What is an Adequate Decision Support System for the Operational Level of War?

A Monograph
by

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This monograph seeks to define what a decision support system (DSS) is to the military decision-maker, suggest some evaluation criteria, and propose a sample decision-making aid. It examines the current doctrinal or academic work in that arena.

The definition of a DSS, as defined by this paper, is a system that contributes to decision-making. This is a system that helps the military decision-maker use data (reports and observations) and modelling (wargaming) to solve unstructured problems (the fog of war and the environment of operations). The two major objectives of this DSS are to use time more efficiently, and to have better situational awareness.

Civilian sources primarily contribute to what a DSS should be and provide some criteria to determine how to evaluate one.

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For the criteria one would use to determine the effectiveness of a DSS from a military perspective, two documents come to the forefront, FM 100-5 Operations and TRADOC Pamphlet 11-9, Blueprint of the Battlefield (Draft). These are used to establish evaluation criteria that are used to measure the effectiveness of two experimental DSSs used in the monograph's cited exercises.

A sample DSS is discussed. This DSS was actually used and evaluated during two exercises conducted at the School of Advanced Military Studies at Fort Leavenworth. These exercises were conducted at both the tactical and operational levels of war. The experimental DSSs were used by the students during these exercises with success in that they gave the commanders and staffs better situational awareness and enabled them to use time more efficiently.

Finally, a decision support matrix handbook is included as an annex. This handbook is simply a compilation of wargaming techniques and criteria from numerous sources. Although most of the rationale is seemingly tactical in nature, it constitutes the best wargaming rationale that was revealed during the research and in the cumulative, may have applicability for the operational level of war.

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ABSTRACT

What is an Adequate Decision Support System for the Operational Level of War?; by Major Patrick J. Becker, USA, 74 pages.

This monograph seeks to define what a Decision Support System (DSS) is to the military decision-maker, suggest some evaluation criteria, and propose a sample decision-making aid. It examines the current doctrinal or academic work in that arena.

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Civilian sources primarily contribute to what a DSS should be and provide some criteria to determine how to evaluate one. For the criteria which one would use to determine the effectiveness of a DSS from a military perspective, two documents come to the forefront, FM 100-5, Operations and TRADOC Pamphlet 11-9, Blueprint of the Battlefield (Draft). These are used to establish evaluation criteria that are used to measure the effectiveness of two experimental DSSs used in the monograph's cited exercises.

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Strategy is the art of making use of time and space.
I am less chary of the latter than the former.
Space we can recover, lost time never.[1]

Napoleon

SECTION I. INTRODUCTION.

The conduct of war requires the ability to make rapid, informed, and correct decisions. Decision-making is an essential aspect of war. One of the most critical goals of military decision-making is to decide when and where to apply force. Mass and momentum are elements of force in war-making and are prerequisites to victory. Normally, the side that can make quick and correct decisions about when and where to apply this force maintains its momentum. This decision-making may be greatly aided through the use of a decision support system (DSS).

This monograph will explore some of the characteristics, evaluation criteria, and sources of information that may be useful in the construction of a military DSS. A DSS, as defined in this monograph, is any system that contributes to decision-making. To a computer scientist, it is characterized as "an interactive computer-based system that helps decision-makers utilize data and models to solve unstructured problems."[2] A DSS, for a military decision-maker, should help him use data (reports) and modelling (wargaming) to solve unstructured problems (the fog of war and the environment of operations). The characteristics of this definition parallel the findings of the First International Conference on Decision Support

Systems. Their studies indicate that some of the major characteristics of a DSS are:

- They tend to be aimed at the less well structured, underspecified problems that upper-level managers typically face.

- They attempt to combine the use of models or analytical techniques with traditional data access and retrieval functions.

- They specifically focus on features that make them easy to use by noncomputer people in an interactive mode.

- They emphasize flexibility and adaptability to accommodate changes in the environment and decision-making approach of the user.[3]

All of these characteristics would be very useful in a military DSS which must operate in the chaotic environment of war.

To a military decision-maker, an effective DSS is one that displays critical information to the commander and helps him make decisions. Although there is much discussion about exactly which information is critical to the commander,[4] this monograph uses a sample system whose focus is information that shows the major components of friendly and enemy force. This information includes such things as force structure, logistics, phasing, use of time, and so forth. A DSS is thus used to portray this information to the decision-maker to help him make decisions.

Despite what a computer scientist may say, a military DSS could be either a manual or electronic processing in the processing of information. The major contributions of any military DSS should be at least twofold: first, it must use time more efficiently than the enemy.

and second, but more importantly, it must provide better situational awareness than the enemy. I will discuss both of these in turn.

The most significant benefit of a DSS, situational awareness, will be addressed at this time. Situational awareness is the ability to understand what is occurring on the battlefield. It is the ability to understand your own and your enemy's capabilities, and the possible interaction between the two. The situational awareness provided by a DSS could provide some decision-makers not gifted with the *coup-d'oeil* of great captains of history the ability to make better decisions through better insight.

Situational awareness is a vital ability of operational commanders. FM 100-5 specifically states that "The commander must anticipate the enemy's actions and reactions and must be able to foresee how operations may develop."[5] I would suggest that situational awareness is not only important regarding simply the enemy's actions but, of equal importance, is the ability to "foresee" the action of one's own forces. TRADOC Pamphlet 11-9, Blueprint of the Battlefield (Draft), establishes many criteria in its Operational Operating Systems (OOS) that are the ingredients of situational awareness (project future campaigns, assess operational situation, etc.).[6]

Many of these same criteria will be used to evaluate the hypothetical DSS proposed. Since command and control is largely a function of situational awareness, much of this monograph will be interested in the command and control OOS as a criterion of effectiveness.

The other cited contribution of a military DSS, the more efficient use of time, is related to situational awareness. Not only must the commander be given a proper "read" of the theater of operations, this picture must be provided as rapidly as possibly. Obviously, any event that occurs within the theater of operations takes time to accomplish. More importantly, time is one aspect of war that is common to both opposing decision-makers and is one factor in war that cannot modified by either belligerent. The passage of time does not physically affect the warring parties (as compared to terrain or the effects of weather). Time as a medium is the most versatile, operationally significant, and universally applicable medium. Thus the DSS not only allows the rapid movement of information, it also shows the major components of friendly and enemy force in relation to one another with respect to time.

Since armies normally synchronize activity based on either the occurrence of an event or the passage of time, time is of greater importance when we see it as an essential aspect of synchronization. Time is the superior and more common synchronization medium because the many elements that must be synchronized, particularly at the operational level, base their operations on time (e.g., the Air Tasking Order [ATO] of an air force). Time is the only medium we can use to project the impact of friendly activities on the enemy for long-term planning. It is for these very reasons that time is a critical aspect in any decision-making process and is therefore a critical aspect of any DSS. A more thorough evaluation of the DSS with respect to time is included in section III.

There is also another aspect of synchronization that becomes an integral component of any decision support system. Synchronization is crucial for the generation of maximum combat power. Synergism (or the action of two or more components of military power to get an effect greater than any single component) is the result of synchronization and a natural byproduct of any military DSS.

The usefulness of a military DSS will be evaluated through the mechanism of two exercises that were conducted at the School of Advanced Military Study. Experimental DSSs were developed based on the requirements of the student role-playing the commanders for a corps (tactical) and a JTF (operational) exercise. These experiments will be discussed in greater detail in section IV.

Work toward the synchronization aspect of a DSS is at present difficult as there are no doctrinal documents that show a comprehensive technique for synchronizing an operation. A useful academic work concerning military decision-making is Major Clyde Long's Synchronization of Combat Power at the Task Force Level: Defining a Methodology. This thesis has a clearly tactical perspective but does provide some insight into wargaming and synchronization at that level of war and suggests insights for application at the operational level.[7]

The military intelligence community has done works towards a DSS of sorts, the decision support template (DST). FM 34-1 Intelligence Preparation of the Battlefield shows intelligence and operations officers how to develop the DST but does not provide insight into synchronizing friendly/enemy interaction. This is not to mean that the operations defined in FM 34-130 are not useful in DSS, but they in themselves are not sufficient.

Now that the objectives and of a DSS have been discussed, any study concerned with a systems analysis has to address the adequacy of that system. In our present study we must determine the adequacy of the DSS. One obvious measure is to determine whether the DSS is used by the decision-maker in actual or simulated operations. If the DSS does not appear to be useful and provide the decision-maker some benefit, then he will not use the DSS. Another measure of adequacy is the degree of modification that the DSS must undergo to be considered a useful tool. Decision-makers involved in the test exercises cited later in this study were looking for a system that portrayed as a minimum the plans of both their forces and the enemy's, possible branches to these plans, force correlations, activity, and significant logistic factors. Other factors that will be dicussed in more detail later are: the effectiveness in the amount of information that can be portrayed visually, the interrelationship of this information; whether it is useful; and most importantly, whether it helps to use time more efficiently and provides situational awareness. The decision support matrices (DSM) developed accomplished these tasks with little modification (these will be discussed later).

The DSS should be evaluated in terms that are meaningful to the Army at large. Two other sources of criteria are FM 100-5 and TRADOC Pamphlet 11-9 (Draft) (particularly the command and control OOS).

These are sources of criteria useful at both the tactical and operational levels of war.

The tenets of AirLand Battle provide another means with which to measure the effectiveness of the DSS. The DSS should demonstrate capabilities in terms of its ability to facilitate operations in respect to agility, initiative and especially synchronization and depth.

Although FM 100-5 and TRADOC Pam 11-9 (Draft) provide insight into both how we intend to fight in war and a systematic analysis about how this is done, they are not all inclusive in defining the parameters useful in designing a DSS. Therefore, a review of other doctrinal and academic literature is necessary to gain a more complete grasp of the problem. In particular, what components most directly contribute to situational awareness and the efficient use of time?

SECTION II. REVIEW OF THE LITERATURE.

> *If I am able to figure out the enemy's dispositions while simultaneously conceal my own then I can concentrate while he must divide. And if I concentrate while he divides, I can use my entire strength to attack a fraction of his. There, I will be numerically superior. Then, if I am able to use many to strike few at the selected point, those I deal with will be in dire straits.*[8]
>
> Sun Tzu

This review of current doctrinal literature pertinent to the operational planner is focused on manuals above the tactical level, but for the sake of continuity some consideration is given to relevant tactical documents as well. The focus will be on manuals FM 100-5, Operations, FM 100-6 Large Unit Operations (Coordinating Draft), FM

100-15, Corps Operations, and FM 71-100, Division Operations. Additionally FM 34-130, Intelligence Preparation of the Battlefield, FM 17-101 Light Cavalry Troop, and FM 17-95, Cavalry Operations, provide some additional pertinent information.

Of the doctrinal manuals reviewed, none provide a methodology to develop situational awareness or synchronize, much less establish a DSS. However, TRADOC Pam 11-9, Blueprint of the Battlefield (Draft), provides a framework for the basis of an operational DSS structure by defining the operational operating systems (OOS). The pamphlet explains the interaction of the OOS with the tactical operating systems and the soon-to-be published strategic operating systems. The pamphlet defines six subsystems: movement and maneuver, intelligence, protection, command and control, fires, and support.

TRADOC Pam 11-9 (Draft) is important because "it serves as a common reference system for field commanders, combat developers, analysts, trainers, and planners for analyzing and integrating the actions the Army performs in, and in support of combat operations."[9] The blueprint could serve to define the architecture for a DSS at the operational level of war. Because it serves as a common reference for all operational participants, TRADOC Pam 11-9 (Draft) is a critical document for the development and evaluation of a DSS.

Blueprint of the Battlefield (Draft) defines the six OOS and their associated subfunctions. In addition to the other subfunctions discussed earlier, these are the subfunctions to acquire and communicate operational information, assess the operational situation, decide the need for action or change, and determine operational actions.[10] Parenthetically, the pamphlet also suggests that operational intelligence is predictive in nature, contains elements of risk, and focuses on the enemy center(s) of gravity. Operational intelligence efforts must also probe the mind of the enemy commander.[11] This later insight suggests that it is important to disrupt somehow the enemy commander's situational awareness.

Previous research efforts have also been examined. The U.S. Army War College's Campaign Planning provides some insight into planning at the operational level. Several theses and monographs of students from the U.S. Army Command and General Staff College (CGSC) and the School of Advanced Military Studies (SAMS) have attempted to explore the decision-making process and the problem of synchronizing military effort. Although focused at the task force level, both Battle Staff Operations: Synchronization of Planning at Battalion and Brigade Level and Synchronization of Combat Power at the Task Force Level: Defining a Planning Methodology are exceptional works providing insight into military decision-making with further application at the operational level. A SAMS monograph, Fighting by the Numbers: The Role of Quantification in Tactical Decision Making is again focused at the tactical level; yet, the scientific process the author defines has applicability at the operational level.

It is important to note that, although these works have a predominately tactical orientation, they are pertinent in that the models and matrices proposed can provide the basis for a quantitative method for analyzing war at higher levels. The resulting architecture for a DSS should be useful in decision-making at either the operational or tactical level of war. A major difference, in theory, between the operational and tactical DSS would be wargaming. DSS accuracy would be affected by the quality of the wargaming if one wargamed at too low a level. If the time estimates made for an operational level DSS are based on tactical wargaming rationale, then these estimates should be theoretically less accurate than if one were to wargame with an operational level wargaming rationale. Currently, there is little available in the form of operational wargaming information so a bottom-up synthesis, using tactical rationale, may be the best current solution.

The military has not totally overlooked other aspects of DSS research. The U.S. Army Research Institute (ARI) is involved in research efforts with the goal of constructing a DSS that has joint applicability. "The Command and Control Decision Aid Information System (C2DAIS)" has information pertinent to ongoing tri-service efforts for DSS development. It is a database of up-to-date information for anyone involved in the design, development, and use of command and control DSS.[12] The document specifies major DSS subcategories but unfortunately provides little information specific to this study.

As this review of literature suggests, there is at best some preliminary discussion ongoing in the Army at large. What is required, I believe is some useful "push" to get decision-makers to move beyond research into the realm of practical application. This monograph is intended to be such a push.

SECTION III. DEFINING THE DECISION SUPPORT SYSTEM.

Now those skilled in war must know where and when a battle will be fought. They measure the roads and fix the date. They divide the Army and march in separate columns. Those who are distant start first, those who are nearby, later. Thus the meeting of troops from distances of a thousand li takes place at the same time.[13]

Tu Yue as quoted by Sun Tzu

Right now there is no doctrinally established means to portray all the information critical to a commander without the benefit of some sort of DSS. The DSS that I propose portrays friendly troops' actions, locations, and status; daily sustainment and future logistic requirements; and action in respect to the enemy. Its basic components should contain structures that aid in information gathering, mission analysis, situation estimation, course of action development and analysis, and plan/order development.[14] All these elements taken together will contribute to the sense of situational awareness discussed earlier.

A consolidated display (manifested in the DSS architecture) is necessary to show the interaction of information. This display must be dynamic. If effectively integrated, the display will provide situational awareness. Situational awareness is the goal of the DSS although crisis action planning, deliberate planning, and mission execution are also important products.

If a DSS can comprehensively represent a campaign, then a decision support matrix (DSM) can be developed that synchronizes both friendly internal activities as well as friendly versus enemy activities. The DSM could provide a decision cuing system for the military artist, a method to supervise the execution of the battle, a system for collecting information, and better situational awareness.

The DSS should also provide a projection and prediction capability, since the DSS tracks enemy and friendly actions and activities (e.g., unit movements). Essentially, this carries the commander's situational awareness into the future. This will give the planner the ability to forecast logistic requirements and a whole host of other factors. These projections also aid the operators in conducting operations in that they provide a means to gauge the impact of information on their plans and those of the enemy's. Logistic requirements can be forecasted (projected) based on friendly/enemy interaction or purely friendly requirements (e.g., refueling or reorganization). These projections are estimated in terms of time. Time projections are a function of the wargaming process.

One of the distinguishing differences between a DSS at the tactical and operational levels is that in the latter instance forecasting becomes more important because we are forced to look further into the future. At the tactical level we are driven to consider the immediate present. Considering the way the Soviets make decisions at the tactical level, probably the best way for us to affect the Soviets' decision-making process is at the operational level. This being the case, opponent interaction or wargaming, forecasting, synchronization, templating, and estimates are appropriate considerations. This is true at the tactical level, the operational, and possibly at the strategic levels of war. If, as Clausewitz suggests, there is linkage among engagements, battles, and campaigns, then the operational planner can analyze anticipated activities through the use of a DSS.

If wargaming can provide the ability to project actions, then appropriate information could be entered into a DSS that would enable the user to monitor the capabilities of a joint task force (JTF) or army group versus those of the enemy. The campaign planner should have a basic understanding of the requirements for the campaign, if not for its entirety, then at least by phase. If a significant event were to occur not represented in the wargaming, (e.g., the surrender of an enemy army or the removal of one's supporting air forces), then the DSS should quickly surface this difference and help quantify its impact. As an example, if campaign planners anticipated that an opposing force would be destroyed after five days of combat and it surrendered after two, the campaign planner would quickly realize how much of a logistical surplus he would then have and could identify the impact on his subsequent activities. He might be able to reallocate resources to prevent culmination of forces elsewhere in the theater of operations. Such a reallocation, clearly made at the operational level, demonstrate how a DSS as this level might differ from its tactical counterpart.

Operations must be planned and conducted based on the availability of resources. Generally opponents cannot be equally strong everywhere. The operational artist attempts to apply resources, as they become available, to an area in which he can obtain an advantage over his opponent. He does this at a rate that maintains his momentum and keeps his opponent "off-balance." Time is required to mass forces to obtain local superiority. This may be because resources normally are distributed throughout the theater of operations before an operation begins. This dispersion of resources may be for protection, deception, or simply because they are not available. Since the rate that force is applied is generally as important as the amount of force applied, operations often are phased to ensure that an achievable mission is assigned to the force when massed. As further force is accumulated, subsequent missions are assigned. But to achieve maximum affect, these resources must be synchronized.

Armies attempt to synchronize their resources and activities to ensure the maximum synergistic effect of the forces they apply. In the planning process, time is naturally the optimal medium for synchronization. One reason is that staffs can calculate the rate at which movements are made or material amassed (e.g., it takes twelve days to sail from Jacksonville, Florida to Berbera, Somalia). Time is the product of analyzing the rate of accumulation versus the quantity required. Time is a common reference for tactical, operational, and strategic planners.

It is imperative to establish the importance of time to the military artist. If information is the fuel of any DSS, then time is the lubricant. Time is the essence of tempo (the rate that actions are completed in time). Tempo, when combined with mass, is the mechanism through which we apply overwhelming force in a specific area, usually at the decisive point. Rate of closure is another aspect of tempo. As an example, a course of an action is of no importance to a friendly commander if it permits him to conduct an operation successfully in three weeks if the enemy can attack and overwhelm him in two weeks.

Although the significance of a particular unit of time may have varying degrees of significance for commanders at different levels, its passing is constant for all. An hour period may be particularly significant to the tactical commander for he can influence a great deal with his resources in that time. The operational commander, on the other hand, can probably only begin to set into motion some event in that same hourly period. It is simply a measure of scope.

Time is the medium in which to synchronize activity and the common thread in the comparison of information. Time is the most common medium for synchronizing and coordinating activity. Time has worldwide significance and is constant in multiple theaters of war. This is particularly important when attempting to synchronize operational and strategic activities.

Now that the DSS has been defined, we understand what it should be able to do, and what it may entail; let us examine what one may look like and what products are necessary to create one. A major component of a DSS is the decision support matrix (DSM) (see Annex B). A JTF or army group should be able to develop a DSM. The DSM should be based on the results of the commander's wargaming (several courses of action), the J2's event analysis matrix, reconnaissance and surveillance plan, and the collection plan; the J2's and J3's decision support template (DST); the J3's synchronization matrix; and eventually subordinate unit input.

Building the DSS should begin when the planning DST and the other contributing documents mentioned have been developed. It is important that the DSS include the results of the wargaming process. Wargaming adds validity to the information incorporated into the DSS; adds the commander's insight into the conduct of the operation; and provides a more comprehensive matrix. The DSS itself is the architecture for displaying information. The quality of wargaming determines the accuracy of the DSS but does not alter the structure or the principle of the DSS, rather only its accuracy. The DSS is revised based on realities at the time the plan is implemented.

The DSS, based on several of the informational products mentioned, could be used to compare the consequence of friendly actions with the changing actions of the enemy. Because of the changing nature of the supporting products and the enemy, the DSS is subject to constant review and revision. This further reflects the fact the commander's situational awareness must require constant revision. Although this will be a continuous process, the relative stability of the information should show that it is a timely and useful tool to oversee the operations of a JTF or army group. Revisions are required when information from subordinate units is received (e.g., when new branches to the unit's base plan are produced or when the results of enemy action change a friendly situation).

When constructing either a manual or automated DSS, it is imperative to have an information prioritization methodology. Information abounds and it is important that the DSS key on the commander's critical information needs. Only in this fashion can useful information be separated from the noise and fog of war. This is particularly critical if the DSS becomes an automated system. Computers tend to treat every piece of information, including cybernetic noise, as having the same value. Without a means of prioritizing critical information, an automated DSS could quickly bog down in the presentation of meaningless information. Critical information must be presented on the DSS and be integrated to show interaction. But this integration is always a function of time.

Because the actions of friendly and enemy forces are analyzed based on time, the DSS should have usefulness in planning future operations and crisis action planning. Planning is aided by being able to understand the time and space relationship between friendly and enemy forces. Crisis action planning is enhanced by the DSS's ability to show time, space, action, and force relationships. By comparing time to space on the DSS, the commander can assess and decide the availability of his forces to react to unforeseen circumstances. Because the DSS reduces the friendly situational awareness, the DSS may permit us to operate faster than the enemy and help to regain the initiative.

An important aspect of the DSS is to provide the means to visualize wargaming and show branches and possible sequels. This notion brings to the fore the idea of forecasting situational awareness. By portraying the friendly and enemy base plans and branches, one can visualize the flow of the campaign and possibly make sense of what previously may have been confusing noise and incomplete information. The DST provides the methodology to track the enemy and shows possible future enemy action and suggests our own counter-action. By portraying the friendly and enemy options in a DSS, belligerent action can be followed as if it were analyzed in a program evaluation and review technique (PERT) diagram. Our goal, however, is to assess constantly the forces' "program" and attempt to find enemy vulnerabilities.

Information thus programmed into the DSS (e.g., wargamed data) should be pertinent to appropriate level of war. The information should be a product of appropriate wargaming techniques and values (relative friendly/enemy values can be adjusted based on regional assessments) with the intent of providing a standard for these efforts. These could be included in a DSS handbook or a field manual, particularly FM 101-5. This is not a novel concept as the Soviets have wargaming norms that a commander must use to determine the correct correlation of forces necessary to ensure mission accomplishment (for example).[15]

A sample DSM or an example of a DSS is shown below (Table 1). The DSM shows information from each file (the vertical column) in terms of time (the horizontal axis).

Table 1 JTF ___ DECISION SUPPORT MATRIX

[extract from Annex B]

	D-Day	D+_	D+_	D+_	D+_	D+_	D+_	D+_
Decision Cuing								
Political								
Strategic								
Phase								
GCC								
XVIII ABC								
101 Abn Div (AASLT)								
24 Inf Div (Mech)								
Oman								
I MEF								
8 MEB								
Reserve								
ACC								
TAR								
BAI								
CAS								
Reserve								
SOF								
NCC								
TF 80.1								
TF BBG								
Intel								
Weather								
Collection/Sensors								
Dissemination								
Rear								
Deep								
Logistics								
Infrastructure								
Ports								
Supply Forecasted								
Supply Required								
C2/Planning								
CMO								
Enemy/USSR								
Logistics								
PDRY								
5 MRD								
NAVY								
Air Forces								
Cuban Army								
Cienfueros								

Time on the DSM can be divided into different increments based on the resolution desired (e.g., for the corps exercise in the experiment two hour increments were good; for the operational exercise, day increments were more useful). Time is not relative; yet, commanders at different levels have differing requirements for resolution within the same period (e.g, day, week, etc.).

Depending on the size of the DSM, the base plan and possible branches of both opponents (derived from the wargaming) can be included on the DSM. This fosters better situational awareness and aids friendly decision-making by reducing the friendly decision cycle. In this manner, wargaming becomes a vital aspect in determining the basic time, space, and force relationships. As such, it becomes a primary component of the DSS function.

Having laid the groundwork for building a DSS, a further discussion of evaluation criteria would be appropriate. This discussion will help assess whether or not the DSS architecture constructed has the capabilities which we specified in our definition of a DSS. Evaluation criteria for a DSS will be the effectiveness in the amount of information that can be portrayed visually, the interrelationship of this information, whether it is useful, and most importantly whether it helps to use time more efficiently and provides situational awareness. If the DSS accurately portrays operational information (e.g., time, space, and force relationships) and logistical requirements, then a change in one of these variables should impact on the other. Therefore, for example, a significant change in logistics should impact on operational requirements and the extent of this impact should become readily apparent. It also should provide insight into phasing; when an operational pause may be warranted; or when an operation should be concluded.

Measuring the effectiveness of the DSS in terms of the operational operating systems (OOS) would provide additional evaluation criteria. Movement and maneuver, fires, protection, intelligence, support, and command and control may all be facilitated by a DSS, primarily with respect to situational awareness. Command and control could especially be enhanced by better situational awareness. The ability to perceive and project support requirements could be enhanced by a better understanding of the operation and the time and space relationship. The impact of movement and maneuver on an operation could be more readily assessed when graphically depicted in terms of time and in relationship to the enemy.

As mentioned earlier, additional criteria would be to measure the effectiveness of the DSS in terms of the tenets of AirLand battle. The DSS should be evaluated in terms of its ability to facilitate operations in respect to agility, initiative and especially synchronization and depth. If a DSS is successful, it should provide a means to synchronize activity and/or show when there is an opportunity to exercise initiative. The DSS also should enable our force to be more agile than the enemy by permitting our force to make decisions and act faster than the enemy. The DSS adds depth in terms of time in that if you can execute events faster than your enemy than this capability permits you to have greater freedom in positioning your force. You can position your forces at greater distances than your enemy from a decisive point and still act faster than him relative to that decisive point.

Now that the framework for the DSS has been established, an evaluation of the DSS based on some practical application would be appropriate. An adequate test of the concept was to use it during an exercise with interactive opponents. The opportunity to do this was presented during two of the many exercises conduct throughout the academic year in the Advanced Military Studies Program.

SECTION IV. THE EXPERIMENT AND EVALUATION.

> *Now if the estimates made in the temple before hostilities indicate victory it is because calculations show one's strength to be superior to that of his enemy; if they indicate defeat, it is because calculations show that one is inferior. With many calculations, one can win; with few one can not. How much less chance of victory has one who makes none at all! By this means I examine the situation and the outcome will clearly be apparent.*[16]
>
> Sun Tzu

As a means to test the adequacy of the postulated DSS, the effectiveness of two experimental DSM's was evaluated. These DSM's were the products of both the corps and the joint operations exercises conducted at the School of Advanced Military Study (SAMS)(AY 89-90). This evaluation was an empirically objective evaluation by seminar participants. Although both experiments are discussed, the question of DSS adequacy will be most focused on the operational exercise.

Both SAMS exercises involved both friendly and enemy player cells. This provided a degree of player free play and the dialectic interaction that Clausewitz says is an integral facet of war.[17] There was a faculty controller cell charged with keeping the exercise in the realm of the plausible, ensuring that course objectives were met, and most importantly providing the students an arena to be imaginative and challenge existing ideas.[18]

Engagement assessments were helped by computer simulations with a predominately attrition orientation. This expedited problem play and added a degree of realism regarding weapons effects. Because these computer simulations are attrition oriented, they do not consider the moral and, to some extent, the cybernetic domains of warfare.

Although the exercises were conducted using unclassified information, the quality and quantity of information used in the exercise was a realistic representation of the information that might be involved in actual operations. The quality of this information was relative to both sides but neither side was portrayed at an advantage because of this. The basic DSS architecture accommodated the information available in both the corps and the JTF exercises.

Although the corps exercise had a predominately tactical orientation, it provided the test vehicle to examine the utility of the DSS and clarify the theoretical significance of the time and space relationships. Building on the experience of the corps exercise as simply a point of departure, the DSS architecture was then redefined for the joint operations exercise that had a clearly operational focus. One of the areas of redefinition included wargaming.

As we know, wargaming plays an important role in U.S. Army doctrine. Although a stated aspect of course of action analysis, wargaming criteria are not included in any Department of the Army-level wargaming manual or guide.[19] Since wargaming is an aspect of the DSS, the quality of wargaming may be affected by the accuracy of information included in the DSS. The design of the DSS's basic architecture is sufficiently redundant to ensure that information quality was the same for the corps or the JTF experiment.

The first testing of the DSS was during the corps exercise. The friendly commander was the commander of the X (US) Corps. X (US) Corps was a four division corps with an armored cavalry regiment, aviation brigade, engineer brigade, and a multi-brigade corps artillery. X (US) Corps was opposed by a five division combined arms army that also included one independent tank regiment.[20]

The corps had just completed a successful offense and was assigned the mission to defend. The DSM that was developed started with the movement of the corps' subordinate units into their defensive positions.[21] The activity portrayed on the DSM showed the movement of the subordinate units into their positions and several days of the defense based on the commander and staff's wargaming.

The DSM also portrayed the anticipated activity of the enemy. All times and anticipated enemy branches were derived from both the G2/G3 decision support template (DST) and the G2's event analysis matrix.[22]

The DSM proved to be a very useful tool for the corps commander, who used it to provide himself better situational awareness. He referred to the DSM to gauge the impact of his action versus what was anticipated of the enemy.[23] At the same time it should be noted that the DSM was not a decision-making system that made decisions for the commander; it was used to cue when decisions should or could be made.

A particularly good example of the usefulness of the DSM in this regard was in timing the corps counterattack (review Annex A). The criteria set by the corps commander for the counterattack were threefold: first, he wanted the first echelon division committed across the river; second, he desired information about when and where the second echelon divisions would be committed; and finally, he wanted reasonable expectation that his forces could move quickly enough to isolate the first echelon from the second. The DSM projected this event seventy-two hours prior to its occurrence and was accurate to within fifteen minutes of its actual realization.[24]

The DSM presented much other critical information to the commander that was useful in his command of the battle. Additionally, the DSM provided much useful information for the staff's use and in the control and direction of battle-related activity.

Although this DSM is a manual system, it is somewhat easy to present and maintain information. As a manual system, any change in one of the matrix files (e.g., a tank divisions movement toward the battlefield) warranted the movement of data across that matrix file's line. This required physically erasing data, computing changes, and placing the information back into the DSM. Had the DSM been automated, the process could have been calculated more quickly. (A discussion of further automation possibilities will be addressed in section V.)

Generally, the corps DSM proved to be an effective tool for the corps commander. Although only one of many tools he used to assess the battle, the DSM proved to be the most efficient and the preferred manner to measure possible actions and their anticipated outcome.[25]

The second experimental case involved a joint operations exercise which was based on a contingency operation in Southwest Asia. The exercise involved one U.S. Army corps, an U.S. Marine Expeditionary Force (MEF), two carrier battle groups (CVBG) and a Surface Action Group (SAG), several multi-role wings of U.S.A.F. aircraft, and the sovereign forces of the host nation (1 ground division, 1 squadron of fighters and many patrol craft).[26] Although not a force on the scale of Allied Forces Central Europe, the joint task force was clearly involved in conducting a campaign at the operational level of war.

As one would expect, the amount of operational-level information portrayed was a great deal more than for the tactical corps exercise; yet it was not unmanageable. There were many more files to manage because of the addition of naval, marine, and air forces. The degree of resolution for army forces went down to the division/separate brigade level. This was because these were the major combat formations resourced to the operational commander, and due to their phased arrival into the Tactical Area Own Responsibility (TAOR). This caused the operational commander to phase his operations based on their availability. He had to assign achievable missions for the units then in theater.

Some of the most significant information that everyone needed therefore concerned the arrival of friendly and enemy forces into the theater of operations. Considerations such as the arrival of forces into the theater provide us with potential discriminators to distinguish the operational employment of the DSS vice its tactical use. This established the scope and tempo of operations. Additionally, this aided logistics planning. In reference to the enemy, the Joint Task Force (JTF) got an insight into the ability of the enemy's logistics infrastructure to support its forces by analyzing enemy requirements versus capabilities. Through this analysis, greatly aided by the DSS, the JTF determined when the enemy was compelled to pause because of logistics. On the friendly side, planners throughout the JTF were focused on the arrival of selected units, their associated support requirements, and when these forces could be employed.[27]

As a result there was more information portrayed in the JTF DSM because of the interval programmed. But there was also somewhat more stability and less information transcription required. This was because events at the operational level tend to be more stable. At the tactical level, the temporal granularity of combat actions require more frequent system updates because of the speed at which new information is generated. The size of the display became more awkward though it, too, was manageable. Under most practical circumstances, operational headquarters should not have to track to the degree of resolution as in this exercise and therefore the scope of their DSM should be more manageable.

As with the previous experiment, the DSM for the JTF proved to be extremely useful. The JTF had begun the exercise without establishing a DSM. They were soon inundated by the amount of information that they were required to track and assimilate.[28] This in itself was sufficient to require the matrix. Of greater importance was the fact that the staff had difficulty in determining the interrelationship of this information. Again the matrix proved useful in visually displaying these relationships.

The DSM also placed the current situation into clearer perspective and enabled the players to begin to make a more coherent projection of future activities and outcomes. Because of the situational awareness gained in respect to future activities, the JTF could accurately anticipate and plan for the requirements of the later phases of the operation (redeployment and peacekeeping phases).[29]

As with all operational-level exercises, the status of the logistic infrastructure was extremely important. The scope of logistics is thus another discriminator of an operational-level DSS vice a tactical one. Because it was such an undeveloped theater, what little infrastructure that was in place was very critical. Ports were therefore assessed as an allied (U.S./host nation) vulnerability.[30] The capacities of the ports had a direct influence on the ability of the allies to deploy forces quickly into combat operations. As a change occurred in status of the ports of debarkation (degraded by enemy air action) resolution was immediately made on the DSM. This quickly caused a reassessment in the operational plan for the employment of in-place forces and those forecasted.

The port capacity example is a good instance of the interaction of information for the friendly forces. Particularly for contingency operations, ports are critical for the support of friendly forces. When the commander has made his plan for the employment of arriving forces, the receiving ports are notified of their future requirements to receive these units. This determines the level of capability that is required during that time. It also determines what service support organizations will be required to handle the arrival of the forecasted units. If for some reason the capacity of the receiving ports is degraded (e.g., because of an enemy air attack) then the port commander will submit a bottom-up report that will get resolution on the JTF DSM. This means that all affected JTF activities for which that information was critical could quickly measure the impact of the port degradation.

Conversely, if operational planners changed their operational plan warranting a change in the port of debarkation (POD), the planners would submit a top-down report. This information would get resolution on the DSS and all affected parties (e.g., the port commander) would quickly assess the impact of that change. The important point of this particular discussion is that the DSS establishes the communication channels that can quickly surface critical information.

As it did in the corps exercise, the DSS provided an effective tool for the JTF (operational) commander, staff, and subordinate commands.[31] Again the premier benefit of the DSS was situational awareness. Because of the vast expanse of the theater of operations and the dispersion of the JTF's resources in both time and space, situational awareness was enhanced even more so than for the corps exercise. This was beneficial from both the friendly and enemy perspective.

The DSS also provided a means to synchronize activity and/or show when there was an opportunity to exercise initiative. This should further enable our force to be more agile than the enemy by permitting our commander to make decisions and act faster than the enemy.

In terms of agility, the situational awareness provided by the DSS enabled the commanders to project force closure rates and find windows of opportunity. FM 100-5 says a commander must be able to "read the battlefield" to realize opportunities[32]. With the improved situational awareness provided by the DSS the commander "read" the battle more knowingly. The DSS proved to be effective in helping him in that regard.

The DSS added depth to the campaign in respect to time. This was added because the commander gained a more concise appreciation for the relative capability of forces, in that the proximity of the force was not as important as how long it would take to move into a position in which it could have a meaningful impact on his operations. Although the enemy's source of supply was nearer to the battle area than the JTF's bases, the JTF could move supplies faster and consequently the JTF could operate in a much larger "area" and still be more agile than the enemy. By depicting the enemy's probable actions on the exercise DSMs, the commander could assess possible enemy actions and outcomes as projected in time.[33] Depending on the accuracy of these projections, the operational commander could then remain further dispersed with an "undiscernible shape". Time is as much a dimension to the operational commander as space.

Another measure of evaluation was developed in terms of the TRADOC OOS. The TRADOC OOS and subfunctions (indicated in bold print) provided an effective and contemporarily meaningful means to evaluate and structure the DSM and the architecture for a DSS. Although the DSS has usefulness for gaining situational awareness in all six OOS and their associated subfunctions, this evaluation focuses predominately on the command and control OOS.

A DSS, particularly when automated, could provide the means to **acquire and communicate operational level information and maintain status** (the bold phrases now indicate criteria from the command and control OOS from TRADOC Pam 11-9 (Draft)). In the evaluation information critical for timely decision-making was expeditiously presented when the DSS and its associated information conduits were established. The reporting system was largely established for the information required in the DSS. The DSS provided a centralized system to assess the "value" of the information.[34]

As previously mentioned, the DSS also provided assistance in **communicating operational information** simply by portraying selected information. Through timely information flow and presentation, the staff could **maintain operational information and force status** thus communicated. The staff was already receiving the information essential to the decision-makers; however, the ability to see the significance of the information was lacking until portrayed on the DSS.[35] The DSS architecture provided gates for the commander's critical information that helped **manage the means of communicating operational information** through the display of selective information.

During the exercises, the military artist had an increased ability to **assess operational information.** By displaying information that had a critical operational impact, the DSS enabled the commander to understand information interaction and make more rapid assessments. This was particularly critical when reacting in a crisis action situation.[36]

By managing and displaying critical information in a timely fashion, the commander can **review the current situation.** This capability will be enhanced when the DSS is automated and each major activity listed (e.g., X (U.S.) Corps) has an interactive system. An example would be a proposed action that the army group has for its corps. The army group transmits a fragmentary order (FRAGO) to the corps and its estimates for how long it will take the corps to complete that task. The corps receives the FRAGO and sends the army group its estimate concerning the mission when its calculations are completed. Thus the information on the DSS, which reflects where subordinate units are and in this case where they will be, is revised providing more current situational awareness. A simple flagging system alerts both participants when changes occur and their relative impact on projected activities.

The DSS proved to be particularly beneficial when used to project future campaigns of major operations and their requirements. This ability was a function of the projection capability of the system. By analyzing future requirements and comparing them with forecasted and available resources, the staff was more able to make projections. Although associated with a deal of risk, the DSS had usefulness in predicting or projecting long-range activities (enemy and friendly). This capability was particularly significant at the operational level, for managing time is one of the most critical tasks and the greatest resource of the operational commander. Through projecting activity in time, the operational commander could decide the need for action or change based on these projections. As always, the DSS only suggests to the commander that a potential decision point has been reached.

The DSS is a system that is not designed to replace the current U.S. Army decision-making process nor is it to "make" decisions. Its goal is to display information that contributes to the decision-making process and provides a means of tracking information pertinent to that battle. Yet, during the tests, we know that the DSS helped provide projections and these projections were used as a baseline for conducting future estimates.[37] Obviously, we know the DSS is not entirely divorced from the decision-making process.

Once a decision is made that selects a plan, the baseline plan and its branches are introduced into the DSS. The DSS can then be used to assess the plan (with branches and eventually sequels) and its ability to survive its encounter with the enemy. By displaying both the friendly and enemy base plans and branches, one can track the action and reaction that probably will be the outcome of the interaction of the belligerent.

Although not directly an aspect of the decision-making process, the DSS did have some usefulness in **determining operational actions.** This was particularly apparent in terms of planning "sequels and anticipating campaigns or major operations."[38] The projection capabilities of the DSS provided insight into windows of opportunity, culminating points, and phasing.

In respect to courses of action, the DSS did have some utility in **analyzing courses of action, developing courses of action, selecting or modifying courses of action, and comparing courses of action.** Once both friendly and enemy courses of action were determined, the DSS was used as a tool in wargaming the possible scenarios. Phrases in TRADOC Pam 11-9 (Draft) such as: "to anticipate and define multiple, feasible employment options" and "each friendly course of action is wargamed against the enemy courses of action"[39] indicate that those capabilities in a DSS would be and were useful in the test. The DSS has the ability to display the course of action options, which are potential sequels and contingencies, which enable the operational commander to react rapidly to changing situations.[40]

The situational awareness provided by the DSS was more beneficial once an operation began. Missions assigned to subordinate units permitted the greatest latitude to the subordinates. The situational awareness provided by the DSS was not only useful to the operational commander but also to his subordinates. The DSS helped the commander direct and lead subordinate operational forces. This was largely accomplished by his being able to portray graphically his intent.[41] Particularly evident was the direction he chose to take and his assessment of the battle. By doing this he was able to provide operational command preference.

The DSS was incorporated into existing C3 structures, those being the command's staff and communication means that are currently in existence. The only addition to the existing C3 structure was the device selected to display the information (e.g, a cathode ray tube (CRT)). The DSS used those structures as a conduit for its information. Through this means the DSS can help prepare campaign and major operational plans and orders and aid in their dissemination. As mentioned before, the communication system supporting the DSS and the DSS's ability to convey future intent may help subordinate planners plan concurrently and within the overarching intent of the operational commander.

The DSS was not a substitute for issuing plans and orders. However, it was truly effective as a supplement to the normal order or plan. If the information is properly presented, then the DSS can do a great deal in presenting the commander's perception of how he envisions conducting the battle. It was as if the DSS was an action graphic showing his intent.

The critical subfunction of **Synchronizing operations** was facilitated by comparing all participants in the medium of time. Time, being the most common and universal medium of synchronizing activities, proved to be the most useful and relevant medium when viewed across the entirety of the theater of operations. The improved situational awareness of the commander enabled him to more wisely decide the timing, nature, and the desired effect of an operation.[42] What were broadly stated goals in his intent could be actualized only when resources became available over time.

Another subfunction that was unexpectedly aided by portrayal on the DSS was in the arena of developing plans and orders. This byproduct of the DSS is that the commander's intent and concept can be graphically portrayed and used to develop and complete operational plans and orders. This was done during the exercises.[43]

One function of a DSS is to get approval for plans and orders. Although this is only a small aspect of the use of the DSS in the initial planning process, it becomes particularly useful during a crisis period. Because of the commander's and staff officer's ability to use the DSS to put events in perspective, the estimate and approval processes can benefit from the insight provided by the DSS.

TRADOC Pamphlet 11-9 (Draft) stipulates that to coordinate effectively service components, theater army and other support, " a consistent and mutual understanding of the operational commander's priorities, support requirements, concept and intent, and objectives are necessary."[44] Again the DSS provided that insight during both exercises to the participants role-playing the Navy, Marine, and Air Force component commanders.[45]

The DSS can aid in the employment of command, control, and communication countermeasures (C3CM). Since the user of the DSS has the capability to show the interaction of friendly and enemy information, the user can determine when both the friendly and enemy C3 functions may be vulnerable or when they may be more heavily taxed. This capability could show when one should be sensitive to protecting one's own C3 and the opportunity to deny or degrade the enemy use of his C3.

On the whole the experimental results tended to support the adequacy of the DSS designed for the two exercises.[46] Admittedly much of this assessment was subjective. I do believe, however, that at the macro level it is clear that the play of the two games would have been severely degraded without use of the DSS. What then, do the results of this assessment suggest to a decision-maker? I turn to this question next.

SECTION V. CONCLUSIONS.

> *Let us admit that boldness in war even has its own prerogatives. It must be granted a certain power over and above successful calculations involving space, time, and magnitude of forces, for whenever it is superior, it will take advantage of its opponent's weakness. In other words, it is a genuinely creative force.*[47]
>
> Clausewitz

A DSS, at both the tactical and operational levels of war, was used to monitor the capabilities of the corps and JTF versus those of the enemy. The DSS gave the campaign planner a basic understanding of the requirements for the campaign, if not for its entirety, then at least by phase.

The DSS did provide a common frame of reference for all staff elements that previously did not have a common or clear picture of the future phases of the campaign. A clearer picture was presented to the JTF commander. The staff did excel in gathering information and keeping him informed; however, until the DSS was implemented, the significance of the interaction of this information was not clear.

Another benefit of the DSS was that it was helpful in articulating requirements between the services and subordinates. Based on the requirements of the army group commander to slow the tempo of enemy operations, the (air force) commander would program his forces to delay the enemy forces for the time required by striking either at the force or its supporting infrastructure.[48]

The awareness of the time dimension provided by the DSS showed what kind of activity was needed and also provided an idea of the duration of that effort. Notice that the air force commander was not told what specifically to do, but the general effect desired in terms of tempo or time.

Another unexpected benefit of the DSS in terms of time and resources was the ability to project the probable activity of a force over time. By showing the probable employments options of a force (base plan and branches) and wargaming them to logical conclusions, the staff could determine when forces may become available for future activities. This became apparent and invaluable during the closing days of battle in the operational exercise for the purposes of selecting forces for redeployment and to perform the peacekeeping mission.[49] The primary emphasis during the wargaming was to defeat the enemy, but the subsidiary benefit was the availability of the force for future operations.

The DSS provided benefits but these did have a corresponding cost. Managing the DSS manually was a difficult and time consuming task that required a dedicated person to maintain its currency. This person was not only a secretary, but he was also an information qualifier of sorts. If information did not seem credible, then the DSS operator could screen the information's quality. Much of this effort could be reduced through automation.

The DSS can be an automated system. Through computer networking, program design, proper file management, and information gates, information can be received that automatically revises the DSS. A flagging system should be used to alert the staff and commander of these changes. Through automation, the DSS can be more effectively managed and distributed to appropriate users. The DSS can be automated either as a decision support system that simply manages data or developed as a system that can analyze and assist in decision-making.

Automation can cut planning time, standardize staff processes, and facilitate situational awareness by presenting the most current information to the commander. Automation could be the means of distributing the DSS. Although the DSS is not a substitute for an order or plan, it can be used to supplement those products.

Any automated DSS architecture developed should tie-in other echelon synchronizing systems (e.g., maneuver control system) in the event they become available. In essence, pertinent information at a lower level should be communicable to a higher level DSS.

An automated DSS should interface with existing and developing database information systems. There has been much work done in command and control decision aid information systems (C2DAIS). The DSS tested during the exercises should be compatible with these efforts.

The ability to synchronize friendly/enemy interaction needs to be developed and be included in an operator-type manual (e.g., a field manual, particularly FM 101-5, Staff Organization and Operations or a new manual like FM 101-10-1/X). The information included should provide insight into wargaming and synchronization at the operational level. The information useful to wargaming currently found in special texts produced at Fort Leavenworth and other centers should be included in one wargaming manual, ideally in one of the manuals already recommended. This will help the wargaming process and provide for a mutual understanding of the wargaming and estimate processes and be the basis for standardizing staff procedures. Places like the National Simulation Center could be used to further develop such procedures.

We have defined, constructed, and evaluated a DSS but we have not discussed whether or not the commanders thought it was an adequate system. In terms of adequacy, the DSSs used gave the commanders a method to organize the vast information presented and enabled them to make more timely decisions. The systems used for the two exercises cited in this monograph gave the commanders concerned tools that provided information, identified requirements, capabilities, and opportunities, and showed combat activities. This system provided the commanders situational awareness that enabled them to effect the enemy's tempo. Situational awareness is a particularly vital aspect of the command and control OOS.[50]

In closing, war is not solely the purview of military scientists. It is not just the effort of machines, time schedules, and calculations. Clausewitz warns that "Military activity is never directed against material force alone; it is always aimed simultaneously at the moral force which gave it life and the two cannot be separated."[51] War is the product of the effort of warriors. The performance of a warrior is not strictly calculable. Man's performance in war may vary. The DSS does not attempt to deny the existence of the moral aspect of war. It does, however, attempt to provide a ledger for measuring the impact of the moral domain on the physical domain of war.

War, as it is, cannot be left exclusively to the "science" of the staff officer. It must remain under the command of the commanders like the "great generals" of old. These were commanders with keen insight and experience. Yet such warriors may be increasingly more difficult to find. This is not because the commanders of today are inferior to their predecessors, but because experience gained through combat is becoming less available and warfare more complex. Experience coupled with a keen mind (genius, if you prefer) develops the coup-d'oeil that our commanders require. The DSS proposed is designed as a tool to be used by the military artist to gain a clearer perspective of the operation so that they may make more informed decisions. The

DSS is not championed as a device to make decisions for them.

The concept for a DSS presented here has stood the test at the tactical and operational levels of war. It has been useful when examined by the tenets of AirLand battle and the operational operating systems. A DSS provides the Army the architecture for processing and analyzing the plethora of combat information available to operational commanders. This architecture is necessary to provide the framework and blueprint to guide the Army's current efforts to automate command and control operations.

The DSS emphasis on the efficient management of events places appropriate emphasis on the operational commander's most precious resource: time. Time is an integral aspect of any operation. Both the control of time and the understanding of the significance of an event in terms of time are critical elements of any successful operation. Only through the rapid development of situational awareness that the DSS provides can the commander maintain a positive balance of that most precious resource.

ENDNOTES

1. David G. Chandler, Campaigns of Napoleon, (New York, The MacMillan Company, 1966), 67.

2. Ralph H. Sprague, Jr. and Eric D. Carlson, Building Effective Decision Support Systems, (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1982), 4.

3. Ibid., 6.

4. William F. Crain, (MAJ, USA, "Battle Staff Operations: Synchronization of planning at Battalion and Brigade Level," (Fort Leavenworth, Kansas: U.S. Army Command and General Staff College, 1989), 10.

5. Department of the Army, Field Manual 100-5, Operations, (Washington, D.C., Headquarters, Department of the Army, 1986), 23.

6. Department of the Army, TRADOC Pamphlet 11-9 (Draft), Blueprint of the Battlefield, (Fort Monroe, Virginia: U.S. Army Training and Doctrine Command, 1989), 4-12 - 4-14.

7. The Clyde Long study, Synchronization of Combat Power at the Task Force Level: Defining a Planning Methodology, was intended to "identify a planning model and matrix from current doctrinal sources that explains how to synchronize combat operations in planning." It concluded that there was no doctrinal process specified at any level of command. His works defines some planning factors, "and relates these terms to time, space, and purpose."

The model and matrix that he presents provide information in such detail that it should be a useful contributor to information for the DSS proposed by this monograph. His products are like "worksheets" for the DSS.

8. Sun Tzu, The Art of War, (London, Oxford University Press, 1963), 98.

9. TRADOC Pam 11-9 (Draft), 1-1.

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12. Department of the Army, "The Command and Control Decision Aid Information System (C2DAIS)," (Fort Leavenworth, Kansas: U.S. Army Research Institute, 1990), 1.

13. The Art of War, 99.

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15. A. Ya Bayner, Tactical Calculations, (Moscow: Voyennoye Izdatel'stvo, 1982), 4.

16. The Art of War, 71.

17. Carl von Clausewitz, On War, (Princeton, New Jersey: Princeton University Press, 1976), 77.

18. Patrick J. Becker, "Exercise Notes" (Fort Leavenworth: School of Advanced Military Studies, Academic Year 1989-1990). These are unpublished notes and observations made during the conduct of the exercise. Some can be substantiated in the exercise log or in the student handouts.

19. Department of the Army, Field Manual 101-5, Staff Organization and Operations, (Washington D.C.: Headquarters, Department of the Army, 1984), 5-4.

20. "Exercise Notes."

21. Ibid.

22. Ibid.

23. Ibid.

24. Ibid.

25. Ibid.

26. Ibid.

27. Ibid.

28. Ibid.

29. Ibid.

30. Ibid.

31. Ibid.

32. FM 100-5, 16.

33. "Exercise Notes."

34. Ibid.

35. Ibid.

36. Ibid.

37. Ibid.

38. TRADOC Pam 11-9 (Draft), C-16.

39. Ibid., xx.

40. Ibid., C-17.

41. "Exercise Notes."

42. Ibid.

43. Ibid.

44. TRADOC Pam 11-9 (Draft), 4-14.

45. "Exercise Notes."

46. Ibid.

47. On War, 190.

48. "Exercise Notes."

49. Ibid.

50. TRADOC Pam 11-9 (Draft), 4-9.

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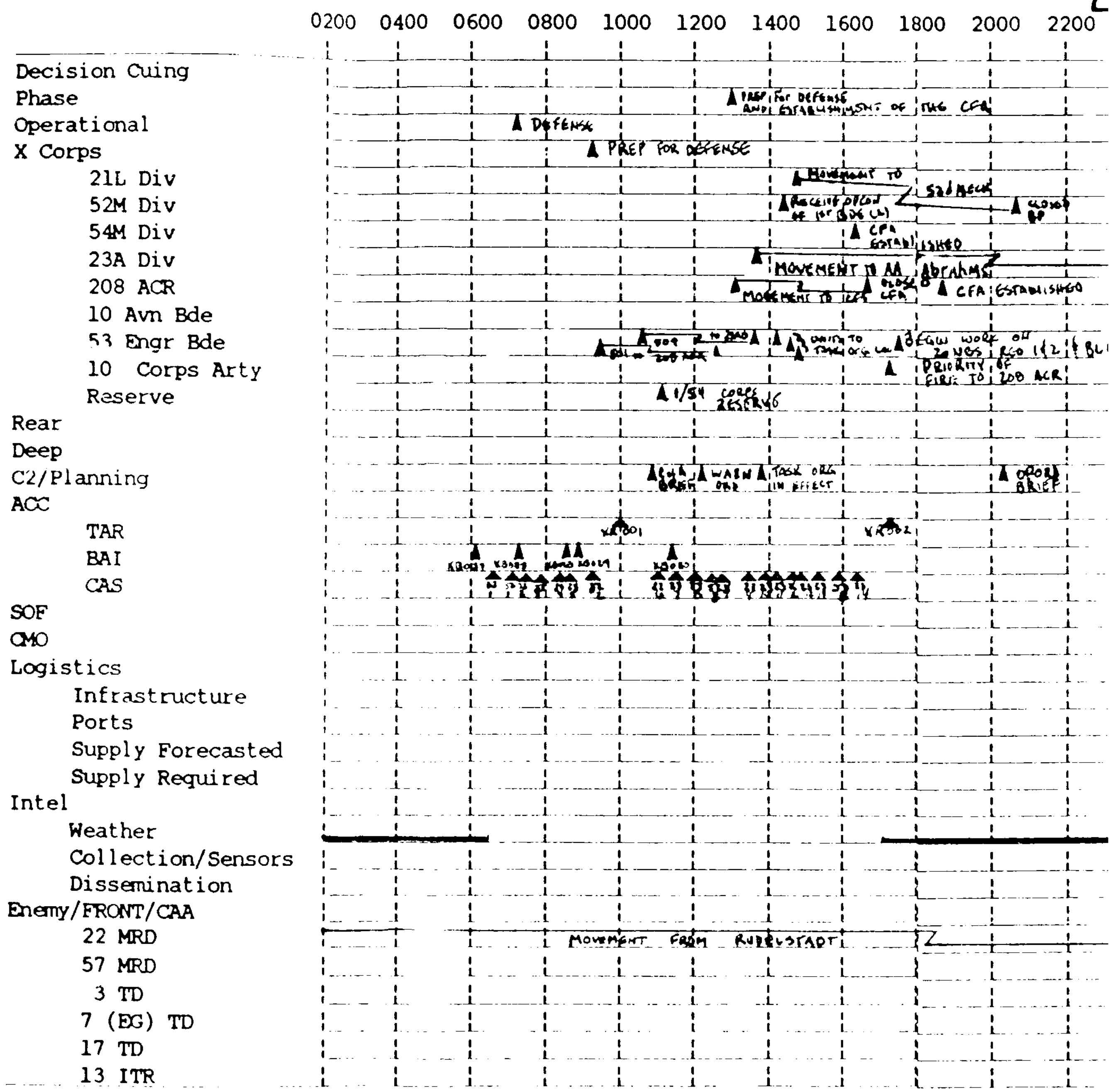
Appendix A (Corps Exercise Decision Support Matrix)

X Corps Decision Support Matrix A:<A



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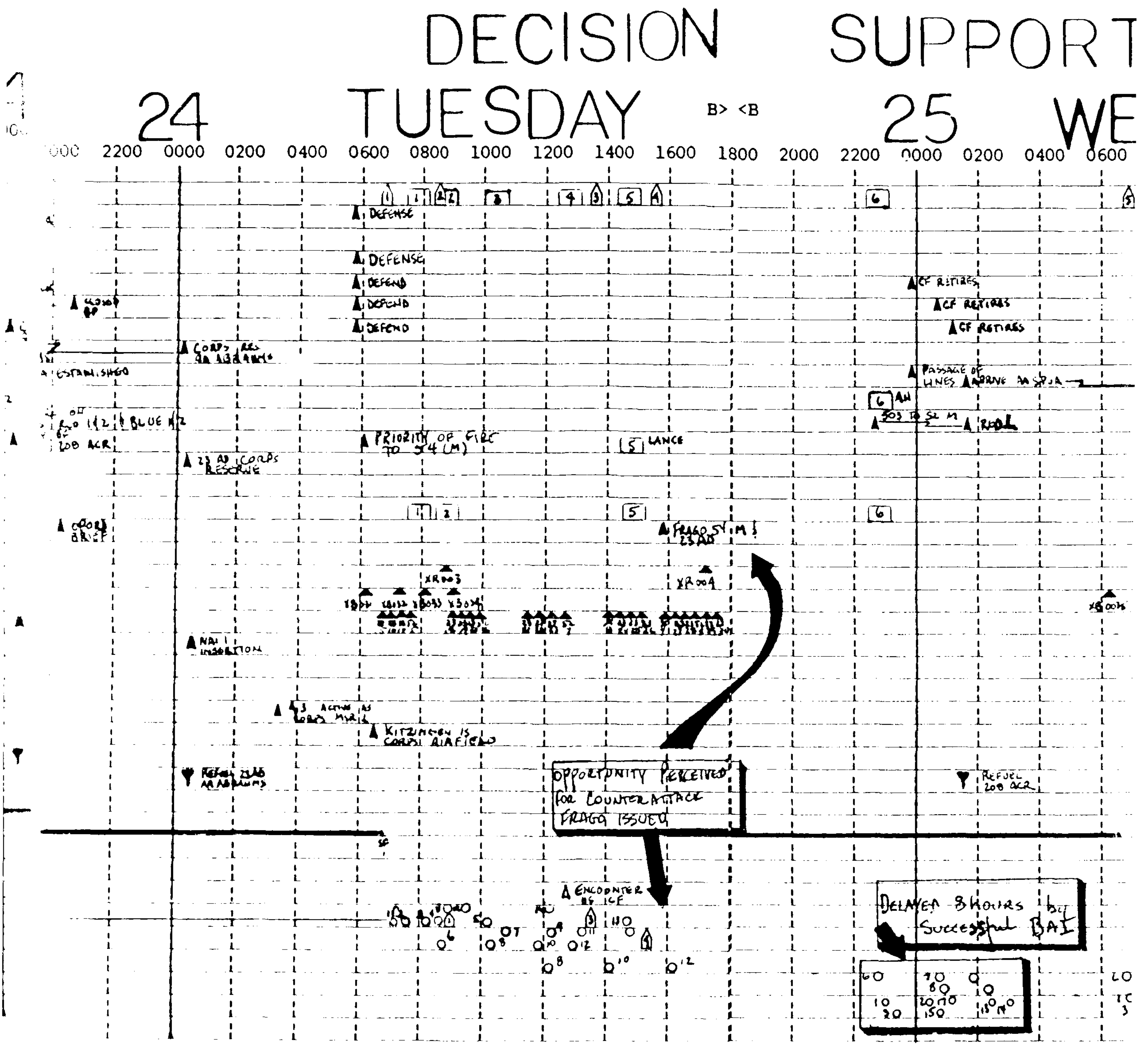
APPENDIX A


DECISION SUPPORT
24 TUESDAY
25 WE
2200 0000 0200 0400 0600 0800 1000 1200 1400 1600 1800 2000 2200 0000 0200 0400 0600
DEFENSE
DEFENSE
DEFEND
DEFEND
DEFEND
CF RETIRES
CF RETIRES
CF RETIRES
CORPS RES
ESTABLISHED
PASSAGE OF LINES
BLUE
208 ACR
PRIORITY OF FIRE TO 54 (M)
LANCE
23 AD CORPS RESERVE
FRAGO 54 M
23 AD
XR003
XR004
INSERTION
KITZINGEN IS CORPS AIRFIELD
REFUEL
REFUEL 208 ACR
OPPORTUNITY PERCEIVED FOR COUNTERATTACK FRAGO ISSUED
ENCOUNTER BY ICF
DELAYED 8 HOURS by Successful BAI

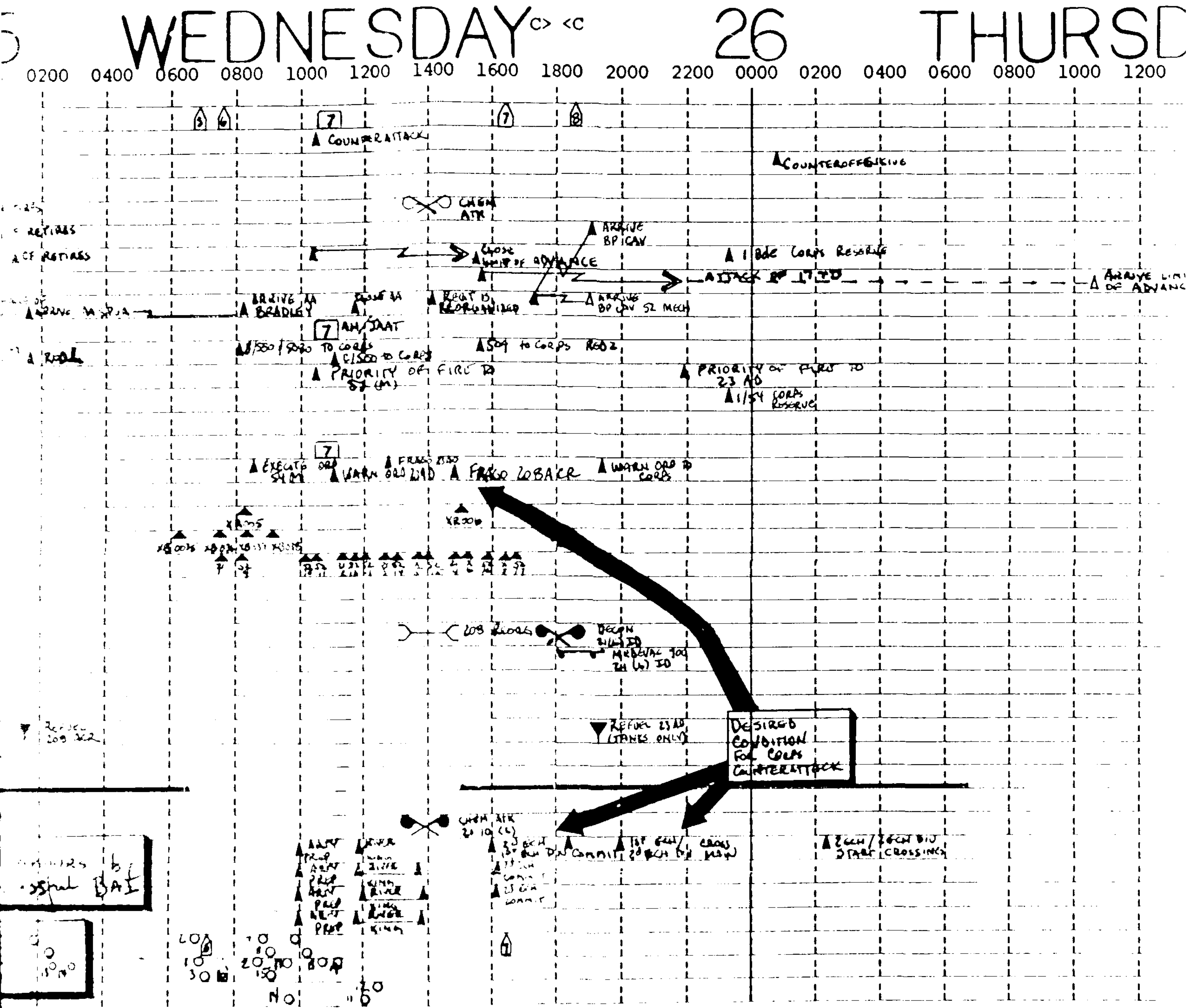
B> <B

2

<C

<B

PORT MATRIX



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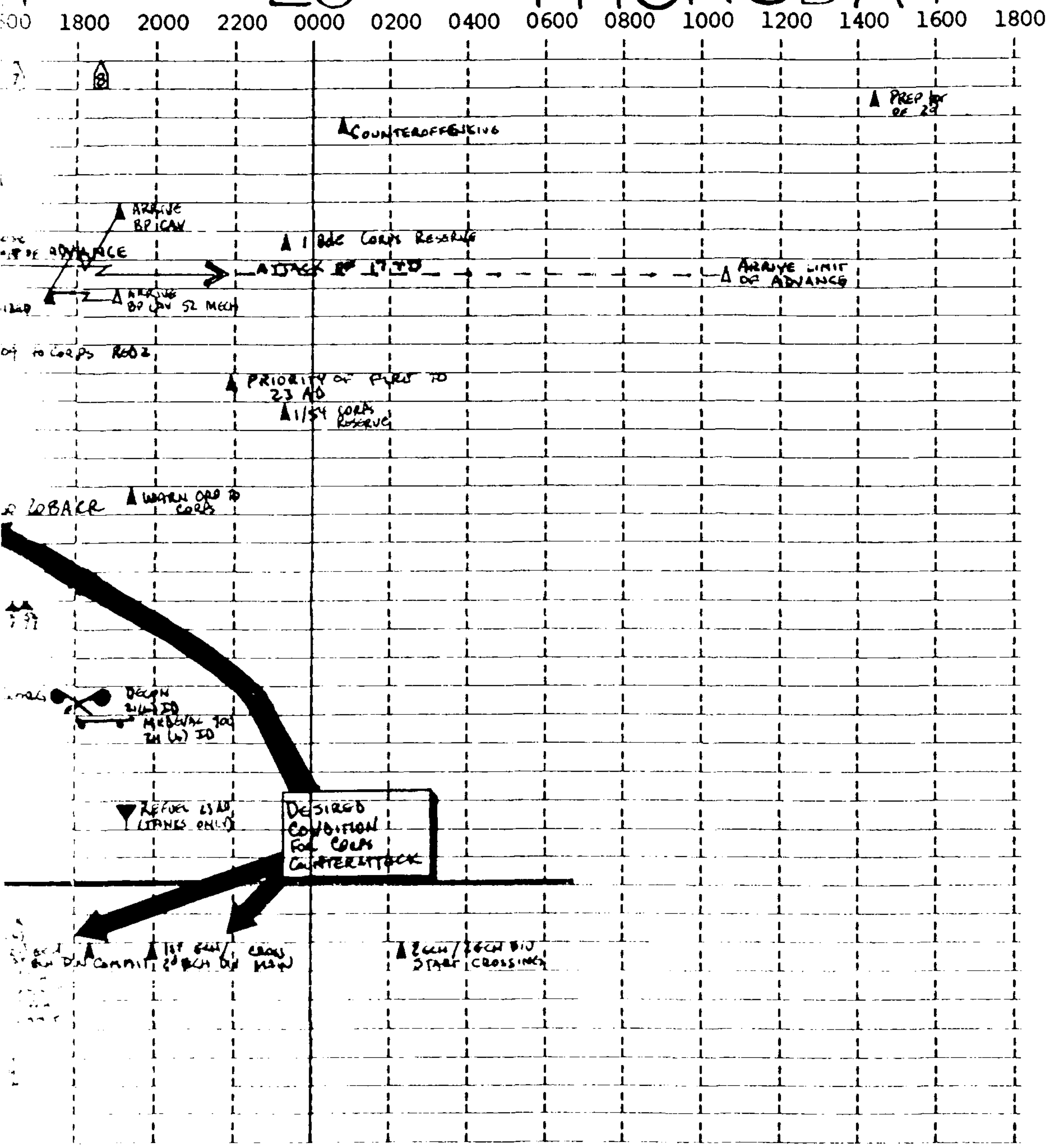
X

Y C> <C 26 THURSDAY D>



D>

D>

Logistics	
Infrastructure	
Ports	
Supply Forecasted	
Supply Required	REFUEL [illegible] AA [illegible]
Intel	
Weather	
Collection/Sensors	
Dissemination	
Enemy/FRONT/CAA	
22 MRD	MOVEMENT FROM RUDOLSTADT
57 MRD	
3 TD	
7 (EG) TD	
17 TD	
13 ITR	

A> <A

1

<A

B>

<B

DP 01 Execute TAI[illegible]

DP 02 Cancel TAI01

DP 03 Execute TAI02

DP 04 Execute TAI03

Cancel TAI01

DP 05 Execute TAI04

DP 06 Execute TAI[illegible]5

DP 07 Reserve to AA Eagle

DP 08 Cxl

DP 09 Cxl

DP 10 Reserve to AA Hole

DP 11 Execute TAI[illegible]

DP 12 Reserve to AA Eagle

DP 13 Execute TAI10

DP 14 Execute TAI11

Cancel TAI10

DP 15 23 AD CA

DP 16 Execute TAI[illegible]

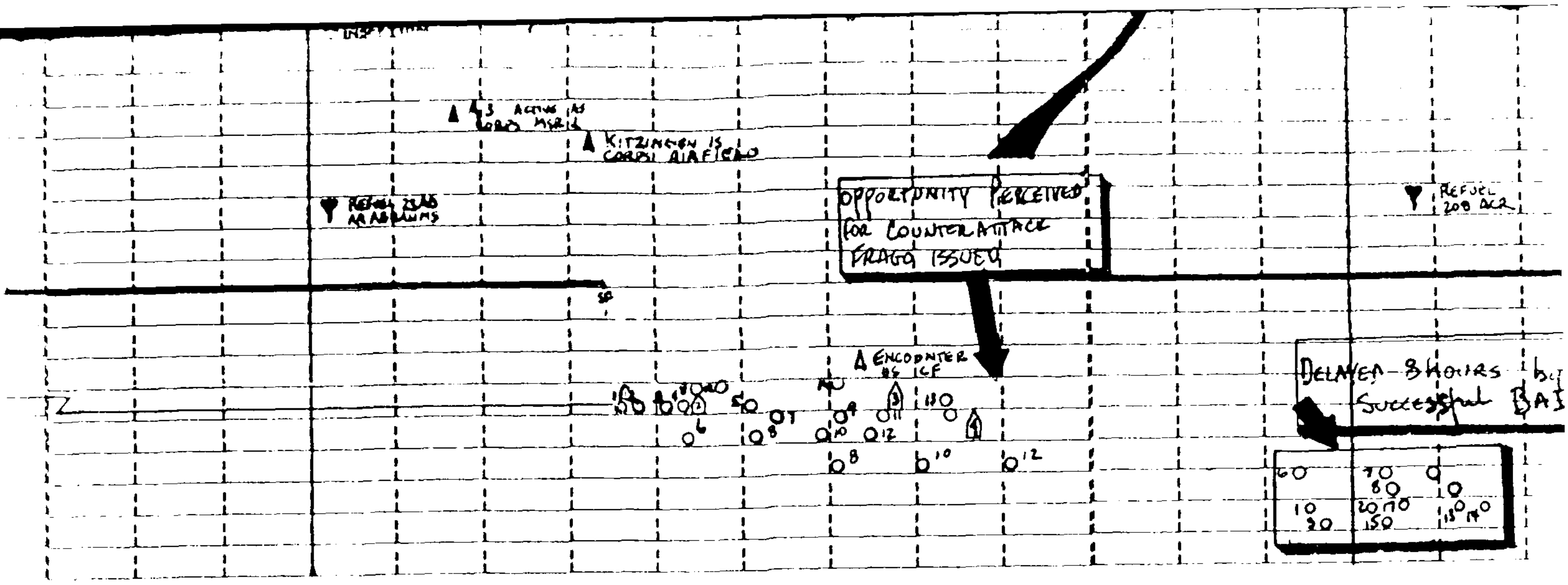
DP 17 CXL

DP 18 54 M CA

NAI 1 AA 1 or [illegible]

NAI 6 AA 1 or [illegible]

NAI 11 AA 2 or



A> <A

B> <B

2

B> <B

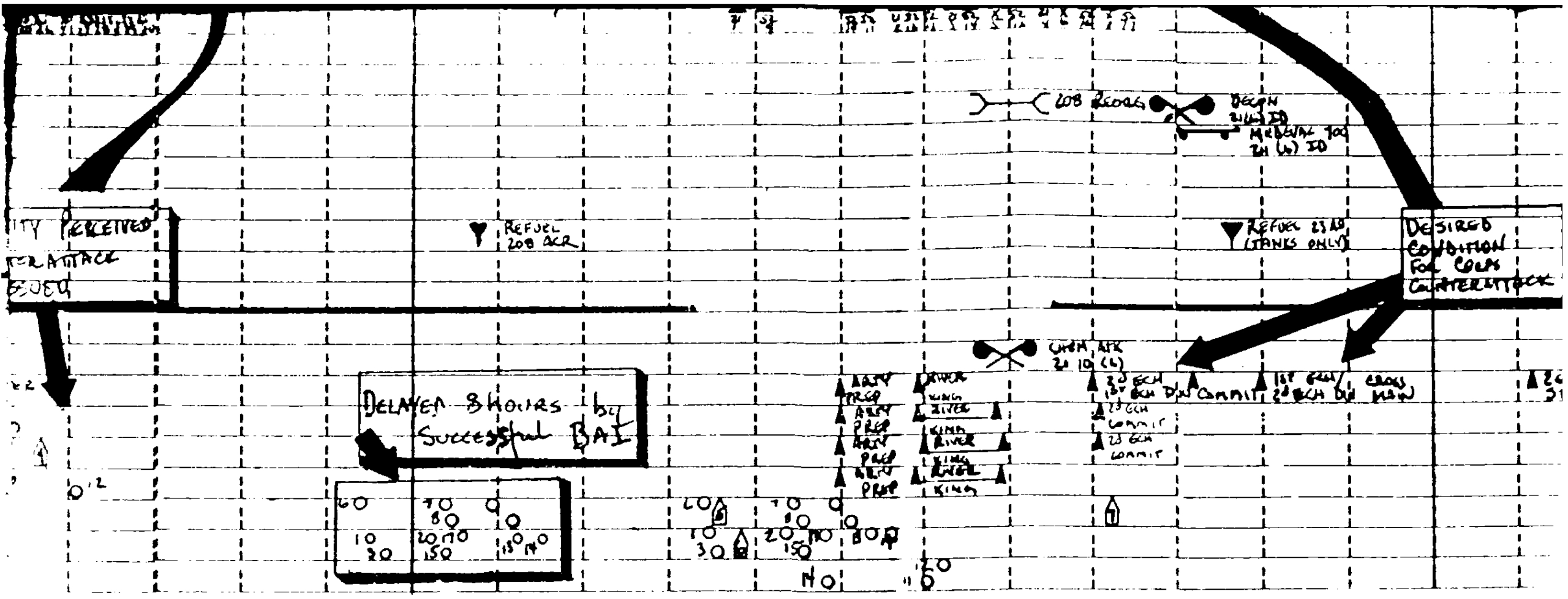
C>

Rate

NAI 1 AA 1 or 2 NAI 2 of March NAI 3 AA 1 or 2 NAI 4 AA 2 or 3 NAI 5 AA 3

NAI 6 AA 1 or 4 NAI 7 AA 1 or 4 NAI 8 AA 4 NAI 9 AA 4 NAI 10 AA 1 or 2

NAI 11 AA 2 or 3 NAI 12 AA 3 NAI 13 AA 3 NAI 14 AA 2 NAI 15 AA 3



REFUEL 20B ACR
REFUEL 23 AD (TANKS ONLY)
DESIRED CONDITION FOR CORPS COUNTERATTACK
DELAYED 8 HOURS by SUCCESSFUL BAI

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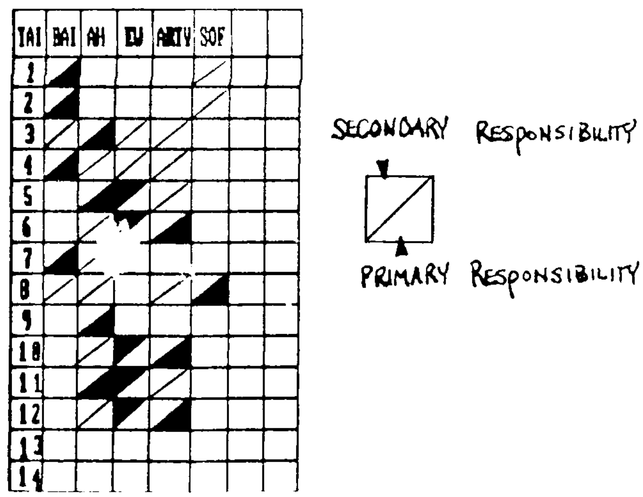

TAI
BAI
AH
EW
ARTY
SOF
1
2
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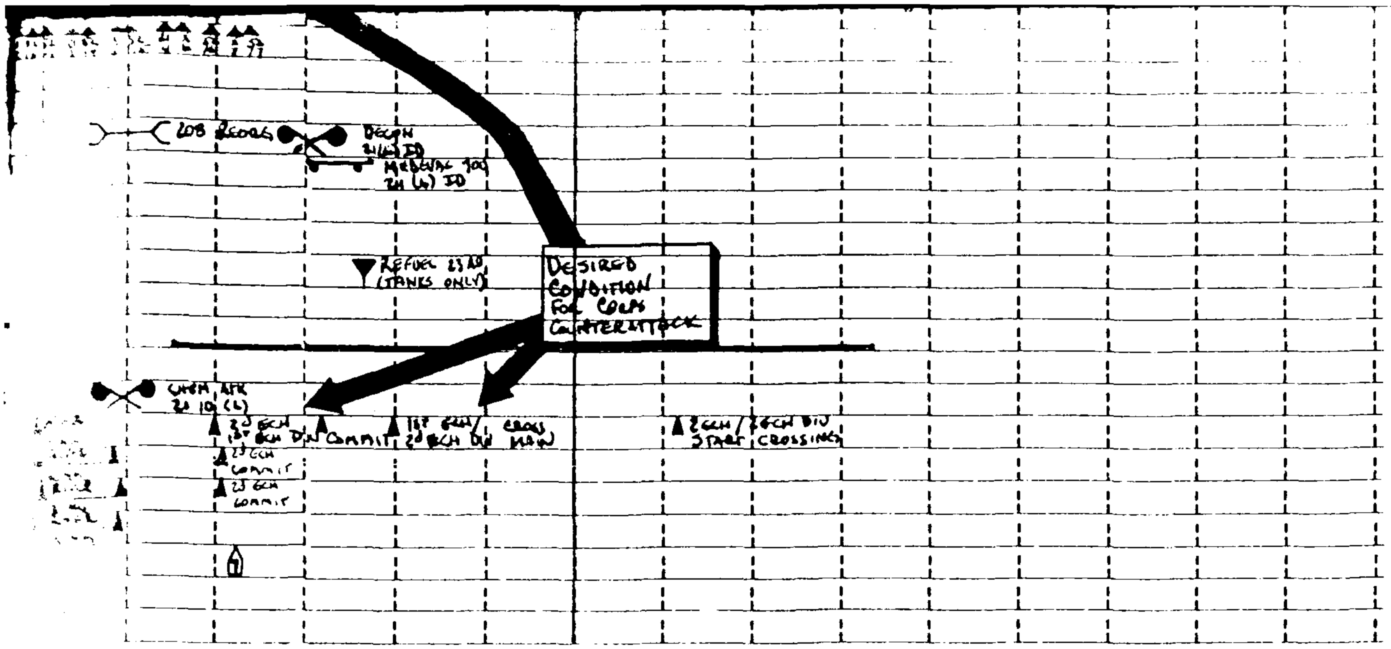
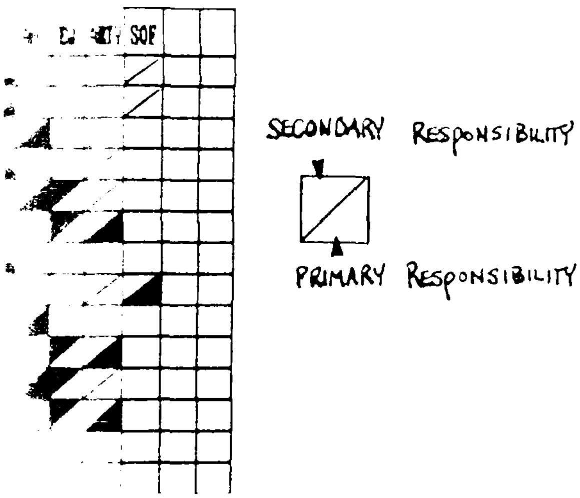
13
14
SECONDARY RESPONSIBILITY
PRIMARY RESPONSIBILITY



REFUEL 23 AD (TANKS ONLY)
DESIRED CONDITION FOR CORPS COUNTERATTACK
CHEM ATK
COMMIT
START CROSSINGS

D>

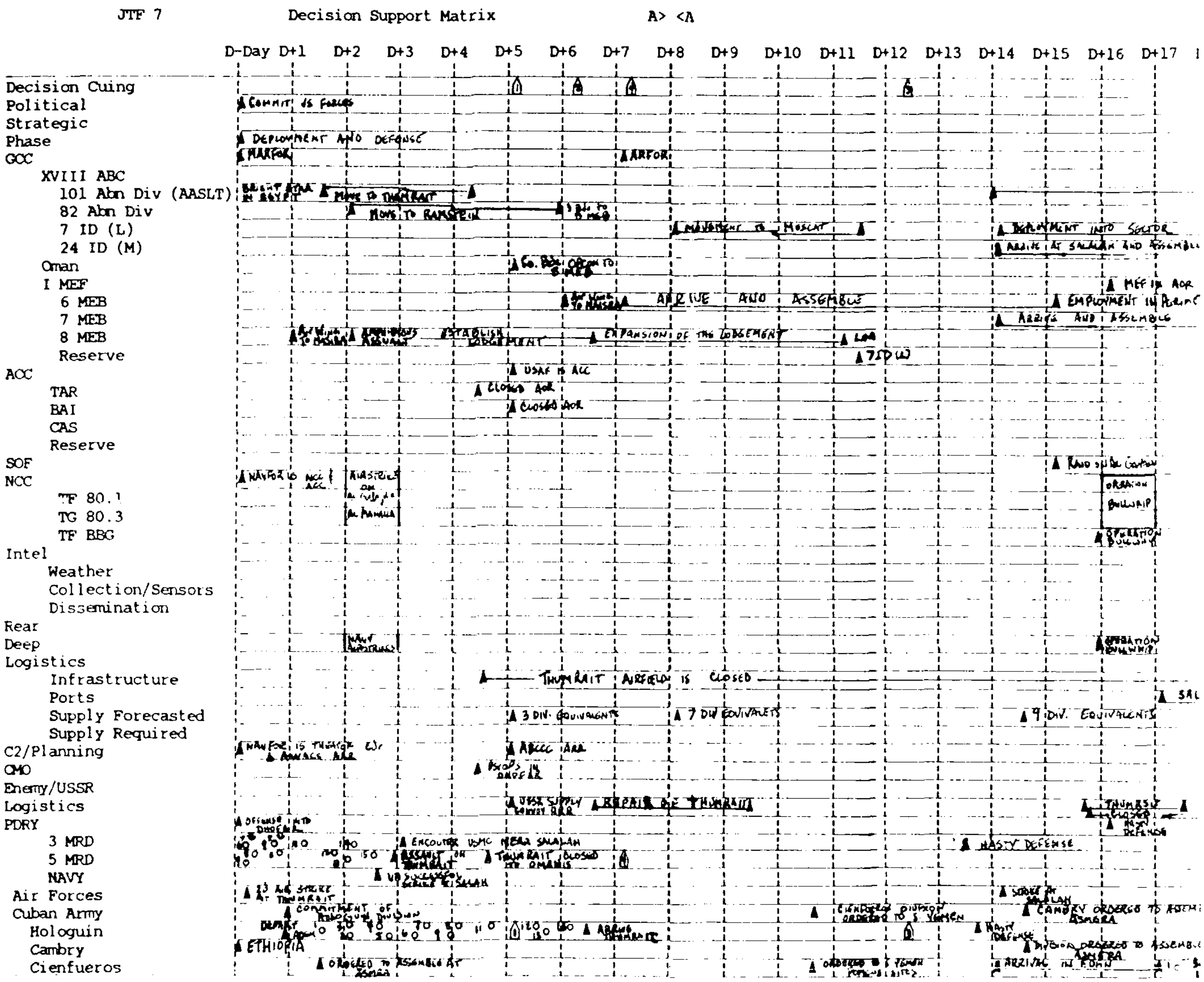
D>



SOF
SECONDARY RESPONSIBILITY
PRIMARY RESPONSIBILITY

APPENDIX B

Appendix B (Joint Exercise Decision Support Matrix)



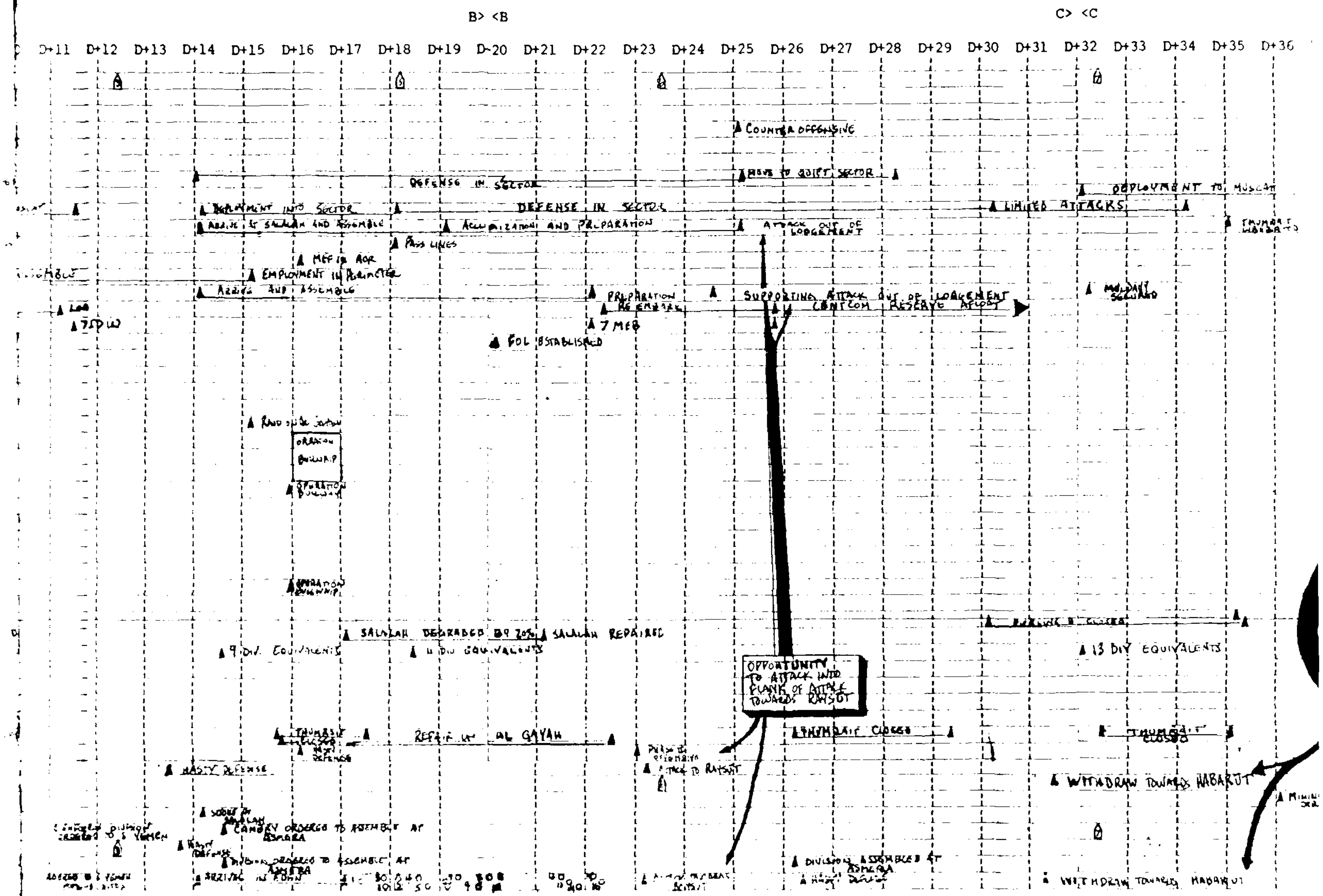
DP 01 Execute TAI01 DP 02 24th to Salalah DP 03 Execute TAI02 DP 04 7ID to Muscat DP 05 Execute TAI04
24th ID

DP 06 attack sect DP 07 ATK Axis Babarut

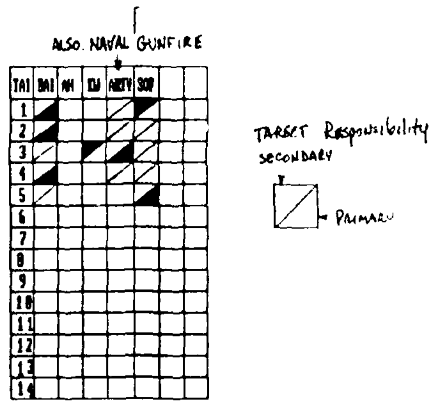
NAI 1 AA 1 or 2 NAI 2 AA 1 or

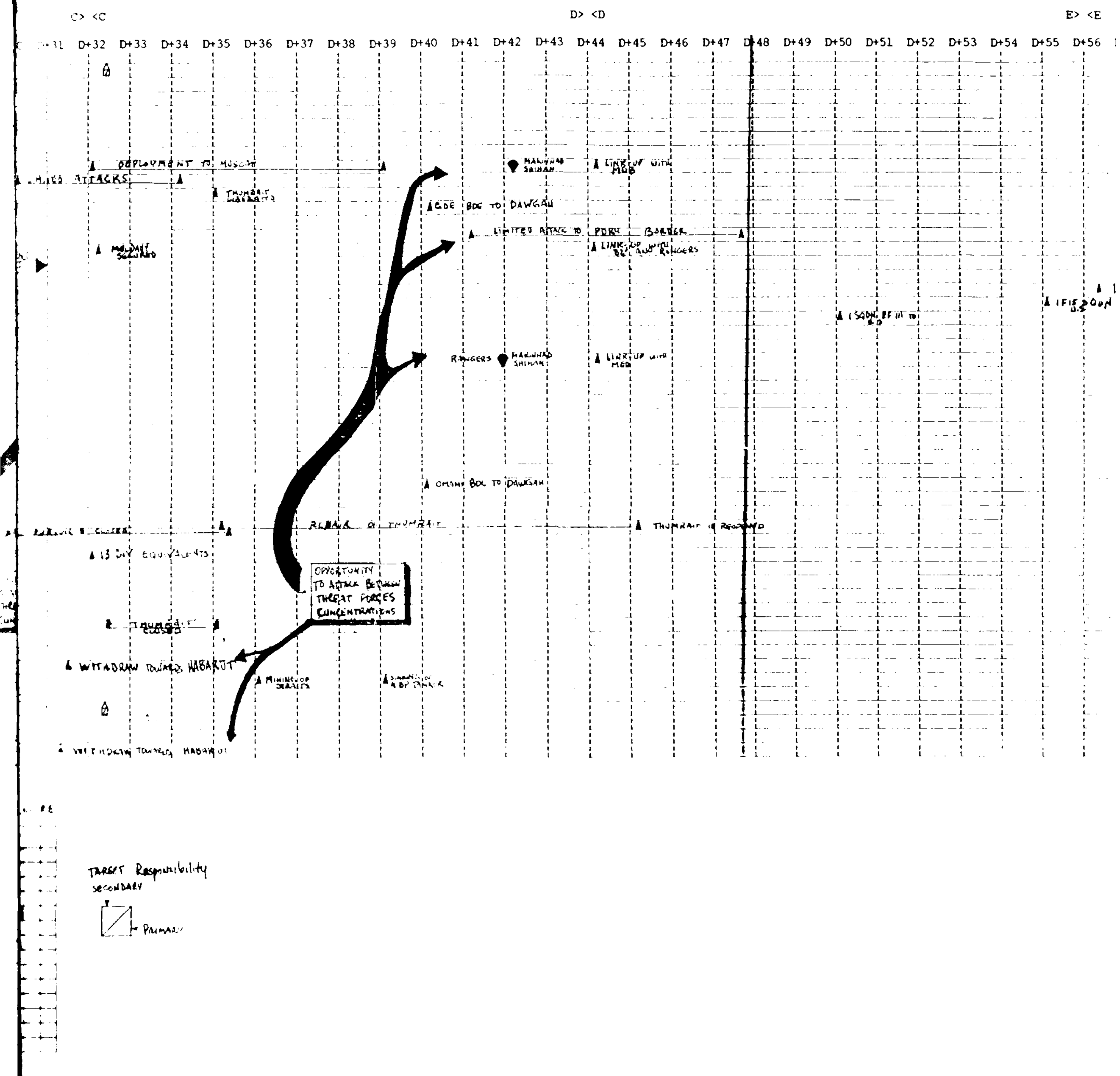
NAI 6 AA 1 or 2 NAI 7 AA 1 or

NAI 11 AA 2 or 3 NAI 12 of Ma

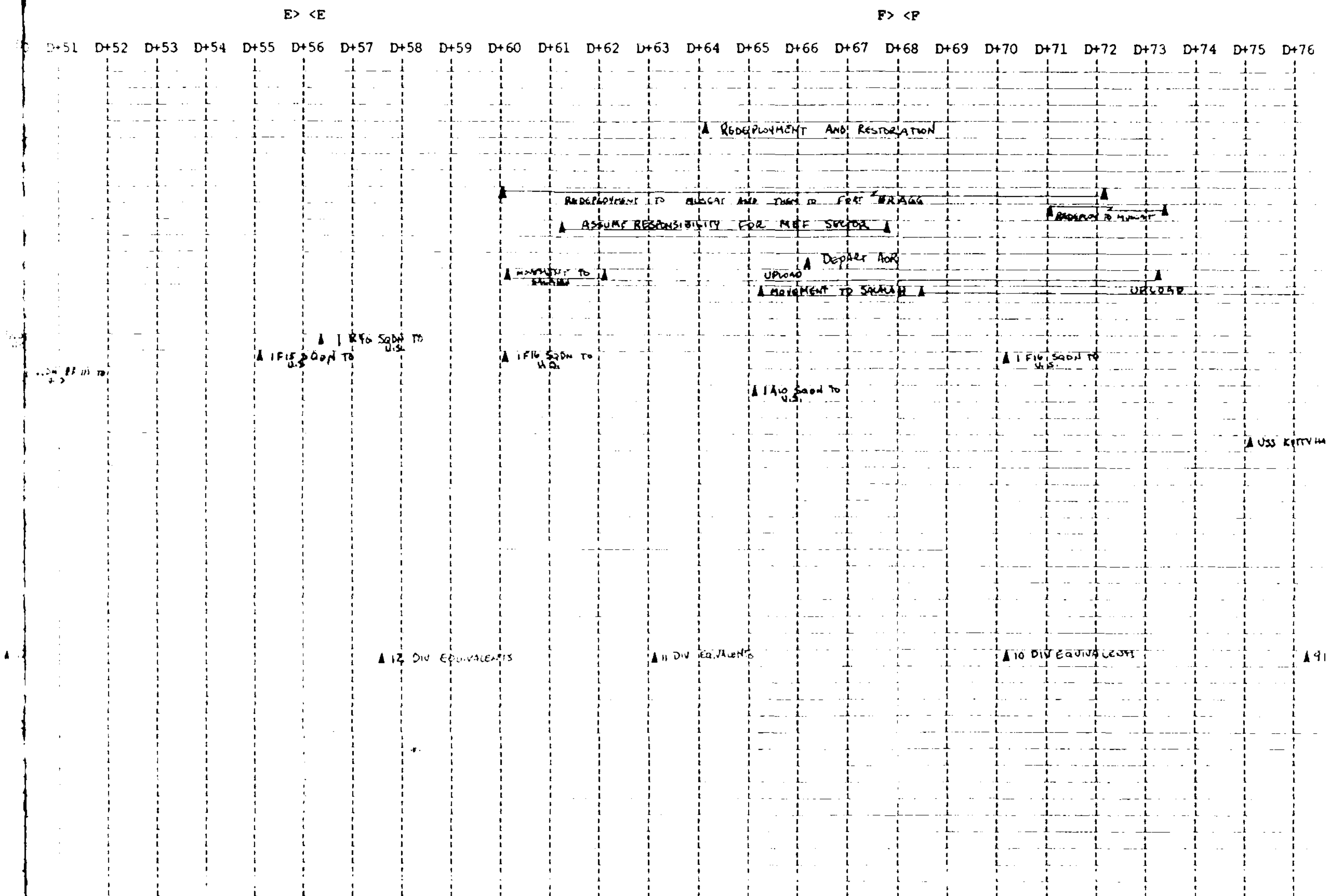


NAI 1 AA 1 or 2 NAI 2 AA 1 or 2 NAI 3 AA 2 or 1 NAI 4 AA 2 or 1 NAI 5 AA 1 Or 2
Rate
NAI 6 AA 1 or 2 NAI 7 AA 2 or 1 NAI 8 AA 2 or 1 NAI 9 AA 1 or 2 NAI 10 of March
Rate Rate Rate
NAI 11 AA 2 or 3 NAI 12 of March NAI 13 AA 3 or 1 NAI 14 of March NAI 15 of March

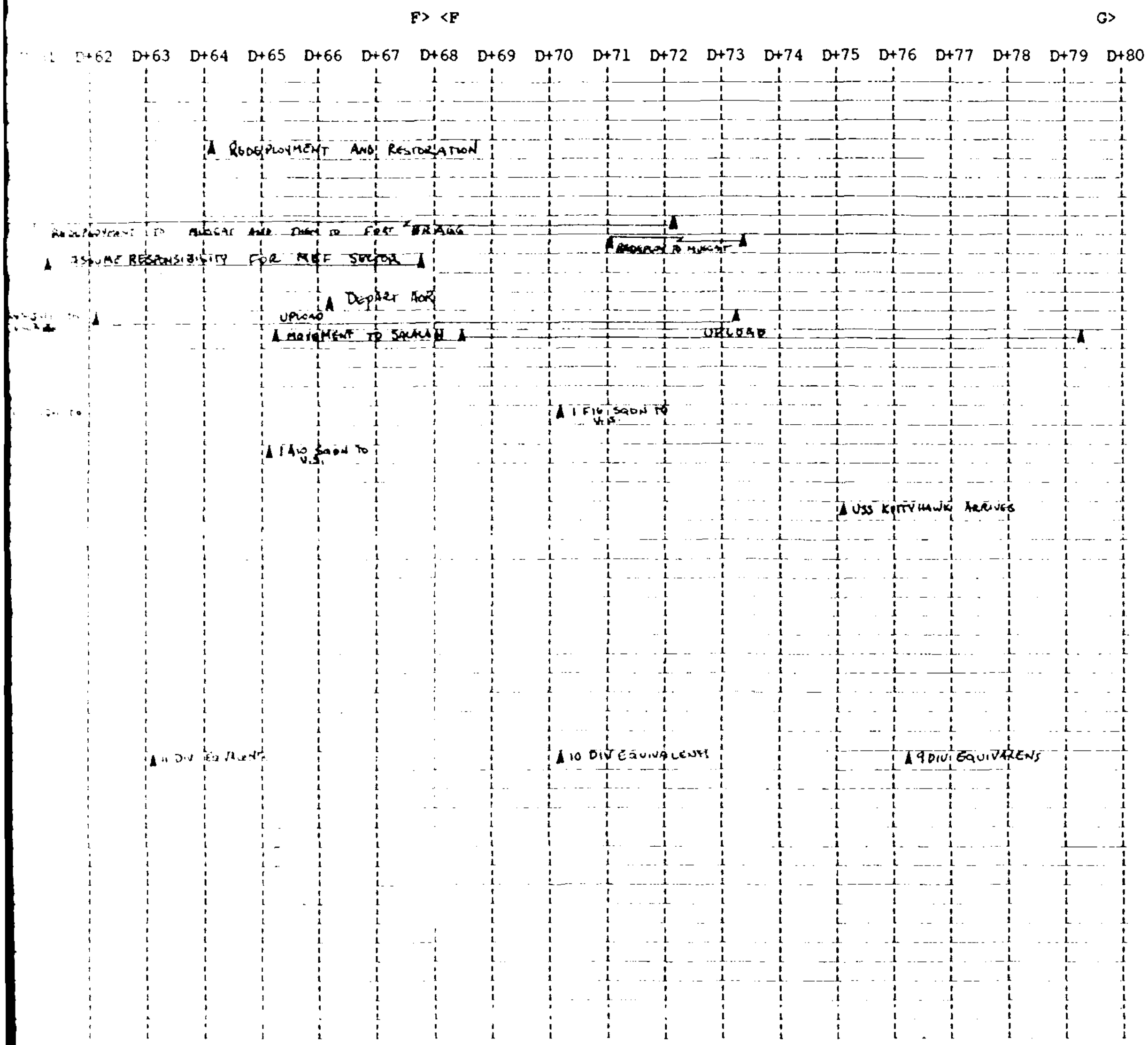




C> <C
D> <D
E> <E
D+32 D+33 D+34 D+35 D+36 D+37 D+38 D+39 D+40 D+41 D+42 D+43 D+44 D+45 D+46 D+47 D+48 D+49 D+50 D+51 D+52 D+53 D+54 D+55 D+56
DEPLOYMENT TO MUSCAT
ATTACKS
THUMRAIT
LINK UP WITH MBB
BDE BDE TO DAWGAH
LIMITED ATTACK TO PORT BORDER
LINK UP WITH BDE AND RANGERS
RANGERS
LINK UP WITH MBB
OMANI BDE TO DAWGAH
THUMRAIT IS RECAPTURED
13 DIV EQUIVALENTS
OPPORTUNITY TO ATTACK BETWEEN THREAT FORCES CONCENTRATIONS
THUMRAIT CLOSED
WITHDRAW TOWARD HABARUT
WITHDRAW TOWARD HABARUT
TARGET Responsibility
SECONDARY
PRIMARY



E> <E
F> <F
D+51 D+52 D+53 D+54 D+55 D+56 D+57 D+58 D+59 D+60 D+61 D+62 D+63 D+64 D+65 D+66 D+67 D+68 D+69 D+70 D+71 D+72 D+73 D+74 D+75 D+76
REDEPLOYMENT AND RESTORATION
ASSUME RESPONSIBILITY FOR MEF SECTOR
DEPART AOR
UPLOAD
MOVEMENT TO SAUDI
UPLOAD
1 F15 SQDN TO U.S.
1 F16 SQDN TO HQ.
1 F16 SQDN TO U.S.
1 A10 SQDN TO U.S.
USS KITTY HA
12 DIV EQUIVALENTS
11 DIV EQUIVALENTS
10 DIV EQUIVALENTS

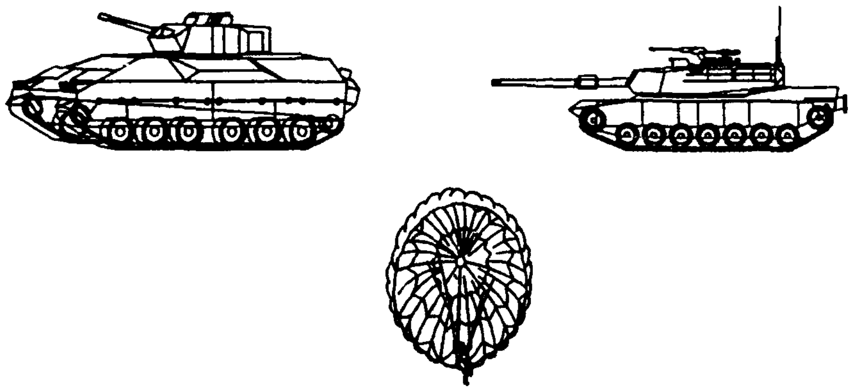


F> <F
G>
D+62 D+63 D+64 D+65 D+66 D+67 D+68 D+69 D+70 D+71 D+72 D+73 D+74 D+75 D+76 D+77 D+78 D+79 D+80
REDEPLOYMENT AND RESTORATION
DEPART FOR
UPLOAD
UNLOAD
USS KITTY HAWK ARRIVES
10 DIV EQUIVALENTS
9 DIV EQUIVALENTS

Appendix C (Decision Support System Handbook)

DECISION SUPPORT SYSTEM HANDBOOK

(Compiled by MAJ Patrick Becker)



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

Any comments or recommendations can be addressed to the Director School of Advanced Military Studies U.S. Army Command and General Staff College, Fort Leavenworth, Kansas 66027.

SECTION I - CONCEPT DEVELOPMENT

The DSS is a decision-making aid. The DSS should help the military decision-maker use data (reports) and modelling (wargaming) to solve unstructured problems (the environment of combat).[1] A DSS should be optimized to unstructured, problems for upper-level managers (commanders), through the use of analytical techniques, and are flexible and adaptable, and most importantly easy to use by computer illiterate users.[2]

The DSS architecture is independent of wargaming. However, wargaming is an essential aspect of the estimate process. Wargaming provides the specific data the is introduced into the DSS. One can deduce that the accuracy of the DSS is dependent on the quality of the wargaming (or other data introduced). Therefore, if you maintain a DSS at the tactical level, one would expect a tactical wargaming rationale. At the operational level one would hope to find operational wargaming rationale. Unfortunately, nothing has been found that was specifically labelled "operational wargaming", and tactical wargaming to date appears to be a product of a bottom-up analysis of the battle.

If cne agrees with Clausewitz's assessment that engagements, battles, and campaigns are interlinked, then a bottom-up

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1 Ralph H. Sprague, Jr. and Eric D. Carlson, Building Effective Decision Support Systems, (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1982), 4.

2 Ibid., 6.

calculation process may not be too unrealistic for worst case calculations. This form of calculation is an inherent aspect of most of the combat models that we use in our computer simulations replicating combat.

A problem with bottom-up calculation is that the results are the sum of the components and does not take into account the synergistic effect of the components that is commonplace in warfare. Because of this, the military artist must use his experience to place the appropriate emphasis on the results of the wargaming.

To provide some wargaming rationale to use to experiment with the DSS, I have included the factors in section II of this handbook. They represent the current rationale being taught or used by the source indicated in the credit line for that particular table. Admittedly, there is no specific rationale that is indicated as "operational level" rationale; however, much of what large unit formations do is "a sum of the components".

SECTION II - SYNCHRONIZATION INFORMATION

A. Unit Comparative Evaluation

Table B-1 US versus Soviet Combat Comparison Values
(source USAC&GSC ST 100-9, p. 3-3)

US (J-Series)		SOVIET				
M113 Bn	=1.5	BTR Bn	=1.0			
M2 Bn	=2.0	BMP Bn	=1.5			
		Tk Bn	ITR	TR	ITB	MRR
M1A1 Bn	=3.15	T-80	2.42	1.56	2.0	2.0
M1 Bn	=3.0	T-64	2.23	1.44	1.86	1.86
M60A3 Bn	=2.25	T-72	1.86	1.2	1.55	1.5
ACR Sqdn	=2.75	T-62	1.24	0.8	1.0	1.0
Div Cav Sqdn	=1.5	T-55	1.0	0.64	0.83	0.83
Div Cav Sqdn(H)	=2.0					
Aviation						
AHB (AH64)	=4.0	AHB	=1.0			
AHB (AH1S)	=3.0	AH Sqdn	=2.0			
Artillery						
FA Bn	=2.0	FA Bn	=2.0			
MLRS Btry	=2.0	MRL Btry	=1.0			

NOTES:

1. The above table is based on analysis of the units using the BTR battalion as the base unit. It allows for selection and comparison from both columns without regard to type of unit.
2. As a G3 or commander, you should develop your own table. The comparison of relative combat powers should be based on the current intelligence available and experience.
3. The number and quality of the major weapon systems in the units listed were used to arrive at the *subjective* values shown in the table.
4. Comparison values should be modified based on a type units available strength (e.g., an M2 Bn at 80% strength would have a comparative factor of 2.0 x 0.8 or 1.6).

Table 3-2 Historical Planning Ratios for the Army of Friendly Units
(source USAC&GSC ST 100-9, p. 3-5)

Friendly Mission	*Friendly: Enemy*	*Notes*
Delay	1:6	
Defend	1:3	Prepared or Fortified
Defend	1:2.5	Hasty
Attack	3:1	Prepared or Fortified
Attack	2.5:1	Hasty Position
Counterattack	1:1	Flank

B. Unit Movement Rates

Table B-3 Unopposed Rates of Movement
(source USAC&GSC ST 100-9, p. 4-19)

		Type of Force			
		Foot Infantry		Armored or Mechanized	
		Day	Night	Day	Night
Type	GO	4.0 khmp	3.2 khmp	24.0 khmp	24.0 khmp*
of	SLOW-GO	2.4 khmp	1.6 khmp	16.0 khmp	8.0 khmp**
Terrain	No-GO	1.0 khmp	0.1 to 0.5 khmp	1.0 khmp	0.1 to 0.5 khmp

NOTES: * With lights/passive.
** Blacked out

Table B-4 Unopposed Rates of Movement (Pure M1/M2)
(source USAC&GSC ST 100-9, p. 4-19)

Type Road March	Paved Road	Gravel Road	Tank Trail	Go Terrain
DAY	65 khmp	60 khmp	50 khmp	40 khmp
NIGHT (white headlights)	65 khmp	60 khmp	50 khmp	40 khmp
NIGHT (red headlights)	60 khmp	50 khmp	40 khmp	35 khmp

Table B-5 Brigades and Below Opposed Rates of Advance
(km/day*)
(source USAC&GSC ST 100-9, p. 4-20 [adapted from CACDA Jiffy III War Game, Vol II, Methodology])

Degree Resistance Attacker to Defender Ratio	Prepared Defenses*						Hasty Defense**					
	Go Terrain		Slow-Go Terrain		No-Go Terrain		Go Terrain		Slow-Go Terrain		No-Go Terrain	
	Arm/Mech	Inf	Arm/Mech	Inf	Arm/Mech	Inf	Arm/Mech	Inf	Arm/Mech	Inf	Arm/Mech	Inf
Intense Resistance 1:1	0.6	0.5	0.5	0.3	0.15	0.1	1.0	0.8	0.8	0.5	0.4	0.2
Very Heavy 2:1	0.9	0.6	0.6	0.4	0.3	0.2	1.5	1.0	1.0	0.7	0.6	0.3
Heavy 3:1	1.2	0.7	0.75	0.5	0.5	0.3	2.0	1.2	1.3	0.9	0.8	0.5

Degree Resistance Attacker to Defender Ratio	Prepared Defenses* Go Terrain Arm/Mech	Inf	Slow-Go Terrain Arm/Mech	Inf	No-Go Terrain Arm/Mech	Inf	Hasty Defense** Go Terrain Arm/Mech	Inf	Slow-Go Terrain Arm/Mech	Inf	No-Go Terrain Arm/Mech	Inf
Medium 4:1	1.4	0.8	1.0	0.6	0.5	0.5	2.4	1.4	1.75	1.1	0.9	0.8
Light 5:1	1.5	0.9	1.1	0.7	0.6	0.5	2.6	1.6	2.0	1.2	1.0	0.9
Negligible 6+:1	1.7+	1.0+	1.3+	0.8+	0.6+	0.6+	3.0+	1.7+	2.3+	1.3+	1.1+	1.0+

* Units can not sustain these rates for 24 hours. These rates are reduced by 1/2 at night.

The relative combat power ration must be computed for the unit under consideration.

When there is complete surprise, multiply these figures by the following surprise factors:

Complete surprise x 5 (e.g., Germans at Ardennes in 1944, Arabs in 1973).

Substantial surprise x 3 (e.g., German invasion of Russia in 1941, Israel's invasion of the Sinai in 1967).

Minor surprise x 1.3 (e.g., Allied Normandy landing in 1944, Pakistan's attack on India in 1971).

The effects of surprise last for three days, being reduced by 1/3 on day 2 and 2/3 on day 3.

Prepared defense is based on defender in prepared positions (24 hours or more).

Hasty defense is based on 2 to 12 hours preparation time.

The ratios used here are to determine the degree of resistance. There is no direct relationship between advance rates and force ratios. However, sustained advances probably are not possible without a 3:1 ratio. Advance is possible against superior forces but can not be sustained.

Rates greater than 6:1 will result in advances between these and the opposed rates.

Table B-6 Division Opposed Rates of Advance (kmpd)

(source USACGSC ST 100-9, p. 4-20 [Numbers, Predictions and War, T.N. Dupuy)

Degree Resistance Attacker to Defender Ratio	Prepared Defenses* Go Terrain Arm/Mech	Inf	Slow-Go Terrain Arm/Mech	Inf	No-Go Terrain Arm/Mech	Inf	Hasty Defense** Go Terrain Arm/Mech	Inf	Slow-Go Terrain Arm/Mech	Inf	No-Go Terrain Arm/Mech	Inf
Intense Resistance 1:1	2.0	2.0	1.0	1.0	0.6	0.6	4.0	4.0	2.0	2.0	1.2	1.2
Very Heavy 2:1	5-6	4.0	2-3	2.0	1.5-1.8	1.2	10-12	8.0	5-6	4.0	3.0-3.6	2.4
Heavy 3:1	7-8	5.0	3-4	2.5	2.1-2.4	1.5	13-16	10.0	8.0	5.0	3.9-4.8	3.0
Medium 4:1	8-10	6.0	4-5	3.0	2.4-3.0	1.8	16-20	12.0	10.0	6.0	4.8-6.0	3.6
Light 5:1	16-20	10.0	8-10	5.0	4.8-6.0	3.0	30-40	18.0	20.0	9.0	9.0-12.0	5.4
Negligible 6+:1	24-30	12.0	12-15	6.0	7.2-9.0	3.6	48-60	24.0	30.0	12.0	14.4-18.0	7.2

Time Distance Table
(source FC 17-102, p. C-21)

Speed Miles/ Kilometers per Hour	Rate of March Miles/Kilometers in the Hour	Minutes to Travel 1 Kilometer	Minutes to Travel 1 Mile
10 mph 16 kmph	8 mih 12 kmih	5	7.5
15 mph 24 kmph	12 mih 20 kmih	3	5
20 mph 32 kmph	16 mih 25 kmph	2.4	3.75
25 mph 40 kmph	20 mih 32 kmph	1.84	3
30 mph 48 kmph	25 mih 40 kmih	1.5	2.4
35 mph 56 kmph	30 mih 46 kmih	1.3	2
40 mph 65 kmph	33 mih 53 kmih	1.13	1.8

This table provides the time required to travel 1 kilometer or 1 mile while using specified march speeds. The travel times are calculated based upon movement rates of march (miles/kilometers in the hour) and include time for scheduled short halts and time lost due to road and traffic conditions. The time for long halts must be added to the total travel time. Multiply the total distance to be traveled (miles or kilometers) by travel time factor for 1 mile or 1 kilometer for the designated speed.

EXAMPLE: Determine TDIS for a column traveling 310 kilometers at a speed of 24 kmph. Multiply 310 (km) x 3 (min) = 930 minutes. Convert 930 minutes to 15 hours and 30 minutes.

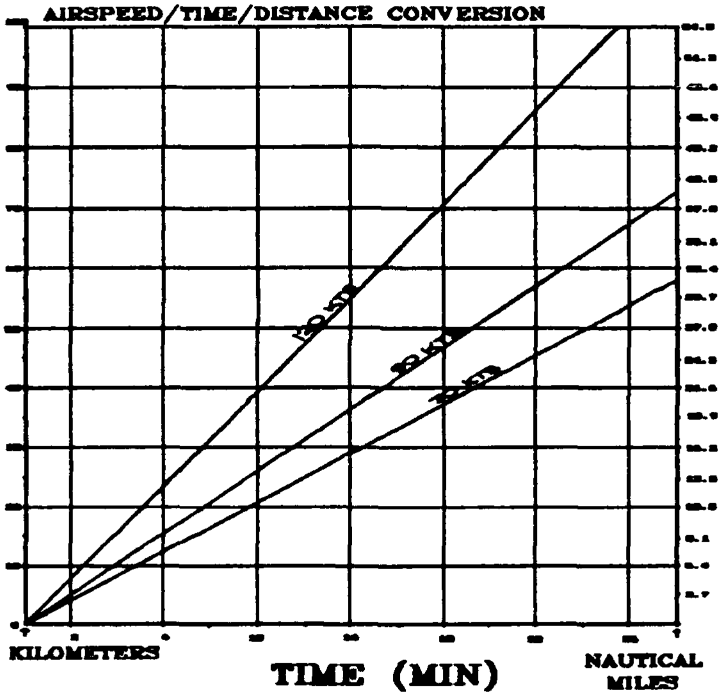
NOTE: Fractional parts of an hour are converted to minutes by multiplying the fraction by 60 and rounding off to the next higher minute.

Miscellaneous Movement Rates
(source Singapore Warfare School [in Kmph])

Terrain Factor	Foot non-Tactical	Foot Tactical	Wheeled non-Tactical	Wheeled Tactical	Heavy Truck	Light Truck
Basic Rate X-Country (tracks/trails)	3	2	15	10	12	15
X-Country (shrubs\veg)	3	1.5			0.8	0.5
Swamp or Marsh	1	0.5				
Primary Jungle	2	0.5				
Secondary Jungle	0.75	0.25				
Slopes:						
20-30%	2	1	10	5		
> 30%	0.5	0.25				
Fordable Water Waste deep-50m	5 Minutes	10 Minutes	5 Minutes			

Terrain Factor	Foot non-Tactical	Foot Tactical	Wheeled non-Tactical	Wheeled Tactical	Heavy Truck	Light Truck
Built-up Area On Roads	4	1	25	10	10	10
Rubbled Area	1	0.5	0.5	0.2	2	1
Plantation	3	1.5	15	10	12	1
Roads, Surfaced	4	2	35	15	15	15

AIRSPEED/TIME/DISTANCE CONVERSION
(101st Airborne Division (Air Assault) Aviation Liaison Officer's Guide)



SOVIET ROAD MOVEMENT NORMS (Time norms only)
(source Soviet Army Studies Paper)

1. For road movement, schedule a one hour break for every three hours of driving for marches of 18 hours or less. For marches of over 18 hours, include an additional four hour break every 24 hours.
2. Time for a Column of Route to Move Up to the Line of Departure (SP).

$$tn = T - \frac{Di \times 60}{Vv}$$

tn = time for starting movement of the column of route in hours and minutes.
T = time for crossing the SP by lead column of route in hours and minutes.
Di = distance of the SP from troop position in kilometers.

60 = coefficient for converting hours to minutes.
Vr = rate of movement of a column of route drawing up in kmph.

3. Vehicle Movement Speeds:

Road Conditions	Day	Night
Wheeled Vehicles (except tank transporters)		
All weather, hard surface	35	22
All weather, loose or light surface	30	17
Fair weather, loose surface	25	15
Tracks, trails	15	10
Tracked Vehicles and Tank Transporters:		
All weather, hard surface	27	20
All weather, loose or light surface	23	15
Fair weather, loose surface	15	10
Tracks, trails	15	10

SOVIET RAIL MOVEMENT NORMS (Time norms only)
(source Soviet Army Studies Paper)

1. Loading/unloading capability: each loading/unloading site has the following capability:

Fixed loading/unloading points	Number	Time to Load/Unload
Fixed	2	2 hrs
Expedient	2	3 hrs

2. Soviet trains transiting the border transloading zone by rail require 3 hrs per 40 car train.
3. Entrain/Detrain time for tracked vehicles of units:
   a. By type unit (includes staging time):

TR, TD	7 hrs
TR, MRD	6 hrs
BMP Regt	5 hrs
BTR Regt	3 hrs
Arty Regt, MRD/TD	4 hrs
Other Division assets, MRD/TD (SAM Regt, Recce Bn, Engr Bn)	4 hrs

   b. By train: 2 hrs
4. Train Data (normally an engine and 40 four axle cars).
   a. Normal train interval is 20 min.
   b. Train Speeds:

	Diesel	Steam
Single track	35 kmph	25 kmph
Double track	45 kmph	35 kmph

5. Time for transporting units by rail:

$$T = \frac{D}{V} + \frac{N-1}{n} \times 24 + \frac{D1}{V1} + \frac{D2}{V2} + TL + Tu + To$$

T = time for transporting troops by rail in hours.
D = length of railroad route in kilometers.

V = average daily rate of movement of the trains in kmpd.
N = number of waves being transported. A wave is one cycle of movement assets by type.
n = rate of transport (based on the loading conditions and the characteristics of the railroad route) in trains per day.
24 = factor for converting days to hours.
D1 = distance from the starting area to the loading area in kilometers.
V1 = average rate of movement to the loading area in kmph.
TL = loading time.
D2 = distance from the unloading area to the new concentration area in kilometers.
V2 = average rate of movement to the new area in kmph.
Tu = unloading time.
To = time for organizing transport in hours. [army = 4hrs, division = 3 hrs].

FORM FOR CALCULATING THE LENGTH OF ROUTES AND THE AVERAGE RATE AND TIME FOR MOVEMENT OF COLUMNS OF ROUTES
(source Soviet Army Studies Paper)

	Starting data, Fixed Values Operations	Measure (accuracy)	Route 1	2	3	4	5	6	Remarks
1	Length of all weather, hard surfaced roads	km (1.0)							
2	Speed of movement on (1)	k/h (1.0)							
3	Length of all-weather, loose or light surfaced roads	km (1.0)							
4	Speed of movement on (3)	k/h (1.0)							
5	Length of fair weather, loose or	km (1.0)							
6	Speed of movement on (5)	k/h (1.0)							
7	Length of trail and track	km (1.0)							
8	Speed of movement on (7)	k/m (1.0)							
9	Length of moving column	km (1.0)							
10	Depth of new assembly area	km (1.0)							
11	Overall time for halts and stops	km (1.0)							
12	Length of march route	km (1.0)							
	(1)+(3)+(5)+(7)	km (1.0)							
13	(1) : (3)	(0.1)							
14	(3) : (4)	(0.1)							
15	(5) : (6)	(0.1)							
16	(7) : (8)	(0.1)							
17	Time of movement: (13)+(14)+(15)+(16)	h(0.1)							
18	Average Speed: (12) : (17)	k/h (1.0)							
19	(9)-(10) if (9)>(10)	(0.1)							
20	Time of movement to new assembly area: (19):.6:(18)	h(0.1)							
21	Duration of transit: (11)+(17)+(20)	h(0.1)							

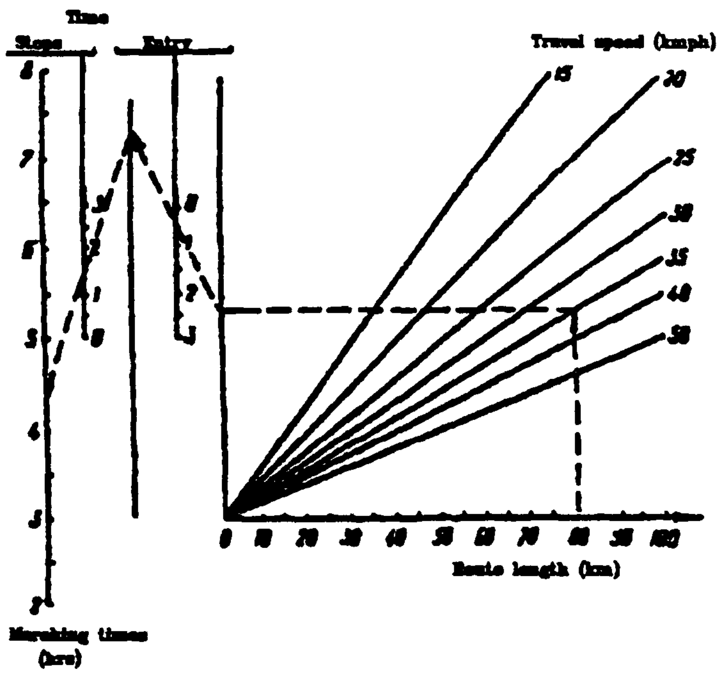
FORM FOR CALCULATING THE TIME FOR TRANSPORTING UNITS BY RAILS
(source Soviet Army Studies Paper)

	Starting data, Fixed Values Operations	Measure (accuracy)	Route 1	2	3	4	5	6	Remarks
1	Length of rail route	km (10)							
2	Avg speed in 24 hour period	km/24 hr (10)							
3	Number of trains, minus one: (N+1)	unit(1.0)							
4	Transportation rate: (trains per 24 hr period)	unit(1.0)							
5	Distance from assembly area to loading area	km (1.0)							
6	Average speed of movement to loading area	k/h (1.0)							
7	Time required to load train	hr(0.1)							
8	Distance of new assembly area	km(1.0)							
9	Average speed of movement to new assembly area	k/h (1.0)							
10	Time required to unload train	hr(0.1)							
11	Time for organizing transportation	hrs(1.0)							
12	(1) : (2)	(0.01)							
13	(3) : (4)	(0.01)							
14	(12)+(13)	(0.01)							
15	(14)x 24 hrs	(1.0)							
16	(5) : (6)	(0.1)							
17	(8) : (9)	(0.1)							
18	Time of transporting troops by rail: (17)+(10)+(15)+(16)+(11)+(7)	hrs(0.1)							
19	Time for transportation: (18) : 24 hrs	24 hr periods(0.1)							

SOVIET TACTICAL CALCULATIONS

The following nomograph are extracted from a book Tactical Calculations, second edition, revised and supplemented, published in Moscow by Voyennoye Izdatel'stvo in 1982. The book is designed to acquaint commander's and staff with techniques for tactical calculations (both with computers and without). The book states that the "battle for time gains the primary task."

March Duration This calculation is used for determining the time required for the advancement of subunits from one region to another.



NOMOGRAM FOR CALCULATING MARCHING TIME
(source Tactical Calculations, 2nd edition)

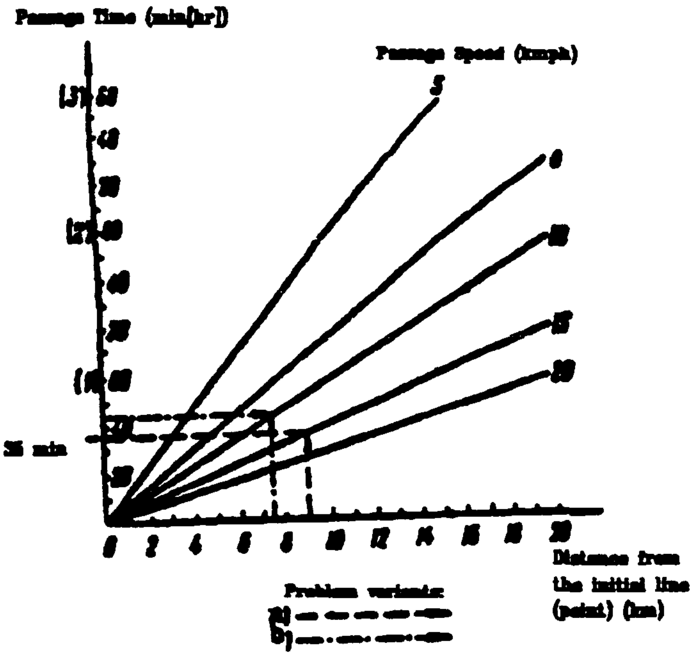
EXAMPLE: The marching time along an 80 km long route must be calculated when the average travel is 35 kmph, the length of the stops and the entry are 1 hr and 30 min and 30 min respectively.

Using the Nomogram: From the "80" mark on the "route length" scale, draw a perpendicular line to the intersection with the "35" speed line. Draw a horizontal line from the obtained point to the intersection with the unnamed scale. On the "entry time" scale find the mark which corresponds to 0.5 hr (30 min), and draw a line through this mark and the point on the unnamed scale to the intersection with the second unnamed scale. Having connected the obtained point with the "1.5" mark on the "stop length" scale, and having extended the line, find the answer - 4.3 hrs (4 hrs and 20 min) on the "marching time" scale.

Using the Formula: $t = D/V + t_s + t_e$ where t is the marching time in hours, D is the route length in kilometers; V is the average travel speed of the route columns in kilometers per hour; t_s is the total stopping time during the travel in hours and t_e is the time it takes to pull into the new concentration area in hours. For an example where the length of the route is 140 km, the average travel speed of a route column is 35 kmph, the stopping time is 1 hour and the time it takes to enter the new concentration area is 30 minutes. Solution $t = 140/35 + 1 + 0.5 = 4 + 1 + 0.5 = 5.5$ Hours or 5 hr. 30 min.

Using this particular nomogram, it is possible to determine the required travel speed when the marching time, the lengths of the stops and entry are assigned and the lengths of the stops, the enroute delays at the assigned marching time, the entry time and the travel speed are permissible.

Entry Time of a Route Column to the Initial Point This calculation is used to determine the time for the start travel of route columns so that they simultaneously arrive at an established time and pass a designated initial line (point).



NOMOGRAM FOR CALCULATING THE PASSAGE TIME OF ROUTE COLUMNS TO AN INITIAL LINE (POINT)
(source Tactical Calculations, 2nd edition)

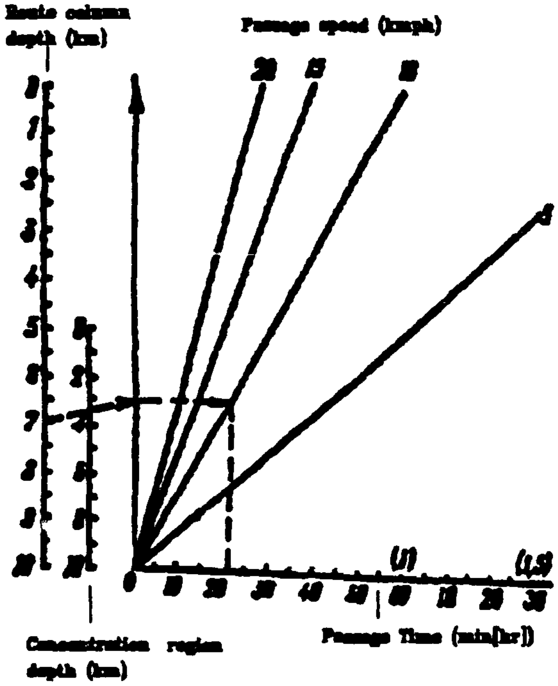
EXAMPLE: To determine the time for the onset of passage of a route column when the time for passage of the initial point by the head of the route column is 21:00 6.8, the distance of the initial point is 9 km, the column travel speed with passage is 15 kmph.

Using the Nomogram: Draw a vertical line from the "9" mark (variant a) on the "Distance to initial line (point)" scale to the intersection with the "Passage speed 15" line, from the point of intersection, we draw a horizontal line to the "Passage time" line and find the answer - 36 minutes. Consequently, the time for the beginning of the route column travel is 20:24 6.8.

Another capability is to use the nomogram to calculate the required travel speed for the on-time break out to the initial line (point), if the distance to the line (point) and the time remaining to its passage are known.
To determine the travel speed with passage of a route column, when the distance to the initial line is 7.5 km, the time for passage of the line by the head of the column is 21:45, the real time is 21:00, (i.e., 45 min remain to the moment of passage of the initial line by the head of the column (variant b). We draw a horizontal line from the "45" mark on the "Passage time" scale to the intersection with a perpendicular established from the "7.5" mark on the "Distance to the initial line (point)" scale; they intersect at the "Passage speed - 10" line; this means that the travel speed with passage by the route column must be at least 10 kmph.

Using the Formula: $t_b = T - ((D_i)(60)/(V_p))$ where t_b is the travel start time of the route column, in hours and minutes; T is the time of passage of the assigned point by the head of the route column, in hours and minutes; D_i is the distance of the initial point from the force location region, in kilometers; 60 is the factor for converting hours into minutes; and V_p is the travel speed of the route column with passage in kilometers per hour. For example, to determine the time for the onset of passage of a route column when the time for passage of the initial point by the head of the column is 21:00 6.8, the distance of the initial point is 9 km, the column travel speed with passage is 15 kmph. Solution t_b = 21:00 - 0.36 = 20:24, (i.e., for timely passage of the assigned point, the column must begin travel at 20:24, 6.8.

Passage Time of a Route Column into a Concentration Region. This calculation is used to determine the passage time of a route column into a new concentration region if it is determined when the depth of this region is less than the depth of the route order.



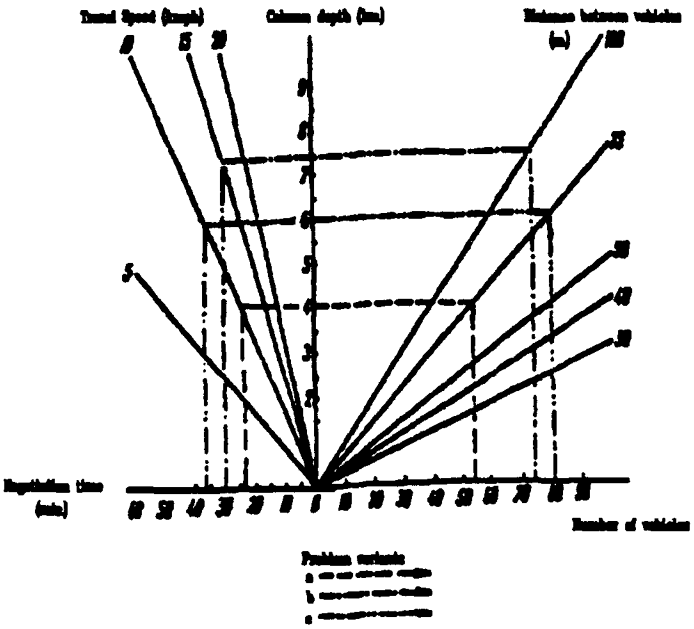
NOMOGRAM FOR CALCULATING THE PASSAGE TIME OF ROUTE COLUMNS INTO A CONCENTRATION REGION
(source Tactical Calculations, 2nd edition)

EXAMPLE: To determine the length of passage of a route column into a concentration region when the depth of the column is 7 km, the depth of the concentration region is 3.5 km, and the travel speed of the column upon passage is 10 kpmh.

Using the Nomogram: Draw a line through the "7" mark on the "Route column depth" scale and the "3.5" mark on the "Concentration region depth" scale until intersection with the unnamed scale. From the point of intersection, draw a horizontal line to the intersection with the "Passage speed-10" line, from the obtained point drop a perpendicular line and on the "Passage time" scale, read the calculation result - 21 minutes.

Using the Formula: $t_{pl} = (D_c - D_r)/V_p$ X 60 where t_{pl} is the passage length of the route column into the concentration area, in minutes; D_c is the depth of the route column in kilometers; D_r is the depth of the concentration region in kilometers; V_p is the travel speed of the route column with passage in kmph; and 60 is the factor for converting hours into minutes. For example, to determine the length of passage of a route column into a concentration region when the depth of the column is 7 km, the depth of the concentration region is 3.5 km, and the travel speed of the column upon passage is 10 kmph. Solution $t_{pl} = (7 - 3.5)/(10)(60) = 0.35$ X 60 = 21 minutes.

Time for Negotiating Bottlenecks and Almost Impassable Route Sections. There are two types of sections which must be negotiated: small ones, whose depth is significantly less than the depth of the route column (e.g., a bridge, grade, or turn in the route), and large ones, whose length is equal or greater than the depth of the route column (e.g., a mountain pass, swamp area, etc.).



NOMOGRAM FOR CALCULATING THE TIME IT TAKES TO NEGOTIATE BOTTLENECKS ON TRAVEL ROUTES
(source Tactical Calculations, 2nd edition)

EXAMPLE:

a. To determine the time it takes to negotiate a steep decline (incline) by a column of 54 vehicles when the distances between the vehicles are 75 meters and the permissible travel speed in the section is 10 kilometers per hour.

Using the Nomogram: From the "54" mark (variant a) on the "Number of vehicles scale, we establish a perpendicular to the intersection with the "Distance between vehicles - 75" line. From this point, we draw a horizontal line to the intersection with the "Travel speed - 10" line. From the obtained point, we drop a perpendicular to the "Negotiation time" scale, where we read the calculation result - 24 minutes.

b. To determine how many vehicles may pass through the obstacle on the route in 30 minutes when the permissible travel speed is no more than 15 kmph and the distance between the vehicles is 100 meters.

Using the Nomogram: Establish a perpendicular line from the "30" mark on the "Negotiation Time" scale to the intersection with the "Travel Speed - 15" line, from the obtained point we draw a horizontal line to the intersection with the "Distance between vehicles - 10" line and drop a perpendicular line to the "Number of Vehicles" scale, where we find the answer - 75 vehicles.

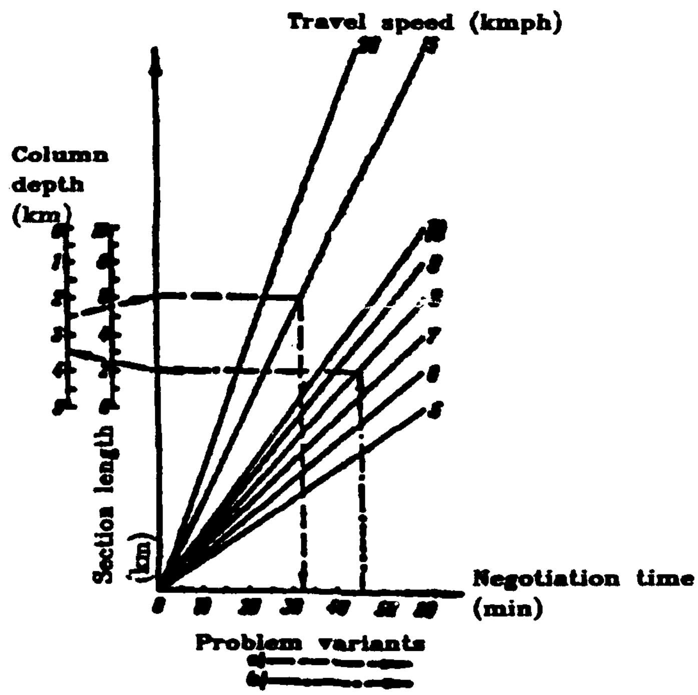
c. You can also calculate the distance between vehicles in a column which consists of 80 vehicles in order for the column to cross a bridge in 36 minutes with a permissible travel speed of no more than 10 kmph.

Using the Nomogram: From the "80" mark on the "Number of vehicles" scale, we establish a perpendicular. Then, establish the perpendicular line from the "36" mark on the "Negotiation Time" scale and continue it to the intersection with the "Travel Speed - 10". From the obtained point we draw a horizontal line to the intersection with the first perpendicular time. the point of intersection is found on the "Distance Between Vehicles - 75" line. This means that the distance between the vehicles must be no more than 75 meters.

Using the Formula: $t = ((N_m)(d_m)(0.06))/V$, where t is time it takes to negotiate the obstacle, in minutes; N_m is the number of vehicles in the column; d_m is the distance between the vehicles in the column, in meters; 0,06 is the factor for converting kmph to meters per minute; and V is the travel speed of the vehicles in the section being negotiated, in kmph. For example, to determine the time it takes to negotiate a steep decline by a column of 54 vehicles when the distance between the vehicles are 75 m and the permissible speed is 10 kmph. Solution: t = ((54)(75)(0.06))/10 = 24 Min.

<u>Time for Negotiating Bottlenecks and Almost Impassable Route Sections</u>

This nomograph calculates the time required to negotiate small and large bottlenecks.



NOMOGRAM FOR CALCULATING THE TIME IT TAKES TO NEGOTIATE NEARLY IMPASSABLE SECTIONS ON TRAVEL ROUTES

(source <u>Tactical Calculations</u>, 2nd edition)

EXAMPLE: For calculating time for larger obstacles, this is a more appropriate monogram.

a. To determine the time required to negotiate a marshy section of a road if the section is 5.5 kilometers, the column depth is 2.5 kilometers, and the average travel speed on the section is 15 kmph.

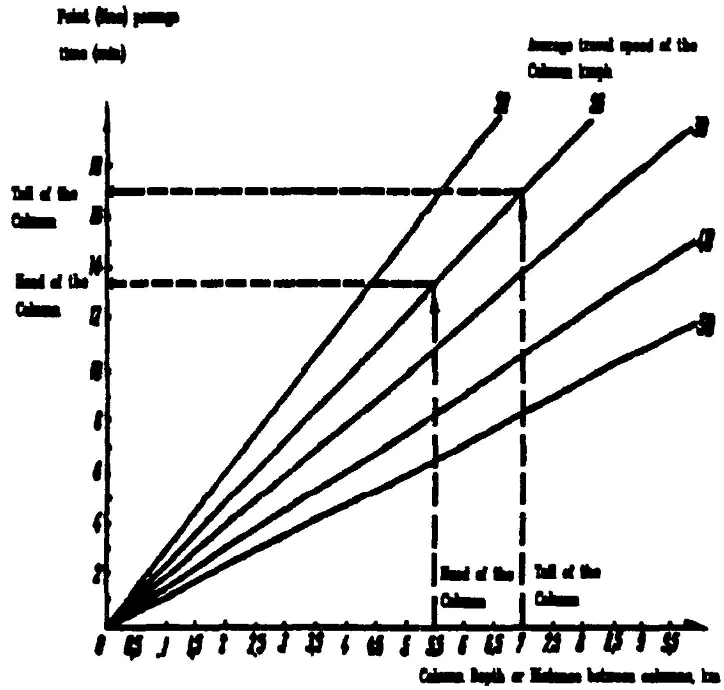
Using the Nomogram: Make appropriate marks (variant A) on the "Column Depth" scale ("2.5") and the "Section Length" scale ('5.5") and draw a line through them to the intersection with the unnamed scale. From the point of intersection, we draw a horizontal line to the "Travel Speed - 15" line and dropping a perpendicular line from the obtained point to the "Negotiation Time" scale, we find the answer to be - 32 minutes.

b. To determine how deep a column may go through a pass of 2.5 kilometers in length at a travel speed of 8 kmph.

Using the Nomogram: From the "45" mark on the "Negotiation Time" scale, we establish a perpendicular line to the intersection with the "Travel Speed - 8" line. From the obtained point, we draw a horizontal line to the unnamed scale; we connect the obtained point with the "2.5" point on the "Section Length" scale and continue the line to the intersection with the "Column Depth" scale, where we read the calculation result - 3.5 kilometers. This means that a column with a depth of 3.5 kilometers may negotiate the pass in the cited time.

Using the Formula: $t = (D_c + D)/V$, where T is the takes to clear the obstacle, in hours; D_c is the depth of the route column, in kilometers; D is the length of the section being negotiated in kilometers, and V is the travel speed of the route column through the obstacle in kmph.

Time for passage of an Initial Point and a Point for Adjusting the Head and Tail of a Route Column. This is a useful calculation useful in the construction of the route formation, the depth of the route columns and the established distances between them, the travel speed, and the time for passing a particular point by the head of the route formation.



NOMOGRAM FOR CALCULATING THE PASSAGE TIME OF A LINE (POINT) BY THE HEAD AND TAIL OF A ROUTE COLUMN
(source Tactical Calculations, 2nd edition)

EXAMPLE: To determine the passage time by the head and tail of a route column 7 kilometers deep with the condition that the line passage time by the tail of the forward column is 20:00, the distance between the columns is 5.5 kilometers and the travel speed is 25 kmph.

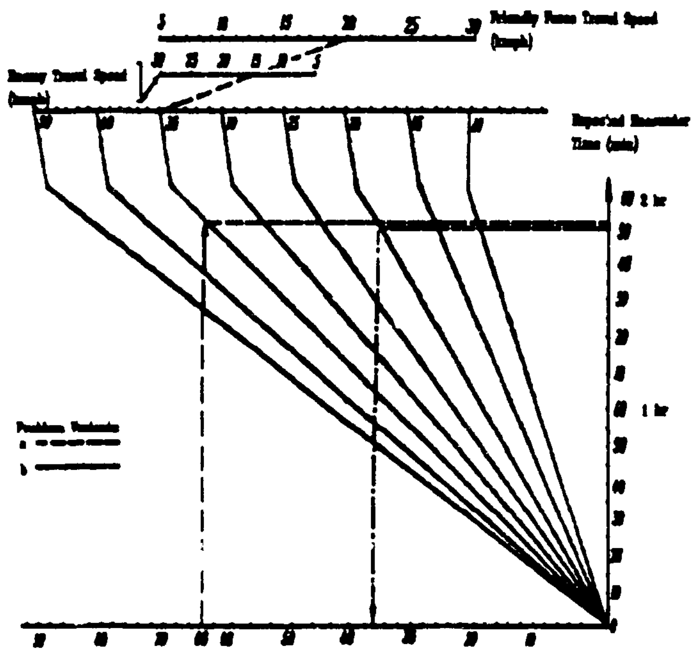
Using the Nomogram: Establish a perpendicular line on the "Column depth or distance between columns" scale to the intersection with the "Mean travel speed of the column - 25" line. From that point of intersection, we draw a horizontal line to the "Point passage time" scale and read the result, 13.3 or approximately 13 minutes. This is the time in which the head of the particular column must pass the point after it is passed by the previous column (at 20:00).

To determine the time of passage of a point by the tail of a particular column is solved in a similar manner. For this purpose, establish a perpendicular line from the "7" mark on the "Column depth or distance between columns" scale to the intersection with the "Average travel speed of the column - 25" line. From the point of intersection, draw a horizontal line to the "Point passage time" scale and read the result - 17 minutes. This means that this particular column must pass the cited point with its tail at 20:30 (20:13 + 0:17).

Using the Formula: $t_i = T_{i-1} + ((d_i)(60))/V$ and $t'_i = t_i + ((D_i)(60))/V$ where t_i is the passage time of the line by the head of the i route column, in hours and minutes; T_{i-1} is the time for passing the line by the tail of the lead route column, in hours and minutes; for the head (the first in the route formation) column, this time is the time specified for passing the point by the head of the entire route formation, (e.g., by the column of the lead forces on a route); d_i is the established distance between the lead and the i route columns, in kilometers; 60 is the factor for converting hours to minutes; V is the average travel speed in kmph; t'_i

is the time for passing the point by the tail of the i route column in hours and minutes; and D_i is the depth of the i column, in kilometers. For example, to determine the passage time of a point by the number 1 head and tail of a third column, when the passage time of the cited point by the tail of the previous column is 21:15, the established distance between the columns is 1.5 kilometers, the depth of the column is 1.8 kilometers and the travel speed is 25 kmph. SOLUTION: $T_3 = 21{:}15 + ((1.5)(60))/25 = 21{:}15 + 0.04 = 21{:}19$; $t_3 = 21{:}19 + ((1.8)(60))/25 = 21{:}19 + 0.04 = 21{:}23$, that is, the third column in the route formation will pass the regulating point with the number 1 head at 21:19 and by the tail at 21:23.

Expected Time for Encounter and Distance of the Probable Enemy Encounter Line. The expected time for encounter and the probable lines of encounter with the enemy are determined with consideration of the mutual distance of the sides forces and their mean travel speeds.



NOMOGRAM FOR CALCULATING THE EXPECTED TIME AND DISTANCE OF THE PROBABLE LINE OF ENCOUNTER WITH THE ENEMY
(source Tactical Calculations, 2nd edition)

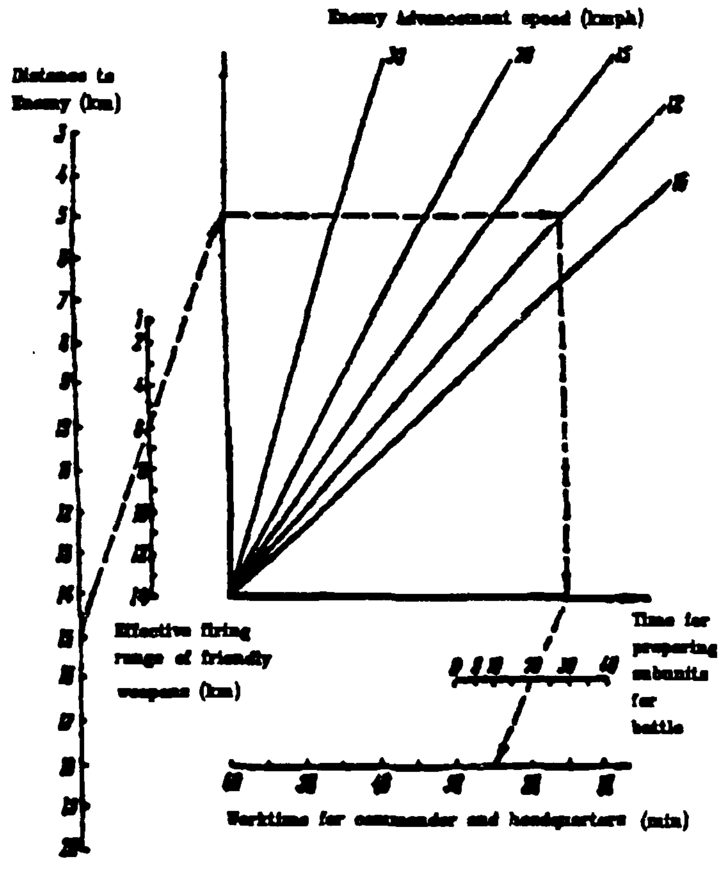
EXAMPLE: To determine the expected time of encounter and the distance to the probable line of encounter with the enemy if at 18:00 5.6 the advancing enemy is located at a distance of 64 kilometers, his average travel speed is 15 kilometers per hour and the friendly force travel speed is 20 kilometers per hour.

Using the Nomogram: a. To calculate the expected time of encounter with the enemy (variant "a") find the marks "20" and "15" on the Friendly forces travel speed" and "Enemy travel speed" scales, respectively. Draw a line through these points to the intersection with the unnamed scale and get a mark of "35". Advance downwards along the line shown by the dots, to the intersection with a perpendicular established from the "64" mark on the "Distance between friendly and enemy forces" scale. From the point of intersection, draw a horizontal line to the "Expected encounter time" scale and read the calculation result - 1 hour and 50 minutes. This will be the expected enemy encounter time from the moment of approach of the two opposing forces (the actual astronomical time will be 19:50 5.6 or (18:00 + 1+50).

b. To calculate the distance of the probable encounter line with the enemy (variant "b") from the obtained result (1 hr, 50 min), draw a horizontal line to the intersection with the speed line (in this particular case to the line with the mark "20", which corresponds to the travel speed of friendly forces). From the obtained point, drop a perpendicular line to the "Distance between friendly and enemy forces" scale and read the calculated result - 36 kilometers.

Using the Formula: $t_e = D/(V_f + V_e)$ and $d_1 = (t_e)(V_f$, where t_e is the expected time of enemy encounter, in hours; D is the distance between the forces, in kilometers; V_f is the travel speed of friendly forces, in kmph; V_e is the travel speed of enemy forces ,in kmph; and d_1 is the distance from the probable line of encounter with the enemy to the initial position of friendly forces, in kilometers. For example, to determine the expected time of encounter and the distance of the probable encounter line with the enemy when the enemy is located at a distance of 63 kilometers, his average speed is 25 kmph and the average travel speed of friendly forces is 20 kmph. SOLUTION: $t_e = 63/(20+25) = 63/45 = 1.4$ hrs = 1 hr 24 min; $d_1 = 1.4$ times $20 = 28$ kilometers.

<u>Calculating the Worktime for a Commander and Staff</u>. This is used to determine the time the commander and staff spend to organize a defeat by firing on an advancing enemy relative to the distance to the enemy, the speed of his advance, the effective range of friendly weapons, and the time required to prepare subunits to fire.



NOMOGRAPH FOR CALCULATING THE WORK TIME OF THE COMMANDER AND THE HEADQUARTERS IN ORGANIZING COMBAT OPERATIONS THE REPEL AN ADVANCING ENEMY
(source <u>Tactical Calculations</u>, 2nd edition)

EXAMPLE: To determine the time the commander and staff spend on organizing the destruction of an advancing enemy if he is located a distance of 15 kilometers, his advancement is 12 kmph, the effective range of destruction by friendly weapons is 6 kilometers, and the time for preparing the subunits preparation time is 20 minutes.

Using the Nomogram: First mark the "15" and "6" on the "Enemy distance" and "Effective range of friendly fire" scales, respectively, draw a straight line through them to the intersection with the unnamed line. From the point of intersection, draw a horizontal line to the "Enemy advancement speed - 12" line. From the obtained point, drop a perpendicular line to the unnamed line and make a mark on it, draw a line through this mark and the "20" point on the "Time for preparing the subunits for battle" scale. At the point of intersection of this line and the "Commander and headquarters work time", read the calculation - 25 minutes.

Using the Formula: $t = ((D-d)(60)/V_e - t_p$ where t is the time required by the commander and the staff to organize the destruction of the advancing enemy, in minutes; D is the distance to the advancing enemy, in kilometers; d is the maximum range of the destructive weapons, in kilometers; 60 is the factor for converting hours into minutes; V_e is the enemy advancement speed, kmph; and t_p is the time required to prepare the subunits for the advancing enemy by fire, in minutes.

For example, to determine the time the commander and staff spend on organizing the destruction of an advancing enemy if he is located a distance of 25 kilometers, his average advancement is 15 kmph, the effective range of destruction by friendly weapons is 12 kilometers, and the time for preparing the subunits preparation time is 30 minutes.

SECTION III - THE DECISION SUPPORT MATRIX

A Decision Support Matrix is only one example of a DSS. This section will address the construction of a DSM similar to those used in the cited exercises. The basic format had usefulness at both the tactical and operational levels of war.

The horizontal axis of the DSM is time. The time increment on this axis can broken into whatever time increment is more meaningful to control operations. Hourly increments seemed most useful at the tactical level whereas daily increments proved more useful at the operational level. At any level, time was a common aspect of both level DSMs and the passage of time was an absolute for both regardless of whether it was managed by the hour or by the day.

The vertical axis depicts those elements that one either desires to gain better situational awareness of or synchronize. Generally, major maneuver elements of both the friendly and enemy forces, the friendly planning cycle, and several functions (battlefield operating systems and operational operating systems) are useful. Additionally, higher level input was tracked that could impact on the conduct of operations.

Information for the vertical files was provided by the appropriate staff agency or the subordinate unit indicated. Input for friendly files was normally characterized by routine reports commonplace in operations, or orders, plans, and observations. Enemy input was a product of reports, the Decision Support Template (DST), Event Analysis Matrix, and the G2's collection plan and the Reconnaissance and Surveillance plans. The DST is a critical product necessary for the preparation of the plan's DSM. Without a properly prepared DST, the time and space relationship between the enemy and friendly forces is difficult to assess.

The DSM is based on numerous products and is subject to constant review and revision. Revisions are required when information from subordinate units is received, when the results of enemy action change a friendly situation, or based on the revised analysis of the enemy. Initial time estimates are made by the planning headquarters staff during the wargaming process of the course of action analysis. These time estimates are then revised when subordinate headquarters determine the more probable time to execute their missions.

Major components of the DST (e.g., decision points [DP], named areas of interest [NAI], and targeted areas of interest [TAI]) are indicated on the DSM. The most probable paths that the enemy could take are indicated on the DSM. This is similar to mapping Program Evaluation and Review (PERT) information on a Gantt chart. All distances from the DST are turned in to time calculations. Several NAI's should be placed along these probable paths to monitor the rate of advance of the enemy.

The next page depicts a sample operational level DSM. It would probably be appropriate for an army group in Central Europe. The time increment selected is a twenty-four hour period probably because a great number of significant events can occur in a twenty-four hour period in that area. In a larger area with lower troop densities, possibly a week would be a more meaningful time increment.

JTF 7 Decision Support Matrix

	D-Day	D+1	D+2	D+3	D+4	D+5	D+6	D+7	D+8
Decision Cuing									
Political									
Strategic									
GCC									
Corps									
Corps									
Corps									
Corps									
Reserve									
ACC									
TAR									
BAI									
CAS									
Reserve									
SOF									
SCC									
TF									
TG									
TF									
Intel									
Collection/Sensors									
Dissemination									
Rear									
Deep									
Logistics									
Infrastructure									
Ports									
Supply Forecasted									
Supply Required									
C2									
CMO									
Phase									
Enemy									
1st Echelon									
CAA									
CAA									
CAA									
2nd Echelon									
CAA									
CAA									
CAA									

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