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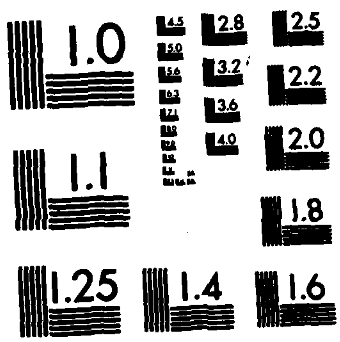

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INTEGRATED NUCLEAR AND CONVENTIONAL THEATER WARFARE SIMULATION (INWARS) LEVEL III SPECIFICATIONS

VOLUME V: COMMAND, CONTROL, AND INTELLIGENCE (C^2I) MODELING

This document is submitted to Headquarters, Department of the Army, Office of the Deputy Chief of Staff for Operations and Plans, ATTN: Mr. P. E. Louer (DAMO-ZD) Washington, D.C. 20310

FOREWORD

This document is Volume V of five volumes presenting the Level III Specifications for the Integrated Nuclear and Conventional Theater Warfare Simulation (INWARS) under development for the U.S. Army by the BDM Corporation. This volume is concerned with the Command, Control, and Intelligence (C^2I) process to be represented in INWARS.

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CHAPTER I
FOREWORD TO C^2I MODELING

A. INTRODUCTION

This volume presents the Level III Specifications of the Command, Control, and Intelligence (C^2I) processes to be represented in INWARS, the central focus of the modeling effort. This Chapter provides a discussion of the conceptual approach to C^2I modeling and its application to INWARS. A concluding overview surveys the present status highlighting changes and advances from the Level II Specifications. Chapters II and III concern the static structure and dynamic updating of a C^2I element's understanding of the situation or UOS. Chapters IV and V present the specifications of C^2I processes involved in developing, executing and controling ground operations. Chapter VI treats the analogs of these processes for air operations development, execution, and control. Finally, Chapter VII surveys the degradation and destruction of C^2I processes and the question of developing data to support the representation of C^2I processes.

B. CONCEPTUAL APPROACH TO C^2I MODELING

1. Basis of the Approach: Functional Commonality

The overall system by which a military force carries out its C^2I process can be viewed as a network of individual headquarters or <u>C^2I elements</u>, each associated with a given organizational unit. The links in this network represent the information flows among the C^2I elements, in terms of the formal chain-of-command and operational linkages. Three basic types of information flow in this network: missions, requests, and reports. A relatively standard input-output structure can thus be imputed to the C^2I elements as shown in Figure I-1. As illustrated, reports flow in all directions in the network,

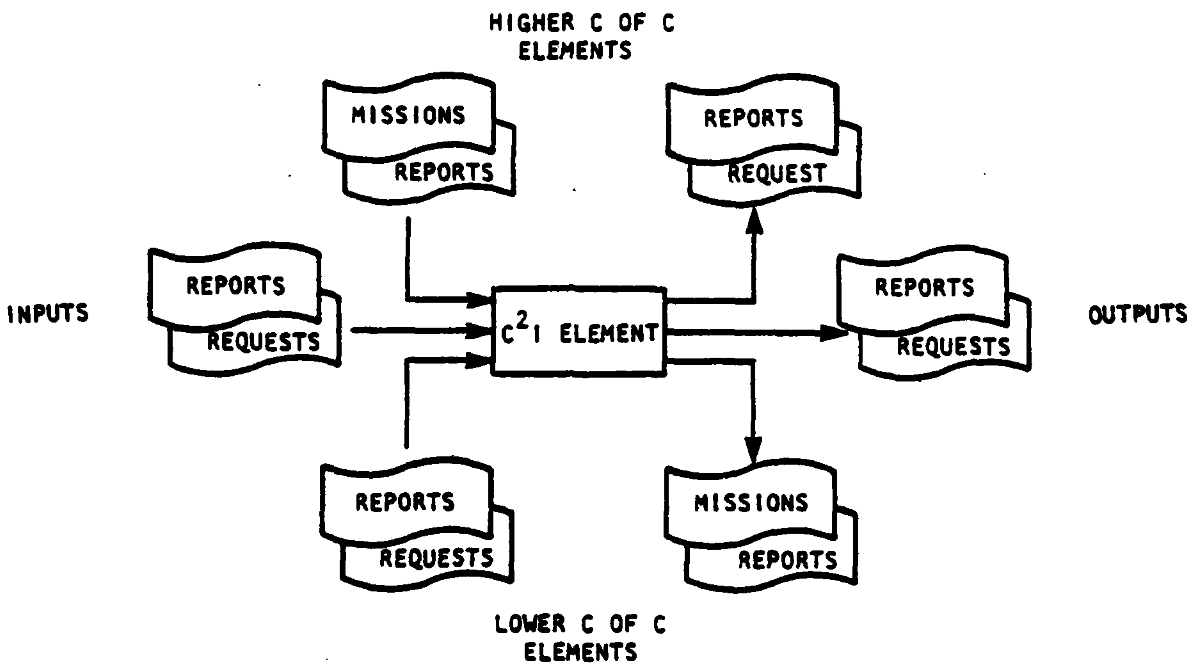


Figure I-1. Standard I/O Structure of a C^2I Element missions flow only downward through the chain-of-command hierarchy, and requests flow both upwards and laterally.

The C^2I process at each node in the C^2I network encompasses a series of continuous, closely related, interdependent activities which enable decisionmakers to consider essential elements of data, make decisions, and communicate orders to be executed. The functions comprising the C^2I process are basically identical in nature at all echelons of command, varying principally in scope, level of detail, processing time, formality, number of persons directly involved, and speed of execution. These variances are caused by the inherent differences in resources, responsibilities, scope, and interests associated with successive levels of command. The fundamental commonality derives from the fact that all C^2I elements have the same basic function: to efficiently and effectively use the resources at their disposal to accomplish the missions assigned to them by higher C^2I elements.

Thus, there is a basic commonality among C^2I process which spans echelons, roles and missions, and even nationalities. This *commonality lies in the functional aspects of the* C^2I process, considered in abstraction from position in the overall C^2I structure of a force.

2. Modeling Implications of This Fundamental Commonality

This line of reasoning suggests that C^2I structure and function be separated in the modeling effort by modeling the processes common to all C^2I elements in the form of a "generic" C^2I element. A particular C^2I element would then be represented as the generic C^2I element together with the specific resources, interests, and responsibilities characterizing that element and its overall position in the network. Essentially, these element-specific resources, interests, and responsibilities would give substance and specificity to the generic C^2I element.

3. Modeling Approach: Structure of C^2I Processes

The C^2I modeling approach is based on the following fundamental observation. The complex information processing by which C^2I element: (1) interprets its missions and objectives; (2) develops a concept of operation; (3) plans for, requests, interprets and integrates information;

(4) perceives and recognizes situations; (5) conceives, evaluates, and selects among alternative courses of action; (6) develops and implements operational plans; and, (7) controls and adapts the execution of its plans to the developing combat situation, is all conducted on the basis of that C^2I element's understanding of the situation (UOS). In other words, a C^2I element's UOS is the basis upon which it decides and acts.

The central role played by the understanding of the situation in C^2I processes suggests that any model of C^2I process must take account of: (1) the nature of the UOS, and (2) its role in the C^2I processes. In particular, this orientation around the C^2I element's UOS leads to a decomposition of C^2I processes into:

(1) the processes by which the UOS is developed, maintained, and updated as the situation evolves through time considering:
   (a) the integration of new information into the understanding,
   (b) the enhancement of the completeness of the understanding, and
   (c) the maintenance of consistency, coherence, currency, and relevance;

(2) the processes by which the UOS is monitored for such operationally significant changes as:
   (a) receipt of a new mission,
   (b) emergence of an operational problem, and
   (c) identification of an operational opportunity;

(3) the processes by which the UOS is used in structuring and resolving operational decisions considering:
   (a) development of alternative courses of action,
   (b) evaluation of alternative courses of action vis-a-vis objectives and possible enemy reactions,
   (c) selection and implementation of a particular course of action, and

(d) adaptation of a course of action to the evolving situation. Figure I-2 depicts these processes and their interrelationships with the UOS, in the context of the generic C^2I element.

4. Modeling Approach: Content of C^2I Processes

The preceding characterization provides a decomposition of C^2I processes into a systematic structure of component subprocesses and thus provides a perspective on what must be treated in a C^2I model. It does not, however, offer guidance on how these component processes should be treated.

One broad approach to the "how" question is optimization. Drawing on decision/game theory, mathematical programming, and control theory, such an approach models C^2I elements as optimal decisionmakers. However, besides problems in determining just what is to be optimized, such optimal decisionmaking models carry a heavy cost in terms of computer run time due to the exhaustive option generation and evaluation procedures. More importantly, however, such models do not adequately represent the human decisionmaker. Research into the psychology of decisionmaking suggests that, unlike the so-called "optimal" decisionmaker, the human decisionmaker typically considers only a few "reasonable" options, evaluates these against only a few key criteria. and selects that alternative which appears most "reasonable".

For these reasons, the optimization approach does not appear to be suited for general C^2I modeling, and will, therefore, not be employed in INWARS. Rather, INWARS C^2I processes will be modeled in terms of doctrinally based heuristic decision procedures. As used here, 'heuristic decision procedure' refers to a procedure which resolves a relatively specialized decision problem by means of a decision logic reflecting the particular features of that problem. The central feature of heuristics is their reliance on problem-specific knowledge and logic. Unlike optimal decision procedures, heuristics do not exhaustively generate and evaluate all conceivable alternatives. Rather, heuristics exploit the special features of the problem to reduce the number of alternatives to be considered and guide their evaluation. In developing

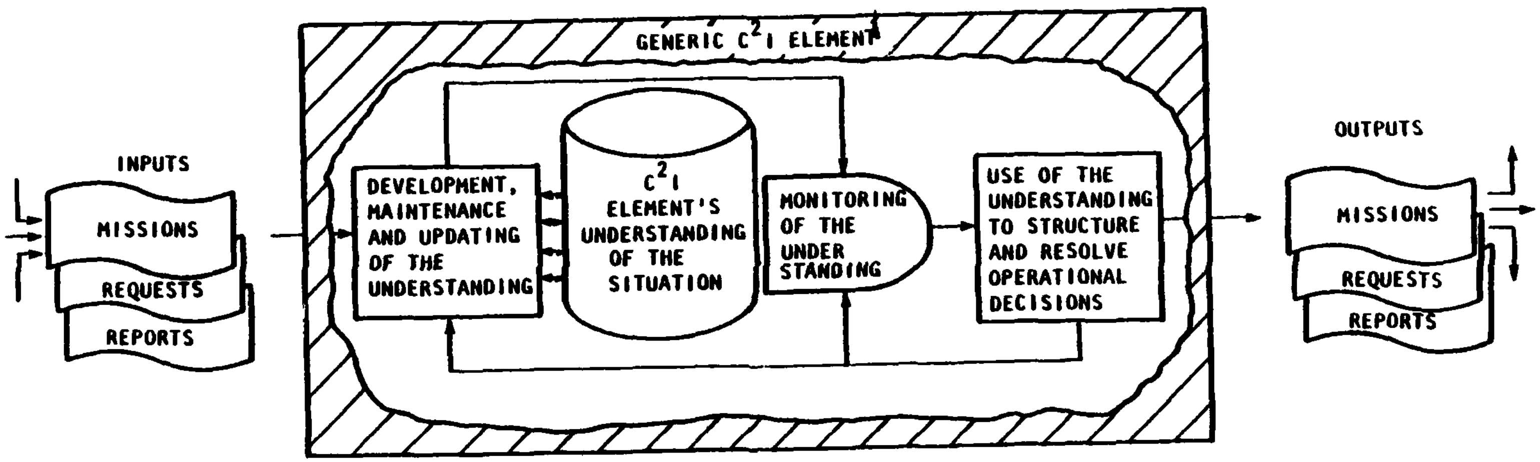


Figure I-2. Conceptual View of the Generic C^2I Process heuristic decision procedures for a decision problem, the aim is not to provide optimal decisions but rather decisions which are "reasonable" given the particular nature of that problem.

In the battlefield context, doctrine plays a key role in guiding command decisionmaking by specifying, in general form, the types of options which are "reasonable" to entertain in specific types of situations, and the considerations by which each of these options should be evaluated. From a modeling point of view, then, doctrinal guidance can be usefully exploited to develop heuristic decision procedures for particular classes of decision problems. In essence, this approach yields "doctrinal decisionmaker" representations of C^2I elements. Such representation provide the ability to explicitly model different doctrines (e.g., NATO vs Warsaw Pact).

C. APPLYING THE APPROACH TO INWARS

The preceding section has presented the general conceptual approach to C^2I modeling which will be employed in the INWARS program. To proivde a bridge between the general approach and the more detailed specifications in later chapters, this section discusses the application of the general approach to INWARS.

Modeling decisionmaking and other "mental" processes by means of heuristics has two basic methodological features. First, as suggested earlier, heuristics are heavily dependent on context--they are most appropriate when they can exploit special features of the decision problem they are intended to resolve. Second, the power of the heuristic decision procedure approach lies in the decomposition of complex decisions into particular sequences of simpler and more specific subdecisions which can be resolved in a relatively independent fashion. Consequently, the design and development of the INWARS C^2I processes can be characterized as a process of decomposing the broad areas of decision to be included in INWARS into systems of simpler and relatively independent decision problems. This is being accomplished in stages thus resulting in "nests" of simpler and simpler decisions, each with its own heuristic decision procedure, as depicted in Figure I-3. The following chapters can be regarded as presenting the Level III stage of this decomposition.

Viewed as a process of decomposition, the design of the INWARS C^2I processes is guided by both doctrinal and modeling considerations. As will become apparent in the following chapters, the doctrinal literature often provides useful insights regarding both the component decisions involved in a broad decision problem and their interrelationships. Additionally, the design will be guided by test and experimentation with the heuristics. It is primarily for this reason that the INWARS development program has been structured into a basic development phase and a formal refinement phase. During the basic phase, a complete system of C^2I processes will be designed and developed. As will be seen over the sequel, the guiding criterion in this phase has been <u>simplicity</u>. For example, in decomposing a particular decision problem, subdecisions have been treated as independent to the maximum extent possible. Similarly, simple heuristic procedures drawing on aggregate situation information have been emphasized.

This complete but "simple" system of C^2I processes will then be subjected to test and experimentation. Testing will involve examining the behavior and responses of the various C^2I element as they develop and execute operations. Such testing will permit the identification of certain broad areas requiring refinement or more detailed treatment. In addition, however, man-in-the-loop experimentation will be conducted. Here, the aim will be to compare the particular decisions and responses of the model with those of experienced military commanders serving in the "man-in-the-loop" role. It is anticipated that this will provide more detailed insight into potential refinements in the modeled C^2I processes.

To enable man-in-the-loop experimentation, INWARS will be constructed such that any of the C^2I elements at echelons above division may call a remote entry device that permits man-in-the-loop intervention. In such a configuration, whenever a decision is required of a particular

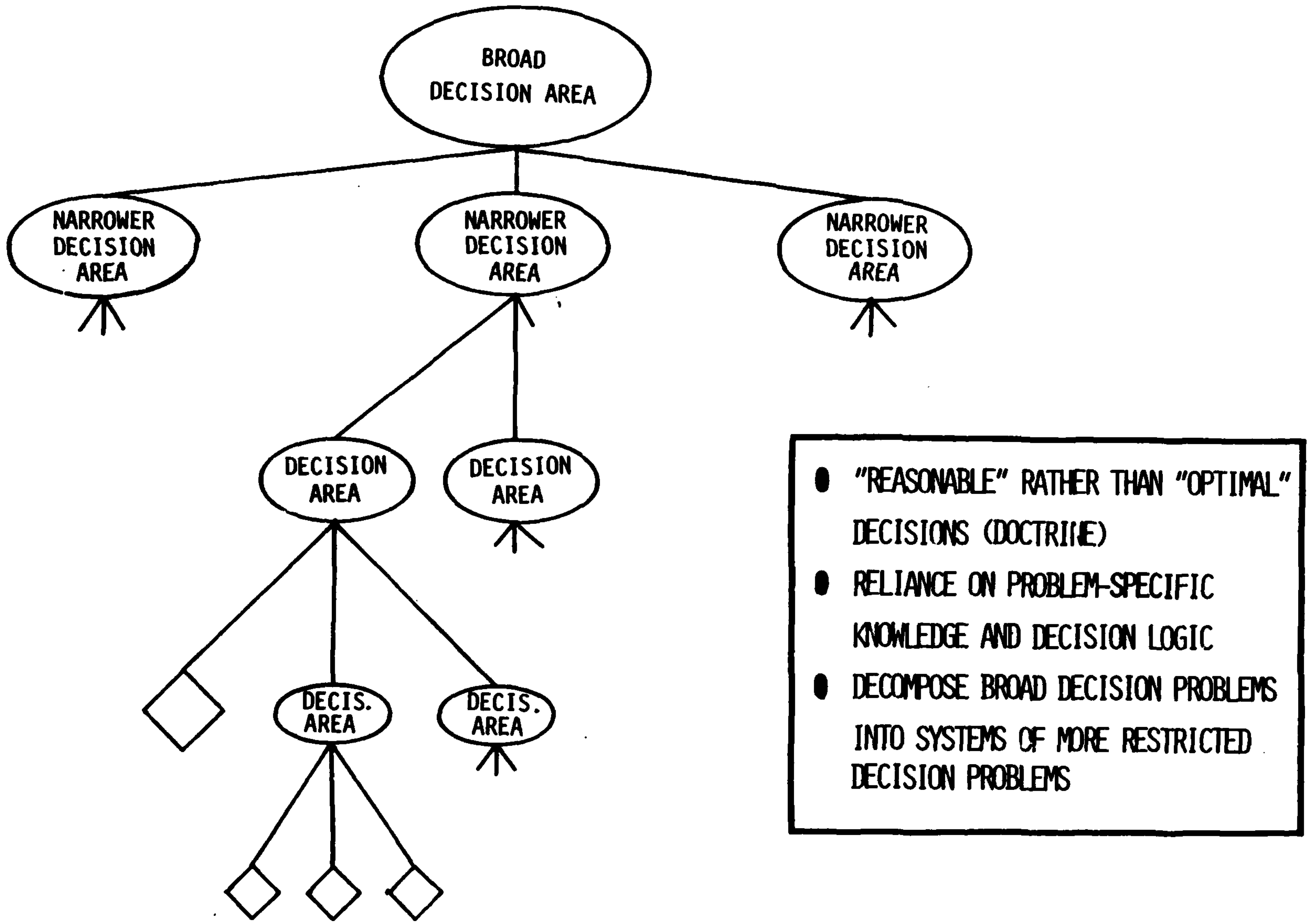


Figure I-3. Heuristic Decision Procedures

C^2I element, the simulation will "call" the C^2I processes associated with that element. But instead of using their automated decision logic, the processes will transfer control to the remote entry device where the man-in-the-loop could intervene and input a decision. When the remote entry device is called, the data displayed to the human will be the same data that would be available to the automated C^2I processes. The data might be output in the form of a visual display such as a commander's situation map, an order received from a superior commander, or status reports from subordinates. Based on his assessment of the data, the man-in-the-loop will decide how to respond to the situation. This response will be entered into the remote entry device and translated into an appropriate internal representation. At this point, the simulation would be restarted and would then run in accordance with the man-in-the-loop's guidance.

Based on the results of the test and experimentation, a set of refinements to the C^2I processes will be specified, designed, and implemented. This formal refinement phase will be accompanied by additional test and experimentation.

D. STATUS OVERVIEW

At the present state of the design process, the C^2I specifications provide an adequate characterization of the structure and content of the INWARS C^2I processes to begin software design and development. The components of the UOS have been specified in terms of structure and types of variables along the lines presented in the Level II Specifications. Ground operations development processes have changed somewhat from the Level II Specifications; although the basic "philosphy" of operations development is the same, the particular procedures have been refined and more highly structured around the development of a complex information structure representing a generic concept of operation. Ground operations execution and control processes have been likewise refined and elaborated in terms of contingency response and recognition procedures. Air operations development, execution and control procedures have been more fully specified (including, in particular, the resolution of the design issue concerning the scheduling of air mission packages). Finally, a representation of C^2I performance and degradation in terms of reaction times has been developed.

Nonetheless, open areas remain: exact definition and "coding" of UOS information elements is not yet fixed, and certain decision and information processing rules at the "bottom level" of the hierarchy of heuristic procedures (Figure I-3) are not yet fixed. In part, this reflects a design decision to leave these areas "open" to permit appropriate tradeoffs during software design: both areas will have significant impacts on storage and run time and should not be fixed until these software impacts can be more precisely defined and balanced. However, this also reflects a need for further research into doctrine and data availability, as well as further discussion with users.

It should also be emphasized that the particular formulations of C^2I decision and information processing rules are starting points which emphasize simplicity. This is especially true of the system of contingencies which essentially characterizes operations execution and control activities (as discussed in Chapter V, below). It has become apparent that INWARS is sufficiently complex that perfect foresight of all situations which could confront C^2I elements in the model is essentially impossible. It is felt that the system of contingencies presented in Chapter V will provide reasonable completeness and responsiveness. At the same time, it is anticipated that during test and experimentation, desirable additions and modifications will become apparent.

CHAPTER II

STRUCTURE OF A C^2I ELEMENT'S UNDERSTANDING OF THE SITUATION (UOS)

A. INTRODUCTION

As was noted in the preceding chapter, each C^2I element will maintain its own Understanding of the Situation (UOS). In effect, a C^2I element's UOS represents its "mental state" at any point in time, and provides the base of information upon which it develops and controls its operations. All C^2I elements in INWARS will have a UOS involving three basic components: (1) a fixed store of Fundamental Knowledge, (2) a more volatile collection of Situation Data, and (3) a Situation Representation. Figure II-1 presents an orienting overview of these components. The structure and contents of each of the main components as well as their subcomponents is presented in this chapter.

B. FUNDAMENTAL KNOWLEDGE COMPONENT

The Fundamental Knowledge component of a C^2I element's UOS will contain information concerning both friendly and enemy doctrine as well as its own specific operating procedures and parameters. Likewise, information concerning friendly and enemy organizations, typical deployments, and typical tactics will be included in this component. Finally, all fixed values, preferences, decision thresholds, and rules associated with the C^2I element's information and decision processing will reside in that element's fundamental knowledge component. Since there will be commonality among groups of C^2I elements by side, nationality, and/or echelon of command, elements of fundamental knowledge will actually be stored in common locations to conserve storage space--a particular C^2I element's Fundamental Knowledge component will actually contain various "keys" allowing him to access appropriate information from these common locations.

Information in the Fundamental Knowledge component will not be altered in the course of a simulation run. Thus, for example, there will be no

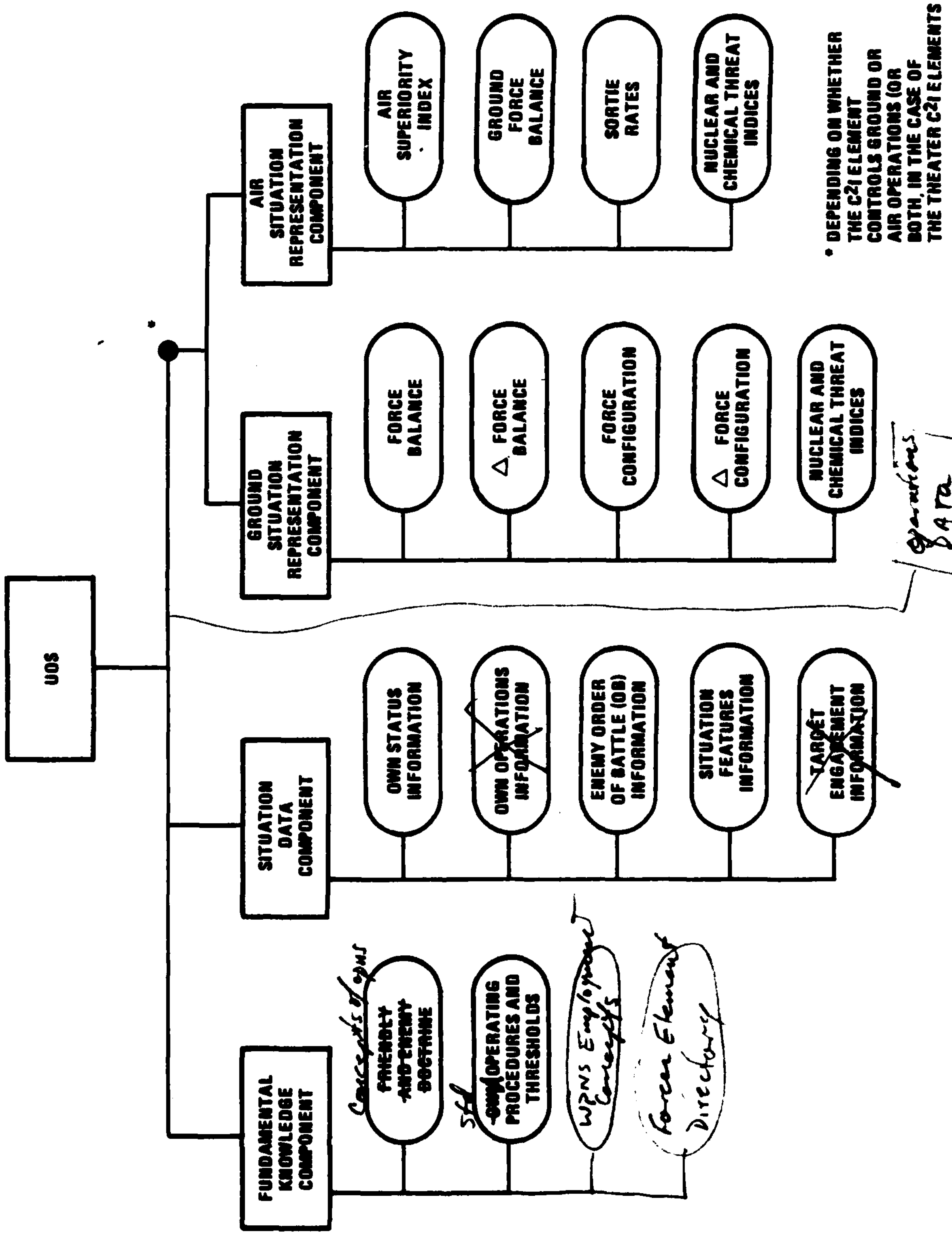


Figure II-1. Structure of UOS

"learning" or adaptive modification of the element's own basic operating procedures during a run.

C. SITUATION DATA COMPONENT

The Situation Data component of a C^2I element's UOS will contain specific items of information about the overall situation faced by that C^2I element. Situation Data will be obtained or developed from reports received (via communications) from other force elements or direct perceptions of the C^2I element. As presently envisioned, five main types of information will be included in the Situation Data component: (1) Own Status information, (2) Own Operations information, (3) Enemy Order of Battle information, (4) Situation Features information, and (5) Target Engagement information (see Figure II-1). The environmental information elements identified in the Level II Specifications have been deleted since C^2I elements will have direct access to true environmental data. The structure and contents of each of these types of information is presented in the following subsections.

1. Own Status Information

Own Status information relates to the status of the entire organization commanded by the C^2I element. Such information will be obtained from status reports received from the C^2I element's subordinates. It will be maintained down to and including the immediate subordinate level of detail. Higher level units (Corps/Army and above) may, in addition, have access to information about the next lower level thus providing a total of two lower levels. Figure II-2 summarizes the structure and contents of Own Status information in a C^2I element's UOS.

Own Status information is structured into a list of blocks of data, each concerned with the status of a particular force element. The top-most block in the list structure concerns the overall status of the force commanded by the C^2I element; the lower-level blocks in the structure concern the status of that C^2I element's subordinates.

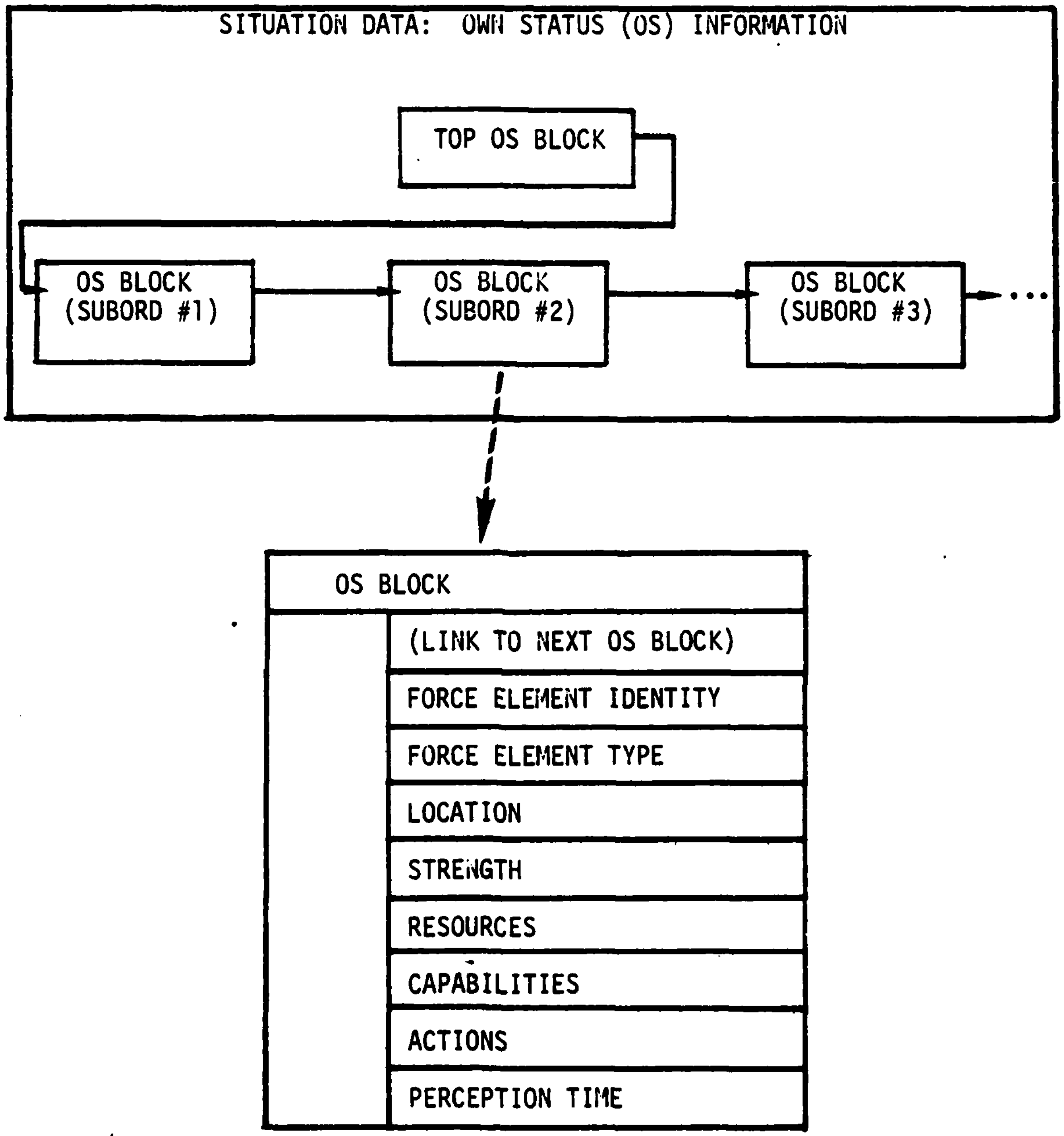


Figure II-2. Own Status (OS) Information: Structure and Content

Each Own Status information block contains standard items of information reflecting the results of self-perception (see Volume IV, Chapter II, Section B.1) as well as the time of that perception. Of course, the interpretation of the various items of information depends on the type of force element. As discussed in more detail in the next chapter, information is filled into subordinate OS blocks based on reports received from those subordinates. By contrast, information in the top-most OS block is derived by aggregating over the subordinate OS blocks (more precisely, over maneuver subordinate OS blocks).

2. Own Operations Information

Own Operations information concerns the status of the operations of the entire organization commanded by the C^2I element. Specifically included in this type will be the current operations directive received from the C^2I element's superior governing the operations of the C^2I element's command. Also included will be the C^2I element's translation of this operations order into a plan for its own organization, i.e., operations directives for its subordinates, and overall control measures such as boundaries, timing, and phase lines. Finally, mediating between these operations orders is the "concept of operation", a complex data structure representing the current status and expected evolution of the current operation. The nature of the generic concept of operation and its role in C^2I activities will be discussed in Chapter IV below (see especially Section B.2).

3. Enemy Order of Battle Information

Enemy Order of Battle (OB) information concerns information needed by the C^2I element to assess enemy capabilities and operations in its area of operations. Also like status information, enemy OB data will be maintained down to the next lower organizational level. Figure II-3 depicts the structure and contents of Enemy Order of Battle information in a C^2I element's UOS.

As with Own Status information, Enemy OB information is structured into linked blocks of data, each concerned with a particular type of enemy force element. Here, however, a more complex linking is required, because

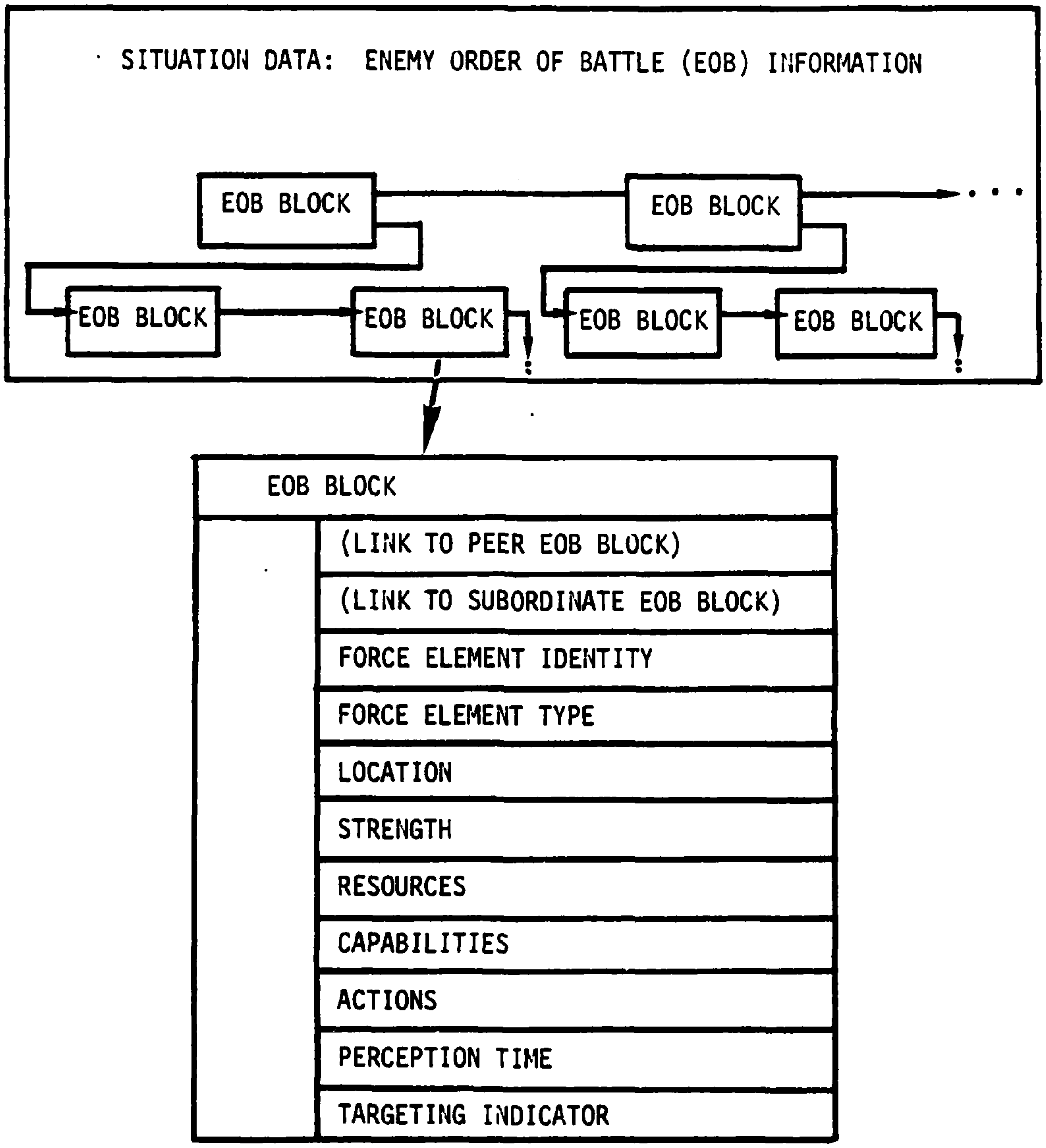


Figure II-3. Enemy Order of Battle (EOB) Information: Structure and Content a given C^2I element may have information about several enemy force elements at the same echelon of command (e.g., a U.S. Corps may have knowledge of several Soviet Armies). Hence, two links are provided, one to force elements at the same level of command (peers) and one to subordinate force elements. This permits a "tree-like" structuring paralleling the chain-of-command organization of the enemy force.

Each Enemy Order of Battle information block contains standard items of information reflecting the results of intelligence perception (see Volume IV, Chapter II, Section B.2) as well as a perception time. Information is filled into these blocks based on intelligence reports received by the C^2I element. As with Own Status information, higher level information blocks may reflect an aggregation over lower level blocks. The "targeting indicator" information element provides for cross referencing from Enemy Order of Battle information to Target Engagement information described below.

4. Situation Features Information

Situation Features information concerns aspects of the situation which are not necessarily attributable to a particular friendly or enemy force element, but which are nevertheless important to the C^2I element. These features include concentrations of enemy units, and indications of nuclear or chemical threat. (Expansion capabilities will permit treatment of additional features.) Figure II-4 portrays the structure and contents of Situation Features in the UOS. Structurally, the information is organized into a list of "Situation Feature Blocks" in order to facilitate addition (and deletion) of features as they are perceived.

5. Target Engagement Information

Target Engagement information concerns targets acquired by the C^2I element as well as engagement actions taken against those targets. Acquisition information will be organized on a target-by-target basis, and will include target type and location as well as cross references to relevant enemy OB data, if any exists. Engagement action information will be associated with the particular target engaged and will include type of engagement action and results obtained. Various sizes of targets may be

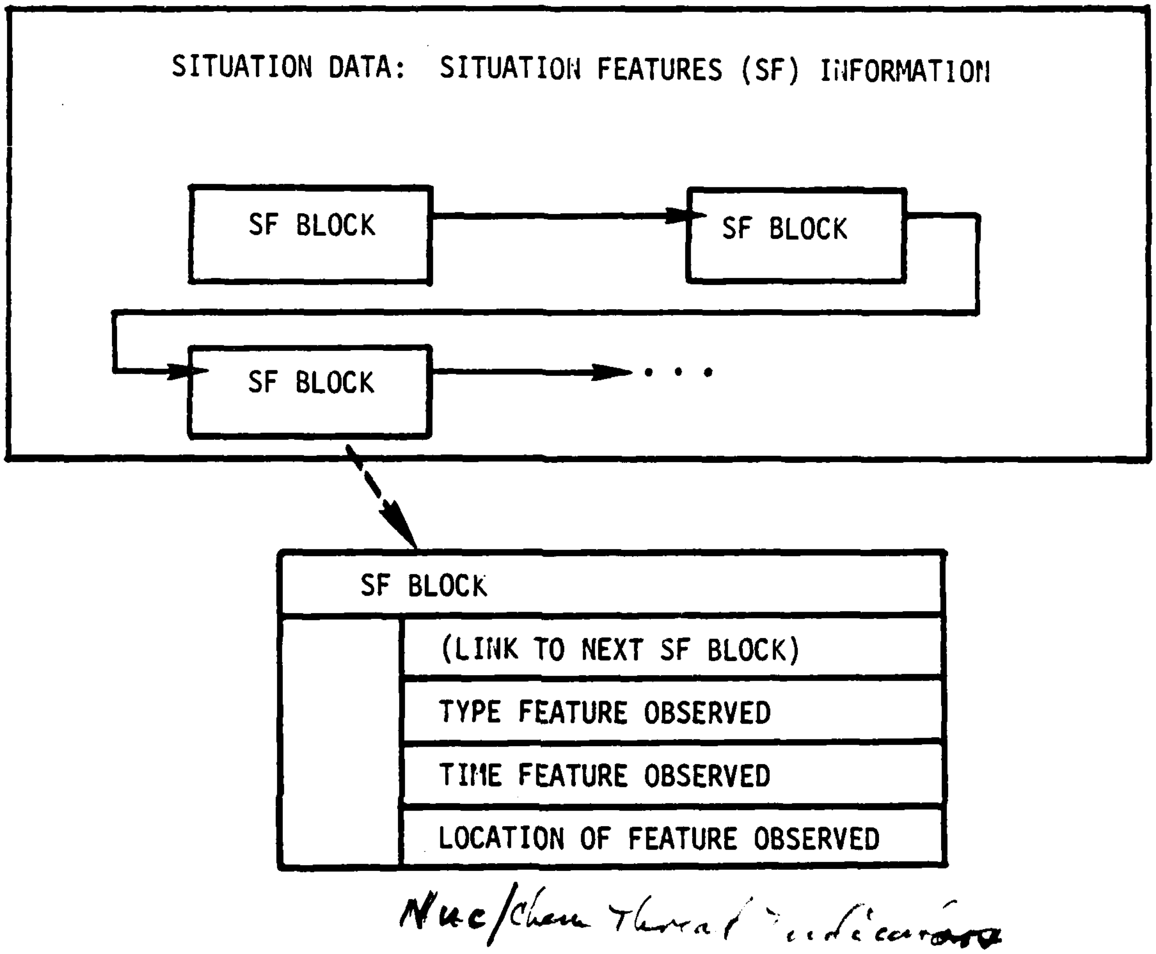


Figure II-4. Situation Features (SF) Information: Structure and Content maintained by a C^2I element; thus, for example, corps level C^2I elements may maintain target engagement information on enemy regiments. Figure II-5 depicts the structure of this type of information. Again a list structure is used to organize the blocks of information in order to facilitate addition and deletion of targets.

Note that in some cases, an enemy force element may be carried in both the EOB information and Target Engagement information lists. The duplication is necessary due to the different roles of EOB and targeting information in C^2I activities. Cross referencing will be possible since both information blocks contain the identity of the unit.

D. SITUATION REPRESENTATION COMPONENT

The Situation Representation component is the key component of a C^2I element's UOS. It is in the Situation Representation that the individual items of situation data are "synthesized" into a coherent description of the situation. The C^2I element will use this synthesized description to monitor its ongoing operations, identify emerging operational problems and opportunities, and assess alternative approaches to their solution or exploitation. The Situation Representation will also provide information for operations development activities. Whereas the Fundamental Knowledge and Situation Data components are essentially similar for ground and air C^2I elements, the Situation Representation components are very different reflecting the different types of operations these elements develop, execute and control; consequently, Ground and Air Situation Representations are described separately in Subsections 1 and 2 below.

1. Ground Situation Representation Component

The Situation Representation component of ground C^2I elements will contain information concerning: (1) Force Balance, (2) Changes in Force Balance, (3) Force Configuration, (4) Changes in Force Configuration, and (5) Nuclear and Chemical Threat. Figure II-6 illustrates the structure and contents of the ground Situation Representation component. As can be seen, the information is structured into linked blocks of situation blocks.

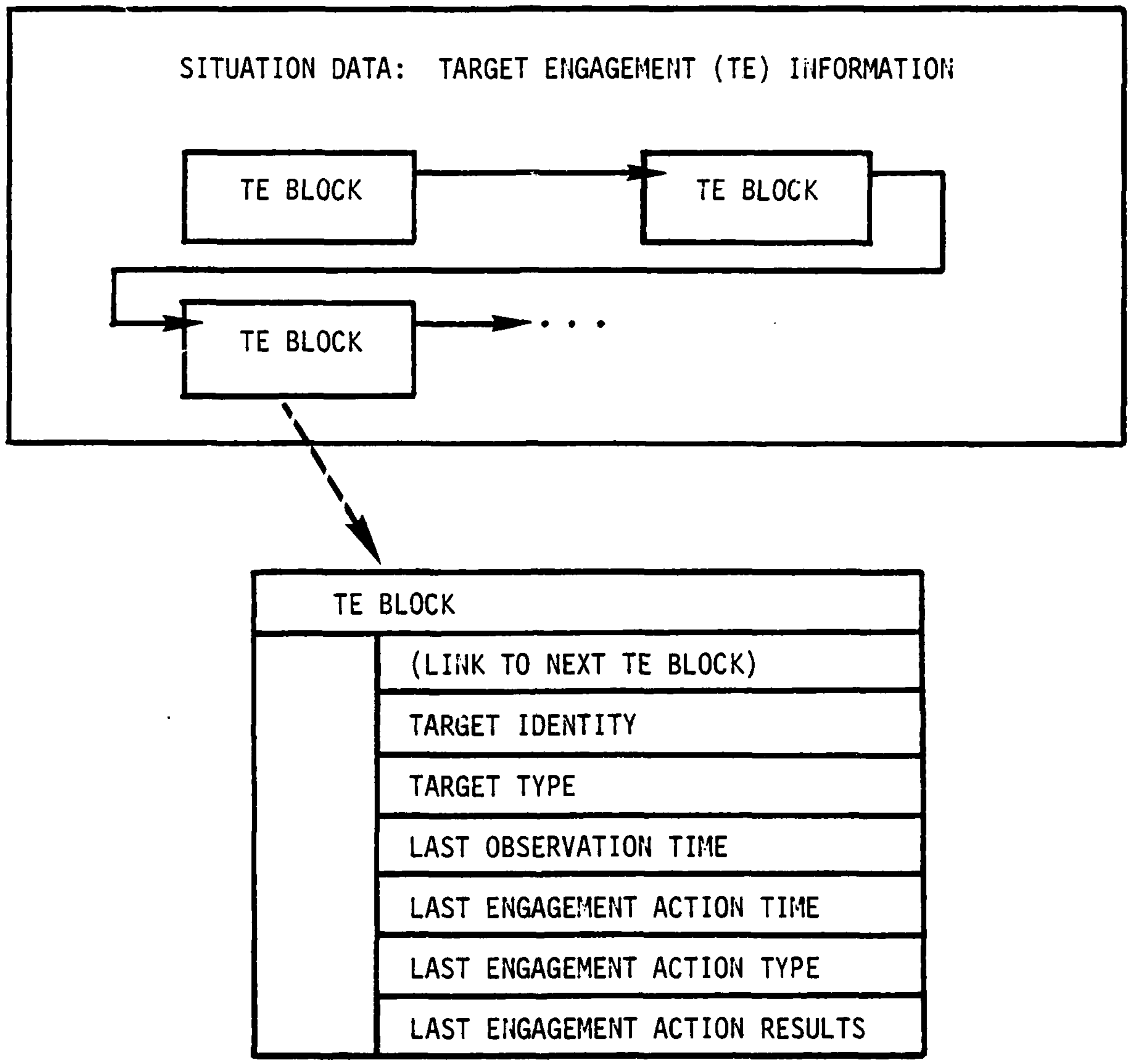


Figure II-5. Target Engagement (TE) Information: Structure and Content

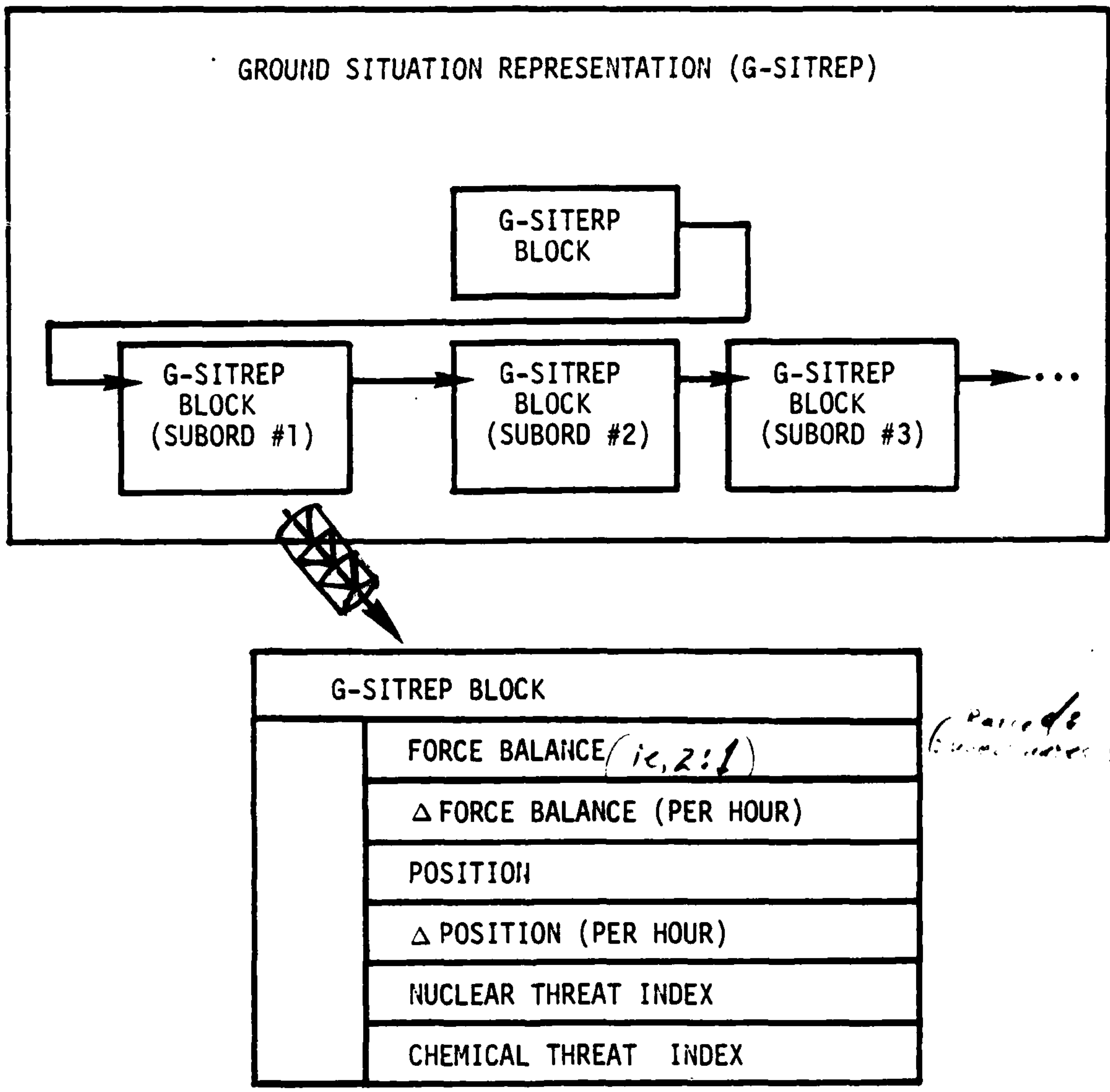


Figure II-6. Ground Situation Representation: Structure and Contents

As with Own Status information, the top-most block in this list structure contains the representation of the situation faced by the overall organization commanded by the C^2I element; lower level blocks contain situation representation data for subordinate maneuver organizations. Information may be filled into those blocks based on reports received from subordinates or directly developed from Own Status, Enemy Order of Battle, and Situation Features information drawn from the Situation Data component of the UOS.

a. Force Balance Information

Force balance information is a key component in any aggregate characterization of the battlefield situation faced by a ground C2I element. This is due to the fact that force balance provides a simple representation of the operational distribution of forces, a concept which is especially important to the operations of the higher-level C^2I elements treated in INWARS.

For the purposes of INWARS, force balance will be represented in the standard fashion, i.e., as the ratio of friendly strength to enemy strength. However, the computation of this ratio is somewhat more complicated in INWARS than in sector models. This is due to the fact that force elements in INWARS are not represented in terms of a fixed collection of sectors. Hence, the model structure does not provide an inherent correspondence between friendly and enemy force elements. But such a correspondence must be established in order to determine the denominator of the friendly enemy force balance ratio. In INWARS, this correspondence will be established on the basis of the regions of operations of the friendly force elements. As discussed in Chapter IV, each C^2I element will be given an explicit "region of operations" as a part of operations development. Any enemy forces located in this region will therefore be associated with the given C^2I element's organization for the purposes of force balance ratio computation. To summarize:

$$\text{FBAL(I)} = \text{STRENGTH(I)}/\Sigma\{\text{STRENGTH(J)}/\text{J AN ENEMY UNIT IN UNIT I REGION OF OPERATIONS}\}$$

Thus far, the discussion has centered on the static characterization of force balance, i.e., a "snapshot" of the force balance existing at a particular point in time. However, changes in force balance are also of interest to higher echelon C^2I elements. For this reason, the ground situation representation will also contain information relating to the rate of change in the static force balance ratio. This will be computed whenever the force balance information is changed, and will be expressed in terms of a rate of change per hour to facilitate comparisons.

It was suggested in the Level II Specifications that analogs of the aggregate and detailed force balance would be maintained for forces which could be in contact within an appropriate planning horizon. Such force balance potentials were intended to reflect enemy force capabilities. In effect, these measures would be computed based on enemy units located in a region containing the region of operations but including additional areas in which the command is "interested". It has been decided that the regular storage and updating of this type of force balance potential information is not warranted; rather, it will be computed on an "as-needed" basis by C^2I elements.

b. Force Configuration Information

As used here, "force configuration" refers to the general "shape" or spatial distribution of forces in contact within a ground C^2I element's region of operations. In effect, force configuration information characterizes the Forward Edge of the Battle Area (FEBA) of a ground C^2I element. Of course, since the INWARS physical processes do not impose an artificial FEBA, each C^2I element must identify a FEBA--as an "idealized construct"--within its own region of operations. This information will be used in recognizing penetrations, flanking situations, and envelopments.

The simple characterization of force configuration suggested in the Level II Specifications will be adopted for INWARS. This approach represents force configuration in the form of "average" line of contact positions relative to a C^2I element's region of operations. This would be computed from positional data reported by subordinate force elements (which would be stored in the appropriate subordinate Situation

Representation blocks). Differences between the overall position and subordinate positions would then be used to characterize force configuration. Such a series of measures will assist in recognizing penetrations and identifying exposed flanks; they may not, however, be useful in a situation involving significant intermingling of forces.

As with Force Balance information, it is necessary to supplement the static ("snapshot") Force Configuration characterization with an indication of dynamics. This will be accomplished by computing and storing information regarding rates of change in the average positions. Maintained in aggregated and subordinate forms, this rate of change information provides a simple pattern of force movements.

c. Nuclear and Chemical Threat Indices

As the name suggests, nuclear and chemical threat indices will have no absolute quantitative significance, but will simply provide a relative scale upon which to reflect the nuclear and chemical threat faced by a C^2I element (as assessed by that element). These threat indices will be based on nuclear and chemical related activities of enemy force elements. (These activities nuclear and chemical related will be identified as a part of intelligence perception.) The perceived occurrence of such activities will increase or decrease the appropriate threat index on the basis of a scoring system.

2. Air Situation Representation Component

The Situation Representation component of C^2I elements controlling air operations (Theater and ATAF/TAA C^2I elements) will contain information concerning: (1) Air Superiority, (2) Supported Ground Force Situation, (3) Sortie Rates, and (4) Nuclear and Chemical Threat. These elements are discussed below.

a. Air Superiority Information

The degree of air superiority is a principal aspect of an aggregate characterization of the operational situation facing any air C^2I element. In INWARS, this "degree of air superiority" will be represented as a simple index reflecting the ratio of friendly aircraft capable of undertaking offensive counterair missions to enemy aircraft capable of undertaking offensive counterair missions. (This is a refinement of the Level II Specifications proposal to use the ratio of total attack aircraft). This ratio would be computed on the basis of aircraft strengths information carried in Own Status and Enemy Order of Battle information elements. The inclusion of strengths of particular aircraft types would be based on the ability of that type to undertake offensive counterair missions as reflected in the type mission matrix discussed in Volume III, Chapter .

b. Ground Force Balance Information

The balance between opposing ground forces is important not only to the ground C^2I elements but also the supporting air C^2I elements. Ground force balance information in the Air Situation Representation will concern not only the supported ground unit (Army Group/Front but also its subordinates. The information will not be developed by the air C^2I element but will rather be directly accessed from the Situation Representation of the supported ground C^2I element.

c. Sortie Rate Information

Sortie rates are an important planning factor for air C^2I elements in that they reflect the expected availability of type aircraft to fly missions over the course of a day. Thus, a sortie rate of 1.5 for a given type aircraft reflects an expectation that each aircraft of that type will be able to fly at least one mission a day and, with probability 0.5, an additional mission. Consequently, if a C^2I element had 10 aircraft of that type available at the start of the day, it could expect to use these aircraft in 15 separate missions over the course of the day. Whether the C^2I element would actually be able to realize the 15 missions as the situation evolves over the day would depend on the attrition sustained by the 10 aircraft on their first mission of the day and the launch capacity of the air bases. Air C^2I elements will maintain sortie rate information for each type of aircraft they control. As suggested in the Level II Specifications, sortie rates will be established by user input; however, in order to represent surge conditions, it will be possible for these sortie rates to change over the course of a simulation in accordance with a user-defined schedule.

d. Nuclear/Chemical Threat Information

The Air Situation Representation will contain nuclear and chemical threat indices analogous to those contained in the Ground situation Representation. (See Section D.1.c, above.) Air C^2I elements will maintain and update these indices with the same procedures used by ground C^2I elements.

E. AFTERWORD

The preceding presentation of UOS structure and composition reflects a refinement and structuring of the UOS components and subcomponents as presented in the Level II Specifications. At this stage, the logical structure and contents of the UOS are determined. The exact definition and "coding" of the various UOS information elements must be done during software design. As was noted in the Level II Specifications, the UOS representation could become a heavy user of internal storage; consequently, sizing tradeoffs may be required which will impact on the range of information which any particular information element may represent.

CHAPTER III

UPDATING AND DEVELOPING THE UNDERSTANDING OF THE SITUATION (UOS)

A. INTRODUCTION

As is apparent from the discussion of its structure and contents, a C^2I element's UOS is a dynamic structure of information which changes as new information about the situation is received. This chapter is concerned with the processes by which a C^2I element updates its UOS. However, it is emphasized that the C^2I element is not merely a "passive" updating of its UOS; indeed, C^2I elements may actively attempt to develop its understanding of the situation by requesting information from associated force elements, and, in some cases, by directing the operations of intelligence collection agencies (PHOTINT and SIGINT elements) within its command.

In the broadest sense, updating the UOS involves introducing new information into one or more of the component elements of the UOS. The new information may be totally new or it may replace some older information introduced into the UOS previously. Generally speaking, this new information is received by the C^2I element in the form of a message--updating may be regarded as the interpretation of the message by the C^2I element. Consequently, a C^2I element will update its UOS whenever it receives a message. Additional occasions to update its UOS may be scheduled by a C^2I element in the form of an internal "review".

A C^2I element's UOS is not simply a collection of isolated items of information, but is rather a system of interrelated information. For example, information elements in the Situation Representation component of the UOS are essentially synthesized from more basic information elements in the Situation Data component. Even within the Situation Data component, interrelationships exist in the form of aggregations (e.g., the aggregation of subordinates' status information into status information for the whole organization) and cross references (e.g., the link between enemy order of battle data and target engagement data). For this reason, updating is inherently more complex than simply "reading" new information into appropriate information elements: related information elements may also have to be altered in some way to be consistent with the new information. It is convenient to distinguish between: basic updating, during which newly received information is directly introduced (or "read") into appropriate UOS elements; and derivative updating, during which related UOS elements may be recomputed or otherwise changed on the basis of the newly received information.

It should also be noted that based on newly received information, the C^2I element may determine that some other type of command and control actions are necessary. Thus, updating the UOS provides opportunities to monitor the UOS for operationally significant changes. Although discussed in more detail in Chapter V below, such opportunities are identified in the following discussion of updating.

B. UPDATING THE UOS IN RESPONSE TO MESSAGES RECEIVED

As was indicated above, messages provide opportunities for C^2I elements to update their UOS. Within the model then, the occurrence of a "message-received-by-C^2I-element" event will always involve certain UOS updating operations on the part of the receiving C^2I element. These operations will always include basic updating and may also involve derivative updating. The exact structure depends on the type of message. Updating procedures for status reports, intelligence reports, requests, and directives are outlined in subsections 1 - 4 respectively, below.

1. Updating in Response to Status Reports

Status reports provide C^2I elements access to information about the disposition, status, and operations of friendly force elements, generally subordinates. Consequently, Own Status and Own Operations information are the basic Situation Data elements affected by the receipt of a status report. Derivatively, Situation Representation elements such as force balance or force configuration may need to be updated. The procedures vary somewhat between regular status reports and spot status reports.

a. Updating in Response to Regular Status Reports

Upon receipt of a regular status report from a subordinate, basic updating procedures will simply find the Own Status information block corresponding to that subordinate and "read" the accessed information into it. Derivative updating procedures will then recompute the aggregated information in the parent Own Status block at the top of the status block list (see Figure II-2) if appropriate. Own Operations information may also require derivative updating. Situation Representation information elements such as force balance or configuration will not be updated at this point in order to reduce processing time (see Section C below for further discussion).

b. Updating in Response to Spot Status Reports

Spot status reports contain special information relating solely to exceptional conditions such as excessive losses, low supplies, or attack by enemy forces. Like regular status information, this data will be entered into the appropriate subordinate force element Own Status block. Also like regular status information, this may require a derivative updating of aggregate information in the parent Own Status block. It should be noted that since spot reports will generally reflect exceptional conditions, some response on the part of the control functions may be required. Accordingly, spot reports may trigger, via monitoring processes, control decision processes.

2. Updating in Response to Intelligence Reports

Intelligence reports provide C^2I elements access to information about the disposition, status, and operations of enemy force elements as well as special features of the situation. Consequently, Enemy Order of Battle and Situation Features information are the basic Situation Data element affected by the receipt of an intelligence report. Derivatively, Target Engagement information and Situation Representation elements may require alteration based on information received in intelligence reports. Particular updating procedures vary depending on the content of the intelligence report (force elements versus situation features). Before presenting these procedures, some complexities of intelligence updating must be discussed.

a. Complexities of Intelligence Updating and Their Treatment In INWARS

Updating the UOS in response to intelligence reports is a more complex process than that previously described for status reports. The principal cause of this additional complexity arises from incompleteness of the data and more specifically, from uncertainity regarding the identity of the enemy force element being reported on.

The nature of this problem can be clarified by contrasting it with status report updating. When a C^2I element receives a status report, the exact identity of the reporting force element is known perfectly; consequently, the C^2I element knows exactly which subordinate force element data block needs revision. By contrast, enemy force element reports will typically be fragmentary and, in particular, will not generally contain exact identity information. Consequently, the C^2I element must infer which enemy force element EOB information block needs revision. These inferences must be based on information in the report, e.g., type and level of command, location, and so forth, and is further complicated by the fact that the report may concern a new enemy force element, one not yet having an EOB information block.

The identification process is clearly a complex inference process. For this reason, it has been decided to follow the possibility suggested in the Level II Specifications, namely, to include, as a part of each inelligence report, exact identity information on any enemy force elements involved in the report. This exact identify information will take the form of the "internal" model name of the unit. C^2I elements will thus be able to use this information to correctly determine whether information in a newly received intelligence report should be "read" into an existing EOB block (and, if so, which one) or whether a new EOB block needs to be created.

As was noted in the Level II Specifications, this approach to the identification problem "sidesteps" a major source of uncertainty in the overall C^2I processes. However, in view of the complexity of the problem, it is not clear that a more elaborate treatment would add significantly to the realism of the model within reasonable run time and storage constraints. In any event, it is felt that the suggested approach provides a reasonable starting point for Basic INWARS.

b. Updating in Response to Enemy Force Element Reports

Upon receipt of an intelligence report concerning an enemy force element, the C^2I element will scan its Enemy Order of Battle (EOB) information blocks to determine if it already has some information concerning the particular force element. (This is where the exact identity information is made.) If no information currently exists, a new EOB block will be created. Once an enemy force element report has been correlated with a new or existing EOB data block, the updating process proceeds much as in the case of status reports: information in the report will be "read into" the EOB data block and revisions will be made to aggregated information in higher echelon EOB data blocks as appropriate.

An additional consideration in processing Enemy Force Element Reports is the target acquisition and engagement aspect. In particular, the enemy force element information may need to be introduced not only into the intelligence-oriented EOB blocks, but also into the Target Engagement Information blocks. Thus, for example, if the C^2I element determines that the report concerns a new enemy force element, it must then decide whether that element is sufficiently identified and located to be treated as an acquired target. In fact, even if the report concerns an already identified force element, it will still be necessary to determine whether the element warrants treatment as an acquired target. Generally speaking, this decision will be made on the basis of the source of the information. If the report is from a maneuver element, it will be regarded as suitable for inclusion in the Target Engagement information blocks (provided the report includes appropriate type and location information). However, if the report comes from an intelligence collection agency (i.e., a PHOTINT or SIGINT element), then its inclusion will be determined by comparing the value of its "acquired strength" perception on that force element to "targetability" threshold. For example, it may be that force elements identified by PHOTINT and SIGINT agencies will be considered "targetable" if the acquired strength value exceeds .80.

c. Updating in Reponse to Situation Feature Reports

Upon receipt of an intelligence report concerning a situation feature such as enemy force concentration or nuclear/chemical indicator, the C^2I element will create a Situation Feature information block (see Figure II-4), above) and fill it with the newly received information. Note that there will be no attempt to correlate newly received situation features information with existing situation features blocks. As with enemy force element identification, it is felt that the complexity of such correlation processes would be difficult to treat within reasonable run time and storage space limitations. Derivatively, situation feature reports may cause certain elements in the Situation Representation to be updated. A typical example of this is revising the nuclear/chemical threat indices in response to reports of nuclear or chemical activities.

3. Updating in Response to Requests

Requests received from subordinate or adjacent force elements specify support desired by those elements; this may concern reinforcement, fire support, close air support, logistics support, or information support. The receipt of a request will always trigger control actions to consider whether or not to respond to the request (and perhaps, the degree to which the request will be satisfied). Additionally, however, requests implicitly provide information about deviations between planned support allocations and actual support requirements. Accordingly, requests may be used to adjust support allocations for future periods. Such adjustments will be made in the Own Operations information elements of the Situation Data component.

4. Updating in Response to Directives

Directives received from superior C^2I elements prescribe general missions, objectives, and operating constraints which guide the recipient's operations and activities. Such directives will be inserted into the Own Operations component of the Situation Data. This, in turn, will trigger operations development processes at the C^2I element to develop directives for subordinate force elements as discussed in Chapter IV below.

C. UPDATING THE UOS DURING SELF-SCHEDULED REVIEWS

The preceding section described the specialized basic and derivative updating procedures by which C^2I elements interpret messages. It should be noted, however, that the derivative updating procedures did not generally alter Situation Representation information such as force balance or force configuration. Rather, Situation Representation information will be updated during "reviews" scheduled by the C^2I elements themselves. (This is a change from the Level II Specifications and reflects a design decision to minimize run-time by reducing the number of occasions upon which the relatively complex force balance and configuration computations will need to be executed.) These reviews will also provide the C^2I element with the opportunity to monitor the situation for operationally significant changes as discussed in Chapter V, below.

These internal reviews will be scheduled to occur on a periodic basis. The interval between reviews will depend on the level of command with longer intervals being associated with higher levels of command. During each review, the C^2I element will: (1) update the Situation Representation component of its UOS, (2) purge aged information from the Situation Data component, and (3) formulate requests for information from subordinates. Additionally, certain command and control activities may be initiated during these reviews. These review procedures will not be presented in more detail.

1. Updating the Situation Representation Component

At each review, ground C^2I elements will recompute Force Balance and Force Configuration information on the basis of particular strength and position information contained in the Situation Data component at the time of the review. Air C^2I elements will recompute the air superiority information and access the ground force balance information from the corresponding ground force element. Both static and dynamic aspects of these representations will be recomputed as described in Chapter II. The new values will then be compared with appropriate operational thresholds as a part of the monitoring process.

2. Purging the Situation Data Component

At each review, C^2I elements will survey selected Situation Data information blocks to identify blocks whose information has aged past its "useful life". The age of a particular block will be determined by subtracting the perception time indication in the block itself from the current time (i.e., the time of the review). If this block age exceeds a "useful-life" threshhold, the block will be purged from the UOS.

Types of Situation Data blocks surveyed will include: (1) Enemy Order of Battle blocks (Figure II-3), (2) Situation Features blocks (Figure II-4), and (3) Target Engagement Information blocks (Figure II-5). Different "useful-life" thresholds will be set for each of these types of information to reflect their relative volatility. (For example, Enemy Order of Battle information would have a longer useful life than Target Engagement information.)

3. Formulating Requests for Subordinate Information

It will have been noted that the purging process just described does not survey information blocks concerning the C^2I element's own status and operations. Of course, such information can become aged due, e.g., to communications delays. However, the appropriate C^2I action here is not to purge the data but rather to request new data from the appropriate subordinate. Thus, at each review, C^2I elements will survey Own Status and Own Operations blocks to identify such information needs (again by comparing block age with a suitable "useful-life" threshold). Appropriate information request messages will be formulated and transmitted in an attempt to satisfy these needs.

This method of identifying information needs could easily be extended to other types of Situation Data as well. Moreover, it could provide the basis for formulating collection taskings to controlled collection agencies (i.e., the PHOTINT and SIGINT agencies discussed in Volume IV, Chapter III). For example, two age thresholds could be associated with Enemy Order of Battle and Target Engagement data. The first threshold would be lower and, when breached, would cause the C^2I element to attempt to get more information, either by request or collection directive. The second threshold would correspond to the useful life threshold and, when breached, would cause that information to be purged. Such extensions will not, however, be implemented in Basic INWARS in the interest of reducing running time.

CHAPTER IV
GROUND OPERATIONS DEVELOPMENT

A. INTRODUCTION

A principal group of operational decisions made by commanders at all levels concerns the development of operations to accomplish missions assigned by higher level commanders. In reality, these operations development decisions occur in a complex, continuing planning process involving coordination among superior and subordinate commanders. Within this planning process, receipt of an operations order or plan from a superior commander acts as a stimulus to develop operations order or plans to guide the operations of subordinate commanders. In a somewhat abstract sense, operations development can be regarded as a transformation of a directive, received by one level of command, into a coordinated system of directives for the next lower level of command (See Figure IV-1). It is in this sense that the development of operations will be represented in INWARS, i.e., as a successive transformation of operations directives, received by one level of command, into systems of more detailed and specific operations directives sent to the next lower level of command.

Some changes have been made in the treatment of ground operations development presented in the Level II Specifications. The overall "philosophy" of operations development as a top-down process of conceiving the operation, detailing it to "fit" the situation, and finally implementing it, has been retained. However, the particular procedures involved in accomplishing these activities have been altered and further articulated. Most significantly, they have been more highly structured by the introduction of a information structure which represents a generic "operational concept". As discussed in more detail in Section B below, this information structure mediates the transformation of operations directives from superiors into systems of operations directives for subordinates, and is retained to assist in the execution and control of the operation. Besides featuring a better structuring of operations development activities, the generic

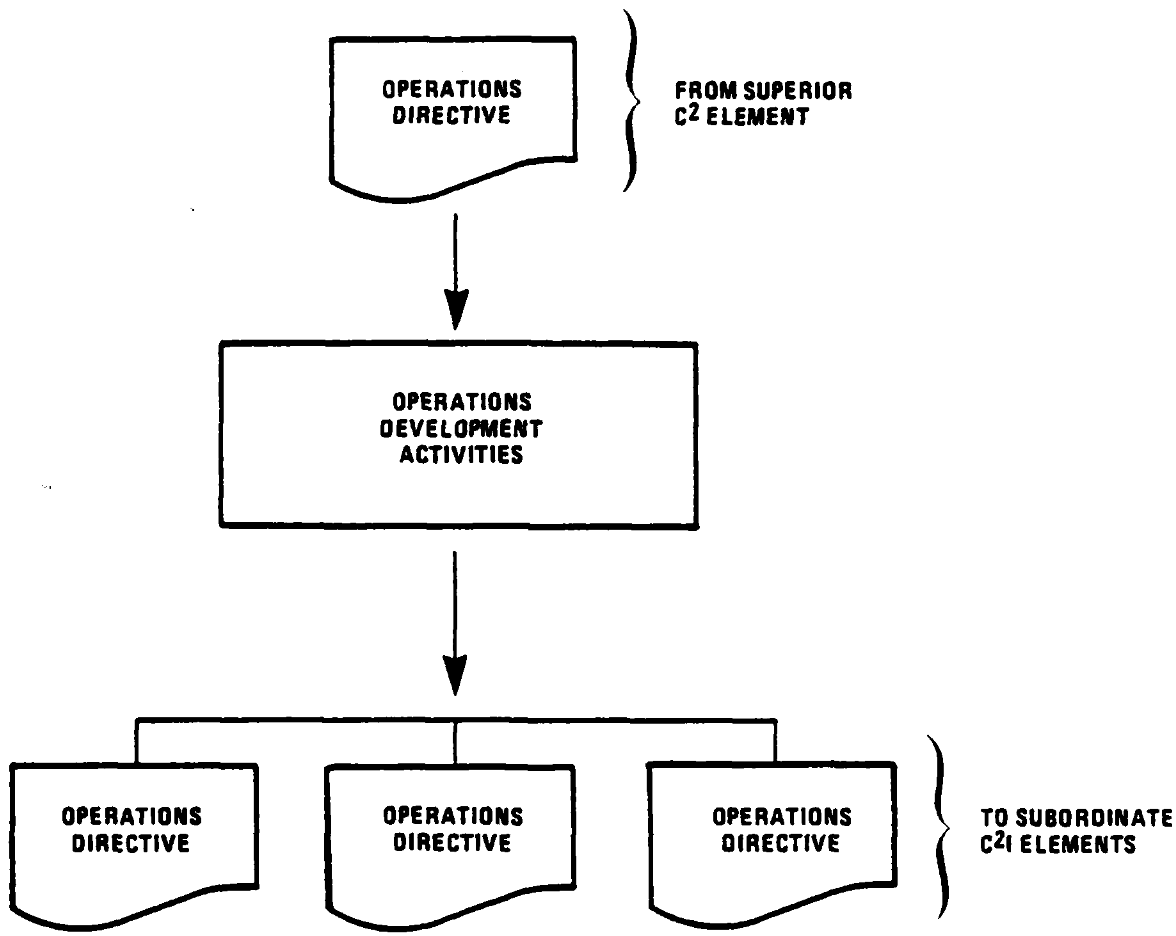


Figure IV-1. Operations Development by a C^2I Element as a Transformation of a High-Level Operations Order into a Coordinated System of Lower-Level Operations Orders operational concept structure permits a more standardized treatment which will facilitate changes via data (as opposed to "recording").

Although there will be no attempt to emulate the actual planning processes of command/staff groups, it appears that the representation generally follows the flow of the planning sequence as described in the doctrinal literature. Moreover, the specific decisions and considerations involved in conceiving an operation and detailing it to the situation will also be guided by doctrine. It might also be noted here that this overall representation exploits the breadth and generalized nature of operation planning at higher echelons. For example, breadth limits the number of distinct concepts which need to be considered at higher levels--variations within a concept are worked out as the concept is detailed to fit the situation.

B. INFORMATION STRUCTURES ASSOCIATED WITH GROUND OPERATIONS DEVELOPMENT

As a transformation of a higher-level operations directive into a system of lower-level operations directives, operations development involves two basic types of information structures. The first of these is, of course, the operations directives themselves whose structure and content are described in Section 1 below (along lines presented in the Level II Specifications). The second is a more complex information structure which is intended to represent the generic form of a concept of operation. This operational concept structure is described in Section 2 below.

1. Structure of Operations Directives

From the point of view of the INWARS representation, "operations directive" refers to a data structure containing information which guides the operations of a force element (players or entities). Consequently, the structure and composition of operations directives will vary depending on the type of force element it is intended to guide. Essentially, an "operations directive" in this sense corresponds to a particular subordinate's "slice" of a complete operations order--it contains tasking, control, and resource allocation information to guide the operations of a single subordinate.

The basic structure of a ground player operations directive is exhibited in Figure IV-2. Note that there are four basic categories of information: (1) mission, (2) control measures, (3) resource allocations, and (4) operating thresholds. The particular elements of information in these categories will vary by level of command. Within INWARS, these ground player operations directives will provide a basic detailed planning structure which, when complete, can serve as a content block for a message.

2. Structure of a Concept of Operations

As presented in the Level II Specifications, operations development was structured around the creation and gradual elaboration of a system of operations directives to guide the operations of subordinates. However, it has become apparent that the operations directives themselves will not provide for all of the various information needed during the development of operations and their eventual execution and control. Accordingly, a new information structure has been developed to serve as an intermediate step between the receipt of an operations directive from a superior C^2I element and the formulation of operations directives for subordinates.

Intended to provide a means of representing "concepts of operation" such as envelopment, penetration, or mobile defense, this information structure will permit a more flexible ground operations development process and will also carry information about the operation for use during its execution. Each side will be provided with a set of concepts of operation. Each concept in this set will represent a particular type of operation. "Offensive" concepts will include: (1) envelopment, (2) penetration, and (3) frontal attack. "Defensive" concepts will include: (1) mobile defense, (2) position defense, (3) delay, and (4) withdrawal.

Taken as a whole, the set of concepts represent the broad alternatives open to a C^2I element in developing an operation. At this level, however, the concepts in the set may be regarded as "abstract" in the sense that many elements of information in the structure are not filled with specific values. These "open" elements are filled in by a C^2I element during operations development as it "fits" the abstract concept of operation

MISSION
("Attack", "Defend", etc. with appropriate modifiers such as "Main", "Supporting", etc.)
CONTROL MEASURES
OBJECTIVE AREAS (Specific terrain regions) REGION OF OPERATIONS (Specified as a quadrilateral) TIMING (Start and end times for this operational phase)
RESOURCE ALLOCATIONS
REINFORCEMENTS (Assignment) INDIRECT FIRE SUPPORT (Support mission assignment and priorities) TACTICAL AIR SUPPORT (Sorties by type and priorities) NUCLEAR/CHEMICAL WEAPONS (Allocations and assignments) LOGISTICS SUPPORT (Desired supply rates)
OPERATING THRESHOLDS
LOSSES (Upper total and rate) MOVEMENT (Upper and lower movement rate) SUPPLIES (Lower stockage level and upper consumption rate)

Figure IV-2. Ground Player Operations Directive Format to the particular situation it faces. Thus, the process of operations development may be characterized as the selection and refinement of an "abstract" concept of operation into a specialized concept of operation, and then into a system of particular operations directives for subordinates.

As depicted in Figure IV-3, a concept of operation has six component structures: (1) a list of suitability requirements, (2) a list of information requirements, (3) a list of contingency indicators, (4) a "region layout" structure, (5) an "operation description" structure, and, (6) an "operations form" structure. Each of these components is described briefly below. The role of each will become clearer as the operations development process is described over the sequel.

a. Suitability Requirements

The list of suitability requirements is intended to represent the various conditions which must be satisfied in order for a C^2I element to even consider utilizing a concept of operation in a particular situation. Commensurate with the abstract character of the concept structure, each suitability requirement concerns a broad condition. For an envelopment concept, a typical suitability requirement might be "subordinate force balance $\geq t$ for left-most (or right-most) subordinate," to reflect the requirement for a relatively "open" outside sector. For a mobile defense concept, a typical suitability requirement might be "at least one subordinate with strength $\geq p$ in reserve status" to reflect the requirement for an effective counterattack force. In effect, each suitability requirement identifies a particular assessment procedure to be applied to the situation; within the model, each requirement will cause an appropriate subroutine to be applied to the data in the UOS. The subroutine will then return with an indication of whether or not the suitability requirement is satisfied in the (perceived) situation.

b. Information Requirements

The list of information requirements represents the information needs appropriate to the given concept. Each information requirement is associated with a particular operational region (see below, paragraph B.2.f) and indicates the relative effort to be devoted to obtaining infor-

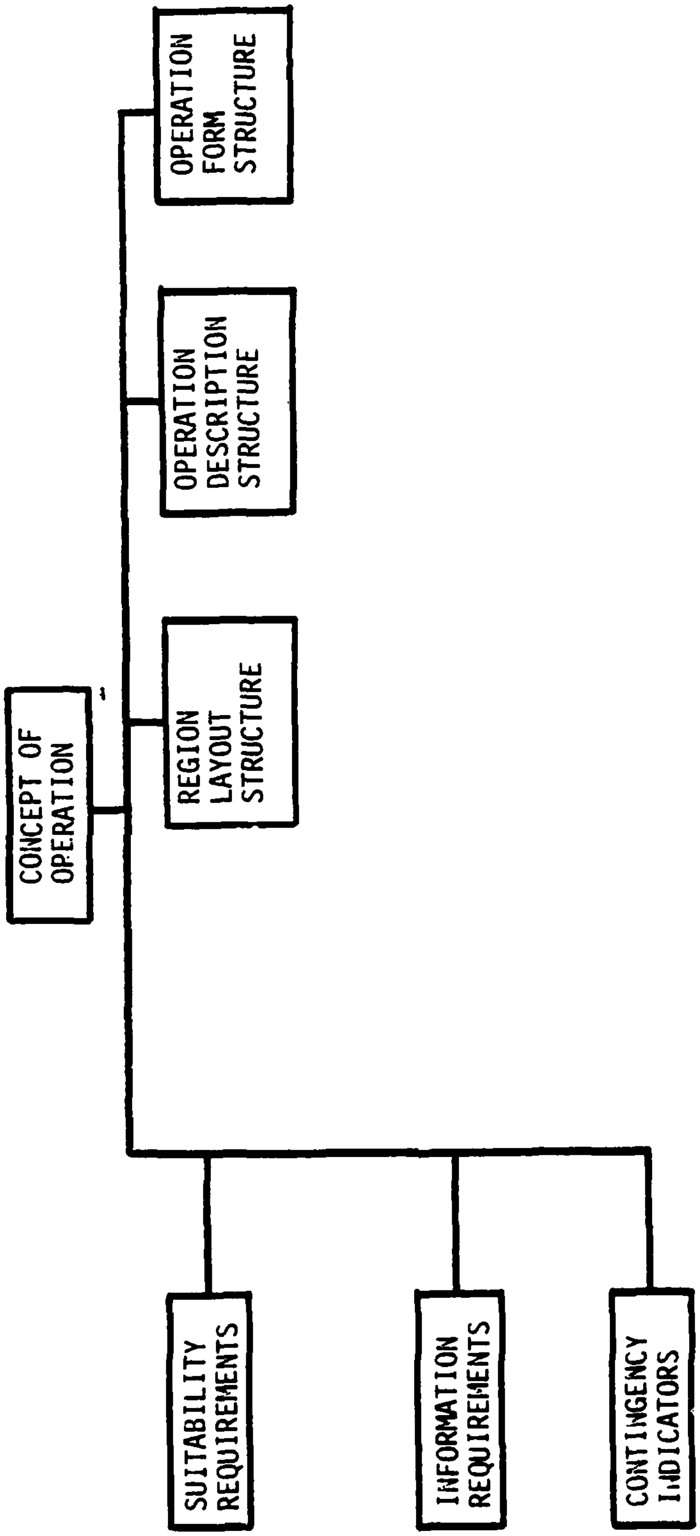


Figure IV-3. Concept of Operation Structure mation about enemy forces in the referenced region. Each requirement can thus be directly translated into a collection tasking for an intelligence collection agency (as discussed in Volume IV, Chapter III, Section D.1).

c. Contingency Indicators

The list of contingency indicators represents particular problems or opportunities to be "watched for" during operation execution and control. As is discussed in more detail in Chapter V, below, some contingencies are of concern in the execution and control of any operation (e.g., force imbalance, or nuclear/chemical threat increase). However, certain contingencies are irrelevant to some operations (e.g., penetration of a defensive line is irrelevant to the conduct of offensive operations). This list of contingency indicators provides a means to reflect these differences. Specifically, only those contingencies indicated in the list of a particular concept of operations need be "watched for" during the conduct of such an operation.

d. Region Layout Structure

The region layout structure represents an abstract partition of the overall region of operations into subregions of significance to the operation. If an envelopment is being planned, the region of operations will be analyzed differently than if a frontal attack is being developed. In the former case, one operationally significant region is a long and probably somewhat narrow "corridor" running up (one or both) sides of the overall region of operations, in the latter case, however, no such corridor would be of concern. The region layout associated with a particular operational concept reflects a view of the terrain appropriate to that concept.

The region layout structure consists of a set of labelled regions together with suitably coded spatial interrelationships among the regions. The structure is abstract in that the specific positions of the regions are "open" and must therefore be set by the C^2I element during operations development (as discussed in Section E.1 below).

e. Operation Description Structure

The Operation Description structure is an array of parameters used in the development, execution, and/or control of an operation. Typical parameters might include force balance thresholds at which some control action is required, and a system of target type priorities to guide target engagement activities. The exact contents of the operation description will be determined on the basis of the particular heuristic decision procedures to be employed. However, the parameters contained in the Operation Description structure of a particular concept of operation may be peculiar to that operation. For example, force balance thresholds characterizing a problematic force imbalance would vary between offensive operations and defensive operations. The Operation Description structure of an operational concept is the mechanism through which such differences will be represented in INWARS.

f. Operation Form Structure

The Operation Form structure is perhaps the key component of a concept of operation in that it abstractly specifies "who must do what when" in the overall conduct of the operation. Structurally, an operational form is a collection of nodes (role nodes, phase nodes, and operation nodes) linked into a matrix-like structure as shown in Figure IV-4. The "rows" in the structure are indexed by particular role nodes and the "columns" by particular phase nodes; the "cells" or operation nodes in the matrix are there inherently associated with both a role and a phase. The specification is abstract in that: (1) no units are associated with the roles, (2) no timing is associated with the phases, and (3) no specific objectives are associated with the goals. Hence, the operational form only specifies the interrelations, not the specifics.

1) Role Nodes

Each role node abstractly specifies a certain function to be performed by some force element in the conduct of the operation. "Main attacker", "supporting attacker", and "reserve" are example roles. The particular role nodes included in the operation form structure are peculiar to that concept. Role nodes are abstract in that the particular

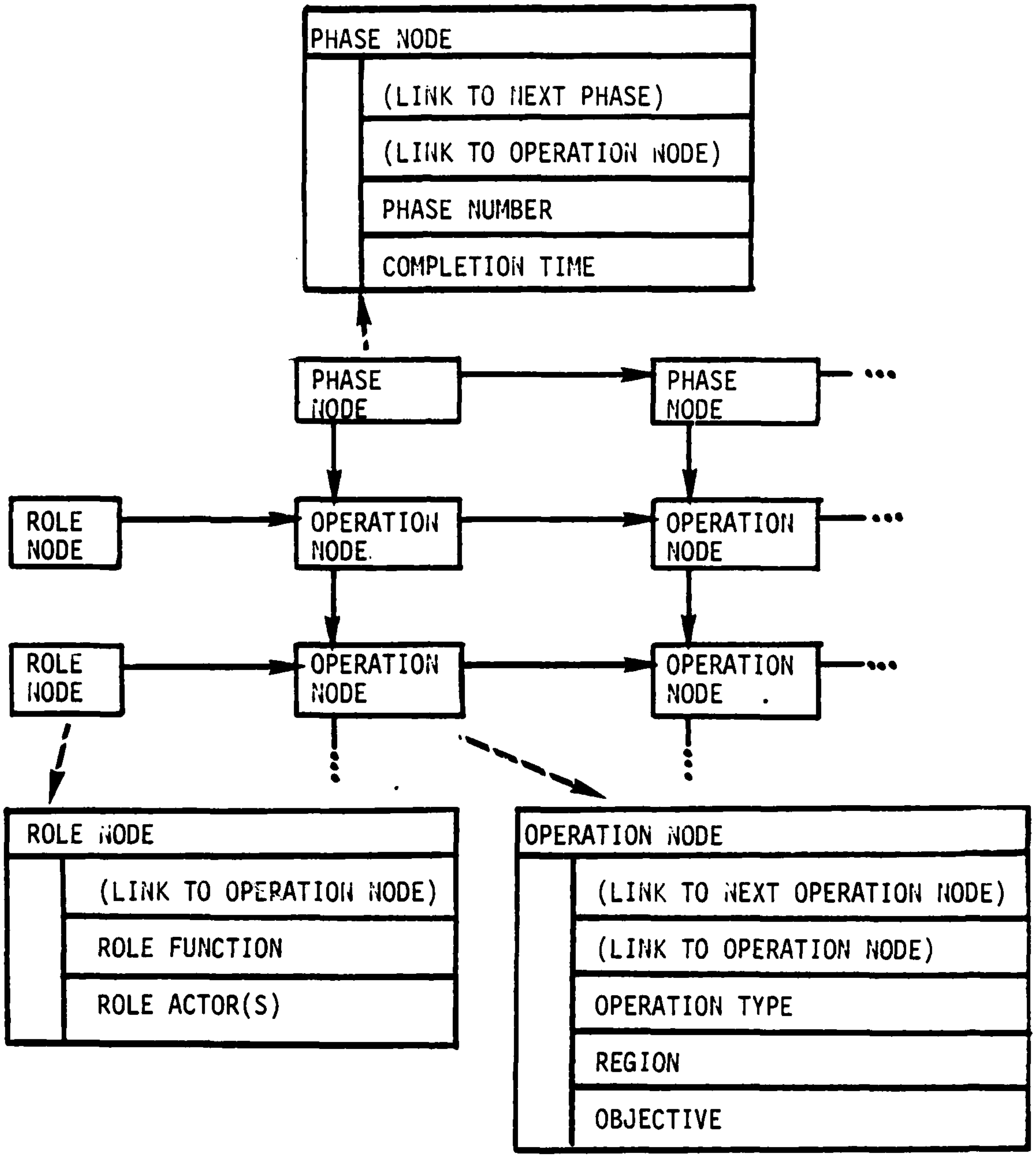


Figure IV-4. Operation Form Structure

force element serving the role is "open" and must be set during operations development (as discussed in Section E.3, below).

2) Phase Nodes

Each phase node abstractly specifies a particular segment in the overall conduct of the operation. Phasing is needed because the scope, duration and complexity of higher level operations typically prevent a command/staff group from forecasting its exact progress from start to finish. Phases decompose the overall operation into small "sub-operations", which can be effectively developed and executed by subordinates. In actual conflict situations, the decomposition of an operation into phases, is one of the most complex aspects of operational planning; it is here that the commander's visualization of the operation is most pertinent in determining allocation of forces, points at which new actions may be initiated, and major force regroupings which may be required. In INWARS, this process will be represented only to the extent that a sequence of phases peculiar to the operation will be included in the operation from structure.

Phase nodes are abstract in that their completion time is "open" and must be set during operations development (as discussed in Section E.4, below).

3) Operation Nodes

Operation nodes constitute the "cells" of the matrix-like operation form structure, and are accordingly associated with both a role and a phase. Each operation node specifies what the associated role should be doing and where it should be during the associated phase. Key contents of the node accordingly include a type of operation (move, attack, defend, withdraw, and so forth), a reference to a region in the region layout structure, and an objective. The operation type is essentially a reference which can access a range of appropriate planning factors as will be seen in the discussion of the operations development process. Objective nodes are abstract in that particular objectives (i.e., hexes) are open and must therefore be set during operations development (as discussion in Section E.2, below).

C. STRUCTURE OF GROUND OPERATIONS DEVELOPMENT

This section surveys the general structure of the ground operations development in INWARS, i.e., the types of processes involved and their sequencing. The individual processes will be discussed in more detail in the remaining sections of this chapter. As will be seen, there is a similarity between the present structure and the three-stage "conceive-detail-implement" structure proposed in the Level II Specifications.

1. Initiation of Ground Operations Development Activities

Operations development activities will be initiated by ground C^2I elements in response to the receipt of an operations directive from their parent C^2I element. In addition, operations development activities may be undertaken in response to the occurrence of certain contingencies over the course of an ongoing operation. Generally, these "self-initiated" development activities will not involve radical departures from ongoing operations but will rather be oriented towards limited adjustments to ongoing operations such as generation of a counterattack operation in response to a developing penetration.

In either case, the ground operations development activities will be conducted within the context of an existing operations directive from the C^2I element's parent. This will provide the frame of reference--overall mission, objectives, controls and resources--to guide the C^2I element's development activities.

2. The Ground Operations Development Sequence

Ground operations development starts with an abstract concept of operation and refines it down to the point where specific operations directives for subordinates can be formulated and transmitted. The concepts are obtained from the set of concepts associated with the C^2I element's side. As indicated earlier, these concepts are organized on the basis of the type of operation (offensive or defensive). Within each type, the concepts are organized in order-of-preference from "most preferred" to "last resort".

The refinement process proceeds tentatively in stages. Each stage introduces an additional level of detail into the concept of operation (thus making it more specific). The concept is then appraised. If the appraisal is satisfactory (or if the concept is the "last resort"), the next refinement is conducted and the concept is again appraised. If at any stage the appraisal is unsatisfactory, that particular concept will be discarded and the refinement process "restarted" on a new concept of operation. It is in this sense that the process proceeds "tentatively". Of course, since the possible concepts of operation are limited, the "concept of last resort" may eventually be reached. As suggested above, the "concept-of-last-resort" implicitly "passes" every appraisal in order that some operation be developed.

The particular stages of refinement to be included in INWARS are as follows: (1) adapting a concept of operations for development, (2) developing the adopted concept, (3) detailing the developed concept, and (4) implementing the detailed concept. These are discussed in Sections D through G, respectively.

D. ADOPTING A CONCEPT OF OPERATIONS FOR DEVELOPMENT

As indicated above, each side represented in INWARS will have a set of concepts of operation organized into subsets associated with the type of the concept (offensive concepts versus defensive concepts). The concepts of given type will be organized as a list which is ordered in terms of doctrinal preference. For example, doctrine prescribes that, within offensive operations, an envelopment is preferred to a penetration which, is in turn, preferred to a frontal attack (the offensive "concept-of-last-resort"). Moreover, doctrine typically associates with each concept of operation a collection of "suitability requirements" which indicate when that concept is appropriate to the situation. Each such requirement is included in the list of suitability requirements discussed in Section B.2.a above.

These concepts of operation are the starting point in the ground operations development process. In INWARS, concepts of operation will be adopted--not developed--by C^2I elements from the doctrinally specified set associated with their mission. Thus, a C^2I element developing an attack operation will adopt either envelopment, penetration, or frontal attack. A tentative adoption will be made on the basis of the relative doctrinal preference and the suitability requirements: the concepts of appropriate type are sequentially examined in order of preference until one is found which is suitable in the particular situation. This concept is then tentatively adopted for further development. More specifically, the first (most preferred) concept in the appropriate list is accessed and its suitability requirements are appraised. If all suitability requirements are satisfied, this first concept is tentatively adopted. However, if one or more of the suitability requirements are not met, the next concept on the list (i.e., the second-most preferred) is accessed and its suitability requirements are assessed. This process is continued until a concept of the appropriate type is found whose suitability requirements are all satisfied or until the last concept in the list is reached (the "concept of last resort"). Note, that some concept will always be adopted. Its identity is then recorded for use in the next step of the operations development process.

Within the model, the significance of tentatively adopting a concept of operation is the guidance and structuring it provides for the remaining steps in the operations development process. In general, adopting a particular concept of operation implies: (1) a spatial and temporal configuration of subordinate objectives; (2) an associated configuration of subordinate missions; (3) certain requirements for combat power and support; and (4) a potential for certain future contingencies (problems and opportunities). This reduces the range of employment options and alternatives.

Since a concept of operation is adopted on the basis of gross considerations of suitability, it may turn out to be inadequate on more detailed development. It is in this sense that adoption will be treated as tentative or provisional. Thus, if inadequacies in the adopted form of maneuver appear in subsequent development, it can be "revoked". Should this occur, the operation conception process will "backtrack" to adopt a new form of maneuver.

E. DEVELOPING THE ADOPTED CONCEPT OF OPERATION

The concept adopted in the first stage of the ground operations development process is still "abstract" in that operationally significant regions, units, objectives, and phase completion times have not yet been specified. The next stage in the process specializes the abstract concept by specifying these elements of information.

1. Specifying the Regions

The first step in developing a concept of operation is "fitting" it to the ground. As a part of the operations directive received from the present C^2I element, a particular region of operations will have been assigned. Moreover a structure of operationally significant subregions will be included as a part of the concept of operation selected for development (recall Section B.2.f above). Within INWARS, "fitting the concept to the ground" involves defining a set particular subregions which position the assigned region of operations according to the structure specified in the concept.

This will be done in a very simple fashion which essentially uses the region layout structure as a "template" to breakup the particular region of operations into corresponding specific subregions. Defining parameters of the subregions will then be recorded in the spaces provided in the region layout. Note that this process does not include consideration of terrain features or force element positions: the aim at this stage is merely to establish a specific partition of the overall region of operations into subregions which are operationally significant in the concept of operation.

2. Assigning Objectives to Roles

Once the particular regions implied in the concept have been specified, it becomes possible to assign specific objectives to the roles of the concept on a phase-by-phase basis. These objectives are stated in terms of particular hexes, and are entered into the concept's operation form structure.

Overall, the assignment of objectives is carried out on a role-by-role basis. Within each role, objectives are assigned on a phase-by-phase basis starting with the last phase and working backward through the operations nodes to the first phase of the operation. The actual assignment process is based on the fact that each operation node is already associated with an abstract region (as described in B.2.e(3) above). However, now that the regions have been specified, each operation node has become associated with a specific region. Hence, specific hexes may be selected as objectives within the associated region. This process will distribute specific hex objectives toward the "forward" or "trailing" edge of the region depending on whether an offensive or defensive operation is being developed. If a single region is involved in more than one phase, the additional hex objectives will be distributed within the region to provide an orderly progression of the operation.

3. Assigning Force Elements to Roles

The next step in developing the adopted concept is to assign specific maneuver force elements to fill the roles specified in the concept of operation. This involves, for example, determining the main attacker, the supporting attackers, the reserve, and so on in the operation. An initial assignment is made by comparing the current positions of the subordinate maneuver elements with the specific regions now associated with the roles. If a single subordinate is in the region associated with a particular role, that subordinate will be assigned to the role. If more than one subordinate is in the region, a selection will be made based on the nature of the role. For example, the stronger of the two units would be assigned to a main attacker role while the weaker would be assigned to a supporting attacker or reserve role.

Once the initial assignment is made, it is assessed against desired force balance ratios associated with the various roles. Reinforcements on hand or available (i.e., specified in the operations directive received from the parent C^2I element) will then be associated with the subordinates to ameliorate force balance deficiencies as much as possible. (These associations will be translated into specific assignments later in the development process--see Section F.3.a below.)

This process may seem to be a rather arbitrary method of filling the roles in a concept of operations. However, in appraising the general suitability of the concept, it will have been established that there are no serious conflicts between role locations and specific force element positions. Otherwise, the particular concept would not have been selected for further development. Thus, for example, if a "right-envelopment" is the concept under development, the suitability requirements will have insured that in the "right side" of the region of operations an effective subordinate has a "reasonable" balance of forces against enemy force elements. It should also be noted that this assignment process reflects the real limitations on commanders at echelons above division where the sheer size of the units involved prevents radical repositioning to "set up" a particular operation.

4. Assigning Phase Completion Times

The final specification which must be made to specialize the abstract concept concerns the completion times of the various phases in the operation. Now that particular objectives are associated with particular force elements, this can be done on a phase-by-phase basis. Starting with the first phase, the times required by each role to achieve their objective for that phase are estimated (as described below). The longest of these times is then added to the start time of the overall operation (as specified in the operations directive from the parent C^2I element) to estimate the completion time of the first phase. The role associated with the longest of the completion times is also identified as the "critical" role for that phase. This process continues on through all phases in the concept. Note that the estimated completion time of the final phase may or may not correspond to the operation completion time specified in the operation directive from the parent C^2I element. Comparison between these two times provides the basis for appraising the concept as discussed below.

To estimate the time required by a particular force element to accomplish a particular objective, an "adjusted planning factors" approach similar to that described in the Level II Specifications will be used. Specifically, planning factors for general advance rate of subordinates (as a function of force balance) will be used to estimate the times required for a force element to traverse the distances between its objectives. Figure IV-5 presents a numerical example of this phasing process.

This "adjusted planning factors" phasing method is only sensitive to the general features of the situation. It does, however, provide a means to make the necessary phasing determinations in a way which is not unreasonable. Moreover, other adjustments may be introduced during experimentation and refinement to enhance sensitivity to the situation.

5. Appraising the Developed Concept

As indicated above, the time specified by the parent C^2I element for the completion may not match the estimated completion time for the last phase. A comparison of these two times provides a natural way to appraise how well the specialized concept "fits" the situation. If the estimated time to completion is significantly larger than the specified time to completion, the specialized concept will be revoked. A new abstract concept will then be adopted and subjected to development and specialization as just described. Otherwise, the specialized concept will be considered "viable" and will be subjected to further development (detailing) as described in the next section.

F. DETAILING THE DEVELOPED CONCEPT OF OPERATION

The general suitability and viability of a concept of operation will have been established over its development. Moreover, a considerable amount of information regarding the application of the concept in the specific situation will have been generated. The next step in the operations

PHASE TIME PLANNING DATA

1. EXPECTED SUBORDINATE

ADVANCE RATE (PLANNING FACTOR) 20 KM/DAY

2. FORCE BALANCE ADJUSTMENT FACTORS:

FORCE BALANCE	SCALING FACTOR
7:1	1.3
6:1	1.1
5:1	1.0
4:1	.7

SITUATION

1. DISTANCE TO NEXT OBJECTIVE: 30 KM

2. FORCE BALANCE IN REGION OF OPERATION: 6:1

ESTIMATE OF TIME TO ACCOMPLISH NEXT OBJECTIVE

DISTANCE/ADJUSTED ADVANCE RATE =

30 KM/(1.1 X 20 KM/DAY) = 1.4 DAY

Figure IV-5. Example of Time Estimating Process development process is detailing the concept. Its function is to determine the specific missions, control measures, resource allocations, and operating thresholds necessary to implement the first phase of the operation. Preparation of subordinate maneuver element operations directives (Figure IV-2) provides the vehicle for accomplishing this stage, i.e., detailing involves transforming the concept of the operation into operations directives specifying missions, control measures, resource allocations, and operating threshholds. The specification of each of these elements is discussed below. Detailing concludes with another appraisal, this time of the specific allocations of resources as discussed in Section F.5 below.

1. Missions

Missions for subordinate maneuver force elements are based on the roles played the respective elements. The particular mission type (main attack, supporting attack, etc.) is extracted directly from the operation node associated with the role and phase.

2. Control Measures

Control measures are essentially determined by the operation form and region layout structures of the specialized concept of operation. Objectives are extracted directly from the operation nodes associated with the given role and phase. Regions of operation are extracted from the region layout structure via region references contained in the operation node associated with the given role and phase. Timing is determined by reference to the phase completion times stored in the phase nodes of the operation form structure (this includes both start times and end times).

3. Resource Allocations

Resources which must be allocated among subordinate force elements include: (1) reinforcements, (2) fire support (including artillery and tactical air sorties as well as nuclear and chemical planning guidance), and (3) logistics support (supplies and replacements). The particular allocations are based on desired levels or rates associated with the types of operations to be conducted by the subordinates. The type operation for a given force element is extracted from the operation node associated with that force element's role and the phase being detailed. It is then used to reference into appropriate resource allocation information tables.

a. Assignment of Reinforcements

Any assignments of reinforcements "on hand" will have already been worked out during the development of the concept as described in Section E.3 above. These are then simply recorded in the appropriate section of the operations directives for the subordinate force elements to which the reinforcements are assigned. A reinforcement priority indicator will also be set for that force element which has been marked as "most critical" in terms of completion time for the phase being detailed.

b. Allocation of Artillery Resources

Allocation of artillery involves two distinct allocations: (1) the allocation of newly received "reinforcement" artillery units (if any) and (2) allocation of artillery support from an organic artillery unit (e.g., corps artillery). Both allocations are based on desired levels of artillery support for each subordinate looked up from a table on the basis of the type of operation that subordinate is conducting in the phase being detailed. These desired levels will be expressed in terms of artillery battalions in direct support. Reinforcing artillery units (if any) will first be allocated against these requirements. This will take the form of direct attachments. If the desired support levels are not filled (in particular, if there were no "reinforcing" type artillery units), artillery units organic to the C^2I element (if any) will be assigned direct support (DS) missions. Any remaining organic artillery will be assigned GS missions.

c. Allocation of Tactical Air Support

Tactical air support will be allocated among subordinates on the basis of desired levels of support (goals) associated with operations. The desired levels of support for all subordinates will be "looked up" based on the subordinates' operations. These desired levels will then be converted into relative desired levels by a simple normalization. Fianlly, these fractional levels will be applied to the total sorties available as specified in the operation directive received from the present C^2I unit.

This results in an allocation of available tactical air support which is proportional to the desired level of support.

d. Allocation of Nuclear and Chemical Weapons

Nuclear and chemical weapons are "allocated" among subordinates in the sense of planning guidance only. That is, an allocation of nuclear or chemical weapons will only authorize the subordinate to plan to employ those weapons. It will not authorize the subordinate to use those weapons. Allocations will be "looked up" in a table based on the subordinates' role in the overall concept. These will then be scaled based on the planning guidance contained in the operations directive received from the parent C^2I element.

e. Allocation of Logistical Support

Logistical resources--supplies and replacements--will be allocated in a manner analogous to tactical air support. Desired rates of supply for each subordinate will be "looked up" based on the subordinates' operations. Desired rates of replacement will be determined based on the difference between the present strength of the unit (found in the UOS) and its desired strength ("looked up" from a table based on the unit's operation). In both cases, the desired rates will be normalized and then applied to the rates of issue which the associated combat source support complex can support. As with air support, this results in an allocation of available support which is proportional to the desired level of support.

4. Operating Thresholds

Operating thresholds provide guidance to subordinate force elements in the form of tolerances on losses, movement, and supply consumption. In effect, this guides the "intensity" with which the subordinates prosecute their individual operations. Additionally, these thresholds serve as control measures in that the force elements must report "out-of-tolerance" conditions to their parent C^2I element. Operating thresholds will be set for: (1) losses (an upper loss total and an upper loss rate), (2) movement (an upper and lower movement rate), and (3) supplies (a lower stock level and an upper consumption rate). These thresholds will be "looked up" for each subordinate from a table based on the type of operation that subordinate is conducting in the phase being detailed.

5. Appraisal of the Detailed Concept

The principal feature which must be considered in appraising the detailed concept is the allocation of the various resources. In most cases, these allocations were set by scaling desired levels down to available levels. It is thus necessary to check whether there will be sufficient support for the operation. This is done by simply comparing the actual allocations with the desired allocations (derived, as discussed above, from table "look ups"). Any significant shortages will cause the detailed concept to be revoked and operations development will be restarted with the adoption of a new concept. Otherwise, the detailed concept will be judged feasible and will be implemented as discussed in the next section.

During this appraisal process, total shortages will also be accumulated in the various categories. If the concept is deemed feasible, these total shortages will be translated into appropriate requests and then transmitted to the parent C^2I element.

G. IMPLEMENTING THE DETAILED CONCEPT OF OPERATION

The detailing of the developed concept of operation was conducted by preparing specific operations directives for the principal maneuver subordinates. These need only be appended as "content blocks" to appropriate message header blocks for transmission to the principal subordinates. However, operations directives for non-principal subordinates (artillery units, intelligence collection agencies, and combat service support complexes) must still be developed. These are directly formulated from the appropriate sections of the principal subordinates' operations directives and the detailed concept of operation.

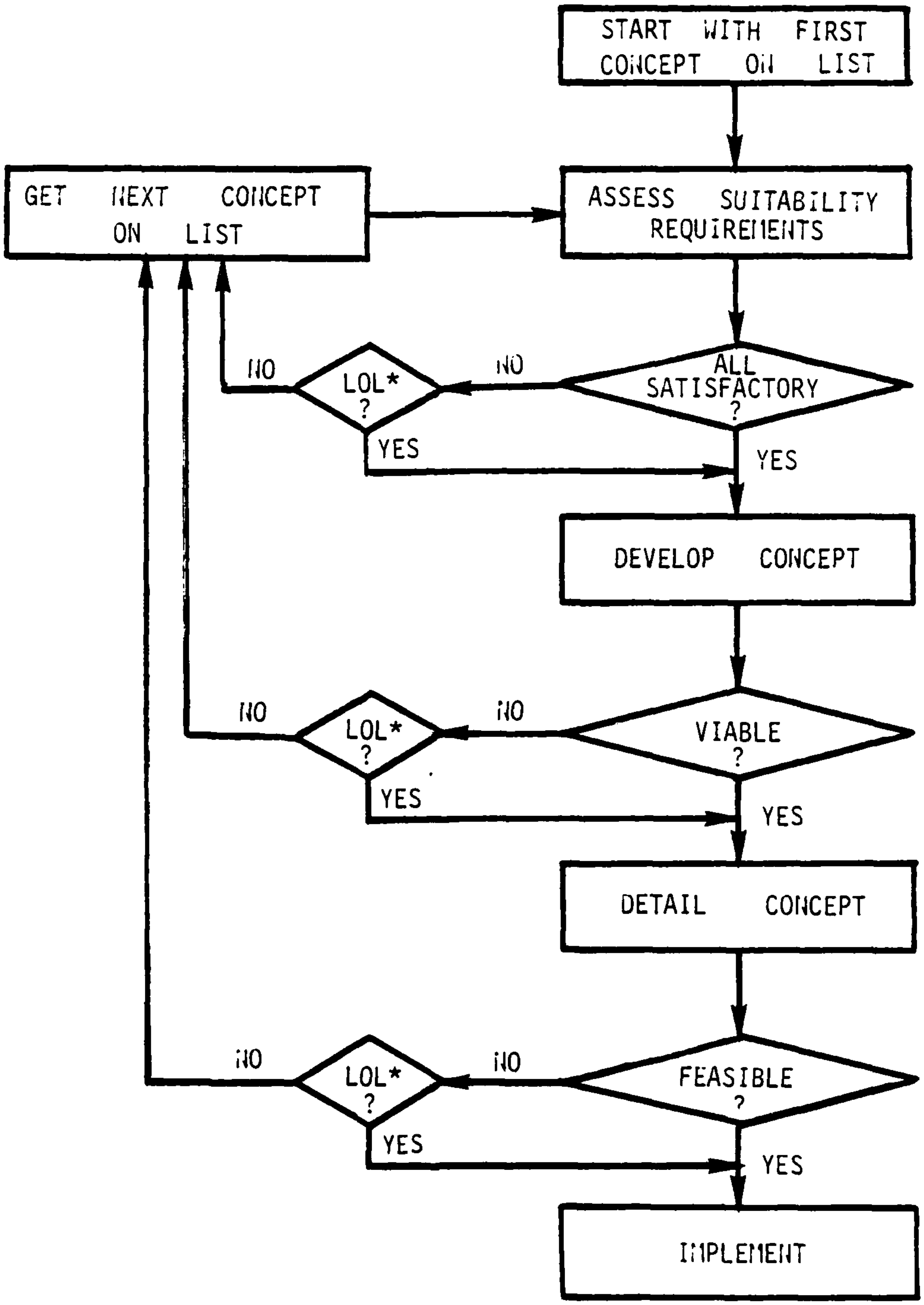
For example, the operations directive to the supporting combat service support complex will specify desired support rate guidance for all principal subordinates. But this information has already been specified in developing the logistics support resource allocations for principal subordinates. Thus, formulating the combat service support complex operations directive is simply a matter of extracting the appropriate rates from the principal subordinates' operations directives. In a similar manner, the information requirements list in the concept of operation provides the basis for collection taskings to subordinate (or, in the case of air, parallel) intelligence collection agencies.

In effect, then, the implementation of a detailed concept is largely a necessary but routine "bookkeeping" operation. It results in a set of operations directive messages for all subordinate force elements.

H. SUMMARY

As described above, ground operations development is essentially represented in INWARS as a sequence of broad "design-type" decisions. Figure IV-6 portrays the sequence in the form of a flow chart. Notice that within the sequence, each decision sets or restricts the context of the next decision. Even with the possibility of "backtracking" to reconsider earlier decisions, this general flow still admits of "suboptimization". Of course, in reality, command planning also admits of suboptimization. The queston, as stated in the Level II Specifications, is whether the INWARS representation will allow the development of ground operations which are so "obviously" or "unreasonably" suboptimal that they would never be adopted by a real command/staff group. This will be one of the key issues for the experimentation phase of the overall INWARS development program.

A range of refinements are possible to reduce the potential for suboptimization. Indeed, the ground operations development process described above admits a considerable growth potential in terms of refinements. Obviously, refinements will increase the complexity (and hence, resource requirements) of INWARS. It appears that the ground operations development approach described above is a reasonable starting point in the development program described above is a reasonable starting point.



LOL = IS THIS THE LAST CONCEPT ON THE LIST

Figure IV-6. Flow Chart Representation of Ground Operations Development

CHAPTER V
GROUND OPERATIONS EXECUTION AND CONTROL

A. INTRODUCTION

Besides operations development decisions, command and staff groups at all levels of command make a variety of operations execution and control decisions. These decisions are concerned with adapting the execution of the planned operation to the perceived situation as it evolves. Execution and control involves a continuous monitoring of the operations in order to identify emerging operational problems and opportunities. The identification of such a problem or opportunity, a contingency, raises the question of what to do about it. Thus, a response decision will typically be oriented around the contingency identified. Command and staff groups will not develop an entirely new operation in response to most contingencies; rather, they will attempt to adapt the ongoing operation to the contingency. This is especially true for the higher levels of ground command treated in INWARS: the size of these commands and the scope, complexity, and momentum of their operations will generally preclude frequent or radical changes. Of course, in certain cases, it may not be possible to adapt ongoing operations to an emerging contingency; likewise, radical changes in the situation such as the transition from conventional to nuclear operations may cause correspondingly significant changes in ongoing operations. Under such exceptional conditions, redevelopment of operations may be necessary.

The import of these observations for INWARS C^2I modeling is the emphasis placed on specialized responses to specialized situations as opposed to large scale redevelopment of operations. Ground operations execution and control in INWARS accordingly will be treated as a process of recognizing and responding to relatively specialized contingencies such as "force imbalance," "targeting opportunity," "nuclear threat change," and "penetration." Section B discusses the general structure of the monitoring, recognition, and response procedures by which contingencies will be represented in INWARS. Section C discusses the design and development of a complete system of contingencies for INWARS. Finally, Section D presents the specific contingencies to be included in Basic INWARS.

B. THE STRUCTURE OF OPERATIONS EXECUTION AND CONTROL IN INWARS

As suggested above, the operations execution and control activities of ground C^2I elements in INWARS will involve recognizing and responding to contingencies. "Contingency" is used here in the broad sense of a situation requiring some response in the form of changes to current operations; in other words, a contingency associates certain (perceived) situations with decisions concerning possible changes to current operations. Consequently, contingencies will be represented as a pairing of a recognition procedure with a response procedure. The recognition procedure essentially defines the contingency by specifying how to decide if it is present or developing; Thus, the recognition procedure provides a means of classifying perceived situations. The response procedure defines what types of changes (or other actions) should be considered as alternative responses to the contingency, and specifies how to select among these alternatives. It therefore provides a means of developing and tailoring a response to the contingency.

Operations execution and control activities are initiated by a ground C^2I element when it has developed and implemented an operation. The C^2I element will then monitor this operation by selectively activating contingency recognition procedures based on changes in its UOS. (See Section 1 below). Once activated, a particular recognition procedure will consider information in that element's UOS and may accordingly recognize the associated contingency. (See Section 2 below). If the contingency is recognized, the corresponding contingency response procedure will be activated. Once activated, this response procedure will develop an appropriate response to the contingency. (See Section

3 below). The response, if any, will then be implemented by formulating and transmitting appropriate reports, operations directions, and/or requests to the force element involved.

1. Execution and Control Dynamics: Monitoring the Operations

Ground C^2I elements in INWARS will monitor the conduct of the operations they develop by selectively activating contingency recognition procedures on the basis of changes in their UOS. Since changes in the UOS derive from information about the situation, monitoring may be regarded as a link between a C^2I element's information inputs and its higher-level inferences about the situation.

In some cases this link may be quite direct. As was suggested in the discussion of UOS updating procedures, many information inputs will directly trigger contingency recognition procedures. A typical example is a subordinate status report indicating an exceptional condition such as "excessive" losses or "low" supply status. In other cases, the link may be made via synthesized data. As an example, a regular status report from a subordinate may not directly activate a contingency recognition procedure, but when the force balance information is updated on the basis of this status information, a major change may appear. This would activate a contingency recognition procedure to determine if an operationally significant force imbalance has developed.

The preceding discussion of monitoring activities has focused on the activation of contingency recognition procedures as a more-or-less direct response to information received by C^2I elements via communications or direct perceptions. Such information-driven activations are very important, for they enable C^2I elements in INWARS to be sensitive and responsive to the situation as it evolves (more precisely, as it is perceived to evolve). Nonetheless, the INWARS ground C^2I elements will also monitor their operations by means of the self-scheduled UOS "reviews" discussed in Chapter III, Section C, above. In addition to the UOS updating procedures, such a review will involve sequentially applying certain general contingency recognition procedures to the UOS. Periodic reviews are necessary to preclude circumstances in which a series of small and individually inconsequential changes in the perceived situation accumulate into an operationally significant but unrecognized contingency.

2. Recognizing Contingencies

Once activated by monitoring processes, contingency recognition procedures will be applied to the information contained in the C^2I element's UOS. The procedure itself may be a more-or-less complex system of processes, and may involve a more-or-less broad range of UOS information. In all cases, however, the recognition procedure is fundamentally a classifier which partitions all possible perceived situations into a relatively small number of categories.

a. Inputs to Contingency Recognition Procedures

Contingency recognition procedures have two basic types of inputs: (1) perceived situation information pertinent to the contingency, and (2) specification/control information. The first category includes the substantive elements of information which the procedure uses in its assessment of the contingency. In a force imbalance recognition procedure, force balance information from the UOS (Situation Representation Component) would be a principal input of this type. The second category includes parameters which specify or "define" the contingency, or which otherwise control the recognition procedure. Again, for a force imbalance procedure, imbalance thresholds (e.g., 6:1 for attack, 3:1 for defense) provide an example of information which "specifies" the contingency; such information would be drawn from the Operation Description Structure of the governing concept of operation.

b. Outputs of Contingency Recognition Procedures

The output of a contingency recognition procedure may essentially be regarded as a "label" which signifies how the particular perceived situation was classified by the procedures. The significance of the recognition procedure outputs lies in their ability to trigger associated contingency response procedures. From this point of view, every contingency recognition procedure must have a "null" label which does not trigger any response procedure. Additionally, the output range must include at least one "non-null" label which will trigger a specific response procedure. The more non-null labels a recognition procedure has in its output range, the more selective will be its activation of response procedures. For example, a "developing" label could trigger procedures to select a response involving actions to gather more information about the contingency, to prepare to respond should it eventually arise, or even to initiate actions intended to prevent it from arising at all.

3. Responding to Contingencies

Once triggered by a contingency recognition procedure, contingency response procedures will develop an appropriate response. Depending on the nature of the contingency, the complexity of the response procedure may range from the direct implementation of a prespecified response to a complete redevelopment of the overall operation. In all cases, however, the response procedure represents a decision process concerned with adapting to the recognized contingency, generally within the context of ongoing operations.

a. Input to Contingency Response Procedures

Aside from the output label of the recognition procedure which triggered it, response procedures will draw their inputs from the C^2I element's UOS.

b. Outputs of Contingency Response Procedures

The principal output of a contingency response procedure is a set of operations directives to subordinates which implement the response developed by the procedure. In some cases, requests to superior or adjacent C^2I elements may also be required to implement the response. Finally, the implementation of a response will generally be accompanied by a status report notifying the parent C^2I element of the recognition of the contingency and the response.

c. Structure of Contingency Response Procedures

As noted above, contingency response procedures represent decision processes concerned with adapting the ongoing operations to the recognized contingency. Following the general C^2I modeling approach, these will be developed as doctrinally-based heuristic decision procedures.

Heuristics will be especially useful in contingency response procedures since they can be tailored to exploit the special features of the problem posed by the contingency (such as a limited range of "reasonable" responses to the contingency).

Generally speaking, contingency response procedures will have a three-stage structure analogous to operations development procedures: (1) selecting the form of the response, (2) detailing form to fit the situation, and (3) formulating directives, requests, and reports to implement the detailed response. Given the more limited nature of response decisions, these stages will generally not be as complex as their counterparts in operations development decisions.

C. DESIGNING AND DEVELOPING A SYSTEM OF CONTINGENCIES FOR INWARS

In the preceding section, the general treatment of operations execution and control as a process of recognizing and responding to contingencies has been elaborated. The design and development of a system of contingencies which INWARS ground C^2I elements can recognize and respond to is therefore a principal aspect of C^2I process design and development. Indeed, as was noted in the original technical proposal, a considerable portion of the C^2I modeling effort will need to be devoted to this area. This section discusses the particular approach to be followed in designing a system of contingencies for INWARS. Section D, below, provides a more detailed discussion of some particular contingencies in terms of their recognition and response procedures.

1. Design/Development Problem

There is a wide range of design latitude in developing a system of contingencies around which to structure ground C^2I elements' execution and control operations. At one extreme, the system could include only a few very broad, generally applicable contingencies such as "force imbalance", "force deformation", "targeting opportunity", "threat change", or "end-of-phase". Generally speaking, such broad contingencies would require relatively complex recognition and response procedures; moreover, they would typically be "slow" in recognizing and responding to specific operational problems or opportunities. At the other extreme, the system could include a range of very specific contingencies such as "penetration in Wurzburg region" or "nuclear weapons employed in Fulda region". In this case, relatively simple and specific response procedures could be developed and the system would be very responsive to the specific problems included. However, the simplicity of the individual procedures would be offset by the large number required. More significantly, the system would "miss" problems or opportunities not specifically treated as contingencies.

The essence of the contingency design and development problem is striking a balance between these extremes which: (1) conserves model set-up and run time as well as overall development time, and (2) enables INWARS C^2I elements to execute and control the operations they have developed in a manner which is realistically responsive to the evolving situation.

2. Design Approach

As was noted in the Level II Specifications, the system of contingencies will be founded on a "base system" of general contingencies applicable in all ground operations. This base system will be designed to have the property that any significant operational problem or opportunity will eventually "show up" in terms of the general contingencies included. Consequently, it will include such contingencies as "force imbalance", "targeting opportunity", and "end-of-phase". The base system will ensure completeness in operations execution and control by providing an eventual stimulus to respond to problems or opportunities of interest to INWARS.

The base system will not, however, ensure that emerging operational problems or opportunities will be recognized in a timely manner. For example, an enemy attack with nuclear weapons would likely cause a force imbalance; however, considerable time might pass before this imbalance developed and was recognized as a contingency. Consequently, the general contingencies in the base system will be supplemented with a collection of more narrowly defined and operation-specific contingencies such as "nuclear/ chemical threat", "nuclear/chemical attack", and "penetration". These specific contingencies will be designed to ensure responsive ground operations execution and control by providing a timely stimulus to respond to specific types of problems and opportunities.

3. Design Status

As presented above, the design approach is essentially taken without charge from the Level II Specifications. Working within this approach, it has become apparent that the *a priori* design of a complete system of contingencies is difficult and likely inefficient. Study of friendly and enemy doctrine and military writings reveals little of use in the design of the system (although such works will be valuable in implementing specific contingencies). Likewise, the modeling framework has become sufficiently complex that it is difficult to foresee every eventuality which a C^2I element may encounter and then set up a contingency to provide for recognition and response. For these reasons, the special importance of test and experimentation to contingency design has become apparent.

D. SPECIFIC CONTINGENCIES TO BE TREATED IN INWARS

This section presents a discussion of the specific contingencies presently envisioned for inclusion in INWARS. These include: (1) Force Imbalance, (2) Nuclear/Chemical Threat, (3) Nuclear/Chemical Attack Contingency, (4) Targeting Opportunity, (5) End-of-Phase and (6) Penetration. For each of these contingencies, recognition and response procedures are presented.

1. Force Imbalance Contingency

At the levels of ground command represented in INWARS, command and staff groups are principally concerned with questions of force balance, i.e., concentrating the forces as opposed to actively directing or fighting the battle. As a part of operations development, an initial allocation of forces will have been specified. Consequent... an important contingency area concerns force imbalances: situations where the balance inherent in the initial allocation of forces has become distorted, favorably or unfavorably. Thus, "force imbalance" exemplifies a broadly defined, generally applicable contingency area.

a. Force Imbalance Recognition Procedure

Force imbalance contingencies will be defined in INWARS by force ratio thresholds associated with particular concepts of operation. For example, in the execution of offensive operations, a force imbalance condition might be defined to exist whenever the force balance rises above 7:1 (favorable imbalance) or falls below 5:1 (unfavorable imbalance). Force imbalance conditions will accordingly be recognized by comparing force balance information from the UOS (Situation Representation Component) with the threshold from the governing concept of operation.

A ground C^2I element may be concerned with a variety of force imbalance conditions corresponding to the range of force balance information maintained in its UOS (Situation Representation). For example, a C^2I element will be concerned both with aggregate force imbalances relating to its entire area of operations and with detailed force imbalances relating to subordinates' areas of operations.

b. Force Imbalance Response Procedures

Response to a force imbalance involves reallocation of resources. Exactly how resources are reallocated in response to a force imbalance depends heavily on the degree of imbalance, the mission currently pursued, the reallocation response time, the overall status of the conflict, and the perceived level of the nuclear/chemical threat. In executing defensive operations, a force imbalance situation might induce an attempt to re-establish a balanced "equilibrium" position by reinforcing the defending units; however, in executing offensive operations, a force imbalance might induce an attempt to commit reserve or echeloned units in order to increase the imbalance to a point where, e.g., a breakthrough might develop. The particular decision logic involved in these reallocation type responses will be developed from doctrinal principles.

The most basic response to a force imbalance is a reallocation of forces. This may take several forms in INWARS. First, subordinate zones of operation may be expanded or contracted. Second, uncommitted reserves or reinforcements may be committed or assigned to subordinates.

Another type of force imbalance response involves the application of fire support. Artillery or close air support missions (fixed or rotary wing) may be employed to offset certain force imbalances. An even more significant fire support response in this contingency would be the application of nuclear or chemical weapons. Application of fires may involve a reallocation of support among subordinates and/or requests for additional fire support from superior C^2I elements. Fire support responses may be used individually or in concert with the more basic force reallocation response.

2. <u>Nuclear/Chemical Threat Contingency</u>

Considering the severity of the impact of nuclear or chemical weapons employment, high level C^2I elements are particularly concerned with the threat of enemy use of these weapons. The level of the nuclear/chemical threat obviously has a significant impact on basic operational decisions. Moreover, as the threat increases, various "adaptive measures" may be initiated to reduce overall vulnerability should the threat materialize. Consequently, changes in the nuclear or chemical threat will be explicitly treated as a contingency in INWARS. This exemplifies a more narrowly and specifically defined contingency (relative, e.g., to force imbalance), but one which is still generally applicable.

a. <u>Nuclear/Chemical Threat Recognition Procedures</u>

Like force imbalance, nuclear and chemical threats will be defined in INWARS by thresholds applied to the nuclear/chemical threat indices developed and stored in the UOS (Situation Representation). Essentially, these thresholds will partition the total range of each threat index into intervals representing discrete nuclear and chemical "threat states." Recognition procedures will then compare the threat indices against the threat thresholds to determine which threat state obtains. Changes in the threat states will trigger corresponding response procedures; in other words, the contingency being recognized in this case is a change in threat state.

The range of distinct nuclear and chemical threat states included will be keyed to the range of possible responses (adaptive measures discussed below). The thresholds which define these states in terms of the threat indices will be set by operations development activities. Specifically, these thresholds will be included in the Operations Description portion of the governing concept of operation.

b. Nuclear/Chemical Threat Response Procedures

Changes in the nuclear or chemical threat state will trigger three basic reactions. First, the change will be reported to superior, subordinate and adjacent C^2I elements causing them to reassess their own perceptions of the threat state. Second, the change will stimulate the C^2I element to implement (or de-implement, as appropriate) relevant adaptive measures as discussed below. Finally, the change may, if sufficiently significant, trigger a reassessment of the overall operations being conducted by the C^2I element.

The options considered by the nuclear/chemical threat response procedure are various adaptive measures. Typical measures to adapt a ground operation to a nuclear threat in INWARS will include:

- increasing the nuclear readiness of forces in threatened areas (e.g., dispersal, etc.); and
- attacking threatening nuclear delivery systems with conventional means.

Measures to adapt to a chemical threat in INWARS will consist solely of increasing the chemical readiness of force elements in threatened areas. This will implicitly represent such actions as dispersal, and donning protective clothing.

As was noted in the discussion of the recognition procedure, the exact definition of the threat states will be keyed to the measures by which to adapt to it. Thus, as the threat level increases (or decreases), associated specific adaptive measures will be incrementally implemented (or de-implemented). This considerably reduces the complexity of the response decision -- in essence, as the threat increases (decreases) the response decision concerns whether or not to implement (de-implement) the specific associated adaptive measures.

3. Nuclear/Chemical Attack Contingency

The previously discussed nuclear/chemical threat contingency concerned changes in the potential for enemy attack by nuclear/chemical weapons. Given its significance, the realization of that potential -- the occurrence of an actual nuclear or chemical attack -- will be treated as a separate contingency in INWARS. This nuclear/chemical attack contingency exemplifies a very specific contingency, but is again one which is generally applicable.

a. Nuclear/Chemical Attack Recognition Procedure

Recognition that a nuclear or chemical attack has occurred will not require a complex procedure, but will rather be based directly on reports from other force elements or upon the direct perception of the C^2I element. In other words, such reports or perceptions will directly trigger the associated response procedure.

b. Nuclear/Chemical Attack Response Procedure

The response to a nuclear or chemical attack will have many facets. It is anticipated that variations in this contingency response procedure will be one of the key items for experimentation and evaluation in the overall development program. Specific facets of the response will include the following:

- Reporting (or attempting to report) the attack to other force elements;
- Ascertaining (or attempting to ascertain) the extent of the attack and its effects on subordinate force elements;

- Directing (or attempting to direct) unaffected subordinates to go to a higher nuclear/chemical readiness state;
- Implementing (or attempting to implement) other adaptive measures discussed above as appropriate.

Notice that all of the above facets involve the attempt to perform certain actions. This acknowledges the dependence of these actions on communications which may be severely degraded in the event of a nuclear attack (as discussed in Volume IV, Chapter IV).

The most significant aspects of the response to a nuclear/chemical attack will be the changes in operations. As a part of the response procedure, the C^2I element's operations development processes will be activated to determine how its overall operations should be adapted (if at all) to the new situation. If the nuclear/chemical threat monitoring has been effective, adaptive measures will generally have been implemented which should "ease" the transition. If, however, adaptive measures have not been implemented, considerable changes may be required.

4. Targeting Opportunity Contingency

Target acquisition and engagement will be treated in INWARS as an opportunity type contingency. The recognition of a targeting opportunity contingency corresponds to the acquisition of a target; the response to a targeting opportunity contingency corresponds to the decision about whether or not to attempt to engage the target and, if so, with which particular engagement resources. "Targeting opportunity" exemplifies an event not usually considered a "contingency", but which lends itself to such a treatment within the model. As a contingency it includes a range of narrowly defined recognition conditions (different types of targets); it is applicable in all operations.

a. Target Opportunity Recognition Procedure

Corresponding to the definition of target acquisition, a targeting opportunity is defined as the detection, identification, and location of a target in sufficiently accurate and complete detail to enable effective target engagement actions. The target opportunity recognition procedure will accordingly be concerned with detection, identification and location of force elements suitable for targeting. Figure V-1 exhibits the target categories to be utilized in INWARS.

It will be recalled that the Situation Data component of a C^2I element's UOS contains Target Engagement information in the form of "blocks" describing the target type, location, time of last observation and so on (see Chapter II, Figure II-5). To be recognized as a targeting opportunity, an enemy force element must first appear in The Target Engagement information via the UOS updating processes. (Recall that, depending on the source of the information, this may involve comparison with a "targetability threshold" as discussed in Chapter III, Section B.2.a). However, recognition as a targeting opportunity also requires that the information be sufficiently "current" relative to the frequency with which a target of the given type may be expected to change position. In INWARS, this will be represented by an "acceptable age" threshold associated with each type of target. For example, since maneuver units would typically move more frequently then combat service support complexes, the latter would have a higher acceptable age threshold. (Note that this age threshold is distinct from the age threshold used to purge information from the UOS -- the latter threshold serves a bookkeeping function.)

b. Targeting Opportunity Response Procedure

As presented in the Level II Specifications, a response to a targeting opportunity was to have two basic components: (1) an engagement action, and (2) an information action. The latter concerned the need for continued collection of information about the target in question. However, in view of the aggregate representation of information collection activities in INWARS, it has been decided to delete the information action component. Thus, response to a targeting opportunity will consist solely of an engagement action which may take one of three possible forms: (1) engage with own resources, (2) request or recommend engagement by another force element (such as an air element), or (3) do not engage.

The selection of a specific engagement action will be based on the resources available to the C^2I element and on the "value" of the target. Within the model, target value will be represented in terms of target priorities indicating the relative value of a target. A particular set of target priorities will be associated with each concept of operation. However, during operations execution and control, certain priorities may be altered. For example, in responding to increased nuclear threat, one potential adaptive measure is attacking enemy means of nuclear delivery; in part, this would be implemented by increasing the priority of missile pools as a target type.

Engagement action will be determined by comparing the value (priority) of the target with two thresholds. The lower threshold reflects the general desirability of engaging this target and, if exceeded by a particular target, rules out the "do not engage" option. This leaves only the decision about whether to engage with organic resources or to recommend engagement by another force element. If no available organic resources are capable of engaging the target, an appropriate recommendation will be formulated. If appropriate engagement resources are available, the target priority will be compared with a second (and higher) threshold which reflects the desirability of using organic resources to engage a target of this priority. If this threshold is exceeded, an appropriate fire mission will be formulated directing the available organic resources to engage the target. Otherwise, an appropriate engagement recommendation will be formulated.

If some engagement action is taken, it will be coded into the space provided in the appropriate Target Engagement information block. The thresholds which determine the general and particular desirability of engaging targets may vary depending on the operation and will therefore be contained in the Operation Description section of the governing concept of operation.

It is apparent that this particular targeting engagement response procedure is a highly simplified representation of a highly complex activity. However, it appears that a more realistic treatment would require elaborate procedures to select and allocate weapons resources among target opportunities. Such procedures are expensive in terms of run time and storage space, especially when considered across all echelon-above-division commands in the theater.

1. C^2I Elements (Theater HQ, AG/Front HQ, ATAF/TAA HQ, Corps/Army HQ, Division HQ)

2. Maneuver Elements (Brigades/Regiments)
   - Forward (Committed)
   - Rear (Reserve and Reinforcing)

3. Artillery Units

4. Missile Launchers (as a fraction of missile pools by type and level of command)

5. Forward Air Bases (as a fraction of forward Air Base Clusters by ATAF/TAA)

6. Ground Air Defense Weapons (as a fraction of ground air defense weapons pools by air battle area)

7. Special Weapons Storage Sites/Points

8. Combat Service Support Elements (as a fraction of Combat Service Support Complexes)

Figure V-1. INWARS Target Classes

5. End-of-Phase Contingency

It will be recalled that as a part of operations development, a phasing was developed in accordance with the governing concept of operation. The first phase of an operation is always developed and implemented; however, subsequent phases will not have been developed. For this reason, the end of a phase always requires a response in the form of operations directives specifying the next phase of the operation. Accordingly, "end-of-phase" will be regarded as a contingency in INWARS.

a. End-of-Phase Recognition Procedure

The function of end-of-phase recognition is to trigger the detailing of the next phase. If this triggering is done too early, the next phase will be developed on the basis of inadequate information and may be poorly suited to the situation existing at the time it is implemented. However, if response development is triggered to late, lack of time may cause subordinates to be left waiting at their objectives without guidance about what to do next. Accordingly, the end-of-phase contingency must be recognized before it occurs, i.e., predicted. Consequently, the end-of-phase recognition procedure in INWARS will attempt to estimate "time-to-objective" of the critical subordinate based on the expected completion time for this phase. This estimate will then be compared with a phase development time requirement. If the time-to-objective is less than the time required for development of operations directives implementing the next phase, the "end-of-phase" recognition conditions will be satisfied and the end-of-phase response procedures will be triggered.

b. End-of-Phase Response Procedure

The end-of-phase response procedure involves the detailing of the next phase of the operations. Thus, the procedure corresponds to the operations development procedure discussed in Chapter IV, Section F.

6. Penetration Contingency

To a command conducting defensive operations, a penetration presents a serious threat. Since INWARS ground operations processes will permit penetrations, it is necessary that INWARS mental processes be able to recognize and respond to such contingencies. Penetration exemplifies a contingency which is broadly defined but which is applicable in only certain types of operations (i.e., defensive operations).

a. Penetration Recognition Procedure

In spatial terms, a penetration develops as a localized and relatively narrow "bulge" in the FEBA in the direction of the defender. As this suggests, force configuration information developed and maintained in the UOS (Situation Representation) will provide a partial basis for recognizing penetrations.

A purely spatial characterization of the penetration is, however, inadequate to the overall penetration recognition problem. This is due to the fact that the spatial features of a penetration become apparent only after the operation is well underway. Since a penetration is typically accompanied by a buildup of forces and a concentration of combat power, force balance information from the UOS (Situation Representation Component) will be used in conjunction with force configuration information in the recognition of penetrations.

b. Penetration Response Procedure

Faced with a developing or ongoing penetration, a C^2I element has only a limited number of possible responses. Specifically, it may: (1) counterattack, (2) employ nuclear weapons, (3) reinforce, (4) delay, (5) hold in place, or (6) withdraw. The C^2I element wishes to select the most preferable option that is feasible in the situation. General doctrinal principles suggest that the preferences among the options are relatively independent of the specific situations: faced with a penetration, a C^2I element will prefer counterattack to the employment of nuclear weapons and so on, withdrawal being the normal option of last resort. The specific situation bears on the selection of an option principally by rendering some options infeasible.

Thus, as presently envisioned, penetration response will involve searching through a small list of basic options in order of doctrinal preference and checking option-specific feasibility conditions en route. The first option found which meets all its feasibility conditions is the most preferred feasible alternative and will therefore be selected and implemented.

7. Other Stimuli to Respond

The contingencies discussed above are complex either in the associated recognition or response procedures (or both). Within INWARS, there will be a range of simpler events and conditions which may cause a C^2I element to alter its operations or initiate some specific action. For example, the receipt of a request from a subordinate must be serviced or, at the minimum, denied. As this example suggests, these other stimuli to respond are much more specific and give rise to less elaborate decision problems for C^2I element.

CHAPTER VI
AIR OPERATIONS DEVELOPMENT, EXECUTION, AND CONTROL

A. INTRODUCTION

This chapter presents the INWARS representation of the processes by which air C^2I elements (Theater and ATAF/TAA) develop, execute, and control air operations. In terms of general treatment, INWARS ground and air C^2I processes are similar: operations development is a process of refining a general concept of operations into a specific operation, and operations execution and control is a process of recognizing and responding to contingencies (problems and opportunities which arise over the execution of the specific operation). In terms of specific structure and content, however, INWARS ground and air C^2I processes are quite different. Developing ground operations involved designing coordinated schemes of broad actions with associated broad resource allocations, and is structurally similar at all levels of command treated in INWARS. By contrast, developing air operations involves a more detailed allocation of resources, and has a different orientation at the two levels of air command treated in INWARS, namely, Theater and ATAF/TAA. The types of contingencies recognized and responded to by ground and air operations are correspondingly different.

Broadly speaking, the INWARS Theater C^2I element (i.e., the theater air function) will develop a daily allocation of overall theater air effort among the various air missions on an ATAF/TAA-by-ATAF/TAA basis. This allocation will be based on a concept of operations reflecting emphasis among generic air roles (see Section B). Using the theater level allocation as a framework, each ATAF/TAA will then develop an operation which utilizes its physical resources--aircraft--to implement the theater level guidance (see Section C). Operations execution and control will then begin with a monitoring of the UOS in an effort to recongize and respond to contingencies as discussed in Section D.

B. THEATER LEVEL AIR OPERATIONS DEVELOPMENT

Theater level air C^2I elements develop operations in the form of a broad allocation of air effort (sorties) among alternative air missions for each subordinate ATAF/TAA. The development process at this level starts with a concept of operation implicitly reflecting broad campaign strategy (relative emphasis on air superiority versus support of ground forces). The concept is then refined down to a specific assignment of effort among detailed air missions on an ATAF/TAA-by-ATAF/TAA basis. These detailed assignments of effort are implemented by sending appropriate guidance to the subordinate ATAF/TAA's.

1. Developing the Theater Concept of Operation

The theater level C^2I elements will conceive the air operation in terms of the relative effort to be placed on broad air mission groups or roles in each ATAF/TAA. Figure VI-1 illustrates the structure of the theater concept of the air operation.

Relative effort entries in the concept will be determined as a function of air superiority and ground force balance. Specifically, the entries will be "looked up" in a two-dimensional table based on the air superiority "state" in the given ATAF/TAA and the ground force balance "state" in the associated Army Group/Front as suggested in Figure VI-2. Note that air superiority and ground force balance "states" are simply defined as specific interval ranges of the associated values covered in the air C^2I element's UOS as discussed in Chapter II, Section D.2, above. The particular relative effort functions for each mission will be determined by user input and will implicitly reflect the overall air campaign strategy, including relative emphasis of effort.

As indicated in the Level II Specifications, this approach has been adapted from the IDA TACNUC model as presented in Kerlen, E.P., et al, IDA TACNUC Model: Theater Level Assessment of Conventional and Nuclear Combat, Volume II: Detailed Description, WSEG Report 275, October 1975, Chapter II, Section C.

SUBORDINATE / ROLE (MISSION GROUP)	ATAF/TAA #1	ATAF/TAA #2	
COUNTERAIR	(1)	(1)	
COMBAT AIR SUPPORT	(1)	(1)	
INTERDICTION	(1)	(1)	

NOTE 1 : ENTRIES IN THE STRUCTURE REPRESENT THE RELATIVE EFFORT TO BE PLACED ON THE GIVEN ROLE IN THE GIVEN ATAF/TAA. RELATIVE EFFORT WILL BE EXPRESSED AS A FRACTION OF UNITY.

Figure VI-1. Theater Concept of Air Operations

GROUND FORCE BALANCE STATE \ AIR SUPERIORITY "STATE"		AIR SUPERIORITY INDEX = a			
		$a \leq x$	$x < a \leq y$	$y < a \leq z$	$z < a$
GROUND FORCE BALANCE RATIO = g	$g \leq u$				
	$u < g \leq v$				
	$v < g \leq w$				
	$w < g$				

NOTE: Each cell contains two entries; the first reflects relative effort to be placed on the counterair role; the second reflects relative effort to be placed on combat air support role; the relative effort to be placed on interdiction is 1.0 less the counterair and combat air support efforts.

Figure VI-2. Relative Effort as a Function of the Ground and Air Situation

2. Detailing the Theater Concept of Operation

Once the relative distribution of effort among broad mission areas or roles has been "conceived", the theater must develop detailed allocations of effort among: (1) Air Defense, (2) Air Base/SAM attack (3) Close Air Support, (4) Interdiction, (5) Reconnaissance, and (6) Nuclear Withhold (QRA). In these detailed allocations, effort will be expressed in terms of sorties. Thus, the development involves a translation of the theater air concept into a detailed allocation of effort as shown in Figure VI-3. Essentially, this translation involves two basic steps: (1) estimating total sorties expected to be available for the day, and then, (2) distributing these sorties among particular missions by subordinate ATAF/TAA.

a. Estimation of Sorties Available

Air C^2I elements will estimate the sorties expected to be available over the course of the day for each type of aircraft (on an ATAF/ TAA-by-ATAF/TAA basis). Estimates by type of aircraft will be made as the product of: (1) the perceived number of actual aircraft of the given type available in the ATAF/TAA, and (2) the sortie rate for that type of aircraft. Both of these factors are already contained in the air C^2I element's UOS as discussed in Chapter II. Recall that sortie rates may vary in accordance with a user-defined schedule to reflect surge conditions.

b. Allocation of Estimated Available Sorties

Distributing the sorties estimated to be available among specific missions is a complex process due to the fact that the actual aircraft--and, hence, the sorties--are not a homogenous resource. Sorties can only be allocated against a specific mission if they are capable of performing it. However, the relative effort distribution contained in the theater air concept of operation was generated without regard to capabilities; accordingly, it may not be possible to achieve the desired relative effort distribution. Within INWARS, the relative effort distribution is essentially used to generate a "demand" for sorties which is then filled considering the capability limitations of the specific types of aircraft available.

AIR MISSION \ SUBORDINATE	ATAF/TAA #1	ATAF/TAA =2	
COUNTERAIR	(TOTAL) ③	(TOTAL) ③	
AIR DEFENSE	①	①	
AIR BASE/SAM ATTACK	①	①	
ASSOC. RECONNAISSANCE	①	①	
COMBAT AIR SUPPORT	(TOTAL) ③	(TOTAL) ③	
CLOSE AIR SUPPORT	①	①	
ASSOC. RECONNAISSANCE	①	①	
INTERDICTION	(TOTAL) ③	(TOTAL) ③	
INTERDICTION	①	①	
ASSOC. RECONNAISSANCE	①	①	
NUCLEAR WITHOLD	(TOTAL) ③	(TOTAL) ③	
QRA	②	②	

NOTE 1 : EFFORT FOR COUNTERAIR, COMBAT AIR SUPPORT, AND INTERDICTION WILL BE EXPRESSED IN TERMS OF SORTIES

NOTE 2 : "EFFORT" FOR NUCLEAR WITHOLD WILL BE EXPRESSED NOT IN SORTIES, BUT IN TERMS OF AIRCRAFT WITHELD

NOTE 3 : TOTALS REPRESENT THE SUM OF THE ENTRIES FOR THE SUBORDINATE MISSIONS

Figure VI-3. Theater Allocation of Air Effort

The complete process is somewhat more complex due to various other allocations which must be made. In INWARS, this will be accomplished in four steps: (1) set nuclear withhold, (2) determine desired attack effort by role, (3) allocate attack sorties against desired attack efforts, and (4) allocate reconnaissance sorties.

(1) Step 1: Set Nuclear Withhold. The first step in the allocation is to determine the number of aircraft (if any) which are to be reserved as a nuclear withhold. This is determined by a table "look up" based on the nuclear threat state (as reflected in UOS). This number is entered in the allocation form. Sortie availability estimates for the nuclear-capable types of aircraft are then reduced by the product of: (1) the number of aircraft witheld, and, (2) the sortie rate for that type of aircraft.

(2) Step 2: Determine Desired Attack Efforts by Role. This step is carried out by first summing the remaining sortie estimates over all aircraft types capable of undertaking attack missions (as opposed to reconnaissance) within each ATAF/TAA. The resulting totals may be regarded as an estimate of "available attack effort". This attack effort estimate for each ATAF/TAA is then allocated among the counterair, combat air support, and interdiction roles in accordance with the desired relative effort entries contained in the theater air concept (Figure VI-2). The resulting desired efforts by roles are then entered in the corresponding role "total" cells of the theater allocation structure (Figure VI-3). It is emphasized that these desired efforts may not be attainable with the actual aircraft available. Here, the desired efforts are simply serving to represent a demand for sorties which will be filled--to a greater-or-lesser extent--as the allocation process proceeds.

(3) Step 3: Allocate Attack Sorties against Desired Attack Efforts The desired attack effort goals developed in the preceding steps are filled by sequentially allocating aircraft sorties by type against the remaining goals. This process starts with single-

mission attack aircraft types and proceeds to more versatile multi-mission attack aircraft. For each aircraft type, the estimated available sorties are allocated among its feasible missions in proportion to the desired efforts recorded in the "total" cells. The amounts allocated are added to the appropriate cells, and the desired attack efforts ("demands") are reduced by corresponding amounts in order to reflect the extent to which that particular demand for sorties remains unfulfilled. The process then continues in this fashion until the sorties of all attack aircraft types have been allocated. The "total" cells in the allocation structure are then updated to reflect the sorties actually allocated in the process.

(4) Step 4: Allocate Reconnaissance Sorties. The first step in the sortie allocation process is to allocate reconnaissance sorties. This is done in accordance with the relative effort expressed in the theater concept of operation. The resulting allocations are then entered in the allocation structure and all totals are again updated.

3. Implementing the Detailed Theater Air Concept

The theater will implement its detailed allocation of effort by formulating and transmitting the specific mission allocations to the associated ATAF/TAA's. This will initiate and guide their more detailed operations development activities.

C. ATAF/TAA LEVEL AIR OPERATIONS DEVELOPMENT

Upon receiving the theater C^2I element's guidance concerning allocation of effort for the day, each ATAF/TAA will develop an air operation to realize that action. The essence of this process is translating levels of effort to be expended over the day (sorties) into a sequence of actions to be accomplished over the day. In other words, the ATAF/TAA must schedule the utilization of its physical resources--aircraft--over the day in conformance with the Theater C^2I element's allocation of effort.

Additionally, there is a need to allocate combat air support effort among supported subordinate ground elements (i.e., Corps/Armies).

In reality, aircraft utilization is scheduled in the form of a fragmentary operations order (FRAG) which specifies particular flights of aircraft to be launched on particular missions and against particular targets over the day. Direct simulation of this "fragging" process in INWARS would involve composing and scheduling particular air mission packages (AMPs) to be launched over the course of the day. Since the composition and scheduling would be done at the start of the day, it would have to reflect the expected availability of aircraft over the course of the day. Of course, should this availability not materialize, it would be necessary to change the scheduling. Additionally, changes in the ground situation and identification of new, high priority targets would require modifications to the schedule of air mission packages.

It has been decided that a direct simulation along these lines carries too high a cost in terms of complexity (as an indicator of run-time and storage requirements). Rather, the alternative approach identified in the Level II Specifications will be adopted. Under this alternative treatment of ATAF/TAA operations development, ATAF/TAA's would not attempt to schedule mission packages in advance, but would rather set "utilization guidelines" in terms of level of effort (sorties) to be expended on each type of mission by period in the day. Particular air mission packages would then be composed and launched over the course of the day based on the utilization guidance, the availability of aircraft, and the evolving situation. This departure from reality is adopted as a means of avoiding the complexity of scheduling a day's mission packages in auvance, as well the complexity of altering the schedule as the situation changes over the day. It is felt that this more abstract scheduling of utilization reflects the essence of ATAF/TAA operation development--translating effort into action--at a reduction in complexity.

1. Structure of ATAF/TAA Utilization Guidelines

The ATAF/TAA air operations development process will be organized around an information structure which may be regarded as a "utilization schedule". As exemplified in Figure VI-4, the utilization schedule has a matrix structure whose rows reflect specific air missions and whose columns reflect specific periods of time -- operating periods -- over the day (in the example, two-hour intervals are used). Entries in a given cell of the schedule will reflect level of effort to be expended on the associated mission over the associated operating period. These entries accordingly serve both as goals and constraints during the execution of the operation. As goals, each utilization entry sets a desired level of effort to be launched over that period. If the goal is not met, the remaining effort will be added to the entry for the next period. As constraints, the specification sets a maximum on the amount of sorties of a given type which <u>should</u> be launched over that phase.

2. Developing the ATAF/TAA Concept of Operation

The ATAF/TAA will conceive its operation in the form of a <u>relative</u> utilization schedule. Such a schedule will have the structure shown in Figure VI-4. However, rather than sorties, its level of effort entries will reflect a <u>fractional distribution</u> of sorties over the day within a given mission (that is, the entries will be fractions of unity and will sum to 1.0 across each row). The ATAF/TAA's relative utilization schedule will be a user input--the ATAF/TAA's will <u>not</u> modify it during operations development. (The resulting utilization schedule may, however, be modified during execution as discussed below.) Thus, the ATAF/TAA development of a concept of operation simply involves accessing the appropriate relative utilization schedule.

3. Detailing the ATAF/TAA Concept of Operation

Detailing the ATAF/TAA concept involves using the relative utilization schedule to distribute the sorties allocated by theater over specific time periods. A preliminary step is required to break out the combat air support sorties among the various Corps/Army units subordinate to the supported Army Group/Front. Force balance information provides the basis

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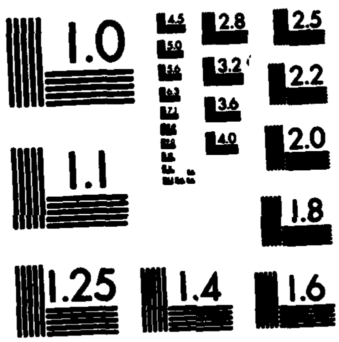

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

MISSION/PERIOD	#	1	2	•••	N
	START	0600	0800	•••	0400
	END	0759	0959		0559
COUNTER AIR				•••	
AIR DEFENSE					
SAM/AB ATTACK					
ASSOC RECCE					
COMBAT AIR SPT, CORPS/ARMY 1				•••	
CLOSE AIR SPT					
ASSOC REC					
•••		•••	•••		•••
COMBAT AIR SPT CORPS/ARMY N				•••	
CLOSE AIR SPT					
ASSOC REC					
INTERDICTION				•••	
INTERDICTION					
ASSOC REC					

Figure VI-4. ATAF/TAA Utilization Schedule for this allocation--each corps/army in contact will receive a share of the Combat Air Support in inverse proportion to the force balance rates it faces (as perceived by the ATAF/TAA).

Once this subordinate allocation of combat air support sorties is accomplished, the ATAF has a total number of sorties for each row in the utilization schedule. These will then be distributed over the operating periods within each row in accordance with the relative utilization schedule accessed during the preceding step.

4. Implementing the Detailed ATAF/TAA Concept of Operation

Once the ATAF/TAA has developed and detailed its utilization of aircraft over time in accordance within the theater allocation of effort, the resulting utiliztion schedule must be implemented. This is done by simply scheduling an "implementaion event" to occur at the start of the first operating period on the schedule. The occurrence of this event is then represented by "passing" the utilization schedule to the Air Base Cluster controlled by that ATAF/TAA.

D. AIR OPERATIONS EXECUTION AND CONTROL

As with ground operations, the execution and control of air operations will be represented as a process of recognizing and responding to contingencies. The reader is referred back to Chapter V, Sections B and C for a general characterization of contingency recognition and response procedures, and a discussion of the approach to contingency design.

The detailed execution of air operations is carried out by the ATAF/TAA controlled Air Base Clusters as discussed in Volume III. Here, contingencies recognized and responded to by the Theater and ATAF/TAA level air C^2I elements themselves will be discussed. These include: (1) End of Operating Period, (2) Targeting Opportunity, (3) Nuclear/Chemical Threat, and (4) Nuclear/Chemical Attack.

1. End of Operating Period

The end of operating period is a contingency associated only with ATAF/TAA level air C^2I elements. It provides an opportunity for each ATAF/TAA to appraise the progress made over the operating period towards completing the goals set during its operation development activities.

a. End-of-Operating Period Recognition Procedures

The recognition of this contingency is very simple--it arises at the ending time of each operating period. For this reason, the end-of-operating-period contingency may be more aptly regarded as an internal, self-scheduled "progress review" by the ATAF/TAA.

b. End-of-Operating Period Response Procedure

The principal response required at the end of each operating period is the transference of the sortie goals scheduled but not completed during that operating period to the next operating period. Thus, at the end of operating period N, the sortie goals remaining for each type of mission (SG(M,N) where M is a type of mission) are simply added to those goals already scheduled for the next period. In other words,

$$SG(M,N+1) = SG(M,N+1) + SG(M,N)$$

Various other redistributions of sortie goals may also be carried out at the end of an operating procedure. For example, the distribution of combat air support sorties among corps/armies might be redistributed based on the current force balance. This and other such redistribution actions will not be treated in Basic INWARS, but will be regarded as potential refinements to be evaluated during test and experimentation.

2. Targeting Opportunity

As a contingency, a targeting opportunity will be recognized by air C^2I elements (ATAF/TAA) in the same manner as ground C^2I elements (see Chapter V, Section D.4.a, above). However, unlike ground C^2I elements, the response to a targeting opportunity will not include the option of recommending engagement by another force element. Rather, the ATAF/TAA must either engage or not engage. Otherwise, the procedures for an ATAF/TAA are analogous to those of a ground C^2I element (see Chapter V, Section

D.4.b, above). Of course, decisions to engage will be implemented by passing an appropriate air mission to the associated Air Base Cluster.

3. Nuclear/Chemical Threat

Changes in nuclear or chemical threat will be treated as contingencies by air C^2I elements in much the same manner as by ground C^2I elements. The principal differences are, of course, the types of responses (adaptive measures).

a. Nuclear/Chemical Threat Recognition Procedures

As with ground C^2I element, air C^2I elements will recognize nuclear and chemical threats in terms of thresholds applied to the nuclear/chemical threat indices developed and stored in their UOS (Situation Representation Component). Essentially, these thresholds will partition the total range of each threat index into intervals representing discrete nuclear and chemical "threat states." Recognition procedures will then compare the threat indices against the threat thresholds to determine which threat state obtains. Changes in the threat states will trigger corresponding response procedures; in other words, as with ground C^2I elements, the contingency being recognized by the air C^2I element is a change in threat state.

The range of distinct nuclear and chemical threat states will be keyed to the range of possible responses. Since the responses available to an air C^2I element are different from those available to ground C^2I elements, different threat states will be associated with air then with ground.

b. Nuclear/Chemical Threat Response Procedures

Changes in the nuclear or chemical threat state may trigger three basic reactions as the part of air C^2I elements. First, the change will be reported to superior and adjacent C^2I elements causing them to reassess their own perceptions of the threat state. Second, the change will stimulate the C^2I element to implement (or de-implement, as appropriate) relevant adaptive measures as discussed below. Finally, the change may, if sufficiently significant, trigger a reassessment of the overall air operations being conducted by that C^2I element.

The options considered by the nuclear/chemical threat response procedure are various adaptive measures. Following MINTSIM, typical measures to adapt an air operation to a nuclear or chemical threat in INWARS will include: (1) dispersing aircraft; (2) withdrawing nuclear-capable aircraft; (3) withholding dual-capable aircraft (theater only); and (4) attacking threatening nuclear delivery systems with conventional means (theater only).

As was noted in the discussion of the recognition procedure, the exact definition of the threat states will be keyed to the measures by which to adapt to it. Thus, as the threat level increases (or decreases), associated specific adaptive measures will be incrementally implemented (or de-implemented).

4. Nuclear/Chemical Attack Contingency

The previously discussed nuclear/chemical threat contingency concerned changes in the potential for enemy attack by nuclear/chemical weapons. Given its significance, the realization of that potential--the occurrence of an actual nuclear or chemical attack--will be treated as a separate contingency in INWARS.

a. Nuclear/Chemical Attack Recognition Procedure

Recognition that a nuclear or chemical attack has occurred will not require a complex procedure, but will rather be based directly on reports from other force elements or upon the direct perception of the air C^2I element. Such reports or perceptions will directly trigger the associated response procedure.

b. Nuclear/Chemical Attack Response Procedure

As with ground C^2I elements, the response of an air C^2I element to a nuclear or chemical attack will involve:

- Reporting (or attempting to report) the attack to other force elements:
- Ascertaining (or attempting to ascertain) the extent of the attack and its effect:
- Implementing (or attempting to implement) adaptive measures discussed above as appropriate.

Notice that all of the above facets involve the attempt to perform certain actions. This acknowledges the dependence of these actions on communications which may be severely degraded in the event of a nuclear attack.

Air C^2I elements will also change their operations to a nuclear attack. This will be implemented at the ATAF/TAA level by changing the aircraft utilization schedules in accordance with a predefined response doctrine. This may include, for example, reducing all current operating period sortie goals for selected missions to zero.

5. Other Stimuli to Respond

As with ground C^2I elements, there will be a range of other stimuli which may casue air C^2I elements to alter their operations. An example is the receipt of a target engagement request ("recommendation") from a supported ground C^2I element. This would cause the recipient in C^2I element to update its UOS and could initiate a targeting opportunity recognition procedure.

CHAPTER VII
TOPICS IN C^2I MODELING

A. INTRODUCTION

This chapter concludes the presentation of the C^2I modeling in INWARS by presenting: (1) the representation of C^2I element performance in terms of reaction time (Section B); and (2) the related representation C^2I element disruption and outright destruction (Section C). Finally, the question of obtaining data for the INWARS C^2I modeling treatment is discussed in Section D.

B. REPRESENTATION OF C^2I ELEMENT PERFORMANCE

Broadly stated, the function of a command/staff group is to efficiently and effectively utilize the resources under its control to attain goals assigned by superior command/staff groups. Thus, equally broadly stated, the C^2I performance of a command/staff group should be assessed in terms of how well it is able to carry out this function. Externally, C^2I performance is reflected in the attainment of assigned goals with a minimal expenditure of resources (i.e., minimal time and losses). Internally, C^2I performance is manifested by the ability to make "good decisions" in a "short time".

The concept of "good decision" is so complex that it may essentially be considered as undefined in all but the most trivial of situations. The theory of games and decisions provides a definition of "good decision" if the following conditions are satisfied: (1) all possible alternatives are known, (2) for each alternative, all possible consequences of selecting that alternative are known, and (3) values can be associated with each possible consequence. Unfortunately, in the context of C^2I modeling, these are conditions virtually always violated.

If the concept of "good decision" is ill-defined, the concept of "poor decision" may essentially be considered as undefinable. Indeed, even if one was willing to postulate a definition of "good decision", defining "poor decision" would still be difficult since a decision can be "un-good" in a variety of ways.

For this reason, there will be no attempt to represent decision quality--"good" or "poor"--in INWARS. Rather, C^2I performance will be represented solely in terms of the time required to reach decisions, both in operations development and in operations execution and control.

1. Structure of the Representation

The representation of C^2I performance in terms of decision times will be implemented by breaking up the various C^2I processes into discrete "tasks", each with its own basic performance time. Thus, for example, updating the UOS in response to the receipt of a regular status report from a subordinate might be a single task. The more complex C^2I processes (e.g., the operations development process) will be broken up into component tasks (such as, e.g., adopting a concept, developing the concept, detailing the concept, and so on).

Tasks would be initiated in the various ways discussed in the previous chapters. Their completion would, however, be represented by a "task completion event" scheduled to occur after a delay time representing the task performance time. In particular, if a task is initiated at time T_o and has a performance time of T_p, then the task completion event would be scheduled to occur at time T_o+T_p. This structure permits a very explicit treatment of the time required to perform C^2I activities.

2. Computation of Task Performance Time

As was suggested above, a basic performance time will be associated with each C^2I task. In fact, the resolution of the C^2I activities into discrete tasks will be based, in part on the availability of basic performance time data. However, the time required by a particular C^2I element to perform the task at a given point in time (T_o) will be computed as the quotient of the basic performance time (T_b) and the "performance index" of the C^2I element at time T_o ($I_p(T_o)$). Thus, in the notation used above:

$$T_p = T_b/I_p(T_o)$$

The performance index of a C^2I element at a particular point in time ($I_p(T_o)$) is simply a number between 0.0 (complete lack of performance) and 1.0 (perfect performance). It provides a means to reflect reduced C^2I performance in that as its value decreases from 1.0 down to 0.0, the performance time of any task increases without bound from the basic performance time of the task (T_b). C^2I element performance indices play a major role in representing the degradation of C^2I elements. Their dynamics will accordingly be discussed in the next section.

C. REPRESENTATION OF C^2I ELEMENT DEGRADATION

INWARS C^2I elements are subject to attack by various different means. When attacked, C^2I element performance will be degraded. Two forms of C^2I element degradation will be treated in INWARS: (1) disruption, in which the performance of the C^2I element is temporarily and partially degraded, and (2) destruction, in which the performance of the C^2I element is permanently and completely degraded. The representation of these two forms of degradation is discussed in Sections C.1 and C.2 below.

1. C^2I Element Disruption

The temporary and partial distruption of a C^2I element will be represented by decreasing the performance index of that C^2I element. As just discussed, this has the effect of increasing the time delays associated with performing C^2I tasks. Specifically, the impact of an attack on a C^2I element will be represented by an impact factor between 0.0 and 1.0 stored in a table indexed by the means of attack (air, nuclear, chemical, and so forth). Thus, the effects of an attack by a particular means (M) on a C^2I element at a given time (T_o) will be "scored" by multiplicatively reducing that C^2I element's performance index ($I_p(T_o)$) by the attack means impact factor (A(M)). In other words,

$$I_p(T_o + \Delta) = A(M)*I_p(T_o)$$

Since the reduction in performance caused by disruption is temporary, the performance index must be increased back to its original level (nominally set at 1.0) over time. This will be accomplished during periodic C^2I regeneration events. At each such event, the performance indices of all disrupted C^2I elements will be multiplied by a regeneration factor (greater than 1.0). Of course, in no case will a performance index be increased above 1.0.

2. C^2I Element Destruction

Some types of attacks on a C^2I element may be so severe as to cause a complete and permanent degradation of that element's performance, i.e., its destruction. Of course, a performance index threshold; if the performance index of a C^2I element sinks below the threshold, that element will be "destroyed" and not capable of further regeneration; otherwise, the element is merely disrupted and may eventually recover its full performance capabilities.

D. THE DATA QUESTION

It is by now apparent that a wide range of data will be required for the C^2I modeling in INWARS. This concluding section discusses the associated data gathering and development problem. Specifically, it surveys the types of data which will be required and discusses their general availability. This discussion is conducted in terms of four basic categories of C^2I data: (1) structural data, (2) planning factors data, (3) decision parameters data, and (4) performance data.

1. Structural Data

As used here, "structural data" refers to data characterizing interrelationships. The prime examples are the concepts of operation, especially as regards their component operation form and terrain layout structures. No direct source for the data exists because, to the best of our knowledge, a structural approach to operations development has never been attempted in previous models. Accordingly, this data--i.e., the concepts of operation--will have to be developed for use in INWARS. The principal references to be used here are doctrinal sources such as Army Field Manuals (especially FM 100-5 and the related "How to Fight" manuals). Soviet military writings and threat descriptions will be used to develop concepts of operation appropriate to the threat forces.

2. Planning Factors Data

Planning factors data includes the range of parameters used by C^2I elements in developing operations. Typical examples are expected subordinate advance rates (together with appropriate force balance scaling factors), desired artillery support levels and supply issue rates (as a function of type of operation), and expected sortie rates (by type air craft). Specific sources for these various planning factors have not yet been identified. However, preliminary investigation suggest that planning factors data is available--indeed, the problem may not be one of finding a reference but of deciding which reference to use. Moreover, the process representations are still sufficiently flexible to be modified to accept particular forms of planning factors.

3. Decision Parameter Data

Decision parameter data includes the range of thresholds, priorities, and other parameters which are used by C^2I elements to make decisions. Typical examples are force balance thresholds defining "force imbalance conditions", nuclear or chemical threat index thresholds defining various "states" of nuclear threat, and target priorities. Such data elements are very sensitive to the specific model in which they are used. For this reason the test and experimentation phase in INWARS will be a principal source of such data. Initial decision parameter values will be developed on the basis of judgement and doctrinal statements. However, it is anticipated that these values will be revised--perhaps extensively--during test and experimentation. Indeed, since these data elements represent decisionmaking behavior, their "validity" (or, at least, their "reasonableness") can best be judged by assessing the realism of the behavior they cause to occur in the model.

4. <u>Performance Data</u>

Performance data includes the information discussed in Sections B and C above, namely, basic C^2I task performance times, performance degradation factors associated with different forms of attack on C^2I elements, and regeneration rates. Some data exists for basic task performance times: as was noted earlier, the specific decomposition of C^2I activities into tasks will be developed on the basis of the data. However, based on initial investigations, it appears that no direct data exists concerning C^2I performance degradation and regeneration. These factors will accordingly need to be estimated and then adjusted during test and experimentation.

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