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A methodology for evaluating the performance of intelligence functions during a computer aided exercise

Towery, Christopher R.

Monterey, California. Naval Postgraduate School

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THESIS

A METHODOLOGY FOR EVALUATING THE PERFORMANCE OF INTELLIGENCE FUNCTIONS DURING A COMPUTER AIDED EXERCISE

by

Christopher R. Towery

September 1995

Thesis Advisor: Sam Parry

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One of the primary training tools available to a Joint Commander in Chief (CINC) for training his staff on their joint mission essential tasks is a command post exercise supported by a computer simulation model. Computer Aided Exercises (CAXs) are an essential part of training a component staff, however one weakness with these valuable training tools lies in the measurement of the level of training received by the players. In most CAXs the players rapidly disperse after the exercise, and little quantitative data are captured during the running of the exercise that will allow for quick post exercise analysis. This research presents a methodology for evaluating the performance of joint intelligence tasks as set forth in the Universal Joint Task List. Instead of attempting to provide individual measures for each joint intelligence task, the methodology presented focuses on the analysis of significant events that occur during an exercise and relating intelligence functions that may have contributed to the outcome of such events. Results of experimental runs of the Joint Theater Level Simulation are presented to demonstrate the methodology and the subsequent analysis process.

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A METHODOLOGY FOR EVALUATING THE PERFORMANCE OF INTELLIGENCE FUNCTIONS DURING A COMPUTER AIDED EXERCISE

Christopher R. Towery
Lieutenant United States Navy
B.S., University of Oklahoma, 1988

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Author: [redacted]
Christopher R. Towery

Approved by : [redacted]
Sam Parry, Thesis Advisor

[redacted]
Paul S. Bloch, Second Reader

[redacted]
Frank C. Petho, Chairman
Department of Operations Research

ABSTRACT

One of the primary training tools available to a Joint Commander in Chief (CINC) for training his staff on their joint mission essential tasks is a command post exercise supported by a computer simulation model. Computer Aided Exercises (CAXs) are an essential part of training a component staff, however one weakness with these valuable training tools lies in the measurement of the level of training received by the players. In most CAXs the players rapidly disperse after the exercise, and little quantitative data are captured during the running of the exercise that will allow for quick post exercise analysis. This research presents a methodology for evaluating the performance of joint intelligence tasks as set forth in the Universal Joint Task List. Instead of attempting to provide individual measures for each joint intelligence task, the methodology presented focuses on the analysis of significant events that occur during an exercise and relating intelligence functions that may have contributed to the outcome of such events. Results of experimental runs of the Joint Theater Level Simulation are presented to demonstrate the methodology and the subsequent analysis process.

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Executive Summary

One of the primary training tools available to a Joint Commander in Chief (CINC) for training his staff on their joint mission essential tasks is a command post exercise supported by a computer simulation model. This is commonly referred to as a Computer Aided Exercise (CAX). The primary role of the computer simulation is to present a stochastic decision environment within which the staff can be presented with realistic results. Based on this simulated environment, staffs implement plans, monitor the current situation, and further develop or alter those plans as required by changing requirements. Computer Aided Exercises are an essential part of training a component staff, however one weakness with these valuable training tools lies in the measurement of the level of training received by the players. In most CAXs the players rapidly disperse after the exercise, and little quantitative data are captured during the running of the exercise that will allow for quick post exercise analysis. Measurement of a staff's capability to perform mission essential tasks is ultimately important for two reasons. First, it is important to insure that training resources are being used wisely, and progress is being realized in the training program. Second, it is important to determine the tasks for which there exists the greatest need for further training. This research is intended to furnish a CINC staff with a methodology for evaluating the performance of intelligence functions in the context of a CAX.

In the development of this methodology, it is insightful to regard the measure of any intelligence process as the answer to the question: How well was the information

necessary for optimizing the outcome of an action provided in a timely, accurate, and understandable manner? An answer to this question is the goal for any analysis methodology. This research provides two methodologies for measuring effectiveness in the performance of intelligence joint tasks during a CAX. First, a theoretical methodology which relies on a computer simulation model that is currently not in existence is discussed. Second, a more practical methodology which could be used with only slight modification to some of the computer simulations in use today is presented. The practical methodology focuses on the analysis of significant events that occur during an exercise and relating causal factors that may have contributed to the outcome of such events.

This thesis also provides a demonstration of the application of the practical methodology using the Joint Theater Level Simulation which is currently in use for the training of CINC staffs. Specifically, the demonstration shows how that with only minor changes, a simulation model can furnish the data necessary to provide greatly enhanced measures of how an intelligence staff performed throughout the conduct of an exercise.

The methodology presented does not attempt to assign values to the performance of each individual joint intelligence task stated in the UJTL, but seeks to determine how intelligence functions contributed to the outcome of significant events that occurred during the exercise. The methodology is relatively uncomplicated, but retains the robustness necessary to be applicable in many different exercise scenarios. Since it is uncomplicated, it allows for quick analysis that can be easily understood in post exercise debriefings. An additional strength is that interaction with the computer model is very limited with most of the data necessary to use the methodology readily available and easy to output in most event step simulation models.

I. INTRODUCTION

A. BACKGROUND

The Chairman Joint Chiefs of Staff (CJCS) Memorandum of Policy 26 (MOP 26) establishes a program for carrying out the joint training responsibilities of the CJCS, the Joint Commander in Chiefs (CINCs), and the CINC's component staffs. MOP 26 institutes a method for identifying training requirements through the review of the CINC's mission, and the compilation of the CINC's Joint Mission Essential Task Lists (JMETL) required to accomplish that mission. A CINC's JMETL is intended to provide the basis for all joint training.

The Universal Joint Task List (UJTL), a document devised to support the Joint Training Manual (MCM 71-92), outlines a comprehensive list of joint essential tasks. The UJTL is intended to provide a common language for describing joint warfighting capabilities throughout the entire range of military operations to include operations other than war. Specifically, tasks are defined as they relate to the strategic (both national and theater), operational, and tactical levels of war. Each joint task is broken down into *supporting* tasks which may be further refined into *enabling* tasks.

One of the primary training tools available to a CINC for training his staff on their joint mission essential tasks is a command post exercise supported by a computer simulation model. This is commonly referred to as a Computer Aided Exercise (CAX). The primary role of the computer simulation is to present a stochastic decision environment within which the staff can be presented with realistic results. Based on this simulated environment, staffs implement plans, monitor the current situation, and further develop or alter its plan as required by changing requirements. Computer Aided Exercises are an essential part of training a component staff, however one weakness with these valuable training tools lies in the measurement of the level of training received by the players. In most CAXs the players rapidly disperse after the exercise, and little quantitative data are captured during the running of the exercise that will allow for quick post exercise analysis. Measurement of a staff's capability to perform mission essential tasks is ultimately important for two reasons. First, it is important to insure that training resources are being used wisely, and progress is being realized in the training program. Second, it is important to determine the tasks for which there exists the greatest need for further training.

B. PROBLEM STATEMENT

This research develops an exercise analysis methodology for evaluating CINC staff performance in the execution of joint tasks during the conduct of a CAX, focusing on Strategic Task Three, Develop Theater Intelligence, as stated in the UJTL. Specific objectives are :

1) Develop the analytical tools necessary to provide insight into the value of intelligence information during the conduct of a CAX designed to work in conjunction with data manipulated by an unspecified computer simulation.

2) Test methodology using the Joint Theater Level Simulation (JTLS).

Develop a standardized ASCII file for capturing parameters and demonstrate a potential post-exercise analysis. This objective entails a practical application of the methodology to an existing theater level simulation. Included in this are the alignment of the model's database with required parameters necessary for utilizing the methodology, development of algorithms required in post processing, and specification of output format.

It is important to emphasize that this research is part of a larger ongoing research project which will attempt to provide an overall analysis methodology for all of the joint tasks specified in the UJTL within the context of a CAX. Concurrent with the development of the methodology presented in this paper was the development of a methodology for assessing the performance of Strategic Task Eight, Provide Theater Sustainment, presented in a paper by Captain Ray Combs U.S.A. Since the performance of one joint task during a CAX often impacts the performance of another joint task, it is strongly recommended that the reader read both papers in order to gain insight into an overall analysis methodology which will attempt to identify common causal factors that influence significant events that occur during a CAX.

C. THESIS STRUCTURE

Chapter II provides a brief overview of the Intelligence Process, and some of the known problems in measuring the impact of Intelligence Products. Chapter III will describe the proposed analysis methodology used to assess staff performance. The presented methodology focuses on the analysis of significant events that occur during an exercise and related intelligence functions that may have contributed to the outcome of such events. Chapter IV looks at applying the methodology to a typical exercise scenario using the Joint Theater Level Simulation. This chapter discusses the data manipulation that is necessary for post exercise analysis using an existing computer simulation. A summary of observations and possible inferences from the validation run are included in this chapter. Chapter V summarizes the methodology, and provides recommendations for further refinements and study.

II. OVERVIEW OF INTELLIGENCE

This chapter provides a general overview of intelligence. Specifically, it attempts to furnish insight into the underlying concepts of the structure of the intelligence tasks in the UJTL. In addition, this chapter addresses some of the past problems that have necessitated the need for determining the value of intelligence, and the problems that have arisen from the attempt to assess that value.

A. DEFINITION OF INTELLIGENCE

Intelligence is a term for which no clear-cut definition exists. Not only does it not have a precise and agreed definition, but those who attempt precision give it multiple meanings. *The Department of Defense Dictionary of Military and Associated Terms* (JP1-02) defines intelligence as " the product resulting from the collection, processing, integration, analysis, evaluation, and interpretation of available information concerning foreign countries, or areas." This definition is followed by a listing of forty-one subcategories of definitions for intelligence, thus demonstrating the difficulty in containing the definition of the term intelligence to one, all-encompassing definition. It is important to distinguish the difference between information and intelligence. Information is the raw material from which intelligence is derived. To produce intelligence, the raw information must be processed into a product which is accurate and relevant. Although not easy to define, intelligence does have a clear purpose in that it is intended to provide potentially significant information to military planning and operations. Dr. R.V. Jones, the head of the British Air Ministry's intelligence section during World War II, stated, "The ultimate objective of intelligence is to enable action to be optimized." [Ref. 1] This statement highlights the overall goal for intelligence, that being to reduce uncertainty and the element of risk in the planning and execution of any military operation.

B. LEVELS OF INTELLIGENCE

Joint Military Intelligence exists at three levels, the highest level being strategic intelligence which is required for the formulation of strategy, policy, and military plans and operations at the national and theater level. The next level is operational intelligence which provides for conducting campaigns and major operations within a theater or area of operation. The lowest level is tactical intelligence which supports the planning of battles and engagements, focusing at this level on specific combat elements and objectives. These three levels of intelligence compose the basic hierarchy of intelligence. Many of the past boundaries that existed between these levels of intelligence are growing less clear with the changes in information management systems and the rapid increase in technology. As an example, satellite reconnaissance, once a tool reserved for strategic intelligence, gradually became an integral part of operational intelligence. Now, through such programs as Tactical Exploitation of National Capabilities (TENCAP), the development of enhanced hardware, software, and communications architecture will allow for direct "sensor to shooter" relays of satellite information to the operator at the tactical level.

C. THE INTELLIGENCE CYCLE

The most widely accepted model for the intelligence process is referred to as the intelligence cycle (Figure 1). The intelligence cycle is divided into four phases. The first phase, requirements, involves specifying the perceived need for intelligence and a plan for how to best collect the information required to satisfy that need. In the second phase, collection, actual assets are tasked with the collection of the information. The third phase is the processing of raw information collected into an intelligence product. An intelligence product can take many different forms, from a formal National Intelligence Estimate (NIE) to a simple verbal report given over the telephone. The final phase is that of dissemination of the intelligence product to the user.

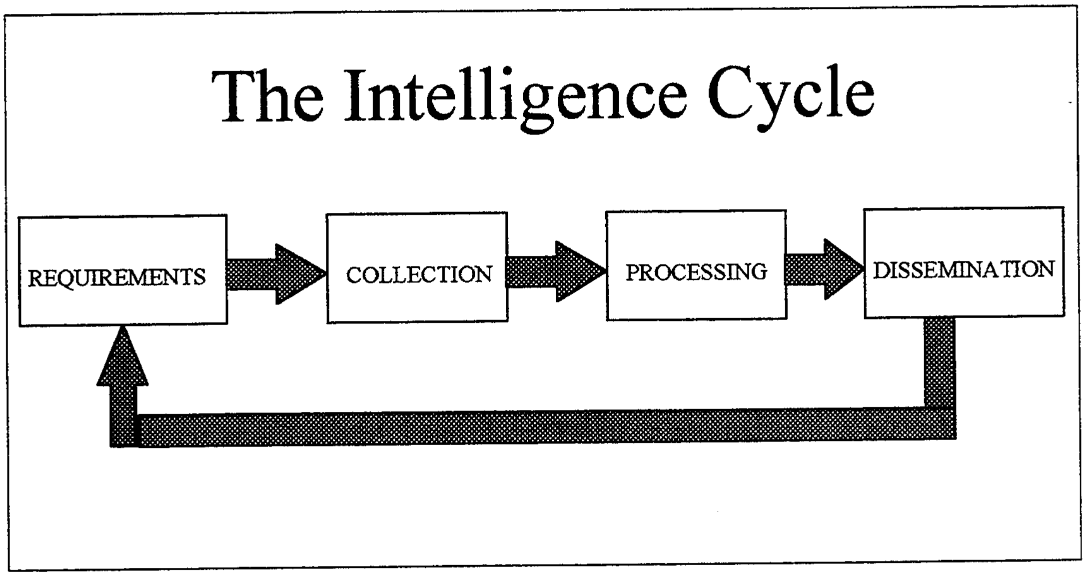


Figure 1. The Intelligence Cycle

1. Requirements

In the cycle model of intelligence, requirements are supposed to come from the decision makers. However, requirements are usually established in different ways, ranging from explicit tasking to vague questions which are left to an intelligence staff to interpret into specific intelligence requirements. Intelligence requirements may be generated by events that were not anticipated, but because they have taken place, intelligence collection is required. Establishment of intelligence requirements is essentially determining what is to be done, with the necessary condition of who will do it. Because of the difficulty in explicitly defining the inputs for requirement development, the UJTL addresses the requirements phase of the intelligence cycle in a very general manner. The joint and supporting tasks for the establishment of intelligence requirements are summarized in Figure 2.

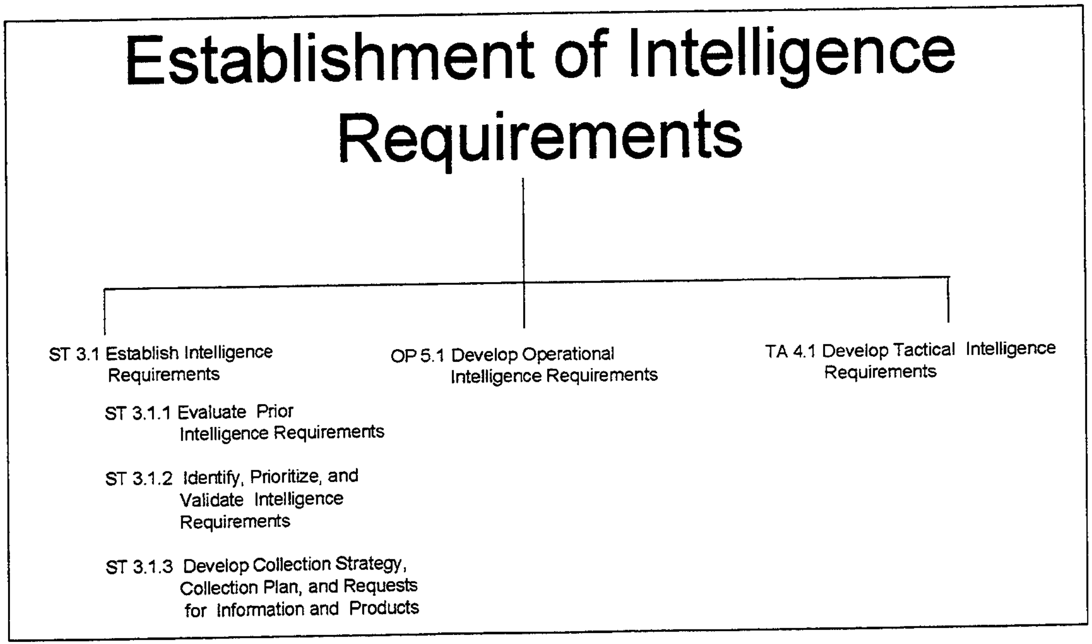


Figure 2. The UJTL joint and supporting tasks for intelligence requirements

2. Information Collection

Collection in the intelligence cycle refers to the gathering of raw data through human sources (special forces, espionage, etc.), technical means (photography, interception of electronic communications, etc.), or in any other manner such as from "open source". [Ref. 2] The raw data to be collected during the collection phase are not restricted to the obvious candidates such as enemy unit and target location, but also includes demographics of an area of operation which can play a significant role in any military operation. The UJTL separates the levels of collection into the joint and supporting tasks depicted in Figure 3 . Collection is the phase of the intelligence cycle that comes closest to what is most commonly considered intelligence activity.

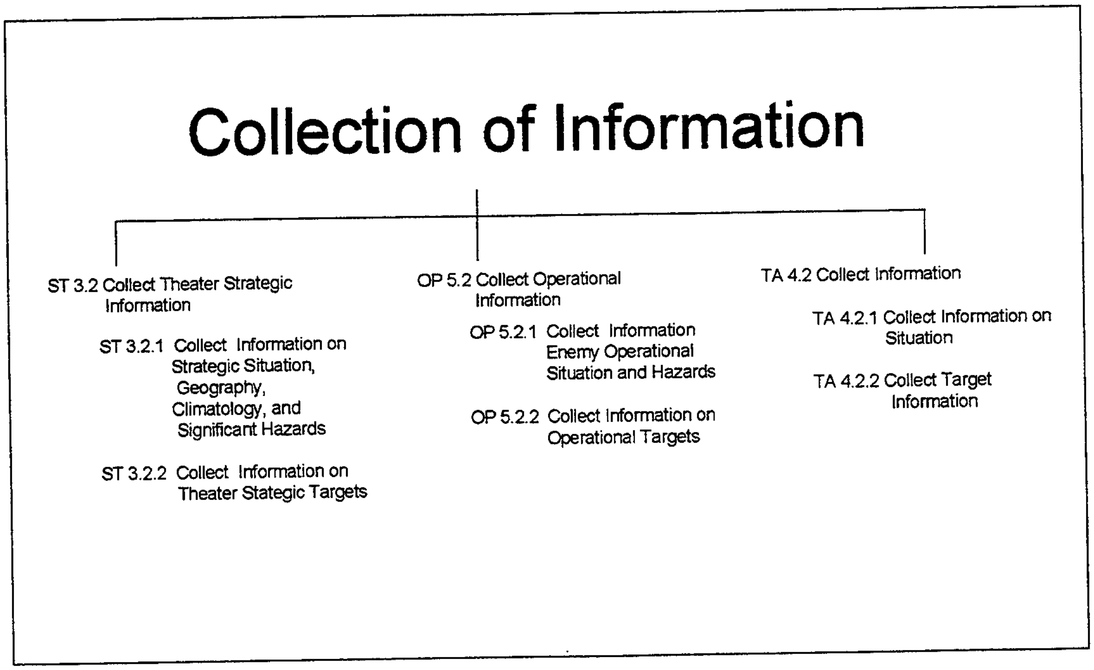


Figure 3. The UJTL joint and supporting tasks for intelligence collection

3. Information Processing

Unfortunately, no matter how good the collected information is, it seldom provides the useful information without some analysis or processing. In the vast majority of cases the information collected is fragmentary, ambiguous, and susceptible to widely divergent interpretations. Thus, the process of analyzing the available information to make judgments about capabilities, intentions, and actions of another party is a vital part of the intelligence cycle. [Ref. 2] The processing of raw information into intelligence takes a wide variety of forms, from the photographic interpreters analyzing imagery data to analysts using super-computers to decode enemy communications. Processing of raw data into intelligence can take place even on a very low level in the form of a tactical operator of a weapon system making basic judgments using past experience. The UJTL breaks information processing into the joint and supporting tasks summarized in Figure 4.

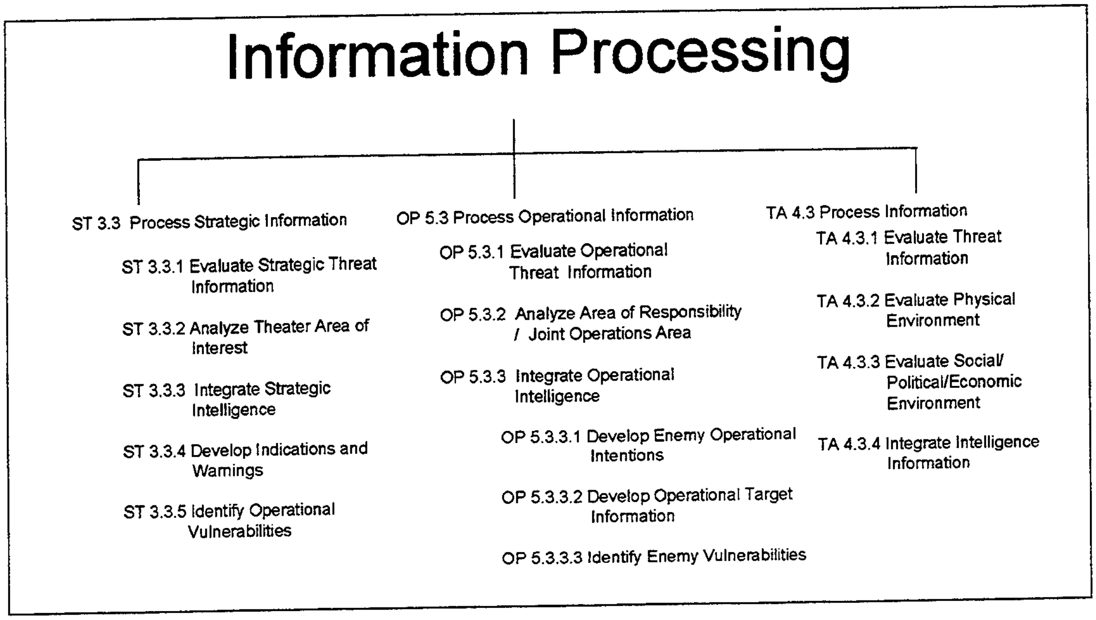


Figure 4. The UJTL joint and supporting tasks for intelligence processing

4. Dissemination of Intelligence

The most commonly overlooked phase of the intelligence cycle is that of dissemination. Dissemination is simply getting the right intelligence product to the military personnel who need it and can use it. Intelligence products can be broken down into three categories: current intelligence, basic descriptive intelligence, and intelligence estimates. Current intelligence reports are designed to provide intelligence information that may affect operations in the immediate future. Included in this category are *Indications and Warnings*, usually referred to as I&W, which are designed to provide timely warning of hostile action. I&W are based on an analysis that when certain "indicators" occur, such as a particular airfield conducting air operations, there is a likelihood of enemy action.

Current intelligence reports may be issued daily, hourly, or immediately upon receipt of the information. Basic intelligence is a general type of intelligence product that contains information that is usually less susceptible to change, such as an enemy's air order of battle or a hostile country's demographics. Basic intelligence reports are usually issued on a periodic basis. Intelligence estimates are the most ambitious type of intelligence product. These estimates are supposed to take the broadest view of the subject and project the current situation into the future. A substantial effort is devoted to providing a single estimate of how a current situation will evolve. However, sometimes dissenting opinions are expressed in what has been traditionally called a footnote, even though the dissent may be included in the text of an estimate. [Ref. 2] The UJTL breakdown of the dissemination of intelligence is summarized in Figure 5.

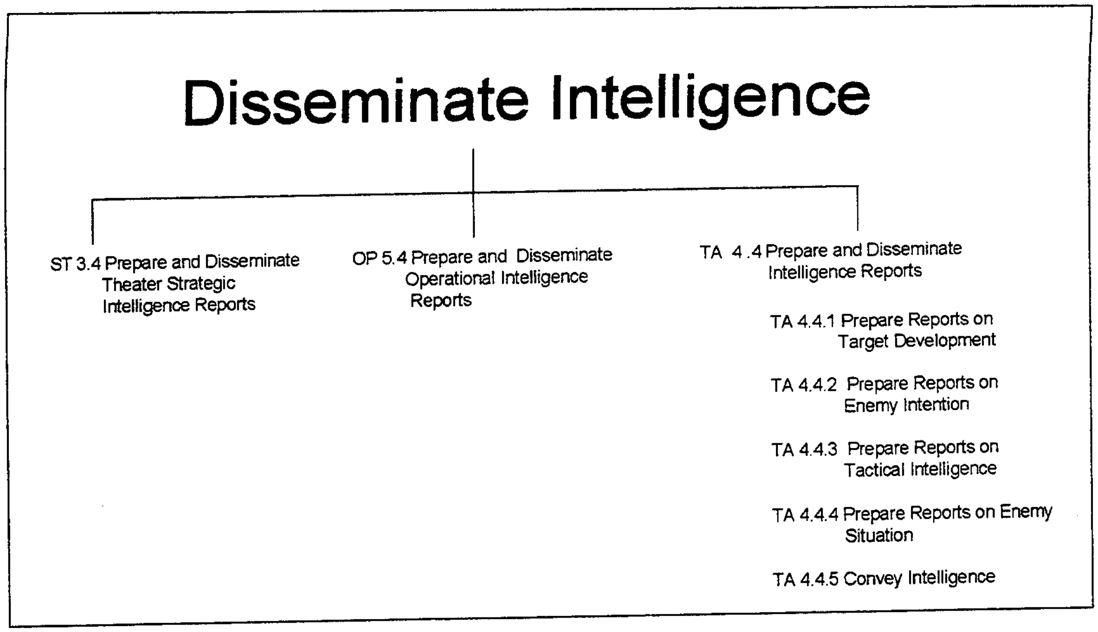


Figure 5. The UJTL joint and supporting tasks for intelligence dissemination

D. KNOWN PROBLEMS IN MEASURING VALUE OF INTELLIGENCE

Questions on the value of intelligence are frequently asked, but are seldom answered in specific terms. One such example occurs in the weapons system procurement area. What is the value of a new intelligence terminal that will allow real time overhead imagery to be displayed to a tactical commander? This question can only be answered by answering another question. What is the value of real time intelligence in a tactical situation? Based on this question many large intelligence agencies such as the National Security Agency (NSA) have been asked to justify their budgets measured in the billions to Congress and to other supervising bodies. [Ref. 3] In the joint training environment the question is asked, How well are the intelligence staffs trained to provide for the success of a mission? Once again this a question of the value of intelligence produced by the joint intelligence staff. There is a general consensus that timely, accurate, relevant, and well presented intelligence can be seen as *force multiplier*, and the lack of it can be considered both literally and figuratively as a *force divider*. Unfortunately, there has been no real way to quantify the use of intelligence as a *force multiplier*. Like a catalyst in a chemical reaction, intelligence, with its intangible output, is known to be a vital constituent of the process it influences so critically, but its precise function is difficult to isolate and measure with accuracy. [Ref. 4]

Frequently, when trying to determine the value of intelligence, the issue of the cost of intelligence arises. This issue is not easily addressed, since the determination of the cost of the inputs to intelligence products is not always clear, neither is it an easy problem to attach a value to the benefits from the decisions made with aid of intelligence, as opposed to decisions made without intelligence. For example, say an attack submarine has the collateral mission of gathering information on enemy shipping activities, and the information on enemy shipping supplements information gained from intelligence agents and assists a theater commander to make a decision to commence a blockade. How would the cost of the submarine collecting information as part of a secondary mission be determined? What is the value in dollars of information that merely supplements information used in decision making? Unfortunately, cost of intelligence is an area that yields little insight into the value of intelligence.

A methodology for assisting the commander and his staff in assessing the value of intelligence shortfalls in its collection, and its contribution to the total campaign during a

CAX is described in the next chapter. A demonstration of the application of these methods is presented in Chapter IV.

III. METHODOLOGY

In the development of an exercise analysis methodology for evaluating CINC staff performance in the execution of joint intelligence tasks during the conduct of a CAX, it is insightful to regard the measure of any intelligence process as the answer to the question: How well was the information necessary for optimizing the outcome of an action provided in a timely, accurate, and understandable manner? An answer to this question is the goal for any analysis methodology. This chapter provides two methodologies for measuring effectiveness in the performance of intelligence joint tasks during a CAX. First, a theoretical methodology which relies on a computer simulation model that is currently not in existence is discussed, and second, a more practical methodology which could be used with only slight modification to some of the current computer simulations in use today is presented.

A. SIGNIFICANT EVENTS

A common part to both post exercise analysis methodologies for evaluating intelligence staff performance presented is the concept of a *significant event*. A significant event for this paper is defined as any event occurring during an exercise that would be useful in the post exercise reconstruction for analysis of intelligence inputs into the decision making process. Significant events can be classified in terms of theater, operational, and tactical levels as well as to the degree of their significance, which may be somewhat subjective. An example of a significant event may be that of an Iraqi invasion of Kuwait which would also be an event with a very high degree of overall significance. An example of a significant event at the tactical level may be that of an infantry platoon engaging in a firefight with the enemy and sustaining minor casualties. The degree of significance of this event would have to be evaluated in relation to mission objectives and expectations.

The identification of a significant event allows for the potential determination of how well an intelligence staff was able to provide needed intelligence information by analysis of intelligence functions and perceptions that had an impact on the outcome of the significant events.

B. A THEORETICAL METHODOLOGY

A problem with measuring an intelligence staff's performance based solely on the outcome of significant events is that it involves the assumption that, provided perfect intelligence, all decision making will result in optimal event outcomes. Unfortunately, due to multiple factors including the stochastic nature of combat engagements, sub-optimal decision making can result in sub-optimal outcomes to significant events, even though perfect intelligence information has been provided.

In order to minimize the impact of imperfect decision making and the stochastic nature of most exercise simulations, a methodology for solely evaluating an intelligence staff's ability to provide the required intelligence would involve using a computer simulation model where the decision makers are part of the simulation, and would make decisions and issue orders according to a programmed set of decision rules. An intelligence staff would then provide inputs to the model for one run of the simulation, and scenario outcome measures would be collected such as the number of casualties, amount of ordinance expended, amount of terrain gained or lost, etc. . The outcome measures would then be compared to benchmark simulation runs where the model is provided perfect information, or no information. An intelligence staff's performance would then be compared to the mean outcomes of the two benchmarks, which could be run multiple times to assist in the minimization of stochastic effects.

This type of methodology attempts to sanitize the environment in which intelligence products are delivered. A major deficiency in its successful implementation is the construction of decision rules. Building a set of decision rules that would handle a majority of the situations would be an enormous undertaking. Most military leaders would find it extremely difficult to provide the essential elements necessary for them to make decisions, or the weighting given to different, sometimes conflicting, intelligence reports.

C. A PRACTICAL METHODOLOGY

It is unlikely that any simulation in the foreseeable future will provide an environment for assessing a CINC's intelligence staff free of nuisance variables. However, it is possible to develop a methodology which can work with existing computer simulation models that will provide quantifiable measures that can be used to audit intelligence functions leading up to significant events.

1. Intelligence Report Scoring

One insightful and manageable question involving the performance of an intelligence staff is: How good was the information on the potentially hostile units in the area of interest? The concept of *report scoring* used in this analysis attempts to answer that question by taking the approach that an intelligence report on any Other Than Friendly Unit (OTFU) can be decomposed into three essential report elements: location of the unit, the unit strength, and an estimate of the unit's course of intended action . One method for measuring the accuracy of each report element (e.g., position of an enemy unit) would be to compare the intelligence reported position to the actual or ground truth position and assign a score based on the difference for that particular type of unit. The greater the difference between the intelligence report element and ground truth "reality," the lower the Report Score.

However, another important factor that must be considered in measuring the worth of intelligence is the depreciation of intelligence information value over time . The inherent value of intelligence may depreciate with time from :

Actual changes in the situation.

Possible, but unknown change - so that the report cannot be used with the same level of confidence as before.

It is important to emphasize that intelligence information need not only be accurate, but that it must also be "fresh", so that a decision maker will remain confident in the use of it. The rate at which the value of an intelligence report element will depreciate is a function of the type of OTFU reported. For example, intelligence on the location of an infantry battalion will depreciate faster than intelligence on the location of an aircraft factory. [Ref. 1]

Incorporating the concept that value of intelligence depreciates with time, utility weighting curves can be constructed for each OTFU type and intelligence report element with respect to time. Utility weighting functions and the resulting utility weighting curves express the decay in the value of an intelligence report on an OTFU as the report is allowed to age. Since the depreciation of intelligence value will vary with report element type, the attributes of these utility weighting curves will most likely be different for each intelligence report element.

This paper suggests three possible functional forms, borrowed from the study of economics, to express the manner in which intelligence information may be perceived to depreciate . Determining the actual depreciation functions for intelligence information on any particular unit for a given scenario is challenging, however common properties to all intelligence depreciation functions would be that they are monotonic decreasing and they return weights between zero and one, with one representing the value of perfect information. The first depreciation function is simple linear depreciation:

$$w(t) = -\alpha t + 1 \text{ for } 0 \leq \alpha \leq 1,\ t \geq 0, \qquad (1)$$

$$w(t) = 0 \text{ for } \alpha t > 1,$$

where t is time and α is the decay rate. A second depreciation function suggested is that of "constant percentage" depreciation commonly used in the calculation of depreciation in the value of machinery. It could be used for most categories of intelligence information and is expressed by:

$$w(t) = (1-\alpha)^t \text{ for } 0 \leq \alpha \leq 1,\ t \geq 0\ . \qquad (2)$$

The third function is essentially one minus a logistic function and is shown below:

$$w(t) = 1 - \frac{1}{1+\beta e^{-\alpha t}} \text{ for } 0 \leq \alpha \leq 1,\ \beta \geq 0\ , t \geq 0 \quad . \qquad (3)$$

Equation 3 has the distinguishing property of decreasing slowly for small values of t, and then decreasing dramatically faster as t increases, where the shape parameters, α and β, adjust the rate of decay. This functional form is intended to model the value of some type of information that may retain much of its value for a certain period of time, but after that time has passed, it quickly depreciates. These three suggested depreciation functions are not meant to capture every possible structure for which information value will depreciate, but merely to provide a sound starting point in the development of utility weighting functions for the value of intelligence information. Figure 6 provides sample curves for the three functions given above with specified decay and shape parameters.

Currently most computer simulation models do not provide for the real world problem of inaccuracies in the reporting of intelligence information. Most simulations provide a sensor with a baseline probability of detection, perhaps adjusted for range, and environmental variables such as jamming, commonly multiplied by a target detection multiplier for the target to be observed. The simulation then performs a draw from a random number generator to determine whether sensor A detects target B. If a detection is made, then the simulation provides actual information on the target without error.

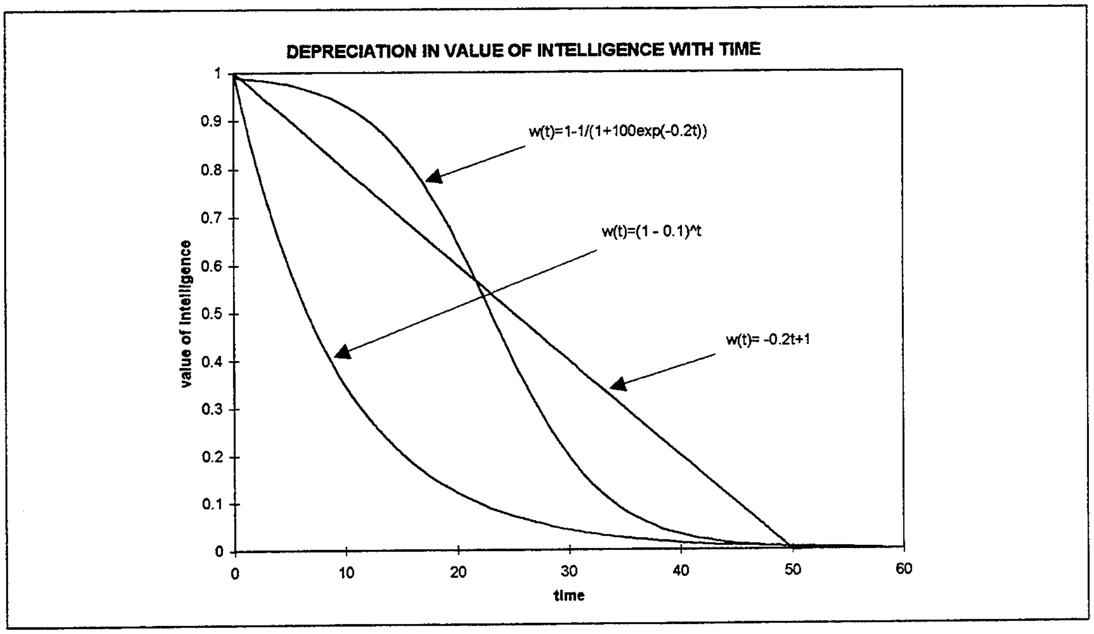


Figure 6. Depreciation of intelligence value with time.

There may be some delay time inherent in the simulation for the sensor information to be processed, but the information at time of detection is 100% accurate. Consequently, the only way that intelligence information becomes inaccurate is by the passage of time. This fact results in the determination of the utility for the OTFU intelligence report elements of location, estimate of course of action, and strength simply as a function of their age without including the possibility that the information has inaccuracies at the time of detection.

Position, course of intended action, and strength information are the core elements for an intelligence report on an Other Than Friendly Unit, and examples can easily be constructed to show cases where all three elements would be critical to good decision making, as well as examples where knowledge of any one or two elements would be sufficient. Since it may prove difficult to determine the potential critical intelligence report element, the Report Score will be composed of a sum of the values of the three elements. However, this methodology will still allow that an OTFU's Report Score could be broken down into finer detail to provide the audit trail into the values for each individual intelligence report element, should that be necessary.

Typically a decision maker relies on two important pieces of information to make a judgment on the quality or value of an intelligence report. The first is reliability of the source of the intelligence. However, computer simulations generally do not attempt to model unreliable information sources. The second is age of the intelligence which can be modeled in most simulations. Therefore the main measure of how good the intelligence is on a particular OTFU will be measured by the Report Score shown in equation 4.

$$\text{Report Score}_{\text{i}}\,(\text{t}) = \frac{\sum_{l} w_{l,i,j(t)}}{3} \qquad (4)$$

where

$w_{l,i,j(t)}$ - A utility weighting factor from 0 to 1 of the depreciation of intelligence data as a function of intelligence report element type, OTFU type, and age.

indices:

i - Other Than Friendly Unit { 1st Rep Guard, 2nd Artillery Battalion...}

t - time {in integer hours from start of CAX t = 0,1,2....}

j(t) - age of last intelligence update

l - intelligence report element type { location, estimate of COA, strength }

The Report Score can provide a measure of how effective a CINC's intelligence staff was at providing valuable information on OTFUs with only limited assumptions as to the structure of the decay of the value of the information as it is allowed to age. Combined with the identification of significant events occurring during an exercise, and the corresponding significant OTFUs, the Report Score will furnish some insight into the ability of an intelligence staff to furnish "fresh" information.

2. The Asset Needs Function (ANF)

One of the most demanding functions performed by an intelligence staff is the tasking of intelligence assets. Poor intelligence collection asset allocation was specifically noted as a deficiency for Operation Desert Shield/Storm. [Ref. 5] In large, complex exercises the assessment of the surpluses and shortages of collection assets that occur can provide insight into how well an intelligence staff made use of those collection assets at its disposal. To adequately address the question of why intelligence information on an enemy unit was deficient, it is necessary to determine whether collection assets were not available, or were merely under utilized.

An important aspect of the problem of collection asset allocation is the determination of the potential need for any particular collection asset or type of collection asset at any given time. The framework for measuring an intelligence staff's ability to adequately provide collection asset coverage within a theater of operation will be centered on maintaining a record of each collection asset's availability, and the potential need for that asset at any time during an exercise. An intelligence collection asset is considered to be available if it is determined that it could be tasked by the intelligence staff during a specified time window to conduct a collection mission. Determination of the potential need for any collection asset at a specific time is slightly more involved. Potential need is established by whether there exists a *significant* Other Than Friendly Unit or units that have a sufficiently low Report Score, and whether there exists a collection asset that has a sufficiently high probability of detection for any of those *significant* OTFUs. The purpose of the Asset Needs Function is to show the existence of a perceived need for a particular collection asset to provide information on a particular OTFU at a specific time in the exercise. The Asset Needs Function can be written in the form:

$$\mathbf{ANF_{i,k}\,(t) = (1\text{-}(Report\ Score_i\ (t)) \times pd_{i,k}(t) \times IMF_i(t) \times SRF_k \times TRF_{i,k}} \qquad (5)$$

where the indices are :

i - Other Than Friendly Unit { 1st Rep Guard, 2nd Artillery Battalion,...}

k - intelligence collection asset { JSTARS, TR-1, HUMINT teams,...}

t - time {in hours from start of CAX t = 0,1,2,....},

and the component variables are defined as follows :

$\mathbf{pd_{i,k}(t)}$ - the probability of detecting OTFU, i, at time t, given that OTFU, i is within sensor range of collection asset, k .

$\mathbf{IMF_i(t)}$ - an importance factor assigned for the degree of significance of OTFU, i , at time, t.

$\mathbf{SRF_k}$ - a sensor range factor to adjust for the difference in volume of search area covered by the different sensors carried by the collection asset, k.

$TRF_{i,k}$ - a target range factor to compensate for the range of the target from the staging point of the collection asset. Essentially, this implies that targets at the extreme limits of a collection asset's ability to search may be harder to detect.

For the ANF to return a high value, the Report Score on OTFU, i , must be low, and the probability of detection by collection asset, k ,must be sufficiently high. In summary, the Asset Needs Function is intended to express the potential of a collection asset to improve the Report Score of an Other Than Friendly Unit.

Once the ANF values have been determined for each collection asset, it is possible to classify each by whether there exists a potential need for that asset, and whether it is available for tasking. Each collection asset at time, t, would be in one of four disjoint states:

State One - there existed a need for the collection asset manifested by a high ANF for an OTFU of significance, and the asset was available to be tasked.

State Two - there existed a need for the collection asset manifested by a high ANF Report Score for an OTFU of significance, and the asset was not available to be tasked.

State Three - there did not exist a need for the collection asset, and the asset was available to be tasked.

State Four - there did not exist a need for the collection asset, and the asset was not available to be tasked.

Of course, some threshold values will have to be established for an ANF to be considered high.

By identifying significant events that occur during a Computer Aided Exercise, and subsequently determining which units were significant to the outcomes of those events, it is possible in post exercise analysis to use the Report Scores to gain insight into the ability of the intelligence staff to provide the highest value intelligence possible. In addition, by analysis of collection asset availability, and the ANFs for collection assets, it is possible to show potential shortages and surplus in the allocation of assets to collect information.

IV. APPLICATION

This chapter demonstrates an application of the practical methodology for evaluating the performance of an intelligence staff described in Chapter III, using a computer model currently in use for the training of CINC staffs. Specifically, it shows how that with only minor changes, a simulation model can furnish the data necessary to provide greatly enhanced measures of how an intelligence staff performed throughout the conduct of an exercise. It is important to emphasize that this experiment was not intended to demonstrate tactics or to evaluate the performance of the computer model.

A. JOINT THEATER LEVEL SIMULATION (JTLS)

JTLS is an interactive, multi-sided, joint (air, land, naval, and special operations) and combined (coalition warfare) constructive simulation model. This computer-based wargaming system uses inherent functions - sea, air, land, special operations, intelligence, and logistics - to model conflict (pre-combat, combat operations, and post combat) at the operational level of war with tactical fidelity. The Joint Warfighting Center is the joint sponsor of JTLS, and has used JTLS (release 1.85) as the exercise driver for the combined exercise Keen Edge 94 in support of U.S. Forces and Japan's Joint Self-Defense Forces, and for a combined U.S. Thailand exercise , Cobra Gold 95, among others.

A new open system version of JTLS (release 2.0) which provides a much improved user interface was utilized to support this study. The scenario for the study was adapted from an existing Desert Storm scenario with orders being scripted to limit operator interaction with the model during the simulation runs. The ability to enter all necessary orders before the execution of a simulation run allowed for multiple repetitions of the same scenario to be run with different random number seeds. In this experiment the unit orders for seven simulation days were entered prior to the first simulation run, and three repetitions of the same scenario were run to determine the difference in the output data resulting from purely stochastic events.

Routines for capturing the parameters required to implement the methodology were developed by Rolands and Associates Inc., the primary contractor for JTLS. The calculation of Report Scores during each simulation run required a file to be maintained that contained the time of each detection, and the time that an intelligence update was issued for each Other Than Friendly Unit (OTFU). Although not required for calculating Report Scores, it was beneficial to output to the file the mission name that made the detection of the OTFU to assist in post exercise analysis. In addition, a separate file was maintained which contained the number of each intelligence collection asset available by squadron and the time whenever a change in availability status occurred. Both output files were in a standard ASCII format that was easily read into a commercial spreadsheet package. Sample spreedsheets of both output files are contained in the appendix.

B. SCENARIO DESCRIPTION

The simulated intelligence staff for this sample exercise had the assigned mission of designing and executing a collection plan for the entire theater of operations. Two areas of primary interest were the tracking of Iraqi mobile tactical ballistic missiles (TBMs) and the monitoring of the five Iraqi Republican Guard divisions in Iraq at the beginning of the exercise. Collection assets were limited to six aircraft types in eight different squadrons operating out of four bases in theater. Table 1 provides a summary of the detection capabilities of the six aircraft types and the JTLS squadron designations for the squadrons that operated them during the exercise. The aircraft types for the experiment were created by altering the sensor performance parameters of existing aircraft in the JTLS database. The specific purpose of changing the sensor parameters was to assist in exercising the analysis methodology, and *should not* be considered representative of the performance characteristics of actual aircraft. Baseline Probability of Detection (BPD) is the baseline probability in JTLS that a sensor will detect a target or unit. In JTLS when a target or unit is within range of a sensor, the sensors BPD is multiplied by the target's Target Detection Multiplier (TDM) and any relevant environmental factors such as jamming or bad weather, and the product is the probability of detection of the target by the sensor. The Range Factor (RF) was determined by the range of the sensor which for airborne sensors is measured in hexes. Therefore, for this analysis, if a sensor has a range of two hexes, it would have a RF of two. Mean Fusion Time (MFT), which is measured in hours, is the mean of an exponential distribution of how long it takes from sensor detection to delivery of the information to the player. If an aircraft has a MFT of zero, it is considered to be a real time sensor.

Aircraft Type	Baseline Probability of Detection(BPD)	Mean Fusion Time (MFT) in hours	Range Factor (RF)	Operating Squadrons	Total Number of Aircraft
Aircraft A	0.5	0	2	94FS	24
Aircraft B	0.2	0	1	389FS	24
Aircraft C	0.4	1	1	152ANG	12
Aircraft D	0.5	1	2	VF-84 VF-154	20
Aircraft E	0.2	1	1	VFA-87 VFA-195	24
Aircraft F	0.5	0.5	1	3UAVCO	12

Table 1. Summary of Reconnaissance Aircraft Types

The collection plan developed called for the theater to be divided into three major sections. The first section is the portion of Iraq where the TBM batteries would be forced to operate in order to launch attacks. The second section is a 300 km wide corridor from Baghdad to the Kuwait border. The third section is Kuwait, and a zone 100 km into Iraq along the Kuwaiti border. These three major sections were patrolled by the use of eight different air reconnaissance routes for each section.

An Air Tasking Order (ATO) for each day would task squadrons to fly missions at designated times along specified routes. Utilizing the JTLS squadron designations, squadrons 94FS, 389FS, and 152ANG were assigned to the TBM section patrols, while VF-154 patrolled the corridor to Baghdad, and the remaining squadrons patrolled Kuwait and the Iraqi border. It is important to emphasize that although the JTLS squadron designations are used throughout this application no conclusions should be drawn as to the capabilities or characteristics of *actual* squadrons. All missions were composed of two aircraft. A total of 144 missions (288 sorties) were scheduled to be flown on each of the seven days of the exercise.

C. ANALYSIS OF TBM INTELLIGENCE

The intelligence staff for the simulated exercise allocated three squadrons for a total of 60 aircraft for the task of reporting the eight different mobile TBM batteries which were expected to be operating in a 200 km x 200 km area. The collection plan was that each squadron would be responsible for flying missions composed of two aircraft every four hours along predetermined search routes each day. The goal of this collection plan was to provide the most up-to-date information possible on each of the eight mobile TBM batteries.

1. Significant Events

In an actual exercise, critical events would be determined for post exercise analysis. Examples of possible critical events in this exercise would be a massive launch of TBMs on a specific day, or the random launches of TBMs over the entire period of the exercise. To facilitate the demonstration of the analysis methodology for the case of the mobile TBMs, the missile launches will be considered to be randomly distributed throughout the exercise, thus the entire time span of the exercise is considered to be one significant event.

2. Report Scores

In the calculation of Report Scores, the first question that must be considered is: What is the expected decay rate and functional form for representing the depreciation of intelligence for the Other Than Friendly Unit (OTFU) reported? For this case of the reporting of TBM batteries, only the location information will be considered, since strength and course of intended action information would not be expected to change significantly in the limited exercise scenario considered. A base depreciation function for TBM batteries over the course of the exercise is the constant percentage depreciation function shown in equation 2 with a decay rate of 0.2 per hour (20% per hour) for utility weights used in the Report Score for specific TBM batteries. Two alternative depreciation functions are presented to show the sensitivity of the Report Score to changes in the functional form and the decay rates of the depreciation function. The alternative depreciation functions are a constant percentage depreciation with a decay rate of 0.1 per hour (10% per hour), and the logistic functional form of equation 3 with shape parameters $\alpha=0.8$ and $\beta=100$. Figure 7 shows the three depreciation functions described above.

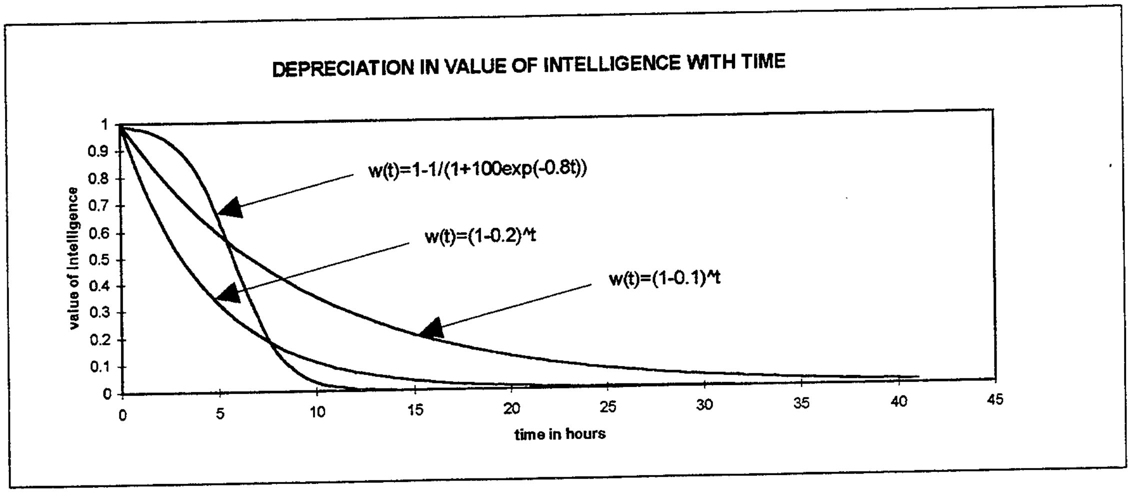


Figure 7. Utility weight functions used in analyzing TBM intelligence Report Scores

Utilizing the base constant percentage depreciation of 20% per hour Figures 8 and 9 show the Report Scores for two of the eight TBM batteries for the seven simulation days of repetition one. Each of the "peaks" in the plots corresponds to an intelligence update resulting from a sensor detection of the TBM battery, and the "valleys" correspond to the depreciation in value of the updates as they are allowed to age. Note that some of the "peaks" in the Report Score do not start at one, because the fusion time inherent in some sensors results in a delay in the time it takes for an intelligence update to be delivered from the time of detection.

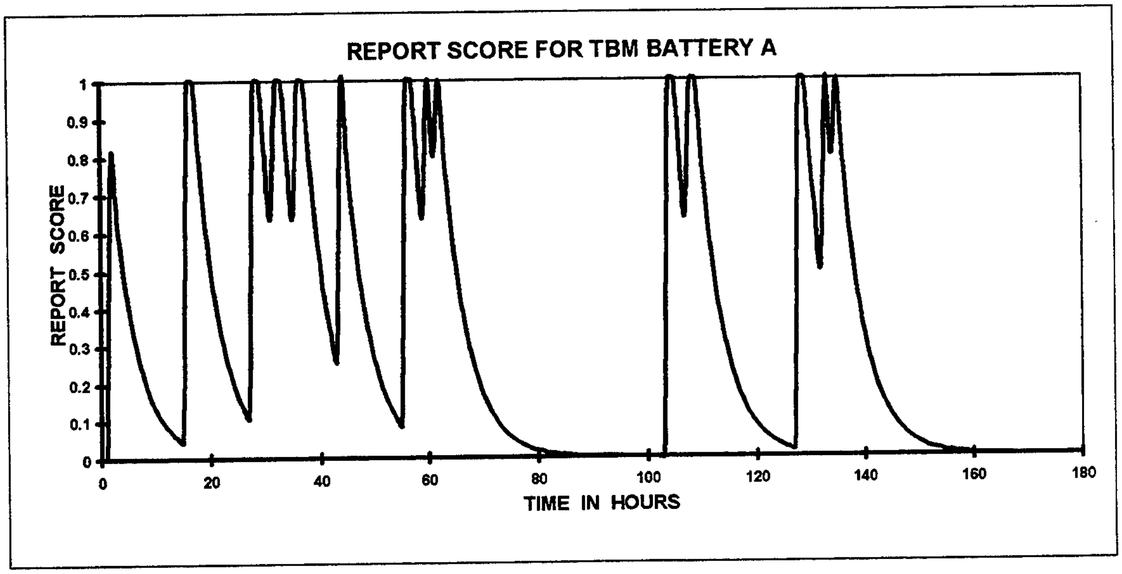


Figure 8. Report Score for TBM battery A

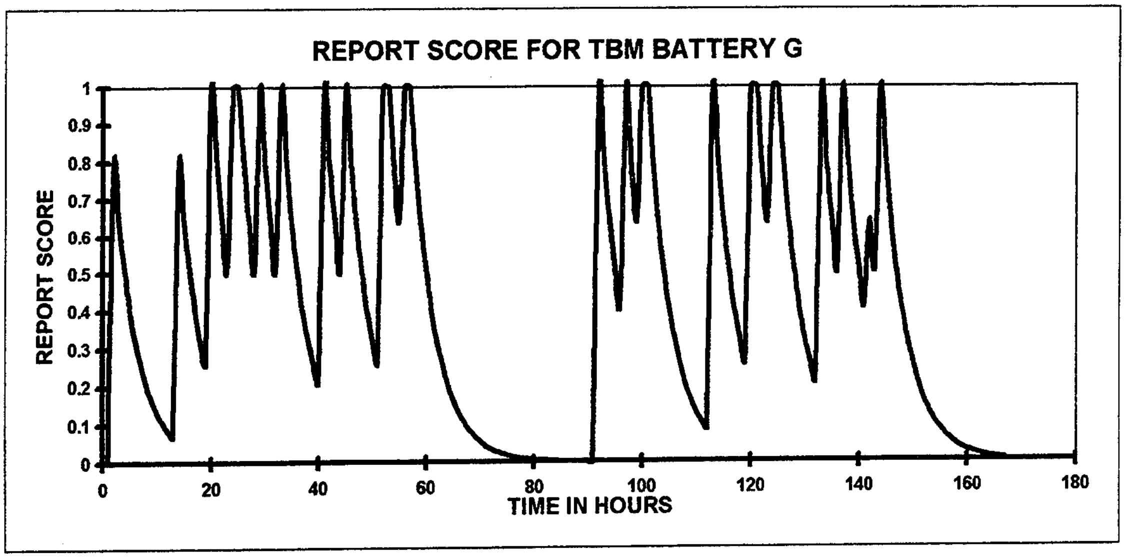
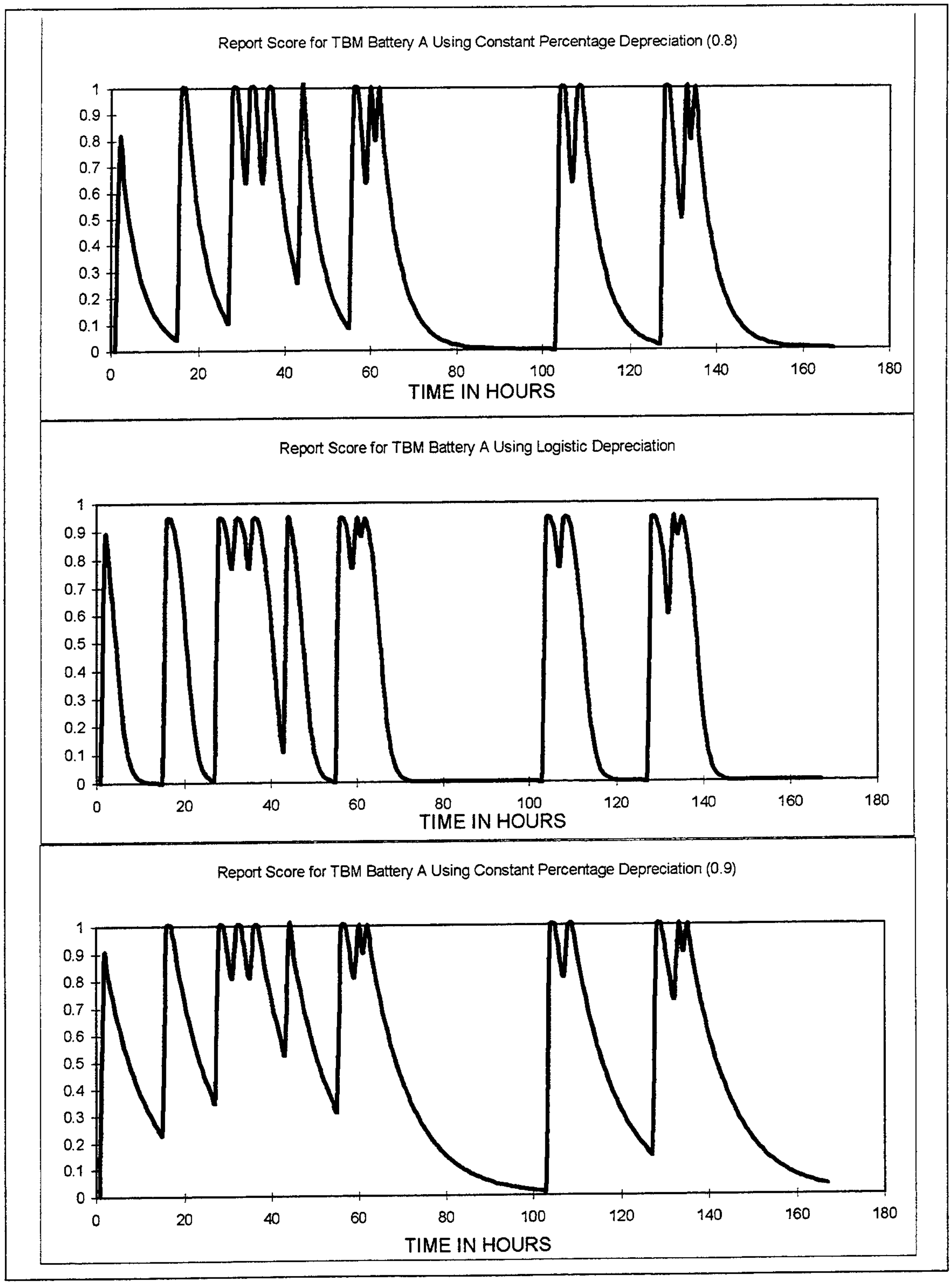


Figure 9. Report Score for TBM battery G

If the random launches of TBM over the entire seven day exercise were regarded as being significant events, then it would be of interest as to how well the TBM batteries were being detected over that total period. Figures 8 and 9 indicate where there existed long periods of low Report Scores. One area of particular interest is the period around hour 80 (the fourth day) in which Report Scores for both TBM batteries were basically zero for almost an entire day. In fact, the Report Scores for all eight TBM batteries indicate low Report Scores around the fourth day. The low Report Scores on the fourth day of the simulation would indicate that closer analysis should be done into the potential causal factors for the reduced detections, and how they relate to the overall campaign plan. Some causal factors for day four were that Aircraft A, the best sensor for detecting TBMs, was tasked with patrolling less prolific search routes, and was suffering from lower aircraft availability due to maintenance. An important note is that in this limited demonstration exercise no attrition was played for either collection assets or TBM batteries. If attrition had been played, then the campaign plan may have called for prosecution of the mobile TBM batteries early, and the collection plan may have been adequate. However, if the early attacks were unsuccessful then the window of low Report Scores on day four may indeed denote a problem.

Figure 10 shows a graphical representation of how the Report Score for TBM battery A would appear using the three different depreciation functions given in Figure 7. Although three different depreciation functions were used, Figure 10 shows the same pattern of low Report Scores on day four. The differences between the Report Scores utililizing slightly different depreciation functions can become more pronounced by the selection of a threshold value, perhaps representing a minimum acceptable level, and calculating the amount of time spend above or below this threshold.


Report Score for TBM Battery A Using Constant Percentage Depreciation (0.8)

Report Score for TBM Battery A Using Logistic Depreciation

Report Score for TBM Battery A Using Constant Percentage Depreciation (0.9)

Figure 10. Report Scores for TBM Battery A using three different depreciation functions

3. Asset Needs Function

From Table 1, it can be seen that of the three types of aircraft tasked with locating the mobile TBM batteries, Aircraft Type A had the greatest potential for detection with BPD of 0.5 and SRF of two. Consequently, for demonstration of the Asset Needs Function (ANF) Aircraft Type A will be the sample asset. The ANF defined in Chapter III will be simplified for this presentation by holding all factors constant with the exception of Report Scores for each OTFU. A value of 0.8 was assigned to the Target Detection Multiplier (TDM) for the mobile TBM batteries, hence the probability of detection for Aircraft Type A was 0.4, which is BPD x TDM. The assumptions for the ANF components for Aircraft Type A and mobile TBM batteries used are summarized below:

pd = 0.4,
IMF =1,
SRF=2,
TRF=1.

Thus the ANF for k = Aircraft Type A, with respect to i = mobile TBM batteries, at time, t, is :

$$\text{ANF}_{i,k}(t) = (1\text{-Report Score}_i(t)) \times 0.4 \times 2 \ .$$

In this simplified case the ANF is almost the compliment of the Report Score, so a "peak" in the Report Score will result in a "valley" in the ANF, and vice versa. Note that this should not always be assumed to be the case, since a decrease in Report Score may be the result of a factor that contributes to a decrease in the ANF as well. For example, heavy jamming or extremely bad weather may render a particular sensor completely ineffective against an OTFU, so both the Report Score and the ANF for that OTFU will decrease, as the collection asset's detection capabilities are degraded.

One potential use of the ANF is to group the exercise into time intervals (e.g., days), and compute daily average ANFs for a particular asset. Table 2 shows such an example for Aircraft A, and the mobile TBM batteries.

	Average ANF TBM Battery A	Average ANF TBM Battery B	Average ANF TBM Battery C	Average ANF TBM Battery D	Average ANF TBM Battery E	Average ANF TBM Battery F	Average ANF TBM Battery G	Average ANF TBM Battery H
Day 1	0.5	0.32	0.51	0.4	0.47	0.55	0.45	0.65
Day 2	0.28	0.44	0.26	0.34	0.43	0.16	0.27	0.35
Day 3	0.43	0.28	0.39	0.42	0.39	0.33	0.46	0.46
Day 4	0.79	0.74	0.7	0.74	0.75	0.76	0.68	0.79
Day 5	0.5	0.34	0.26	0.4	0.38	0.35	0.37	0.25
Day 6	0.45	0.43	0.25	0.4	0.42	0.63	0.26	0.47
Day 7	0.78	0.78	0.74	0.74	0.74	0.8	0.66	0.79

Table 2. Average Daily ANF Values for Aircraft A and TBM Batteries.

By using the daily averages in Table 2 the ANF for a particular collection asset and a set of OTFUs, it is possible to determine which time periods exhibited the greatest need for the collection asset, and to prioritize the requirement for the collection assets to track specific OTFUs . Note the relatively small amount of variability between the ANFs for the TBM batteries on any given day. Also note that days four and seven had the largest ANF in comparison to the other days of the scenario. Using daily average ANFs has the additional advantage of allowing for the comparison of whether the collection asset was available or not on any particular day. One way to determine asset availability is by calculating the average number of aircraft available at any time throughout the day. By comparing average collection asset availability with average ANFs, it is possible to show potential surpluses and shortages of the asset. For example, examination of Table 2 reveals high average ANF's for Aircraft A and all TBM batteries on days four and seven, but comparison to Table 3 shows on average only two of Aircraft A were available in theater. With an average of only two Aircraft A available it is doubtful that any additional sorties could have been generated that potentially would have improved the reporting of the mobile TBM batteries. On day seven, however, there existed an average of 9.9 Aircraft A available throughout the day, which may have allowed for the tasking of additional sorties which may have resulted in an improvement in the reporting of TBM batteries.

	Average # of Aircraft A Available
Day 1	14.8
Day 2	8.1
Day 3	3.9
Day 4	2
Day 5	12.6
Day 6	11.8
Day 7	9.9

Table 3. Average Number of Aircraft A Available on Each Day of the Exercise

Once preliminary analyses of the ANFs for critical OTFUs and collection assets have revealed time intervals in which there existed high need for a collection asset, as on days four and seven, investigation into possible causal factors can be pursued. Investigation into causal factors for the case of mobile TBM batteries should start by analyzing air tasking in the daily ATOs, then searching for common features of days with low asset need and days with high asset need for particular collection assets. In addition, asset availability should be analyzed looking for trends that may have resulted in periods of high ANFs.

D. ANALYSIS OF REPUBLICAN GUARD INTELLIGENCE

The intelligence staff for the simulated exercise was tasked with the surveillance of the largest perceived enemy threat in the theater, the five Iraqi Republican Guard Divisions held in reserve at the start of the scenario. The Republican Guard Divisions were expected to be highly mobile and capable of quick entry into any engagement. Intelligence was limited in that only Aircraft D had the performance characteristics necessary to operate in the region where the Republican Guard Divisions were expected to be located. This limited the efforts to track the five divisions to the two aircraft squadrons equipped with Aircraft D, a total of 20 aircraft.

1. Significant Events

On the first day of the scenario, Iraqi forces in Kuwait attack into Saudi Arabia. This invasion is considered to be a significant event in the exercise. A key area of interest for post exercise analysis of the performance of intelligence functions is how well the Iraqi Republican Guard Divisions were tracked on the first day of the scenario. This part of the application of the methodology is intended to illustrate the potential analysis of a one day time period out of a larger exercise time frame.

2. Report Scores

Once again, the first question in the calculation of the Report Score for an OTFU that must be considered is: What is the expected decay rate and functional form for representing the depreciation of intelligence information for that OTFU? For this case of the five Republican Guard Divisions, a base depreciation function is the constant percentage depreciation function expressed in equation (2) and illustrated in Figure 7 with a decay rate of 0.2 per hour (20%). Also, as in the TBM example, only the location information will be considered. Figures 11 through 15 show graphical representations of the value of intelligence for the five Republican Guard Divisions throughout the first day. It is important to point out that Aircraft D, which was the only aircraft type tasked with the reporting of the Republican Guard units, was equipped with a non-real time sensor with a MFT of 1.0 hours. The MFT results in a delay from the time of detection of a unit by the sensor to the time of a report being issued. Thus, when the report is received the intelligence information has already been allowed to age. Because of this delay from detection to reporting, and the decay rate of 0.2 per hour, the average Report Score for a Republican Guard Division at the time of a report is 0.8, instead of the 1.0 that would be expected of a real time sensor. Also, since MFT is the mean of an exponential distribution sampled by the computer model to determine the actual fusion time from detection to reporting, it is not uncommon to have reports being issued in excess of three hours after detection occurred. This is evident in Figure 11 where the first report issued at the four hour point is from a detection almost three hours prior.

Analyses of the Report Scores for the five Republican Guard divisions during the first day of the scenario reveal some interesting points. First, Figure 12 shows that no reports were issued on the 10th Armor Division until the 15 hour mark. Also note that both the 52nd Armor and the Baghdad Divisions suffered from low Report Scores during the first 15 hours of the exercise. Second, the Report Scores for all five Republican Guard Divisions demonstrate the disadvantage of a non-real time sensor compared to what would have been expected of a real time sensor in that the time spent between detection and reporting results in a much lower average Report Score over the time period.

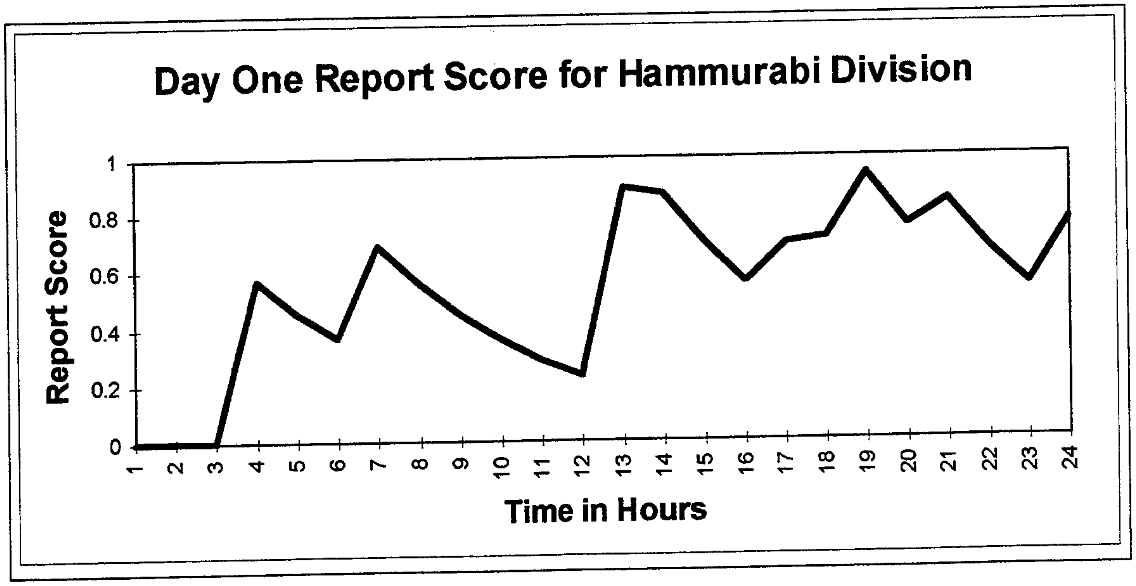


Figure 11. Day one Report Score for Iraqi Republican Guard Hammurabi Division

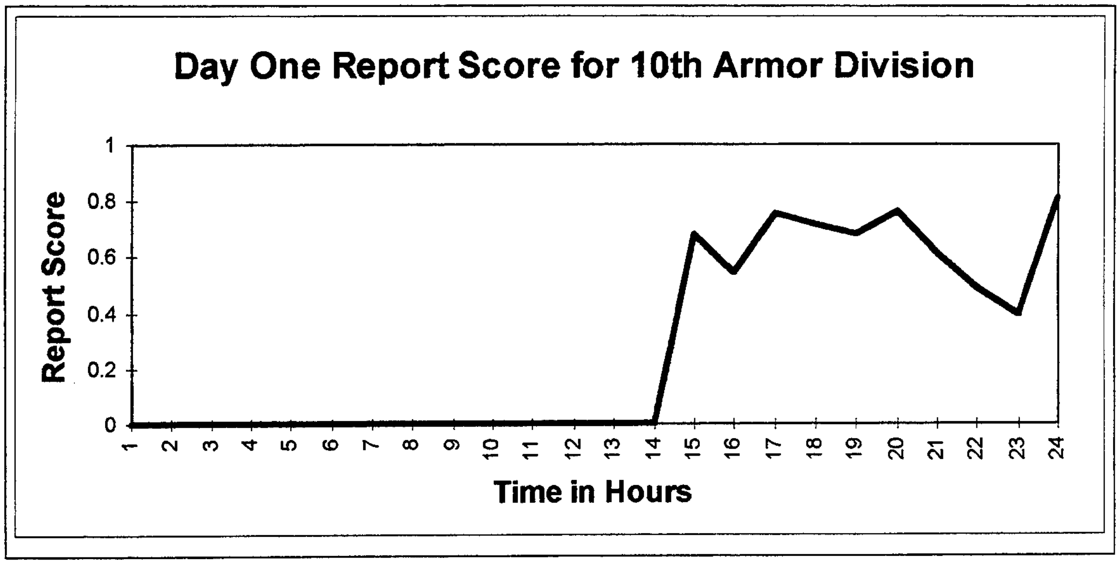


Figure 12. Day one Report Score for Iraqi Republican Guard 10th Armor Division

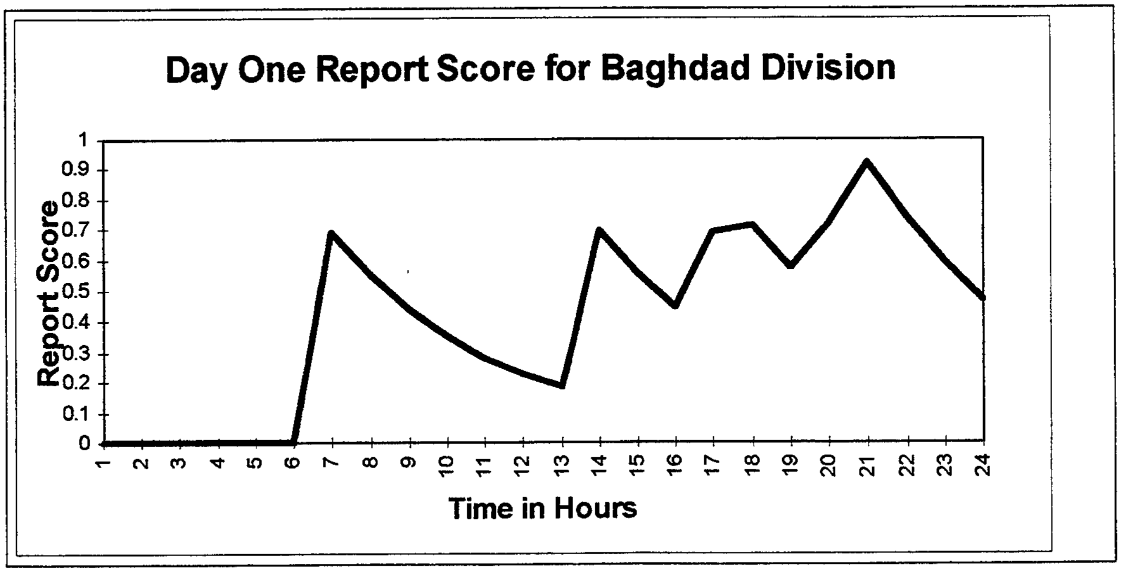


Figure 13. Day one Report Score for Iraqi Republican Guard Baghdad Division

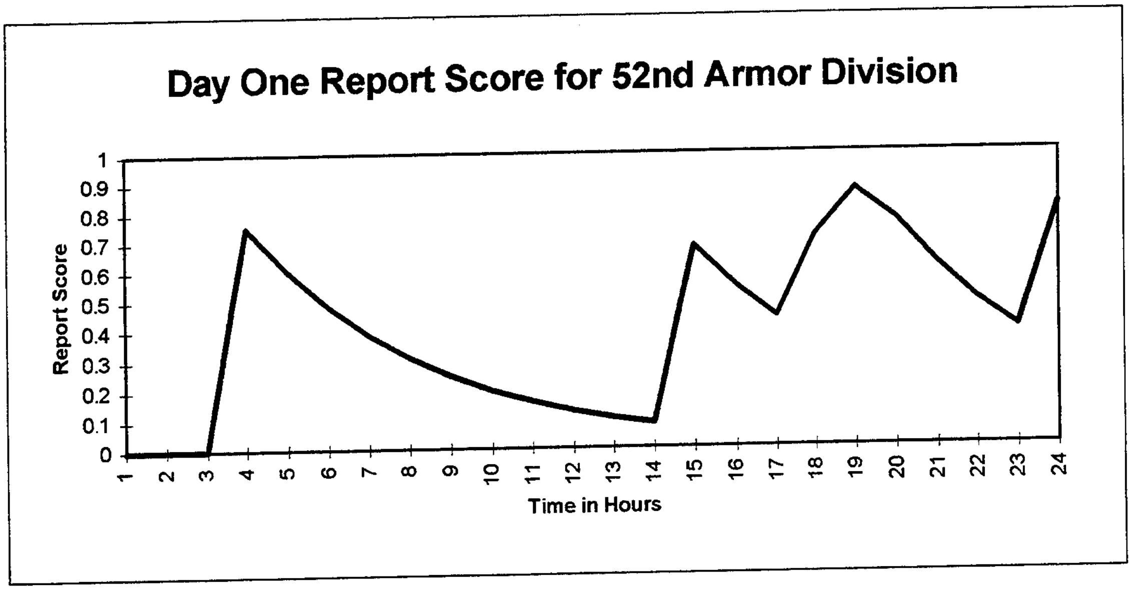


Figure 14. Day one Report Score for Iraqi Republican Guard 52nd Armor Division

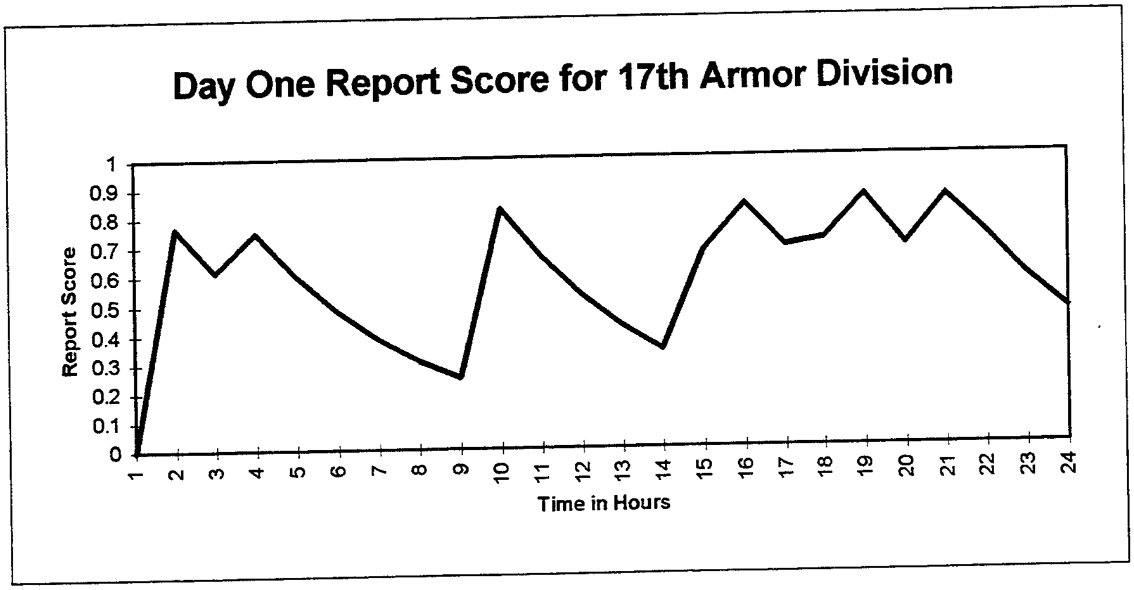


Figure 15. Day one Report Score for Iraqi Republican Guard 17nd Armor Division

E. SUMMARY

This chapter has demonstrated through the use of small, illustrative examples how the methodology can be applied to a proven simulation model. The methodology is intended to provide for post exercise analysis of intelligence functions through the identification of significant events and the use of measures which attempt to capture the value of intelligence for key units. In addition, the methodology shows the potential for improving the intelligence picture of the battlespace by looking at the availability and need for collection assets. This experiment, conducted with JTLS, has established how, with only limited interaction with the model, all of the information necessary to implement the methodology can easily be output.

V. SUMMARY AND RECOMMENDATIONS

A. SUMMARY

This research has provided a post exercise analysis methodology for evaluating the performance of intelligence functions during a computer aided exercise. The methodology presented does not attempt to assign values to the performance of each individual joint intelligence task stated in the UJTL, but seeks to determine how intelligence functions contributed to the outcome of significant events that occurred during the exercise. The first step in the implementation of the methodology is to determine the significant events. Next, determine how well the intelligence staff was able to provide detection and subsequent updates of the Other Than Friendly Units of interest throughout the exercise by analysis of unit report scores. Lastly, by analysis of Asset Need Functions for critical units during the exercise and collection asset availability, determine where there may have existed potential shortages, and surpluses, in allocation of assets.

One strength of the methodology is that it is relatively uncomplicated, but retains the robustness necessary to be applicable in many different exercise scenarios. Since it is uncomplicated, it allows for quick analysis that can be easily understood in post exercise debriefings. An additional strength is that interaction with the computer model is very limited with most of the data necessary to use the methodology readily available and easy to output in most event step simulation models.

B. RECOMMENDATIONS

A fundamental step in the implementation of the methodology is the determination of the depreciation functions for intelligence information described in Chapter III. Through the use of surveys, simulation, and historical analysis it is possible to develop a library of depreciation functions which correspond to the intelligence report elements for specific unit types (e.g., position information on mobile TBM batteries). Such a library would be essential in the development of a packaged post exercise processor capable of rapidly processing the large quantities of data generated in an actual exercise.

Theater level models by design usually lack tactical fidelity, and JTLS is no exception. For this reason, the JTLS database was modified to provide collection assets with reasonable capabilities of what might be expected for the aircraft types described in Chapter IV. To truly evaluate intelligence functions, especially the use of specific collection assets, the JTLS database would need to be modified to present a more accurate representation of actual collection assets and sensor loads capabilities.

JTLS also does not attempt to model uncertainty or inaccuracy in the reporting of target information upon detection. As discussed in Chapter III, as with many theater simulation models, the information on the target is perfect at the time of detection. Although modeling imperfect detection information is a challenging task, one candidate method would be to perturb the detection information depending on the detecting sensor and the target, and then assign confidence levels with the report of the information to the player.

The development of a post exercise processor to automate calculations necessary to furnish Asset Needs Functions and Report Scores would offer the ability to quickly sort information necessary for analysis. Chapter IV of this research demonstrated how a methodology for evaluating intelligence functions can be implemented in a small experimental exercise. Real world exercises commonly consist of hundreds of players and can run over a period of weeks. To provide timely post exercise analysis of the potentially vast quantity of data, it is essential that an automated post exercise processor be developed. The post exercise processor should be contain a graphical interface capable of generating a host of tables and charts to facilitate timely analysis and debriefing of results.

APPENDIX

A. JTLS OUTPUT FILE FOR UNIT DETECTIONS

The report below is a sample of the JTLS output data imported directly into Microsoft Excel for the detection of mobile TBM batteries in the experimental exercise discussed in Chapter IV.

Time update was issued in hours from start of CAX	JTLS unit/target name	JTLS sensor name that made the detection	Probability of detection for the sensor	Mission name	Time of detection in hours from start of CAX
26.36667	C.BY.SCUD	SURF3	0.32	sbx14c	20.45
28.23333	H.BY.SCUD	SURF2	0.4	sbx515	28.23333
28.26667	F.BY.SCUD	SURF2	0.4	sbx115	28.23333
28.33333	F.BY.SCUD	SURF2	0.4	sbx115	28.28333
28.36667	A.BY.SCUD	SURF2	0.4	sbx515	28.35
28.58333	F.BY.SCUD	SURF2	0.4	sbx115	28.23333
28.65	G.BY.SCUD	SURF2	0.4	sbx315	28.65
28.65	H.BY.SCUD	SURF2	0.4	sbx515	28.58333
28.71667	A.BY.SCUD	SURF2	0.4	sbx515	28.7
28.8	C.BY.SCUD	SURF2	0.4	sdr715	28.78333
29.26667	C.BY.SCUD	SURF2	0.4	sdr715	28.78333
31.88333	A.BY.SCUD	SURF2	0.4	sbx315	31.88333
32.11667	A.BY.SCUD	SURF2	0.4	sbx315	31.88333
32.36667	H.BY.SCUD	SURF1	0.16	sbx216	32.3
32.46667	A.BY.SCUD	SURF2	0.4	sbx315	32.43333
32.46667	F.BY.SCUD	SURF2	0.4	sbx315	32.43333
32.61667	G.BY.SCUD	SURF2	0.4	sbx115	32.58333
32.68333	C.BY.SCUD	SURF2	0.4	sdr715	32.63333
33	A.BY.SCUD	SURF2	0.4	sbx515	32.98333
36.11667	H.BY.SCUD	SURF2	0.4	sbx315	36.11667
36.13333	H.BY.SCUD	SURF2	0.4	sbx515	36.11667
36.15	H.BY.SCUD	SURF2	0.4	sbx115	36.08333
36.2	H.BY.SCUD	SURF2	0.4	sbx315	36.11667
36.3	A.BY.SCUD	SURF2	0.4	sbx115	36.28333
36.51667	C.BY.SCUD	SURF2	0.4	sbx515	36.5
36.58333	D.BY.SCUD	SURF2	0.4	sdr715	36.58333

B. JTLS OUTPUT FILE FOR COLLECTION ASSET AVAILABILITY

The report below is a sample of the JTLS output data imported directly into Microsoft Excel for the availability of collection assets in the experimental exercise discussed in Chapter IV.

JTLS squadron name	Time in hours from start of CAX	Number of aircraft available
3.UAV.CO	24.15	6
VF-154	24.16667	4
152RG.ANG	24.41667	7
VFA-87	24.58333	8
152RG.ANG	24.68333	8
152RG.ANG	24.93333	9
3.UAV.CO	25.36667	8
VFA-195	25.41667	6
3.UAV.CO	25.46667	6
VFA-195	25.46667	8
VFA-195	25.5	9
VF-84	25.58333	7
VFA-87	25.6	10
152RG.ANG	25.65	11
152RG.ANG	25.75	12
VF-84	25.85	9
VF-84	25.95	7
VF-84	25.95	5
VFA-87	26	8
VFA-195	26	7
VFA-195	26	5
VF-154	26	2
VF-154	26	0
VF-154	26.26667	2
94FS	26.36667	10
94FS	26.36667	8
94FS	26.36667	6
VF-84	26.53333	6
VF-154	26.56667	4
VFA-195	26.63333	6
VF-154	26.63333	6
94FS	26.71667	4

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U.S. Total Army Personnel Command
Alexandria, VA 22332

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B927 Pentagon
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