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# DEVELOPMENT AND IMPLEMENTATION OF MEASURES OF EFFECTIVENESS FOR THE UNIVERSAL JOINT TASK LIST IN THE JOINT THEATER LEVEL SIMULATION

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## ABSTRACT

This paper presents a methodology for evaluating tasks performed by a joint staff as set forth in the Universal Joint Task List (UJTL). Measures of effectiveness are defined for selected sustainment and intelligence tasks. Results of experimental runs of the Joint Theater Level Simulation are presented to demonstrate the analysis process. Emphasis is placed on providing the staff planner with an ability to associate causal reasons for significant events in the exercise.

## 1 INTRODUCTION

The Universal Joint Task List (MCM 147-93), a supplement to the Joint Training Manual (MCM 71-92), is a comprehensive listing of all joint tasks pertaining to the Armed Forces of the United States. It 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 in turn be further refined into *enabling* tasks.

One of the primary training tools available to a 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 decision environment within which the staff can be presented with realistic, stochastic 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.

This paper develops an exercise analysis methodology for evaluating CINC staff performance in the execution of joint tasks during the conduct of a CAX. Specific objectives are: 1) Determine quantifiable measures of effectiveness (MOEs) designed to work in conjunction with data manipulated by a futuristic computer simulation. 2) Ensure the measures reflect the hierarchical structure of tasks as applied to the three levels of war (vertical linkage), and functionality considerations between related enabling tasks (horizontal linkage). 3) Test measures of effectiveness using the Joint Theater Level Simulation (JTLS). Develop a standardized ASCII file for capturing MOE parameters and demonstrate a potential post-exercise analysis. This objective entails a practical application of the objective portion of the methodology to an existing theater-level simulation. Included in this are the alignment of the model's database with required MOE parameters, development of algorithms required in post processing, and specification of output format.

This paper provides a demonstration of the methodology for two strategic tasks: sustainment (logistics) and intelligence (reconnaissance). For each task a brief description of the MOEs is presented, followed by results from three runs of JTLS. The scenario used for the demonstration runs was an adaptation of the Gulf War conflict with modifications to stress the logistics and intelligence gathering functions. A compressed eight day conflict was played, with forces continuing to enter the theater after commencement of hostilities. It is important to understand that the results presented in this paper serve only to demonstrate the methodology. In particular, several of the combat functions such as attrition from and to aircraft and attrition of supply depots and convoys were not played in the experiment in order to more clearly demonstrate methodology objectives. Therefore, the results are not intended to be representative of what one might expect in an actual conflict.

## 2 SUSTAINMENT OF THE FORCE

Fundamental to the methodology is the assumption that execution of any given task at a specified level of war is related to the execution of similar tasks at other levels of war. For instance, the strategic joint task "Provide Theater Sustainment" is related to the respective operational and tactical tasks "Provide Operational Support" and "Provide Combat Service Support" by virtue of their common *functionality.* Furthermore, the concept of a functional relationship establishes the idea of vertical and horizontal linkages existing among tasks. Vertical linkage not only describes the relationship existing between similar tasks across respective levels of war, but also between joint, supporting, and enabling tasks within a given level of war. Horizontal linkage, on the other hand, pertains to the dependent relationship existing between task(s) describing one particular function or component with those describing another. For example, how well forces are sustained is dependent upon how well the functions of arming, fueling, maintaining, manning, etc. are executed. Similarly, the functional area pertaining to the manning of forces is dependent upon the components field services, health services, reconstitution, training, and reception. Staff activities, as described by various tasks, become compartmentalized across components and functions as the size of the staff increases. In analysis, it is necessary to reflect the dynamics of vertical and horizontal linkage as a matter of aggregation and in the interest of maintaining the appropriate level of abstraction.

### 2.1 Dendritic

The purpose of the dendritic is to refine task requirements to the point where data explicative of performance can be gathered. The dendritic is formed by focusing on the overall intent of related (across levels of war) joint tasks and reformulating it in the form of a question. This question represents the overall issue to be resolved. Likewise, corresponding functional areas form critical (sub) issues that generally reflect the level at which measures of effectiveness (MOEs) are developed. Specific task requirements within each of the functional areas serve to formulate yet another level of sub issues that may determine underlying measures of performance (MOPs). Continued refinement of the (task) requirements ultimately leads to the point where data can be gathered. A complete dendritic addressing the issue regarding tactical forces having the munitions they require is illustrated in Figure 1.

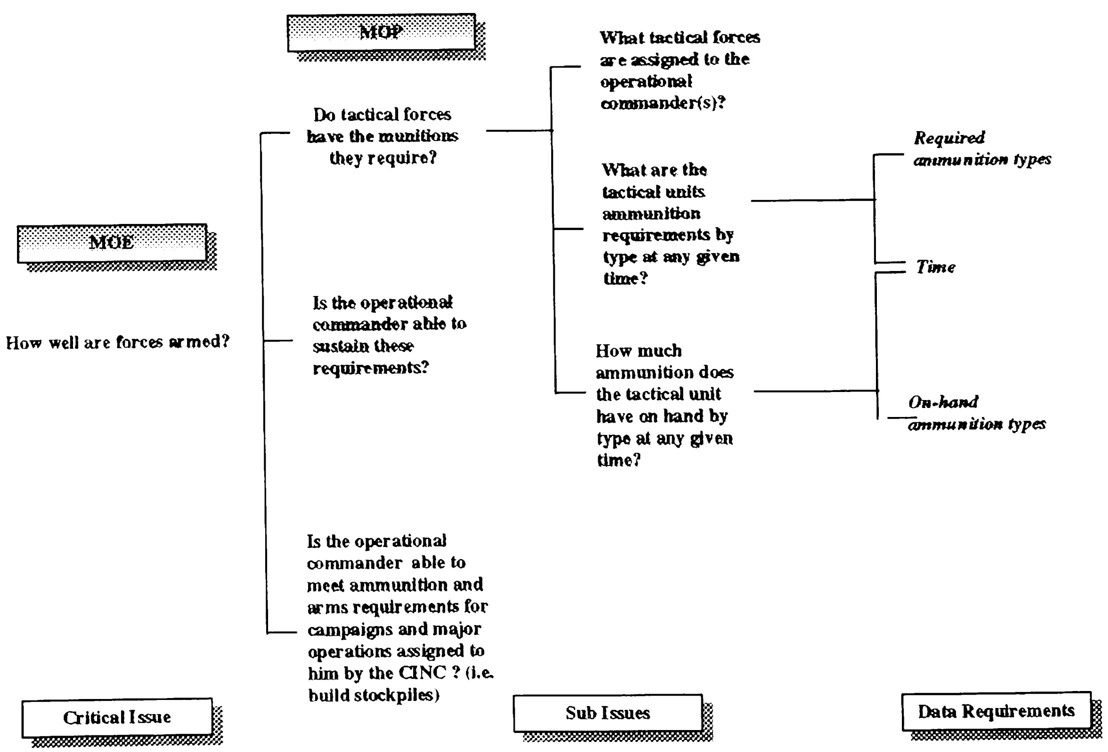


Figure 1: Dendritic

## 2.2 Measures of Effectiveness

In this paper, only those measures used in the experimental runs of JTLS are described. A more complete discussion of the logistical MOEs is given in Combs (1995). A generic representation of the measures used to describe the components of a logistics plan is shown in Figure 2. The following definitions apply to the figure:

$TACREQ_{k,i,j}(t)$ = amount of ammunition type, $i$, requirements for each unit, $j$, in operational area, $k$, at time, $t$.

$SPTREQ_{k,i}(t)$ = requirements for ammunition type, $i$, for operational area, $k$, in additional to tactical requirements of individual units within $k$, at time, $t$.

$RAMP_{i,k}(t)$ = rate of build-up of ammunition type, $i$, in operational area, $k$, at time, $t$, required for future planned missions.

$OPREQ_{k,i}(t)$ = total operational requirements for ammunition type, $i$, operational area, $k$, at time, $t$.

The two critical planning factors for the operational staff are the values of SPTREQ and RAMP. The amount of ammunition, SPTREQ, represents a contingency amount in case the individual requirements, TACREQ, are not sufficient for the current mission. The trade-off problem for the planner is the possibility of not having enough at time, $t$, versus having to stockpile and transport unneeded ammunition. RAMP is the rate at which ammunition needs to be stockpiled to meet a future mission requirement, over and above the amount needed for the current mission. This build-up is required because a step function at time, $f$, in Figure 2 is not feasible due to loading and transportation assets limitations. Again, if the ramp function is too steep, excessive supplies will exist at time, $f$, thus creating a storage and transportation problem. In the next section, these measures, along with the actual on-hand amounts from the experimental runs, will be described.

## 2.3 Sample of Demonstration Runs Results

Three runs of JTLS were conducted using the scenario previously described. Each run depicted planned objectives in the form of phased ammunition requirements by type using Basic Load as the parameter. Four categories of Class V (ammunition) were examined: gun ammunition (GVN), short range (M-SR), medium range (M-MR) and long range (ICM) missiles. The eight day scenario consisted of three phases: deployment, friendly defense and friendly attack. The basic load planned requirements for each ammunition category/phase are shown in Figure 3 for each phase. Note that Runs 2 and 3 differ from Run 1 (base case) in the amount of gun versus missile ammunition in the plan.

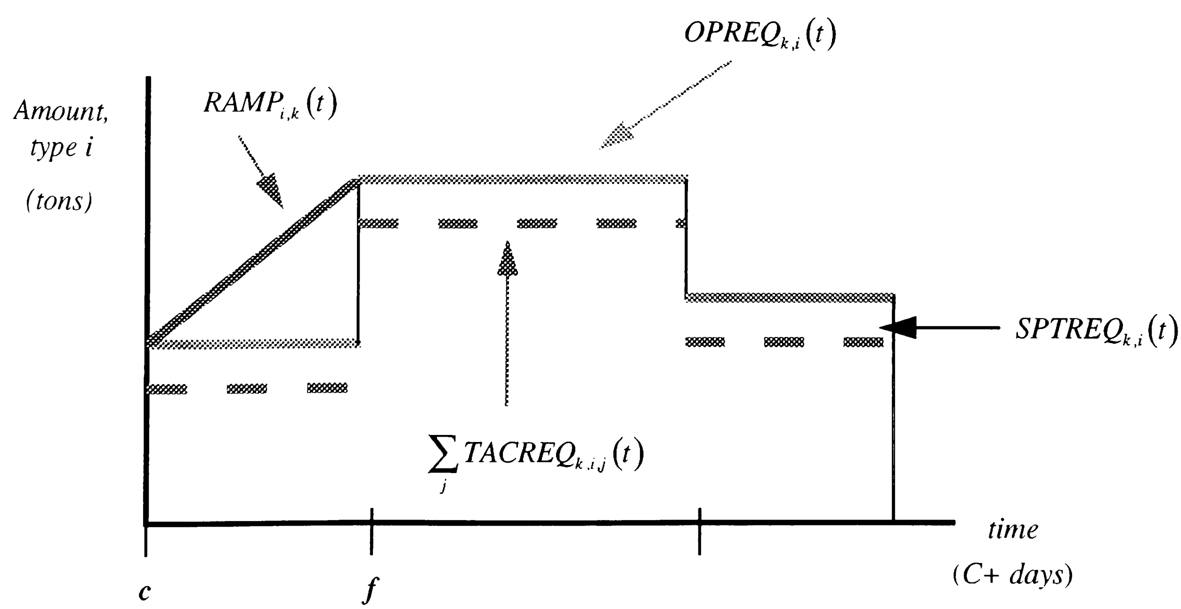


Figure 2: Ramp Function

| | Run 1 | Run 2 | Run 3 |
|---|---|---|---|
| GVN (9) | (1/2/3) | (.5/1/2) | (2/3/4) |
| M-SR (28) | (1/2/3) | (2/3/4) | (.5/1/2) |
| M-MR (29) | (1/2/3) | (2/3/4) | (.5/1/2) |
| ICM (32) | (1/2/3) | (2/3/4) | (.5/1/2) |

Figure 3: Basic Load Requirements by Phase for Each Run

EXCEL spreadsheets utilized large flat files of raw data from JTLS to perform the analyses. For this paper only one comparative analysis is presented. More complete results are given in Combs (1995). In Figures 4 and 5, the planned, revised plan, and on-hand tonnage of gun ammunition (category 9) and short range missiles (category 28), respectively, over time are shown for the 24th Mechanized Infantry Division for Run 1 (base case). The PLAN amounts are those tonnages by day contained in the Operations Plan developed prior to actual exercise initiation. The REV. PLAN amounts represent tonnages by day adjusted for the compression of the scenario upon exercise commencement to account for the early start of the defensive battle. The O/H amounts are those actually possessed by the unit over time, which includes consumption and receipts from higher supply sources.

The ramp function for both planned and required tonnages anticipating the future attack mission is evident in both figures. The actual on-hand quantities, compared with the planned and revised planned amounts, provide the planner with a meaningful picture of how well the sustainment plan worked. Note that in both cases, the on-hand amount did exhibit the ramp effect from day 0 to day 5 in preparation for the attack mission. At the end of day 8 there were 130 tons of category 28 and 6300 tons of category 9 remaining. The exercise analyst would determine whether these quantities represent a shortfall or overage on day 8 and evaluate whether the planned ramp function was adequate. Similar plots of other units, as well as aggregates of units in the theater, serve to give a complete picture of sustainment performance.

## 3 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

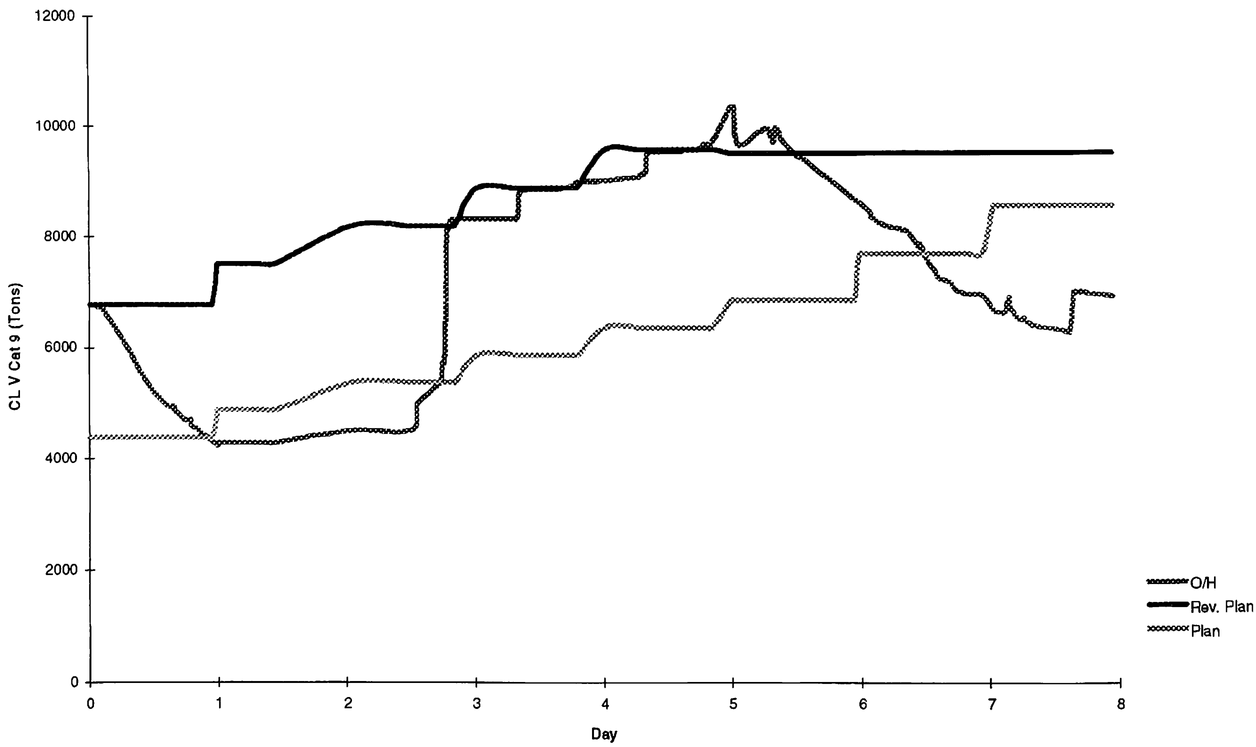


Figure 4: Category 9; Run 1; 24th Mech. Div.

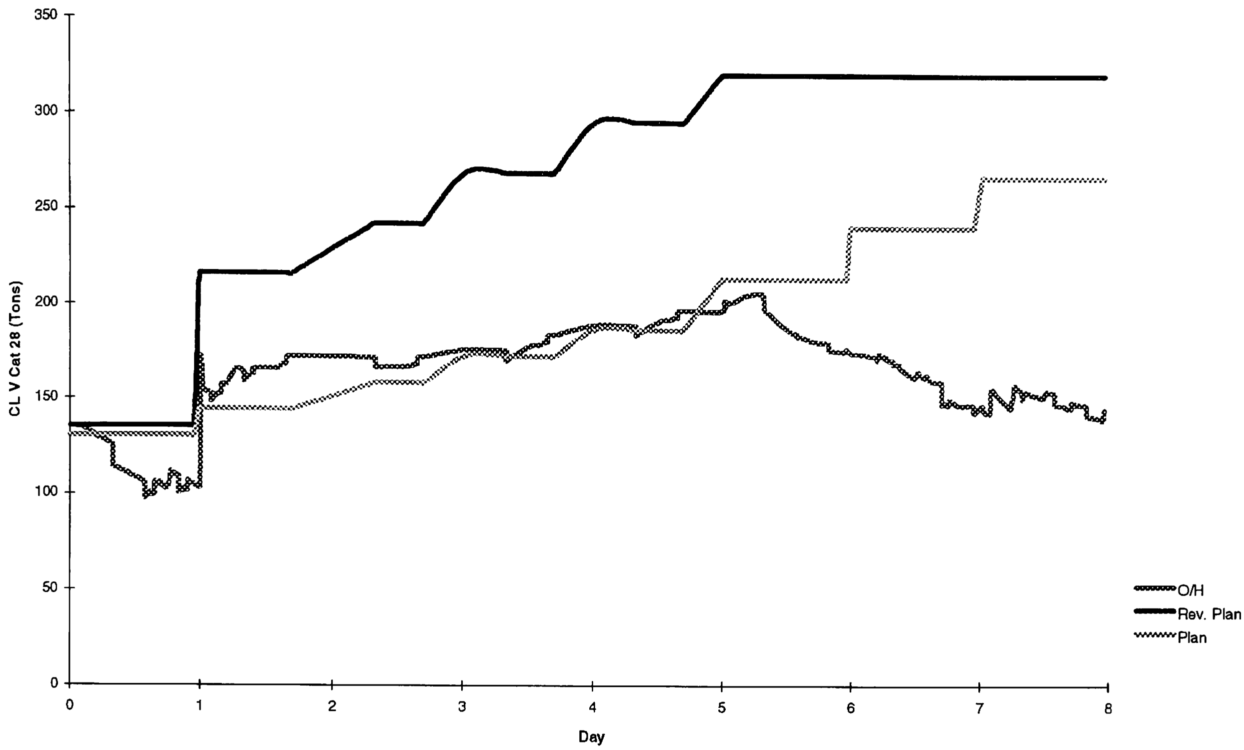


Figure 5: Category 28; Run 1; 24th Mech. Div.

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, and now through such programs as the Tactical Exploitation of National Capabilities (TENCAP) is being used at the tactical level.

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.

### 3.1 Report Score

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, but unfortunately 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 is the intelligence on a particular unit will be measured by the report score shown in Equation (1).

$$\text{Report Score}_i(t) = \frac{\sum_{l} w_{l,i,j(t)}}{3} \qquad (1)$$

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…}

$t$ - current time {in integer hours from start of CAX}
$j(t)$ - age of last intelligence update measured from significant event start time
$l$ - 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.

### 3.2 Asset Needs Function

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 at that time 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:

$$ANF_{i,k}(t) = (1-(\text{Report Score}_i(t)) \times pd_{i,k}(t) \times IMF_i(t) \times SRF_k \times TRF_{i,k} \quad (2)$$

where the indidices 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:

$pd_{i,k}(t)$ - the probability of detecting OTFU $i$ at time $t$, given that OTFU $i$ is within sensor range of collection asset $k$.
$IMF_i(t)$ - an importance factor assigned for the degree of significance of OTFU $i$ at time, $t$.
$SRF_k$ - 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 maybe 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.

### 3.3 Sample Intelligence Results

In order to demonstrate the methodology described above, eight Tactical Ballistic Missile (TBM) batteries were included in the JTLS scenario. These batteries moved continually during the scenario to determine how well the four intelligence platforms employed as reconnaissance assets performed. In addition, these assets were also searching for five Republican Guards Divisions moving out of Baghdad toward Kuwait. For this paper, two sample results are presented demonstrating results for a Report Score and an Asset Needs Function. More complete results are given in Towery (1995).

The Report Score for all reconnaissance assets against TBM Battery A is shown in Figure 6 for the first seven days of the scenario. The "peaks" indicate points in time when a detection occurred followed by a decay in the value of the Report Score due to aging of the intelligence report. Note that during day four (72-96 hours) no detections were made on Battery A. Further causal analysis revealed that most aircraft were down for maintenance, since the intelligence plan had called for flying all available reconnaissance aircraft from the first day. The Report Score results indicate that the plan may have been faulty. This information is critical to the Intelligence planner for adjusting asset allocation over time.

The Asset Needs Function for one of the assets (aircraft A) shown in Figure 7 shows the same problem for day four. The figure also shows variations in the function for different TBMs. More extensive analyses of assets, TBMs, and Republican Guards Divisions are presented in Towery (1995).

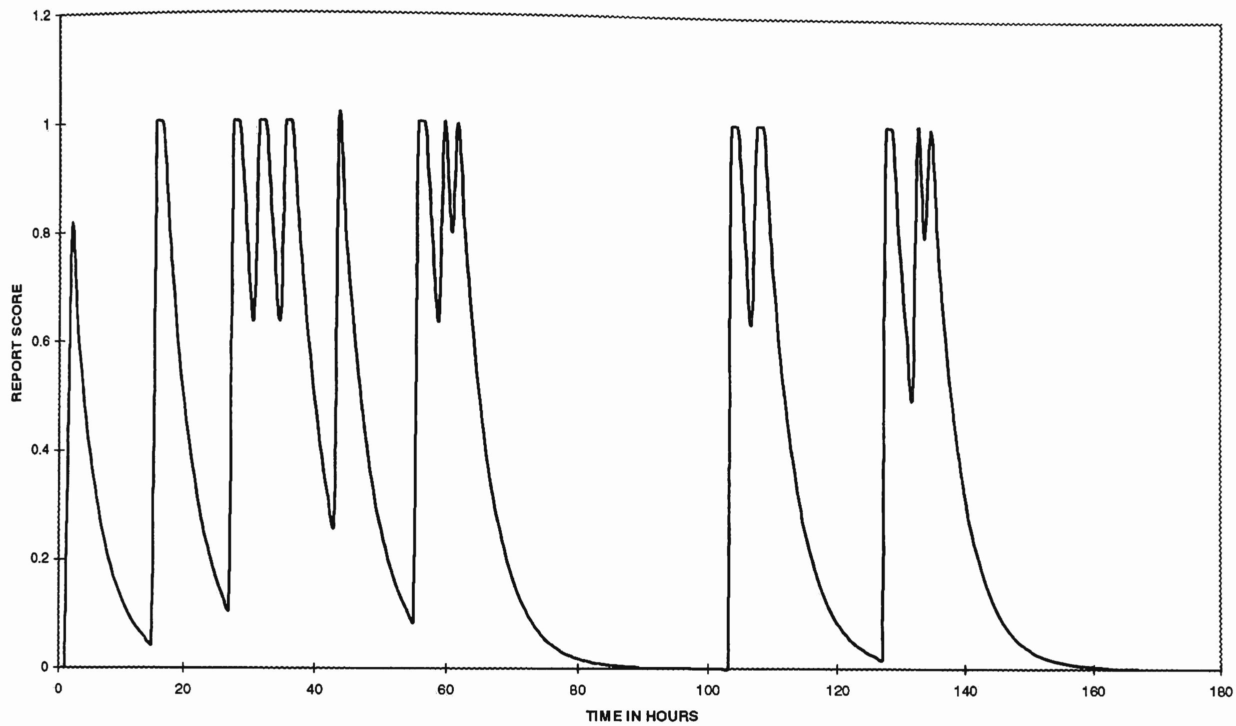


Figure 6: Report Score for TBM Battery A

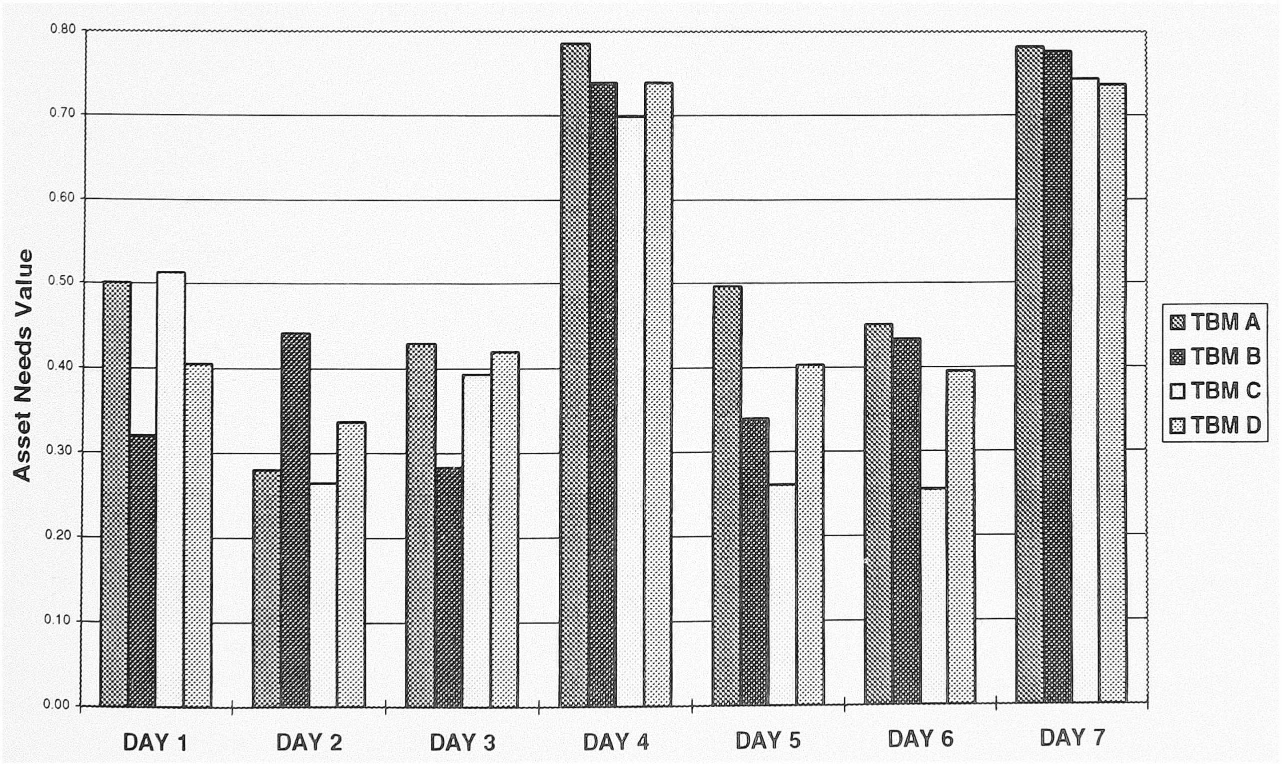


Figure 7: Asset Needs Function Values for Aircraft A

## 4 CONCLUSIONS AND RECOMMENDATIONS

This paper is an initial effort to provide a method for evaluating how well a CINC staff performs various tasks as set forth in the Universal Joint Task List by using an exercise simulation driver such as the Joint Theater Level Simulation. Measures of effectiveness were developed for logistics and intelligence tasks. Output methods were developed to capture JTLS results in a flat file for use in a spreadsheet for post exercise analysis. The primary objective of the analysis was to enable the exercise participants to relate causal reasons to significant events which occurred during the exercise. Research is continuing at the Naval Postgraduate School to increase the scope of results to a broader range of tasks in the UJTL.

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