are relatively new to their positions.

Case Number 2 - The platoon that is firing artillery support for the Task Force element protecting the ASP starts receiving machinegun and indirect fire. The commander must make the decision whether to displace the unit and temporarily stop artillery support or to continue the artillery support and fight off the aggressors.

Case Number 3 - Two large rockets land 3 kilometers upwind from the commander's location. Since the unit is currently in a reduced Mission Oriented Protective Posture (MOPP), the commander must decide whether or not to go to full MOPP and accept a degradation in providing artillery support.

Case Number 4 - A sister unit's defensive position sustained a direct hit with a non-persistent nerve agent resulting in an estimated 60-75 casualties. The commander has been directed to send a platoon to that position to defend and assess/evacuate casualties. Additionally, the deployed platoon is to ensure the security of the nuclear rounds at that location. The decision must be made on which platoon to send to this position in light of each platoon's current status.

Again, since all respondents were Army officers, results have been grouped in the following categories:

- *Total* - includes all survey respondents
- *Artillery* - includes all respondents whose basic branch is Artillery
- *Non-Artillery* - includes all respondents whose basic branch is other than Artillery.

The mutually exclusive sub-groupings (Artillery/Non-Artillery) were used to determine if contextual familiarity made a significant difference in the ranking or scaled values of the factors considered. The Total respondents group was used for comparison with its Infantry counterpart.

a. Interval Scales

The interval scaled results from the Artillery version are depicted in Figures 20, 21, 22, and 23. These diagrams show each case of the scenario and are presented in a manner that allows for comparison between Artillery and Non-Artillery respondents.

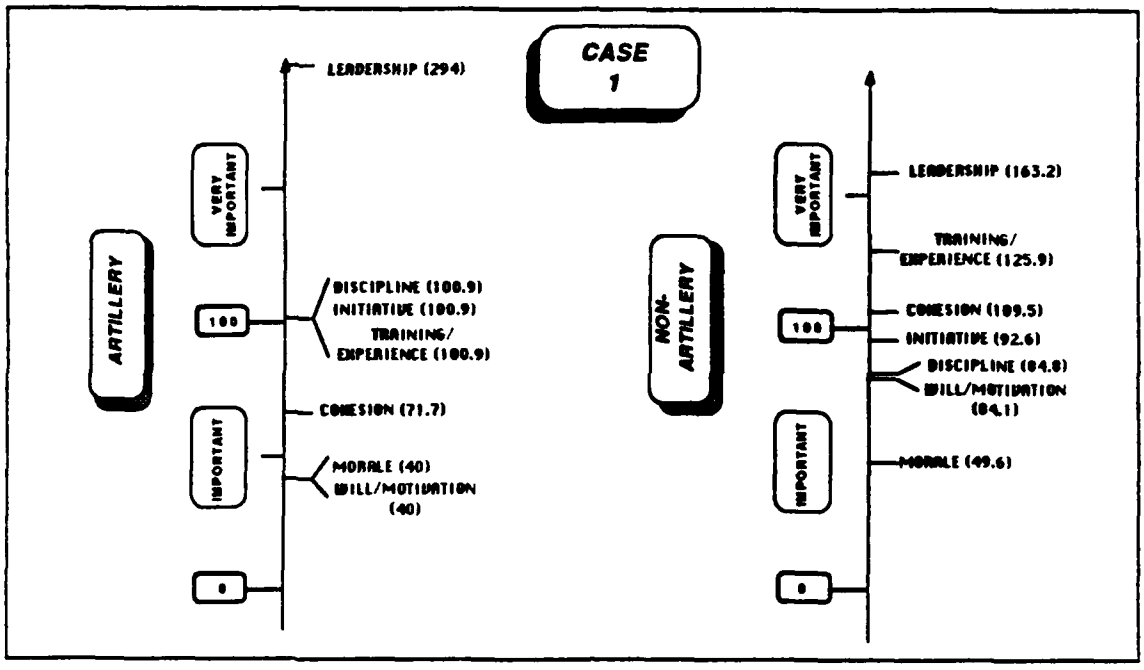

Figure 20. Artillery Version - Case 1 (Artillery versus Non-Artillery)

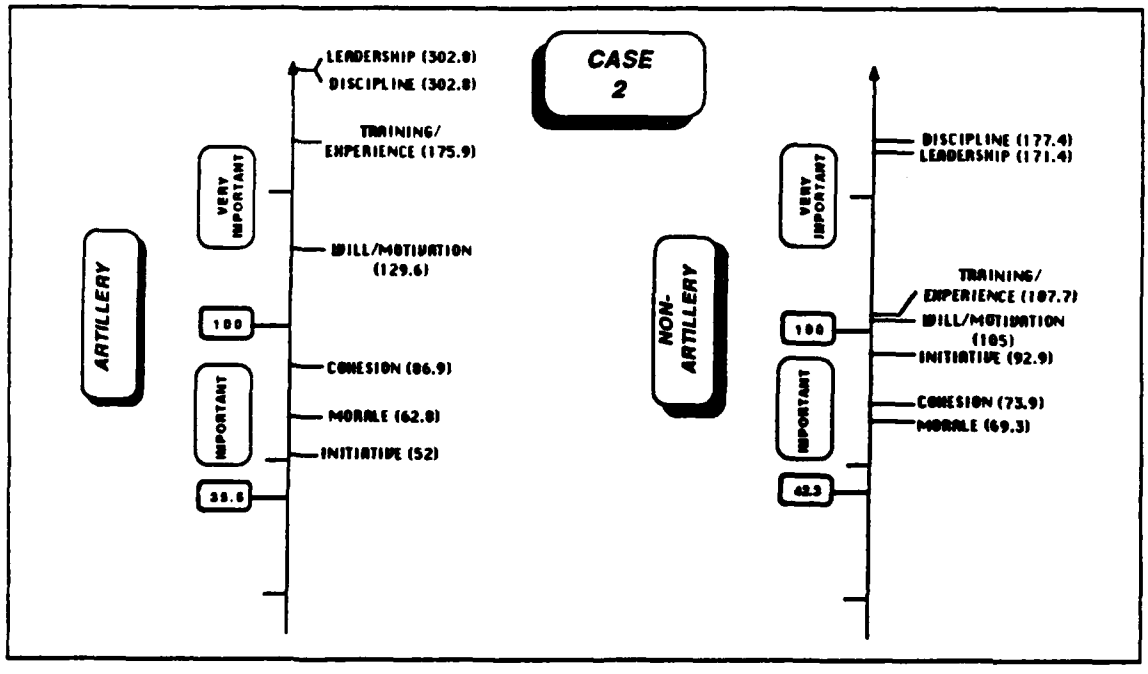

Figure 21. Artillery Version - Case 2 (Artillery versus Non-Artillery)

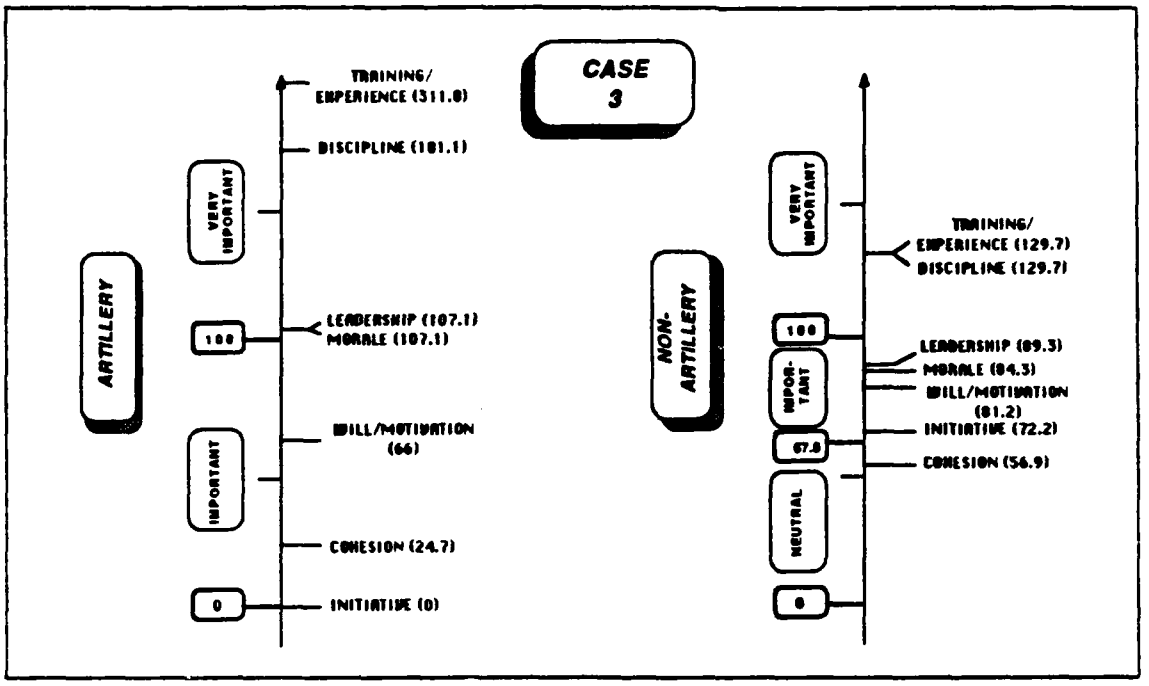

Figure 22. Artillery Version - Case 3 (Artillery versus Non-Artillery)

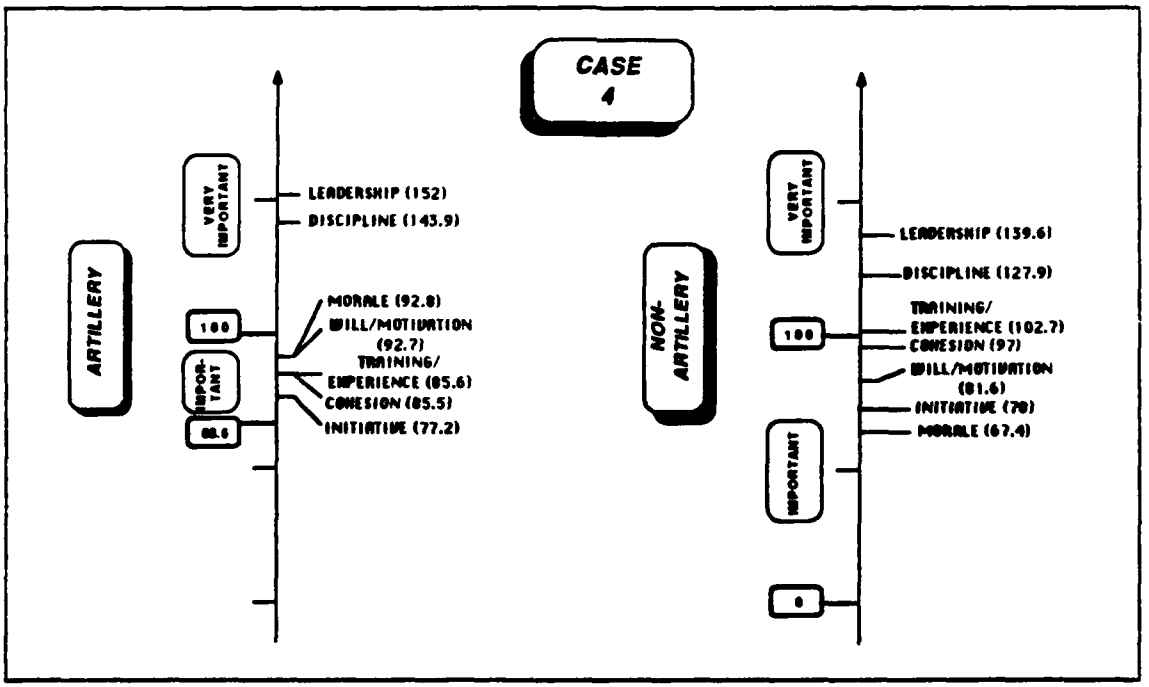

Figure 23. Artillery Version - Case 4 (Artillery versus Non-Artillery)

b. Artillery versus Non-Artillery Comparison

There are several points which can be derived by comparing the interval scaled values for the four Artillery scenario cases.

- The scaled values for some of the factors seen in these cases are higher than those seen in previous scales. This increase in magnitude (i.e., scaled values greater than 300) can be attributed to the relatively small sample sizes. This phenomenon can be seen in both Cases 2 and 3 for Artillery respondents.
- Artillery respondents ranked Leadership as the most important factor in three of four cases. Non-Artillery respondents ranked Leadership as the most important in two of four cases, while ranking it as a close second to Discipline in Case 2.
- With respect to Case 3, Training/Experience was viewed by the Artillery respondents as the most important while Non-Artillery respondents considered Training/Experience *and* Discipline of equal importance.
- There is no clear-cut pattern as experienced in Infantry Case 4. However, the factors which were consistently at the bottom of the scale were Cohesion, Morale, and Initiative.
- With respect to categorization, all factors were categorized as **Important** or **Very Important** with the exception of two factors in Case 3:
  - Cohesion - categorized by Non-Artillery respondents as **Neutral**
  - Initiative - categorized by Artillery respondents on the boundary separating **Neutral** and **Unimportant**.

Other than a variation in the order in which the factors were listed and the differences delineated above, no other significant differences were detected between Artillery and Non-Artillery respondents. As a result, it was determined that the branch of the respondent had no significant impact with respect to the results received in the Artillery version.

C. COMPARISON OF RESULTS

This final section of the results is used to show the differences between the survey results in light of the top seven factors identified in the Initial Survey. Results were determined using Total respondents from Infantry and Artillery surveys.

1. Interval Scales

The interval scales depicting the results from the four cases from Survey II are depicted in Figures 24 through 27. Each case is portrayed in a manner which allows for a side-by-side comparison between the versions of the survey.

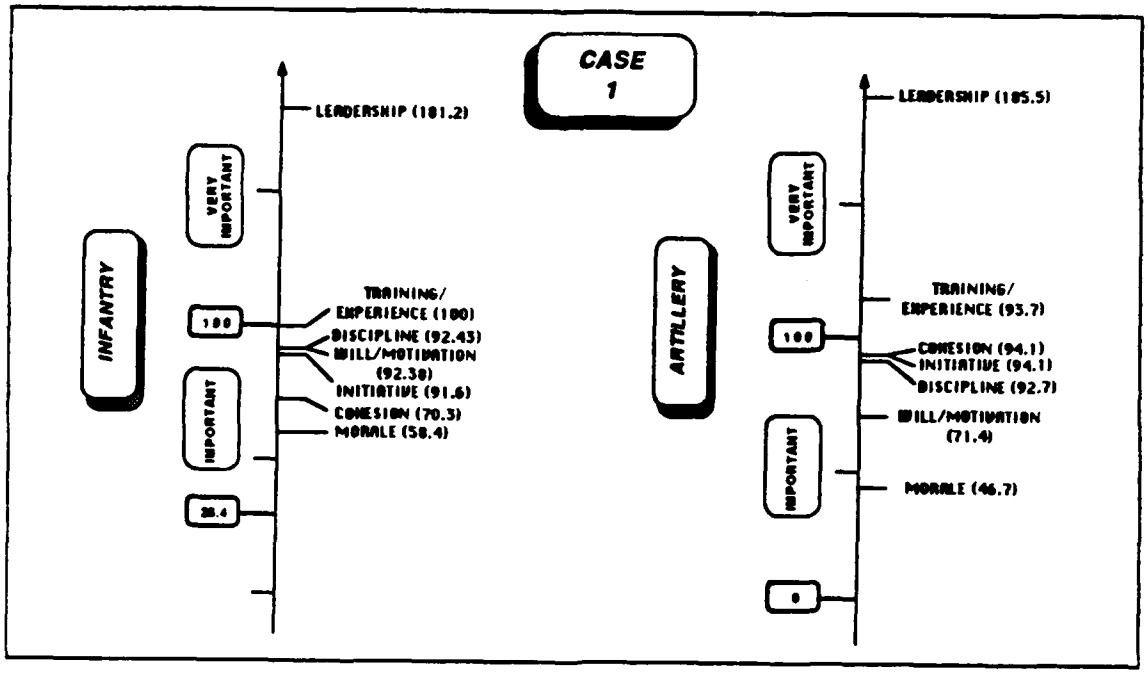

Figure 24. Survey II - Case 1 (Infantry Total versus Artillery Total)

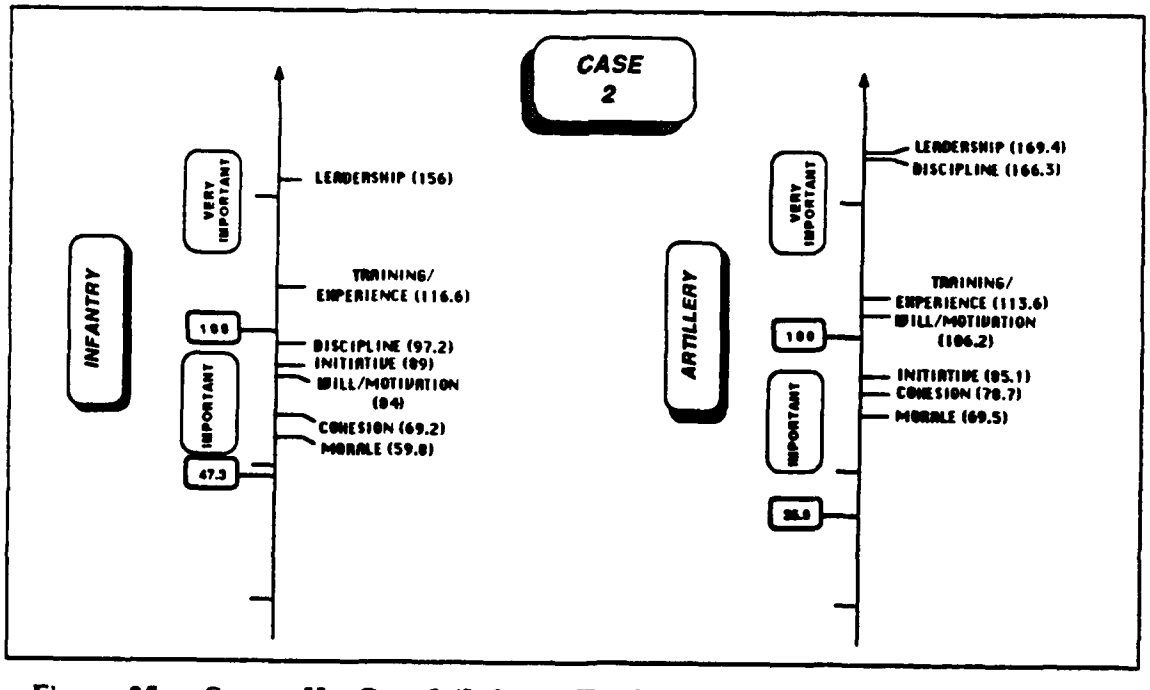

Figure 25. Survey II - Case 2 (Infantry Total versus Artillery Total)

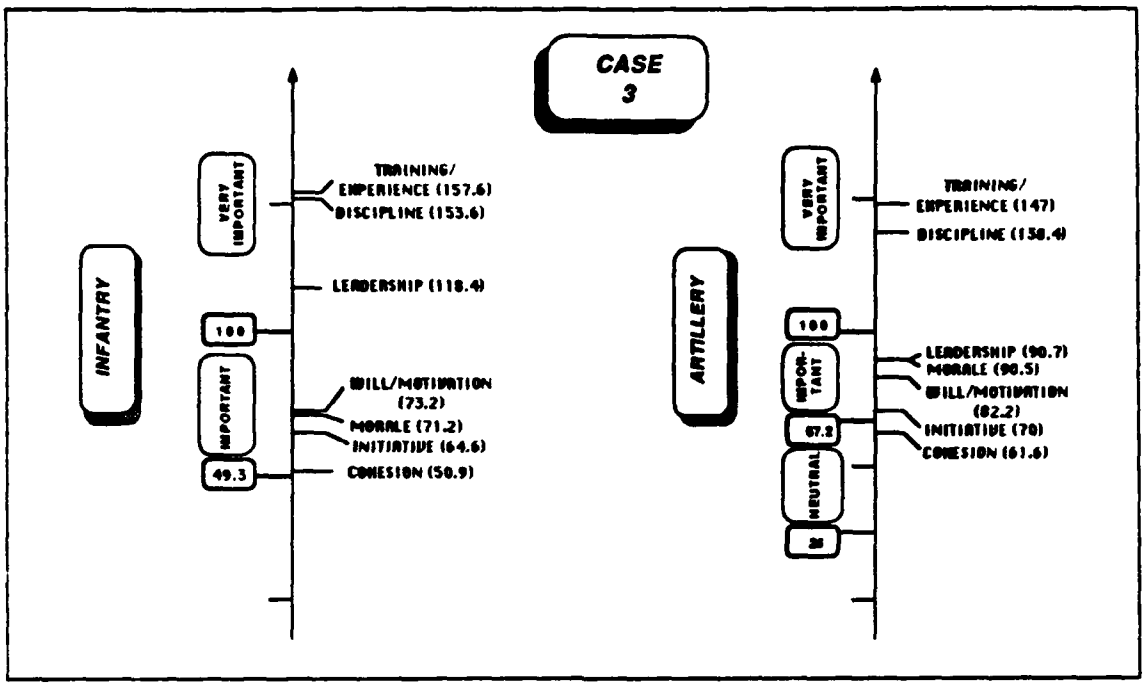

Figure 26. Survey II - Case 3 (Infantry Total versus Artillery Total)

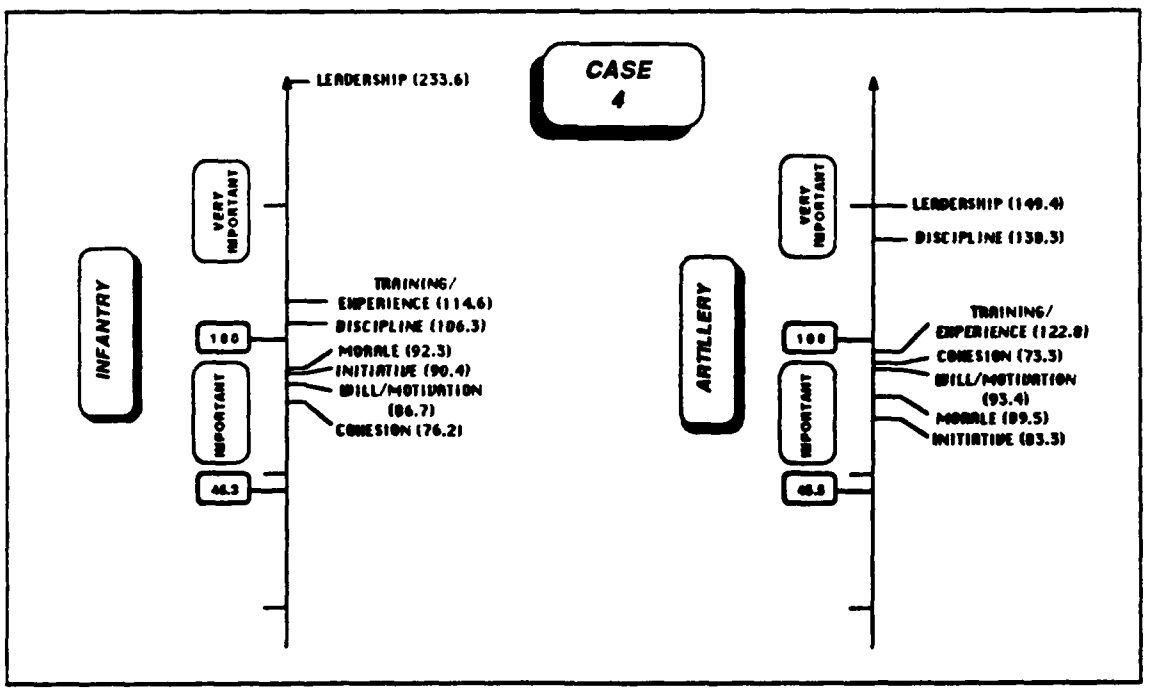

Figure 27. Survey II - Case 4 (Infantry Total versus Artillery Total)

2. Initial Survey versus Follow-On Survey

The interval scales for Total respondents provide an adequate reference from which to derive several conclusions concerning the rank and magnitude variation when compared to the top seven human factors from Survey I. First, if the top seven factors from Survey I are grouped by scaled magnitude, there are four distinct groups of factors. These groupings are as shown in Table 26.

Table 26. SURVEY I - TOP SEVEN FACTORS

Group	Factor	Magnitude
1	*Leadership*	*256.2*
2	*Training/Experience*	*189.2*
	Initiative	*182.2*
	Discipline	*181.7*
3	*Cohesion*	*158.9*
	Morale	*141.0*
4	*Will/Motivation*	*117.6*

In light of these groups of factors, how did the results from the Initial Survey differ from those in the Follow-On Survey? The answer to this question is captured in the following conclusive points:

- In all of the cases considered in Survey II, the order, magnitude, and dispersion of the factors changed with respect to those received in Survey I.
- Leadership remained as the predominant factor with the exception of Case 3. It can be concluded that given a commander has confidence in his equipment, he may rely on the Training/Experience and Discipline of the individual soldiers within the command to react or respond rapidly to an alarm rather than accept a degradation in mission posture. As such, the Cohesion of the unit may weigh less on his decision since individual actions will determine the fate of the unit.
- Training/Experience appear together in seven of eight cases, both weighing extremely heavy in Case 3 which, again, was made in light of the commander's reliance on individual soldier reaction. Overall, application of the scenarios had no major impact on the ranking of these two factors.
- Initiative, the third most important factor as determined through the dimensionless context of Survey I, varied from 3.5 $\Rightarrow$ 7 in Survey II. Therefore, the relative importance of Initiative is heavily dependent on the context of the scenario in which it is applied.
- Will/Motivation was the least significant factor (of the top seven) as determined in Survey I, however once applied to a specific context, it was found to much more significant. This factor was generally ranked as 4 $\Rightarrow$ 5 in level of importance.
- Cohesion and Morale tended toward the lower rankings in all cases. The fluctuation seen in these factors was primarily caused by the perceived increased importance of Will/Motivation and the decreased importance of Initiative. In light of the other factors considered, the application of these factors varied slightly from Survey I to Survey II.

V. CONCLUSIONS AND RECOMMENDATIONS

Command and Control decisions impact on the effectiveness of tactical units. Since a combat environment is characterized by an extreme chaotic nature, the command and control system supporting the commander must be capable of allowing for well-grounded decisions within this environment. In addition to the multitude of other factors which a commander must consider during the decision-making process, human dimensions and human factors inherent to the unit are considered -- sometimes consciously, other times subconsciously.

In isolating those factors which might be important to a commander, 61 human factors were identified. Emphasis was placed on first order effects throughout the study. This was necessary to avoid premature aggregation of the factors under consideration in an effort to establish clear causal/effect relationships. The factors were categorized using a model developed by Vandivier which allowed for discrete categorization. Once categorized, endogenous factors (those factors which are inherent *within* the soldier) provided the primary research focus.

Two surveys were used to determine the factors which impact on a commander's decision. The Initial Survey (Survey I) focussed on determining the rank order and magnitude of the 27 endogenous factors under consideration. The Follow-On Survey (Survey II) used the top seven factors identified in Survey I as the basis for determining whether the context or scenario to which the factors were applied would make a significant difference in relative importance. The technique used for determining the results (i.e., categorical judgments) made no assumption of the relationship of one factor to another, but placed each factor on its estimated position on a common scale. This analytical procedure, used primarily for constructing the interval scales, was easily performed using the data from the surveys.

Based on the assumptions made for Survey I using categorical judgments (normality, homogeneity of variance), the interval scales obtained yielded pertinent information as to the relative order of importance of human factors. The following list represents the Army Total respondents ranking of the top seven factors considered important to a commander in making a reduced-time C^2 decision:

1. Leadership
2. Training/Experience
3. Initiative
4. Discipline
5. Cohesion
6. Morale
7. Will Motivation

Only *relative* rankings are obtained and no statements can be made about proportionality of values (e.g., ratios between scales). However, comparisons in magnitude can be made. For example, one can make the statement that, if it is determined that Discipline is important to a commander in a decision-making environment, then Leadership is *much more* important. No other statistical conclusions can be inferred.

Survey II assumptions paralleled those of the previous survey. Two versions of this survey were designed (i.e., Infantry and Artillery), each containing four sub-scenarios or cases. When compared to the order and relative magnitudes of the top seven factors from Survey I, the following can be concluded from the results of Survey II:

- In all cases, application of the factors within the context changed the order and relative level of significance.
- Leadership was the predominant factor in three of four cases (for each version). Only Case 3, where the commander's decision was seen to rely more on the individual actions of soldiers within the command, was leadership less important than Discipline and Training/Experience.
- Initiative was seen with decreased importance once applied within a scenario, while Will/Motivation assumed a much greater importance within the context of a specified scenario.

Further study may add to the robustness and increase the foundation established within this research effort. Since this study represented a demonstration of technique and was essentially a 'pilot' effort, results determined herein can be substantiated by expanding the sample population to include a wider variety of Army commanders. Future experimental design to support these findings should include:

- Varying the ***type of external environment*** in which the factors are to be applied. For instance, an experiment designed to apply factors within a jungle environment may conclude differing results from those found within this study.
- Along with the environment, the ***type or level of combat*** could be varied to check for sensitivity in the ranking of the factors. This could be accomplished by presenting respondents with a Low Intensity conflict scenario as opposed to the Mid to High Intensity scenario painted within Survey II.
- Finally, varying the level at which the factors are considered may produce different results. Do the human factors that a Battalion Commander considers differ from those considered by a Company Commander?

Returning to Dr Vandivier's human factors model points out one strong consistency. Recall that the model discretely classified the factors under consideration into four categories: endogenous/transitory, endogenous/enduring, exogenous/transitory, and exogenous/enduring. The common thread that ties that model and the current study together lies in the factors identified as *most important* through Survey I. The top seven factors (as determined by all four military services) were classified as ***endogenous/enduring factors***. As such, it is highly recommended that future research focus primarily on factors within that category.

From a broader perspective, how can the results of this study be used? With projected budget cuts and a shrinking force size within the Army, the human dimensions relative to the development of future systems will, most assuredly, receive much greater emphasis. The greatest contributions that research efforts such as this one provide can be narrowed to two areas: modeling and training/doctrine.

If combat models are to represent a realistic combat environment, the entities within that environment must be realistically modeled. Combat is a human venture; as such, humans contribute directly to the uncertainty and lack of predictability experienced in battle. Combat modelers, therefore, must strive to integrate the human dimension into the models. One of the pieces of the 'integration puzzle' has been addressed in this study - that is, *which* factors are considered important enough to be modeled. The question, left to the modeler, is how to model human factors. To date, modelers are unsure whether the integration of human factors into combat models will significantly change the outcome of simulated battles. This question cannot be answered until after the factors are adequately modeled.

An awareness of important human factors has potential for advances in the training and doctrine arena. If there is a specified number of factors that current commanders consider important in their decisions, the focus of the institutional base should be to emphasize those factors not only in a school environment, but also in the doctrine which guides commanders in the field. With respect to training, some of the artificialities which are necessary due to peacetime constraints undoubtedly have an effect on how commanders are trained to formulate decisions. Most importantly, the absence of the threat of personal injury (or death) as a result of enemy actions creates a wide, but relatively unknown effect on the methodology a commander uses to derive C^2 decisions. It is difficult, at best, to create many of the emotional consequences which have been experienced in past conflicts.

Overcoming obstacles such as the inherent qualitative nature or the intangibility of human factors is by no means an easy task. It does, however present a challenge to the ambitious and imaginative -- that challenge is to increase the comprehension of man's understanding of man.

APPENDIX A. ACRONYMS

The following is a comprehensive list of acronyms which are used throughout this document:

ACRONYM	MEANING
AI	Artificial Intelligence
APL	A Programming Language
ARTEP	Army Training and Evaluation Program
ASP	Ammunition Supply Point
C^2	Command and Control
CINC	Commander-in-Chief
HQ	Headquarters
MANPRINT	Manpower and Personnel Integration
MILES	Multiple Integrated Laser Engagement System
MOE	Measure of Effectiveness
MOPP	Mission Oriented Protective Posture
MORIMOC	More Operational Realism in the Modeling of Combat
MORS	Military Operations Research Society
NCO	Noncommissioned Officer
NPS	Naval Postgraduate School
NTC	National Training Center
TRADOC	Training and Doctrine Command
XO	Executive Officer

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APPENDIX B. HUMAN FACTORS DEFINITIONS

Listed below is a comprehensive list of the human factors considered in the development of this study. Definitions not specifically referenced represent the author's interpretation of the factor for the purposes of this study.

- *ALTITUDE* - How far above sea level the battlefield is. (Reduced oxygen at high altitudes is likely to impair physical and cognitive performance) [Ref. 25: p. A-2].

- *ATTITUDE* - Any habitual mode of regarding anything; a settled behavior or conduct; an indicating opinion or purpose regarding anything [Ref. 24: p. 184].

- *BOREDOM* - The condition of being bored; a person or thing that wearies one through lack of interest [Ref. 24: p. 312].

- *COGNITIVE FACTOR* - Various mental abilities which can be measured on standardized tests such as the Armed Services Vocational Aptitude (ASVB) [Ref. 25: p. A-1]. (Can be referred to as intellect).

- *COHESION* - A feeling of group unity which entails common interests, goals, and responsibilities [Ref. 25: p. A-2].

- *COMRADESHIP* - Fear of failure in front of comrades.

- *CONFINEMENT* - Restricted within limits or boundaries; feeling of being physically enclosed or confined in a definitive space.

- *COORDINATION* - Gross (large muscle) and fine (visual-motor) coordination [Ref. 25: p. A-1].

- *COWARDLINESS* - One who shrinks from one's duty; one who lacks courage [Ref. 24: p. 601]. Withdrawing from one's duty; lacking courage.

- *CROWDING* - The closeness or the closing in of battle around a unit.

- *CULTURE* - The training, development, or strengthening of the powers, mental or physical, or the condition thus produced; improvement or refinement of mind, morals, or tastes [Ref. 24: p. 629].

- *DARKNESS* - Lack of light.

- *DECISION-MAKING* - The ability of someone in charge to make sound, logical decisions in view of available information [Ref. 25: p. A-1].

- *DEDICATION* - To devote or give up, as oneself, to some special purpose; to direct attention or energy toward; as, to dedicate oneself to a cause [Ref. 24: p. 667].

- *DEPRESSION* - A falling of the spirits; dejection (ref.2 p.684). [Ref. 24: p. 684].

- *DISCIPLINE* - Systematic training or subjection to authority [Ref. 24: p. 721].

- *DRIVE* - To carry forward or prosecute with urgency [Ref. 24: p. 762].

- *EDUCATION LEVEL* - The amount of education that one possesses.

- *EMOTION* - An act or state of excited feeling [Ref. 24: p. 813]. The power or state of feeling.

- *ENDURANCE* - The capacity or power to endure; ability to suffer pain, distress, hardship, or any very prolonged stress without succumbing [Ref. 24: p. 820].

- *ENERGY* - The capacity to keep going around the clock (can be referred to as Drive).

- *ESPRIT de CORPS* - A spirit of common devotedness, sympathy, or support among the members of an association or a body [Ref. 24: p. 852].

- *EXCITEMENT* - Stimulation [Ref. 24: p. 870].

- *EXPERIENCE* - The amount of time in combat scldiers have actually worked on a daily basis in a particular specialty [Ref. 25: p. A-1].

- *FEAR* - To regard with fright or terror; to be afraid [Ref. 24: p. 903].

- *FIRE* - The evolution of heat [Ref. 24: p. 926].

- *FRUSTRATION* - The act of frustrating; bafflement; disappointment; defeat [Ref. 24: p. 988].

- *HONOR* - Fear of failure of country, traditions and family.

- *IDEOLOGY* - Fanciful speculation; the forming of impracticable theories [Ref. 24: p. 1221].

- *INITIATIVE* - An introductory step or action; a first move [Ref. 24: p. 1264]. The capacity to get things going; make a first move.

- *INTUITION* - The quick perception of truth without conscious attention or reasoning (sometimes called "gut feeling").

- *ISOLATION* - The actual or perceived (related to the confusion or fog of war) separation from the group/unit.

- *JET LAG* - Temporary disruption of the normal biological rhythms following long distance airplane travel across several time zones. Closely related to the circadian rhythmic cycle [Ref. 25: p. A-2].

- *LEADERSHIP* - Ability to lead so as to exact maximum effort toward achieving objectives on the battlefield [Ref. 25: p. A-2].

- *MENTAL FATIGUE* - Extreme tiredness which results from prolonged exercise of mental processes [Ref. 25: p. A-1]. Tiredness which results from extended mental exertion with the effect of reduced quantity/quality of decision.

- *MOMENTUM* - The power of overcoming resistance possessed by a body by reason of its motion [Ref. 24: p. 1598].

- *MORALE* - Mental condition in a group which consists of cheerfulness and confidence [Ref. 25: p. A-1]. The state of mind with reference to confidence, courage, and zeal.

- *NATIONAL CHARACTERISTICS* - Differences between soldiers of Armies of different countries which might affect performance [Ref. 25: p. A-2].

- *NATIONAL ETHOS* - The spirit of the people of a nation.

- *NOISE* - The loudness of battle.

- *OBEDIENCE* - Submission to or compliance with a command [Ref. 24: p. 1701].

- *PHYSICAL APTITUDE* - The level of coordination of a person.

- *PHYSICAL CONDITIONING* - The act of being physically fit; capable of enduring.

- *PHYSICAL FATIGUE* - Extreme tiredness which results from prolonged and/or considerable physical exertion during combat [Ref. 25: p. A-1].

- *PRIMARY GROUP* - Small group of comrades that a soldier fights with [Ref. 32: p. 321]; generally three to four other soldiers.

- *PROPAGANDA* - Efforts directed systematically toward the gaining of support for an opinion or course of action [Ref. 24: p. 1985].

- *SLEEP LOSS* - Loss of sleep over a specified period of time. Often quantified as the number of hours sleep sustained for a specified time period. Closely related to the circadian rhythm cycle, which varies soldier alertness as a function of the time of day [Ref. 25: p. A-1].

- *SOCIAL MOTIVATION* - Feeling that your are fighting for a just cause (some relate this to patriotism).

- *SOLDIER LOAD* - The weight foot soldiers are required to carry on or en route to the battlefield [Ref. 25: p. A-1].

- *STRENGTH* - The quality or property of being physically strong; power [Ref. 24: p. 2396].

- *STRESS* - Extreme anxiety that results from the intensity of action, fear of injury or loss of life during combat [Ref. 25: p. A-1].

- *SUPPRESSION* - Pinning down or immobilization on the battlefield and the reduced return of fire or mobility which is likely to result from it.

- *SURPRISE* - To shock or astonish by some unexpected act or event [Ref. 24: p. 2430]. The suddenness of the enemy or enemy fire.

- *TERRAIN* - A physical description of the major geophysical features of the battlefield. Examples include flat, hilly, forest, mountainous, desert, or urban areas [Ref. 25: p. A-1].

- *TOXICITY* - The presence of nuclear, biological or chemical agents on the battlefield. This dimension often refers to degradation in performance which results when soldiers wear MOPP gear [Ref. 25: p. A-2].

- *TRAINING/EXPERIENCE LEVEL* - Resident and unit training. (Training decay is included under this dimension because it results from inadequate refresher training or opportunity to practice the tasks in question) [Ref. 25: p. A-2]. (May include levels -- High, medium, or low unit level training) Individual and unit training as related to the level of expertise achieved.

- *UNCERTAINTY* - Unsureness of what is about to happen. The state of doubt or unsureness of future events or actions.

- *VALUES* - What one believes in. (Could also be looked at as moral values).

- *VISIBILITY* - The ability to see what is happening on the battlefield. Visibility might be hampered by nightfall, fog, weather conditions, or smoke [Ref. 25: p. A-2].

- *WEATHER* - Variations in temperature and humidity (including fog, rain, snow, and other inclement conditions) which affect the soldier's ability to fight [Ref. 25: p. A-1].

- *WILL/MOTIVATION* - Willingness to do whatever is necessary to fight and win [Ref. 25: p. A-1].

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APPENDIX C. SURVEYS

A. INITIAL SURVEY

1. Description

The Initial survey was designed to determine the most important factors affecting a commander's decision. As such, it had two major objectives:

1. To isolate those factors which respondents perceived would impact on a reduced-time command and control decision.
2. To determine whether there was any difference in how respondents from different services perceived the most important factors.

The survey design showing the layout of the survey is as depicted below.

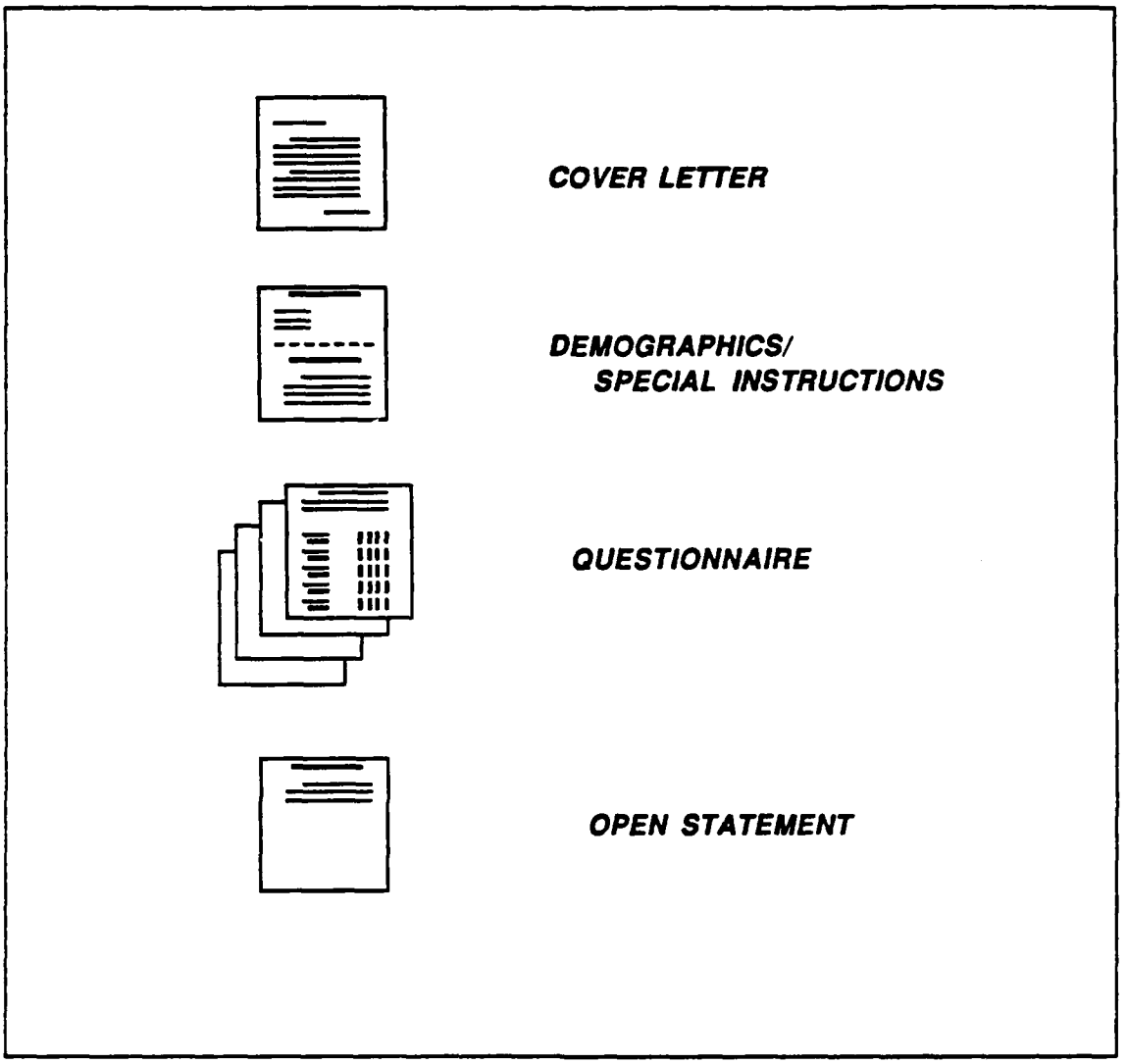

Figure 28. Initial Survey Design

2. Sample Survey

To: Questionnaire Recipient

This questionnaire is part of a study to determine to what degree various human factors impact on operational command and control (C^2) decisions. The objective of this questionnaire is to obtain an estimate of the impact of human factors which are considered by a tactical-level commander in making ***reduced-time***, operational command and control decisions. We believe that the best way to understand which factors a commander would consider important is to ask military officers who have held leadership positions with varying degrees of responsibility.

The questionnaire will not just be used as a subject for a thesis and later disregarded. In fact, the results from this survey will provide the basic framework for advancements in the development of quantified, cause/effect audit trails between specific human factors and combat outcomes. Your honest opinion and perceptions of **how** these factors will affect a commander's decision is critical to the appropriate weighting of the factors. Specific instructions on completing the questionnaire can be found on the next page. ***It will probably take 10-15 minutes to complete the questionnaire.***

Note that there are 3 parts to the survey. Part I consists of basic demographic information. Part II asks to what level of importance the specified human factors would impact on a commander's decision. Part III consists of an open statement that allows you to input any human factors that you consider important but which were not considered in the main part of the survey. The questionnaires are completely confidential. The individual identity of respondents will not be recorded. Please return the questionnaire in the enclosed envelope by ***Friday, 23 February 1990.***

Thank you very much for your help and valuable time.

James S. Couey
Captain, U.S. Army

Randal A. Dragon
Captain, U.S. Army

Part I - DEMOGRAPHICS

SERVICE (circle one): Air Force Army Navy Marine Corps

CURRENT GRADE (circle one): 0-1 0-2 0-3 0-4 0-5 0-6

BRANCH/SPECIALTY: _____

TIME ON ACTIVE DUTY: _____ years _____ months

TIME SPENT IN COMMAND/DEPARTMENT HEAD: _____ years _____ months

TIME SPENT AS A STAFF OFFICER: _____ years _____ months

COMBAT VETERAN (circle one): YES NO

IF YES, WHERE: _____ HOW LONG: _____

SPECIAL INSTRUCTIONS

The questionnaire is self-explanatory. If there is any difficulty in interpreting the questions, try to give the most reasonable answer possible.

On the following pages are 27 human factors for your consideration. In general, you should approach this survey as a tactical-level commander whose force is actively engaged with an enemy force. The scenario and context have been purposely left open-ended and provide a "dimensionless" environment allowing you to apply the listed factors in accordance with your personal experiences. With this in mind, your response should reflect the relative importance of each human factor in light of a reduced-time, operational C^2 decision.

Your answers are extremely important in insuring that the appropriate and most significant factors are identified. Again, we are interested in knowing, based on your past experiences, to what extent each human factor impacts on the commanders thought process.

PART II - QUESTIONNAIRE

Of the Human Factors listed below, some are inherent in the individual service member, some apply only to the level possessed by a unit, while others can apply to both the individual and unit.

How important is each of these HUMAN FACTORS (as possessed by the unit or individuals within the unit) ***to a commander in his formulation of a reduced-time, operational command and control decision?***

	VERY IMPORTANT	IMPORTANT	NOT IMPORTANT	VERY UNIMPORTANT
COGNITIVE FACTOR Various mental abilities which can be measured on standardized test such as the Armed Services Vocational Aptitude (ASVB). (can be referred to as **intellect**)	( )	( )	( )	( )
COHESION The feeling of group unity which entails common interests, goals, and responsibilities.	( )	( )	( )	( )
COMBAT EXPERIENCE The amount of time in combat soldiers have actually experienced.	( )	( )	( )	( )
COMRADESHIP The fear of failure in front of comrades.	( )	( )	( )	( )
CONFINEMENT Restricted within limits or boundaries; the feeling of being physically enclosed or confined in a definitive space.	( )	( )	( )	( )
COWARDLINESS *Withdrawing from one's duty;* lacking courage.	( )	( )	( )	( )
DISCIPLINE The systematic training or subjection to authority.	( )	( )	( )	( )

PART II (continued)

Of the Human Factors listed below, some are inherent in the individual service member, some apply only to the level possessed by a unit, while others can apply to both the individual and unit.

How important is each of these HUMAN FACTORS (as possessed by the unit or individuals within the unit) ***to a commander in his formulation of a reduced-time, operational command and control decision?***

	VERY IMPORTANT	IMPORTANT	NOT IMPORTANT	VERY UNIMPORTANT
EMOTION The power or state of feeling.	( )	( )	( )	( )
ENERGY The capacity to keep going around the clock. (can be referred to as **Drive**)	( )	( )	( )	( )
FEAR To regard with fright or terror; to be afraid.	( )	( )	( )	( )
HONOR The fear of failure of country, traditions, and family.	( )	( )	( )	( )
INITIATIVE The capacity to get things going; make a first move.	( )	( )	( )	( )
INTUITION The quick perception of truth without conscious attention or reasoning. (sometimes called a **'Gut Feeling'**)	( )	( )	( )	( )
ISOLATION The actual or perceived separation from the one's group/unit.	( )	( )	( )	( )

PART II (continued)

Of the Human Factors listed below, some are inherent in the individual service member, some apply only to the level possessed by a unit, while others can apply to both the individual and unit.

How important is each of these HUMAN FACTORS (as possessed by the unit or individuals within the unit) ***to a commander in his formulation of a reduced-time, operational command and control decision?***

	VERY IMPORTANT	IMPORTANT	NOT IMPORTANT	VERY UNIMPORTANT
JET LAG The temporary disruption of the normal biological rhythms following long distance airplane travel across several time zones.	( )	( )	( )	( )
LEADERSHIP The ability to lead so as to exact maximum effort toward achieving objectives on the battlefield.	( )	( )	( )	( )
MENTAL FATIGUE The extreme tiredness which results from prolonged exercise of mental processes. Tiredness which results from extended mental exertion.	( )	( )	( )	( )
MORALE The state of mind with reference to confidence, courage, and zeal.	( )	( )	( )	( )
NATIONAL CHARACTERISTICS The differences between soldiers of Armies from different countries which might affect performance.	( )	( )	( )	( )
PHYSICAL FATIGUE The extreme tiredness which results from prolonged and/or considerable physical exertion during combat.	( )	( )	( )	( )

PART II (continued)

Of the Human Factors listed below, some are inherent in the individual service member, some apply only to the level possessed by a unit, while others can apply to both the individual and unit.

How important is each of these HUMAN FACTORS (as possessed by the unit or individuals within the unit) ***to a commander in his formulation of a reduced-time, operational command and control decision?***

	VERY IMPORTANT	IMPORTANT	NOT IMPORTANT	VERY UNIMPORTANT
SLEEP LOSS The loss of sleep over a specified period of time.	( )	( )	( )	( )
SOCIAL MOTIVATION The feeling that you are fighting for a just cause.	( )	( )	( )	( )
STRESS Extreme anxiety that results from the intensity of action, fear of injury or loss of life during combat.	( )	( )	( )	( )
SURPRISE To shock or astonish by some unexpected act or event; the suddenness of the enemy or enemy fire.	( )	( )	( )	( )
TRAINING/EXPERIENCE LEVEL Individual and unit training as related to the level of expertise achieved.	( )	( )	( )	( )
UNCERTAINTY The state of doubt or unsureness of future events or actions.	( )	( )	( )	( )
WILL/MOTIVATION The willingness to do whatever is necessary to fight and win.	( )	( )	( )	( )

Part III - OPEN STATEMENT

Please add any other ***human factors*** that we may not have listed which a commander should consider when making a reduced-time operational C^2 decision. Thanks again for your assistance.

B. FOLLOW-ON SURVEY

1. Description

The Follow-On Survey was designed to determine whether the relative significance of the top seven factors identified from the Initial Survey varied when applied within a specified context. As such, the primary objective was to determine whether respondents felt that the factors had the same (or differing) relative importance based on four prescribed scenarios. There were two versions of the survey, one Infantry-based and the other Artillery-based. The versions have a parallel structure with the basic design as depicted in the figure below.

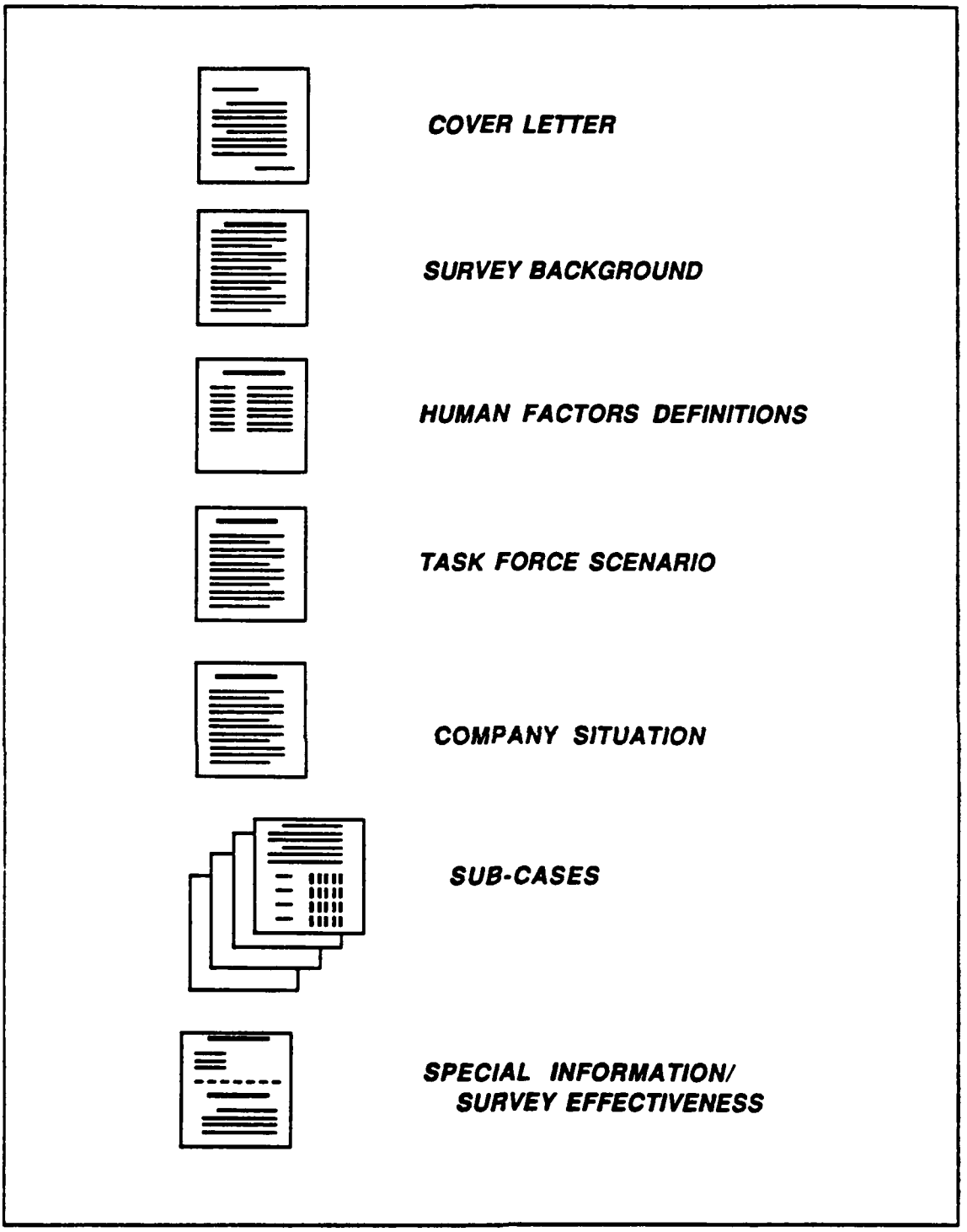

Figure 29. Follow-On Survey Design

2. Sample Survey

Both versions of the sample surveys are included here to illustrate the point of parallel design. Each of the sub-cases establishes similar parameters for respondents to formulate their responses.

a. Infantry Scenario

To: Questionnaire Recipient

This questionnaire is part of a study to determine to what degree various human factors impact on command and control (C^2) decisions. The objective of this questionnaire is to obtain an estimate of the impact of human factors which are considered by a tactical-level commander in making ***reduced-time***, command and control decisions. We believe that the best way to understand which factors a commander would consider important is to ask military officers who have commanded.

The questionnaire will not just be used as a subject for a thesis and later disregarded. In fact, the results from this survey will provide the basic framework for advancements in the development of quantified, cause/effect audit trails between specific human factors and combat outcomes. Your honest opinion and perceptions of **how** these factors will affect a commander's decision is critical to the appropriate weighting of the factors. Specific instructions on completing the questionnaire can be found on the next page. ***It will probably take 20-25 minutes to complete the questionnaire.***

There are four basic parts to the survey:

1. Part I - Survey Background Information
2. Part II - Battalion Task Force Scenario
3. Part III - Company Situation/Sub-cases
4. Part IV - Special Information

The questionnaire is self-explanatory. If there is any difficulty in interpreting the questions, try to give the most reasonable answer possible. Your answers are extremely important in ensuring that the appropriate and most significant factors are identified. Again, we are interested in knowing, to what extent each of the human factors presented impacts on the commander's thought process. The questionnaires are completely confidential. The individual identity of the respondents will not be recorded. Please return the questionnaire in the enclosed envelope by ***Friday, 4 MAY 1990.***

Thank you very much for your help and valuable time.

Randal A. Dragon
Captain, U.S. Army

Part I - BACKGROUND

➪ For the purposes of this survey, perceived truth is considered to be ground truth. In other words, this is not an exercise in how well your intelligence system is working for you. Assume that what you are told is exactly how it exists.

➪ The scenario is written to cover the basic information that you should know as the commander of this unit. You will be time-stepped through a series of different sub-scenarios or sub-cases. **In each sub-case, apply the human factors listed with regards to the weight that they would play on your decision.**

➪ Given the rate of political change within Europe, current trends in force reduction lead one to believe that a conflict is much less likely than three years ago. For the purposes of this survey, assume that (for whatever reasons) tensions have increased to the point that hostilities between NATO and the remains of the Warsaw Pact are imminent.

➪ Also, we realize that applying a list of human factors is not something that you would normally conciously dwell upon, especially when reduced-time decisions are critical. Most of the time these factors are part of a subconcious consideration. We ask that you consider each factor individually and try to avoid aggregation of factors.

➪ Finally, we would ask you not to change a response once it has been made.

➪ The scenario for this survey is set in West Germany. **Your Brigade has been given the mission to defend a sector to the rear of a defending front line division.**

HUMAN FACTORS DEFINITIONS

The following definitions provide the author's intended meaning of the human factors to be applied within this survey. Please refer to these definitions as you complete the survey.

COHESION - A feeling of group unity which entails common interests, goals, and responsibilities.

DISCIPLINE - Systematic training or subjection to authority.

INITIATIVE - An introductory step or action; a first move.

LEADERSHIP - Ability to lead so as to exact maximum effort toward achieving objectives on the battlefield.

MORALE - Mental condition in a group which consists of cheerfulness and confidence.

TRAINING/ EXPERIENCE - Individual and unit training as related to the level of expertise achieved.

WILL/ MOTIVATION - Willingness to do whatever is necessary to fight and win.

Part II - TASK FORCE SCENARIO

➪ Task Force MECH, a mechanized infantry battalion task force, has been given the mission to secure the Brigade Rear Area against possible attacks by both conventional and unconventional forces. **You are the Company Commander of Company A, 1-92 (Mech) Infantry.**

➪ The enemy main body is not expected to cross the Inter-German border for 48 hours, however intelligence indicates that unconventional force raids consisting of 5-30 men can occur at any time. Given the enemy's current capability, indications are that he will target key logistical and C^2 facilities through repeated attacks well in advance of his main effort.

➪ In a conventional attack, it is anticipated that the enemy will employ chemical agents and, as a result the Task Force Commander has ordered the extended wear of MOPP suits, although boots, gloves and masks are to be carried until needed.

➪ The Task Force Commander currently anticipates having to protect the designated key assets with 360 degree security, including protection against possible airborne insertions. He expects to have to fight the rear area battle for the next 36-48 hours. The Task Force has been given a contingency mission to be prepared to move into blocking positions in the event of enemy penetration of forward defenses.

➪ The enemy can establish local air superiority for limited periods.

➪ Terrain - rolling hills with densely forested areas. Urban spread and areas of 500 - 2,000 generally separated by 3-5 kilometers. Open areas are mostly agricultural lands occupied by cattle farmers.

➪ Weather - clear days and cool nights; temperatures range from 42 - 73 degrees (F). Fog in low lying areas in early morning hours. No precipitation expected over the next 72 hours.

Part III - COMPANY SITUATION

➪ You are the Alpha Company Commander which currently consists of:

1st Platoon, A/1-92 Infantry	(organic)
2nd Platoon, A/1-92 Infantry	(organic)
3rd Platoon, A/1-92 Infantry	(organic)
Mortar Platoon, A/1-92 Infantry	(organic)
2 Anti-Armor Sections, E/1-92 Infantry	(attached)

➪ You have been in command of this company for the past 13 months.

➪ Your company CP location is approximately 65 kilometers from the Inter-German Border (IGB).

➪ You are in a defensive posture. Your primary mission is to protect an ammunition supply point (ASP) and to provide perimeter security for the Rear Area Operations Center (RAOC). As a contingency mission, you have been told to be prepared to occupy a Battle positions well forward in the event that the Red Hoard should breakthrough forward defenses.

➪ Although you have not specifically trained for the rear area missions, you realize that the small unit actions required in this environment are similar to those experienced in other missions for which you consider your company fully trained.

➪ You have what you consider to be a well-trained chain of command which you believe adapts well to changing situations.

➪ Equipment is 100% operational; personnel strength is 100%.

➪ Do not consider the success or failure of the Non-Combatant Evacuation (NEO) plan in the ranking of the human factors listed.

Case Number 1

- Your situation remains as indicated above.

- You have decided to protect the Rear Area Operations Center with 2 platoons and the ASP with 1 platoon.

- Your Executive Officer (XO), who by your initial plan was going to ensure the security of the ASP, has fallen, broken his leg, and required MEDEVAC.

- You still have time to modify your plan. Although, you have faith in the abilities of all of your platoons, you know the importance of ensuring that the one that secures the ASP perimeter can operate independently.

- You must decide which platoon to assign to the ASP security mission.

- ***How important is each of the human factors listed below*** (as possessed by the unit or individuals within the unit) ***to you, as the commander, in the formulation of this reduced-time decision?***

	Very Important	Important	Neutral	Unimportant	Very Unimportant
COHESION	( )	( )	( )	( )	( )
DISCIPLINE	( )	( )	( )	( )	( )
INITIATIVE	( )	( )	( )	( )	( )
LEADERSHIP	( )	( )	( )	( )	( )
MORALE	( )	( )	( )	( )	( )
TRAINING/ EXPERIENCE	( )	( )	( )	( )	( )
WILL/ MOTIVATION	( )	( )	( )	( )	( )

Case Number 2

- You chose the 1st platoon for the ASP mission. The 1st platoon leader reports that he has established limited security around the ASP. Meanwhile, political tensions between NATO and the Warsaw Pact have peaked and negotiations appear to be breaking down. At this point, your intel assets indicate a conventional attack will occur within the next 24 hours.

- You have positioned your Company CP inside the perimeter established by your 2nd and 3rd platoons which is protecting the RAOC. Your only reserve consists of 2 scout sections (personnel/equipment/vehicles) which are currently under your operational control. Since you arrived in position just 5 hours ago, your defensive positions are only semi-prepared.

- Your 2nd platoon starts receiving both machinegun and indirect fire. You are not sure whether or not this is a main attack by an enemy force or a diversionary attack. Your decision is whether you should deploy the immediate reaction force (at this point) to assist the 2nd platoon.

- ***How important is each of the human factors listed below*** (as possessed by the unit or individuals within the unit) ***to you, as the commander, in the formulation of this reduced-time decision?***

	Very Important	Important	Neutral	Unimportant	Very Unimportant
COHESION	( )	( )	( )	( )	( )
DISCIPLINE	( )	( )	( )	( )	( )
INITIATIVE	( )	( )	( )	( )	( )
LEADERSHIP	( )	( )	( )	( )	( )
MORALE	( )	( )	( )	( )	( )
TRAINING/ EXPERIENCE	( )	( )	( )	( )	( )
WILL/ MOTIVATION	( )	( )	( )	( )	( )

Case Number 3

- You controlled the situation by deploying the reaction force who engaged 10 ground warriors in civilian clothes carrying satchels of high explosives and armed with light machineguns, light antitank weapons, and man-portable mortars.

- Reports coming from the forward defense units is that they are receiving intense, concentrated artillery fire. This is prep fire for the Pact's first echelon forces as they have started their rapid advance toward the border.

- You receive a report that 2 large rockets have landed 3 kilometers upwind of the RAOC. If this is a chemical round, you're not really sure that the vapor cloud would reach your position. You realize that if you go to full MOPP now, a degradation in performance occurs which will increase the remaining 4 hours of defensive preparation to 10 hours. You are fully confident in the chemical detection devices that you have emplaced on your perimeter.

- You must now decide whether to go to full MOPP and accept the degradation in performance.

- ***How important is each of the human factors listed below*** (as possessed by the unit or individuals within the unit) ***to you, as the commander, in the formulation of this reduced-time decision?***

	Very Important	Important	Neutral	Unimportant	Very Unimportant
COHESION	( )	( )	( )	( )	( )
DISCIPLINE	( )	( )	( )	( )	( )
INITIATIVE	( )	( )	( )	( )	( )
LEADERSHIP	( )	( )	( )	( )	( )
MORALE	( )	( )	( )	( )	( )
TRAINING/ EXPERIENCE	( )	( )	( )	( )	( )
WILL/ MOTIVATION	( )	( )	( )	( )	( )

Case Number 4

- You made the choice not to go into full MOPP.

- In the interim, the Pact is making an all out attempt to penetrate NATO's *forward defenses. Your scout sections have been pulled back to* battalion; your commander's emphasis has shifted from the rear area mission to integrating the battalion into the depth of the defense.

- One of your sister unit's defensive positions has just sustained a direct hit by a non-persistent nerve agent. As a result, you have been ordered to re-distribute your forces by moving one platoon into that position to "defend and assess/evacuate casualties." Early reports are that the company has sustained 110 -115 KIA's. Your battalion commander has ordered you (personally) to remain with the RAOC mission.

- You must decide which platoon to send to handle the position defense/casualty assessment mission.

- ***How important is each of the human factors listed below*** (as possessed by the unit or individuals within the unit) ***to you, as the commander, in the formulation of this reduced-time decision?***

	Very Important	Important	Neutral	Unimportant	Very Unimportant
COHESION	( )	( )	( )	( )	( )
DISCIPLINE	( )	( )	( )	( )	( )
INITIATIVE	( )	( )	( )	( )	( )
LEADERSHIP	( )	( )	( )	( )	( )
MORALE	( )	( )	( )	( )	( )
TRAINING/ EXPERIENCE	( )	( )	( )	( )	( )
WILL/ MOTIVATION	( )	( )	( )	( )	( )

Part IV - SPECIAL INFORMATION

CURRENT GRADE (circle one): 0-2 0-3 0-4 0-5

BRANCH/SPECIALTY: _____

TIME ON ACTIVE DUTY: _____ years _____ months

TIME SPENT IN COMMAND: _____ years _____ months

TIME SPENT AS A STAFF OFFICER: _____ years _____ months

COMBAT VETERAN (circle one): YES NO

IF YES, WHERE: _____ HOW LONG: _____

SURVEY EFFECTIVENESS

1. Were the situations presented **understandable**? (***Yes*** or ***No*** - circle one) If not, why not?

2. Would you say that the situations presented were **realistic**? (***Yes*** or ***No*** - circle one) If not, why not?

3. What **assumptions** did you have to make in order to complete this survey?

b. Artillery Scenario

To: Questionnaire Recipient

This questionnaire is part of a study to determine to what degree various human factors impact on command and control (C^2) decisions. The objective of this questionnaire is to obtain an estimate of the impact of human factors which are considered by a tactical-level commander in making ***reduced-time***, command and control decisions. We believe that the best way to understand which factors a commander would consider important is to ask military officers who have commanded.

The questionnaire will not just be used as a subject for a thesis and later disregarded. In fact, the results from this survey will provide the basic framework for advancements in the development of quantified, cause/effect audit trails between specific human factors and combat outcomes. Your honest opinion and perceptions of **how** these factors will affect a commander's decision is critical to the appropriate weighting of the factors. Specific instructions on completing the questionnaire can be found on the next page. ***It will probably take 20-25 minutes to complete the questionnaire.***

There are four basic parts to the survey:

1. Part I - Survey Background Information
2. Part II - Battalion Task Force Scenario
3. Part III - Battery Situation/Sub-cases
4. Part IV - Special Information

The questionnaire is self-explanatory. If there is any difficulty in interpreting the questions, try to give the most reasonable answer possible. Your answers are extremely important in ensuring that the appropriate and most significant factors are identified. Again, we are interested in knowing to what extent each of the human factors presented impacts on the commanders thought process. The questionnaires are completely confidential. The individual identity of the respondents will not be recorded. Please return the questionnaire in the enclosed envelope by ***Friday, 4 MAY 1990.***

Thank you very much for your help and valuable time.

James S. Casey

James S. Casey
Captain, U.S. Army

Part I - BACKGROUND

➪ For the purposes of this survey, perceived truth is considered to be ground truth. In other words, this is not an exercise in how well your intelligence system is working for you. Assume that what you are told is exactly how it exists.

➪ The scenario is written to cover the basic information that you should know as the commander of this unit. You will be time-stepped through a series of different sub-scenarios or sub-cases. **In each sub-case, apply the human factors listed with regards to the weight that they would play on your decision.**

➪ Given the rate of political change within Europe, current trends in force reduction lead one to believe that a conflict is much less likely than three years ago. For the purposes of this survey, assume that (for whatever reasons) tensions have increased to the point that hostilities between NATO and the remains of the Warsaw Pact are imminent.

➪ Also, we realize that applying a list of human factors is not something that you would normally conciously dwell upon, especially when reduced-time decisions are critical. Most of the time these factors are part of a subconcious consideration . We ask that you consider each factor individually and try to avoid aggregation of factors.

➪ Finally, we would ask you not to change a response once it has been made.

➪ The scenario for this survey is set in West Germany. **Your Brigade has been given the mission to defend a sector to the rear of a defending front line division.**

HUMAN FACTORS DEFINITIONS

The following definitions provide the author's intended meaning of the human factors to be applied within this survey. Please refer to these definitions as you complete the survey.

COHESION - A feeling of group unity which entails common interests, goals, and responsibilities.

DISCIPLINE - Systematic training or subjection to authority.

INITIATIVE - An introductory step or action; a first move.

LEADERSHIP - Ability to lead so as to exact maximum effort toward achieving objectives on the battlefield.

MORALE - Mental condition in a group which consists of cheerfulness and confidence.

TRAINING/ EXPERIENCE - Individual and unit training as related to the level of expertise achieved.

WILL/ MOTIVATION - Willingness to do whatever is necessary to fight and win.

Part II - TASK FORCE SCENARIO

➪ Task Force MECH, a mechanized infantry battalion task force, has been given the mission to secure the Brigade Rear Area against possible attacks by both conventional and unconventional forces. **You are the Battery Commander of C Battery, 1-22 Field Artillery.**

➪ The enemy main body is not expected to cross the Inter-German border for 48 hours, however intelligence indicates that unconventional force raids consisting of 5-30 men can occur at any time. Given the enemy's current capability, indications are that he will target key logistical and C^2 facilities through repeated attacks well in advance of his main effort.

➪ In a conventional attack, it is anticipated that the enemy will employ chemical agents and, as a result the Task Force Commander has ordered the extended wear of MOPP suits, although boots, gloves and masks are to be carried until needed.

➪ The Task Force Commander currently anticipates having to protect the designated key assets with 360 degree security, including protection against possible airborne insertions. He expects to have to fight the rear area battle for the next 36-48 hours. The Task Force has been given a contingency mission to be prepared to move into blocking positions in the event of enemy penetration of forward defenses.

➪ The enemy can establish local air superiority for limited periods.

➪ Terrain - rolling hills with densely forested areas. Urban spread and areas of 500 - 2,000 generally separated by 3-5 kilometers. Open areas are mostly agricultural lands occupied by cattle farmers.

➪ Weather - clear days and cool nights; temperatures range from 42 - 73 degrees (F). Fog in low lying areas in early morning hours. No precipitation expected over the next 72 hours.

Part III - BATTERY SITUATION

➪ You are the Charlie Battery Commander which currently consists of:

1st Platoon, C/1-22 Artillery	(organic)
2nd Platoon, C/1-22 Artillery	(organic)
Maintenance Team, 1-22 Artillery	(attached)

➪ You have been in command of this battery for the past 13 months.

➪ Your battery CP location is approximately 65 kilometers from the Inter-German Border (IGB).

➪ You are in a direct support posture. Your primary mission is to provide artillery support for Task Force MECH which has responsibility for the security of the Brigade Rear Area. As a contingency mission, you have been told to be prepared to deploy well forward in the event that the Red Hoard should breakthrough forward defenses.

➪ Although you have not specifically trained for the rear area missions, you realize that being able to provide artillery fire in all directions as required in this environment are similar to those experienced in other missions for which you consider your battery fully trained.

➪ You have what you consider to be a well-trained chain of command which you believe adapts well to changing situations.

➪ Equipment is 100% operational; personnel strength is 100%.

➪ Do not consider the success or failure of the Non-Combatant Evacuation (NEO) plan in the ranking of the human factors listed.

Case Number 1

- Your situation remains as indicated above.

- C Battery has just arrived in the AA (assembly area) when you receive orders to deploy one platoon forward immediately to support a portion of Task Force MECH who are guarding an ASP (ammunition supply point).

- The 1st and 2nd platoon leaders have been in the battalion for five months, but have only been with the battery for eight days and you are not yet sure of their capabilities in leading a firing platoon.

- Although, you have faith in the abilities of both firing platoons, you must now make the decision on which platoon to deploy forward in support of this critical mission, considering the platoon will be acting independently from the battery.

- ***How important is each of the human factors listed below*** (as possessed by the unit or individuals within the unit) ***to you, as the commander, in the formulation of this reduced-time decision?***

	Very Important	Important	Neutral	Unimportant	Very Unimportant
COHESION	( )	( )	( )	( )	( )
DISCIPLINE	( )	( )	( )	( )	( )
INITIATIVE	( )	( )	( )	( )	( )
LEADERSHIP	( )	( )	( )	( )	( )
MORALE	( )	( )	( )	( )	( )
TRAINING/ EXPERIENCE	( )	( )	( )	( )	( )
WILL/ MOTIVATION	( )	( )	( )	( )	( )

Case Number 2

- You chose the 1st platoon to deploy forward in support of Task Force MECH. Meanwhile, political tensions between NATO and the Warsaw Pact have peaked and negotiations appear to be breaking down. At this point, your intel assets indicate a conventional attack will occur within the next 24 hours and that possible airborne insertions could occur sooner on key logistical sites.

- An airborne insertion has just occurred at the ASP and Task Force MECH defending it is engaging the enemy. The 1st platoon is firing artillery in support of the task force. Should this ASP be captured or destroyed, 70% of the brigades ammunition would be lost. Therefore, this mission has high priority. Suddenly, 1st platoon starts receiving both machine gun and indirect fire.

- You must decide whether to displace 1st platoon to an alternate position and stop firing; which means the task force is without artillery support for a short time and the ASP could be lost or to continue the artillery fires and defend yourself the best you can.

- ***How important is each of the human factors listed below*** (as possessed by the unit or individuals within the unit) ***to you, as the commander, in the formulation of this reduced-time decision?***

	Very Important	Important	Neutral	Unimportant	Very Unimportant
COHESION	( )	( )	( )	( )	( )
DISCIPLINE	( )	( )	( )	( )	( )
INITIATIVE	( )	( )	( )	( )	( )
LEADERSHIP	( )	( )	( )	( )	( )
MORALE	( )	( )	( )	( )	( )
TRAINING/ EXPERIENCE	( )	( )	( )	( )	( )
WILL/ MOTIVATION	( )	( )	( )	( )	( )

Case Number 3

- 1st platoon was left in position to continue their artillery support and repeled the ground force attackers.

- Reports coming from the forward defense units is that they are receiving intense, concentrated artillery fire. This is prep fire for the Pact's first echelon forces as they have started their rapid advance toward the border.

- You receive a report that 2 large rockets have landed 3 kilometers upwind of the battery location. If this is a chemical round, you're not really sure that the vapor cloud would reach your position. You realize that if you go to full MOPP now, your soldier's performance will be degraded severly. You are fully confident in the chemical detection devices that you have emplaced on your battery perimeter.

- You must now decide whether to go to full MOPP and accept the degradation in performance or take the chance that the rockets were not chemical rockets.

- ***How important is each of the human factors listed below*** (as possessed by the unit or individuals within the unit) ***to you, as the commander, in the formulation of this reduced-time decision?***

	Very Important	Important	Neutral	Unimportant	Very Unimportant
COHESION	( )	( )	( )	( )	( )
DISCIPLINE	( )	( )	( )	( )	( )
INITIATIVE	( )	( )	( )	( )	( )
LEADERSHIP	( )	( )	( )	( )	( )
MORALE	( )	( )	( )	( )	( )
TRAINING/ EXPERIENCE	( )	( )	( )	( )	( )
WILL/ MOTIVATION	( )	( )	( )	( )	( )

Case Number 4

- You made the choice not to go into full MOPP.

- In the interim, the Pact is making an all out attempt to penetrate NATO's forward defenses.

- One of your sister unit's firing positions has just sustained a direct hit by a non-persistent nerve agent. As a result, you have been ordered to re-distribute your forces by moving one platoon into that position to "defend and assess/evacuate casualties and ensure the security of the nuclear rounds." Latest reports are that the battery has sustained 60 - 75 KIA's.

- You must decide which platoon to send to handle the position defense/casualty assessment mission.

- ***How important is each of the human factors listed below*** (as possessed by the unit or individuals within the unit) ***to you, as the commander, in the formulation of this reduced-time decision?***

	Very Important	Important	Neutral	Unimportant	Very Unimportant
COHESION	( )	( )	( )	( )	( )
DISCIPLINE	( )	( )	( )	( )	( )
INITIATIVE	( )	( )	( )	( )	( )
LEADERSHIP	( )	( )	( )	( )	( )
MORALE	( )	( )	( )	( )	( )
TRAINING/ EXPERIENCE	( )	( )	( )	( )	( )
WILL/ MOTIVATION	( )	( )	( )	( )	( )

Part IV - SPECIAL INFORMATION

CURRENT GRADE (circle one): 0-2 0-3 0-4 0-5

BRANCH/SPECIALTY: _____

TIME ON ACTIVE DUTY: _____ years _____ months

TIME SPENT IN COMMAND: _____ years _____ months

TIME SPENT AS A STAFF OFFICER: _____ years _____ months

COMBAT VETERAN (circle one): YES NO

IF YES, WHERE: _____ HOW LONG: _____

SURVEY EFFECTIVENESS

1. Were the situations presented **understandable**? (***Yes*** or ***No*** - circle one) If not, why not?

2. Would you say that the situations presented were **realistic**? (***Yes*** or ***No*** - circle one) If not, why not?

3. What **assumptions** did you have to make in order to complete this survey?

APPENDIX D. PROGRAM LISTINGS

The following is a complete listing of the APL (A Programming Language) programs used in transforming survey results to interval scales. These programs were developed by Professor Glenn F. Lindsay, an operations research instructor at the Naval Postgraduate School.

To use these programs, one must input the following values:

- N = Number of instances
- M = Number of categories
- R = A vector of consecutive rows of the raw frequency matrix data

From this data, the PMATRICE R function will give the matrix of cumulated proportions P. If these values satisfy the requirements of being greater than 0.02 and less than 0.98, then the SCALE P function will compute the category bounds, standard deviations, and scaled values for the instances.

A. PMATRICE R FUNCTION

This function converts the raw data into a cumulated relative frequency array.

```
      ∇PMATRICE[□]∇
      ∇ PMATRICE R
[1]   F←(N,M)⍴R
[2]   L←⍴F
[3]   N←L[1]
[4]   M←L[2]
[5]   F1←+\F
[6]   P←⍉(M,N)⍴(F1[;M])
[7]   P←F1⌷P
[8]   P←P[;⍳(M-1)]
[9]   'THE P MATRIX IS;'
[10]  P
[11]  ' '
[12]  ' '
      ∇
```

B. NQUAN FUNCTION

This function converts the PMATRICE R data into their corresponding z values from the Normal distribution table computations.

```
      ∇NQUAN[□]∇
      ∇ Q←NQUAN P;C0;C1;C2;D1;D2;D3;V;PP;T
[1]   ⍝ P IS A VECTOR OF PROBABILITIES
[2]   ⍝ Q IS THE CORRESPONDING SET OF GAUSSIAN QUANTILES
[3]    →L1×⍳(0<+/P=0)∨(0<+/P=1)
[4]    C0←2.515517
[5]    C1←0.802853
[6]    C2←0.010328
[7]    D1←1.432788
[8]    D2←0.189269
[9]    D3←0.001308
[10]   PP←(P×1-V)+(1-P)×V←P≥0.5
[11]   Q←T-(C0+T×(C1+T×C2))÷1+
       T×(D1+T×(D2+D3×T←(¯2×⍟PP)*0.5))
[12]   Q←(Q×V)-Q×1-V
[13]   →0
[14] L1:'SOME PROBABILITIES ARE ZERO OR ONE'
       ∇
```

C. CATEGORICAL FUNCTION

This function computes the bounds and the standard deviations between the categorical descriptors and the scaled values for each instance.

```
      ∇CATEGORICAL[□]∇
      ∇ CATEGORICAL Z
[1]   L←⍴Z
[2]   N←L[1]
[3]   M←L[2]+1
[4]   BOUNDS←(+⌿Z)÷N
[5]   'CATEGORY UPPER BOUNDS'
[6]   BOUNDS
[7]   ' '
[8]   BARZ←(+/Z)÷(M-1)
[9]   BBAR←(+/BOUNDS)÷(M-1)
[10]  NUM←+/((BOUNDS-BBAR)*2)
[11]  DEN←⍉(((M-1),N)⍴BARZ)
[12]  DEN←+/((Z-DEN)*2)
[13]  SD←(NUM×(÷DEN))*0.5
[14]  'STANDARD DEVIATIONS ARE:'
[15]  SD
[16]  ' '
[17]  S←BBAR-(SD×BARZ)
[18]  ' '
[19]  'INSTANCE SCALE VALUES ARE:'
[20]  ' '
[21]  S
      ∇
```

D. SCALE P FUNCTION

This function combines the previous functions to present the upper bounds, standard deviations, and scaled values.

```
      ∇SCALE[□]∇
      ∇ SCALE P
[1]   M←M-1
[2]   Z←NQUAN(,P)
[3]   Z←(N,M)ρZ
[4]   CATEGORICAL Z
      ∇
```

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APPENDIX E. SURVEY RESULTS

The following tables represent raw, refined, and ranked data. All of the services data is shown, however, only the Army Total category will be presented in its entirety with initial and final data results for the other services.

A. RESULTS - SURVEY I

Table 27. SURVEY I - OVERHEAD

SERVICE		Number Distributed	Number Returned	Percent Returned	Average Time in Service	Range of Time in Service
Army	*Total*	*147*	*101*	*68.72*	*9 years, 4 months*	*5 years 8 months to 17 years, 7 months*
	Combat Arms	*77*	*55*	*71.43*	*9 years, 1 month*	*5 years 9 months to 17 years, 7 months*
	Non-Combat Arms	*70*	*46*	*65.71*	*9 years, 7 months*	*5 years 8 months to 15 years, 2 months*
Air Force		*70*	*32*	*55.99*	*7 years, 8 months*	*3 years 8 months to 18 years, 6 months*
Marine Corps		*120*	*61*	*50.83*	*11 years, 2 months*	*4 years 9 months to 19 years, 8 months*
Navy		*122*	*63*	*51.64*	*8 years, 11 months*	*3 years 10 months to 18 years, 6 months*

1. Raw Frequency Results

The following tables show the raw data collected for Survey I in the following order:

- Army Total
- Army Combat Arms
- Army Non-Combat Arms
- Air Force
- Marine Corps
- Navy

Table 28. SURVEY I RESULTS - ARMY TOTAL

HUMAN FACTOR	Very Unimportant	Not Important	Important	Very Important
Cognitive Factor	*1*	*23*	*67*	*10*
Cohesion	*0*	*1*	*28*	*72*
Combat Experience	*1*	*20*	*51*	*29*
Comradeship	*1*	*17*	*62*	*21*
Confinement	*9*	*67*	*20*	*5*
Cowardliness	*3*	*26*	*52*	*20*
Discipline	*1*	*0*	*21*	*79*
Emotion	*1*	*19*	*62*	*19*
Energy	*0*	*2*	*44*	*55*
Fear	*2*	*22*	*65*	*12*
Honor	*2*	*17*	*55*	*27*
Initiative	*0*	*0*	*21*	*80*
Intuition	*0*	*14*	*51*	*36*
Isolation	*1*	*37*	*45*	*18*
Jet Lag	*7*	*48*	*43*	*3*
Leadership	*0*	*0*	*6*	*95*
Mental Fatigue	*1*	*3*	*44*	*53*
Morale	*0*	*0*	*35*	*66*
National Characteristics	*6*	*42*	*46*	*7*
Physical Fatigue	*0*	*1*	*57*	*43*
Sleep Loss	*0*	*3*	*49*	*49*
Social Motivation	*5*	*22*	*51*	*23*
Stress	*0*	*2*	*64*	*35*
Surprise	*0*	*10*	*52*	*39*
Training/Experience	*0*	*0*	*19*	*82*
Uncertainty	*0*	*23*	*68*	*10*
Will/Motivation	*0*	*4*	*29*	*68*

Table 29. SURVEY I RESULTS - ARMY COMBAT ARMS

HUMAN FACTOR	Very Unimportant	Not Important	Important	Very Important
Cognitive Factor	*1*	*16*	*32*	*6*
Cohesion	*0*	*0*	*16*	*39*
Combat Experience	*1*	*11*	*25*	*18*
Comradeship	*1*	*10*	*30*	*14*
Confinement	*7*	*35*	*10*	*3*
Cowardliness	*1*	*18*	*27*	*9*
Discipline	*1*	*0*	*11*	*43*
Emotion	*1*	*10*	*36*	*8*
Energy	*0*	*0*	*26*	*29*
Fear	*2*	*8*	*38*	*7*
Honor	*2*	*14*	*27*	*12*
Initiative	*0*	*0*	*12*	*43*
Intuition	*0*	*8*	*28*	*19*
Isolation	*0*	*19*	*27*	*9*
Jet Lag	*4*	*27*	*23*	*1*
Leadership	*0*	*0*	*3*	*52*
Mental Fatigue	*0*	*0*	*23*	*32*
Morale	*0*	*0*	*15*	*40*
National Characteristics	*2*	*26*	*22*	*5*
Physical Fatigue	*0*	*0*	*32*	*23*
Sleep Loss	*0*	*1*	*25*	*29*
Social Motivation	*4*	*17*	*26*	*8*
Stress	*0*	*1*	*36*	*18*
Surprise	*0*	*6*	*28*	*21*
Training/Experience	*0*	*0*	*9*	*46*
Uncertainty	*0*	*14*	*33*	*8*
Will/Motivation	*0*	*3*	*16*	*36*

Table 30. SURVEY I RESULTS - ARMY NON-COMBAT ARMS

HUMAN FACTOR	Very Unimportant	Not Important	Important	Very Important
Cognitive Factor	*0*	*7*	*35*	*4*
Cohesion	*0*	*1*	*12*	*33*
Combat Experience	*0*	*9*	*26*	*11*
Comradeship	*0*	*7*	*32*	*7*
Confinement	*2*	*32*	*10*	*2*
Cowardliness	*2*	*8*	*25*	*11*
Discipline	*0*	*0*	*10*	*36*
Emotion	*0*	*9*	*26*	*11*
Energy	*0*	*2*	*18*	*26*
Fear	*0*	*14*	*27*	*5*
Honor	*0*	*3*	*28*	*15*
Initiative	*0*	*0*	*9*	*37*
Intuition	*0*	*6*	*23*	*17*
Isolation	*1*	*18*	*18*	*9*
Jet Lag	*3*	*21*	*20*	*2*
Leadership	*0*	*0*	*3*	*43*
Mental Fatigue	*1*	*3*	*21*	*21*
Morale	*0*	*0*	*20*	*26*
National Characteristics	*4*	*16*	*24*	*2*
Physical Fatigue	*0*	*1*	*25*	*20*
Sleep Loss	*0*	*2*	*24*	*20*
Social Motivation	*1*	*5*	*25*	*15*
Stress	*0*	*1*	*28*	*17*
Surprise	*0*	*4*	*24*	*18*
Training/Experience	*0*	*0*	*10*	*36*
Uncertainty	*0*	*9*	*35*	*2*
Will/Motivation	*0*	*1*	*13*	*32*

Table 31. SURVEY I RESULTS - AIR FORCE

HUMAN FACTOR	Very Unimportant	Not Important	Important	Very Important
Cognitive Factor	*0*	*3*	*22*	*7*
Cohesion	*0*	*0*	*5*	*27*
Combat Experience	*0*	*2*	*20*	*10*
Comradeship	*0*	*6*	*19*	*7*
Confinement	*2*	*14*	*14*	*2*
Cowardliness	*1*	*7*	*18*	*6*
Discipline	*0*	*0*	*11*	*21*
Emotion	*0*	*4*	*19*	*9*
Energy	*0*	*1*	*11*	*20*
Fear	*0*	*11*	*18*	*3*
Honor	*0*	*8*	*13*	*11*
Initiative	*0*	*2*	*6*	*24*
Intuition	*0*	*5*	*12*	*15*
Isolation	*0*	*9*	*20*	*3*
Jet Lag	*1*	*11*	*17*	*3*
Leadership	*0*	*1*	*6*	*25*
Mental Fatigue	*0*	*0*	*18*	*14*
Morale	*0*	*0*	*10*	*22*
National Characteristics	*0*	*15*	*15*	*2*
Physical Fatigue	*0*	*1*	*21*	*10*
Sleep Loss	*0*	*2*	*23*	*7*
Social Motivation	*0*	*6*	*16*	*10*
Stress	*0*	*3*	*21*	*8*
Surprise	*0*	*1*	*18*	*13*
Training/Experience	*0*	*0*	*12*	*20*
Uncertainty	*0*	*9*	*18*	*5*
Will/Motivation	*0*	*0*	*7*	*25*

Table 32. SURVEY I RESULTS - MARINE CORPS

HUMAN FACTOR	Very Unimportant	Not Important	Important	Very Important
Cognitive Factor	*1*	*18*	*36*	*6*
Cohesion	*0*	*0*	*16*	*45*
Combat Experience	*1*	*10*	*29*	*21*
Comradeship	*1*	*20*	*25*	*15*
Confinement	*7*	*33*	*17*	*4*
Cowardliness	*4*	*16*	*25*	*16*
Discipline	*0*	*0*	*12*	*49*
Emotion	*2*	*12*	*31*	*16*
Energy	*0*	*3*	*20*	*38*
Fear	*2*	*13*	*31*	*15*
Honor	*1*	*13*	*31*	*16*
Initiative	*0*	*0*	*11*	*50*
Intuition	*1*	*1*	*22*	*37*
Isolation	*4*	*24*	*25*	*8*
Jet Lag	*4*	*35*	*19*	*3*
Leadership	*0*	*1*	*7*	*53*
Mental Fatigue	*0*	*1*	*32*	*28*
Morale	*0*	*0*	*19*	*42*
National Characteristics	*3*	*25*	*28*	*5*
Physical Fatigue	*0*	*1*	*36*	*24*
Sleep Loss	*0*	*4*	*40*	*17*
Social Motivation	*1*	*18*	*32*	*10*
Stress	*0*	*2*	*41*	*18*
Surprise	*0*	*1*	*33*	*27*
Training/Experience	*0*	*1*	*11*	*49*
Uncertainty	*1*	*12*	*37*	*11*
Will/Motivation	*2*	*2*	*11*	*46*

Table 33. SURVEY I RESULTS - NAVY

HUMAN FACTOR	Very Unimportant	Not Important	Important	Very Important
Cognitive Factor	5	7	39	12
Cohesion	1	1	17	44
Combat Experience	1	12	30	20
Comradeship	2	14	38	9
Confinement	11	28	21	3
Cowardliness	8	13	27	15
Discipline	0	3	12	48
Emotion	1	9	38	15
Energy	0	2	27	34
Fear	3	18	35	7
Honor	0	10	30	23
Initiative	0	0	13	50
Intuition	1	5	23	34
Isolation	5	23	27	8
Jet Lag	7	31	21	4
Leadership	0	0	9	54
Mental Fatigue	2	2	38	21
Morale	0	1	20	42
National Characteristics	4	23	25	11
Physical Fatigue	1	2	37	23
Sleep Loss	1	3	46	13
Social Motivation	4	15	26	18
Stress	1	6	37	19
Surprise	1	9	33	20
Training/Experience	0	1	25	37
Uncertainty	0	20	37	6
Will/Motivation	0	1	19	43

2. Refined Frequency Results

A walk-through is initially presented which shows the steps taken in attaining scaled values for the Army Total respondent category. This is depicted in the tables which follow, showing a logical progression of steps taken to obtain values on a common scale. Most of this data is the resultant output after using the categorical judgments APL programs. Following the computations, scaled data, transformed data, and rankings for all services are listed. The last table shows an overall Interservice Rank Comparison of the human factors from Survey I.

Table 34. RELATIVE FREQUENCIES - ARMY TOTAL

HUMAN FACTOR	Very Unimportant	Not Important	Important	Very Important
Cognitive Factor	*0.009*	*0.221*	*0.670*	*0.100*
Cohesion	*0*	*0.009*	*0.277*	*0.714*
Combat Experience	*0.009*	*0.191*	*0.510*	*0.288*
Comradeship	*0.009*	*0.161*	*0.620*	*0.208*
Confinement	*0.089*	*0.663*	*0.198*	*0.050*
Cowardliness	*0.030*	*0.257*	*0.515*	*0.198*
Discipline	*0.009*	*0*	*0.208*	*0.783*
Emotion	*0.009*	*0.181*	*0.620*	*0.188*
Energy	*0*	*0.020*	*0.435*	*0.544*
Fear	*0.020*	*0.218*	*0.644*	*0.118*
Honor	*0.020*	*0.168*	*0.545*	*0.267*
Initiative	*0*	*0*	*0.208*	*0.792*
Intuition	*0*	*0.139*	*0.505*	*0.356*
Isolation	*0.009*	*0.361*	*0.450*	*0.179*
Jet Lag	*0.069*	*0.475*	*0.426*	*0.030*
Leadership	*0*	*0*	*0.059*	*0.941*
Mental Fatigue	*0.009*	*0.030*	*0.436*	*0.525*
Morale	*0*	*0*	*0.347*	*0.653*
National Characteristics	*0.059*	*0.416*	*0.455*	*0.070*
Physical Fatigue	*0*	*0.009*	*0.564*	*0.427*
Sleep Loss	*0*	*0.030*	*0.485*	*0.485*
Social Motivation	*0.050*	*0.218*	*0.505*	*0.227*
Stress	*0*	*0.020*	*0.633*	*0.346*
Surprise	*0*	*0.100*	*0.514*	*0.385*
Training/Experience	*0*	*0*	*0.188*	*0.812*
Uncertainty	*0*	*0.228*	*0.673*	*0.099*
Will/Motivation	*0*	*0.040*	*0.287*	*0.673*

Table 35. CUMULATIVE FREQUENCIES - ARMY TOTAL

HUMAN FACTOR	Very Unimportant	Not Important	Important	Very Important
Cognitive Factor	*0.009*	*0.230*	*0.900*	*1*
Cohesion	*0*	*0.009*	*0.286*	*1*
Combat Experience	*0.009*	*0.200*	*0.710*	*1*
Comradeship	*0.009*	*0.170*	*0.790*	*1*
Confinement	*0.089*	*0.752*	*0.950*	*1*
Cowardliness	*0.030*	*0.287*	*0.802*	*1*
Discipline	*0.009*	*0.009*	*0.217*	*1*
Emotion	*0.009*	*0.190*	*0.810*	*1*
Energy	*0*	*0.020*	*0.455*	*1*
Fear	*0.020*	*0.238*	*0.882*	*1*
Honor	*0.020*	*0.188*	*0.733*	*1*
Initiative	*0*	*0*	*0.208*	*1*
Intuition	*0*	*0.139*	*0.644*	*1*
Isolation	*0.009*	*0.370*	*0.820*	*1*
Jet Lag	*0.069*	*0.544*	*0.970*	*1*
Leadership	*0*	*0*	*0.059*	*1*
Mental Fatigue	*0.009*	*0.030*	*0.470*	*1*
Morale	*0*	*0*	*0.347*	*1*
National Characteristics	*0.059*	*0.475*	*0.930*	*1*
Physical Fatigue	*0*	*0.009*	*0.573*	*1*
Sleep Loss	*0*	*0.030*	*0.515*	*1*
Social Motivation	*0.050*	*0.268*	*0.773*	*1*
Stress	*0*	*0.020*	*0.653*	*1*
Surprise	*0*	*0.100*	*0.614*	*1*
Training/Experience	*0*	*0*	*0.188*	*1*
Uncertainty	*0*	*0.228*	*0.901*	*1*
Will/Motivation	*0*	*0.040*	*0.327*	*1*

Table 36. REMOVE P_{ij} > 0.98 AND P_{ij} < 0.02 - SCALE 1

HUMAN FACTOR	Very Unimportant	Not Important	Important
Confinement	*0.089*	*0.752*	*0.950*
Cowardliness	*0.030*	*0.287*	*0.802*
Fear	*0.020*	*0.238*	*0.882*
Honor	*0.020*	*0.188*	*0.733*
Jet Lag	*0.069*	*0.544*	*0.970*
National Characteristics	*0.059*	*0.475*	*0.930*
Social Motivation	*0.050*	*0.268*	*0.773*

Table 37. REMOVE P_{ij} > 0.98 AND P_{ij} < 0.02 - SCALE 2

HUMAN FACTOR	Not Important	Important
Cognitive Factor	*0.230*	*0.900*
Combat Experience	*0.200*	*0.710*
Comradeship	*0.170*	*0.790*
Emotion	*0.190*	*0.810*
Energy	*0.020*	*0.455*
Intuition	*0.139*	*0.644*
Isolation	*0.370*	*0.820*
Mental Fatigue	*0.030*	*0.470*
Sleep Loss	*0.030*	*0.515*
Stress	*0.020*	*0.653*
Surprise	*0.100*	*0.614*
Uncertainty	*0.228*	*0.901*
Will/Motivation	*0.040*	*0.327*

Table 38. REMOVE $P_{ij} > 0.98$ AND $P_{ij} < 0.02$ - SCALE 3

HUMAN FACTOR	Important
Cohesion	*0.286*
Discipline	*0.217*
Initiative	*0.208*
Leadership	*0.059*
Morale	*0.347*
Physical Fatigue	*0.573*
Training/Experience	*0.188*

Table 39. NORMALIZE - SCALE 1

HUMAN FACTOR	Very Unimportant	Not Important	Important
Confinement	*-1.346*	*0.682*	*1.650*
Cowardliness	*-1.886*	*-0.561*	*0.849*
Fear	*-2.058*	*-0.714*	*1.181*
Honor	*-2.058*	*-0.885*	*0.621*
Jet Lag	*-1.481*	*0.112*	*1.886*
National Characteristics	*-1.560*	*-0.062*	*1.481*
Social Motivation	*-1.650*	*-0.621*	*0.746*

Table 40. NORMALIZE - SCALE 2

HUMAN FACTOR	Not Important	Important
Cognitive Factor	*-0.738*	*1.282*
Combat Experience	*-0.841*	*0.553*
Comradeship	*-0.954*	*0.806*
Emotion	*-0.878*	*0.878*
Energy	*-2.058*	*-0.112*
Intuition	*-1.087*	*0.368*
Isolation	*-0.331*	*0.915*
Mental Fatigue	*-1.881*	*-0.075*
Sleep Loss	*-1.886*	*0.037*
Stress	*-2.058*	*0.394*
Surprise	*-1.287*	*0.289*
Uncertainty	*-0.746*	*1.287*
Will/Motivation	*-1.756*	*-0.449*

Table 41. NORMALIZE - SCALE 3

HUMAN FACTOR	Important
Cohesion	*-0.561*
Discipline	*-0.779*
Initiative	*-0.815*
Leadership	*-1.560*
Morale	*-0.400*
Physical Fatigue	*0.187*
Training/Experience	*-0.865*

Table 42. GRAND AVERAGE - SCALE 1

HUMAN FACTOR	Very Unimportant	Not Important	Important	Row Total	Row Average ($\bar{z}_i$)
Confinement	*-1.346*	*0.682*	*1.650*	*0.986*	*0.329*
Cowardliness	*-1.886*	*-0.561*	*0.849*	*-1.599*	*-0.533*
Fear	*-2.058*	*-0.714*	*1.181*	*-1.590*	*-0.530*
Honor	*-2.058*	*-0.885*	*0.621*	*-2.322*	*-0.774*
Jet Lag	*-1.481*	*0.112*	*1.886*	*0.517*	*0.172*
National Characteristics	*-1.560*	*-0.062*	*1.481*	*-0.141*	*-0.047*
Social Motivation	*-1.650*	*-0.621*	*0.746*	*-1.525*	*-0.508*
Column Totals	*-12.039*	*-2.049*	*8.414*	*Grand Average:* $\bar{b} = -0.270$	
Column Averages: b_j	*-1.720*	*-0.293*	*1.202*		

Table 43. GRAND AVERAGE - SCALE 2

HUMAN FACTOR	Not Important	Important	Row Total	Row Average ($\bar{z}_i$)
Cognitive Factor	*-0.738*	*1.282*	*0.544*	*0.272*
Combat Experience	*-0.841*	*0.553*	*-0.288*	*-0.144*
Comradeship	*-0.954*	*0.806*	*-0.148*	*-0.074*
Emotion	*-0.878*	*0.878*	*0*	*0*
Energy	*-2.058*	*-0.112*	*-2.170*	*-1.085*
Intuition	*-1.087*	*0.368*	*-0.719*	*-0.359*
Isolation	*-0.331*	*0.915*	*0.584*	*0.292*
Mental Fatigue	*-1.881*	*-0.075*	*-1.956*	*-0.978*
Sleep Loss	*-1.886*	*0.037*	*-1.849*	*-0.924*
Stress	*-2.058*	*0.394*	*-1.664*	*-0.832*
Surprise	*-1.287*	*0.289*	*-0.998*	*-0.499*
Uncertainty	*-0.746*	*1.287*	*0.541*	*0.271*
Will/Motivation	*-1.756*	*-0.449*	*-2.205*	*-1.102*
Column Totals	*-16.501*	*6.173*	*Grand Average:* $\bar{b}$ = *-0.397*	
Column Averages: b_j	*-1.269*	*0.475*		

Table 44. GRAND AVERAGE - SCALE 3

HUMAN FACTOR	Important	Row Total	Row Average ($\bar{z}_i$)
Cohesion	*-0.561*	*-0.561*	*-0.561*
Discipline	*-0.779*	*-0.779*	*-0.779*
Initiative	*-0.815*	*-0.815*	*-0.815*
Leadership	*-1.560*	*-1.560*	*-1.560*
Morale	*-0.400*	*-0.400*	*-0.400*
Physical Fatigue	*0.187*	*0.187*	*0.187*
Training/Experience	*-0.885*	*-0.885*	*-0.885*
Column Totals	*-4.813*	*Grand Average:* $\bar{b} = -0.688$	
Column Averages: b_j	*-0.688*		

Table 45. UPPER BOUNDS - COLUMN AVERAGES

	Very Unimportant	Not Important	Important
Scale 1	*-1.720*	*-0.293*	*1.202*
Scale 2	*NA*	*-1.269*	*0.475*
Scale 3	*NA*	*NA*	*-0.688*

The sum of squares for the column differences are computed using the following general equation:

$$B = \sum_{j=1}^{m-k} (b_j - \bar{b})^2.$$

For Scales 1 and 2, the sum of the squares for column differences are:

$$\begin{aligned} B(Scale\ 1) &= \sum_{j=1}^{m-k} (b_j - \bar{b})^2 \\ &= (-1.720 - (-0.270))^2 + (-0.293 - (-0.270))^2 \\ &\quad + (1.202 - (-0.270))^2 \\ &= \mathbf{4.269} \end{aligned}$$

$$\begin{aligned} B(Scale\ 2) &= \sum_{j=1}^{m-k} (b_j - \bar{b})^2 \\ &= (-1.269 - (-0.397))^2 + (0.475 - (-0.397))^2 \\ &= \mathbf{1.521} \end{aligned}$$

Table 46. SUM OF SQUARE DIFFERENCES - SCALE 1

	$A_{ij} = (z_{ij} - \bar{z}_j)^2$			$A_i = \sum A_{ij}$
HUMAN FACTOR	Very Unimportant	Not Important	Important	
Confinement	*2.805*	*0.125*	*1.745*	*4.675*
Cowardliness	*1.831*	*0.001*	*1.909*	*3.741*
Fear	*2.335*	*0.034*	*2.927*	*5.296*
Honor	*1.648*	*0.013*	*1.946*	*3.607*
Jet Lag	*2.733*	*0.003*	*2.937*	*5.673*
National Characteristics	*2.289*	*0.001*	*2.334*	*4.624*
Social Motivation	*1.304*	*0.013*	*1.572*	*2.889*

Table 47. SUM OF SQUARE DIFFERENCES - SCALE 2

$A_{ij} = (z_{ij} - \bar{z}_j)^2$			$A_i = \sum A_{ij}$
HUMAN FACTOR	Not Important	Important	
Combat Experience	*1.02*	*1.02*	*2.02*
Cognitive Factor	*0.485*	*0.485*	*0.970*
Comradeship	*0.774*	*0.774*	*1.548*
Emotion	*0.770*	*0.770*	*1.540*
Energy	*0.946*	*0.946*	*1.892*
Intuition	*0.529*	*0.529*	*1.058*
Isolation	*0.388*	*0.388*	*0.776*
Mental Fatigue	*0.815*	*0.815*	*1.630*
Sleep Loss	*0.925*	*0.925*	*1.850*
Stress	*1.503*	*1.503*	*3.006*
Surprise	*0.621*	*0.621*	*1.242*
Uncertainty	*1.032*	*1.032*	*2.064*
Will/Motivation	*0.427*	*0.427*	*0.854*

Table 48. SCALED VALUES - SCALE 1

HUMAN FACTOR	$\bar{b} - \bar{z}_N\sqrt{B/A_i}$	S_i
Confinement	$-0.270 - (0.329\sqrt{4.269/4.675})$	*-0.584*
Cowardliness	$-0.270 - (-0.533\sqrt{4.269/3.741})$	*0.299*
Fear	$-0.270 - (-0.530\sqrt{4.269/5.296})$	*0.206*
Honor	$-0.270 - (-0.774\sqrt{4.269/3.607})$	*0.572*
Jet Lag	$-0.270 - (0.172\sqrt{4.269/5.673})$	*-0.419*
National Characteristics	$-0.270 - (-0.047\sqrt{4.269/4.624})$	*-0.225*
Social Motivation	$-0.270 - (-0.508\sqrt{4.269/2.889})$	*0.347*

Table 49. SCALED VALUES - SCALE 2

HUMAN FACTOR	$\bar{b} - \bar{z}_N\sqrt{B/A_i}$	S_i
Combat Experience	$-0.397 - (-0.272\sqrt{1.521/2.020})$	*-0.632*
Cognitive Factor	$-0.397 - (-0.144\sqrt{1.521/0.970})$	*-0.217*
Comr: leship	$-0.397 - (-0.074\sqrt{1.521/1.548})$	*-0.324*
Emotion	$-0.397 - (0\sqrt{1.521/1.540})$	*-0.397*
Energy	$-0.397 - (-1.085\sqrt{1.521/1.892})$	*0.575*
Intuition	$-0.397 - (-0.359\sqrt{1.521/1.058})$	*0.0337*
Isolation	$-0.397 - (-0.292\sqrt{1.521/0.776})$	*-0.806*
Mental Fatigue	$-0.397 - (-0.978\sqrt{1.521/1.630})$	*0.547*
Sleep Loss	$-0.397 - (-0.924\sqrt{1.521/1.850})$	*0.441*
Stress	$-0.397 - (-0.832\sqrt{1.521/3.006})$	*0.1953*
Surprise	$-0.397 - (-0.499\sqrt{1.521/1.242})$	*0.1556*
Uncertainty	$-0.397 - (0.270\sqrt{1.521/2.064})$	*-0.629*
Will/Motivation	$-0.397 - (-1.102\sqrt{1.521/0.854})$	*1.073*

Table 50. SCALED VALUES - SCALE 3

HUMAN FACTOR	$\bar{b} - \bar{z}_i$	S_i
Cohesion	*-0.688 – (-0.561)*	*-0.127*
Discipline	*-0.688 –(-0.779)*	*0.091*
Initiative	*-0.688 – (-0.815)*	*0.127*
Leadership	*-0.688 – (-1 560)*	*0.872*
Morale	*-0.688 – (-0.400)*	*-0.288*
Physical Fatigue	*-0.688 – (0.187)*	*-0.875*
Training/Experience	*-0.688 – (-0.885)*	*0.197*

The final product of this outlined procedure are the scaled values of the instances which are on the same interval scale as the category bounds, b_j. With this scale established, a linear transformation may be performed using the general formula:

$$y = \alpha + \beta x, \beta > 0$$

which will adjust the scale as desired. By establishing this linear transformation equation and letting x represent the raw or scaled data and y represent the transformed data, the level of magnitude for each factor can be determined.

The simultaneous equations for Scale 1 are:

$$100 = \alpha + \beta(1.202)$$

$$0 = \alpha + \beta(-1.720)$$

and transformed values are given in Table 51.

Table 51. TRANSFORMED DATA - SCALE 1

HUMAN FACTOR	x Value	y Value
Confinement	*-0.584*	*39.172*
Cowardliness	*0.299*	*69.621*
Fear	*0.206*	*66.414*
Honor	*0.572*	*79.034*
Jet Lag	*-0.419*	*44.862*
National Characteristics	*-0.225*	*51.552*
Social Motivation	*0.347*	*71.276*
Upper Bound	1.202	100
Middle Bound	-0.293	49.207
Lower Bound	-1.720	0

The simultaneous equations for Scale 2 are:

$$100 = \alpha + \beta(0.475)$$

$$49.207 = \alpha + \beta(-1.269)$$

and transformed values are given in Table 52.

Table 52. TRANSFORMED DATA - SCALE 2

HUMAN FACTOR	x Value	y Value
Cognitive Factor	*-0.632*	*67.441*
Combat Experience	*-0.217*	*79.647*
Comradeship	*-0.324*	*76.500*
Emotion	*-0.397*	*74.353*
Energy	*0.575*	*102.941*
Intuition	*0.033*	*87.029*
Isolation	*-0.806*	*62.323*
Mental Fatigue	*0.547*	*102.118*
Sleep Loss	*0.441*	*99.000*
Stress	*0.195*	*91.745*
Surprise	*0.155*	*90.588*
Uncertainty	*-0.629*	*67.529*
Will/Motivation	*1.073*	*117.580*
Upper Bound	**0.475**	**100**
Lower Bound	**-1.269**	**49.207**

Table 53 represents the values determined using the regression technique on the Special Transformation Case. The third point used in the technique came from Scale 2.

Table 53. TRANSFORMED DATA - SCALE 3

HUMAN FACTOR	x Value	y Value
Cohesion	*-0.127*	*158.920*
Discipline	*0.091*	*181.740*
Initiative	*0.1270*	*182.240*
Leadership	*0.872*	*256.160*
Morale	*-0.288*	*141.000*
Physical Fatigue	*-0.875*	*84.010*
Training/Experience	*0.197*	*189.180*
Upper Bound	-0.688	100
Rescaled Value	-0.550	117.588
Lower Bound	-1.720	0

The transformed data along with the ranking of each of the human factors are shown in the following tables. One can see how the categorical judgment technique obtains a numerical value and, as a result, a ranking structure for each factor. It should be noted here that the rankings and transformed values of the factors used are *relative* to the other factors.

Table 54. TRANSFORMED DATA - ARMY TOTAL

HUMAN FACTOR	Scaled Data	Transformed Data	Ranking
Cognitive Factor	*-0.632*	*67.441*	*22*
Cohesion	*-0.127*	*158.920*	*5*
Combat Experience	*-0.217*	*79.647*	*15*
Comradeship	*-0.324*	*76.500*	*17*
Confinement	*-0.584*	*39.172*	*27*
Cowardliness	*0.299*	*69.621*	*20*
Discipline	*0.091*	*181.740*	*4*
Emotion	*-0.397*	*74.353*	*18*
Energy	*0.575*	*102.941*	*8*
Fear	*0.206*	*66.414*	*23*
Honor	*0.572*	*79.034*	*16*
Initiative	*0.127*	*182.240*	*3*
Intuition	*0.033*	*87.029*	*13*
Isolation	*-0.806*	*62.323*	*24*
Jet Lag	*-0.419*	*44.862*	*26*
Leadership	*0.872*	*256.160*	*1*
Mental Fatigue	*0.547*	*102.118*	*9*
Morale	*-0.288*	*141.000*	*6*
National Characteristics	*-0.225*	*51.552*	*25*
Physical Fatigue	*-0.875*	*84.010*	*14*
Sleep Loss	*0.441*	*99.000*	*10*
Social Motivation	*0.347*	*71.276*	*19*
Stress	*0.195*	*91.745*	*11*
Surprise	*0.155*	*90.588*	*12*
Training/Experience	*0.197*	*189.180*	*2*
Uncertainty	*-0.629*	*67.529*	*21*
Will/Motivation	*1.073*	*117.580*	*7*

Table 55. TRANSFORMED DATA - ARMY COMBAT ARMS

HUMAN FACTOR	Scaled Data	Transformed Data	Ranking
Cognitive Factor	*-0.082*	*62.532*	*22*
Cohesion	*-0.023*	*141.435*	*6*
Combat Experience	*0.427*	*80.721*	*15*
Comradeship	*0.307*	*76.414*	*16*
Confinement	*-0.858*	*34.821*	*27*
Cowardliness	*-0.006*	*65.264*	*21*
Discipline	*2.589*	*157.939*	*4*
Emotion	*0.089*	*68.650*	*19*
Energy	*-0.503*	*104.067*	*9*
Fear	*0.021*	*66.221*	*20*
Honor	*0.105*	*69.204*	*17*
Initiative	*0.207*	*159.341*	*3*
Intuition	*-0.075*	*90.116*	*12*
Isolation	*-0.817*	*62.088*	*23*
Jet Lag	*-0.673*	*41.414*	*26*
Leadership	*1.027*	*223.179*	*1*
Mental Fatigue	*-0.368*	*114.577*	*8*
Morale	*-0.515*	*145.717*	*5*
National Characteristics	*-0.334*	*53.529*	*25*
Physical Fatigue	*-0.779*	*82.580*	*14*
Sleep Loss	*0.445*	*101.755*	*10*
Social Motivation	*-0.204*	*58.182*	*24*
Stress	*0.090*	*90.594*	*11*
Surprise	*0.056*	*89.525*	*13*
Training/Experience	*0.407*	*174.911*	*2*
Uncertainty	*-0.654*	*67.201*	*18*
Will/Motivation	*0.946*	*117.497*	*7*

Table 56. TRANSFORMED DATA - ARMY NON-COMBAT ARMS

HUMAN FACTOR	Scaled Data	Transformed Data	Ranking
Cognitive Factor	*-0.577*	*70.356*	*20*
Cohesion	*1.220*	*120.684*	*4*
Combat Experience	*-0.359*	*76.448*	*16*
Comradeship	*-0.447*	*73.983*	*18*
Confinement	*-0.554*	*43.250*	*26*
Cowardliness	*0.229*	*73.725*	*19*
Discipline	*-0.039*	*188.810*	*3*
Emotion	*-0.359*	*76.445*	*17*
Energy	*0.678*	*105.496*	*7*
Fear	*-0.831*	*63.221*	*23*
Honor	*0.055*	*88.059*	*14*
Initiative	*0.041*	*197.912*	*2*
Intuition	*0.057*	*88.118*	*13*
Isolation	*0.061*	*65.211*	*22*
Jet Lag	*-0.457*	*46.725*	*25*
Leadership	*0.691*	*271.864*	*1*
Mental Fatigue	*1.019*	*99.432*	*8*
Morale	*-0.654*	*118.840*	*6*
National Characteristics	*-0.440*	*47.321*	*24*
Physical Fatigue	*0.342*	*96.087*	*10*
Sleep Loss	*0.319*	*95.445*	*9*
Social Motivation	*0.623*	*85.293*	*15*
Stress	*0.219*	*92.636*	*11*
Surprise	*0.168*	*91.227*	*12*
Training/Experience	*-0.039*	*188.810*	*3*
Uncertainty	*-0.756*	*65.328*	*21*
Will/Motivation	*1.111*	*117.636*	*5*

Table 57. TRANSFORMED DATA - AIR FORCE

HUMAN FACTOR	Scaled Data	Transformed Data	Ranking
Cognitive Factor	*-0.110*	*80.519*	*18*
Cohesion	*0.536*	*175.630*	*1*
Combat Experience	*0.106*	*87.315*	*12*
Comradeship	*-0.271*	*75.465*	*20*
Confinement	*-0.279*	*49.143*	*27*
Cowardliness	*0.319*	*69.097*	*21*
Discipline	*-0.071*	*129.140*	*6*
Emotion	*-0.050*	*82.409*	*14*
Energy	*0.854*	*110.852*	*8*
Fear	*-0.772*	*59.698*	*24*
Honor	*-0.115*	*80.371*	*19*
Initiative	*1.821*	*141.248*	*3*
Intuition	*0.389*	*96.236*	*9*
Isolation	*-0.653*	*63.459*	*23*
Jet Lag	*-0.008*	*58.190*	*25*
Leadership	*1.705*	*137.588*	*4*
Mental Fatigue	*-0.631*	*86.260*	*13*
Morale	*-0.016*	*133.350*	*5*
National Characteristics	*-1.082*	*49.959*	*26*
Physical Fatigue	*0.162*	*89.091*	*11*
Sleep Loss	*-0.052*	*82.346*	*15*
Social Motivation	*-0.084*	*81.337*	*17*
Stress	*-0.056*	*82.214*	*16*
Surprise	*0.321*	*94.085*	*10*
Training/Experience	*-0.154*	*122.790*	*7*
Uncertainty	*-0.554*	*66.572*	*22*
Will/Motivation	*0.302*	*157.710*	*2*

Table 58. TRANSFORMED DATA - MARINE CORPS

HUMAN FACTOR	Scaled Data	Transformed Data	Ranking
Cognitive Factor	*-0.209*	*62.658*	*23*
Cohesion	*-0.084*	*155.629*	*5*
Combat Experience	*0.365*	*84.483*	*15*
Comradeship	*0.019*	*71.312*	*20*
Confinement	*-0.778*	*41.011*	*27*
Cowardliness	*-0.012*	*70.164*	*21*
Discipline	*0.134*	*174.822*	*2*
Emotion	*0.136*	*75.795*	*17*
Energy	*0.358*	*111.875*	*9*
Fear	*0.087*	*73.916*	*18*
Honor	*0.158*	*76.608*	*16*
Initiative	*0.193*	*180.017*	*1*
Intuition	*1.305*	*120.232*	*8*
Isolation	*-0.387*	*55.894*	*24*
Jet Lag	*-0.688*	*44.437*	*26*
Leadership	*1.997*	*156.297*	*4*
Mental Fatigue	*-0.167*	*97.653*	*10*
Morale	*-0.230*	*142.774*	*6*
National Characteristics	*-0.446*	*53.654*	*25*
Physical Fatigue	*-0.292*	*94.274*	*12*
Sleep Loss	*-0.606*	*85.745*	*14*
Social Motivation	*-0.087*	*67.304*	*22*
Stress	*-0.506*	*88.474*	*13*
Surprise	*-0.199*	*96.772*	*11*
Training/Experience	*1.170*	*133.982*	*7*
Uncertainty	*0.028*	*71.662*	*19*
Will/Motivation	*2.427*	*162.894*	*3*

Table 59. TRANSFORMED DATA - NAVY

HUMAN FACTOR	Scaled Data	Transformed Data	Ranking
Cognitive Factor	*-0.129*	*65.911*	*19*
Cohesion	*1.551*	*133.629*	*4*
Combat Experience	*0.172*	*78.044*	*15*
Comradeship	*-0.207*	*62.682*	*20*
Confinement	*-0.951*	*32.754*	*27*
Cowardliness	*-0.237*	*61.540*	*21*
Discipline	*1.147*	*145.803*	*3*
Emotion	*0.085*	*74.536*	*17*
Energy	*0.049*	*103.456*	*9*
Fear	*-0.367*	*56.282*	*23*
Honor	*-0.449*	*84.197*	*12*
Initiative	*-0.125*	*201.820*	*2*
Intuition	*0.819*	*104.129*	*8*
Isolation	*-0.486*	*51.484*	*25*
Jet Lag	*-0.792*	*39.177*	*26*
Leadership	*0.125*	*233.700*	*1*
Mental Fatigue	*0.376*	*86.238*	*11*
Morale	*0.359*	*115.394*	*6*
National Characteristics	*-0.359*	*56.597*	*22*
Physical Fatigue	*0.474*	*90.214*	*10*
Sleep Loss	*0.141*	*76.766*	*16*
Social Motivation	*-0.030*	*69.875*	*18*
Stress	*0.257*	*81.456*	*13*
Surprise	*0.228*	*80.270*	*14*
Training/Experience	*0.142*	*107.004*	*7*
Uncertainty	*-1.211*	*54.788*	*24*
Will/Motivation	*0.411*	*117.421*	*5*

Table 60. SURVEY I RESULTS - INTERSERVICE RANK COMPARISON

HUMAN FACTOR	Army			Air Force	Navy	Marine Corps
	Total	Combat Arms	Non-Combat Arms			
Leadership	1	1	1	4	1	4
Training/Experience	2	2	3.5	7	7	7
Initiative	3	3	2	3	2	1
Discipline	4	4	3.5	6	3	2
Cohesion	5	6	5	1	4	5
Morale	6	5	7	5	6	6
Will/Motivation	7	7	6	2	5	3
Energy	8	9	8	8	9	9
Mental Fatigue	9	8	9	13	11	10
Sleep Loss	10	10	10	15	16	14
Stress	11	11	12	16	13	13
Surprise	12	13	13	10	14	11
Intuition	13	12	14	9	8	8
Physical Fatigue	14	14	11	11	10	12
Combat Experience	15	15	17	12	15	15
Honor	16	17	15	19	12	16
Comradeship	17	16	19	20	20	20
Emotion	18	19	18	14	17	17
Social Motivation	19	24	16	17	18	22
Cowardliness	20	21	20	21	21	21
Uncertainty	21	18	22	22	24	19
Cognitive Factor	22	22	21	18	19	23
Fear	23	20	24	24	23	18
Isolation	24	23	23	23	25	24
National Characteristics	25	25	25	26	22	25
Jet Lag	26	26	26	25	26	26
Confinement	27	27	27	27	27	27

B. RESULTS - SURVEY II

This appendix contains the data obtained from Survey II. The sample population has been grouped as follows:

- Infantry Version (Cases 1-4)
  1. Total Respondents
  2. Infantry Respondents
  3. Non-Infantry Respondents

- Artillery Version (Cases 1-4)
  1. Total Respondents
  2. Artillery Respondents
  3. Non-Artillery Respondents

The data collected will be shown for each group first as raw data. From the raw data, the categorical judgement method was employed to derive scaled values from each group. Next the actual ranking of the factors for each case and group will be illustrated.

Table 61. SURVEY II - OVERHEAD - INFANTRY VERSION

RESPONDENT GROUP	Number Distributed	Number Returned	Percent Returned	Average Time in Service	Range of Time in Service
Total	*65*	*42*	*65*	*9 years, 2 months*	*5 years 4 months to 13 years, 11 months*
Infantry	*22*	*15*	*68*	*9 years, 1 months*	*6 years 11 months to 12 years, 11 months*
Non-Infantry	*43*	*27*	*63*	*9 years, 5 months*	*5 years 4 months to 13 years, 11 months*

Table 62. SURVEY II - OVERHEAD - ARTILLERY VERSION

RESPONDENT GROUP	Number Distributed	Number Returned	Percent Returned	Average Time in Service	Range of Time in Service
Total	*65*	*34*	*52*	*9 years, 5 months*	*6 years 0 months to 17 years, 0 months*
Artillery	*17*	*10*	*59*	*9 years, 7 months*	*7 years 10 months to 12 years, 0 months*
Non-Artillery	*48*	*24*	*50*	*9 years, 5 months*	*6 years 0 months to 17 years, 0 months*

1. Infantry Version Results

On the following pages are the raw and refined results for the Infantry Version of Survey II. Raw frequency results for Total, Infantry, and Non-Infantry respondents are shown in Tables 63, 64, and 65, respectively. This is followed by tables depicting the scaled values and rank orders on a case-by-case basis.

Table 63. SURVEY II RESULTS - INFANTRY VERSION (TOTAL)

Case	HUMAN FACTOR	Very Unimportant	Unimportant	Neutral	Important	Very Important
1	*Cohesion*	0	1	3	30	8
	Discipline	0	0	3	21	18
	Initiative	0	1	4	18	9
	Leadership	0	0	1	5	36
	Morale	0	0	8	30	4
	Training/Experience	0	0	3	18	21
	Will/Motivation	0	0	7	16	19
2	*Cohesion*	2	1	8	22	9
	Discipline	1	1	5	14	21
	Initiative	0	1	7	16	18
	Leadership	0	1	1	7	33
	Morale	2	3	10	21	6
	Training/Experience	0	1	1	14	26
	Will/Motivation	1	2	6	16	16
3	*Cohesion*	4	2	14	18	4
	Discipline	2	0	1	9	30
	Initiative	4	3	10	14	11
	Leadership	1	0	3	12	26
	Morale	2	3	11	13	13
	Training/Experience	1	0	1	8	32
	Will/Motivation	1	3	12	12	14
4	*Cohesion*	0	1	9	21	11
	Discipline	0	0	5	14	23
	Initiative	0	3	9	11	19
	Leadership	0	0	2	3	37
	Morale	0	1	5	19	17
	Training/Experience	0	1	3	14	24
	Will/Motivation	0	2	7	17	16

Table 64. SURVEY II RESULTS - INFANTRY VERSION (INFANTRY)

Case	HUMAN FACTOR	Very Unimportant	Unimportant	Neutral	Important	Very Important
1	*Cohesion*	0	0	0	12	3
	Discipline	0	0	1	7	7
	Initiative	0	0	2	4	9
	Leadership	0	0	0	3	12
	Morale	0	0	2	12	1
	Training/Experience	0	0	1	5	9
	Will/Motivation	0	0	3	5	7
2	*Cohesion*	0	1	5	7	2
	Discipline	0	1	2	9	3
	Initiative	0	1	2	5	7
	Leadership	0	1	0	3	11
	Morale	0	2	3	9	1
	Training/Experience	0	1	0	3	11
	Will/Motivation	0	2	3	7	3
3	*Cohesion*	2	0	4	8	1
	Discipline	1	0	0	3	11
	Initiative	1	1	6	4	3
	Leadership	1	0	1	3	10
	Morale	1	1	2	4	7
	Training/Experience	1	0	0	5	9
	Will/Motivation	1	0	4	2	8
4	*Cohesion*	0	0	4	7	4
	Discipline	0	0	1	6	8
	Initiative	0	1	2	5	7
	Leadership	0	0	1	1	13
	Morale	0	0	2	7	6
	Training/Experience	0	0	1	7	7
	Will/Motivation	0	1	4	6	4

Table 65. SURVEY II RESULTS - INFANTRY VERSION (NON-INFANTRY)

Case	HUMAN FACTOR	Very Unimportant	Unimportant	Neutral	Important	Very Important
1	*Cohesion*	0	1	3	18	5
	Discipline	0	0	2	14	11
	Initiative	0	1	2	14	10
	Leadership	0	0	1	2	24
	Morale	0	0	6	18	3
	Training/Experience	0	0	2	13	12
	Will/Motivation	0	0	4	11	12
2	*Cohesion*	2	0	3	15	7
	Discipline	1	0	3	5	18
	Initiative	0	0	5	11	11
	Leadership	0	0	1	4	22
	Morale	2	1	7	12	5
	Training/Experience	0	0	1	11	15
	Will/Motivation	1	1	3	9	13
3	*Cohesion*	2	2	10	10	3
	Discipline	1	0	1	6	19
	Initiative	3	2	4	10	8
	Leadership	0	0	2	9	16
	Morale	1	2	9	9	6
	Training/Experience	0	0	1	3	23
	Will/Motivation	0	3	8	10	6
4	*Cohesion*	0	1	5	14	7
	Discipline	0	0	4	8	15
	Initiative	0	2	7	6	12
	Leadership	0	0	1	2	24
	Morale	0	1	3	12	11
	Training/Experience	0	1	2	7	17
	Will/Motivation	0	1	3	11	12

Table 66. SCALED VALUES CASE 1 - INFANTRY

HUMAN FACTOR	Total	Infantry	Non-Infantry
Cohesion	*70.28*	*30.43*	*66.50*
Discipline	*92.43*	*97.79*	*89.74*
Initiative	*91.56*	*133.71*	*84.50*
Leadership	*181.19*	*170.07*	*259.00*
Morale	*58.38*	*43.93*	*54.68*
Training/Experience	*100.00*	*124.14*	*93.74*
Will/Motivation	*92.38*	*93.93*	*91.32*

Table 67. RANKING CASE 1 - INFANTRY

HUMAN FACTOR	Total	Infantry	Non-Infantry
Cohesion	*6*	*7*	*6*
Discipline	*3*	*4*	*4*
Initiative	*5*	*2*	*5*
Leadership	*1*	*1*	*1*
Morale	*7*	*6*	*7*
Training/Experience	*2*	*3*	*2*
Will/Motivation	*4*	*5*	*3*

Table 68. SCALED VALUES CASE 2 - INFANTRY

HUMAN FACTOR	Total	Infantry	Non-Infantry
Cohesion	*69.21*	*53.00*	*74.16*
Discipline	*97.21*	*66.06*	*125.89*
Initiative	*88.95*	*93.89*	*87.95*
Leadership	*155.95*	*168.94*	*158.52*
Morale	*59.75*	*44.89*	*60.42*
Training/Experience	*116.55*	*168.94*	*104.90*
Will/Motivation	*84.00*	*56.72*	*96.16*

Table 69. RANKING CASE 2 - INFANTRY

HUMAN FACTOR	Total	Infantry	Non-Infantry
Cohesion	*6*	*6*	*6*
Discipline	*3*	*4*	*2*
Initiative	*4*	*3*	*5*
Leadership	*1*	*1.5*	*1*
Morale	*7*	*7*	*7*
Training/Experience	*2*	*1.5*	*3*
Will/Motivation	*5*	*5*	*4*

Table 70. SCALED VALUES CASE 3 - INFANTRY

HUMAN FACTOR	Total	Infantry	Non-Infantry
Cohesion	*50.89*	*46.38*	*52.14*
Discipline	*153.58*	*170.19*	*143.14*
Initiative	*64.58*	*55.19*	*69.67*
Leadership	*118.37*	*139.75*	*109.40*
Morale	*71.16*	*89.88*	*63.86*
Training/Experience	*157.58*	*124.13*	*168.75*
Will/Motivation	*73.32*	*92.00*	*66.78*

Table 71. RANKING CASE 3 - INFANTRY

HUMAN FACTOR	Total	Infantry	Non-Infantry
Cohesion	*7*	*7*	*7*
Discipline	*2*	*1*	*2*
Initiative	*6*	*6*	*4*
Leadership	*3*	*2*	*3*
Morale	*5*	*5*	*6*
Training/Experience	*1*	*3*	*1*
Will/Motivation	*4*	*4*	*5*

Table 72. SCALED VALUES CASE 4 - INFANTRY

HUMAN FACTOR	Total	Infantry	Non-Infantry
Cohesion	*76.20*	*72.95*	*73.32*
Discipline	*106.29*	*103.41*	*108.69*
Initiative	*90.40*	*93.89*	*83.26*
Leadership	*233.57*	*255.41*	*222.08*
Morale	*92.25*	*90.14*	*89.53*
Training/Experience	*114.35*	*97.36*	*122.79*
Will/Motivation	*86.65*	*67.79*	*93.37*

Table 73. RANKING CASE 4 - INFANTRY

HUMAN FACTOR	Total	Infantry	Non-Infantry
Cohesion	*7*	*6*	*7*
Discipline	*3*	*2*	*3*
Initiative	*5*	*4*	*6*
Leadership	*1*	*1*	*1*
Morale	*4*	*5*	*5*
Training/Experience	*2*	*3*	*2*
Will/Motivation	*6*	*7*	*4*

2. Artillery Version Results

On the following pages are the raw and refined results for the Artillery Version of Survey II. Raw frequency results for Total, Artillery, and Non-Artillery respondents are shown in Tables 74, 75, and 76, respectively. This is followed by tables depicting the scaled values and rank orders on a case-by-case basis.

Table 74. SURVEY II RESULTS - ARTILLERY VERSION (TOTAL)

Case	HUMAN FACTOR	Very Unimportant	Unimportant	Neutral	Important	Very Important
1	*Cohesion*	*0*	*0*	*4*	*14*	*16*
	Discipline	*0*	*0*	*1*	*18*	*15*
	Initiative	*0*	*0*	*4*	*14*	*16*
	Leadership	*0*	*0*	*2*	*6*	*26*
	Morale	*0*	*0*	*8*	*19*	*7*
	Training/Experience	*0*	*0*	*1*	*13*	*20*
	Will/Motivation	*0*	*0*	*3*	*21*	*10*
2	*Cohesion*	*0*	*2*	*5*	*16*	*11*
	Discipline	*0*	*1*	*2*	*4*	*27*
	Initiative	*0*	*1*	*5*	*15*	*13*
	Leadership	*0*	*1*	*1*	*5*	*27*
	Morale	*0*	*1*	*4*	*20*	*7*
	Training/Experience	*0*	*1*	*1*	*12*	*20*
	Will/Motivation	*0*	*1*	*3*	*11*	*19*
3	*Cohesion*	*0*	*3*	*12*	*16*	*3*
	Discipline	*0*	*1*	*1*	*8*	*24*
	Initiative	*1*	*3*	*12*	*11*	*7*
	Leadership	*0*	*1*	*5*	*14*	*14*
	Morale	*0*	*3*	*4*	*13*	*14*
	Training/Experience	*0*	*1*	*1*	*7*	*25*
	Will/Motivation	*0*	*1*	*6*	*17*	*10*
4	*Cohesion*	*0*	*2*	*7*	*9*	*16*
	Discipline	*0*	*0*	*3*	*7*	*24*
	Initiative	*0*	*1*	*9*	*15*	*9*
	Leadership	*0*	*0*	*3*	*6*	*25*
	Morale	*0*	*0*	*7*	*18*	*9*
	Training/Experience	*0*	*1*	*4*	*13*	*16*
	Will/Motivation	*0*	*2*	*3*	*16*	*13*

Table 75. SURVEY II RESULTS - ARTILLERY VERSION (ARTILLERY)

Case	HUMAN FACTOR	Very Unimportant	Unimportant	Neutral	Important	Very Important
1	*Cohesion*	0	0	1	6	3
	Discipline	0	0	1	4	5
	Initiative	0	0	2	3	5
	Leadership	0	0	1	1	8
	Morale	0	0	2	7	1
	Training/Experience	0	0	1	4	5
	Will/Motivation	0	0	2	7	1
2	*Cohesion*	0	0	1	5	4
	Discipline	0	0	1	1	8
	Initiative	0	0	2	6	2
	Leadership	0	0	1	1	8
	Morale	0	0	1	7	2
	Training/Experience	0	0	1	2	7
	Will/Motivation	0	0	1	3	6
3	*Cohesion*	0	0	4	4	2
	Discipline	0	0	1	2	7
	Initiative	0	0	5	4	1
	Leadership	0	0	3	2	5
	Morale	0	0	1	4	5
	Training/Experience	0	0	1	1	8
	Will/Motivation	0	0	2	5	3
4	*Cohesion*	0	1	3	2	4
	Discipline	0	0	2	1	7
	Initiative	0	0	3	4	3
	Leadership	0	0	1	1	8
	Morale	0	0	2	3	5
	Training/Experience	0	0	2	4	4
	Will/Motivation	0	0	1	4	5

Table 76. SURVEY II RESULTS - ARTILLERY VERSION (NON-ARTILLERY)

Case	HUMAN FACTOR	Very Unimportant	Unimportant	Neutral	Important	Very Important
1	*Cohesion*	0	0	3	8	13
	Discipline	0	0	0	14	10
	Initiative	0	0	2	11	11
	Leadership	0	0	1	5	18
	Morale	0	0	6	12	6
	Training/Experience	0	0	0	9	15
	Will/Motivation	0	0	1	14	9
2	*Cohesion*	0	2	4	11	7
	Discipline	0	1	1	3	19
	Initiative	0	1	3	9	11
	Leadership	0	1	0	4	19
	Morale	1	1	4	13	5
	Training/Experience	0	1	0	10	13
	Will/Motivation	0	1	2	8	13
3	*Cohesion*	0	3	8	12	1
	Discipline	0	1	0	6	17
	Initiative	1	3	7	7	6
	Leadership	0	1	2	12	9
	Morale	0	3	3	9	9
	Training/Experience	0	1	0	6	17
	Will/Motivation	0	1	4	12	7
4	*Cohesion*	0	1	4	7	12
	Discipline	0	0	1	6	17
	Initiative	0	1	6	11	6
	Leadership	0	0	2	5	17
	Morale	0	0	5	15	4
	Training/Experience	0	1	2	9	12
	Will/Motivation	0	2	2	12	8

Table 77. SCALED VALUES CASE 1 - ARTILLERY

HUMAN FACTOR	Total	Artillery	Non-Artillery
Cohesion	*94.13*	*71.71*	*109.50*
Discipline	*92.73*	*100.99*	*84.75*
Initiative	*94.13*	*100.98*	*92.57*
Leadership	*185.47*	*294.00*	*163.21*
Morale	*46.73*	*40.00*	*49.64*
Training/Experience	*113.33*	*100.99*	*125.90*
Will/Motivation	*71.40*	*40.00*	*84.07*

Table 78. RANKING CASE 1 - ARTILLERY

HUMAN FACTOR	Total	Artillery	Non-Artillery
Cohesion	*3.5*	*5*	*3*
Discipline	*5*	*2.5*	*5*
Initiative	*3.5*	*4*	*4*
Leadership	*1*	*1*	*1*
Morale	*7*	*6.5*	*7*
Training/Experience	*2*	*2.5*	*2*
Will/Motivation	*6*	*6.5*	*6*

Table 79. SCALED VALUES CASE 2 - ARTILLERY

HUMAN FACTOR	Total	Artillery	Non-Artillery
Cohesion	*78.72*	*86.91*	*73.88*
Discipline	*166.33*	*302.82*	*177.41*
Initiative	*85.06*	*52.00*	*92.88*
Leadership	*169.39*	*302.82*	*171.35*
Morale	*69.48*	*62.82*	*69.28*
Training/Experience	*113.61*	*175.91*	*107.65*
Will/Motivation	*106.22*	*129.55*	*105.00*

Table 80. RANKING CASE 2 - ARTILLERY

HUMAN FACTOR	Total	Artillery	Non-Artillery
Cohesion	*6*	*5*	*6*
Discipline	*2*	*1.5*	*1*
Initiative	*5*	*7*	*5*
Leadership	*1*	*1.5*	*2*
Morale	*7*	*6*	*7*
Training/Experience	*3*	*3*	*3*
Will/Motivation	*4*	*4*	*4*

Table 81. SCALED VALUES CASE 3 - ARTILLERY

HUMAN FACTOR	Total	Artillery	Non-Artillery
Cohesion	*61.16*	*24.78*	*56.93*
Discipline	*138.36*	*181.11*	*129.74*
Initiative	*69.96*	*0*	*72.17*
Leadership	*90.72*	*107.12*	*89.26*
Morale	*90.48*	*107.13*	*84.37*
Training/Experience	*147.00*	*311.78*	*129.74*
Will/Motivation	*82.24*	*66.00*	*81.22*

Table 82. RANKING CASE 3 - ARTILLERY

HUMAN FACTOR	Total	Artillery	Non-Artillery
Cohesion	*7*	*6*	*7*
Discipline	*2*	*2*	*1.5*
Initiative	*6*	*7*	*6*
Leadership	*3*	*4*	*3*
Morale	*4*	*3*	*4*
Training/Experience	*1*	*1*	*1.5*
Will/Motivation	*5*	*5*	*5*

Table 83. SCALED VALUES CASE 4 - ARTILLERY

HUMAN FACTOR	Total	Artillery	Non-Artillery
Cohesion	*91.35*	*85.47*	*97.05*
Discipline	*138.28*	*143.93*	*127.90*
Initiative	*72.25*	*77.22*	*69.95*
Leadership	*149.44*	*152.00*	*139.57*
Morale	*77.44*	*92.73*	*67.38*
Training/Experience	*96.85*	*85.59*	*102.74*
Will/Motivation	*88.50*	*92.74*	*81.58*

Table 84. RANKING CASE 4 - ARTILLERY

HUMAN FACTOR	Total	Artillery	Non-Artillery
Cohesion	*4*	*6*	*4*
Discipline	*2*	*2*	*2*
Initiative	*7*	*7*	*6*
Leadership	*1*	*1*	*1*
Morale	*6*	*4*	*7*
Training/Experience	*3*	*5*	*3*
Will/Motivation	*5*	*3*	*5*

3. Respondent Comments

At the end of Survey II, all respondents were asked to comment on:

- Whether the survey was understandable;
- Whether the survey was realistic;
- Assumptions required to complete the survey;

Of the 130 total respondents (Infantry and Artillery combined), 128 regarded the survey as both understandable and realistic. Assumptions made by individual respondents are listed on the following page.

Survey II Respondent Assumptions

- Threat actions would proceed in accordance with established threat doctrine, especially the Spetznatz-type rear area actions. Each scenario required individual ranking of factors, based on the type of decision made. For example, selection of the ASP platoon depended most on leadership, initiative of the platoon leader selected, since the XO was gone, while the MOPP decision depended on the troops' level of training and discipline under NBC conditions. The company commander was competent and fully understood the strengths/weaknesses of his unit.
- I assumed the soldiers I would order on a mission were similar to those I worked and trained with when I was stationed in Germany and at Fort Campbell, KY.
- I feel that no matter what mission you perform the human factors you listed are all very important. I have real trouble saying that any one of them is less than "very important".
- The platoons within the company were all in the same basic state for the given human factors.
- That the company was properly trained to do each required mission. The commander had complete control over each situation.
- The majority of the unit had been together at least 9 months; the unit had performed at least company ARTEP evaluations within 60 days; platoon leaders: 3 out of the 4 were 1st lieutenants, commander had at least 2 months command with the battalion; and that the commander will use the external fire support.
- Thorough knowledge of junior leader capabilities under stressful conditions. General high level of competence/training in the NCO chain of command in each platoon.
- Mainly to assume away those external factors that would primarily drive many of these decisions. Morale and cohesion are things to build in peacetime, and it's always better to have them than not, but I think that rarely will they be significant factors in making these decisions. I had difficulty making the distinctions between neutral, unimportant, and very unimportant. If it's not important in a decision, how much "not important" is hard to say.
- Soldiers perform the same during combat situations as in peacetime situations/exercises. That these human factors would have any bearing on the outcome of each action(this is coupled to the above statement).

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