TACTICAL DECISION MAKING: A PROPOSED EVALUATION CRITERIA MODEL FOR THE INFANTRY BATTALION'S TACTICAL ESTIMATE DURING OFFENSIVE OPERATIONS

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirements for the degree

MASTER OF MILITARY ART AND SCIENCE

by

JOHN A. DAVIS, MAJ, USA
B.S., United States Military Academy, 1980

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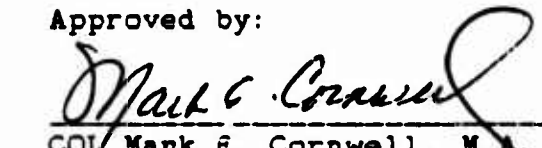

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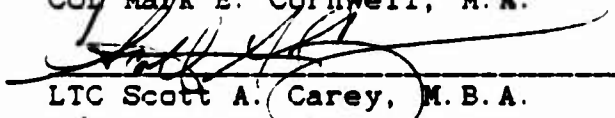

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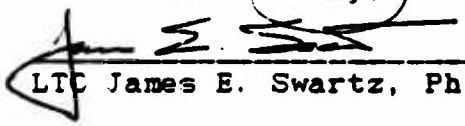

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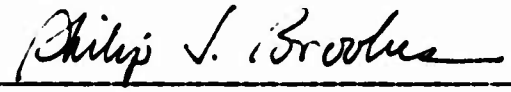

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The opinions and conclusions expressed herein are those of the student author and do not represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

ABSTRACT

TACTICAL DECISION MAKING: A PROPOSED EVALUATION CRITERIA MODEL FOR THE INFANTRY BATTALION'S TACTICAL ESTIMATE DURING OFFENSIVE OPERATIONS, by MAJ John A. Davis, USA, 184 pages.

This study seeks to determine if it is possible to construct an evaluation criteria model that improves the infantry battalion's capability to select the best course of action during the deliberate tactical estimate. It examines U.S. and selected foreign army doctrine, related literature, and lessons from the U.S. Army Combat Training Centers.

The literature review concludes that there is no agreement on the selection and use of evaluation criteria during the tactical estimate. However, it provides an operational definition for the "best" course of action, as well as several theoretical requirements for the "optimal" evaluation criteria model.

Using the results of the literature review, the study presents a proposed model that the author believes will improve the capability of selecting the best course of action during the tactical estimate. The study tests the model using a tactical scenario developed at the Joint Readiness Training Center. Model evaluation is based on established measures of effectiveness that relate the performance of the proposed model to the characteristics of the theoretically optimal model.

The study concludes that the proposed model is applicable for use as an instructional aid, but that further research and field testing are required before it should be applied by units throughout the U.S. Army.

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Finally, while acknowledging those who provided me invaluable help, I remain solely responsible for any remaining errors and faults in this thesis.

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INTRODUCTION

> [I]t is essential that all leaders . . . familiarize themselves with the art of clear, logical thinking. It is more valuable to be able to analyze one battle situation correctly, recognizing its decisive elements and devise a simple, workable solution for it, than to memorize all the erudition ever written about war.[1]
>
> Infantry In Battle, (1939)

During the planning of combat operations, tactical decision making is usually a difficult, complicated endeavor. As indicated in the preceding quote, the first critical key to successful tactical decisions is the recognition of "decisive elements" in the combat situation. By successfully identifying these elements, it would appear that a commander and his staff could then use them as the basis for evaluating possible solutions in order to choose the best one.

Since 1910, the U.S. Army's tactical decision making process has not significantly changed.[2] An integral part of this process is the evaluation of possible tactical solutions, called courses of action (COAs), in order to decide which one is "best." This highlights the important link between the identification of "decisive elements" and their use as evaluation criteria in the current tactical decision making process.

Definition of the Problem

The purpose of this thesis is to develop an evaluation criteria model that will improve the current U.S. Army tactical decision making process. The scope of the thesis limits research to the infantry battalion (light, airborne, air assault, and ranger) level, and is further defined by parameters that are reviewed later in this chapter. The primary research question that this thesis serves to answer is: Is it possible to construct an evaluation criteria model that improves the infantry battalion's capability to select the best COA during the deliberate tactical estimate process? In essence, the research is a quest to more clearly define the "decisive elements" previously described, and incorporate them into the tactical estimate.

In order to answer the primary research question, the following six secondary questions require research and analysis:

1. What is the purpose and process of the tactical estimate of the situation?

2. What problems exist in the tactical estimate process?

3. How can a standard evaluation criteria model contribute to solving problems that have been identified in the estimate process?

4. What does doctrine and related literature reveal about the selection and use of evaluation criteria during the tactical estimate?

5. What essential elements define the "best" COA, and how are these elements measured?

6. What are the doctrinal and theoretical requirements for the development of an optimal evaluation criteria model for an infantry battalion during the estimate?

In order to explain the nature of this research and provide perspective for the approach to solving the problems of the study, this chapter provides background, assumptions, definitions, limitations, and delimitations. It concludes by stating the significance of the research.

Background

In order to set the stage for this research, it is important to review the tactical decision making concept and define the purpose and process of the estimate of the situation within this concept. Next, preliminary investigation reveals several problems associated with the tactical estimate process. Finally, this section describes how these problems relate to the research.

What Is Tactical Decision Making?

Tactical decision making is a subordinate element of the military command and control system in the tactical planning context. It is both an art and a science. Commanders make decisions during the planning phase of tactical operations. The most important of these decisions focuses on the selection of the best COA for the organization, given the situation and an analysis of possible solutions.

Due to the relationship between the requirement for an organization to act, the situation that defines the context of the act, and the responsibility of the organization's commander to determine the best possible way to accomplish the requirement, U.S. Army doctrine views the tactical decision making process as a problem solving process.[4]

The problem solving process entails a systematic approach that is based in effective analysis (the science aspect) and is designed to enhance effective application of professional knowledge, logic, and judgment (the art aspect). The following six steps define the systematic approach of the problem solving process:

1. Recognize and define the problem.
2. Gather facts and make assumptions necessary to determine the scope of and the solution to the problem.
3. Develop possible solutions.
4. Analyze each solution.
5. Compare the outcome of each solution.
6. Select the best solution available.[5]

Of particular note is the role of criteria in this process. Criteria, which are "the data that define the limits within which the solutions to a problem must fall,"[6] impact directly on steps three through six of this process. There are two categories of criteria; screening and evaluation. Screening criteria impact on step three by defining the limits that establish whether or not a proposed solution is, in fact, possible. If a particular solution does not meet the screening criteria, it is not considered in any of the subsequent steps of the process. Evaluation criteria impact on steps four through six by establishing a set of standards

for assessment and comparison of possible solutions in order to facilitate selection of the best one.

In terms of tactical decision making, this systematic approach to problem solving has evolved into a process called the estimate of the situation, which is conducted as part of the organization's overall tactical planning process. In essence, the estimate process "requires full definition of the mission, collection of all pertinent information, development and analysis of options, and finally, a decision which forms the basis for a plan or order."[7] The purpose of the estimate is to

> collect and analyze relevant information for developing, within the time limits and available information, the most effective solution to a problem. The estimate is applicable to any situation and to any level or type of command.[8]

Within the military decision making process, the estimate begins with the receipt of a mission and ends with the commander's decision on the best solution to accomplish the mission. The interim steps involve certain staff actions and actions accomplished by the commander, as depicted in figure 1.

Figure 2 identifies the phases in this process, which consist of mission analysis, COA development, COA analysis, COA comparison, and the decision. Note here that the comparison phase mentions the determination of decision criteria and that a key product of this action is the decision matrix (figure 3). This matrix and the decision

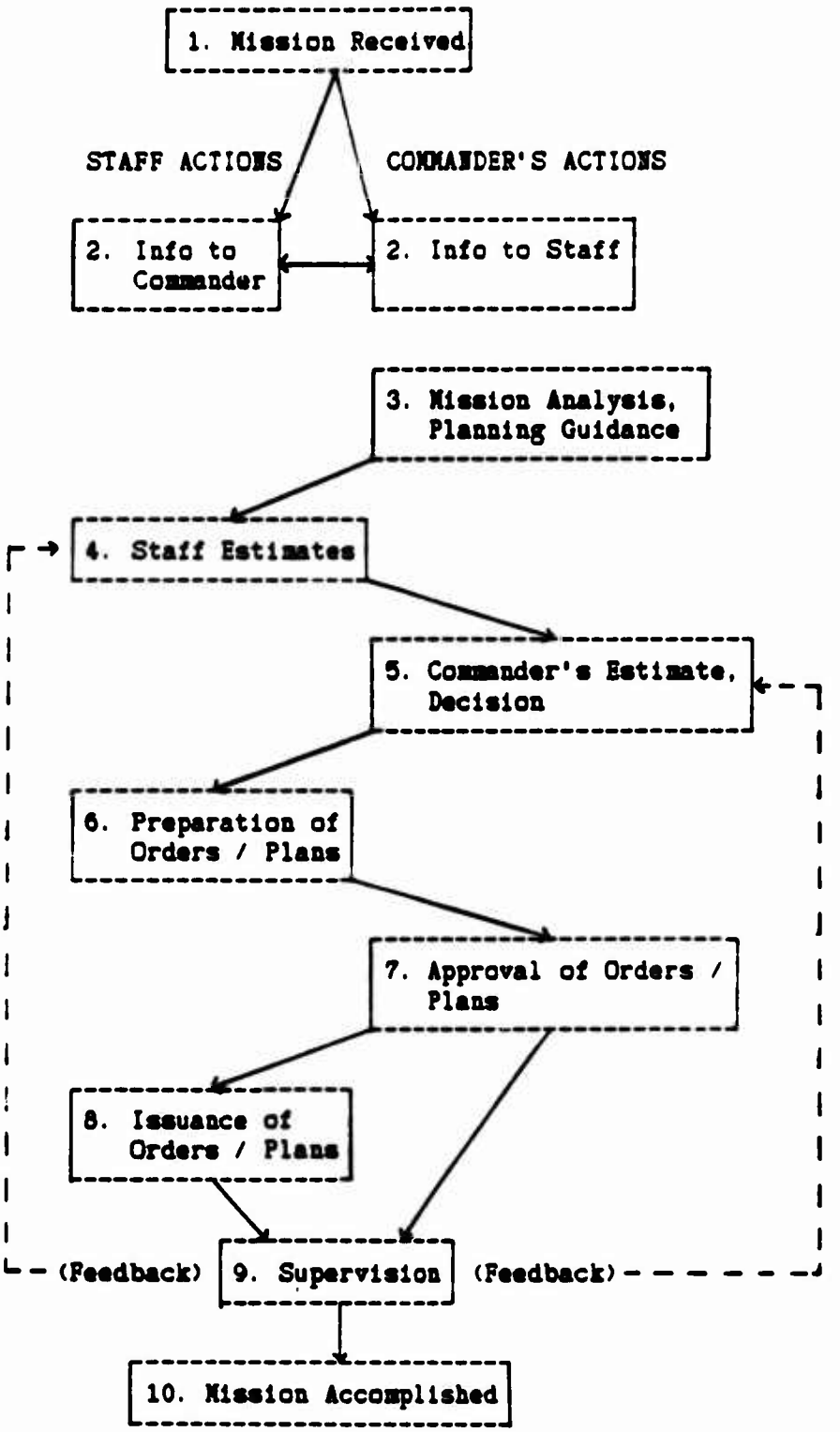


Figure 1. Military Decision Making Process. The Estimate of the Situation is shown as steps 1 - 5.

TACTICAL DECISION MAKING PROCESS

PHASES

1. Mission Analysis

   - Facts
   - Assumptions
   - Analysis of higher mission
   - Limitations
   - Analysis of time

2. COA Development

   - Analyze relative force ratios
   - Array initial forces
   - Develop scheme of maneuver
   - Determine C^2 means
   - Determine control measures
   - Prepare COA statements / sketches
   - Apply screening criteria to verify suitability, feasibility, acceptability, variation, and completeness

3. COA Analysis

   - Wargame

4. COA Comparison

   - Determine DECISION (EVALUATION) CRITERIA
   - Assign weighting values to criteria
   - Compare COAs (*CONSTRUCT DECISION MATRIX)
   - Make recommendation

5. Decision

Figure 2. Phases of the Tactical Estimate. Note that decision (evaluation) criteria are not determined until phase 4.

DECISION MATRIX

	COA #1	COA #2
EVALUATION CRITERION #1		
EVALUATION CRITERION #2		
EVALUATION CRITERION #3		
EVALUATION CRITERION #4		
TOTAL		

Figure 3. Generic Decision Matrix. This matrix compares the COAs by using nominal values to rank order each COA according to each evaluation criterion. By totaling the nominal values, the matrix indicates which COA best satisfies the criteria overall. This indicates the "best" COA.

criteria selected for use in the matrix are the means by which the staff justifies a recommended COA to the commander. It is designed to graphically indicate the "best" COA. For clarity, decision criteria in this context refer to evaluation criteria.

While the estimate process corresponds to a methodology that evolved from "scientific" problem solving, it is important to recognize the doctrinal emphasis on the art versus science aspects of this process. Doctrinally, the science aspect of tactical decision making provides a frame of reference that aids the decision maker in organizing thought and developing judgment. The art aspect preserves the commander's experience, skill, and judgment as the final arbiter in applying the scientific model in order to make the decision. Doctrinally, the U.S. Army allows considerable latitude to the commander in this sense. In fact, the emphasis on "tactical genius as an art . . . is reflected in current US tactical quantification practice with respect to doctrine, training, research and field application."

Using these complementary aspects of decision making as a doctrinal foundation, this study recognizes that research designed to improve the estimate process must account for the balance between art and science. A "cookie cutter" evaluation criteria model is not the objective of this study, because:

> The leader who would become a competent tactician must first close his mind to the alluring formulae that well-meaning people offer in the name of victory. To master his difficult art he must learn to cut to the heart of a situation, recognize its decisive elements and base his course of action on these.[10]

What Are Some of the Problems Associated With the Estimate?

Ultimately, the commander alone makes the decision of which COA best accomplishes the mission. The commander bases his decision on some set of evaluation criteria, whether stated or not, since criteria are fundamental in problem solving, and the estimate of the situation is nothing more than an application of the problem solving process in the context of a tactical situation. A central aspect of this thesis is the contention that since evaluation criteria are a fundamental part of the problem solving process, they are also a fundamental part of the tactical decision making process in general, and of the estimate in particular. Moreover, this thesis contends that the selection and use of evaluation criteria are even more important than the selection of the best COA, because the latter is simply the applied result of the former--if done correctly. All too often the opposite is the case.

The problem is to determine what evaluation criteria a commander uses to decide the best COA and how he selects these criteria. The U.S. Army's current doctrine does not clearly define these criteria or provide sufficient guidance on how to select them. It only provides the vague statement that a commander uses his "judgment, skill, and experience"[11] in

making the decision. This highlights what is clearly, and rightfully, a central aspect of command; the "art" of decision making. But this is only half of the equation. Current decision making doctrine does not provide specific guidance for the selection of evaluation criteria, or the details for a method to organize thought about the critical elements to consider in applying judgment to make the decision. Thus, "[t]he reality of current US tactical decision making practice is that COA . . . analysis is primarily an intuitive process."[12] This reveals a lack of the "science" aspect of decision making.

Additionally, the doctrinal decision making process depicted in figure 1 prescribes a parallel estimate process by the staff and the commander. While the parallel process saves time, the lack of clearly defined evaluation criteria prior to separate analysis and comparison by the staff and commander can lead to inconsistent analysis and ineffective estimates. That which a staff officer considers as a "decisive element" may not coincide with the same for the commander.

Formal analysis of the estimate conducted by the Fort Leavenworth office of the Army Research Institute indicates several concerns that relate to these same issues:

1. Cognitive biases: Human adopted strategies can be suboptimal due to the effects of group thinking and consensus confirmation.

2. Overconfidence of the commander and staff: This leads to a misleading implementation of plans and results in the lack of contingency development.

3. Lack of experience: With many commanders and staffs, the possibility of an inadequate experiential base to make sound tactical judgments exists.

4. Management of the process: The overall group decision making process is poor. A fairly common occurrence is that issues are resolved using the last option discussed.

5. Definition of insufficient options: When multiple options are created, they are often simple variations of a main theme. When there is variance, it is normally the practice to generate something to "throw away" to give the appearance that more than one option was considered.

6. Decision analysis: The applicability of the estimate and its components is highly situational dependent.

As a result of these problems, experience under simulated combat conditions shows that the estimate process can be difficult for tactical units to understand and apply.

Observations from the Combat Training Centers (CTCs) at Fort Irwin, Fort Chaffee, and Hohenfels indicate that many battalion commanders and their staffs have difficulty developing effective tactical plans. The common failure is the incorrect conduct of the tactical decision making process. During training, commanders and staffs have problems understanding how to conduct each step in the estimate process because the doctrine provides insufficient detail to plan

quickly and effectively. Doctrine provides a logical sequence, but little detail on how to execute the individual steps to meet different conditions. "The result is [that] commanders and staffs deviate from the doctrinal process by eliminating or shortening necessary steps, causing their plan to be ineffective."[4]

How Does This Relate to the Research?

Tactical decision making is heretofore defined as a problem solving process in a tactical planning context. Within the tactical decision making framework the estimate of the situation is the heart of the process that directly relates to a problem solving, methodical series of activities that commanders and staffs use to examine battlefield possibilities in order to determine the best solution. The key node in the estimate is the selection of evaluation criteria, because the application of these criteria determines the best COA. Furthermore, this process is both an art and a science since the process describes an effective procedure to formulate thought, but requires the commander's application of judgment in order to act or decide.

The estimate of the situation has been the foundation for tactical decision making in the U.S. Army since the turn of the century. It has weathered time and combat, but the doctrinal process is apparently not without flaw.

Preliminary analysis of current doctrine and observation of lessons from the CTCs identifies several

problems. Current decision making doctrine lacks a detailed description of the evaluation criteria a commander uses to assess and compare COAs in order to decide which is best, and how he selects these criteria. In other words, it fails to provide a detailed frame of reference to organize thought in an area (selection of evaluation criteria) that is key to the problem solving, and therefore the tactical decision making, process and purpose. Additionally, the lack of evaluation criteria selection prior to separate analysis by the commander and staff during parallel estimates can lead to inconsistent and ineffective results. CTC observations indicate that the estimate is often vague and ineffective because a number of commanders and staffs do not understand the steps in the process.

This description of the estimate process and the identification of problems associated with it lead to the need for research. Specifically, this thesis is designed to answer the primary question of determining if it is possible to develop an evaluation criteria model that improves the infantry battalion's capability to select the best COA during the deliberate tactical estimate. Research and analysis of the secondary questions are required in order to contribute to a solution of the primary research question.

Assumptions

Analytical research on this topic requires the following assumptions:

1. Since this research focuses on evaluation criteria, only the final three phases of the estimate (COA analysis, comparison, and decision) are subject to analysis. In chapter five, Analysis, this study assumes that mission analysis and COA development (phase one and two) are conducted correctly, and that screening criteria are applied correctly to COAs such that they are, in fact, feasible, suitable, acceptable, varied, and complete. The reason for this assumption is because the purpose of the study is to improve the estimate process as it pertains to evaluation criteria and the selection of the best COA from among those that "pass the gauntlet" of screening criteria applied in phase two of the estimate. It is beyond the scope of the research to address any improvements required during mission analysis or COA development.

2. During analysis in chapter five, the study assumes that COA wargaming is conducted correctly in accordance with the procedure outlined in ST 100-9, The Command Estimate. Inherent in this assumption is a staff that is sufficiently experienced to properly conduct the wargame, and sufficiently "honest" during the wargame process. This means that the staff uses established planning data (movement rates, ammunition expenditure rates, combat power ratios, casualty rates, fuel consumption rates, etcetera) accurately, but also tempers these variables through the exercise of experience, skill, and judgment so that the wargame results in an honest visualization of each friendly COA's outcome relative to the

enemy's most likely COA. After all, this is the purpose of the wargame. The reason for this assumption is based again on scope, since it is outside the scope of this research to improve the wargame procedures.

3. In this study, hypothesis (evaluation criteria model) development is predicated on the ability and willingness of the infantry battalion commander to provide planning guidance to the staff at the conclusion of the mission analysis phase of the estimate. Although inconsistently described in current doctrine and related literature, the key component of this guidance is the commander's initial intent.[5] This study assumes that the commander is able and willing to provide initial intent to the staff, including the purpose of the operation, the method for the force as a whole, and the commander's vision of successful endstate relative to the enemy and friendly forces, the terrain, and time. The commander's inability or unwillingness to do so in this form prior to COA analysis and comparison undermines the hypothesis and causes the staff to derive, or worse, "guess" at the commander's definition of success. This increases the risk that the evaluation criteria model will be ineffective and inconsistent.

4. This study assumes that the doctrinal and theoretical requirements for the optimal evaluation criteria model, which are derived from the literature review, are valid and reliable. These requirements are revealed in chapter two, are the foundation for model development in chapter four, and

form the basis for analysis of the model in chapter five. This assumption is specifically addressed in chapter three, Methodology, and evaluated in the thesis conclusion.

These assumptions isolate the issue of evaluation criteria as the object of analysis within the estimate at the expense of any attempt to improve other portions of the estimate process. The effect of each of these assumptions forms the basis for research design evaluation in chapter six, Conclusions.

Operational Definitions

The following operational definitions apply to terms that are integral to this study:

1. Estimate of the situation: A problem solving procedure used by a military organization to collect and analyze relevant information for developing, within the time limits and available information, the most effective solution to a tactical problem. It is applicable to any situation and to any level or type of command. It is composed of the commander's estimate and staff estimates.[16]

2. Command Estimate: Some non-doctrinal manuals and related literature refer to the estimate of the situation as the command estimate. The chief reason for the different terminology is to differentiate between the deliberate estimate process and the abbreviated command estimate, which shortens specific steps of the deliberate estimate process because of the lack of sufficient time. This study focuses

only on the deliberate process. Therefore, the term command estimate is synonymous with the estimate of the situation.

3. Commander's estimate: The process that results in a decision on how to accomplish a given mission. After considering the mission, enemy, terrain, troops available, time, and other relevant factors, a decision is reached. The estimate is based on personal knowledge of the situation, on ethical considerations, and on staff estimates.[17]

4. Staff estimates: The process that a staff uses to assist the commander in reaching a decision by making estimates in their assigned areas of responsibility. These estimates analyze the influence of factors within the staff officer's particular field of interest on the accomplishment of the command's mission and identify those factors that affect formulation, analysis, and comparison of feasible COAs. The operations estimate is identical to the commander's estimate, except that it results in a recommendation. The other staff estimates result in conclusions and recommendations that substantiate the supportability of COAs.[18]

5. Course of action (COA): A feasible way to accomplish a task or mission that follows the guidance given, will not result in undue damage or risk to the command, and is noticeably different from other actions under consideration. It should include the following elements:

WHAT (the type of action)
WHEN (the time the action will begin)
WHERE (the assigned sectors in defense; zones in offense)
HOW (the use of available assets)
WHY (the purpose of the operation)

Each COA should be significantly different from others in terms of the use of reserves, task organization, main effort, and/or scheme of maneuver.[19]

6. Wargaming: A conscious attempt to visualize the flow of battle, given friendly strengths and dispositions, enemy assets and possible COAs, and a set piece of ground. It attempts to foresee the action, reaction, and counteraction dynamics of a battle in order to analyze friendly COAs and determine advantages and disadvantages that can be used to compare COAs and determine which is best.[20]

7. Commander's intent: Provides the basis for developing the concept of operations. It defines the operation's purpose, the method for the force as a whole, and the commander's definition of successful endstate in relation to the status of the enemy, the friendly force, the terrain, and time. During the estimate, it is called the initial intent, and is issued as part of the commander's planning guidance to the staff after the mission analysis phase.[21]

8. Decision Criteria: A set of standards, rules, or tests by which COAs can be judged.[22] Decision criteria consist of screening and evaluation criteria.

a. Screening criteria determine the legitimacy of a COA and apply to the COA development phase of the estimate.

This means the COA must satisfy the following conditions in order to be valid:

> Suitability: Does the COA actually accomplish the mission if carried out successfully? COA does not violate any constraints or limitations imposed on the operation.
>
> Feasibility: Are the required resources, units, and time available?
>
> Acceptability: Even if the COA will accomplish the mission, is it worth the cost in terms of possible losses? Losses include time, material, and position in addition to purely military losses.
>
> Variety: Is the COA sufficiently different from other COAs?
>
> Completeness: Does the COA describe the who (in generic terms of combat power two levels below the planning headquarter level), what, when, where, how, and why of a tactical operation in sufficient detail to allow comparison with other COAs?[23]

b. Evaluation criteria, on the other hand, provide a means for assessing COAs that satisfy the screening criteria. They pertain to both the analysis and comparison phases in the estimate, and determine the best COA. Evaluation criteria should be measurable and observable. During the analysis phase, a COA is assessed against each evaluation criterion to determine advantages and disadvantages. This requires a definition of the distinction between advantage and disadvantage for each evaluation criterion. During the comparison phase, evaluation criteria form the categories in which COAs compare to one another.

Limitations

The following limitations represent weaknesses imposed by constraints beyond the scope, resources, or intent of this research:

1. Effect of time: This research is applicable to current Airland Battle doctrine and the corresponding command and control doctrine that addresses the tactical decision making process. The study recognizes that emerging Airland Operations doctrine may influence the validity of this research because current Airland Battle doctrine is the foundation on which the thesis hypothesis (the proposed evaluation criteria model) is built. The result of this limitation will not negate the value of the study, since it will expand the overall body of research conducted in tactical decision making, and can be used for future study.

2. Effect of research design: Both the derivation of theoretical requirements for an optimal evaluation criteria model and analytical measurement of the proposed model involves some subjective interpretation. Development of the proposed model directly relates to the science aspect of decision making. But,

> science is based on empiricism . . . . Thus, for science all evidence used for theories must come originally from the senses, and it must be possible for any person who has the normal sensory equipment . . . to be able to make the same observation. [4]

This study uses "evidence" gained <u>through observation and interpretation</u> of doctrine and related literature in order to develop a model. It also conducts analytical measurement of

the model through observation and interpretation of the model's application in a tactical scenario. Recognizing the subjective nature of this design, the effect of this limitation will be addressed in chapter six, Conclusions.

Delimitations

This study concentrates on the decision making process as it relates to the following imposed constraints:

1. Level of war: Tactical, as opposed to strategic or operational.

2. Spectrum of conflict: Mid to high intensity, as opposed to low intensity conflict and operations other than war.

3. Type of forces: Combat maneuver, as opposed to fire support (artillery, air defense), combat support, and combat service support.

4. Level of organization: Battalion (the rationale is based on the decision to analyze a line and staff organization that focuses only on close operations, as opposed to higher level organizations that must specifically address deep and rear operations as well[5]).

5. Type of organization: Infantry, defined as light, airborne, air assault, and ranger. Mechanized infantry, armor, and cavalry units are excluded from analysis due to significant differences in mobility and firepower factors.

6. Type of operations: Offensive in general; deliberate attack specifically. Defensive and retrograde

operations are excluded from analysis due to doctrinally different battlefield frameworks and separate planning considerations.

7. Time for decision making: This study focuses on the estimate as a process that aids the commander in his decision on the best COA from among at least two. Therefore, the scope of the study is limited to the deliberate process. Accordingly, "speed" of the estimate process will not be one of the determining factors for the optimal evaluation criteria model.

8. Analysis of foreign decision making methods: The study restricts the review and analysis of foreign methods to the following four: British, German, French, and Soviet. This is based on the need to analyze a variety of methods that allow both comparison and contrast, but are not so completely different as to lose continuity with respect to the basic problem solving process. This variety provides a degree of inductive strength to the thesis hypothesis. The British and German methods provide a process similar to the U.S., and have the added benefit of providing insight into the historical derivation of some current U.S. concepts within the estimate. The French method provides a similar process, but no historical connection. The Soviet method provides an excellent contrasting model because of its centralized process. However, all of these models are normative in that they allow simultaneous analysis of multiple COAs to determine a "best" solution.[4] Far eastern models are excluded because

they are either adaptations of the U.S., British, or French methods (South Korea, Malaysia, Indonesia), or so fundamentally different in procedure and approach that they preclude relevance to the "western" normative process (Chinese, Vietnamese).[27]

Significance of the Study

> The application of knowledge . . . is art. All arts . . . rest on science. War is both a science and an art; and, as for any art, we will apply it more effectively as an art if we understand the science underlying it.[28]

The purpose of this research focuses on improvement of tactical decision making within the parameters previously described. While this study expands the body of research in an area that has ever expanding importance on the modern battlefield, its significant contribution is that the resulting evaluation criteria model complements, rather than contradicts, the delicate art and science balance involved in effective tactical decision making.

> Creative imagination is the essential characteristic of genius . . . when coupled with dynamic energy, it produces an executive genius. When balanced by cool calculation, it makes a Great Captain.[29]

This study's resulting evaluation criteria model provides a framework to organize thought and increase efficiency during the tactical estimate process. However, the effectiveness of the model is predicated on the commander's underlying experience, skill, and judgment.

CHAPTER TWO

LITERATURE REVIEW

> [T]he origin of thinking is some perplexity, confusion, or doubt . . . . Given a difficulty, the next step is suggestion of some way out - the formulation of some tentative plan or project, the entertaining of some theory which will account for the peculiarities in question, the consideration of some solution for the problem. The data at hand cannot supply the solution; they can only suggest it. What, then, are the sources of the suggestion? Clearly past experience and prior knowledge.'
>
> John Dewey, How We Think, (1910)

Purpose

This chapter identifies information requirements and availability for the conduct of the research. It provides a doctrinal framework to establish perspective and approach for solving the research question. It isolates pertinent literature sources that provide the basis for sharpening the focus of the research, and demonstrates credibility through a broad grasp of the existing body of knowledge on the topic of tactical decision making. Finally, it refines the research problem through analysis of the information available and leads to the development of an evaluation criteria model for subsequent testing. In short, the literature review serves as the data at hand that provide a "suggestion" to solve the problem.

Method

In order to accomplish the above purpose, the chapter begins with a description of the research information needs. Next, it examines the three primary U.S. Army manuals that establish the doctrinal framework for tactical decision making at the infantry battalion level. Emerging command and control doctrine from the U.S. Army Combined Arms Command, selected foreign army decision making methods, Command and General Staff College decision making course literature, previous related research, and CTC reports are secondary sources that provide answers to the information needs and sharpen the focus of the research. Finally, the chapter concludes with an assessment of the information as it pertains to the development of a theoretically optimal evaluation criteria model for an infantry battalion during the estimate process.

Information Needs and Availability

Research on the optimal evaluation criteria model for an infantry battalion requires answers to the following (secondary research) questions:

1. What does doctrine and related literature reveal about the selection and use of evaluation criteria in the estimate?

2. What essential elements define the "best" COA, and how are these elements measured?

3. What are the doctrinal and theoretical requirements for the development of an optimal evaluation criteria model?

This information is available through three sources. First, the Combined Arms Research Library at Fort Leavenworth provides U.S. and foreign doctrinal literature, and pertinent related research on military command and control, tactical decision making, and the estimate of the situation. Secondly, the Command and General Staff College at Fort Leavenworth provides literature on current decision making course instruction as well as documentation on emerging command and control doctrine as it pertains to tactical decision making. The third source of information is the Center for Army Lessons Learned at Fort Leavenworth, which provides a data bank of reports from the CTCs. Information in these reports provides an assessment of the current state of tactical decision making based on unit rotation after-action reports.

Current U.S. Doctrine

There are three primary sources for a review of current U.S. Army doctrine as it applies to tactical decision making at the infantry battalion level. In descending hierarchy, they are:

1. FM 100-5, Operations
2. FM 101-5, Staff Organization and Operations
3. FM 7-20, The Infantry Battalion

FM 100-5

The logical place to begin the doctrinal review is with the U.S. Army's capstone doctrinal manual, FM 100-5, which describes Airland Battle doctrine as

> the Army's approach to generating and applying combat power at the operational and tactical levels. It is based on securing or retaining the initiative and exercising it aggressively to accomplish the mission. The object of all operations is to impose our will on the enemy - to achieve our purposes. To do this we must . . . achieve the higher commander's goals.[2]

The command and control system that supports the execution of Airland Battle doctrine describes the planning function as

> the initial basis of action . . . . Ideally, the initial plan for an operation will establish the commander's intent . . . . It will, however, leave the greatest possible . . . tactical freedom to subordinate leaders. The plan must therefore be flexible enough to permit variation by subordinates in pursuit of the commander's goals.[3]

The clear doctrinal emphasis on a flexible command and control system requires a commander to "know the intention of the commander two levels above him."[4]

In hierarchical form then, a central aspect linking Airland Battle doctrine, the supporting command and control system, and the general planning process therein is the notion that "[i]n every case, the only purpose . . . is to implement the commander's will in pursuit of the unit's objective."[5] With this clear emphasis on the central aspect of the commander's will, goal, and intent as an underpinning, the next section examines what the capstone manual reveals about the planning of tactical offensive operations.

Tactical Planning

FM 100-5 describes many general requirements for successfully planning tactical offensive operations, but it does not provide any specific guidance on the selection or use of evaluation criteria for determining the best COA during the estimate process. Analysis of the section entitled "Planning and Conducting Tactical Operations" results in the identification of several key concepts and models which, although inadequate for evaluation criteria purposes, provide insight into the doctrinal requirements for the optimal evaluation criteria model and an operational definition for the "best" COA.

First, this section of FM 100-5 continues to translate the central aspect of "commander's intent," and defines the sole measure of tactical success as the ability to achieve the higher commander's intent in terms of his definition of purpose, method for the force as a whole, and successful endstate relative to the terrain, the friendly force, the enemy, and time.

Secondly, this section of the manual describes the commander's requirement to take risks in order to "inflict heavy losses on the enemy and to retain the initiative."[7] However, the commander must minimize risk in order to preserve the force so that it is capable of achieving the commander's intent.[8] This implies that the commander must determine an acceptable level of risk during planning as it pertains to his definition of successful endstate within his intent.

Finally, this section describes three primary models that require the commander's consideration when planning tactical operations. The first model contains four subordinate models (sub-models). These models are:

1. Tenets of Airland Battle Doctrine
    a. Characteristics of Offensive Operations
    b. METT-T
    c. The Offensive Framework
    d. Battlefield Operating Systems
2. Airland Battle Imperatives
3. Dynamics of Combat Power

Each of these models represents a "scientific" aspect of warfare by providing a framework to organize thought. However, it is a "loose" framework that allows for considerable interpretation, or "art." Analysis of these models will demonstrate that although none of them serve as useful evaluation criteria, each provides a link to doctrinal requirements that help to define an optimal evaluation criteria model.

Tenets

The first model is the Tenets of Airland Battle Doctrine. Success on the battlefield depends on a unit's ability to fight in accordance with four basic tenets: initiative, agility, depth, and synchronization.[7]

Initiative. Initiative is characterized by the setting or changing of the terms of battle by action. At the

tactical level it requires a "willingness and ability to act independently within the framework of the higher commander's intent."[10] Initiative involves risk taking in two forms: "One is the risk of losing men and equipment to attain the mission. The other is that a chosen COA may not be successful, or even if successful, fail to achieve the desired effect."[11]

The first form of risk taking reinforces the notion that the "best" COA optimizes the level of risk to the force without exceeding the commander's determination of acceptable risk. The second form illustrates an important point that relates to decision criteria. By definition, a "legitimate" COA is a feasible way to accomplish the mission. One way to differentiate between several legitimate COAs is to weigh the risk of achieving the desired effect, or endstate as determined by the commander in his intent, and not simply the feasibility to accomplish the mission. Decision criteria used to determine feasibility of mission accomplishment are simply screening criteria, and are used to develop a legitimate COA in the first place.

During offensive operations, initiative requires the elements of surprise, concentration, speed, flexibility, and audacity.[12] These elements form a sub-model within the tenet of initiative called "Characteristics of Offensive Operations." While these elements fail to qualify as adequate evaluation criteria, they reinforce the concept that the comander's intent, and the carrying out of that intent by his

staff during tactical planning, is a key component in determining the "best" way to accomplish the mission.

Doctrinally, "all successful offensive operations are characterized by [each element]."[14] This implies that the elements are of value in developing feasible COAs (screening criteria), but of questionable value in determining the best COA from among several.

Each element in this sub-model addresses the "method" portion of commander's intent, or how the commander envisions the employment of the force as a whole in accomplishing the mission. Two examples that illustrate the link to the commander's intent are speed and flexibility:

> Speed is absoloutely essential to success . . . . [It] depends on the violent execution of the plan . . . , but it will also depend on full understanding of the commander's intent . . . . The attack must be flexible . . . . Subordinates must understand the higher commander's aims so well that they can properly exploit battlefield opportunities even when communications fail.[15]

Agility. The tenet of agility refers to the ability of friendly forces to act faster than the enemy. It is "a prerequisite for seizing and holding the initiative."[16] As applied to tactical decision making, agility is "as much a mental as a physical quality."[17] In order to overcome the friction of battle, leaders must continuously "read the battlefield, decide quickly, and act without hesitation."[18]

FM 100-5 provides a sub-model to assist tactical commanders in "reading the battlefield" during any situation. This sub-model is called "METT-T," and is composed of five factors: (M)ission, (E)nemy, (T)errain and weather, (T)roops,

and (T)ime available.'[8] While these factors do not constitute adequate evaluation criteria for use in determining the best COA during the estimate, this form of guidance is a bit more concrete than words like "audacity," and provides key doctrinal and theoretical requirements for the development of an optimal evaluation criteria model for this study. This next section will first explain the METT-T considerations as they apply to the infantry battalion during offensive operations, then discuss the resulting key doctrinal and theoretical requirements for the development of an optimal evaluation criteria model.

In FM 100-5, the section entitled "Planning, Preparing, and Conducting Attacks" provides an explanation of the METT-T factors as they apply to the tactical unit level during the estimate of the situation.

The mission is what the unit must acomplish. It is restated to contain the elements of WHO, WHAT, WHERE, WHEN, and WHY.

The enemy factor relates to an evaluation of who the enemy is (unit, size, type), and how he fights (doctrine). The goal of enemy analysis is to identify enemy intentions and capabilities.

The terrain factor requires analysis of terrain for its military application (observation/fields of fire, cover/concealment, obstacles, key terrain, and avenues of approach), and for its effect on both friendly and enemy COAs.

The weather is considered for the same reasons and focuses on visibility, precipitation, wind, temperature, and clouds.

The troop factor relates to combat power in terms of relative mobility, protection, firepower, and leadership. Combat power is another, and more "scientific," doctrinal model that is described later in this chapter. The analysis of friendly forces available is essential to establishing what a unit is capable of doing.

The time factor drives tactical planning and execution for all military operations. Analysis of this factor determines the critical time aspects of the operation. This factor is most closely linked to the tenet of agility--the ability to act faster than the enemy.

The METT-T model provides great potential use in this study because it highlights key doctrinal and theoretical requirements for developing an evaluation criteria model designed to help determine the best COA during the estimate. The key requirements are that any valuable evaluation criteria model must be measurable, observable, and adaptable to any situation, because "every situation encountered in war is likely to be exceptional."[19] The METT-T model is the doctrinal method for assessing <u>any</u> situation, and its elements are measurable (even if subjective) and observable.

<u>Depth</u>. This next tenet refers to the extension of operations in time, space, and resources.[20] During tactical planning, commanders must "see beyond the requirements of the moment, actively seek information on the area and the enemy in

depth, and employ every asset available to extend their operations in time and space."[21]

FM 100-5 provides a sub-model to assist commanders in planning offensive tactical operations in depth. It is called the "Offensive Framework." At corps and division level, the framework consists of close, deep, and rear operations. Since this study focuses at the battalion level, only close operations apply.[22] Within the close operations framework, commanders plan the use of the following three complementary elements:

1. A main attack with supporting attacks as required.
2. Reserve operations in support of the attack.
3. A reconnaissance and security operation forward and to the flanks and rear of the main and supporting attacks.[23]

While the tenet of depth and its supporting offensive framework sub-model provide a guide for developing feasible COAs (and therefore are of value with regard to screening criteria), and even relate to the "method" portion of commander's intent, they do not provide any guidance about the selection or use of evaluation criteria.

Synchronization. The final Airland Battle tenet is synchronization, which is the arrangement of battlefield activities in time, space, and purpose to produce maximum relative combat power at the decisive point.[24] "Synchronization is both a process and a result. Commanders synchronize activities; they thereby produce synchronized operations."[25] The "Battlefield Operating Systems" (BOS) sub-

model provides the commander a tool to synchronize battlefield activities.[26]

There are seven BOS elements that serve as a common base for the grouping of subordinate activities. These elements can be reduced to a common denominator of time:

1. Intelligence
2. Maneuver
3. Mobility, Countermobility, Survivability
4. Fire Support
5. Air Defense
6. Command and Control
7. Combat Service Support

Like all previous primary and subordinate models, the BOS model provides a guide for developing feasible COAs, and even helps improve COAs during the wargame through the synchronization of battlefield activities. However, it does not constitute an adequate evaluation criteria model to facilitate the observable, measurable determination of which COA is best.

Airland Battle Imperatives

The second primary model from FM 100-5 that requires the commander's consideration when planning tactical operations is called Airland Battle Imperatives. The ten imperatives are:

1. Ensure unity of effort.
2. Anticipate events on the battlefield.
3. Concentrate combat power against enemy vulnerabilities.

4. Designate, sustain, and shift the main effort.
5. Press the fight.
6. Move fast, strike hard, and finish rapidly.
7. Use terrain, weather, deception and OPSEC [operational security].
8. Conserve strength for decisive action.
9. Combine arms and sister services to complement and reinforce.
10. Understand the effects of battle on soldiers, units, and leaders.[27]

One can almost detect a blending of some of the models previously discussed.

> These imperatives provide more specific guidance than the principles of war and Airland Battle tenets, and they apply to all operations. They are historically valid and fundamentally necessary for success on the modern battlefield.[28]

It is precisely for these reasons that the imperatives do not qualify as adequate evaluation criteria. By the very nature of the term "imperative," they represent <u>screening</u> criteria that separate legitimate COAs from those that will not accomplish the mission. If they were used as <u>evaluation</u> criteria to compare COAs in order to determine the best, four things are evident. First, each COA should adhere to each imperative. Secondly, distinction between COAs is only possible if they adhere to the imperatives in varying degrees. Next, it would be difficult, if not impossible, for a commander to predetermine the "cutoff degree" that separates advantage from disadvantage in terms of a COA's adherence to any particular imperative. Finally, few of the imperatives are measurable or observable.

Dynamics of Combat Power

The last primary model from FM 100-5 relevant to this study is called Dynamics of Combat Power. Combat power decides the outcome of battles and engagements at the tactical level, and is considered the unit's ability to fight. It measures the effect created by combining the elements of maneuver, firepower, protection, and leadership in combat action against an enemy.[29] In measuring the effects created by combinations of the four elements, there is doctrinal emphasis on both the quantitative and qualitative aspects of each element.[30] The elements of friendly force combat power are always relative, and have meaning only as compared to the enemy's combat power.

Maneuver is a function of unit mobility, tactical analysis, resource management, and command / control / communications. It requires knowledge of the terrain and the enemy, logistical support, and flexibility. Maneuver ties to firepower.

Firepower is the actual employment of weapon systems and is a combination of volume of fires, lethality, and weapon systems flexibility. Firepower effects directly contribute to maneuver. Elements that make up the firepower effect variable include target acquisition systems, command and control, adequate ammunition supply, firepower delivery means, and the necessary mobility to range critical targets on the battlefield.

Protection is the sum of defensive measures taken to preserve friendly fighting potential. It has two components. First, protection consists of those actions taken to hide or secure forces. The second component is made up of those things done to maintain the health and fighting spirit of friendly soldiers. Protection is designed for people, equipment, and units.

Leadership is the "most essential element of combat power."[31] It provides purpose, direction, and motivation in combat. It is the "overall effect the leader creates on the battlefield vis-a-vis the enemy through the proper application of his potential maneuver, firepower, and protection capabilities which generates relative combat power."[32]

In a paper entitled "Understanding and Developing Combat Power," by Colonel Huba Wass de Czege, a method identifying analytical techniques for the application of each combat power element provides a "scientific" framework to assist tactical decision makers. This model is depicted in figure 4. It is unique in that it argues against the opposing methods of "gut feel" and "cookie cutter" by placing a heavy emphasis on the intangible factors that temper objective measurement. It "supplements but does not replace the . . . decisionmaking process or the wargaming methodology . . . to analyze courses of action."[33]

Each variable in the model is a factor for the decision maker to consider during the wargame in order to analyze COAs. This model, combined with "scientific" wargame

1. FIREPOWER EFFECT: (Which is a function of)

a. Volume of Fire: Number of delivery means. Supply capability. Rate of fire of weapon systems. Lethality of Munitions: Design characteristics. Explosive energy.
b. Accuracy of Fires: Weapon and munition design. Crew proficiency. Terrain effects. Visibility.
c. Target Acquisition: Intelligence and intelligence analysis. Location and functioning of observers and sensors. Transmission of target data.
d. Flexibility of Employment: Weapons ranges. Mobility. Signature effects. Fire control systems. Tactical employment doctrine.

2. MANEUVER EFFECT: (Which is a function of)

a. Unit Mobility: Physical fitness and health of soldiers. Unit teamwork and esprit. Equipment capabilities. Equipment maintenance. Unit mobility skills.
b. Tactical Analysis: Intelligence and knowledge of enemy tactics. Understanding terrain effects and own unit capabilities.
c. Management of Resources: Utilization of equipment, supplies, personnel, time, and soldier energy.
d. Command, Control, Communications: Span of control. SOPs and doctrine. Staff and communications efficiency.

3. PROTECTION EFFECT: (Which is a function of)

a. Concealment: Camouflage. Stealth. Equipment design. Counter enemy intelligence acquisition means.
b. Exposure Limitations: Minimize potential target size and exposure time. Complicate potential target tracking.
c. Damage Limitations: Individual protective equipment design and use. Use of natural or artificial cover. Combat vehicle design. Medical treatment and evacuation system. Combat equipment cannibalization and repair. Alternate C^2 arrangement. Providing personnel and materiel replacements. Miscellaneous efforts to maintain continued combat effectiveness.

4. LEADERSHIP EFFECT: (Which is a function of)

Technical proficiency, understanding unit capabilities, analytical and communication skills, dedication, commitment, moral force, and understanding battlefield effects.

Figure 4. Combat Power Model.

planning factors (movement, fuel consumption, casualty, and combat power ratio), and tempered by the experience and skill of the wargamers, can improve the realism of the wargame. However, it provides only part of the answer in determining the best COA. It is used during the wargame, and not as a set of criteria to measure the results of the wargame for comparison of COAs.

While the combat power model offers only limited value for use in developing evaluation criteria, it does highlight three doctrinal requirements for the development of an optimal evaluation criteria model. First, it highlights the quantitative and qualitative nature of measurement. This suggests that the optimal evaluation criteria model will contain both objective and subjective criteria. Secondly, it provides insight into the key concept of relativity. This suggests that measurement of the "best" COA is always relative to the situation (METT-T). Finally, it reemphasizes the commander's central role (leadership) in determining what the "best" COA should be. In other words, the optimal model should focus the staff and result from the commander's determination of what is most important "up front," and not simply at the end of the estimate when he makes his decision.

FM 101-5

The second primary doctrinal manual that provides answers to information needs in this thesis is FM 101-5. This manual describes the military decision making process as a problem solving process where

> [s]ound decisions result only from a thorough, clear, unemotional analysis of all the facts and assumptions relating to the situation. A systematic approach to problem solving assists in applying thoroughness, clarity, judgment, logic, and professional knowledge to the task.[34]

This section will review the estimate process prescribed in the manual, demonstrate the manual's ambiguity concerning evaluation criteria models, and reinforce several doctrinal requirements for the development of an optimal evaluation criteria model for an infantry battalion during the estimate.

FM 101-5 highlights the difference between the commander's estimate and the staff officer's estimate during the decision making process. The commander's estimate

> results in a decision on how to accomplish a given mission. After considering METT-T and other relevant factors, a decision is reached. The estimate is based on personal knowledge of the situation, on ethical considerations, and on staff estimates.[35]

The staff officers' estimates

> analyze the influence of factors within the staff officer's particular field of interest on accomplishment of the mission and identify those factors that effect formulation, analysis, and comparison of feasible courses of action. The staff estimate results in conclusions and recommendations which identify feasible courses of action.[36]

This definition of staff estimates demonstrates more of a focus on the <u>screening</u> criteria that identify and substantiate the supportability of feasible COAs, than on the <u>evaluation</u> criteria that identify which COA is best. In fact, the manual states that a commander may have to make the decision without the benefit of staff interaction.[37] This demonstrates that the commander's estimate, which is step five in the military

decision making process, is the hub of the entire process and the focus of the following analysis.

Process

The commander's estimate contains five paragraphs that equate to methodical steps in the problem solving process.

Paragraph one is "MISSION." It is the unit's restated mission and becomes the basis for all further estimates.[34] The mission paragraph does not mention any consideration of higher commander's intent or identification of evaluation criteria that can later assist in analysis or comparison of COAs. Additionally, formulation of commander's intent and determination of an acceptable degree of risk are noticeably absent from this paragraph.

Paragraph two is "SITUATION AND COURSES OF ACTION." It is an analysis of considerations affecting the area of operations, and possible enemy and friendly COAs. In this paragraph the commander analyzes both the enemy and friendly situation. The final portion of the paragraph describes an analysis of relative combat power, and the development of enemy and friendly COAs.[35]

This paragraph fails to identify any specific factors, or evaluation criteria, that can be used later in COA analysis or comparison. It does not provide guidance for determining what constitutes advantages or disadvantages in relation to a friendly COA. It addresses relative combat power, but

provides no guide to quantitative or qualitative analysis of combat power.[40]

Paragraph three analyzes COAs through the wargame process. During wargaming, each friendly COA is "mentally fought" against, at the minimum, the most probable enemy COA. The commander considers the "degree of success" in the face of enemy opposition, and the "degree of risk and its acceptability" for each COA.[41] During this step, the manual clearly states that the commander will not yet compare COAs, but will attempt to "visualize and . . . discover strengths and weaknesses of each course of action."[42] On completion of the wargame, several key results emerge:

1. Requirements for COA improvement.

2. Probable outcome in terms of friendly / enemy action, attrition, location, and time.

3. COA advantages and disadvantages.

The wargame process and results highlight several points key to this research. First, "degree of success and risk" seem to be the only two discernable factors on which the commander bases his advantage / disadvantage assessment. These two factors are clearly elements that the commander defines, and establishes thresholds for, in the "endstate" portion of his intent. Secondly, the wargame's outcome is expressed in terms that are also defined by the "endstate" portion of the commander's intent. Next, the probable outcome emphasizes that friendly action, attrition, location, and time are relative to the same for the enemy. This indicates that

it is possible to measure a friendly COA in relation to its effect on the enemy, attrition, terrain, and time. Finally, the determination of advantages and disadvantages comes at the end of the wargame, or analysis, without any prior definition of the criteria that determine advantage from disadvantage." Are 20% friendly losses at the conclusion of the wargame an advantage or a disadvantage? It would be easy to call this a disadvantage if another COA resulted in only 10% losses, but in the analysis step the advantages and disadvantages of a COA are supposed to be determined without comparison to other COAs.

In paragraph four, the commander compares COAs in order to determine which is best. "He uses his judgment, skill, and experience in making this comparison."[44] He lists advantages and disadvantages that emerged during analysis. This paragraph suggests two methods. The first lists each COA with all the advantages and disadvantages. The second isolates "certain significant factors (such as terrain, time, nuclear vulnerability, and own dispositions)"[45] and discusses all COAs for each factor. Here is the first doctrinal mention of an evaluation criteria model. The manual clearly states that when using the second method, the commander "first determines decisive factors in the situation confronting him because there is no list of significant factors applicable to all situations."[46] Figure 5 is an extract from FM 101-5 showing these two models.

COURSE OF ACTION	ADVANTAGES	DISADVANTAGES
COURSE OF ACTION 1	Main attack avoids major terrain obstacles. Adequate maneuver room for main attack and reserve.	Main attack faces stronger resistance at beginning.
COURSE OF ACTION 2	Main attack gains good observation early. Supporting attack provides flank protection to main attack.	Initially, reserve may have to be employed in zone of supporting attack.
DISCUSSION		

COURSE OF ACTION	SIGNIFICANT FACTORS			
	Dispositions	Weather/Terrain	Supporting Attack	Obstacles
COURSE OF ACTION 1	Avoids main enemy strength.	Not the best avenue of approach to division objective.	Relies heavily on success of supporting attack.	Encounters a limited number of artificial obstacles.
COURSE OF ACTION 2	Hits main enemy strength.	Best of the avenues of approach to division objective being considered. Secures dominant terrain.	Not as dependent on success of supporting attack.	Encounters a large number of artificial obstacles.
Favors	Course of action 1 over course of action 2.	Course of action 2 over course of action 1.	Course of action 2 over course of action 1.	Course of action 1 over course of action 2.

Figure 5. Sample Decision Tables. These tables display two types of evaluation criteria models extracted from FM 101-5.

The following key points emerge from an analysis of FM 101-5's paragraph four:

1. The advantage / disadvantage decision matrix can result in a comparison of "apples to oranges." Without prior definition, the criteria that result in identification of advantages and disadvantages in this matrix are merely an intuitive guess that the commander uses as he assesses the results of the wargame.

2. The selection of evaluation criteria in the second form of decision matrix comes at the end of the process. Therefore, these criteria apply only to the commander's estimate. Since the commander selects them at the end of the process, he cannot use them during his analysis of the individual COAs prior to comparison of all COAs. This goes against the fundamental value of evaluation criteria in the problem solving process.

3. Since the commander selects evaluation criteria at the end of the process, the staff cannot use these critical factors during the analysis and comparison steps of their individual staff estimates. This can result in a divergence between the staff and commander as both proceed through the estimate. In other words, key information that should guide and focus the staff during the estimate process is withheld until it may be too late for effective integration and application.

4. Although FM 101-5 states that no standard list of evaluation criteria, or significant factors, is applicable

to all situations, the wargame always results in a probable outcome measured in terms that are clearly defined in the commander's intent format. This would therefore indicate that, at least in the basic form of enemy, force, terrain, and time, it is possible to establish evaluation criteria that are applicable to all situations.

Summary

FM 101-5 applies the problem solving methodology to the estimate, but it deviates from this methodology concerning evaluation criteria. Although it mentions an evaluation criteria model as a recommended technique, it is ambiguous with regard to the way evaluation criteria are selected, and it places the selection of criteria at the end of the process so that these critical factors are not available in two key areas; during the commander's analysis step, and during his staff's estimates. This can result in an ineffective and diverging process between the commander and his staff.

Although the manual clearly states that development of a standard evaluation criteria model is not possible, it reinforces the opposite view. First, it highlights the central role that certain elements of the commander's intent play in determining inherent advantages and disadvantages of COAs. Secondly, it points to a method of measuring a COA against criteria that are derived from the commander's intent, and available for consistent measure of any COA.

FM 7-20

The final primary doctrinal manual applicable to this research is FM 7-20, The Infantry Battalion. This manual presents doctrine for light, airborne, air assault, and ranger infantry battalions during in combat situations. Section II of the manual concerns the command and control process, and defines planning, the decision making process, troop leading procedures, and the estimate of the situation as they pertain to the infantry battalion level. This section of the literature review will analyze the decision making process outlined in FM 7-20, and discuss key concepts as they relate to the information needs. It will conclude with an assessment of the information.

Process

FM 7-20 provides a detailed procedure for tactical planning and decision making at the infantry battalion level. The procedure recognizes the rapidly changing situation in a combat environment. Commander's intent and common doctrine/volcabulary are the two underlying concepts that reduce the effect that the fog and friction of combat have on a unit's tactical decision making effectiveness.[47]

The commander and his staff use troop leading procedures and command and staff actions to make decisions. The process begins and ends with the commander, is dynamic, and requires the commander to know the troop leading procedures and METT-T[48]. Upon receipt of a mission, the

infantry battalion initiates the decision making process in order to plan and prepare for combat. The relationship between troop leading procedures, the estimate of the situation, and METT-T during this process is illustrated in figure 6.[49]

The estimate of the situation forms step three, "Make a Tentative Plan," of the troop leading procedures. Within the estimate, there are five steps that relate directly to the five paragraphs of the commander's estimate described in FM 101-5, as well as the problem solving methodology described in chapter one of this thesis. The time available and the planner's experience determine the thoroughness of the estimate, but no matter how short the time, each step of the estimate must be at least considered.[50] What follows is a brief review and analysis of each of the five steps described in FM 7-20. Comments will focus on key differences between these steps and the five paragraphs of FM 101-5, as well as key concepts that relate to this study's information needs.

The first step of the estimate is mission analysis. It is the means for the commander to gain an understanding of the mission. Two key products result from this step; the restated mission, and the commander's intent. Unlike FM 101-5, the procedure for applying this step focuses on task analysis and issuance of initial planning guidance.

Task analysis, a subordinate step with mission analysis, identifies all tasks required for success during the operation. Tasks may be specified or implied (not directly

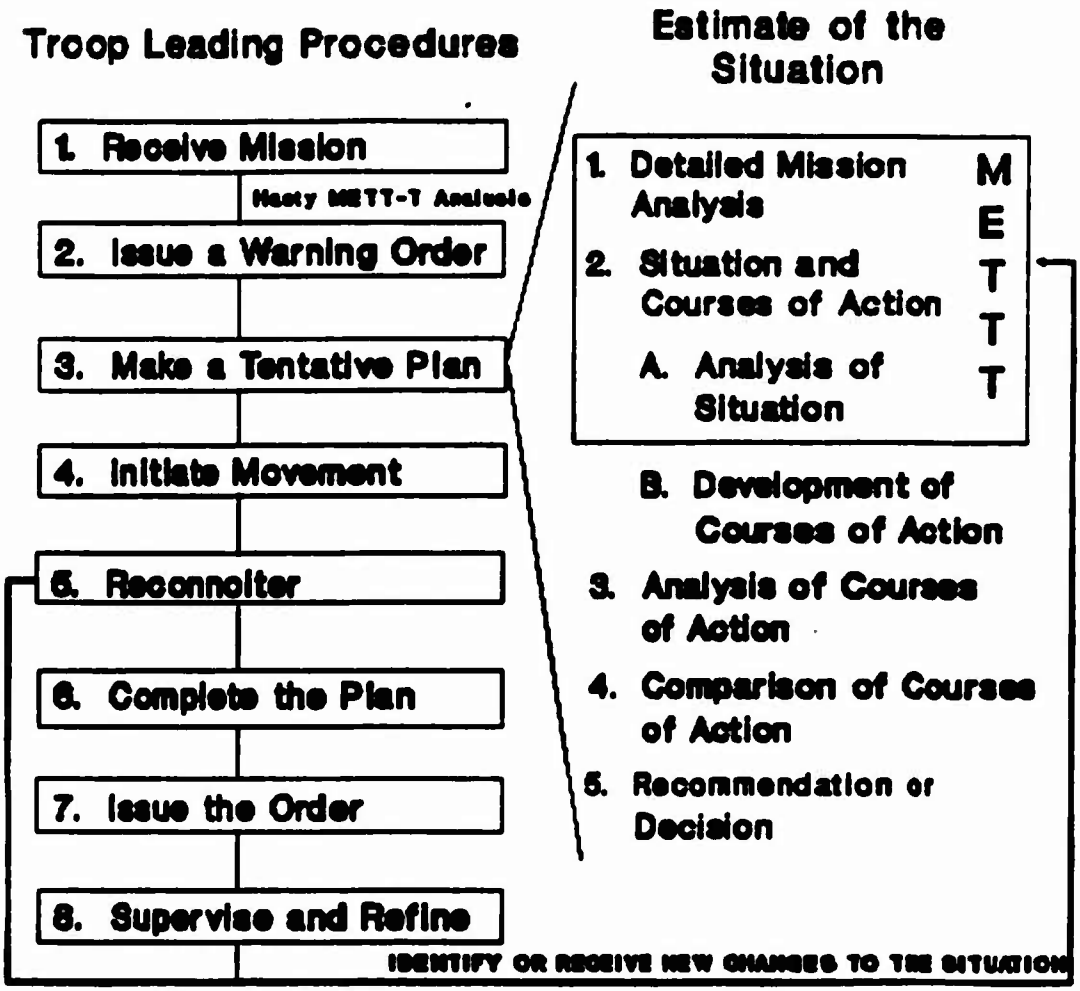


Figure 6. Correlation of Troop Leading Procedures / Estimate of the Situation / METT-T.

stated) in the higher level operations order, but all tasks are oriented as to terrain, enemy forces, friendly forces, or a combination of these factors. Figure 7 illustrates this correlation of METT-T as it applies to doctrinal task terminology. Within the focus of the METT-T correlation, mission analysis ends with the formulation of a restated mission, which identifies the essential task(s) that, if not accomplished, could cause the unit to fail to accomplish its primary purpose for the operation.

Having completed the mission analysis step, the commander issues initial planning guidance to focus the staff's efforts and speed the development of feasible COAs. Although the manual states that the commander's initial intent "provides a framework for the remainder of . . . the estimate process,"[51] the section on "Commander's Guidance" curiously omits any mention of the role that commander's intent provides to focus the staff in subsequent steps of the estimate. In fact, there is no mention of where the commander issues his initial intent during this, or any subsequent portion of the estimate.

Step two is an analysis of the situation and formulation of feasible courses of action. Unlike FM 101-5's focus on relative combat power during this step, this manual again highlights the key role that the METT-T model provides in both analysis of the situation and influence on COA feasibility.[52]

TERRAIN	ENEMY	FRIENDLY	COMBINATION TERRAIN/ENEMY
Seize	Destroy	Overwatch	Reconnoiter
Secure	Neutralize	Screen	Deny
Occupy	Suppress	Cover	Contain
Retain	Disrupt	Guard	Isolate
	Fix	Clear	
	Interdict		
	Breach		
	Feint		
	Demonstrate		
	Block		
	Canalize		
	Isolate		

Figure 7. Correlation of METT-T to Doctrinal Terminology.

After situation analysis, planners should develop two or more COAs. Each COA must be feasible, reasonable, and distinguishable. According to FM 7-20, a feasible COA "must accomplish the mission and support the commander's intent."[53] A reasonable COA does not cause "undue harm to the battalion."[54] The "distinguishable" feature requires the various courses of action to "differ in missions assigned to subordinates to allow the consideration of options. Planning one good course of action then planning others that are not feasible or are like the first is a common pitfall."[55] These elements of feasibility, acceptability, and distinguishability are, in essence, screening criteria. The reference to "commander's intent" and "undue harm" highlight an important point. Up to this point in the estimate process that FM 7-20 prescribes, the commander has not yet issued his initial intent or his determination of the acceptable level of risk.

Step three is the analysis of COAs. The wargame is the primary vehicle for analysis. "Short of combat, the wargame is the best test of a course of action."[56] Wargaming relies heavily on the commander and staff's tactical judgment and experience, but is a step by step process similar to that described in FM 101-5. However, there are some significant differences.

According to FM 7-20,

> the S-3 must . . . select criteria (significant factors) that are used to analyze the courses of action. The degree to which a course of action satisfies a significant factor results in an advantage or disadvantage for that

> . . . course of action. This information helps the commander select the best course of action. The significant factors the commander/S-3 selects help him . . . evaluate the overall concept of each course of action during the wargame. As the planner wargames, he asks for each factor, "Does the course of action accomplish this?" For the wargame to be manageable the number of significant factors should be small. Three to seven are enough. For courses of action to be compared to a common standard, the same significant factors must be used to wargame all courses of action. These factors include mission-specific factors, doctrinal fundamentals, the commander's planning guidance, or any other criteria that the commander/S-3 deems appropriate for this specific situation.[87]

The manual provides a criteria model that is structured from the METT-T model, but adds the factor of logistics. Figure 8 illustrates the criteria by factor. This model is designed to help identify COA advantages and disadvantages without comparison to other COAs.

Analysis of this step leads to several points that are pertinent to this study. First, the wargame results in a subjective probability of success for each COA without regard to comparison with other COAs. The wargame uses objective measurements that are tempered by subjective judgment and experience. This results in a prediction of the COA's endstate relative to the status of the enemy, the force, the terrain, and time. However, the predicted measure of success cannot be compared to the commander's desired degree of success if he has not yet issued his initial intent.

Secondly, many of the evaluation criteria (significant factors) depicted in this manual's model are actually screening criteria. As an example, if the COA "will not

Mission

- Will COA accomplish mission?
- Is COA within commander's intent?
- Is COA restrictive or flexible?
- Does COA allow for follow-on mission posture?
- Is COA within constraints?

Enemy

- Does COA exploit weakness?
- Will COA limit enemy capabilities?
- How will COA affect enemy morale or will to fight?
- How will COA affect enemy intentions?
- How will COA affect enemy reserves, reaction, or both?

Terrain and Weather

- How does COA use avenues of approach?
- How does COA use cover and concealment?
- How does COA use or avoid obstacles?
- How does COA use key or decisive terrain?
- How does COA use ground conditions, speed of movement?
- How does COA facilitate fire and control of movement?
- How is COA affected by weather and visibility?
- How is COA affected by availability of PZs, LZs, and DZs?

Troops

- How does COA use number and type?
- How does COA use location and disposition?
- How does COA use past performance?
- How does COA use leadership and morale?
- How does COA use level of training and discipline?
- How does COA use combined arms?
- How does COA use CS and CSS assets?
- How does COA facilitate task organization?

Time

- How simple or complex is COA?
- Does COA provide adequate time for movement?
- Does COA provide adequate time for preparation and planning?
- Does COA limit enemy reaction time?
- Does COA meet time limitations imposed by higher?
- Does COA provide time for synchronization of the battle?
- Does COA provide time for limited visibility operations?

Logistics

- How does supply availability affect COA?
- How does transportation availability affect COA?
- How does maintenance availability affect COA?

Figure 8. Evaluation Criteria Model in FM 7-20.

accomplish the mission," it is not a legitimate COA at all. Additionally, most of the model's criteria are neither measurable nor observable, and none of them define the difference or degree between advantage or disadvantage.

Finally, the S-3 selects the criteria. If the commander disagrees with his selection, or if the rest of the staff is unaware of the S-3's focus, analysis of COAs by the planning group can result in a diverging process rather than a focused one, as it is intended.

Step four of the estimate compares COAs. FM 7-20 recommends a comparison matrix for this step, and discusses the weighting of significant factors. The comparison matrix uses the same list of significant factors that was developed in step three as the evaluation criteria, and compares each COA to summarize the results of the analysis and comparison steps. Figure 9 illustrates this model.

According to the procedure, the commander/S-3 determine if any of the criteria are more important than others based on the situation, and weight the criteria appropriately to indicate the importance of one or more factors over others.

Analysis of step four indicates that the recommended model fails to translate advantages and disadvantages discovered during step three. It is conceivable that a significant disadvantage common to all COAs for a particular criterion will lose its effect in a simple comparison that rank orders the COAs for that criterion. Additionally, the

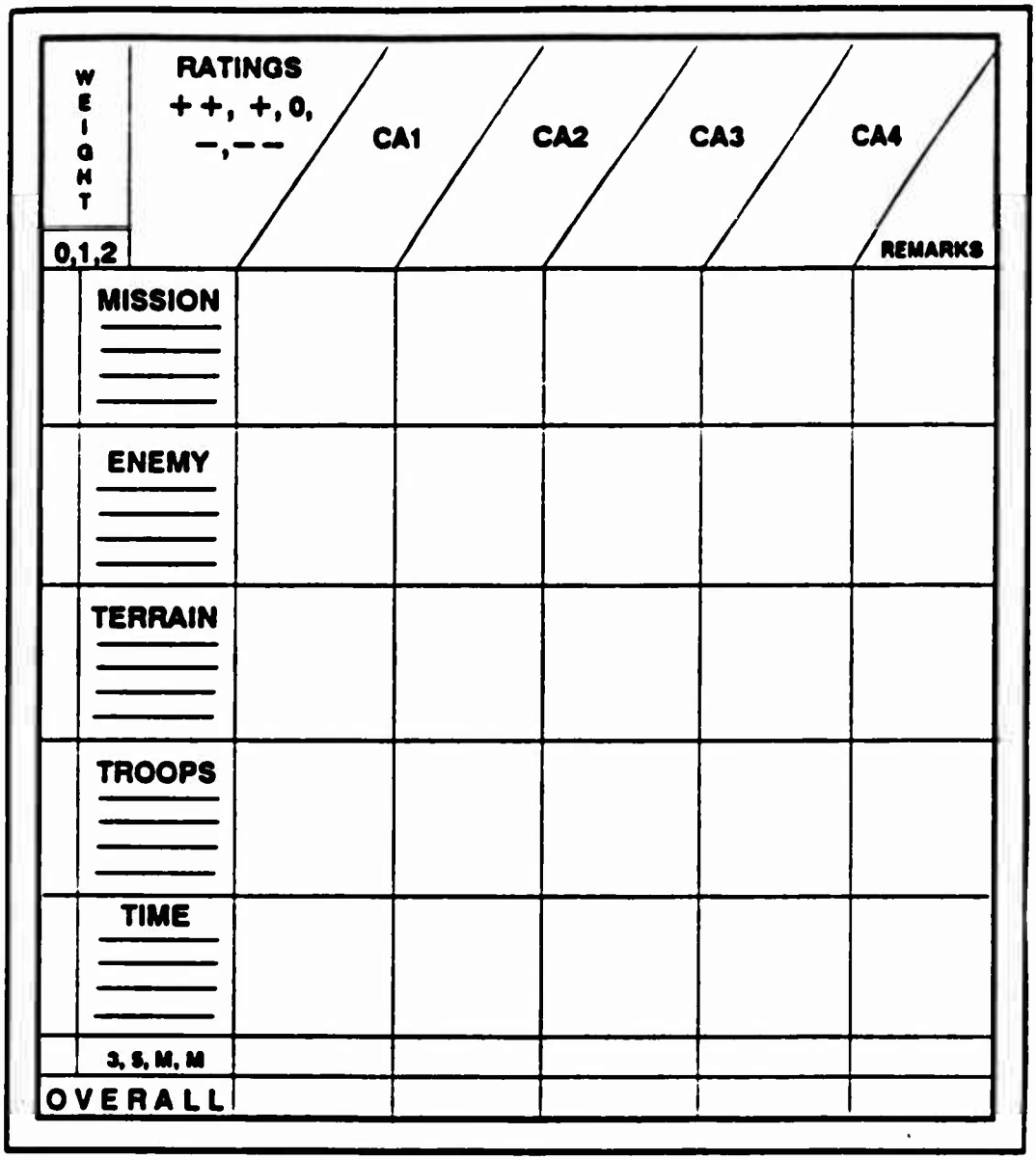


Figure 9. Decision Matrix and Evaluation Criteria Model in FM 7-20.

issue of who weights the criteria again points out the possibility of a diverging process.

The final step in the estimate process is the decision. The staff recommends the best COA and the commander decides. In his recommendation, the S-3 "considers other staff estimates so his recommendation represents a coordinated staff position."[88] This is the first place that other staff estimates are mentioned, and there is no guidance or method for the purpose or process of the staff estimates in this manual.

Summary

FM 7-20 provides a tactical decision making procedure that parallels that of FM 101-5, and is relatively consistent with the problem solving process. However, it provides a model for the selection and use of evaluation criteria during the estimate that is separate and distinct from FM 101-5. The model in FM 7-20 mixes screening and evaluation criteria, provides no guidance on the method of determining advantages or disadvantages for each criterion, contains few criteria that are measurable or observable, can lead to a diverging process because of ambiguity regarding who selects and weights the criteria, and fails to provide a link to the central doctrinal concept that defines success for any organization or mission--the commander's intent.

Analysis of this manual reiterates several important doctrinal and theoretical requirements for the development of

an optimal evaluation criteria model. Although absent from the estimate procedure, the manual reinforces the pivotal role that commander's intent and METT-T provide in tactical decision making. It implies a requirement that the "best" COA must be consistent with doctrine in order to effect unity of effort through a common understanding and language. It highlights the commander's requirement to provide focus to the staff's efforts early the estimate process. It recognizes the wargame as the best method for predicting and measuring a COA's probability of success based on a careful combination of subjective and objective elements. Finally, it reveals a decision making process that first requires analysis of all COAs based on a common set of criteria, and then comparison of COAs with regard to the same criteria.

Secondary Sources

With a current doctrinal framework now established, this section of the literature review examines emerging U.S. Army command and control doctrine, selected foreign army decision making methods, Command and General Staff College decision making course instruction literature, previous related research, and CTC reports in order to sharpen the research focus, as well as to provide answers to the study's information needs.

Emerging C^2 Doctrine

There are only two sources for emerging command and control doctrine in the U.S. Army that pertain to this study.

Both sources come from the Combined Arms Command / Command and General Staff College at Fort Leavenworth. The first source is a coordinating draft of FM 101-5 in the Concepts and Doctrine Directorate, which presents an evolutionary approach to the current decision making process. The approach is evolutionary because it does not significantly change the basic steps in the deliberate estimate as depicted in current doctrine. However, it does address alternative methods for conducting the estimate under time and staff experience constraints. The second source is still in the conceptual stage, and comes from the Center for Army Tactics. This source represents a revolutionary approach because of its radical departure from the current estimate process. Analysis of these two sources will focus only on the evaluation criteria models they contain and the resulting implications for this study.

Draft FM 101-5

Figure 10 illustrates the evaluation criteria model in the draft FM 101-5. This model depicts a combination of the principles of war, Airland Battle imperatives, and the BOS. It incorporates the "weighting" concept as described in FM 7-20. The draft manual states that either the commander or staff may assign criteria pertaining to the mission, and that the principle staff officers assign numerical values for each criterion in order to reflect the relative advantages or disadvantages of each criterion for each COA. It states that

CRITERIA	WT	COURSES OF ACTION 1	2	3
Simplicity	2	2 / 4	1 / 2	4 / 8
Surprise	3	1 / 3	3 / 9	2 / 6
Speed	5	2 / 10	3 / 15	5 / 25
Mass	1	1 / 1	2 / 2	1 / 1
Combined arms	1	3 / 3	4 / 4	3 / 3
Security	1	1 / 1	2 / 2	2 / 2
CSS	2	2 / 4	3 / 6	4 / 8
Objective	1	4 / 4	4 / 4	4 / 4
C^2	1	3 / 3	2 / 2	1 / 1
Offensive	1	2 / 2	2 / 2	1 / 1
Total / Weighted total		21 / 35	26 / 49	29 / 61

Figure 10. Decision Matrix and Evaluation Criteria Model in FM 101-5 (Coordinating Draft).

the commander is responsible for weighting the criteria based on their relative importance. The resulting decision matrix is meant to provide a graphic portrayal of subjective indicators, and not absolute or objective measurements.[78]

Analysis of this model reveals several of the same problems identified earlier. First, the options for criteria (BOS, Principles of War, Tenets, Imperatives, etcetera) are not measurable or observable, making determination of advantages and disadvantages difficult, and are usually not productive except by "gut feel." Secondly, the problem of who assigns the criteria again raises the possibility of a diverging process. Finally, the most important and unifying factor of all is not specifically addressed. The commander's intent serves no apparent role in this model.

The "Revolutionary" Model

Figure 11 illustrates the evaluation criteria model in the "revolutionary" decision making doctrine concept. This model uses three simple criteria: suitability, feasibility, and acceptability.[79] Unlike the current estimate process, this new approach provides a rapid procedure that begins with the commander formulating a concept to accomplish the mission. The concept is subjected to a suitability test to determine if it will accomplish the mission and is within the higher commander's intent. This is done primarily "by inspection." Next, the staff examines the concept to determine if it is feasible. This test is quantitatively based on the

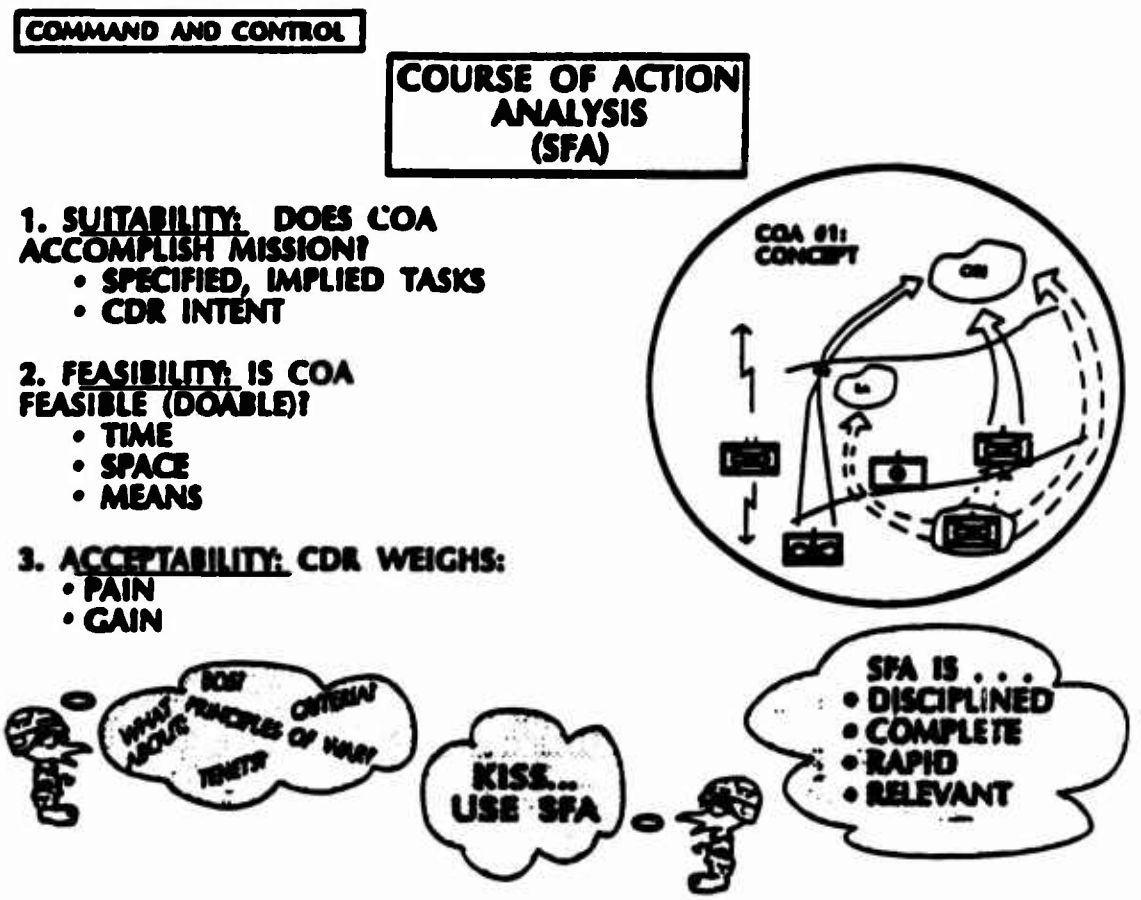


Figure 11. "Revolutionary" Concept for Evaluation Criteria Model.

interpretation of time, space, and means. Time and space calculations are based on objective planning factors. Assessment of means is based on the calculation of force ratios and estimates concerning losses. After determining if the concept is suitable and feasible, the commander and staff develop a COA (a developed concept) and conduct the wargame. After the wargame, the commander uses the final criterion to select a COA. Acceptability refers to the "pain versus gain" aspects of competing COAs. This is determined by comparing the advantages and disadvantages of the COAs, and is envisioned as being a rapid subjective and objective analysis to select the best one.

In essence, suitability and feasibility are nothing more than screening criteria. The only real evaluation criterion is acceptability. This determination is made by the commander. The staff's role is primarily limited to the scientific substantiation of the commander's concepts based on the planning considerations during the feasibility check. Furthermore, the discussion of the acceptability criterion provides no insight into what is going on in the commander's mind, other than the balancing of advantages and disadvantages for the various COAs. If the staff is going to help the commander determine which COA is best, which is their job in the current estimate process, they need to know what he considers important "up front."

Summary

Analysis of these two sources illustrates continuing disagreement on the selection and use of evaluation criteria. It highlights the confusion between screening and evaluation criteria, and provides no definition for the formulation of observable, measurable criteria that assist in the selection of the "best" COA.

Foreign Methods

This section examines four foreign army tactical decision making methods as they pertain to the selection and use of evaluation criteria. These four types consist of the British, German, Soviet, and French methods. The study limits analysis to these four as explained in chapter one (Delimitations).

British

The British method for the estimate is called an appreciation, and consists of five distinct steps that correlate loosely with the U.S. Army's estimate. The first two steps analyze what must be done by "(1) studying the existing situation and (2) specifying the aim to be attained."[61] The next three steps choose how the aim should be attained by "(3) examining and reasoning out all relevant factors, (4) considering all practicable courses, and (5) deciding on the best course of action to attain the aim."[62] A focus on step (2) and (3) will highlight points that are pertinent to this study.

Step (2) is considered to be the crux of the appreciation. Unless the aim is right, the whole appreciation may be worthless. While several things may need to be done at the same time, there must never be more than one aim. The aim must by kept in mind throughout the appreciation process, and all reasoning must relate to its attainment. The aim is different from the mission, and is more akin to the commander's intent within U.S. Army doctrine.

In step (3), a factor is described as "a circumstance, fact or influence contributing to a result."[63] Some factors considered include, but are not limited to, time, space, weather, surprise, comparison of forces, ground, logistics, communication, and morale. Each factor must be discussed in relation to the aim.[64]

Analysis of this method leads to a key point that is relevant to this study. While the British method provides only vague examples of evaluation criteria (factors), and states that its list of factors is not all-inclusive, it does reinforce the concept that each factor, or criterion, must be tied to the aim, or commander's intent (in U.S. doctrine).

<u>German</u>

The German estimate of the situation is a continuous and recurring process. It includes the following steps:

1. Analysis of the mission.
2. Estimate of the friendly and enemy situation.
3. Evaluation of environmental conditions.
4. Comparison of forces.
5. Formulation of own courses of action.
6. Comparison of each course of action.[65]

For purposes of this study, the most significant feature of the German method is the determination of combat power and the estimate of combat effectiveness. These vital elements are a part of each step in the estimate except for the first. Combat power is determined by estimates of personnel and materiel strengths, condition of equipment, degree of mobility, supply status, and capabilities of command and control means.

In addition to these factors, consideration is given to the combat morale of units, capabilities of commanders, level of training, and physical conditioning of soldiers. The details of the individual factors represent the basis for the determination of the combat effectiveness, or "the quantification of forces for a certain mission."[...]

Combat effectiveness is clear if combat power factors are evaluated and rated in relation to mission, enemy, availability of troops in space / time, terrain, weather, and situation of the population. As a result, the combat effectiveness of a unit rates as high, medium, or low.[...]

While the German method provides no specific guidance on the selection or use of evaluation criteria specifically during the comparison step, it is clear that the U.S. Army METT-T and combat power model equivalents play an important role in determining the advantages and disadvantages of COAs.

Soviet

A study of the Soviet decision making process reveals an underlying principle of one-man command and centralization of control. The staff's role is primarily one of scientific substantiation of the commander's concept. The essence of the Soviet style commander's decision is "the result of the creative thought and will of the commander and defines the objective of the combat operations and the forces, resources, procedures, and times for achieving it and also the missions of his subordinates."[68]

The decision is based on the laws and principles of military science, correct understanding of the tactical mission, and evaluation of the situation. Although the Soviet method does not correlate closely with U.S. Army estimate process, the following description of the Soviet commander's thought process during the comparison step provides a striking resemblence to the U.S. Army wargame concept:

> During the course of this process, a competent, experienced commander rather easily "sifts out" the obviously erroneous [courses of action] from the many possible ones. The remaining few (two or three) expedient or well-founded versions are compared by the commander at the end of the decision making process in terms of the anticipated combat results (the possible enemy and friendly losses, the cost in material resources and time of carrying out the mission and capturing of terrain, etc.), and he finally selects the best one.[69]

This implies that the "best" COA is the one that most closely matches the wargame results with the commander's desired outcome. As noted earlier, the same implication is evident in U.S. doctrine.

French

The French method, entitled "La Methode de Raisonnement Tactique" (The Tactical Reasoning Method)[20], is a version of concurrent COA analysis under conditions of uncertainty. Figure 12 portrays this method graphically, and denotes certain "critical factors" that serve as evaluation criteria in determining the best COA. At the battalion level and above, the decision maker keys on time-space factors, the influence of terrain, and the balance of power of forces. He also keys on "where the effects of physical mass and FOS can be concentrated to achieve the greatest effect."[21]

In essence, this is just another method of combining many of the factors already discussed in order to form evaluation criteria.

CGSC Literature

There are two sources for tactical decision making course instruction from the Command and General Staff College. The first is ST 100-9, The Command Estimate. The other is Advance Book A311, Brigade Battle Simulation. Since there are no significant doctrinal differences in the approach to tactical decision making contained in these sources, analysis will focus solely on the evaluation criteria models therein.

The Command Estimate

ST 100-9 mentions the use of evaluation criteria models as a recommended technique for the staff's use in comparison of COAs, and in briefing the commander for his

STEP 1

Determine enemy and friendly COAs.

STEP 2

Analyze friendly COAs as they compare to enemy COAs

	Enemy COA 1	Enemy COA 2	Enemy COA 3
Friendly COA 1			
Friendly COA 2			
Friendly COA 3			

STEP 3

Compare friendly COAs against "critical factors"

	Factor 1	Factor 2	Factor 3
Friendly COA 1			
Friendly COA 2			
Friendly COA 3			

STEP 4

Decide best COA and implement the decision

Figure 12. The French Method. Evaluation Criteria are described as "critical factors."

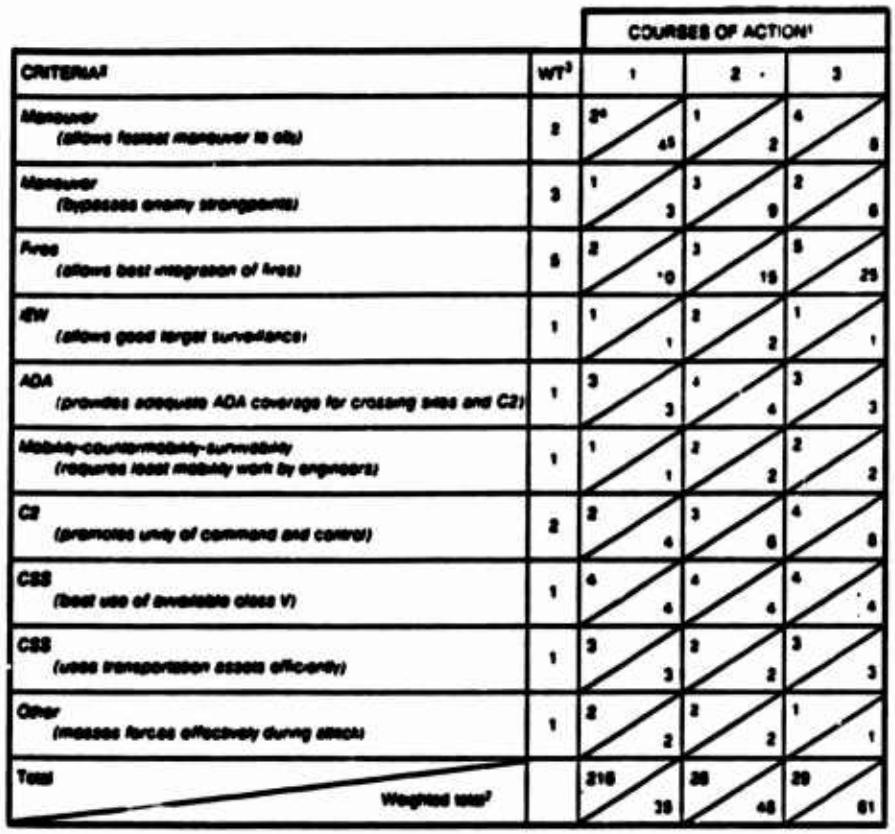
decision. Figures 13 and 14 illustrate examples of the S-3 and S-1 evaluation criteria models.[28] These models are meant to graphically portray subjective indicators, and are not meant to be absolute or objective in nature. The manual states that each staff officer "may use his own matrix for comparison in his own area of responsibility."[29] The criteria options include specific elements of the commander's guidance, BOS, tenets, terrain, or critical events. Additionally, the commander may weight any of the criteria as he deems appropriate.

Brigade Battle Simulation

The A311 booklet provides a "laundry list" of evaluation criteria under each of the BOS categories in its recommendation for a decision matrix. Figure 15 illustrates this model.

Summary

Analysis of these two sources provides no clarification on which model is "optimal." In fact, the more we look, the muddier the water gets. The one key point that emerges from these two sources deals not with evaluation criteria, but with commander's guidance. Both sources emphasize that the commander's guidance, which is issued to the staff prior to the COA development phase, must contain the commander's initial intent. The intent should contain the elements of purpose, method for the force as a whole, and endstate (in terms of desired status of friendly forces, enemy



		COURSES OF ACTION[1]		
CRITERIA[2]	WT[3]	1	2	3
Maneuver (allows fastest maneuver to obj)	2	2[4] 4[5]	1 2	4 8
Maneuver (bypasses enemy strongpoints)	3	1 3	3 9	2 6
Fires (allows best integration of fires)	5	2 10	3 15	5 25
IEW (allows good target surveillance)	1	1 1	2 2	1 1
AOA (provides adequate AOA coverage for crossing sites and C2)	1	3 3	4 4	3 3
Mobility-countermobility-survivability (requires least mobility work by engineers)	1	1 1	2 2	2 2
C2 (promotes unity of command and control)	2	2 4	3 6	4 8
CSS (best use of available class V)	1	4 4	4 4	4 4
CSS (uses transportation assets efficiently)	1	3 3	2 2	3 3
Other (masses forces effectively during attack)	1	2 2	2 2	1 1
Total / Weighted total[7]		21[6] 35	28 46	29 61

[1]Courses of action are those that are selected for war gaming.

[2]Criteria are any factors that pertain to the mission (criteria include specific elements of commander's guidance, battlefield operating systems, tenets of AirLand Battle, OCOKA, critical events). They may be assigned by either the commander or staff. If the criteria are qualitatively the same for each course of action, they may not need to be displayed.

[3]Should the commander desire to emphasize one criterion as more important than another, he assigns weights to each criterion based on relative importance.

[4]The principal staff officers assign numerical values for each criterion after the courses of action are war gamed. These values reflect the relative advantages or disadvantages of each criterion for each course of action. In the example above, course of action 3 is clearly the best.

[5]The weights are multiplied by the initially assigned score in each column.

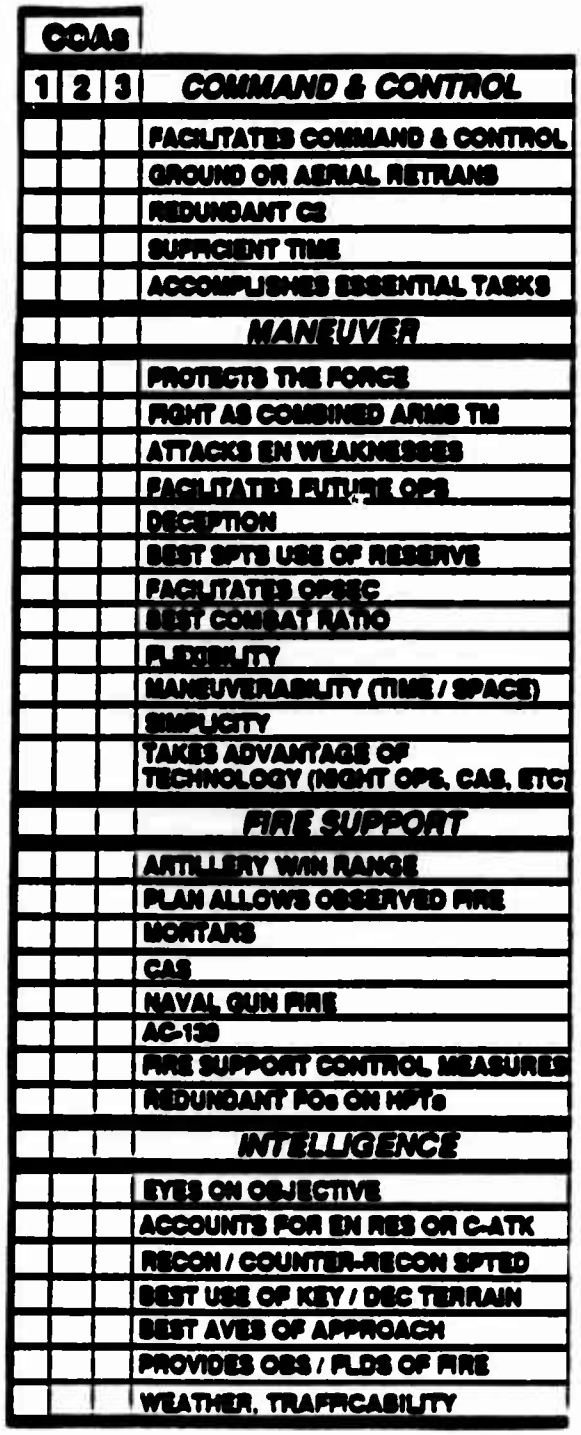
[6]The numbers are totaled to provide a subjective evaluation of the best course of action without weighting one criterion over another.

[7]The scores are totaled to provide a "best" course of action based on weights assigned by the commander.

Figure 13. Decision Matrix and Evaluation Criteria Model in ST 100-9.

Factor	Course of action 1	2
Casualty estimate	+	−
Casualty evac routes	−	+
Suitable location for medical facilities	0	0
Avail EPW facilities	−	+
Suitable CP locations	−	+
Effect of terrain on data processing links	+	−
Courier and dist routes	−	+
Effects of attachments & detachments on force cohesion, casualty reporting, replacement ops, etc.	−	+

Figure 14. Sample Evaluation Criteria Model for the S-1.



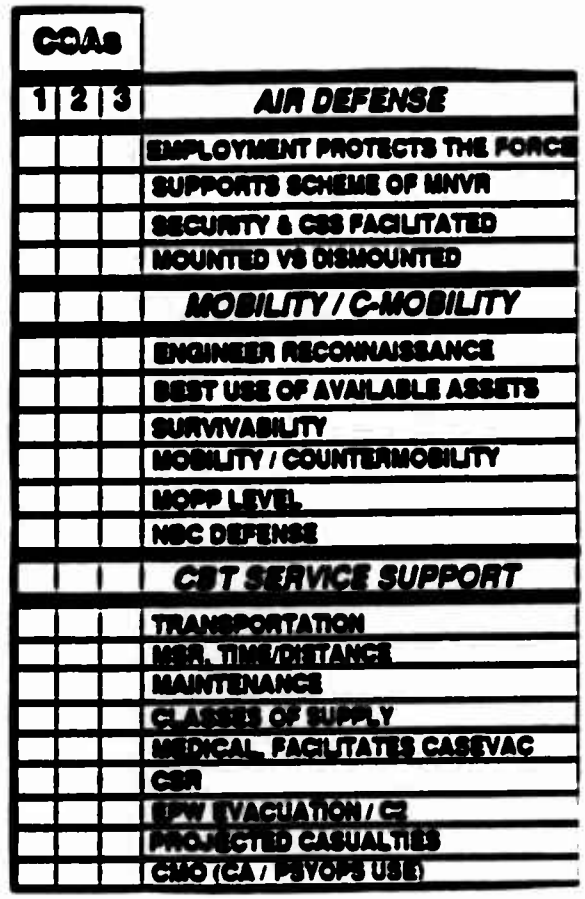


Figure 15. Decision Matrix and Evaluation Criteria Model from Brigade Battle Simulation Course.

forces, terrain, and time). Given this, it would seem that the staff could more easily focus their analysis and comparison of COAs with regard to the commander's initial intent.

CTCs

As stated in chapter one, observations from the Combat Training Centers indicate that many battalions have difficulty developing effective tactical plans, the common cause of which is the incorrect conduct of the military decision making process. Based on this assessment, and on a compilation of techniques and procedures that proved to be successful by various units during CTC rotations, the Center for Army Lessons Learned at Fort Leavenworth documented several recommendations. Analysis will focus on two of these recommendations as they pertain to evaluation criteria.

The first recommendation stems from the observation that commanders often do not provide sufficient planning guidance for their staffs to develop estimates and feasible COAs.[75] The recommended solution for correctly providing planning guidance is that the commander must give the staff "his vision of the operation."[76] One of the most important elements of the commander's vision is his intent. Given this, the staff may more effectively develop options, and analyze and compare those options with regard to a focusing concept.

The second recommendation is related to the observation that

> often a course of action comparison is reduced to a vote by staff officers rather than an actual comparison. A vote for the course of action the staff likes best does not always result in what will be the most successful course of action.[77]

The recommended solution is a detailed analysis during the comparison step that identifies a COA that satisfies the criteria better than the others. As seen in previous literature, the criteria are displayed in a decision matrix.

An example is provided in figure 16.[78] This particular technique requires the staff to develop criteria using commander's guidance, critical events, and "other significant factors" pertaining to the mission. The staff uses the criteria to determine advantages and disadvantages of each COA. It is the comparison of the advantages and disadvantages that helps the staff determine the COA with the highest probability of success. By quantifying the assessment, COAs are rank ordered according to each criterion.

Analysis of these recommendations highlights two key points. First, we now see a practical reason for the commander to state his intent early in the estimate process, not just a doctrinal or theoretical reason. Secondly, the same problems emerge as we look at the recommended evaluation criteria model from this source. The criteria are not used during the analysis step, they are defined by someone other than the commander, they fail to easily distinguish advantage and disadvantage, and they are a mixture of other models that do not adequately constitute evaluation criteria.

FACTORS	COA #1	COA #2	COA #3
Mass			
Simplicity			
Deception			
Fratricide			
Assault			
Supporting Atk			
Passage of Lines			
TOTAL			

Figure 16. Example of Recommended Decision Matrix and Evaluation Criteria Model from Center for Army Lessons Learned.

Concluding Observations.

The literature review results in the following conclusions that pertain to the research information requirements:

1. Nowhere in the literature relevant to this study is there any aggreement on the selection and use of evaluation criteria during the estimate process.

2. There are many examples of evaluation criteria in doctrinal manuals and in related literature, but in every case the examples suffer from one or more of the following problems:

a. The evaluation criteria are confused with screening criteria.

b. The criteria are not measurable or observable.

c. The criteria do not readily distinguish advantage from disadvantage.

d. The criteria are formulated at the end of the process, rather than early in the process so that they can be used during analysis.

e. The criteria are selected by someone other than the commander, which can lead to a diverging estimate process.

3. There appears to be a doctrinal/theoretical basis for operationally defining the "generic" best course of action. This definition is as follows:

> The "best" course of action has the highest relative probability of success.

Therefore, in order to determine the best COA, success must first be defined, and then measured. The operational definition results in the following key points that relate to success definition and measurement:

a. The first key point in this definition relates to the commander's initial intent, as defined in his statement of purpose (related to his higher commander's intent), method for the force as a whole, and endstate relative to the enemy and friendly status, location, and time. This is where the commander defines success to the staff for planning purposes. Doctrinally, the commander should issue his initial intent to the staff prior to COA development. It should be the single most important and unifying factor during planning and execution. It can be stated in measurable terms, such as the desired percentage of enemy destruction or defeat, the acceptable level of risk in terms of friendly losses, the location in which the unit must be postured for future operations, and the critical time factors that impact on success.

b. Once success is defined in the commander's initial intent, the second key point in the definition of the best COA relates to the wargame. This is the doctrinal procedure that a staff uses to measure the probable success of a COA. The results of the wargame correspond directly to the elements of desired endstate as defined by the commander in his intent.

Given these two key points, it appears that the commander's initial intent and the wargame results should be the basis for the formulation of an evaluaton criteria model during the estimate.

4. The doctrinal and theoretical requirements for defining the optimal evaluation criteria model for an infantry battalion during the estimate are as follows:

a. The model must be based on the commander's initial intent.

b. The model must apply to any situation within the infantry battalion's parameters. In essence, this requires the model to be sensitive to METT-T.

c. The model must use criteria that are measurable, observable, and capable of distinguishing advantage from disadvantage in an individual COA prior to comparison of all COAs.

d. The model must focus the planning group during the estimate, not just at the end.

e. The model must exclude screening criteria.

f. The model must sufficiently differentiate COAs during the comparison step.

g. The model must relate directly to the wargame process, since this process is the doctrinal method for COA analysis, and it results in a visualization of the COA's outcome. In essence, it is the best means of measuring a COA's probable outcome against the desired success as defined by the commander in his initial intent.

h. The model must account for both subjective and objective assessments.

i. Elements of the model must conform to current doctrine.

j. The model must complement, rather than contradict, the delicate balance between art and science in the tactical decision making process.

CHAPTER THREE

METHODOLOGY

This study uses two complementary methods in order to answer the primary research question. The first method applies the "scientific approach to inquiry"[1] as a basis for thesis formulation. This is the research design that addresses the application of the thesis, as a whole, in determining the possibility of constructing an evaluation criteria model that improves the infantry battalion's capability to select the best COA during the deliberate tactical estimate. The second method specifically addresses measurement and analysis of the thesis hypothesis (proposed evaluation criteria model), and how the hypothesis is tested. This is the measurement procedure that determines whether the hypothesis is accepted or rejected. The following sections describe these complementary methods in detail.

Research Design

The scientific approach is generally accepted as a reliable way to examine the decision making process.[2] For this reason, the thesis structure parallels the following steps of the scientific approach:

1. Problem identification.
2. Literature review.

3. Hypothesis formulation.

4. Hypothesis testing.

5. Conclusions

Each of these steps and the associated tasks relate directly to the organization of this thesis as subsequently discussed, and as illustrated in figure 17.

Problem Identification (Chapter One)

> Research is rarely an orderly business. . . . Order and disorder, however, are not of primary importance. What is much more important is the controlled rationality of scientific research as a process of reflective inquiry, . . . and the paramount importance of the problem and its statement.[5]

This step in the scientific approach provides focus to the study and involves drafting and reviewing the problem statement. The initial draft of the problem directs the review effort to verify the problem's existence and further narrow the scope. Chapter one accomplishes this by answering the initial two secondary research questions:

1. What is the purpose and process of the estimate?

2. What problems exist in the estimate process?

The review results in an initial problem statement: How can the development of an evaluation criteria model contribute to solving the problems that have been identified? The initial problem statement establishes parameters that make successful research attainable, and guide the study effort. The problems identified in chapter one focus on the lack of

STEP	CHAPTER	DESCRIPTION	TASK
1	One	Define Problem	Draft problem definition. Review current doctrine/CTC experience. Develop final problem definition and parameters.
2	Two	Literature Review	Identify information needs (Doctrinal - US/foreign)(Related sources - CGSC/related research/CTC lessons). Determine availability. Conduct research. Consolidate relevant information.
3	Four	Form Hypothesis	Develop evaluation criteria model. Identify basic model and component elements. Draft model for testing.
4	Five	Test Hypothesis	Scenario vignette. Application of the model. Analysis using MOE. Findings.
5	Six	Conclusions	Evaluate draft model. Identify strengths and weaknesses. Evaluate research design. Revise model.
		(Recommendations)	Finalize model. Identify areas for future study.

Figure 17. Thesis Methodology (Research Design). This figure explains the correlation of the thesis organization to the five steps of the scientific approach.

clear doctrinal guidance on the selection and use of evaluation criteria during the tactical estimate, and its resulting effect on the infantry battalion as observed at the CTCs. The parameters focus the study at the infantry battalion level, and eliminate the problem of decision making time constraints so that the research considers only the deliberate estimate process.

Consequently, this leads to the central issue of the primary research question: Is it possible to construct an evaluation criteria model that improves the infantry battalion's capability to select the best COA during the deliberate tactical estimate?

Literature Review (Chapter Two)

> Social science theories are rarely elegant or sophisticated. In fact, social science theories usually assume the form of a series of assumptions that are loosely tied together and seem to lead to hypotheses.[1]

The purpose of the literature review is to determine what is known about the problem in order to generate a theory that aids in the development of a hypothesis. Chapter two accomplishes this by identifying information needs, determining the availability of this information, conducting research, and consolidating relevant information.

The three remaining secondary research questions represent the information needs for the study:

1. What does doctrine and related literature reveal about the selection and use of evaluation criteria during the estimate?

2. What essential elements define the "best" COA, and how are these elements measured?

3. What are the doctrinal and theoretical requirements for the development of the optimal evaluation criteria model for an infantry battalion during the tactical estimate?

By induction, "observed facts are used to generate a theory consistent with the facts."[5] The research in chapter two concludes that there is no agreement in the literature about the selection and use of evaluation criteria, but reveals an operational definition for the "best" COA, a method for measuring it, and several key doctrinal / theoretical requirements concerning the development of the optimal evaluation criteria model.

These conclusions represent a theory that is consistent with the facts. By deduction, "we ask what are the consequences of the theory?"[6] The consequences of the theory aid in the development of a hypothesis (in the form of the proposed evaluation criteria model central to this thesis), and therefore lead to the next step in the scientific approach.

Hypothesis Formulation (Chapter Four)

> A hypothesis is a conjectural statement of the relation between two or more variables . . . and [carries] implications for testing the stated relations.[7]

Chapter four of this thesis addresses hypothesis formulation and deduces an unproven, preliminary solution to

the primary research question based on the theoretical conclusions of the literature review. Since these theoretical conclusions are based on a review of relevant, current decision making doctrine, the hypothesis is considered to have a degree of deductive validity.[8] In other words, it is based on a review of the "right" data. Since the theoretical conclusions are substantiated by numerous and varied related sources in the literature review, the hypothesis is considered to have a degree of inductive strength.[9] This means that it is consistent with a "variety" of data.

In statement form, the hypothesis declares that the proposed evaluation criteria model improves the infantry battalion's capability to select the best COA during the deliberate tactical estimate. This statement demonstrates a relationship between an independent variable (the proposed model) and a dependent variable (selection of the best COA).

The hypothesis formulation step involves the development, modification, and drafting of the proposed evaluation criteria model for testing. Model development includes identification of the basic evaluation criteria model and its component elements. The doctrinal and theoretical requirements obtained from the research in chapter two provide a yardstick for model examination and modification, which is necessary to finalize the product for subsequent testing. The final product is an evaluation criteria model and decision matrix (that incorporates the model) for use during the

conduct of the infantry battalion's deliberate tactical estimate for a planned offensive operation.

Hypothesis Testing (Chapter Five)

> The quality of research depends not only on the adequacy of the research design but also on the quality of the measurement procedures employed.[10]

This step in the scientific approach tests "the relation expressed by the hypothesis."[11] In other words, does the proposed evaluation criteria model improve the infantry battalion's capability to select the best COA during the deliberate tactical estimate? This test requires a measurement theory, or "a set of assumptions about the way the world of theory is related to the world of observation."[12]

This measurement theory is the subject of special attention in this chapter's subsequent discussion about measurement procedures. For now, a general concept of hypothesis testing is all that is required. This concept includes the following steps:

1. Scenario Vignette
2. Application of the Proposed Model
3. Analysis Using Measures of Effectiveness
4. Findings

Conclusions (Chapter Six)

> Scientific knowledge is knowledge under conditions of uncertainty. . . . Thus, theories and hypotheses can never be ultimately verified on logical grounds, and they can never be ultimately falsified on more practical operational grounds. Theories and hypotheses, however, certainly can and are made more or less plausible, and the

most plausible theory is the one for which we have the strongest evidential support.'[3]

Conclusions determine the verification of the hypothesis and serve as a basis for its improvement. Additionally, the conclusions address an evaluation of the research design based on the following validation questions:

1. Does the design adequately test the hypothesis?

2. Does the design adequately control the variables?

3. Can we generalize the results of the study to other subjects, groups, or conditions?

4. Did experimental manipulation really make a significant difference (internal validity)?

5. When the experiment is completed and a relationship discovered, to what population can it be generalized (external validity)?'[4]

Chapter six provides an evaluation of the proposed evaluation criteria model to determine strengths and weaknesses so that revision is possible. This effort results in a finalized model. Next, the chapter provides an evaluation of the study's research design in accordance with the validation questions listed above. Then, the chapter provides recommendations that focus on the usefulness of the model in light of qualifiers that were identified during the study. Finally, the chapter identifies areas for future study that were beyond the scope of this research.

Measurement Procedure

This section provides an elaboration of the measurement theory used to test the hypothesis in chapter five. The following discussion centers on each of the subordinate steps of the test, and then a summary.

Scenario Vignette

In order to determine if the proposed evaluation criteria model improves the infantry battalion's capability to select the best COA during the deliberate tactical estimate, the first step is the introduction of a situation that causes the infantry battalion to initiate the estimate process.

Chapter five begins by introducing the scenario vignette of an infantry brigade operations order that tasks the battalion to conduct an offensive operation. This vignette comes from the Tactical Commander's Development Course - Light Infantry Section (TCDC-L) at Fort Leavenworth, whose mission is to refresh light infantry battalion commander designees in the command estimate process as part of their Pre-Command Course (PCC) curriculum. Based on the brigade order, the infantry battalion initiates the deliberate estimate process.

Application of the Model

The next step applies the proposed model to the COA analysis, comparison, and decision phases of the estimate. Based on the commander's initial intent, the model lists the

evaluation criteria that define success. These criteria serve to focus the COA analysis process as the staff wargames the COAs.

Based on a comparison of each COA's probable results (from the wargame) against the evaluation criteria that define success (from the commander's initial intent), the infantry battalion applies the model to a decision matrix that indicates which COA has the highest relative probability of success. This, then, results in the selection of the "best" COA.

Analysis Using Measures of Effectiveness (MOE)

The third step in the measurement procedure requires measurement of how well the proposed model performed its function relative to the "perfect" model.[15] This step requires a measurement theory that relates the proposed model to the optimal model that was defined in the literature review. This study uses the concept of "measures of effectiveness" (MOE) in order to accomplish this. The process of developing MOE is described as "an art trying to become a science."[16] MOE relate

> the extent to which a . . . system performs a task assigned to that system under a specified set of conditions. Thus, an individual MOE supplies a partial answer to the question: How well does system X perform assigned task Y under a set of . . . conditions Z?[17]

The lack of standardized MOE to support the Army's tactical decision making process is a documented, historical problem.[18] However, the Military Operations Research Society

(MORS) dedicated a workshop to address this issue in 1985. The workshop developed a guide to command and control systems evaluation and architecture development, which resulted in a list of desired characteristics for MOE.[15]

This study uses that list of desired characteristics to show a direct relation to the theoretical requirements for the optimal evaluation criteria model, as outlined in the literature review. This provides a way to measure the proposed model relative to the theoretically optimal model, and it facilitates the analysis of how well the proposed model improved the infantry battalion's capability to select the best COA. Listed below are the MOE characteristics from the MORS workshop as they relate to the optimal evaluation criteria model definitions. Note the modification of MOE 1 and 6 from the original MORS MOE characteristic titles. This modification facilitates a more accurate description of the MOE as they apply to the theoretically optimal model.

MOE CHARACTERISTIC	DEFINITION(Optimal model must...)
1. Intent-oriented (Mission-oriented)	Relate directly to the definition of successful endstate relative to enemy, force, terrain, and time IAW commander's initial intent
2. Discriminatory	Identify real differences between COAs; sufficiently differentiate COAs during comparison phase
3. Measurable	Account for observed, computed, or estimated results of the wargame
4. Quantitative	Provide a method to assign numbers and rank COAs
5. Realistic	Relate realistically to the C² system and associated uncertainty; adapt to any situation (METT-T)

6. Balanced (Objective)	Account for objective definition tempered by subjective insight
7. Appropriate	Relate to acceptable standards and analysis objectives; conform to current doctrine
8. Sensitive	Reflect change in system variables; distinguish advantage from disadvantage prior to COA comparison
9. Inclusive	Reflect those standards required by the analysis objectives; account for "art versus science" balance
10. Independent	Be mutually exclusive with respect to other measures; exclude screening criteria
11. Simple	Be easily understood; focus the planning group; keep number of criteria to manageable level

Findings

After model analysis using the MOE, the final step consolidates relevant information and forms the basis for conclusions about the proposed model.

Summary

The two complementary methods discussed in this chapter provide the means to answer the primary research question. The scientific approach structures thesis organization in such a way that one can have reasonable confidence in its findings. The method used for hypothesis testing provides a measurement procedure consistent with an accepted (albeit inexact) design for measuring the effectiveness of the decision making process.

CHAPTER FOUR

EVALUATION CRITERIA MODEL AND MATRIX

> We want to assist the commander in (commanding) . . . (so he can) visualize what's happening now and then visualize what the future state must be, and then make the decisions that must be made to get that unit from the current state to the future state.[1]
>
> General Frederick M. Franks, Jr., (1993)

A Proposed Evaluation Criteria Model

The review of literature demonstrates that there is no aggreement on the selection and use of evaluation criteria during the tactical estimate. There are many examples of evaluation criteria models throughout the literature, but all models suffer from one or more of the problems identified earlier in this study.

However, there appears to be a consistently central concept throughout the literature that provides an operational definition for the "best" COA--which is the COA with the highest relative probability of success. If the proposed model is to improve the infantry battalion's capability to select the best COA, it logically follows that this operational definition must form the basis of the proposed model. What follows is an evaluation criteria model that is derived from the doctrinal manuals and other related sources

examined during the literature review, and based on the operational definition of the best COA.

The Basic Model

The first step in developing the model requires an understanding of the relationship between the operational definition of the best COA and the commander's initial intent. For now, discussion excludes the "highest relative probability" elements of the operational defintion and focuses first on the "success" element.

What is success and where is it defined? The answer to this question is the commander's initial intent, which is the single most important aspect of the guidance issued by the commander to his staff at the conclusion of mission analysis (phase one of the estimate).[2]

Three essential parts form the commander's initial intent. The first part is the purpose. This relates the current operation to the higher commander's intent one and two organizational levels up. The second part is the method for the force as a whole. This is a brief statement that provides general guidance to the staff for the development of COAs. Particularly relevant to this study is the third part, which is the endstate. Here, the commander defines the successful endstate of the operation relative to the status of the enemy, the friendly force, the terrain, and critical time aspects. Included in each category is a definition of the level of acceptable risk, if applicable. Thus, the commander's

definition of a successful endstate provides the vital link to the operational definition of the best COA (figure 18).

This definition begins in the mind of the commander. As such, it is clearly within the realm of "art." But it must be expressed to the staff in the most unambiguous terms possible if it is to be useful throughout the subsequent steps or phases of the estimate. This requirement suggests that the commander's initial intent may be significantly more detailed than his final intent, which is issued in the actual order once the estimate is completed. The level of detail in the initial intent should relate directly to the level of experience of the staff. The next step in developing the evaluation criteria model provides an explanation of the components of the basic model.

Components

The basic model described above provides a general framework to systematically formulate evaluation criteria based directly on the commander's initial intent. It provides broad categories, but no detail. In order to formulate detailed evaluation criteria that are useful in both the COA analysis and comparison phases of the estimate, the following considerations apply.

First, each criterion must express an element of the commander's definition of success, by basic model category (enemy, force, terrain, and time), in a manner accessible to quantifiable estimation. However, the term quantifiable does

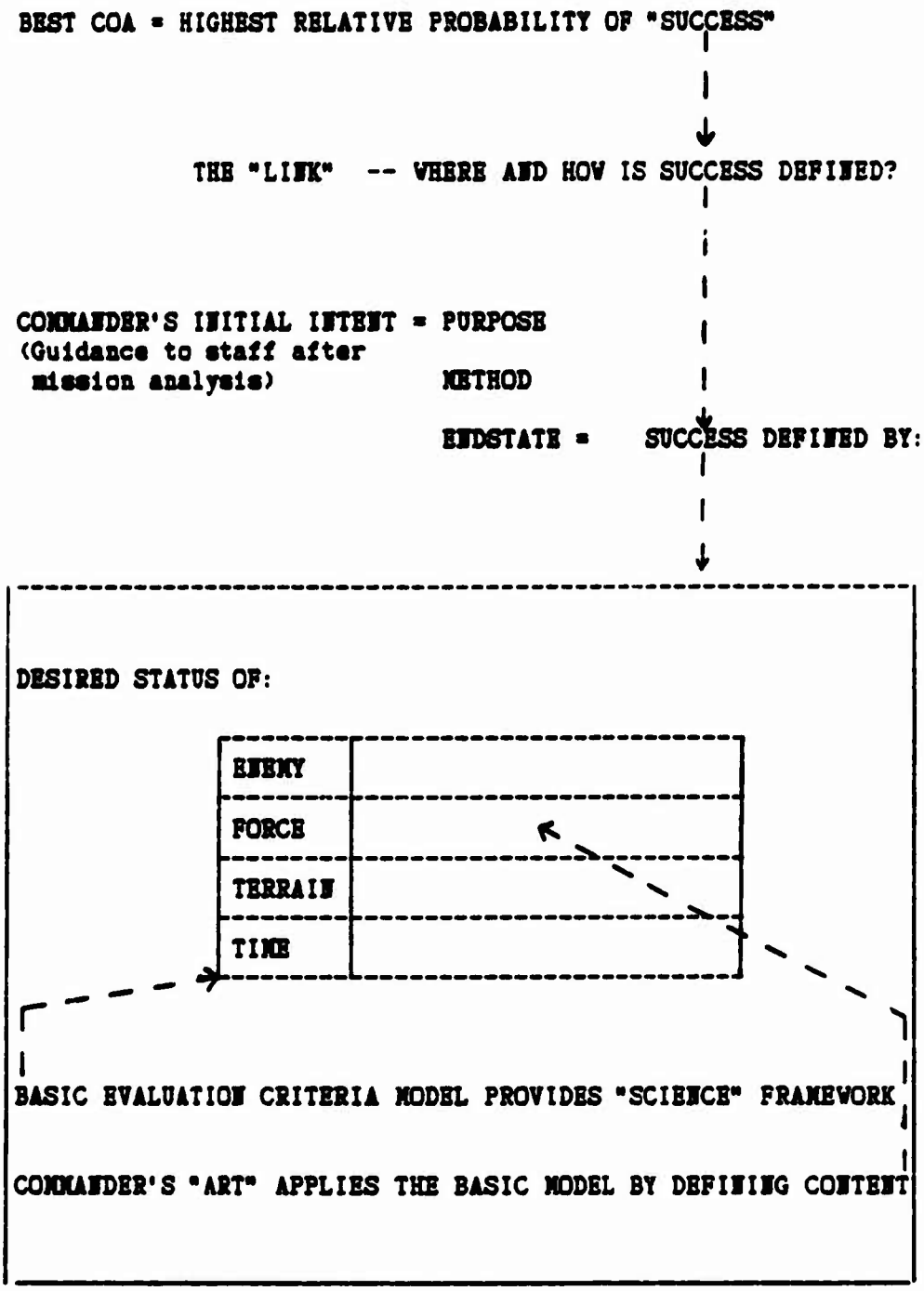


Figure 18. Basic Evaluation Criteria Model. The basic model provides the categories of enemy, force, terrain, and time. The commander applies the basic model by defining the desired status within each category. This results in the commander's definition of success and shows the vital link between the commander's initial intent and the operational definition of the best COA.

not necessarily mean objective. Credible criteria require the application of military judgment, and may be expressed in form other than numbers, such as degrees (high, moderate, or low), percentages, or additional dimensions of value.

Secondly, each criterion must express a clear distinction between advantage and disadvantage. This consideration requires the commander to establish a threshold that distinguishes advantage from disadvantage. It requires more than a simple expression of the acceptable level of risk --a screening criterion. This is particularly important since the doctrinal estimate process requires this distinction during the analysis of each COA, and before the comparison of all COAs.

Lastly, each criterion must be expressed in terms that provide consistent measure among all COAs. This is important for effective application during the COA comparison phase.

Given these considerations and the basic evaluation criteria model's categories, it is possible to develop a component "menu" of separate evaluation criteria. This menu is not an all-inclusive list, but provides a detailed framework to guide the development of specific evaluation criteria that satisfy the conditions stated above. Figure 19 depicts the component menu by basic model category. The thesis appendix provides a detailed statement and description of each component criterion in accordance with the following format:

> Definition: A complete statement of the criterion that includes computational data and methods of processing.

CATEGORY	COMPONENT CRITERION	COMPONENT WEIGHT[1]	CATEGORY WEIGHT[2]
ENEMY			-
	Endstate Combat Power	-	
	Endstate Losses	-	
	Degree of Neutralization	-	
	Level of Effectiveness	-	
	Effect of Reaction / Reinforcement	-	
	Positional Disadvantage	-	
	*Other	-	
FORCE			-
	Endstate Combat Power	-	
	Endstate Losses	-	
	Required Resources Remaining	-	
	Additional Missions Capable	-	
	Probability of Compromise	-	
	Level of Effectiveness	-	
	Positional Advantage	-	
	*Other	-	
TERRAIN			-
	Area Acquired	-	
	Coverage of Target Area	-	
	Degree of Area Control	-	
	Posture for Follow-on Operations	-	
	Degree of Collateral Damage	-	
	*Other	-	
TIME			-
	Time to Complete Mission	-	
	Exposure Time to Enemy Acquisition	-	
	Time Support Available	-	
	Recuperation Time	-	
	Critical Task Timing	-	
	*Other	-	

[1]Rationale for individual component criteria weighting factors within each category: 1 - base value of importance (at least one component criterion must have this value); 1.5 - more important than base value; 2 - significantly more important than base value.

[2]Rationale for overall category weighting factors: Same nominal values as above. Based on the component weights within each category, the same method for assigning nominal values is applied to show the external relationship between categories. Like the component criteria weights, at least one category must have the base value of 1.

Figure 19. Component Menu by Evaluation Criteria Model Category. The thesis appendix provides a detailed presentation of each component criterion. Note: This is not an all-inclusive list, but provides a framework to guide the development of specific component criteria.

Dimension: How the criterion is expressed (level and unit of measure). Levels of measure include nominal, ordinal, interval, ratio, and degree.

Limits: A statement of the commander's designated level of acceptable risk (a screening criterion). Then, a statement of the "threshold" measurement that clearly distinguishes advantage from disadvantage. Note: The disadvantage limit must not violate the level of acceptable risk as determined by the commander.

Rationale: Why the criterion was selected and what properties make it useful.

Relevance: Circumstances in which the criterion contributes to the decision process.[4]

Based on the commander's definiton of success, it is then possible to select the appropriate criteria within the framework of each basic model category as it applies to the situation at hand.

To complete the component listing, the commander decides which, if any, of the selected criteria are more important than the others, and weights them appropriately. He does this for both the component criteria and the basic categories (enemy, force, terrain, and time). The assignment of weights to each component criterion assists in a better assessment of the appropriate weight for the basic category as a whole. This is a worth or value judgment, but should be expressed nominally.

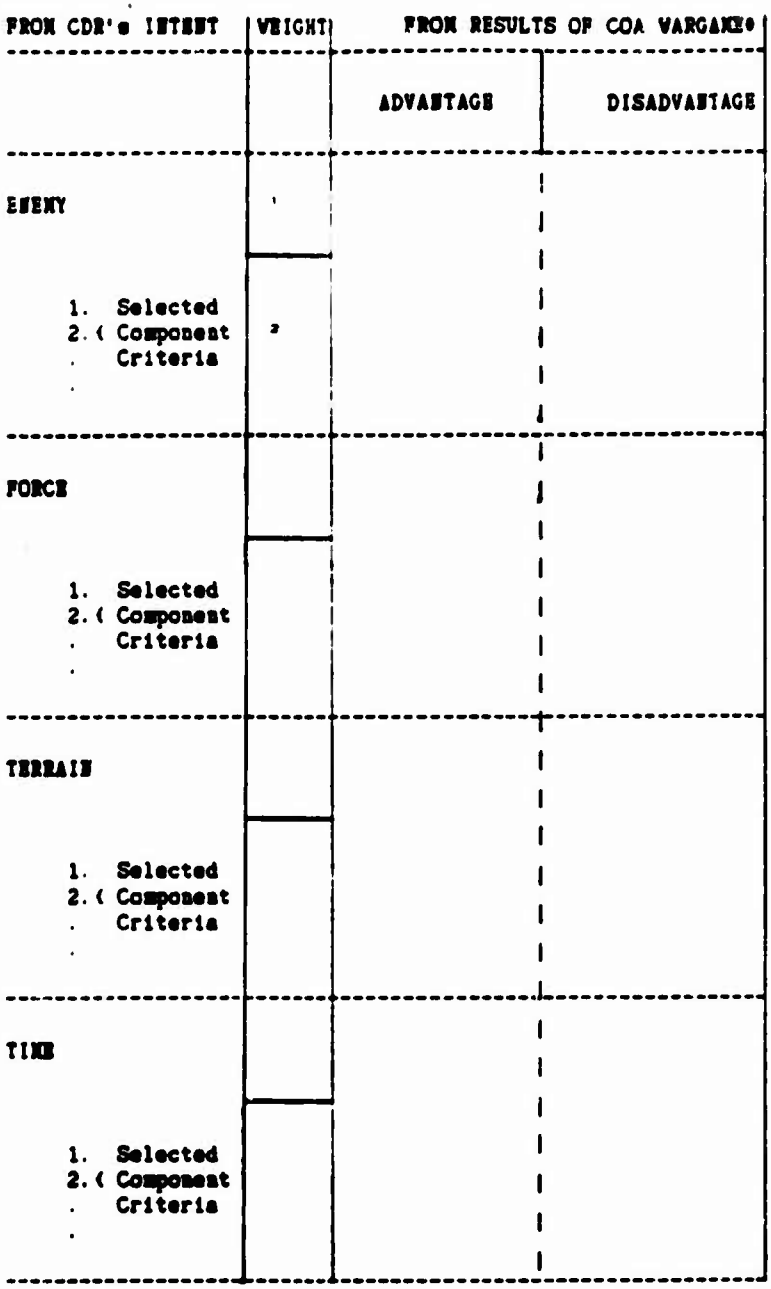
It is extremely important to exercise <u>great caution</u> in assigning weights to evaluation criteria, for haphazard or imprecise weights will result in a misleading analysis and comparison of the COAs. The Combined Arms and Services Staff School teaches one method that facilitates a more "scientific"

approach to establishing nominal weights based on a commander's subjective expression of value judgments." Another, less scientific, method is demonstrated in figure 19. This method seeks to use an "about right" approach in assigning weights to component and category criteria.

In order to complete the model, the "probability" element of the operational definiton of the best COA requires explanation. Doctrinally, the wargame provides the best assessment of the COA's probability of success short of actual or simulated combat. Experienced wargamers temper planning factors and the action-reaction-counteraction procedure with sound military judgment. The result is a COA's probability of success in measurable terms that relate directly to the four basic categories of evaluation criteria; endstate status of the enemy, the friendly force, the terrain, and time. Figure 20 depicts this relationship and the completed evaluation criteria model for COA analysis.

Even though the proposed model is complete, there is one remaining element of the operational definition for the best COA yet unresolved. The "highest relative" aspect of the definition leads into a discussion of the next phase of the estimate; COA comparison.

To demonstrate the relationship between the COA comparison phase, the "highest relative" element of the operational defintion of the best COA, and the proposed evaluation criteria model, the next section introduces



'Overall weight for the basic model category.

²Individual component weights within each category.

Figure 20. Proposed Evaluation Criteria Model for COA Analysis. Based on the results of the wargame and the distinction between advantage and disadvantage for each component and basic criteria (determined by the commander), the staff completes the model by filling in the blanks either during or at the completion of the wargame for each COA. Note: The model pertains to only one COA; comparison of COAs does not occur until the next phase of the estimate.

decision matrices. These matrices provide the basic format for use during the COA comparison and decision phases of the estimate.

A Proposed Decision Matrix

There is nothing fancy or complicated about the formulation of the decision matrix. It is simply a comparison of the results from each independent COA analysis. The following two steps simplify the comparison and demonstrate how it results in a determination of the "highest" probability of success "relative" to the competing COAs.

Raw Data Matrix

This step simply combines the evaluation criteria models for each wargamed COA so that the raw data are available for comparison (figure 21). This is particularly useful when staff teams wargame separate COAs simultaneously. It allows the XO or S-3 to consolidate the information effectively and efficiently.

Given the number of possible criteria selected from the menu and the amount of raw "measured" data from the wargame results, the raw data matrix should now be converted into a simplified decision matrix that briefs easily, and that the commander can understand without the need for excessive elaboration.

CDR'S INITIAL INTENT (Defined Success)		WARGAME RESULTS (Measured Success)			
EVAL CRITERIA	WEIGHT	COA #1		COA #2	
		ADV	DISADV	ADV	DISADV
ENEMY - - -	-----				
FORCE - - -	-----				
TERRAIN - - -	-----				
TIME - - -	-----				

Figure 21. Raw Data Matrix. This matrix is used in the initial portion of the COA comparison phase of the estimate. It combines the evaluation criteria models that were developed separately during the COA analysis phase. In this way, the raw data resulting from each of the separately wargamed COAs can be compared using the same evaluation criteria and weights. Additionally, it provides a graphical comparison of advantages and disadvantages for each COA.

Decision Matrix

Based on the information in the raw data matrix, simple nominal values are applied to each COA for each basic model category. Figure 22 depicts the resulting decision matrix. These nominal values indicate the "relative" aspect of each COA as compared to one another. If higher nominal values indicate a better correlation between the results of the wargame and the defintion of success from the commander's initial intent, then this matrix unambiguously indicates the "best" COA as the one with the "highest relative probability of success."

Once again, it is important to exercise great caution and precision when translating the raw data matrix into nominal values on the simplified decision matrix. Otherwise, imprecise values will only serve to "paint" a false or misleading evaluation. Figure 22 describes one method to translate the raw data into simplified form.

Regardless of the translation method, it is important to use the raw data matrix in a back-up role so that the briefer can answer any specific questions pertaining to the rationale for any of the nominal values on the simplified decision matrix. Additionally, the raw data matrix serves to focus the staff on reducing the identified disadvantages of the selected COA once they begin to formulate and coordinate the operations order.

EVALUATION CRITERIA	WEIGHT	COA #1	COA #2
ENEMY FACTORS	1[a]	15[b]/15[c]	10/10
FORCE FACTORS	1.5	15/22.5	10/15
TERRAIN FACTORS	1	10/10	15/15
TIME FACTORS	2	10/20	20/40
TOTAL /WEIGHTED TOTAL		50[b]/67.5[c]	55/80

GREATER VALUE IS BETTER

[a]Rationale for category weighting factor: 1 - Base value of importance (at least one category must have this value); 1.5 - more important than base value; 2 - significantly more important than base value.

[b]Rationale for translation of raw data into COA nominal values: 10 - Base value of advantage to disadvantage evaluation (at least one COA must have this value for each criterion); 15 - COA with greater advantage to disadvantage evaluation than base value; 20 - COA with significantly greater advantage to disadvantage evaluation than base value.

[c]Weight X nominal value (AxB).

[d]Sum of nominal values (Σ B for each criterion).

[e]Sum of weighted nominal values (Σ C for each criterion).

Figure 22. Simplified Decision Matrix. In this example, analysis of a "notional" raw data matrix resulted in the assessment that COA #1 showed a greater advantage to disadvantage evaluation than COA #2 for both enemy and force criteria. COA #2 showed a greater advantage to disadvantage evaluation than COA #1 for terrain criteria, and a significantly greater advantage to disadvantage evaluation than COA #1 for time criteria. Based on a "notional" commander's value judgment of the criteria, force factors were considered to be more important, and time factors were considered as significantly more important, than enemy and terrain factors (base values). The results of the simplified decision matrix indicate that COA #2 is the best COA. Note: The rationale for assigning category weighting factors and COA nominal values in this figure represents one method that attempts to achieve an "about right" approach. Weighting factors show small variance (1,1.5,2) in order to temper but not disproportionally skew the results. COA nominal values show a larger variance (10,15,20) in order to provide a greater dispersion of the final results. Regardless of the method used to translate these values, the raw data matrix is designed to provide measurable rationale for each of the nominal values in the simplified decision matrix.

Summary

The proposed evaluation criteria model and its incorporation into a decision matrix provide a way to select the best COA. This method is soundly based in doctrine and theory, but it is important to recognize that it is not specifically designed for use as a field model.

The proposed model assists the commander in training his staff to understand and focus on his intent during planning. The more inexperienced the staff, the more detailed the initial intent will likely become, particularly regarding the commander's definition of the desired successful endstate. Once the model is understood and internalized by the staff, it would appear that they may use only the raw data and simplified decision matrices as quick references to assist planning during time constraints.

The model appears to be a logical method for analyzing, comparing, and selecting the best COA. In the next chapter it is applied to a tactical scenario to test its validity and measure its effectiveness as compared to the theoretically optimal model.

CHAPTER FIVE

ANALYSIS

This chapter tests the thesis hypothesis by applying the proposed evaluation criteria model and decision matrix to the tactical estimate process based on an offensive scenario for an infantry battalion. After application of the model and matrix, the chapter then examines how well the proposed model performed relative to the theoretically "perfect" model through the use of the MOE developed in chapter three. As a result of the analysis, the chapter concludes by consolidating all relevant information in the form of findings.

Scenario Vignette

The following scenario vignette provides the strategic, operational, and tactical setting as a basis for application of the proposed evaluation criteria model and decision matrix. It uses an example from the Tactical Commander's Development Course (Light) to do this, and provides critical information from the Joint Task Force and Division level perspective to establish the situation. This example comes from a model scenario that is used at the Joint Readiness Training Center (JRTC) at Fort Chaffee. Next, it provides an infantry brigade operations order (OPORD) that causes the initiation of the estimate process at the battalion

level. Finally, it provides the results of the first two phases in the estimate (mission analysis and COA development), as well as the infantry battalion commander's initial intent, in order to isolate analysis of the proposed model and matrix as they apply to the COA analysis, COA comparison, and decision phases of the estimate.

Strategic Setting

On 10 January 199X, SOUTHCOM Headquarters received a message to establish Joint Task Force (JTF) Cortina for planning purposes. This action was based on the following situation:

> Insurgent activity in the country of Cortina continued to increase. Insurgent operations in the country's mountain regions have brought large rural areas under enemy control, thereby isolating Cortinian military units in the urban areas. Terrorist activities in the urban centers have disrupted communications, causing significant problems in commerce, government, and transportation.
>
> Intelligence sources confirm that the 144th Airborne Rifle Brigade, an element of the People's Revolutionary Armed Forces of Atlantica (PRAFA), recently entered Cortina by ground infiltration. Atlantica is Cortina's communist neighbor. This brigade's suspected mission is to conduct reconnaissance and small unit operations in the Fort Smith area.'

Operational Setting

On 20 March 199X, the X Corps Commander received a warning order to prepare to deploy the 21st Infantry Division (Light), 21 ID (L), and attachments to Cortina within thirty days to conduct combat operations with Cortinian forces as part of JTF Cortina. This action was based on the following situation:

The insurgency continued to escalate. The inability of Cortinian security forces to seal their political border with Atlantica and protect their coastline has made massive quantities of arms available to the People's National Revolutionary Movement (PNRM), an insurgent terrorist group active in Cortina.

The external threat posed by an increasingly well armed PNRM force has heightened U.S. and Cortinian officials' concern. North Korea's providing several new weapon systems in recent months has increased the combat power of the PRAFA forces, further destabilizing the island's political situation.[2]

Tactical Setting

Upon arrival in Cortina, elements of the 21 ID (L) conducted search and attack operations with the Cortinian Army. Their success resulted in the PRAFA forces massing to mount a two-division mechanized and armored attack to seize the industrial complex of Fort Smith and control the Arkansas River Valley area. Although the tactical situation now moved from the low intensity conflict to the conventional operations level, the PRAFA attack met with limited success, and subsequent offensive operations of JTF Cortina resulted in the PRAFA forces establishing hasty defensive positions along the current Forward Edge of the Battle Area (FEBA).

During the last 24 hours, the 21 ID (L) occupied an assembly area in preparation for the next attack. The division will attack in 72 hours to penetrate enemy first echelon defenses, facilitating Cortinian forces passing through U.S. forces to exploit the gaps and cut PRAFA lines of communication, and block the withdrawal of PRAFA forces into Atlantica. If this attack is successful, the Cortinian

Government will gain a strategic advantage during the current peace talks.

Initiation of the Estimate

The 1st Brigade, 21 ID (L) is occupying positions in an assembly area while preparing to attack in 72 hours. 2-67 Infantry (2-67 IN) is a light infantry battalion assigned to 1st Brigade. It has been in the assembly area for 6 hours resupplying in preparation for the upcoming operation. 2-67 IN's Commander has just arrived at the 1st Brigade tactical operations center to receive the new brigade OPORD. The time is now 20 1200 April 199X.

The brigade OPORD provides 2-67 IN with the following information necessary to begin the deliberate tactical estimate process.

21 ID (L) Mission

> 21st ID (L) attacks 23 2100 APR 9X to seize OBJs LEE, BRAGG, POLK, PICKETT, and HOOD NLT 24 0530 APR 9X to destroy the continuity of the enemy's defense and facilitate passage of 313th (US) Sep Mech Bde through zone.[3]

21 ID (L) Commander's Intent

> The intent of this operation is to seize the initiative, exploiting the enemy's inability to sustain offensive operations by attacking to seize critical terrain along PL TAN to assist the passage of 313th (US) Sep Mech Bde in support of the JTF counteroffensive. Success is defined as the unimpeded passage of the 313th Sep Mech Bde and the Division in position to continue the attack.[4]

1st Brigade Mission

> 1st Brigade, 21 ID (L) attacks 23 2100 APR 9X to seize OBJs POLK, PICKETT, and HOOD NLT 24 0530 APR 9X to destroy the continuity of the enemy's defense and facilitate passage of the 313th Sep Mech Bde through zone.[5]

1st Brigade Commander's Intent

Purpose: To destroy or capture enemy forces in zone, secure key terrain in zone and deny the enemy freedom of maneuver and / or the ability to influence the counter-attacking forces as they move through the 2d (US) Brigade's zone to our north and 2d (C) Brigade's zone to our south.

Method: To acomplish this we will first destroy the enemy regimental command post to hinder command and control, then attack his two main defensive positions which control the key terrain in zone and use the attack helicopter support to destroy the enemy counter forces before they can reinforce the enemy defense.

Endstate: The enemy vicinity OBJs POLK and HOOD, including observation posts, will either be destroyed or captured, and the enemy will be unable to maneuver in zone without being engaged by direct fire weapons from either ground or air. Key terrain vicinity OBJs POLK, HOOD, and the high ground vicinity Backbone Narrows will be occupied by a minimum of 2 infantry companies.

1st Brigade Scheme of Maneuver (Figure 23 - 1st Bde Operations Overlay)

2-67 IN (main effort) and 2-68 IN infiltrate beginning 23 2100 APR 9X to destroy enemy and secure key terrain vicinity OBJs POLK and HOOD, respectively. NLT 24 0530 APR 9X. 2-66 IN conducts air assault to destroy enemy regimental CP vicinity OBJ PICKETT NLT 24 0530 APR 9X, then moves to secure key terrain vicinity Backbone Narrows. Task Force SPUR will destroy enemy tank reserve in EA ZOO before it can reinforce the enemy defense in OBJ POLK. Brigade reserve is a tank platoon from B/3-32 AR. Priority of commitment of reserve is 2-67 IN, then 2-68 IN.

Tasks to 2-67 IN

1. Do not allow enemy units in zone to interfere with 313th (US) Sep Mech Bde's movement as they pass through 2d (US) Bde in the north.

2. Coordinate with 1st Bde for commitment of the reserve platoon.

Pertinent Coordinating Instructions

1. Scouts can cross LD/LC NET 22 0100 APR 9X.

2. Be prepared to continue the attack to the east.

NOTE: Figure is not to scale

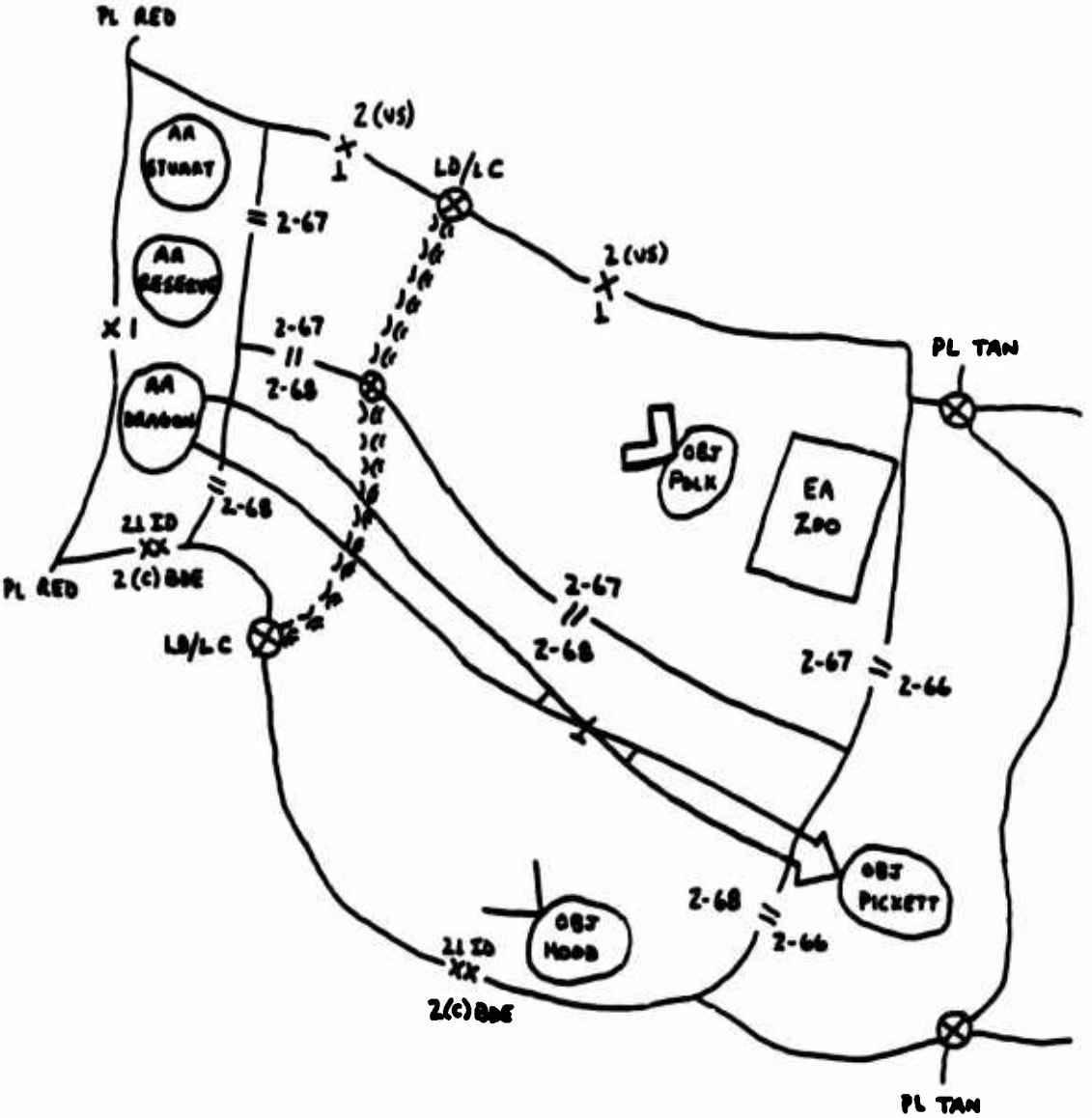


Figure 23. 1st Brigade Operations Overlay.

3. Civilian communities are off-limits without 1st Brigade Commander approval.

4. Carnis and Lone Star Villages are no-fire and off-limits areas."

Enemy Situation (Figure 24)

The Atlantican conventional attack was not successful. Atlantican forces are conducting a retrograde towards the Atlantican border. The enemy is establishing two company sized strongpoints and a possible regimental headquarters within the area of operations. A company (minus) size counterattack force, consisting of one tank platoon and one BMP platoon, can support either strongpoint. The enemy has been preparing positions for the last 24-36 hours.

Disposition

The 11th Motorized Infantry Regiment, 1st Motorized Infantry Division defends in two echelons with the 3d Mechanized Infantry Battalion in the north, the 1st Motorized Infantry Battalion in the south, and the 2d Motorized Infantry Battalion in the rear."

Composition (as it effects 2-67 IN)

Objective POLK contains one mechanized infantry company (minus), with two mechanized platoons and one tank section."

Strength (as it effects 2-67 IN)

1. Committed forces. Regimental recon platoon elements with 8 BRDMs, 3 combat outposts with 1 platoon forward of each objective. One mechanized company (-) on OBJ POLK with two mech platoons and one tank section. 82mm mortars will be in direct support of the enemy in OBJ POLK. RAG assets (122mm, 152mm, and BM21) will provide general support. The enemy in OBJ POLK will be supported by SA 14s and ZSU-23-4. The enemy will prepare extensive defensive positions including wire, bunkers, trenches, and minefields.

NOTE: Figure is not to scale.

Enemy positions / units are superimposed on friendly grapnics for clarity.

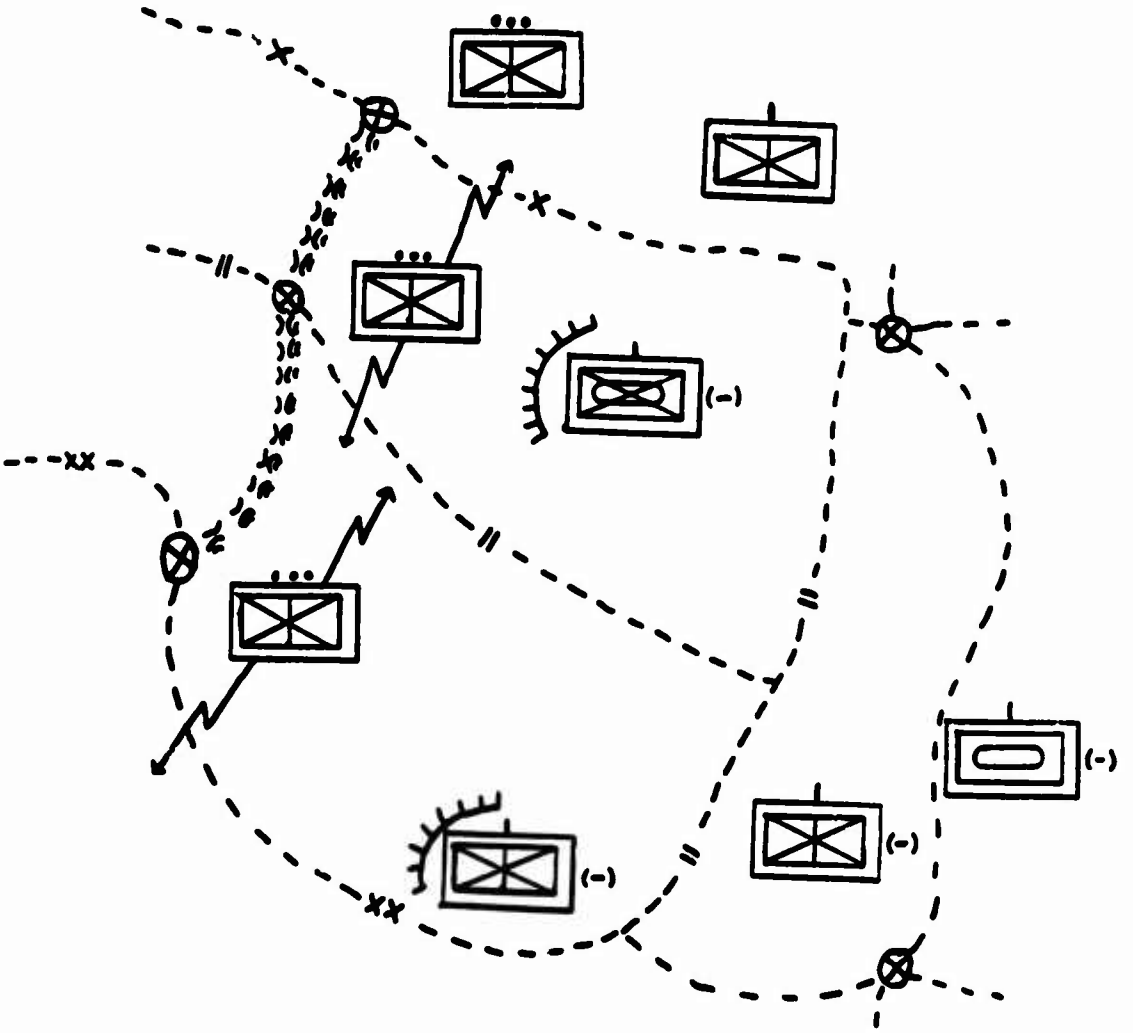


Figure 24. Enemy Situation from 1st Brigade OPORD.

2. Reinforcements. One tank company (-) with one tank platoon and one mech platoon located approximately 30 minutes east of OBJ POLK.[13]

Recent and Present Significant Activities

The 144th ABN RFL BDE continues low level harassment and sniping attacks throughout the 21 ID (L) sector. The 1st Motorized Infantry Division used both persistent and nonpersistent chemical agents in the attack. The PNRM used a female posing as a stranded motorist in the 2d (US) Brigade sector to draw a passing US vehicle into an ambush.[13]

Peculiarities and Weaknesses

Enemy forces on OBJ POLK have been reconstituted to near full strength. However, replacement of further battle losses is unlikely.

The enemy has made extensive use of deceptive radio transmissions, decoys, and deception plans. PNRM intelligence cells in the area will pass information to defending PRAFA forces.

Combat effectiveness of defending forces is high. Regimental recon screen will consist of BRDMs well forward to provide early warning and BMPs operating as mobile observation posts to provide warning and reconnaissance in depth. The enemy will establish combat outposts with one platoon forward of the objective, and conduct patrolling within range of organic mortars. Armor will consist of T-62s and BMPs, which will be in dug-in vehicle fighting positions within the strongpoint. The enemy possesses one set of night vision devices per vehicle. All crew-served weapons will fire from bunkers or trenches to enhance survivability. The enemy will emplace minefields and wire obstacles.

Colonel Thomas Serrano (the enemy regimental commander) is regarded as having great potential for higher command. However, the performance of his regiment in the attack indicates that his reputation may be more due to political maneuvering than to tactical ability. Anticipate that he will direct a determined defense to recover the honor of this regiment, but that his defensive disposition will be flawed and that once it appears that they are being overrun, the enemy strongpoints may attempt to exfiltrate.[14]

Conclusions

1. Seasonal weather predictions favor 1st Brigade operations. The most promising axes of advance include POTATO HILL ROAD and FT SMITH BOULEVARD.

2. The 11th Motorized Infantry Regiment will conduct a tenacious defense of strongpoints to allow withdrawing 1st Motorized Infantry Division forces to pass through the 111 Infantry Division and proceed across the PDRA border. However, once defeat is eminent they may break and run.

3. Remnants of the 2/144 Airborne Rifle Brigade will conduct low level sniping and harassment attacks during hours of darkness to disorganize 1st Brigade's attack.

4. Elements of the PNRM Massard Group will conduct terrorist actions against unprotected targets of opportunity.'[5]

Results of Mission Analysis and COA Development

Based on the information in the 1st Brigade OPORD, 2-67 IN initiated the deliberate tactical estimate process and completed the mission analysis and COA development phases. Additionally, the 2-67 IN Commander issued guidance to his planning staff at the conclusion of mission analysis. This guidance included his initial intent. In order to isolate the analysis of the proposed evaluation criteria model and decision matrix during the COA analysis, comparison, and decision phases, this section summarizes the results of the first two phases in the estimate.

Mission Analysis

After a consideration of specified and implied tasks, limitations, and an initial time analysis, the 2-67 IN staff identified the mission essential tasks and proposed the following restated mission:

2-67 IN attacks 23 2100 APR 9X to seize OBJs POLK 1 and POLK 2 NLT 24 0530 APR 9X in order to destroy the continuity of the enemy's defense and facilitate passage of 313 (US) Sep Mech Bde through 2d (US) BDE zone to the north.

Commander's Initial Intent

The 2-67 IN Commander approved the restated mission statement and issued guidance to his staff for subsequent planning. Recognizing that his staff was relatively inexperienced, he decided to issue very detailed guidance. The most essential element of this guidance was an expanded form of his initial intent, as follows:

PURPOSE. The purpose of this operation is to destroy or capture enemy forces vicinity OBJs POLK 1 and POLK 2, and secure key terrain vicinity Coal Ridge and the intersection of Marietta Church and Potato Hill Roads, in order to facilitate denying the enemy freedom of maneuver and the ability to influence the 313 (US) Sep Mech Bde as they move through 2 (US) Bde zone to the north.

METHOD. 2-67 IN infiltrates, isolates the objectives from enemy approach or withdrawal, and then attacks to destroy enemy forces vicinity the objectives. Since the enemy's defense will be well prepared, I want to focus the attack and breach at a vulnerable point to create confusion and gain surprise.

ENDSTATE. Success is defined as follows: I want effective suppression of the objectives by direct and indirect fires during breaching operations. I want to destroy or capture 75% of the enemy force and 100% of his vehicles in the vicinity of the objectives by 24 0330 APR 9X, leaving him incapable of operating above the squad level. We should retain 2 companies at 90% combat power, without exceeding 20% losses overall. One company size force in the vicinity of Potato Hill Road and Coal Ridge, and one company size force in the vicinity of the Marietta Church / Potato Hill Roads intersection should be in blocking positions by 24 0530 APR 9X. In infiltrating undetected, I want to have limited our exposure time along Auburn Road to 20 minutes. All final positions should be oriented to the east, and we should be prepared to continue the attack NLT 24 0800 APR 9X.

COA Development

Based on the mission analysis and commander's guidance, the staff organized two teams to develop COAs. During the COA brief, the commander and staff determined that both COAs were suitable, feasible, acceptable, significantly different from one another, and doctrinally complete. COA statements and sketches are as follows:

COA #1 Statement (Figure 25 depicts COA #1 sketch)

> 2-67 IN crosses LD/LC 2100 hours and infiltrates along Infil Lane ANNE with one company (3 rifle platoons, 1 GSR platoon, 1 stinger section) in the lead, followed by a company (-) (2 rifle platoons, 1 anti-armor platoon, 1 stinger section), and a third company (+) (4 rifle platoons, 1 engineer platoon) in trail. Scout platoon provides security and guides along Infil Lane Anne. At Checkpoint 2, the lead company moves to establish Ambush Positions A, B, and C to isolate the objectives and destroy enemy armored vehicles that reinforce or withdraw from the objectives. The company (-) moves along Direction of Attack 2 to seize the high ground east of the objectives and support the main attack by fire. On order, the trail company (+) attacks along Direction of Attack 1 as the battalion main effort and seizes OBJ POLK 1, then POLK 2 to destroy or capture enemy personnel and equipment. TF SPUR is 1st Bde's deep fight asset; destroys enemy tank reserve in EA ZOO before it can reinforce OBJs POLK 1 and POLK 2. 2-67 IN accepts risk initially and has no internal reserve. 1st Bde reserve tank platoon has priority of commitment to 2-67 IN. On order, 2-67 IN secures key terrain in zone to deny enemy freedom of maneuver or ability to influence 313 (US) Sep Mech Bde movement through zone to the north. Battalion main effort is one company (+) which occupies Blocking Position 1, orients east and south to deny any vehicular movement throughout the zone. Another company occupies Blocking Position 2, orients north, east, and south to prevent enemy ability to influence 313 (US) Sep Mech Bde movement to the north. One company remains in Assembly Area DOG as reserve. Priority of commitment is to the main effort. Scout platoon screens battalion eastern boundary along Phase Line Banana.

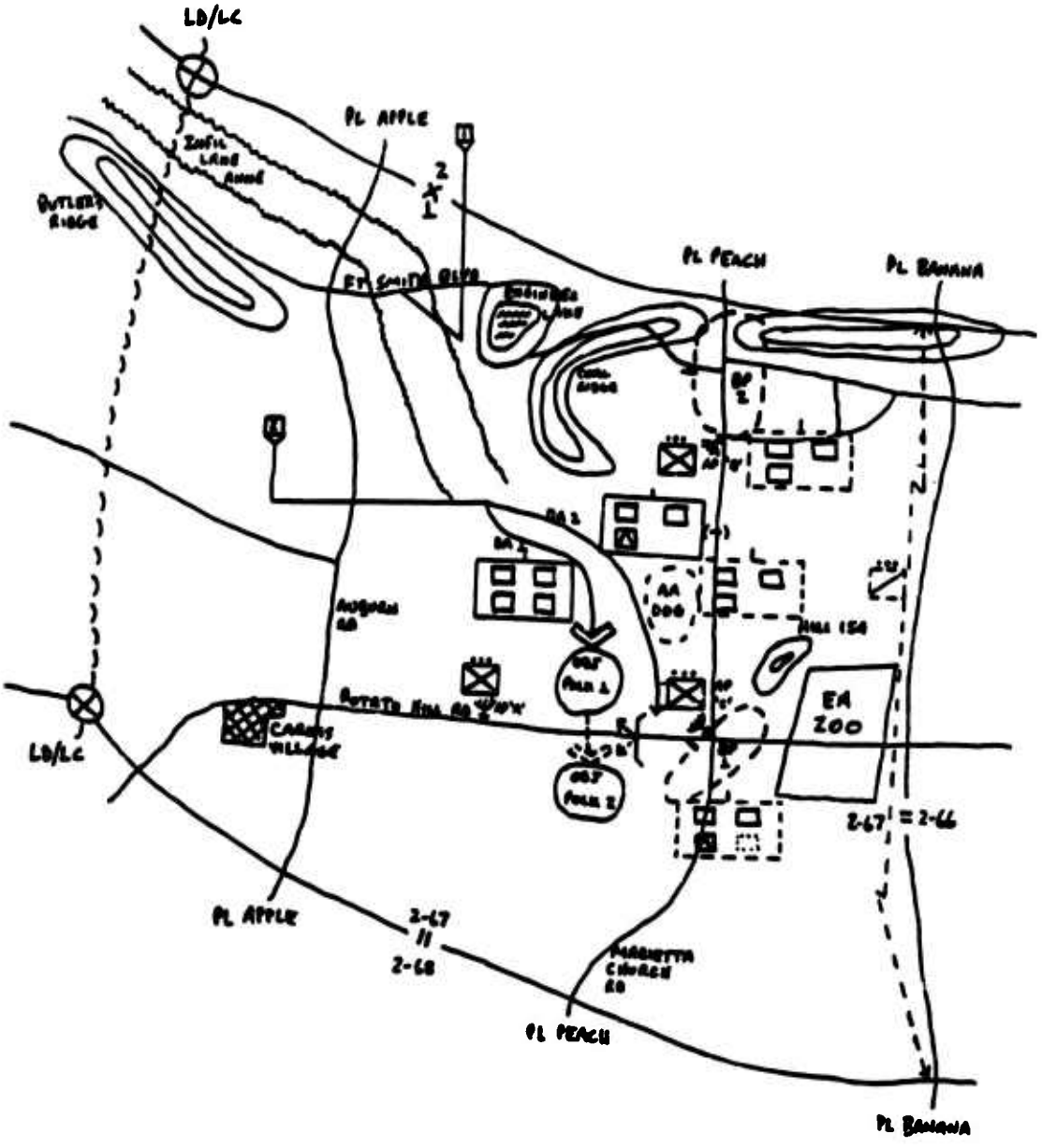


Figure 25. COA #1 Sketch.

COA #2 Statement (Figure 26 depicts COA #2 sketch)

2-67 IN crosses LD/LC at 2100 hours and infiltrates along multiple lanes, with one company (+) (3 rifle platoons, 1 anti-armor platoon, 1 stinger section, 1 GSR team) along Infil Lane BERNICE; one company (3 rifle platoons, 1 engineer platoon [-]) in the lead followed by one company (3 rifle platoons, 1 engineer squad) in trail along Infil Lane GRACE. Scout platoon provides security and guides along Infil Lane Grace. At Checkpoint 1, the company (+) moves to establish Blocking Position 1 and Ambush Positions A and B to isolate the objective and destroy enemy armored vehicles that reinforce or withdraw from the objectives. On order, from Checkpoint 2 the lead company is the main effort; attacks along Direction of Attack 1 to seize OBJ POLK 2 and destroy or capture enemy personnel and equipment. The trail company follows the lead company and assumes the main effort, passes through the lead company, and attacks to seize OBJ POLK 1 in order to complete the destruction or capture of enemy personnel and equipment. TF SPUR is 1st Bde's deep fight asset; destroys enemy tank reserve in EA ZOO before it reinforces OJBs POLK 1 and POLK 2. 2-67 IN accepts risk initially and has no internal reserve. 1st Bde reserve tank platoon has priority of commitment to 2-67 IN. On order, 2-67 IN secures key terrain in zone to deny enemy freedom of maneuver or ability to influence 313 (US) Sep Mech Bde movement through zone to the north. Battalion main effort shifts to one company (+) at Blocking Position 1, which orients east and south to deny enemy vehicle movement throughout the zone. One company occupies Blocking Position 2, orients north, east, and south to prevent enemy ability to influence 313 (US) Sep Mech Bde movement through zone to the north. One company remains in Assembly Area CAT as battalion reserve. Priority of commitment is to the main effort. Scout platoon screens battalion eastern boundary along Phase Line Banana.

Given these two COAs, the commander then directs the staff to wargame each COA.

Application of the Model / Matrix

This section applies the proposed evaluation criteria model and decision matrix to the COA analysis, comparison, and decision phases of 2-67 IN's tactical estimate. For COA analysis, it will apply the evaluation criteria model to COA 1

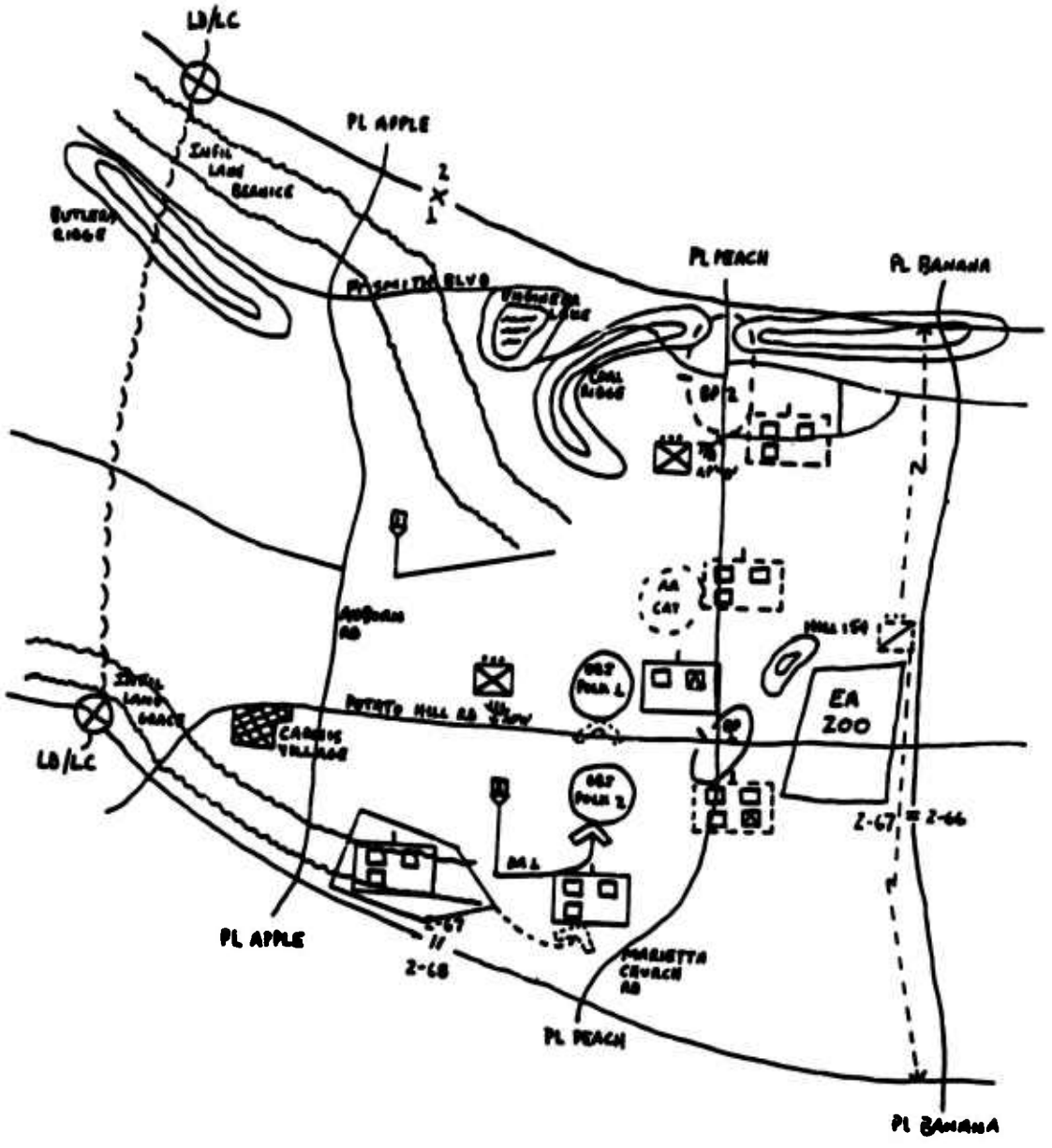


Figure 26. COA #2 Sketch.

and COA 2 based on the commander's initial intent and the wargame results for each COA. For COA comparison, it will apply the decision matrix to determine the best COA. The results of this application provide the information required for analysis of the model, which occurs in the next section.

COA Analysis

Based on the commander's initial intent, and particularly on his definition of successful endstate, the evaluation criteria model for the COA analysis phase forms as shown in figure 27. The commander applies the weights to each component criterion and the overall model categories as indicated in the figure. This illustrates the relative value that the commander places on each individual criterion and the basic model categories. Additionally, the commander identifies the threshold that distinguishes advantage from disadvantage for each component criterion.

During the next portion of COA analysis, the staff wargames each COA based on the most likely enemy COA and a consideration of planning factors (movement, casualty, ammunition expenditure rates, combat power ratios, etcetera). Figure 28 depicts the results of the wargame for COA 1 as they relate to the evaluation criteria model. Figure 29 depicts the same for COA 2. Note that the staff is able to portray advantages and disadvantages for each COA without comparing them.

CATEGORY	COMPONENT CRITERIA	COMP. WEIGHT	CAT. WEIGHT
ENEMY	1. Degree of Neutralization (suppression of Objs) Adv-high, Disadv-moderate/low	1	
	2. Endstate Losses (pers.) Adv-›75%, Disadv-‹75%	1	1
	3. Endstate Losses (veh.) Adv-100%, Disadv-‹100%	1.5[1]	
	4. Endstate Level of Effectiveness Adv-‹Sqd size, Disadv-›Sqd size	1	
FORCE	1. Probability of Compromise Adv-low, Disadv-moderate/high	1	
	2. Endstate Losses (NTE 20%) Adv-‹15%, Disadv-15%-20%	1.5	1.5[2]
	3. Endstate Combat Power Adv-›90% in 2 companies Disadv-‹90% in 2 companies	2	
TERRAIN	1. Degree of Collateral Damage (Carnis Village) Adv-none, Disadv-minimal to high	1	
	2. Degree of Area Control (Co at M.C. Rd and Coal Ridge) Adv-›90% 1 Co, Disadv-‹90% 1 Co	1.5	1.5[2]
	3. Degree of Area Control (Co at P.H./M.C. Rd) Adv-›90% 1 Co, Disadv-‹90% 1 Co	2	
	4. Posture for Follow-on Ops (orientation of forces) Adv-east in zone, Disadv-other	1.5	
TIME	1. Exposure Time to Enemy Acquis. (at Auburn Rd) Adv-‹20 min, Disadv-›20 min	1	
	2. Time to Complete Mission (Objs secure NLT 0530) Adv-NLT 0330, Disadv-0330-0530	2	2[2]
	3. Critical Task Timing (establish Block Posns) Adv-NLT 0530, Disadv-after 0530	2	
	4. Recuperation Time Adv-NLT 0800, Disadv-after 0800	1.5	

[1]Note that this component criterion is considered more important than the other criteria within the category "Enemy".

[2]Note that "Time" category is considered significantly more important, and "Force" and "Terrain" are considered more important than the "Enemy" category (base value).

Figure 27. Evaluation Criteria Model Applied to Commander's Initial Intent. The component criteria, component weights, and category weights in this figure apply only to the study scenario and demonstrate how the proposed model is applied to the 2-67 IN Commander's initial intent and value judgments in this scenario.

FROM CDR'S INTENT		FROM RESULTS OF COA #1 WARGAME	
EVAL CRITERIA	WT	ADVANTAGES	DISADVANTAGES
ENEMY	1		
-Degree of Neutr. (Suppression)	1	HIGH EFFECT	
-Endstate Losses (Pers.)	1	ESTIMATE 80%	
-Endstate Losses (Vehs.)	1.5	ESTIMATE 100%	
-Endstate Lvl Eff (Squad level)	1	ESTIMATE NOTHING ABOVE SCATTERED SQUADS	
FORCE	1.5		
-Prob. Compromise (Force size)	1		HIGH - BASED ON FORCE SIZE
-Endstate Losses (Pers.)	1.5		ESTIMATE 20% - SOME FRATRICIDE FROM SPT FOSN
-Endstate Cbt Pwr (% and # Cos)	2	2 CO_s AT 95%	
TERRAIN	1.5		
-Degree of Collat Damage (Carnis)	1	NONE	
-Degree of Area Cntl (Coal Ridge)	1.5	Co AT BP 2 (95%)	
-Degree of Area Cntl (P.H./M.C.Rd)	2	Co AT BP 1 (95%)	
-Posture for Fol-on Ops	1.5	ALL UNITS ORIENTED EAST	
TIME	2		
-Exposure Time to En Acquis (Auburn)	1		>20 MIN DUE TO FORCE SIZE
-Time to Cmplt Msn (Objs secure)	2		OBJ; SECURE AT 0400
-Crit Task Timing (Establish BPs)	2		BP 2 ESTB AT 0600
-Recuperation Time	1.5	NLT 0800	

Figure 28. Application of Evaluation Criteria Model to COA #1.

FROM CDR'S INTENT		FROM RESULTS OF COA # 2 WARGAME	
EVAL CRITERIA	WT	ADVANTAGES	DISADVANTAGES
ENEMY	1		
-Degree of Neutr. (Suppression)	1		MODERATE - INTERNAL TO CO_1; NOT EFFECTING ON BOTH OBJ, SIMULTANEOUSLY
-Endstate Losses (Pers.)	1	90%; ALL BUT PORTIONS OF FWD PLT	
-Endstate Losses (Vehs.)	1.5	100%	
-Endstate Lvl Eff (Squad level)	1	ESTIMATE NOTHING ABOVE SCATTERED SQUADS	
FORCE	1.5		
-Prob. Compromise (Force size)	1	LOW	
-Endstate Losses (Pers.)	1.5	10-15%	
-Endstate Cbt Pwr (% and # Cos)	2		2 CO_1 AT 85-90%
TERRAIN	1.5		
-Degree of Collat Damage (Carnis)	1		MINIMAL - FORCE ROUTE NEAR CARNIS VILLAGE
-Degree of Area Cntl (Coal Ridge)	1.5		CO_1 FORCE AT BP 2 (85-90%)
-Degree of Area Cntl (P.H./M.C. Rd)	2	CO_1 FORCE AT BP 1 (95%)	
-Posture for Fol-on Ops	1.5	ALL UNITS ORIENTED EAST	
TIME	2		
-Exposure Time to En Acquis (Auburn)	1	<20 MIN (MULTIPLE ET_s)	
-Time to Cmplt Msn (Objs secure)	2	OBJ, SECURE AT 0300	
-Crit Task Timing (Establish BPs)	2	BP 1 EST@ 0230 BP 2 EST@ 0500	
-Recuperation Time	1.5	NLT 0700	

Figure 29. Application of Evaluation Criteria Model to COA #2.

COA Comparison

Using the resulting evaluation criteria models for each COA during the wargame, the staff first compares the raw data of each using the raw data matrix in figure 30. To simplify the results of this comparison, the staff constructs a decision matrix that incorporates the basic categories of the evaluation criteria model, and applies nominal values to indicate which COA best satisfies the commander's definition of success, by basic category, as measured during the wargame. After applying the commander's weighting factors, the matrix indicates the overall "best" COA (figure 31).

Decision

Based on the staff recommendation, the commander finalizes the decision, and is satisfied that the staff has focused its efforts on the "decisive elements" of the operation that he identified in his initial intent. He selects COA #2, directs the staff to begin preparation and coordination of the OPORD, and has the staff attempt to reduce the COA disadvantages that are identified in the raw decision matrix.

Analysis of the Model Using MOE

This section analyzes the applied model to determine how well it worked as compared to the theoretically optimal model. Using the MOE described in chapter three as characteristics of the optimal model, the following discussion demonstrates the proposed model's measure of

CDR'S INITIAL INTENT (Defined Success)		VARGAME RESULTS (Measured Success)			
EVAL CRITERIA	WT	COA #1		COA #2	
		ADV	DISADV	ADV	DISADV
ENEMY	1				
-Degree of Neutralization	1	HIGH EFFECT			MODERATE EFFECT
-Endstate Losses (Pers)	1	80%		90%	
-Endstate Losses (Vehs)	1.5	100%		100%	
-Endstate Lvl of Effectiveness	1	SEVERE OR LESS		SEVERE OR LESS	
FORCE	1.5				
-Prob of Compromise (Force size)	1		HIGH	LOW	
-Endstate Losses (Pers.)	1.5		20%	10-15%	
-Endstate Cbt Pwr (% and # in Cos)	2	2 Cos (95%)			2 Cos (85-90%)
TERRAIN	1.5				
-Prob of Collat Damage (Carnie)	1	NONE			MINIMAL
-Degree of Area Cntl (Coal Ridge)	1.5	Co AT BP2 (95%)			Co AT BP2 (85-90%)
-Degree of Area Cntl (P.H./M.C. Rd)	2	Co AT BP1 (95%)		Co AT BP1 (95%)	
-Posture for Follon Ops	1.5	ALL UNITS EAST		ALL UNITS EAST	
TIME	2				
-Exposure Time to Enemy Acquisition	1		>20 min	<20 min	
-Time to Cmplt Msn (Objs secure)	2		0400	0300	
-Crit Task Timing (Establish BPs)	2		BP2 - 0600	BP1 - 0230 BP2 - 0500	
-Recuperation Time	1.5	NLT 0800		NLT 0700	

Figure 30. Application of the Raw Data Matrix (COA Comparison).

EVALUATION CRITERIA	WEIGHT	COA #1	COA #2
ENEMY FACTORS	1	15/15	10/10
FORCE FACTORS	1.5	10/15	10/15
TERRAIN FACTORS	1.5	15/22.5	10/15
TIME FACTORS	2	10/20	20/40
TOTAL / WEIGHTED TOTAL		50/72.5	50/80

GREATER VALUE IS BETTER

Figure 31. Application of the Decision Matrix. COA #2 is the "best" because it has the highest relative probability of success, as defined in the commander's initial intent and as measured during the wargame.

effectiveness, and the degree that it improves the infantry battalion's capability to select the best COA.

MOE 1--Intent-Oriented

The proposed model related directly to the definition of successful endstate relative to the enemy, the force, the terrain, and time in accordance with the 2-67 IN Commander's initial intent.

MOE 2--Discriminatory

While the wargame process determined real differences between COAs, the proposed model identified those differences and sufficiently differentiated the COAs during the comparison phase.

Interestingly, application of the model during COA comparison was best accomplished by first comparing the COAs using the raw data matrix. This allowed identification of real differences in detail. Then, by converting the raw data matrix to the decision matrix, the detail was lost, but the COA differences were transformed in a simplified manner.

MOE 3--Measurable

As MOE 1 (Intent-oriented) links the perfect model to the definition of desired success, this MOE links it to a measurement of probable success; the wargame. In this situation the proposed model accounted for the observed, computed, or estimated results of the wargame.

Recognizing that the wargame, itself, is an art and a science, the measurable results of the wargame in this scenario took on many forms. "Fuzzy" measurement is not necessarily an indication of error or inaccuracy. What is important is that the measurable results are reliable. One of this model's benefits is that in displaying the wargame results, it provides the opportunity for a "critical eye" to examine the results and apply judgment in their interpretation. This point is lost in most of the tactical decision matrices found in the literature.

MOE 4--Quantitative

This MOE requires that the model provide a method to assign numbers and rank COAs. The proposed model accomplished this in the final decision matrix, where the staff assigned numbers and ranked the COA based on the raw data matrix and the commander's weighting factors.

Superficially, the proposed model appeared to satisfy this MOE. However, closer examination reveals very little of the "method" used to translate the raw data into nominal values and rankings on the decision matrix. It is based primarily on subjective value or worth assessments of both basic category criteria and weights. If the method is "by observation," then the model can be misinterpreted and the matrix can be unjustifiably manipulated. This highlights the importance of using and keeping the raw data matrix as a reference in case questions arise about the rationale for simplified nominal values in the decision matrix.

MOE 5--Realistic

This MOE is perhaps the most difficult to satisfy because it requires the ideal model to relate realistically to the estimate process and associated uncertainties, and therefore, adapt to any situation.

On the positive side, the proposed model has as its heart the METT-T model, except for the M--mission. It omits mission because if a COA does not satisfy any criterion relating to accomplishing the mission, it is not a legitimate COA. Both the commander's definition of successful endstate in his initial intent and the wargame results are expressed in terms of the status of enemy, troops, terrain, and time (ETT-T). Since METT-T is the doctrinal way to analyze and adapt to any situation, and since the estimate is doctrinally valid for any situation, it appears that the proposed model has some credibility.

However, there are three drawbacks to this model that realistically relate to the tactical estimate as a whole. Each drawback relates to three of this study's assumptions. The assumption that the mission analysis and COA development phases are conducted correctly, that the commander is willing and able to define successful endstate in such detail or form, and that a sufficiently experienced staff conducts the wargame correctly and honestly might appear to be "tall orders in the real world." This study makes such assumptions in order to isolate the evaluation criteria model for research. In doing

so, the resulting model appears to risk a degree of idealism at the expense of realism.

MOE 6--Balanced

The proposed model satisfied the requirement to account for objective definition tempered by subjective insight and judgment. The objective criteria were predicated on the subjective insight and judgment of the commander. The objective wargame results were predicated on the staff's experience and skill in the realistic application of planning factors.

MOE 7--Appropriate

This MOE requires the model to conform to doctrinal standards. Nothing about the proposed model or decision matrix appeared to violate doctrinal standards or terminology.

MOE 8--Sensitive

The model provided a distinct mechanism to distinguish advantages from disadvantages for each COA prior to COA comparison. The determination of each COA's advantages and disadvantages during COA analysis had direct bearing on the ultimate ranking of each COA, by basic model category, in the decision matrix.

MOE 9--Inclusive

The standard required by the analysis objective of this study was to account for the complex, but critical, "art versus science" balance in tactical decision making. The

proposed model complements this balance by providing a framework to organize thought and develop judgment. However, it does not preempt or preclude the exercise of judgment, skill, and experience. Rather, it is eminently dependent on them. The proposed model was, therefore, inclusive of both art and science.

MOE 10--Independent

The proposed model provided evaluation criteria that were mutually exclusive with respect to the screening criteria used to develop the two COAs.

MOE 11--Simple

This MOE requires the model to be easily understandable, to focus the planning group, and to keep the number of criteria to a manageable level.

On the positive side, the model focused the planning group throughout the estimate on those decisive elements the commander determined "up front" in his initial intent. Additionally, the simplified decision matrix used only the four basic model categories (enemy, force, terrain, and time) to display the COA comparison for the commander's decision. According to FM 7-20, three to seven criteria represent a manageable number.[18]

On the negative side, the model and raw data matrix can become unwieldy in terms of the number of component criteria. Additionally, a determination of the model's

general acceptance in the field as easily understandable requires further study.

Findings

This final section of the chapter consolidates relevant information from the analysis and forms the basis for conclusions about the model. The findings focus on implications both internal and external to the application of the model in this particular scenario.

Internal Implications

Within the framework of the scenario, the model appears to adequately satisfy all but one of the MOE that characterize the theoretically optimal model.

Analysis of the model in relation to MOE 4 (Quantitative) reveals a weakness in the method of translating raw data into nominal values in the simplified decision matrix. The raw data matrix partially rectifies this weakness by serving as a justification reference for the nominal values assigned to the decision matrix.

Therefore, based on the analysis internal to the scenario, the proposed model appears to improve the infantry battalion's capability to select the best COA.

External Implications

Outside the framework of the scenario, the model appears to satisfy all but two of the MOE that characterize the theoretically optimal model.

Analysis of the model in relation to MOE 5 (Realistic) reveals a propensity toward idealism rather than realism due to the nature of several of the assumptions inherent in this study, and as applied in the scenario. However, the model does adhere to the requirement to be adaptable to any situation since it relates directly to the METT-T model.

Analysis of the model in relation to MOE 11 (Simple) reveals a need for further research to determine if the proposed model is easily understandable among infantry battalions throughout the U.S. Army.

Therefore, based on the analysis there are external implications that require additional research in order to determine if the proposed model will actually improve the tactical decision making process "outside of the laboratory."

CHAPTER SIX

CONCLUSIONS

This chapter determines the verification of the proposed evaluation criteria model and serves as a basis for its improvement. It addresses an evaluation of the model in order to determine strengths and weaknesses, and an evaluation of the thesis research design in order to determine internal and external validity. Next, it will provide recommendations that focus on the usefulness of the model. Finally, the chapter identifies areas for future study.

Model Evaluation

The proposed evaluation criteria model appears to be soundly based in both problem solving theory and current U.S. Army tactical decision making doctrine. Within the framework of this study, it appears to illustrate the basic premise that the best COA is the one whose measured success (wargame results) best satisfies the desired or defined success (commander's initial intent). Therefore based on the research scenario, the proposed model credibly improves the infantry battalion's capability to select the best COA during the deliberate tactical estimate.

The following sections of the chapter identify the strengths and weaknesses of the proposed model, as they pertain to the research scenario.

Strengths

The model addresses all of the problems that were identified in other models during the literature review. It is based first and foremost on the commander's initial intent and the results of the wargame. It adapts to any situation within the infantry battalion's parameters because it incorporates the METT-T model.

Its component criteria are measurable and observable via the wargame, and they provide a mechanism for the identification of advantages and disadvantages during COA analysis, before COAs are compared to one another. It focuses the planning group from the point in time that the commander issues his initial intent. It excludes the screening criteria that are used to develop COAs, and sufficiently differentiates COAs during the comparison phase. It conforms to current doctrine and accounts for both subjective and objective assessments.

Most importantly, it accounts for the critical balance between art and science by providing a logical framework to organize thought and develop judgment, while supporting the commander and staff's application of experience, skill and military judgment.

Weaknesses

During the COA comparison phase of the estimate, the model provides a technique or method to describe how the information in the raw data matrix is transformed nominally into the simplified decision matrix. While the method provides one way to preserve some degree of accuracy, it still risks misinterpretation and inaccurate manipulation of the nominal values in the decision matrix.

This weakness can be somewhat reduced by maintaining the raw data matrix as justification in case questions arise about the rationale for the nominal values assigned to each COA through the translation of raw data from the wargame results.

Research Design Evaluation

The scientific approach to inquiry provides an adequate research design for this study, even though the subject of tactical decision making is primarily one of art and "social" science. The research design results in an acceptable degree of confidence for conclusions about the proposed model within the given test scenario.

However, this design results in a much less conclusive answer to the primary research question when applied to other situations.

The following sections address the internal and external validity of the proposed model, based on the research design.

Internal Validity

Internal to the study, the research design adequately controlled the hypothesis variables and tested the thesis hypothesis. Given the stated scenario, the proposed model demonstrated an effective method to select the best COA by adhering closely to the majority of MOE for the theoretically optimal model.

However, the model's inability to completely satisfy two of the MOE demonstrates several implications that reflect on its external validity.

External Validity

The assessment that the proposed model may not relate realistically to the tactical decision making process and its associated uncertainties (MOE 5) stems from a careful consideration of several thesis assumptions. First, the assumption that the first two phases of the estimate (mission analysis and COA development) are correctly conducted is a valid one in order to isolate analysis of the proposed model within the design of this study. However, this assumption cannot be considered valid in all cases outside of the research design. Secondly, the assumption that the commander is willing and able to issue his initial intent to the staff at the conclusion of mission analysis, in the form and detail associated with that described in this study, cannot be considered valid in all cases outside of the research design. Finally, the same implication is true for the assumption that

an experienced staff conducts the wargame skillfully and honestly, in accordance with the procedure that is taught at CGSC, PCC, and TCDC.

While each of these assumptions is necessary in order to isolate analysis of the proposed evaluation criteria model during the COA analysis, comparison, and decision phases of the tactical estimate, the assumptions result in a degradation of the model's realistic capability to improve any infantry battalion's capability to select the best COA during the deliberate tactical estimate.

The assessment that the proposed model only partially satisfies the requirement to be simple (MOE 11) stems from uncertainties regarding whether or not it is easily understandable among infantry battalions throughout the U.S. Army.

This uncertainty indicates the need to conduct further research, which was beyond the scope, means, or intent of this study's research design.

All of the factors listed above point to possible limitations regarding the proposed model's applicability to the general population of all infantry battalion's within the U.S. Army.

Recommendations

This section of the chapter addresses final modification of the model and its usefulness. It concludes with recommended areas for future study.

Finalized Model and Use

The proposed evaluation criteria model actually incorporates five steps of model construction. Step one is the transformation of the commander's initial intent (successful endstate) into the basic model categories of enemy, force, terrain and time. Step two is the selection of appropriate component criteria within each basic model category, the determination of the dimension of measure and identification of advantage / disadvantage for each component criterion, and the weighting of each component criterion and the overall category criteria to reflect the commander's value judgment. Step three occu during COA analysis, when the COA's wargame results are displayed as a measure of probable success relative to each component criterion. Step four is the initial part of COA comparison, when the raw data matrix displays the information from each separate COA analysis in comparison form. Step five is the simplified decision matrix, which transforms the information from the raw data matrix into nominal values that indicate the COA with the highest relative probability of success.

As indicated earlier in this chapter, it is critical that the raw data matrix from step four accompany the simplified decision matrix in step five in order to account for inherent weaknesses in the transformation between the two matrices.

Based on the model's apparent limitations regarding its external validity, it is primarily useful as a teaching

instrument for the conduct of the infantry battalion's deliberate tactical estimate during a deliberate attack. It provides a method to address problems that have been identified in units at the CTCs, and correct the lack of clearly defined guidance in current decision making doctrine. By teaching, understanding, and internalizing the model, the infantry battalion commander and staff can more effectively apply the tactical estimate process under the realistic conditions of time and experience constraints.

Recommendations for Future Study

The recommendations for future study about this topic center around the research limitations and delimitations addressed in chapter one. They also focus on a proposed direction to lead future research within the same scope of this study.

At the time that this study began, emerging Airland Operations doctrine was not available. The final draft of this doctrine is now in circulation, and should be analyzed to determine its influence on the validity of the proposed model.

This study analyzed current U.S. Army decision making doctrine and related sources in order to arrive at a theory about the requirements for a "perfect" evaluation criteria model. This theory is admittedly based on a subjective interpretation of the literature within the sterile context of peacetime research. Clausewitz wrote:

> Theory must stay with simple terms and straightforward observation of the conduct of war; it must avoid spurious claims and unseemly displays of scientific formulae and historical compendia; and it must stick to the point and never part company with "those who have to manage things in battle by the light of their native wit.'

Keeping Clausewitz's point in mind, future research that focuses on the validity of this study's theoretically optimal model will provide additional evidence to either support or refute the hypothesis of this study.

This study imposed several constraints in order to narrow the scope of the research to a manageable level. These constraints focused on the level of war, spectrum of conflict, type of forces, level of organization, type of organization, type of operations, and time available for decision making. However, it appears that the proposed model may apply outside of this narrow scope. For example, level and type of organization appear to be two constraints that may be excessively restrictive. This model may be just as effective for an armor brigade or a Marine Expeditionary Unit as for an infantry battalion.

Future research to determine the model's applicability outside the bounds of any one of these delimitations will provide valuable insight to a complex topic that will always bear close scrutiny on the future battlefield.

Finally, in proposing a direction to lead future research within the same scope of this study, the Tactical Commander's Development Course (Light) at Fort Leavenworth appears to be an excellent vehicle to test the model's

applicability and acceptance among future infantry battalion commanders. The study's scenario and resulting evaluation criteria model can be compared to actual estimate formulation by students in the course. Additionally, the JANUS computer simulation system can "play out" the selected COA. This provides a means to assess the validity of the model, as it pertains to the raw data from the wargame results.

The model's noted weakness in translating the raw data matrix into nominal values in the simplified decision matrix perhaps warrants additional research in determining the "optimal" translation method. This recommendation for future research would appear to be a suitable task for the U.S. Army's Operational Research Systems Analysis (ORSA) community.

APPENDIX

PRESENTATION OF COMPONENT CRITERIA

1. Basic Model Category: Enemy

2. Component Criterion Title: Endstate Combat Power

3. Definition: The probable proportion of enemy initial combat power (maneuver, firepower, protection, leadership, or any combination rating) at endstate based on the application of established combat power planning factors and sound subjective judgment and experience during the wargame. It can apply to a particular enemy subordinate unit or to the enemy force as a whole. Relation of output to input is:

$$\text{Endstate Combat Power} = \frac{\text{remaining combat power}}{\text{initial combat power}} \times 100$$

4. Dimension: Ratio -- output is a proportion in terms of initial enemy combat power, such as 50%. It is expressed as an estimation of combat power. (During hasty analysis it can be expressed in generic degrees, such as high, moderate, or low.)

5. Limits:

a. Level of acceptable risk - (determined by commander as a screening criterion)

b. Advantage / disadvantage threshold - (determined by commander; disadvantage limit must not violate level of acceptable risk)

c. Output can vary from 0% to the level of acceptable risk.

6. Rationale: This is a direct measure of the probable enemy capabilities degradation as a result of the combat power ratios used during the wargame process. It addresses the probable effectiveness of a COA.

7. Relevance: The criterion is used to evaluate the probability of total force effectiveness when the primary mission is oriented on the enemy or when enemy combat power is of critical importance in defining successful endstate.

1. Basic Model Category: Enemy

2. Component Criterion Title: Endstate Losses

3. Definition: The probable proportion of enemy losses at endstate based on the application of objective combat power ratios, established planning factors, and sound subjective judgment and experience during the wargame process. Losses may include separate categories of personnel, vehicles, weapon systems, or other. Relation of output to input is:

$$\text{Endstate Losses} = \frac{\text{number of loses in force}}{\text{initial number in force}} \times 100$$

4. Dimension: Ratio -- output is a proportion in terms of initial force, such as 50% losses. It is expressed as an estimation of losses. (During hasty analysis it can be expressed in generic degrees, such as high, moderate, or low.)

5. Limits:

a. Level of acceptable risk - (determined by commander as a screening criterion)

b. Advantage / disadvantage threshold - (determined by commander; disadvantage limit must not violate level of acceptable risk)

c. Output can vary from the level of acceptable risk to 100%.

6. Rationale: This is a direct measure of the probable enemy losses suffered as a result of the wargame process. It addresses probable effectiveness of a COA.

7. Relevance: The criterion is used to evaluate the probability of total force effectiveness when the primary mission is oriented on the enemy or when enemy losses are of critical importance in defining successful endstate.

1. Basic Model Category: Enemy

2. Component Criterion Title: Degree of Neutralization

3. Definition: The probable degree of enemy neutralization at endstate or during specific portions (time and location) of the operation based on the applicaiton of established planning factors (combat power ratios, range of engagements, types of weapons and ammunition, expected volume of fire, etcetera) and sound subjective judgment and experience during the wargame process. Relation of output to input is:

$$\text{Degree of Neutralization} = \frac{\#\ (\text{destroyed} + \text{defeated} + \text{suppressed})}{\text{total \# in enemy force}}$$

Note: Numerator can also include other effects such as blocked, denied, jammed, etcetera, but must be defined as "not operating" for a specific period of time. Numerator categories must be exclusive -- one may not be counted in another.

4. Dimension: Ratio -- a pure number expressing a ratio between two counts of force size. May be expressed in terms of a fraction, proportion, or percentage of force size or force capability. It is expressed as an estimate of neutralization. (During hasty analysis it can also be expressed in generic degrees, such as high, moderate, or low.)

5. Limits:

a. Level of acceptable risk - (determined by commander as a screening criterion)

b. Advantage / disadvantage threshold - (determined by commander; disadvantage limit must not violate level of acceptable risk)

c. Output can vary from the level of acceptable risk to unity.

6. Rationale: This is a measure of the probable enemy capabilities degradation that takes account of more than just killed, wounded, and destroyed (equipment) at a given time. It is used to assess both lethal and non-lethal employment of friendly assets.

7. Relevance: The criterion is used to evaluate the probability of total force effectiveness whether the mission is oriented on enemy, force, terrain, or time.

1. Basic Model Category: Enemy

2. Component Criterion Title: Level of Effectiveness

3. Definition: The probable unit proportion of enemy initial force that survives at the time of measure (and possibly at a particular location), based on the application of established planning factors and sound subjective judgment and experience during the wargame process. Relation of output to input is:

$$\text{Level of Effectiveness} = \frac{\text{remaining number in force}}{\text{standard size of selected force level}}$$

Normally, the selected force level is a subordinate unit level of the total enemy force. For example, if a friendly battalion is attacking an enemy reinforced company, the selected force level may be an enemy squad. As a result, the level of effectiveness is a determination of the probable number of enemy squad size units remaining at the time of measure. To carry the example further, four squad size units remaining within a particular location can combine to form an enemy platoon, which exceeds the selected force level. If the four remaining squads are "scattered," then the level of effectiveness does not exceed the squad.

4. Dimension: Nominal values -- output is an estimation of the number and size of the enemy force at the time of measure and throughout the area of operation.

5. Limits:

a. Level of acceptable risk: (determined by the commander as a screening criterion; it is expressed as the maximum enemy unit level he considers incapable of effectively interfering with a particular mission or aspect of the mission)

b. Advantage / disadvantage threshold - (determined by the commander; disadvantage limit must not violate level of acceptable risk)

c. Output can vary from zero to the level of acceptable risk.

6. Rationale: This is a measure of probable enemy capabilities degradation based on the wargame results. It provides an assessment of the enemy's remaining capability to operate at a level that can effectively interfere with friendly operations.

7. Relevance: The criterion is used to evaluate the probability of remaining enemy force effectiveness whether the primary mission is oriented on enemy, force, terrain, or time.

1. Basic Model Category: Enemy

2. Component Criterion Title: Effect of Reaction / Reinforcement

3. Definition: The probable ability of the enemy force to react with internal reserves or reinforce the main force with external reserves based on positioning, detection, decision, movement, firepower, and communications aspects of both the friendly and enemy forces during the wargame process. Relation of output to input is not in formula form, but is expressed by the action, reaction, counteraction process of the wargame.

4. Dimension: Degree -- output is expressed as an estimation of degree that the enemy can influence the action with internal and external reserves, such as high, moderate, or low.

5. Limits:

a. Level of acceptable risk - (determined by the commander as a screening criterion)

b. Advantage / disadvantage threshold - (determined by the commander; disadvantage limit must not violate level of acceptable risk)

c. Output can vary from no ability to react / reinforce to the level of acceptable risk.

6. Rationale: This is a measure of probable enemy capabilities degradation as a result of the action, reaction, counteraction process of the wargame. It addresses probable enemy flexibility versus friendly preemption or counter-measures.

7. Relevance: The criterion is used to evaluate the probability of total force effectiveness whether the primary mission is oriented on enemy, force, terrain, or time.

1. Basic Model Category: Enemy

2. Component Criterion Title: Positional Disadvantage

3. Definition: The probable degree to which an enemy force is vulnerable to friendly operations based on positional orientation, maneuver, detection / surprise, and decisive point(s). It is based on the application of friendly strengths against enemy vulnerabilities during the wargame. The relation of output to input is not in formula form, but is expressed by the action, reaction, counteraction process of the wargame.

4. Dimension: Degree -- output is expressed as an estimation of the degree to which an enemy force is vulnerable to friendly operations, such as high, moderate, or low.

5. Limits:

a. Level of acceptable risk - (determined by the commander as a screening criterion)

b. Advantage / disadvantage threshold - (determined by the commander; disadvantage limit must not exceed level of acceptable risk)

c. Output can vary from the level of acceptable risk to the highest defined level of positional disadvantage.

6. Rationale: This is a measure of probable enemy vulnerability based on the action, reaction, counteraction process of the wargame.

7. Relevance: The criterion is used to evaluate the probability of friendly force effectiveness when the primary mission is oriented on the enemy, or when positional disadvantage is of critical importance in defining successful endstate.

1. Basic Model Category: Force

2. Component Criterion Title: Endstate Combat Power

3. Definition: The probable proportion of initial friendly combat power (maneuver, firepower, protection, leadership, or any combination rating) at endstate based on the application of established combat power planning factors and sound subjective judgment and experience during the wargame process. It can apply to a particular friendly subordinate unit or to the force as a whole. Relation of output to input is:

$$\text{Endstate Combat Power} = \frac{\text{remaining combat power}}{\text{initial combat power}} \times 100$$

4. Dimension: Ratio -- output is a proportion in terms of initial friendly force combat power, such as 90%. It is expressed as an estimation of combat power. (During hasty analysis it can be expressed in generic degrees, such as high, moderate, or low.)

5. Limits:

a. Level of acceptable risk - (determined by commander as a screening criterion)

b. Advantage / disadvantage threshold - (determined by commander; disadvantage limit must not violate level of acceptable risk)

c. Output can vary from the level of aceptable risk to 100%.

6. Rationale: This is a direct measure of the probable friendly force capabilities degradation as a result of the combat power ratios used during the wargame process. It addresses the probable effectiveness, survivability, and flexibility of a COA.

7. Relevance: The criterion is used to evaluate the probability of total force effectiveness when the primary mission is oriented on the enemy, or when friendly combat power is of critical importance in defining successful endstate.

1. Basic Model Category: Force

2. Component Criterion Title: Endstate Losses

3. Definition: The probable proportion of friendly losses at endstate based on the application of objective combat power ratios, established planning factors, and sound subjective judgment and experience during the wargame process. Losses may include separate categories of personnel, vehicles, weapon systems, or other. Relation of output to input is:

$$\text{Endstate Losses} = \frac{\text{number of losses in force}}{\text{initial number in force}} \times 100$$

4. Dimension: Ratio -- output is a proportion in terms of initial force, such as 20% losses. It is expressed as an estimation of losses. (During hasty analysis it can be expressed in generic degrees, such as high, moderate, or low.)

5. Limits:

a. Level of acceptable risk - (determined by commander as a screening criterion)

b. Advantage / disadvantage threshold - (determined by commander; disadvantage limit must not violate level of acceptable risk)

c. Output can vary from 0% to level of acceptable risk.

6. Rationale: This is a direct measure of the probable friendly force losses suffered as a result of the wargame process. It addresses the "cost effectiveness" aspect of a COA.

7. Relevance: The criterion is used to evaluate the probability of cost to a unit when the primary mission is oriented on the enemy, or when friendly losses are of critical importance in defining successful endstate.

1. Basic Model Category: Force

2. Component Criterion Title: Required Resources Remaining

3. Definition: The probable amount of vital friendly force resources remaining at endstate based on the application of objective planning factors (ammunition expenditure rates, fuel / battery / subsistence consumption rates, etcetera) and sound subjective judgment and experience during the wargame process. Relation of output to input is:

Required Resources Remaining	=	initial resource amount(s)	-	resource amount(s) consumed

4. Dimension: Nominal value(s) -- a stated amount of a vital resource or a combination of vital resources. It is expressed an an estimate. (During hasty analysis it can be expressed in generic degrees, such as sufficient, questionable, or insufficient.)

5. Limits:

a. Level of acceptable risk - (determined by commander as a screening criterion)

b. Advantage / disadvantage threshold - (determined by commander; disadvantage limit must not violate level of acceptable risk)

c. Output can vary from level of acceptable risk to initial resource amount(s).

6. Rationale: This measure addresses the probability of both the cost to a unit and the capability of the unit immediately following the operation (flexibility for future operations).

7. Relevance: The criterion is used to evaluate the probability of certain aspects of total force capability whether the primary mission is oriented on enemy, force, terrain, or time.

1. Basic Model Category: Force

2. Component Criterion Title: Additional Missions Capable

3. Definition: The probable degree that the friendly force is capable of performing possible contingencies or follow-on missions based on the status of the force during and after the primary mission. It is based on the action, reaction, counteraction process of the wargame, and relies heavily on sound subjective judgment and experience. Relation of output to input is not in formula form, but is expressed by degree values.

4. Dimension: Degree -- output is expressed as an estimation of the degree that a friendly force is capable of reacting to possible contingencies or the degree that it is capable of performing a branch or sequel to the primary mission. It can be expressed as follows: Fully capable, marginally capable, or incapable without external assistance.

5. Limits:

a. Level of acceptable risk - (determined by commander as a screening criterion)

b. Advantage / disadvantage threshold - (determined by commander; disadvantage limit must not violate level of acceptable risk)

c. Output can vary from level of acceptable risk to fully capable.

6. Rationale: This is a measure that addresses the probability of friendly force flexibility. Effective assessment requires a detailed consideration of possible contingencies, branches, and sequels to the primary mission.

7. Relevance: The criterion is used to evaluate the probability of total force flexibility whether the primary mission is oriented on enemy, force, terrain, or time.

1. Basic Model Category: Force

2. Component Criterion Title: Probability of Compromise

3. Definition: The probable proportion of detection of the friendly force (that might result in a compromise of the primary mission) to detection opportunities of the enemy force. It is based on the action, reaction, counteraction process of the wargame, and takes account of terrain, weather, light, and both human and mechanical sensory means and capabilities. Relation of output to input is:

$$\text{Probablity of Compromise} = \frac{\text{number of detections}}{\text{number of detection opportunities}}$$

4. Dimension: Ratio -- the probable ratio of detections to opportunities. (During hasty analysis, it can be expressed in generic degrees, such as high, moderate, or low. Analysis on this level will likely focus on force size, tempo, terrain, and weather / light data in addition to the enemy's detection capability.)

5. Limits:

a. Level of acceptable risk - (determined by commander as a screening criterion)

b. Advantage / disadvantage threshold - (determined by commander; disadvantage limit must not violate level of acceptable risk)

c. Output can vary from zero to level of acceptable risk.

6. Rationale: This is a measure of probable friendly force capability to surprise the enemy force by eluding detection that will likely result in a compromise of the primary mission.

7. Relevance: The criterion is used to evaluate the probability of force effectiveness whether the primary mission is oriented on enemy, force, terrain, or time.

1. Basic Model Category: Force

2. Component Criterion Title: Level of Effectiveness

3. Definition: The probable unit proportion of friendly initial force that survives at the time of measure (and possibly at a particular location), based on the application of established planning factors and sound subjective judgment and experience during the wargame process. Relation of output to input is:

$$\text{Level of Effectiveness} = \frac{\text{remaining number in force}}{\text{standard size of selected force level}}$$

Normally, the selected force level is a subordinate unit level of the total friendly force.

4. Dimension: Nominal value -- output is an estimation of the number and size of the friendly force at the time of measure and throughout the area of operations.

5. Limits:

a. Level of acceptable risk - (determined by the commander as a screening criterion; it is expressed as the minimum friendly unit level he considers capable of effectively performing a contingency, branch, sequel, or possible follow-on mission)

b. Advantage / disadvantage threshold - (determined by commander; disadvantage limit must not violate level of acceptable risk)

c. Output can vary from level of acceptable risk to full current level of effectiveness.

6. Rationale: This is a measure of the probable friendly force capabilities degradation based on the wargame process. It provides an assessment of the friendly force's remaining capability to operate at a level that can effectively accomplish contingencies, branches, sequels, or possible follow-on missions.

7. Relevance: The criterion is used to evaluate the probability of remaining friendly force effectiveness whether the primary mission is oriented on enemy, force, terrain, or time.

1. Basic Model Category: Force

2. Component Criterion Title: Positional Advantage

3. Definition: The probable degree to which a friendly force achieves a decisive advantage over an enemy force based on positional orientation, maneuver, surprise, and decisive point(s). It is based on the application of friendly strengths against enemy vulnerabilities during the wargame process. The relation of output to input is not in formula form, but is expressed by the action, reaction, counteraction process of the wargame.

4. Dimension: Degree -- output is expressed as an estimation of the degree to which a friendly force achieves a positional advantage over an enemy force, such as high, moderate, or low.

5. Limits:

a. Level of acceptable risk - (determined by commander as a screening criterion; example would be "I will not accept a frontal assault on the enemy position")

b. Advantage / disadvantage threshold - (determined by commander; disadvantage limit must not violate level of acceptable risk -- example would be "I consider it an advantage to envelop the enemy position along a covered and concealed route, but a disadvantage to attack his flank over open terrain")

c. Output can vary from level of acceptable risk to the highest defined degree of positional advantage.

6. Rationale: This is a measure of probable friendly force capability to achieve surprise or to concentrate overwhelming force against an enemy vulnerability based on the action, reaction, counteraction process of the wargame.

7. Relevance: The criterion is used to evaluate the probability of friendly force effectiveness whether the primary mission is oriented on enemy, force, terrain, or time.

1. Basic Model Category: Terrain

2. Component Criterion Title: Area Acquired

3. Definition: The probable amount of area taken by a friendly force as a result of the application of established planning factors (time-distance rates, etcetera) and sound subjective judgment and experience during the wargame process. Input data are the amount of area taken in square meters, square kilometers, or other area measurement, and the length of time required. Relation of output to input is:

Area Acquired = (area held at end time) - (area held at start time)

4. Dimension: Interval -- amount of area in terms of some suitable unit of measure.

5. Limits:

a. Level of acceptable risk - (determined by commander as a screening criterion)

b. Advantage / disadvantage threshold - (determined by commander; disadvantage limit must not violate level of acceptable risk)

c. Output can vary from level of acceptable risk to any value up to the total amount of area assigned as the objective or requirement.

6. Rationale: This is a measurement that directly addresses the probable effectiveness of a COA if the mission is to take terrain. Otherwise, it may still be a useful supplementary measure.

7. Relevance: The criterion can be used to evaluate a COA when the primary mission is to take terrain.

1. Basic Model Category: Terrain

2. Component Criterion Title: Coverage of Target Area

3. Definition: The probable percentage of a given area which is under influence of the friendly force (weapon or surveillance systems, or manned positions) during a critical portion of the operation or at endstate. It is based on the application of established planning factors (equipment and weapon system ranges, etcetera) and sound subjective judgment and experience during the wargame process. Relation of output to input is:

$$\text{Coverage of Target Area} = \frac{\text{area coverage}}{\text{area assigned}} \times 100$$

4. Dimension: Ratio -- a percentage of area in an appropriate unit of measure of area, such as 80% of the engagement area assigned. (During hasty analysis it can be expressed in generic degrees, such as high, moderate, or low.)

5. Limits:

a. Level of acceptable risk - (determined by commander as a screening criterion)

b. Advantage / disadvantage threshold - (determined by commander; disadvantage limit must not violate level of acceptable risk)

c. Output can vary from level of acceptable risk to 100% inclusive. Resolution of the measure depends on refinement of the unit of measure.

6. Rationale: This is a measurement of the probable effectiveness of a COA's degree of influence on the terrain.

7. Relevance: The criterion is used to evaluate the probability of total force effectiveness when the primary mission is oriented on the control of terrain.

1. Basic Model Category: Terrain

2. Component Criterion Title: Degree of Area Control

3. Definition: The probable degree of friendly force control over the assigned area of operation. It can include control of avenues of approach into or out of the assigned area of operation. An integral part of this criterion is the size of force required to establish and maintain control over the area. It is based on the application of established planning factors and sound subjective judgment and experience during the wargame process. Relation of output to input is not in formula form, but is expressed by the action, reaction, counteraction process of the wargame.

4. Dimension: Degree -- output is expressed as an estimation of the degree that the force can control the area of operation and the force size required for such control.

5. Limits:

a. Level of acceptable risk - (determined by commander as a screening criterion)

b. Advantage / disadvantage threshold - (determined by commander; disadvantage limit must not violate level of acceptable risk)

c. Output can vary from level of acceptable risk to the highest defined degree of area control.

6. Rationale: This is a measurement of the probable degree that friendly forces control an assigned area of operation.

7. Relevance: The criterion is used to evaluate the probability of force effectiveness when the primary mission is oriented on terrain or when a critical aspect of the mission is control of terrain.

1. Basic Model Category: Terrain

2. Component Criterion Title: Posture for Follow-on Operations

3. Definition: The probable location and orientation of friendly forces at endstate based on the action, reaction, counteraction process of the wargame. Relation of output to input is expressed as a location and/or an orientation.

4. Dimension: Position / direction -- location and/or orientation.

5. Limits:

a. Level of acceptable risk - (determined by commander as a screening criterion)

b. Advantage / disadvantage threshold - (determined by commander; disadvantage must not violate level of acceptable risk)

c. Output can vary from level of acceptable risk to the best possible location and orientation for the force at endstate.

6. Rationale: This is a measure of the probable friendly force capability to effectively conduct possible follow-on operations.

7. Relevance: The criterion is used to evaluate the probability of force effectiveness whether the primary mission is oriented on enemy, force, terrain, or time.

1. Basic Model Category: Terrain

2. Component Criterion Title: Degree of Collateral Damage

3. Definition: The probable degree of collateral damage to designated civilian personnel, structures, or property based on the action, reaction, counteraction process of the wargame. It takes account of friendly control measures and weapon(s) effects.

4. Dimension: Degree -- output is expressed as an estimation of degree that both friendly and enemy operations will cause non-military collateral damage, such as high, moderate, minimum, or none.

5. Limits:

a. Level of acceptable risk - (determined by commander as a screening criterion; may be dictated by higher headquarters)

b. Advantage / disadvantage threshold - (determined by commander; disadvantage limit must not violate level of acceptable risk)

c. Output can vary from none to the level of acceptable risk.

6. Rationale: This is a measure of the probable cost associated with a COA based on the action, reaction, counteraction process of the wargame.

7. Relevance: The criterion is used to evaluate the probability of total force effectiveness whether the primary mission is oriented on enemy, force, terrain, or time.

1. Basic Model Category: Time

2. Component Criterion Title: Time to Complete Mission

3. Definition: The probable elapsed time from start to end of an assigned mission based on the application of established planning factors (time-distance, etcetera) and sound subjective judgment and experience during the wargame process. Input data are the initiation and completion times, and output is the subtracted difference:

Time to Complete Mission = (end time) - (start time)

4. Dimension: Interval -- output is an estimation of an elapsed time in any appropriate measure of time.

5. Limits:

a. Level of acceptable risk - (determined by the commander as a screening criterion; it is usually a "no later than" or specified time in the higher commander's OPORD, but it can be a different time as long as there is no violation of the mission or higher commander's intent)

b. Advantage / disadvantage threshold - (determined by commander; disadvantage limit must not violate level of acceptable risk)

c. Output can vary from any positive expression of time to the level of acceptable risk.

6. Rationale: This is a measure of the probability of the timeliness of the COA based on the action, reaction, counteraction process of the wargame.

7. Relevance: The criterion is used to evaluate the probability of force effectiveness when the primary mission is oriented on time, or timeliness is of critical importance in defining successful endstate.

1. Basic Model Category: Time

2. Component Criterion Title: Exposure Time to Enemy Acquisition

3. Definition: The probable total elapsed time a friendly force is exposed to enemy acquisition based on the application of established planning factors (time-distance, etcetera), enemy acquisition capabilities, and sound subjective judgment and experience during the wargame process. Input data are start time of exposure and end time. Relation of output to input is the difference in the two input times:

Exposure Time to Enemy Acquisition = (end of exposure timepoint) - (start of exposure timepoint)

4. Dimension: Interval -- an estimation of elapsed time in any appropriate measure of time.

5. Limits:

a. Level of acceptable risk - (determined by commander as a screening criterion)

b. Advantage / disadvantage threshold - (determined by commander; disadvantage limit must not violate level of acceptable risk)

c. Output can vary from zero to level of acceptable risk.

6. Rationale: This is a measure of the probable extent of friendly force vulnerability. It is related to the force's ability to achieve surprise.

7. Relevance: The criterion is used to evaluate the probability of force vulnerability whether the primary mission is oriented on enemy, force, terrain, or time.

1. Basic Model Category: Time

2. Component Criterion Title: Time Support Available

3. Definition: The probable portion of the total time observed during which the type of support examined is available on call. Types of support include resupply, medical, fire support, air defense, communication, engineer, etcetera. It is based on supporting unit capabilities, the action, reaction, counteraction process of the wargame, and sound subjective judgment and experience. Input data are the total elapsed time observed (T) and the sum of the elapsed times of nonavailability for any particular type of support ($\Sigma\ t_1 \ldots t_n$) where n is the number of periods of nanavailability. Relation of output to input is:

Time Support Available = $T - (\Sigma\ t_1 \ldots t_n)$

4. Dimension: Interval -- output is expressed as an estimation of the time that the specified support is available. (During hasty analysis it can be expressed in generic degrees, such as high, moderate, minimal, or not available.)

5. Limits:

a. Level of acceptable risk - (determined by commander as a screening criterion)

b. Advantage / disadvantage threshold - (determined by commander; disadvantage limit must not violate level of acceptable risk)

c. Output can vary from the level of acceptable risk to total elapsed time observed.

6. Rationale: This is a measure of the probable force capability based on critical support aspects of the COA. It also can identify specific vulnerabilities in a COA.

7. Relevance: The criterion is used to evaluate the probability of total force capability whether the primary mission is oriented on enemy, force, terrain, or time.

1. Basic Model Category: Time

2. Component Criterion Title: Recuperation Time

3. Definition: The probable elapsed time that a friendly force requires to consolidate, reorganize, resupply (man, arm, move, fuel, fix) and otherwise recover from the primary mission added to the designated time of mission completion. It is based on both force and support unit capabilities. Input is mission completion time and recovery time. Relation of output to input is:

Recuperation Time = (mission completion time point) + (recovery time period)

4. Dimension: Designated time point -- output is expressed as an estimation of the time point that a unit will be ready to effectively conduct a follow-on mission.

5. Limits:

a. Level of acceptable risk - (determined by commander as a screening criterion)

b. Advantage / disadvantage threshold - (determined by commander; disadvantage limit must not violate level of acceptable risk)

c. Output can be any time point, but cannot exceed the level of acceptable risk.

6. Rationale: This is a measure of the probable force capability to effectively conduct follow-on operations. It addresses force flexibility and timeliness as they relate to sustainability aspects of the COA.

7. Relevance: The criterion is used to evaluate the probability of total force effectiveness whether the primary mission is oriented on enemy, force, terrain, or time.

1. Basic Model Category: Time

2. Component Criterion Title: Critical Task Timing

3. Definition: The probable elapsed time it takes a friendly force to conduct designated critical tasks during an operation. It is based on the application of established planning factors and sound subjective judgment and experience during the wargame process. Critical tasks can include: movement, establishing positions, breaching operations, actions on the objective, reconnaissance, etcetera. The tasks may be prior to, during, or after the execution of the primary mission. Relation of output to input is:

Critical Task Timing = (task end time) - (task start time)

4. Dimension: Interval -- output is an estimation of the elapsed time it takes to accomplish the critical task.

5. Limits:

a. Level of acceptable risk - (determined by commander as a screening criterion)

b. Advantage / disadvantage threshold - (determined by commander; disadvantage limit must not violate level of acceptable risk)

c. Output can be any amount of time as long as it does not exceed the level of acceptable risk.

6. Rationale: This is a measure of the probable timeliness of critical aspects of the mission, rather than simply the mission completion time.

7. Relevance: The criterion is used to evaluate the probability of certain aspects of force effectiveness whether the primary mission is oriented on enemy, force, terrain, or time.

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