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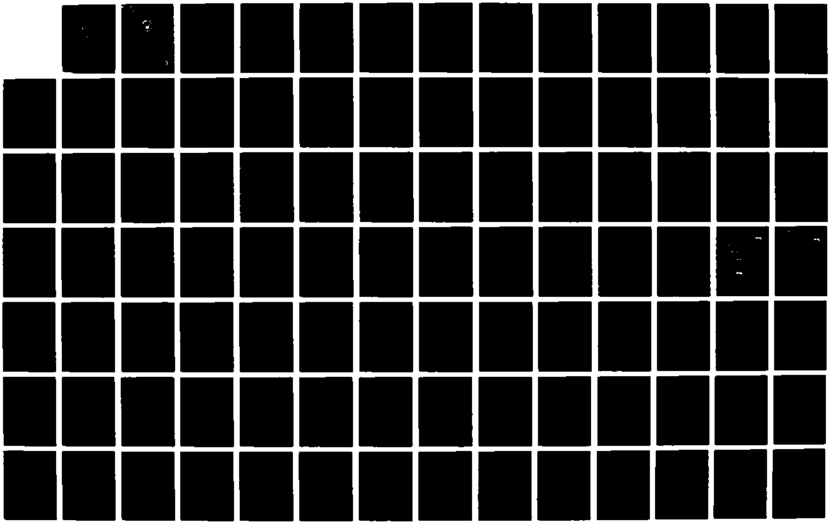

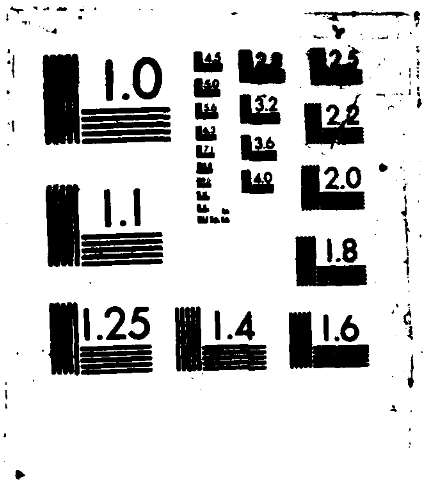

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THESIS

APPLICATION AND EXPANSION OF THE MODULAR COMMAND & CONTROL EVALUATION STRUCTURE (MCES) AS A FRAMEWORK FOR IMPROVING INTEROPERABILITY MANAGEMENT

by

Shelton Lee, Jr.

June 1987

Thesis Advisor: M. G. Sovereign

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This thesis introduces the Modular Command and Control Evaluation Structure (MCES) as a tool which the author recommends for command and control (C2) planners to use when addressing interoperability management problems. The framework of MCES is used to identify the inadequacies of the Marine Corps Technical Interface Concepts (TIC) as an interoperability management tool and provides some insight into how to better define interoperability requirements in terms of message exchange occurrences (MEOs). MEOs are the building block of interoperability, and they can be stored along with their elements of decomposition in an integrated interoperability database (IIDB) for use by C2 planners.

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Application and Expansion of the Modular Command & Control Evaluation Structure (MCES) as a Framework for Improving Interoperability Management

by

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Submitted in partial fulfillment of the requirements for the degree of

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ABSTRACT

This thesis introduces the Modular Command and Control Evaluation Structure (MCES) as a tool which the author recommends for command and control (C2) planners to use when addressing interoperability management problems. The framework of MCES is used to identify the inadequacies of the Marine Corps Technical Interface Concepts (TIC) as an interoperability management tool and provides some insight into how to better define interoperability requirements in terms of message exchange occurrences (MEOs). MEOs are the building block of interoperability, and they can be stored along with their elements of decomposition in an integrated interoperability database (IIDB) for use by C2 planners.

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I. INTRODUCTION

A. STATEMENT OF THE PROBLEM

In the past decade interoperability problems have become intense as technological advancements in the electronic industry drive communications equipment. Designers of command and control (C2) system architectures may have been overly influenced by equipment specifications. In designing a communication system to support a C2 architecture they have concentrated primarily on capabilities derived from technological advancements, rather than on information flow and mission requirements. In some instances, communications system equipment interoperated effectively, while the C2 architecture to be supported was unable to operate effectively as a system. [Ref. 1]

When individuals or command centers within a C2 architecture are not able to interoperate, they lack the ability to effectively function as a system working towards a common goal. The lack of interoperability in a C2 architecture could manifest itself in several forms: (1) individuals not understanding or misinterpreting a message, (2) command centers not able to exchange valuable military information about themselves, or (3) individuals and command centers not fully understanding operational procedures.

> A major goal of the DOD is to provide military planners with accurate, detailed information about C2 system requirements, about the interrelationship of tactical C2 systems, and about the impact that a particular C2 architecture will have on the system as a whole. [Ref. 2: p. 1]

Interoperability of command and control systems can be defined in terms of "information flow". However, presently there is no universal accepted methodology within the Department of Defense (DOD) for documenting "information flow" in a command and control architecture. [Ref. 2]

In order to address the interoperability problem of command and control architectures, a method for identifying, capturing, organizing, and accessing information necessary to describe current and projected command and control systems must be adopted. [Ref. 3: p. 4] The methodology must be able to provide a detailed view of a command and control structure, and be applied as a dynamic analysis tool for problem-solving. [Ref. 2: p. 1] and [Ref. 3: p. 1]

B. OBJECTIVE OF THESIS

This thesis addresses some of the challenges issued by Major Steven L. Pipho, USMC, in his article "Cutting the Gordian Knot of Interoperability: A Systems-Engineered Solution to the Problem of Interoperability Modeling." [Ref. 2] Pipho asserts that:

> The military faces a formidable challenge today in the area of command, control, and communications. Powerful, [communications] systems which exploit a rapidly expanding technological base are fast becoming realities; yet, issues concerning their integration into the larger context of a command and control architecture remain unresolved.

> Military planners require clearly defined standards of compatibility and interoperability to retrofit fielded systems, modify those currently in design, and plan for futures ones. [Ref. 2: p. 1]

The major effort of this thesis deals with expanding and applying a tool to enable analysts to effectively gain new insight into the problem dealing with interoperability of commmand and control architectures. Based upon Marine Corps' efforts, an architecture is defined as: "An aggregate or set of elements systematically associated and structured to accomplish a purpose that is characterized by the peculiar organization of its elements." [Ref. 2: p. ii] Therefore, a command and control architecture [system] associates elements of command and control whose specific structure facilitates the exchange of information by communications to support the achievement of mission objectives. (See Phipho, 1986) [Ref. 2: p. 2]

There are two foci in this thesis, (1) operational considerations and (2) methodological issue.

1. <u>Operational Considerations</u>

After their attempt to design an air defense C2 architecture using the Technical Interface Concepts (TIC) Concepts for Marine Tactical Systems, both the author and Pipho agreed that the methodology set forth in the TIC should be examined and analyzed for its ability to adequately address interoperability problems on an architectural level. This was undertaken by employing, as a test case, the Operational

Facility (OPFAC) tasks associated with a C2 communications architecture that is required to produce an air tasking order (Frag).

2. Methodological Issue

Conversely, by examining the procedures associated with the air tasking order, this thesis will verify the ability of a Lawson-like C2 Process model to practically describe service doctrine.

II. BACKGROUND

A. DEFINING INTEROPERABILITY OF A C2 ARCHITECTURE

Throughout history the military services have been [illegible] with interoperability problems associated with command and control (C2) systems. Interoperability of C2 systems [illegible] arduous topic to fully analyze, because the terms "interoperability" and "C2" have several [illegible] result, one may not be sure of the intended meaning of the phrase "interoperability of a C2 architecture system." [illegible] following two subsections are written to provide [illegible] definition for interoperability of a C2 architecture.

1. Interoperability

For this thesis, the formal definition for interoperability, as defined in the Joint Chiefs of Staff Publication 1, will be used:

> Interoperability is the ability of systems, units or forces to provide service to and accept services from other systems, units or forces and to use the services so exchanged to enable them to operate effectively together. [Ref. 4: A-3]

Interoperability has a major implication that must be taken into account. A system must not only interoperate with other systems, but it should also operate effectively with its own units and forces as a complete system. In other words, there must be both intraoperability (definition of "system") and interoperability in order to have effective operations.

To illustrate the above point, consider a Marine air defense system which is composed of the following control facilities/agencies:

- Tactical Air Control Center (TACC)
- Tactical Air Direction Center (TADC)
- Tactical Air Operation Center (TAOC)
- Light Antiaircraft Missile Battery(LAAM)
- Forward Area Air Defense Battery (FAAD)

Each of these facilities/agencies are made up of several subordinate units and/or sections which perform unique tasks, such as the LAAM battery which has an Antiaircraft Operations Center (AAOC) and a Battery Control Center (BCC). If the subordinate units and/or sections within a facility/agency are unable to interoperate among themselves, then that facility/agency lacks interoperability. And if a facility/agency does not have interoperability within itself, then it can not operate effectively as a subordinate part of a larger organization. In order for an air defense system to be interoperable, interoperability must be established throughout the entire system. The hub of the Marine Corps' air defense operation is the TAOC. (See Figure 2.1) The TAOC must be able to interoperate with the TACC/TADC, LAAM battery, and FAAD battery. If any of these organizations could not interoperate with the TAOC, then there would not be an air defense system. The air defense system requires that all of its facilities/agencies be interoperable in order to be considered a system.

The official Department of Defense (DOD) definition for command and control is:

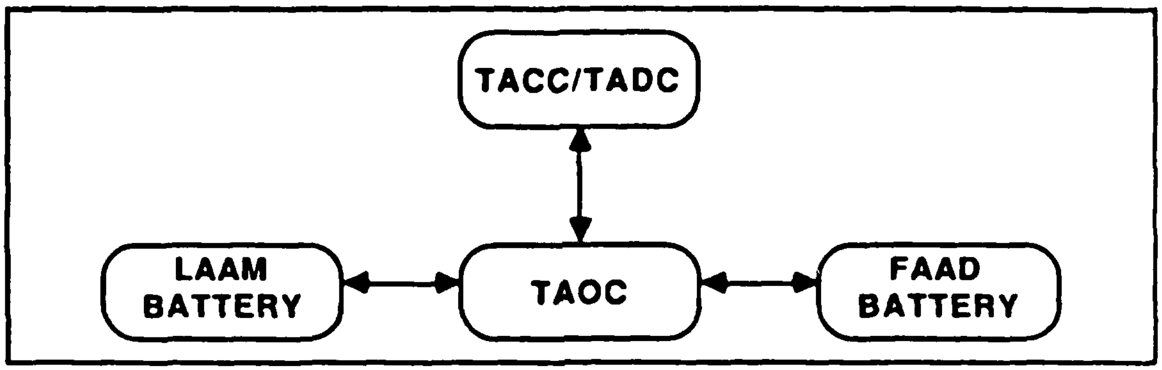

Figure 2.1. A Simple Air Defense System.

> The exercise of authority and direction by a properly designated commander over assigned forces in the accomplishment of the mission. Command and control functions are performed through an arrangement of personnel, equipment, communications, facilities, and procedures which are employed by a commander in planning, directing, coordinating, and controlling forces and operations in the accomplishment of his mission. [Ref. 3: p. 2-2] and [Ref. 5: p. 23]

Therefore, C2 is the total and all encompassing process of a commander accomplishing a mission through the assets of his assigned forces. The commander controls and directs his forces by some means of communication, which can range from a simple manual technique (speech) to a fully automated facility, such as a naval communication station (NAVCOMMSTA). Thus, all forms of communication and their supporting facilities are only means which a commander and his forces utilize to pass information to one another, in order to interoperate and effectively accomplish the assigned mission. In support of C2, C2 systems are developed, acquired, and fielded. The JCS Pub 2 definition of command and control, and information system is used to define C2 systems:

> An integrated system comprised of doctrine, procedures, organizational structure, personnel, equipment, facilities, and communications which provides authorities at all levels with timely and adequate data to plan, direct and control their operations. [Ref. 3: p. 2-3]

2. Interoperability of a C2 Architecture

Based on the above definitions of interoperability, C2, and architecture; "interoperability of a C2 architecture" will be defined for this thesis as: The ability of an aggregate set of control faciltities/agencies associated with an architecture to exchange services among themselves, so that the exchanges enable a commander to accomplish his mission. This definition emphasizes the C2 architecture and not the specific communication system which supports it.

Although interoperability of communications systems is important, the information requirements and functional relationships of a C2 architecture must first be defined. Then, the communication system to support a peculiar C2 architecture and its interoperability requirements can be identified. Following this sequence will better enable planners of communications systems to design systems which will support a commander in accomplishing his mission, rather than one which usually limits him. [Ref. 2]

B. *HISTORICAL PRECEDENCE FOR THE WORK*

In the early 70's, the Marine Corps realized it had a problem with interoperability of C2 systems and attempted to resolve this problem through the Landing Force Integrated Communications System (LFICS) program. During 1985 the LFICS program was redirected. The new thrust was to develop a conceptual framework that could combine information requirements and information flow with the constraints imposed by a particular configuration of communications and information-processing equipment. [Ref. 1: p. 2]

In the conceptional framework of LFICS, C2 doctrine and operational requirements generated information needs. These information requirements were originally known as Needlines, later as Message Exchange Occurrences (MEOs). A MEO summarizes a requirement for information exchange between two nodes. A MEO consists of a sender, receiver, message to be transmitted, and the circuit medium in which to pass the message. (See Figure 2.2). Above the line is the message, below the circuit. The flowline shows sequence and simple timing on the network. MEOs could be chained to one another to form a network that represented information flow over time. (See Figure 2.3) [Ref. 1, 11] and [Ref. 6]

At the heart of the LFICS architecture was a large information base which consisted of a number of related databases. It was planned that the LFICS information base would contain information on the composition of MEOs (source nodes, sink nodes, message types, and circuit medium) and communications equipment specifications. After the construction and maintenance of this information base, it was contemplated that system planners and managers would have a baseline from which to manage their systems. [Ref. 1: p. 2]

The author's interpretation of the LFICS information base is depicted in Figure 2.4. This interpretation structures the information base as a hierarchy of databases. Each database points to other databases which were either a subset or decomposition of a higher order database. For example, the MEO database would point to the C2 nodes database, message types database, and the circuit standards database.

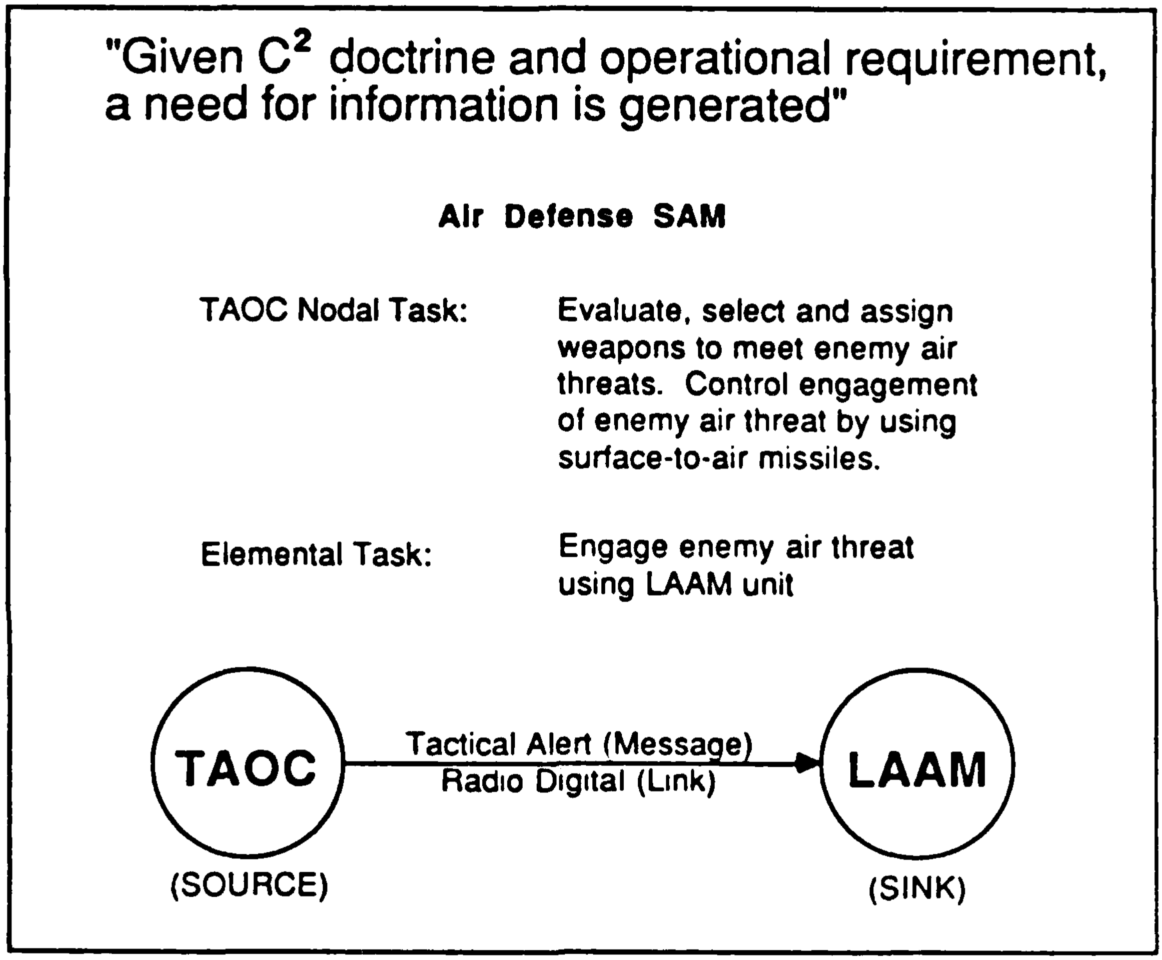

Figure 2.2. A MEO for an Air Defense Envelope.

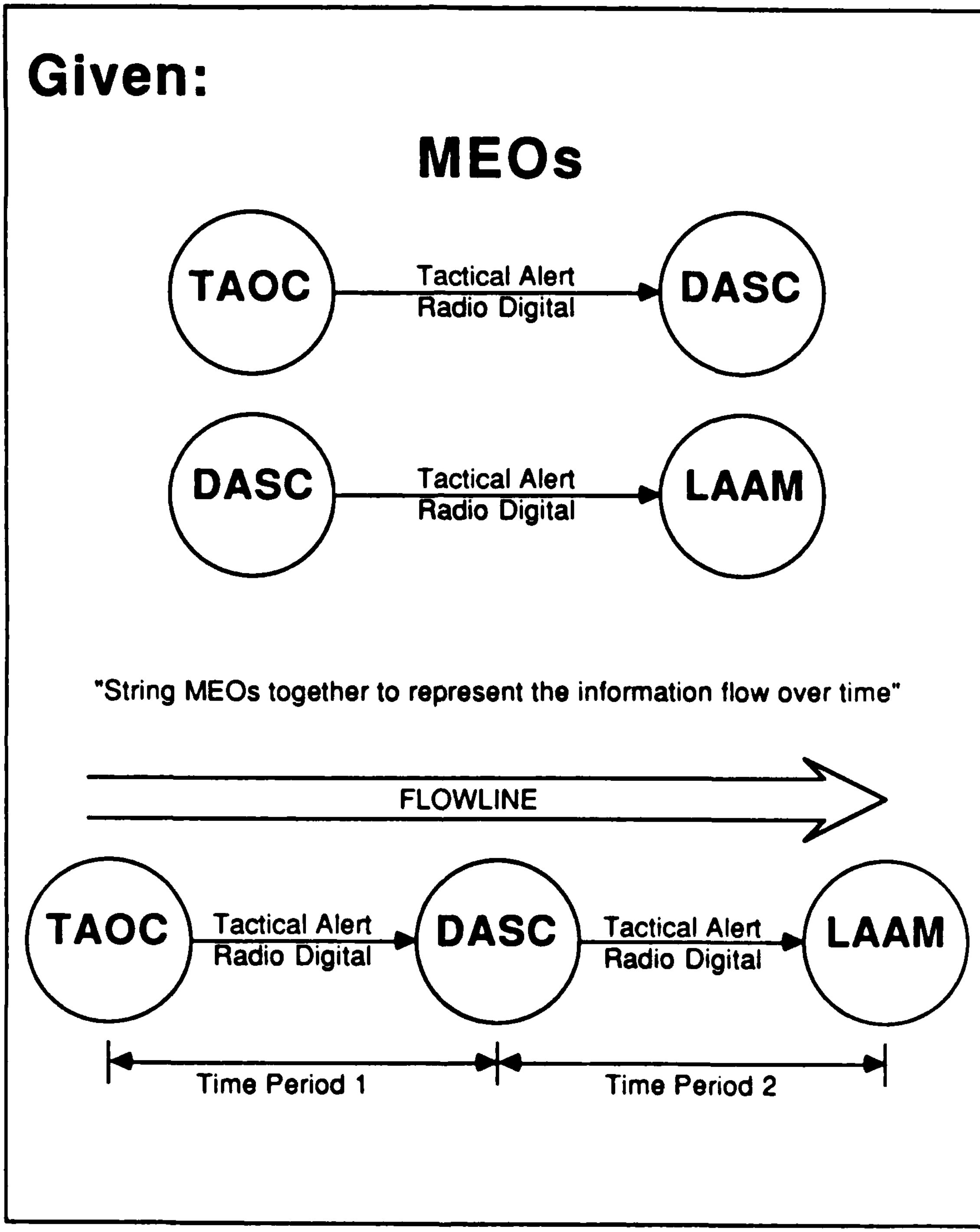

Figure 2.3. Flowline for an Air Defense Example.

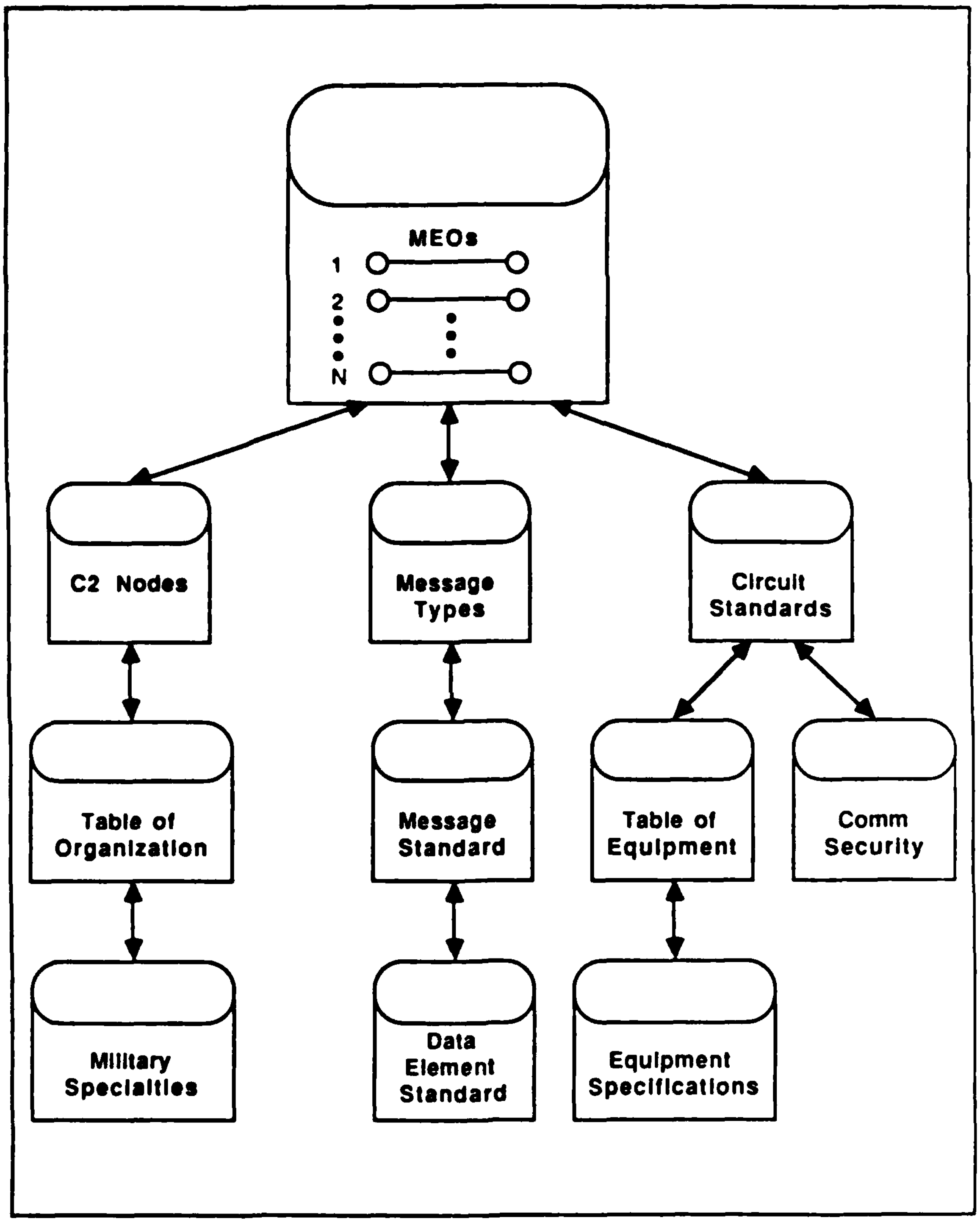

Figure 2.4. An Interpretation of the LFICS Information Base.

An information base would be useful to many different types of users. Below are six broad user areas suggested by Pipho [Ref. 1] in his point paper titled " A Development Strategy for a LFICS/C4I Architecture":

1. System Developers

> System developers have an obvious need for a [LFICS] information base . . . . the nature of the job requires them to extend their knowledge of the current communications systems to assess future requirements.
>
> As sophisticated systems are proposed and accepted, the R&D community must ensure that diverse systems can be integrated efficiently into the general architecture. A typical application program would likely extract information from one database containing equipment specifications, system components, and interoperability standards such as interfaces, protocols, etc., and information from another dabase on how the various sytems are to be used, where they would be deployed, and the number and kind of skills required to operate and maintain a system. Additionally, an R&D database could contain information on engineering change proposals for systems under development to enable a project officer to ascertain the effect of a proposed modification.

2. The Fleet Marine Forces

> A good applications program for the [Fleet Marine Force] FMF would assist the [communication electronic officer] CEO or communications officer in the detailed planning of his communications "order of battle." He may want to access a database to gain detailed specifications of the equipment that is organic to his unit. Or, perhaps, he would want to analyze the loading of his particular node by examining the quantity of data and data rate he needs to successfully pass information between a sender and receiver for a particular type of exchange.

3. Acquisition Managers

> HQMC recently requested MCTSSA and MCDEC to comment on a proposal to use the LFICS study developed by TRIAD Corporation to ascertain the [communication security] COMSEC requirements for the 1990's. The idea was to examine the information needlines [MEOs] and flowlines in the loading analysis, count the number of secured nets, note their type, and produce a final count of COMSEC equipment by category.

4. Doctrine Developers

> Doctrine plays a key role in the [LFICS] architecture. It fundamentally influences the needlines [MEOs] and flowlines of the communications systems because it defines the elements of a combat team and the relationships between them. An applications program for members of the Doctrine Branch or the Advanced Amphibious Warfare Study Group would be one which would access a database, extract organization and C2 information, and explore the effects of doctrine changes on the communications system by substituting or changing the composition of a combat force.

5. Educators

> The [LFICS] information base can be viewed as the repository for all [C2] information. Students at the intermediate and senior level [military] schools could have programs that give them basic information about Marine Corps [C2] architecture. Additionally, schools could request applications programs to enable students to validate their solutions to school exercises in the area of [C2] supportability.

6. Others

> . . . . the [LFICS] information base could serve a wide variety of uses. Its utility could be extended by incorporating ports to other information bases (e.g., JINTACCS) to access information on a wide variety of matters. Its usefulness is really limited only by our imagination and ingenuity.

The general concept of the LFICS program of designing communications systems based on mission requirements was an excellent idea. According to Pipho [Ref. 1] the key to the LFICS program success will be:

> . . . an extensive analysis of the [C2] information requirements. Once these requirements have been identified and verified, they can be matched with various sets of equipment to determine the effectiveness and efficiency of a particular [C2] architecture.

However, several attempts were made to implement a LFICS architecture, but they were unsuccessful. Phipho states that the "failure of earlier attempts was that each [attempt drove] the model [LFICS architecture] by equipment specifications rather than information requirements." Also, system planners for LFICS began to focus on communication needs, rather than on the basic issues of C2. [Ref. 1]

So, after nearly 20 years, the Marine Corps still does not have a satisfactory information base with which it can effectively plan the acquisition of new communication systems which support a C2 architecture. [Ref. 1: p. 1]

C. RELATED WORK

The foundation of this thesis is the related work of two major efforts. One effort is the Marine Corps' approach to resolving the problem of interoperability. A significant part of this effort was from the results of Major Pipho's work [Ref. 2]. The other work evolved from a series of workshops sponsored by MITRE Corporation, the Military Operations Research Society (MORS), and most recently the Naval Postgraduate School (NPS) series of workshops held during the period February 1984 to January 1987 concerning C3 measurement.

1. Marine Corps' Approach

Major Pipho has proposed a tool to resolve the problem of interoperability management. His approach to this dilemma is to first simplify the concept of command and control in order to have a better understanding of the basic issues of interoperability. Secondly, he provides a baseline concept for the design and implementation of a command and control integrated information base that will contain the necessary information required to effectively manage interoperability. [Ref. 2] A discussion of the fundamental structure of C2 architectures is provided for a basic understanding of Pipho's work.

a. Introduction

A command and control architecture is composed of one or more message exchange occurrences (MEOs) operating together to support the commander in the accomplishment of his mission. Pipho defines a MEO to be: "A unique association of four essential components that define information transfer at the fundamental level. These components are source command and control element (C2E), sink, message standard, and C2E link standard." (See Figure 2.5) A C2E consists of equipment, communication, facilities, personnel, and procedures which perform the tasks and functions of a C2 node. A message standard is "a discrete set of message elements that carry information between C2Es." A link standard is "a discrete set of technical specificatons requirements that characterize the signal interface between two C2Es." A C2 node may consist of one or more C2Es. [Ref. 2]

b. Fundamental Structure of C2 Architectures

The simplest of C2 architectures consist of two C2 nodes where each node is represented by a C2E. If the C2Es have an exchange of information over a link, with one C2E always transmitting and the other only receiving, then the C2 architecture can be defined by one MEO. (See Figure 2.5) The ability of two C2Es to exchange information with one another in the support of some mission defines their interoperability. This is true, because in order for two C2Es to be able to exchange information they both must be able to handle the same discrete set of message elements that carry information between them and the same set of technical specifications requirements which enables this exchange of information. Therefore, the MEO, the simplest of C2 architectures, is the basic unit of interoperability. [Ref. 2]

Pipho suggests that a MEO identifies the interoperbility requirements of larger and/or more complex architectures. Architectures which are more complex can be designed by interconnecting MEOs having a common C2E which supports the same mission. (See Figure 2.5). Pipho makes the following comment concerning interoperability of a C2 architecture:

> An [architecture] that consists of a chain of validated MEOs necessarily reflects the compatibility and interoperability inherent in the MEOs that created it. This frees the user from concern about the validity of . . . interoperability in his C2 [architecture]. Instead, he [the user] may concentrate fully on the flow of command and control. [Ref. 2: p. 5]

The validation of a MEO can be accomplished by verifying that it exists at some point in time according to doctrine and/or from the experience of experts in the field. Once MEOs have been validated for a given mission area, they could be recorded

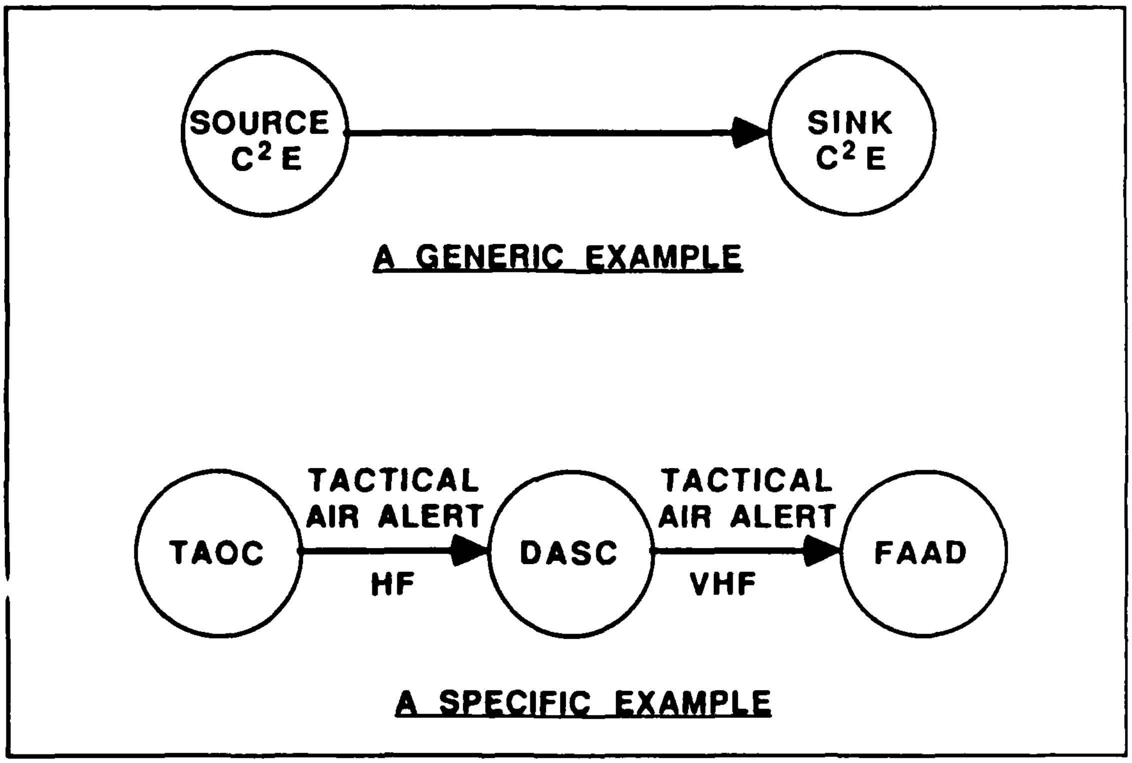

Figure 2.5. A Message Exchange Occurence (MEO).

into an integrated information data base for future reference. C2 planners and designers could use such a data base to study the implementation of potential C2 architectures. [Ref. 2] This integrated data base would necessarily contain the interoperability standards for any C2 architecture designed from the validated MEOs that are recorded in the data base. This data base would be similar to the one proposed for the LFICS program. (See Figure 2.4)

Information exchange requirements are reflected in MEOs. However, there may be times when information that is required to support a task can not be passed. Perhaps the C2Es, link standard, and/or message type are not available in the appropriate arrangement to facilitate an exchange of information. Pipho suggests that an integrated information base could assist C2 planners in solving this problem. [Ref. 2]

The first step toward developing the integrated information base is to identify the set of basic components that define the C2 architecture. At the most general level, these are:

- C2Es
- C2E tasks
- C2E resources
- Information required to perform C2E tasks
- Communication capabilities to support the exchange of information

The relationship of these C2 components is important. Figure 2.6 displays the basic C2 components and their relationship. Resources of a C2E perform tasks. Tasks can be decomposed into subtasks that describe what activities the C2E is required to perform. In order to accomplish the defined tasks or subtasks, information is required to provide knowledge about the tasks. Information is of little value if it is not shared quickly by those who need to act upon it. So, information is exchanged by some form of communications. [Ref. 2: p. 8]

Resources can be grouped into two general categories, people and equipment. Pipho inferred that the degree of automation employed by a C2E is represented in the utilization of one type of resource over the other. The more equipment used to accomplish a task the greater the automation. Figure 2.7 illustrates the point that a C2E can have two types of resources. Personnel perform personnel tasks. The personnel to perform these tasks require some knowledge about the task. This knowledge is contained in information elements. Information elements are then grouped into a message for an exchange of information. Equipment resources follow a similar process. Equipment tasks are performed by equipment and/or systems of equipment. Signals (mechanical or electrical) provide equipment/systems of equipment some form of information so that they can perform equipment tasks. However, the signals must communicate over a circuit. The ability of a C2E to

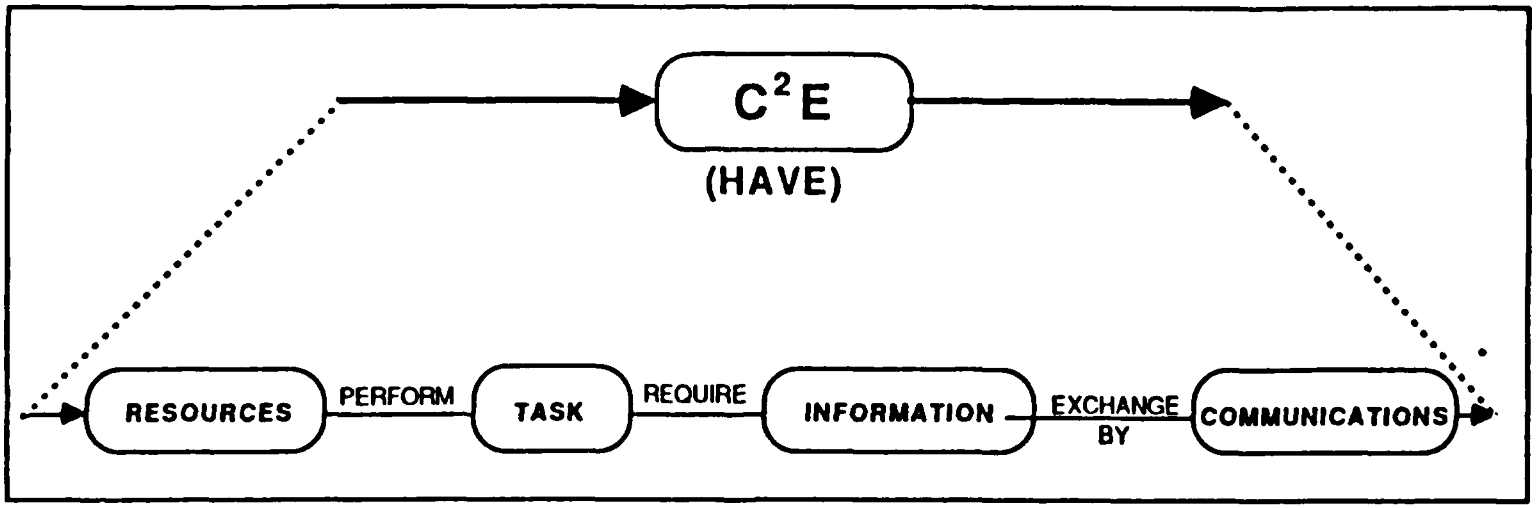

Figure 2.6. Major Components of C^2 Architecture .

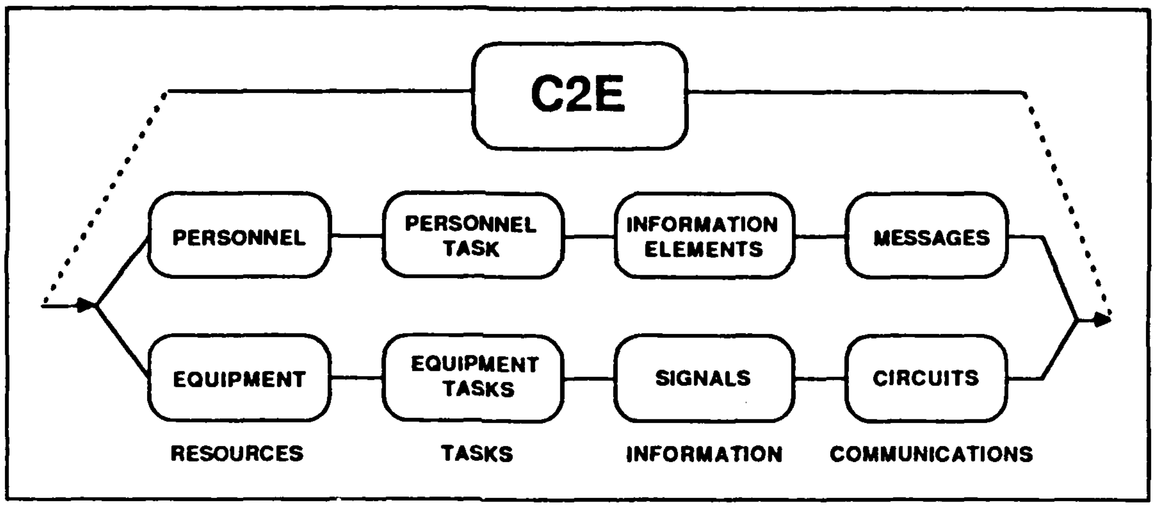

Figure 2.7. Major Components of C^2 Architecture Amplified.

exchange information with another C2E displays its ability to interoperate. [Ref. 2: pp. 5-7]

Another approach to viewing the components of a C2E is depicted in Figure 2.8. The C2E components (resources, tasks, information, and communications) have some degree of interdependence. An increase in either the number of tasks, level of information, or amount of communications will demand larger quantities of resources to perform a particular function. This increase in resources is captured in the resource curve. This curve is for illustrations purposes only. The actual slope of the resource curve will depend on the scenario. Intuitively, it is believed that the resource curve will always be monotonically increasing.

The characteristics of the C2E components determine how a MEO will be defined; recalling that a MEO is defined by a source C2E, sink C2E, message standard, and link standard. The MEO is the basic unit of interoperability and is the foundation on which a C2 architecture should be designed. How MEOs are derived to design an implementation of a potential C2 architecture is the underlying focus of this thesis. The methods proposed in the workshop series will be employed to provide some insights into the interoperability problem.

2. Workshop Effort

a. Introduction

The series of workshops focused on an evaluation structure based upon measures of effectiveness (MOEs), which

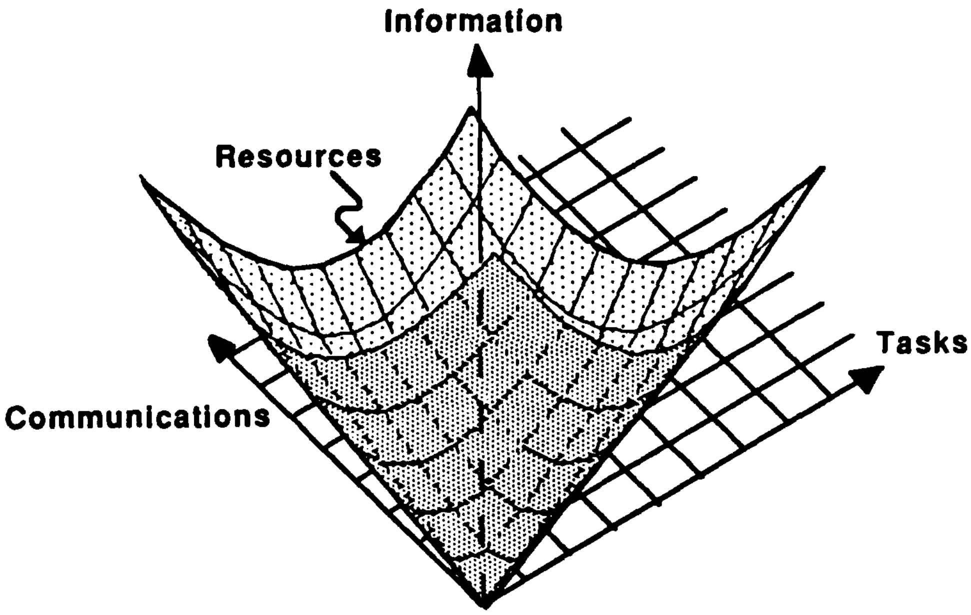

Figure 2.8. Relationship of C^2E Components.

would assist analysts and decision makers in their efforts to evaluate command and control systems in terms of improved combat effectiveness. [Ref. 3: p. iii]

The workshop series resulted in an evaluation-formulation tool, which later became known as the Modular Command and Control Evaluation Structure (MCES). MCES is composed of seven separate modules that guide the analyst through a C3 evaluation, as illustrated in Figure 2.9. [Ref. 8] Below is a brief description of the MCES methodology.

b. MCES' Methodology

(1) Module One (Problem Formulation)

Module one, the problem formulation block, addresses the question of the decision maker's needs and objectives in a specific problem. For a military sytstem, these could include the concept definition and development, system design, acquisition, or operations. This module is analogous to the systems approach "objectives of the system. . . . those goals or ends toward which the system tends." The objectives need to be identified as "real" goals or "stated" goals, and once identified, need to be operationalized. [Ref. 7]

(2) Module Two (C2 System Bounding)

Module two is the system bounding block and is used for identifying relevant quantities, including physical entities and structure, and boundaries of the subsystem, system, own forces, environment and reset of the world. Figure 2.10 depicts the "onion skin" that describes the MCES systems bounding. . . . .[Module two] includes everything outside the system's control [the environment] and everything that determines how the system performs. [Ref. 7]

(3) Module Three (C2 Process Definition)

Module three, the process definition module, takes a given system configuration (i.e., a specific scenario and mission) and defines the processes needed to fulfill the mission. It maps the processes needed to fulfill the mission. It maps

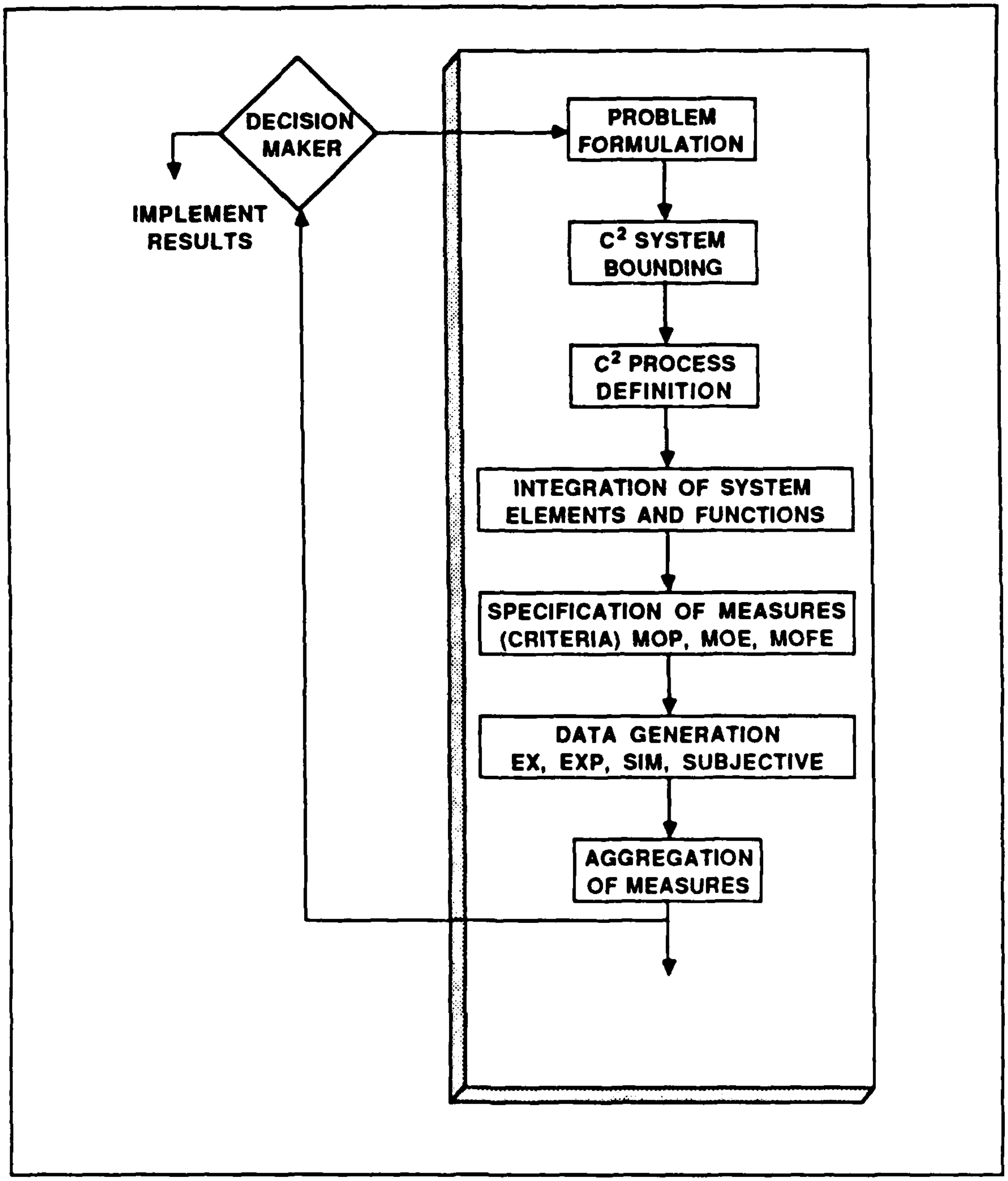

Figure 2.9. Modular Command and Control Evaluation Strucure (MCES).

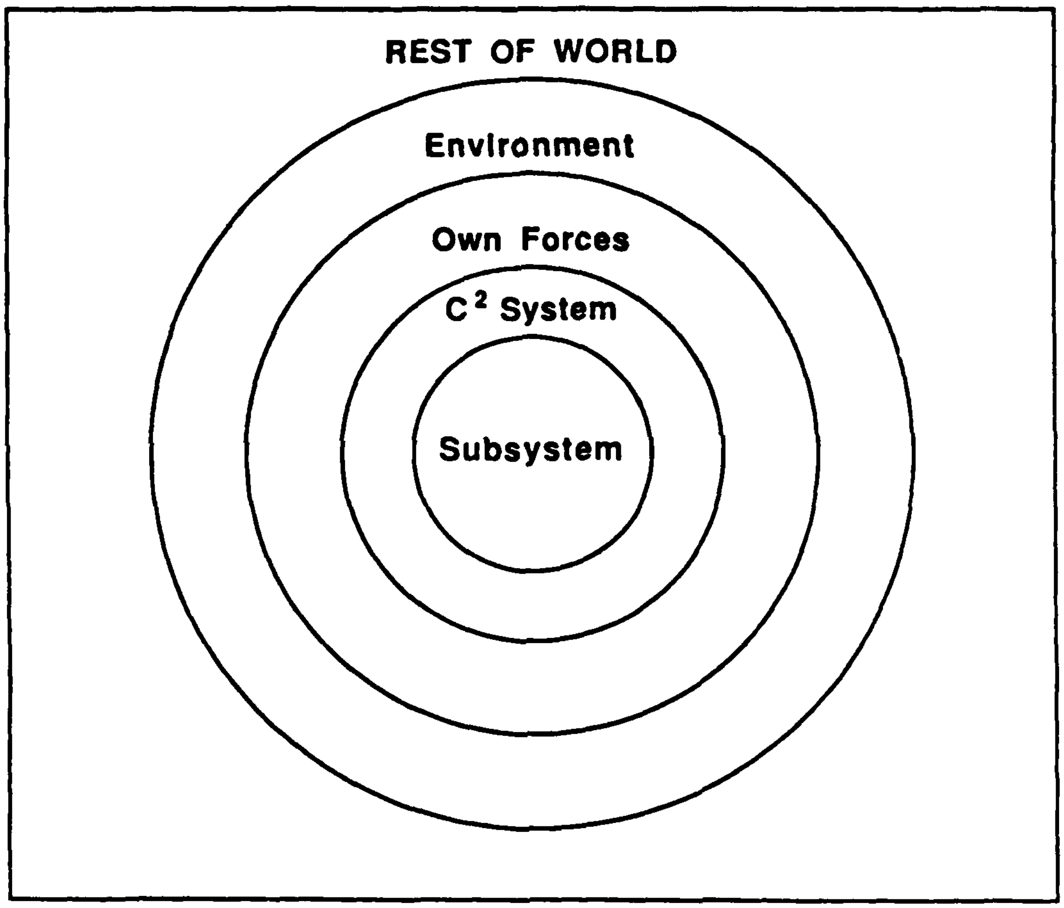

Figure 2.10· Onion Skin Concept.

the processes needed to a Lawson-like loop system configuration. The concept focuses attention on the environmental "initiator," the internal process function, and the input to and output from the internal process and environment, including enemy forces, own/neutral forces and usual environmental components. [Ref. 7] (This concept is explained in Chapter III).

(4) Module Four (Integration of System Elements and Functions)

Module four, the integration of statics and dynamics module, relates the information flow and process functions to the organizational structure as well as relating the physical entities ot the process functions. [Ref. 7]

(5) Module Five (Specification of Measures)

[Module five is the specification of measures]. Guidelines are provided to identify, develop and select measures that gauge the C2 system's response. These measures will provide a standard for comparison as the underyling architecture of the C2 system is reconfigured; they are directly tied to operational issues relating to the archtiecture. [Ref. 8]

(6) Module Six (Data Generation)

Given that measures have been selected, the sixth module identifies the need to develop a data generator that will provide values for the C2 system's response. [Ref. 8] Module six encompasses data generation by exercise, simulation, experiment, and/or subjective judgements. [Ref. 7]

(7) Module Seven (Aggregation of Measures)

In the seventh module, techniques are provided to aggregate measures in a way that relates measurement of C2 response to combat outcome. [Ref.8]

The decision maker has several options after progressing through the seven modules. The options are do nothing, implement results, or make another iteration through one or more of the seven MCES modules. [Ref. 9]

The author will integrate the conceptual model of MCES with the MEO concept in order to provide some insight into how to address interoperability problems on an architectural level.

III. EXPANSION OF MCES FOR INTEROPERABILITY ANALYSIS

A. INTRODUCTION

This chapter serves to demonstrate the application of MCES as a tool to assist C2 managers and planners to better define interoperability requirements of C2 communications architectures through improving their ability to manage the sort of interoperability problems addressed in Chapter II, Section B titled "HISTORICAL PRECEDENCE FOR THE WORK."

In this MCES application, Pipho's concept of a MEO will be added as the major tool for interoperability analysis. The MEO is considered to be the basic building block for C2 communications architectures and the fundamental unit of interoperability. This concept will be further expanded by the author.

B. BACKGROUND

The author first attempted to apply Pipho's concept of a MEO as described in Pipho's paper titled "Cutting the Gordian Knot of Interoperability: A Systems-Engineered Solution to the Problem of Interoperability Modeling" [Ref. 2] to an air defense C2 architecture. The author used the Marine Corps' "Technical Interface Concepts for Marine Tactical Systems," otherwise known as the "TIC" to verify Pipho's claim.

[The TIC] . . . establishes Marine Corps interoperability and intraoperability[1] requirements. In these areas, it provides planning guidance for true specification and development of Marine Corps tactical data systems, equipments, and procedures. [Ref. 10; p. 1]

The following is quoted from the TIC concerning information exchange requirements:

Information exchange requirements were developed from approved doctrine, existing standing operating procedures, and established techniques played against a scenario depicting Marine Corps units in . . . amphibious and land combat operations. These requirements were further categorized and correlated with the broad operational tasks and information categories of JCS Pub 12, providing two-way traceability between defined agency [OPFAC] tasks and the broad operational tasks." [Ref. 10: pp. 1-2]

From the above quote, the TIC should be able to support Pipho's MEO approach to designing a C2 architecture. But the author found that it does not as described below.

The author defined the archecture C2Es[2] as shown in Figure 3.1 for an air defense scenario. The air-defense system was defined by the following control facilities/agencies:

- Tactical Air Control Center (TACC)
- Tactical Air Operations Center (TAOC)
- Light Antiaircraft Missile Battery (LAAM)
- Forward Area Air Defense Battery (FAAD)
- Combat Air Patrol (CAP)

---

[1] Intraoperability is equivalent to interoperability except that intraoperability is concerned with operations within one system, whereas interoperability is focused on operations between different systems.

[2] The TIC refers to the C2E concept as an operational facility (OPFAC) [Ref. 14: p. 2-1] The terms C2E and OPFAC will be used interchangeably in this chapter.

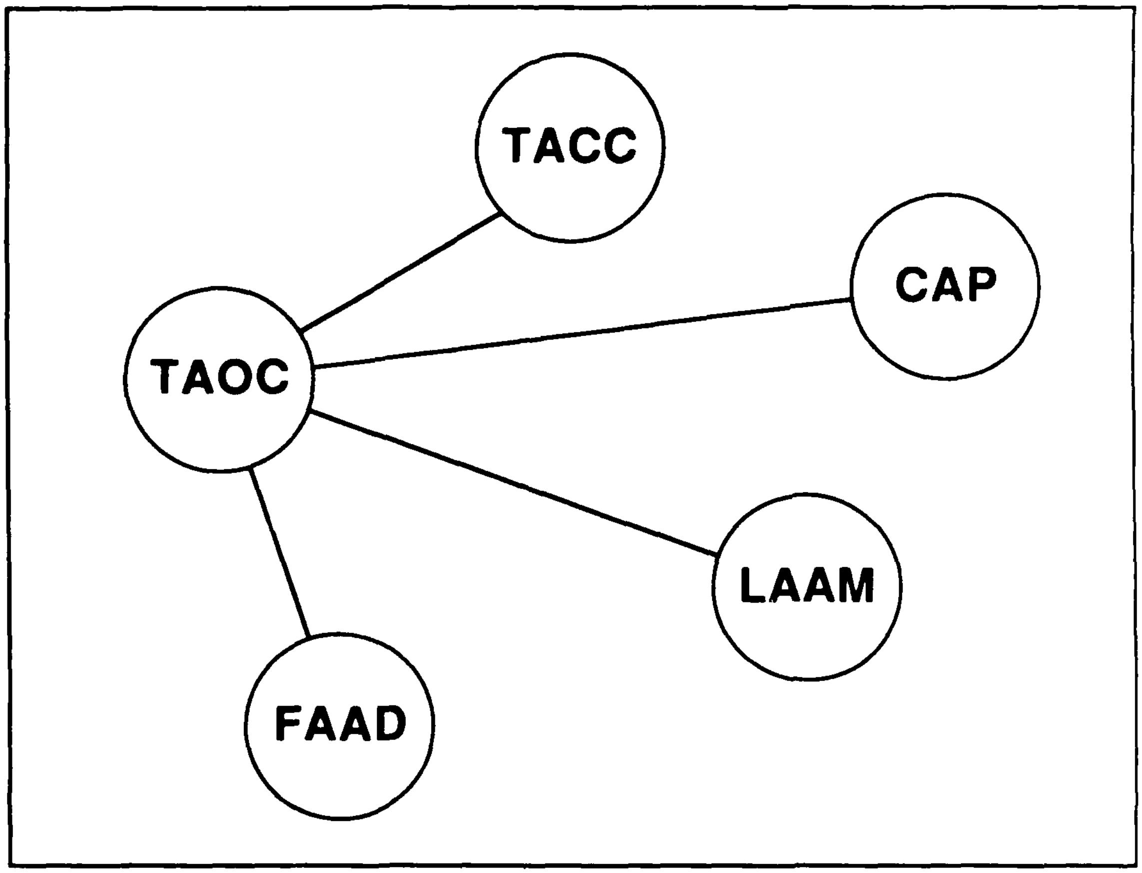

Figure 3.1. An Air Defense Organization.

He then proceeded to identify the information exchange requirements between C2Es without much success. Although the basic ideas supporting the MEO concept are there, the description of the tasking of OPFACs is not appropriate. There is no definitive way to implement the resultant exchange information exchange requirements. The author found it impossible to identify what type of information had to be exchanged between C2Es using the TIC. Therefore, the author was unable to build MEOs and consequently he was also unable to design an air defense architecture from the TIC alone.

The OPFAC tasks were not logically organized. An OPFAC task consists of a five digit number. The first three digits represents a particular OPFAC, i.e., OPFAC #650 (TACC) (See Appendix A). The last two digits identify a functional area category (See Appendix B). Numbers were assigned to OPFAC tasks without regard to operational considerations; such as the force level (company, battalion, or division) or the interrelationships of tasks.

The narrative summaries in the TIC associated with the OPFAC tasks do not allow distinguishing between hierarchical levels, e.g., MAU vs MAF, or between specific mission areas, such as anti-air warfare and land combat operations. This made it impossible to apply Pipho's MEO approach to analyze interoperability requirements, at the appropriate level and for designated missions from the TIC. Therefore, an additional technique as described in the next section was developed.

C. DESCRIPTION OF PROBLEM

Recalling that a MEO is defined by a source C2E, sink C2E, a message standard, and a link standard, the author expanded the TIC's approach to interoperability management requirements. In order to define a MEO, its four elements must be identified in terms of their characteristics. First both source and sink C2Es are determined. These are very easy to characterize, while the remaining two elements of a MOE are not. The message standards are dependent on what type of tasks are being performed. However, all too frequently, the tasks to be performed are neither well delineated nor well documented. Since tasks are often difficult to define, message standards, which depend on task definitions, are subsequently difficult to characterize. Link standards, in turn, are dependent on message standard characteristics. The relationship between C2Es and tasks can be analogous to a sentence structure diagram (See Figure 3.2). The C2Es can be considered to be similar to subject/object which are the "doers"; while the task can be equated to a verb, which describe the action between the C2Es. [Ref. 11]

A C2E can be characterized by its (1) nation, (2) service, (3) branch, (4) echelon, and (5) unit. The following is an example: Communications Support Company, Eight Communications Battalion, Force Service Support Group, Fleet Marine Force Atlantic, United States of America. If the unit is unique and one is familar with it, one may also know the identify of its

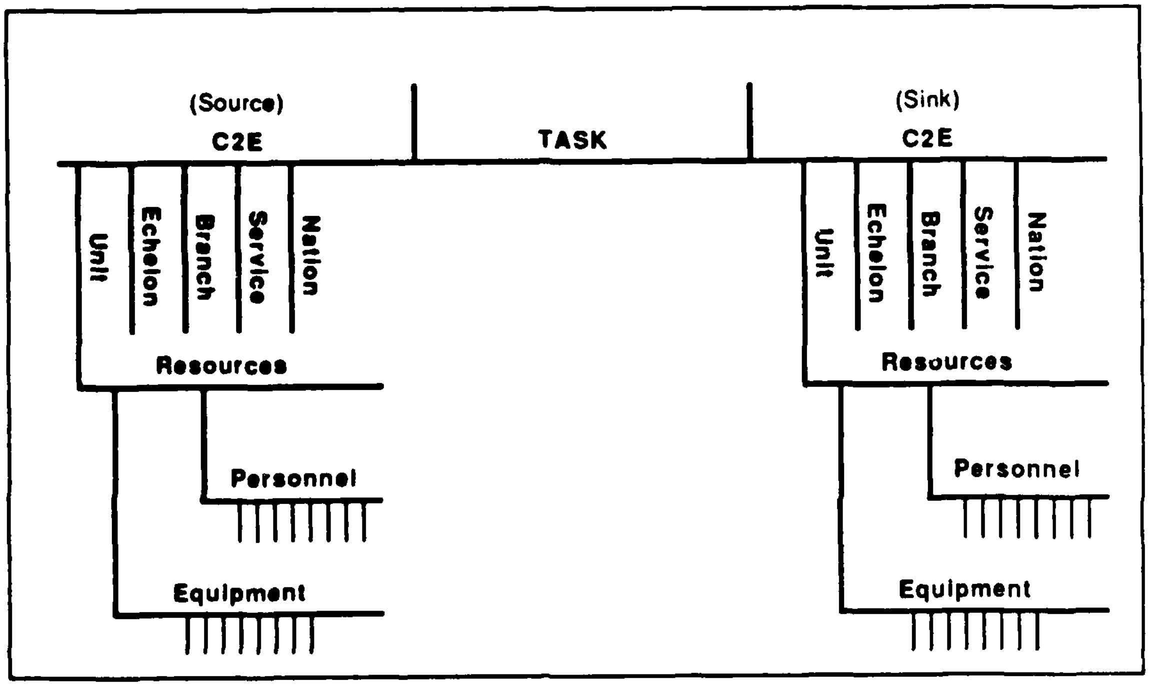

Figure 3.2. C^2E and Task Structure.

echelon, branch, service, and nation; such as in the example: Communication Support Company is unique to the U.S. Marine Corps and the Eight Communications Battalion, so the other organizational levels are implicitly known. A unit has certain resources (equipment and personnel) which further characterizes a C2E. [Ref. 11]

Task or OPFAC task are not as easily characterized. The TIC is a first attempt at task specification; however, as indicated previously, its approach is not refined enough to meet this challenge. The narrative summaries defining OPFAC tasks are too broad. They address several tasks which makes it very difficult to identify what is actually being done and what information requirements are associated with a given task. Also, if one could identify the information requirements needed to develop message standards for a collection of MEOs, they most likely could not work backwards. That is, given an MEO, what task is associated with it? The narrative summary for OPFAC task 65001 (TACC) is provided to illustrate the above point. [Ref. 11]

> TACC Task 67500. Supervise and coordinate the operational planning and tactical execution thereof by subordinate and supporting agencies to preserve economy and unity of effort, while ensuring the accomplishment of the missions of the TACC in support of the MAGTF objectives; modify the tasking of supporting agencies as required. [Ref. 10: p. D-2]

Examining the above narrative, it is very difficult to tell where one task ends and another begins. Also, it is impossible to determine what organizational level this summary is referring to. However, assuming there is an MEO defined for one of the tasks contained in the above summary, it would be very difficult, if not impossible, to tell what task the MEO is related to.

Using the MCES structure, the author synthesized the above approaches to characterizing C2Es to respond to the analytic challenge of characterizing tasks.

1. Problem Formulation

There are two foci in this thesis, (1) operational considerations and (2) methodological issue.

a. Operational Considerations

After their attempt to design an air defense C2 architecture using the TIC, both the author and Pipho agreed that the methodology set forth in the TIC should be examined and analyzed for its ability to adequately address interoperability problems on an architectural level. This was undertaken by employing, as a test case, the OPFAC tasks associated with a C2 communications architecture that is required to produce an air tasking order (Frag).

b. Methodological Issue

Conversely, by examining the procedures associated with the air tasking order, this thesis will verify the ability of a Lawson-like C2 Process model to practically describe service doctrine.

2. C2 System Bounding

The physical entities of the C2 communications architecture are the Combat Operations Center Marine Air-Ground Task Force (COC MAGTF), Combat Operations Center Ground Element (COC GE), and Tactical Air Command Center (TACC). (See Figure 3.3) These three OPFACs are the C2Es of a Marine Amphibious Brigade (MAB). The COC GE and TACC are considered to be on the same organizational level, although the TACC supports the COC GE with air support requirements. Each of the C2Es are commanded by a commander who is supported by a staff. The commander of the COC MAGTF is called the MAGTF commander or MAB commander, but for this thesis the MAGTF commander title will be used. The COC GE is commanded by the Ground Combat Element Commander (GCE) who is responsible for identifying, planning, and establishing target priorities and coordinating the air attacks as directed by the MAGTF commander [Ref. 12: p. 1-4]. The ACE commander has the authority to plan, control, and coordinate all air operations within his assigned area [Ref. 12: p. 1-4]. Both the GCE commander and ACE commander report directly to the MAGTF commander who is in charge of the overall combat operation.

The bounding process also specifies the physical relationship of C2Es. Although this C2 communications architecture is organized to employ the doctrine of centralized control, the physical entities are by doctrine distributed physically. (See Figure 3.4) In one typical scenario, the

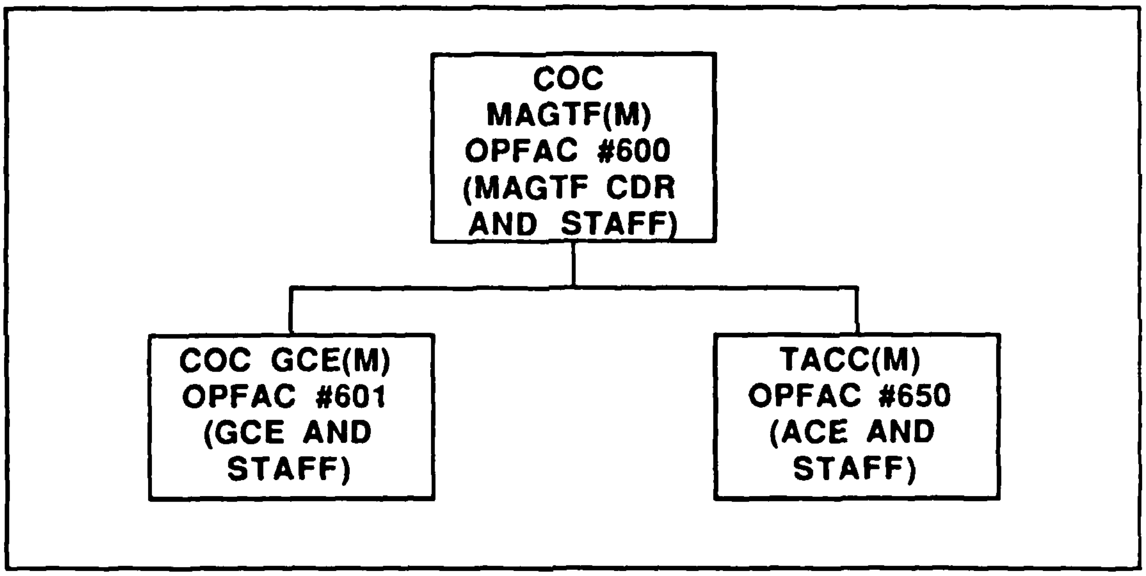

Figure 3.3. Organizational Structure for a MAGTF.

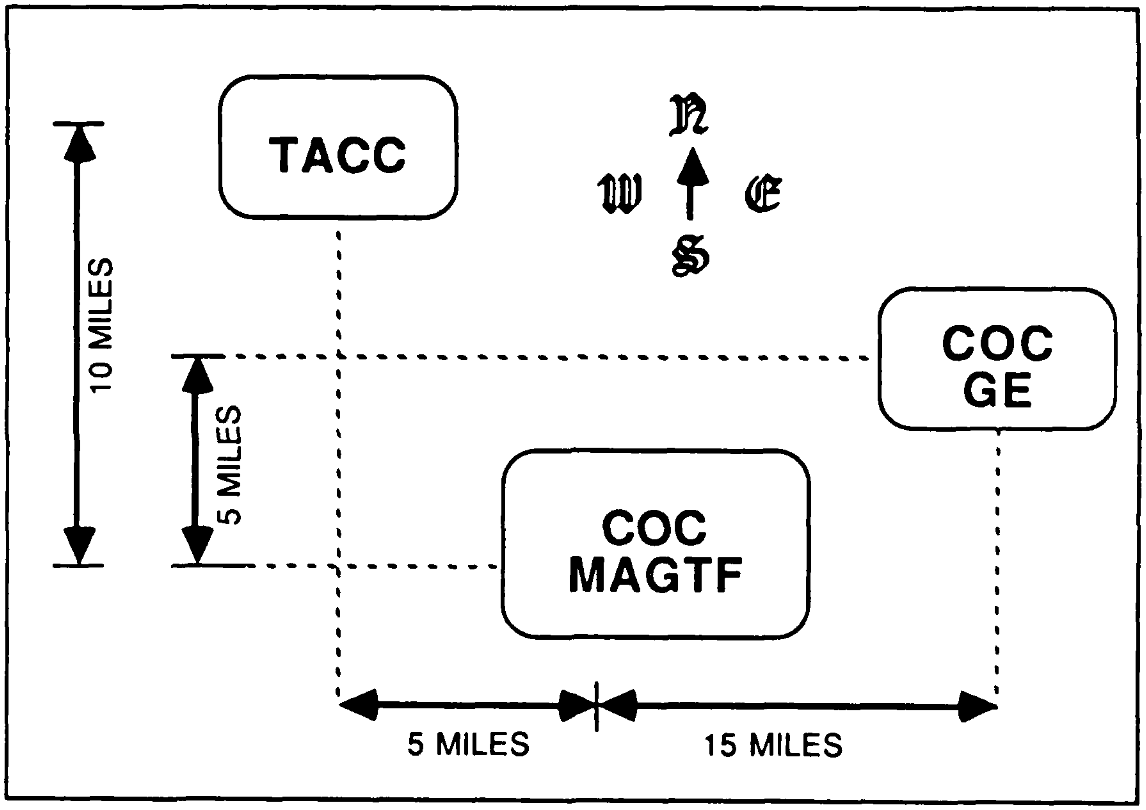

Figure 3.4. A Typical Geographic Arrangement of a MAGTF.

TACC is located ten miles north and five miles west of the COC MAGTF, while the COC GE is located five miles north and fifteen miles east of the COC MAGTF. This geographic separation is a consideration when defining interoperability requirements of communications systems. Essential interoperability requirements are depicted in Figure 3.5a, while intraoperability requirements within an OPFAC are illustrated in Figure 3.5b.

3. C2 Process Definition

a. Marine Air-Ground Task Force

> The Marine Air-Ground Task Force (MAGTF) is a force of combined arms task organized for a specified mission. The MAGTF may be employed in an amphibious operation or a land campaign. In either concept of employment the MAGTF is task organized to exploit the combat power inherent in closely integrated air and ground forces. [Ref. 12: p. 1-1]

For the purposes of this thesis, the author only considered the ACE commander plus his immediate staff working in the TACC as the air component, as well as the GCE commander plus his immediate staff, manning the COC GE, as the ground component force. So, the MAGTF for this problem consisted of the TACC and COC GE under the direction of the MAGTF commander.

(1) Ground Combat Element Commander (GCE)

> [The GCE commander is responsible to the MAGTF commander]. Through target analysis and his assigned mission objectives, the GCE commander recommends the apportionment and allocation of offensive air support. The GCE commander decides by priority which targets require interdiction by aviation. While selecting targets for air interdiction, the GCE commander receives and estimate of aviation support required to atack these targets and, by subtraction, determines how many remaining air assets will be available for close air support. Once the air interdiction targets are

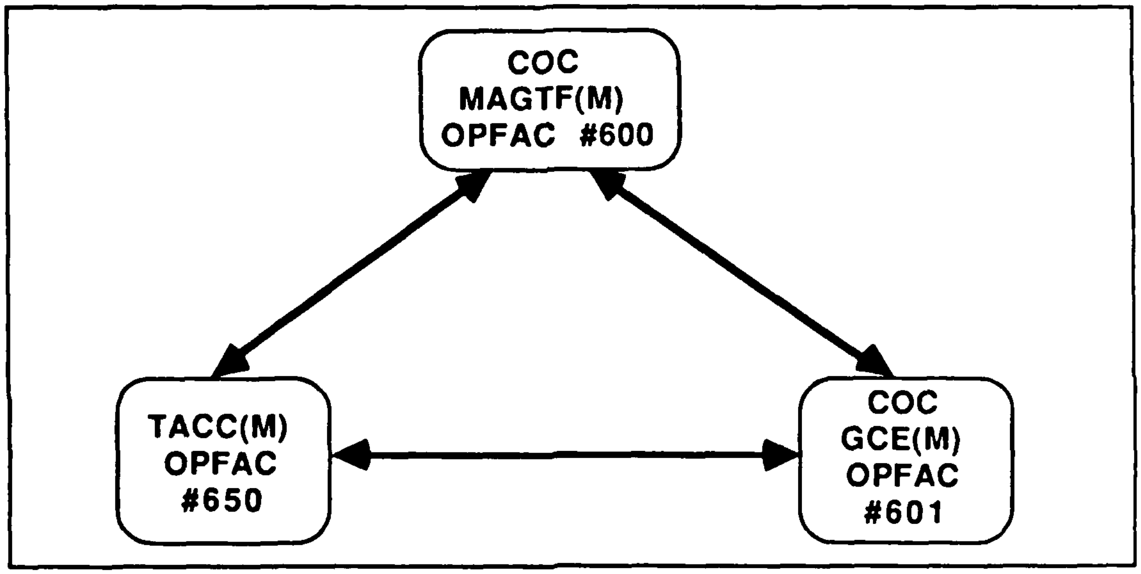

Figure 3.5a. Essential Interoperability Requirements for Air Tasking Order.

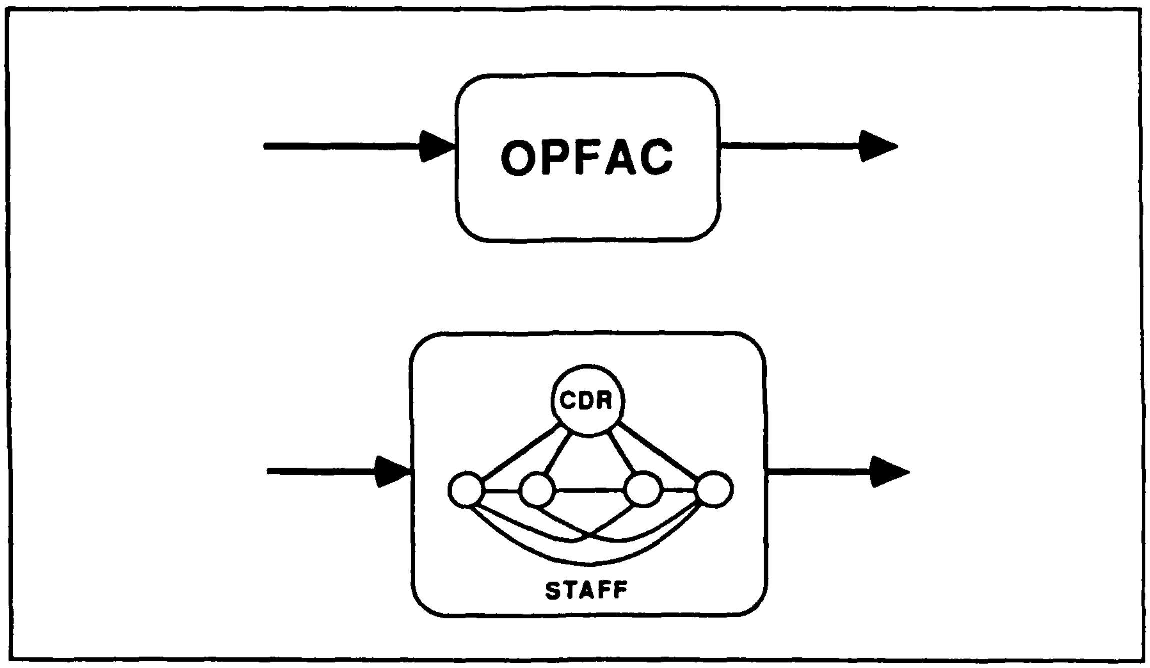

Figure 3.5b. Intraoperability Requirements Within an OPFAC.

identified, the MAGTF commander approves the offensive air support apportionment and allocation. The GCE commander must now decide how much of the remaining air assets to use for preplanned CAS [close air support] missions, and how much, if any, to place in an appropriate alert condition for immediate CAS missions. [Ref. 12: p. 1-4]

(2) Aviation Combat Element Commander (ACE)

The ACE commander commands a supporting force the "air arm." Within the division of authority, the ACE commander is responsible to the MAGTF commander for analyzing all aspects of antiair warfare, formulating an antiair warfare concept to include offensive and defensive requirements, and presenting the concept for approval. The ACE commander also provides the ground combat element commander (GCE) with an estimate of the aviation capability that can be applied to the remaining function offensive air support. [Ref. 12: p. 1-4]

The aviation combat element of the larger MAGTF's normally possesses diverse employment capabilities. However, considering the threat that the MAGTF will likely face, planning for the effective employment of its tactical air arm is not a simple matter. The MAGTF relies heavily on its aviation force, and every effort must be made to insure its most effective employment. In "target rich" environments, tactical air resources will rarely be sufficient to meet demand. [Ref. 12: p. 1-1]

Therefore, it is paramount that the air tasking process be well defined in terms of functional requirements.

(3) Aviation Tactical Functions

The aviation combat element is task organized to provide the required functional air requirements of the MAGTF. The functions of principal concern to the air tasking process are, (1) antiaiar warfare, (2) offensive air support, and (3) air command and control. A firm knowledge of these functions and types of targets associated with each is the most important requirement for understanding the air tasking process. [Ref. 12: p. 1-1]

Figure 3.6 graphically depicts the air tasking process as done in the Marine Corps according to the Operational Handbook (OH) 5-3, Tasking USMC Fixed Wing Tactical Aviation." [Ref. 12: Appendix A)]

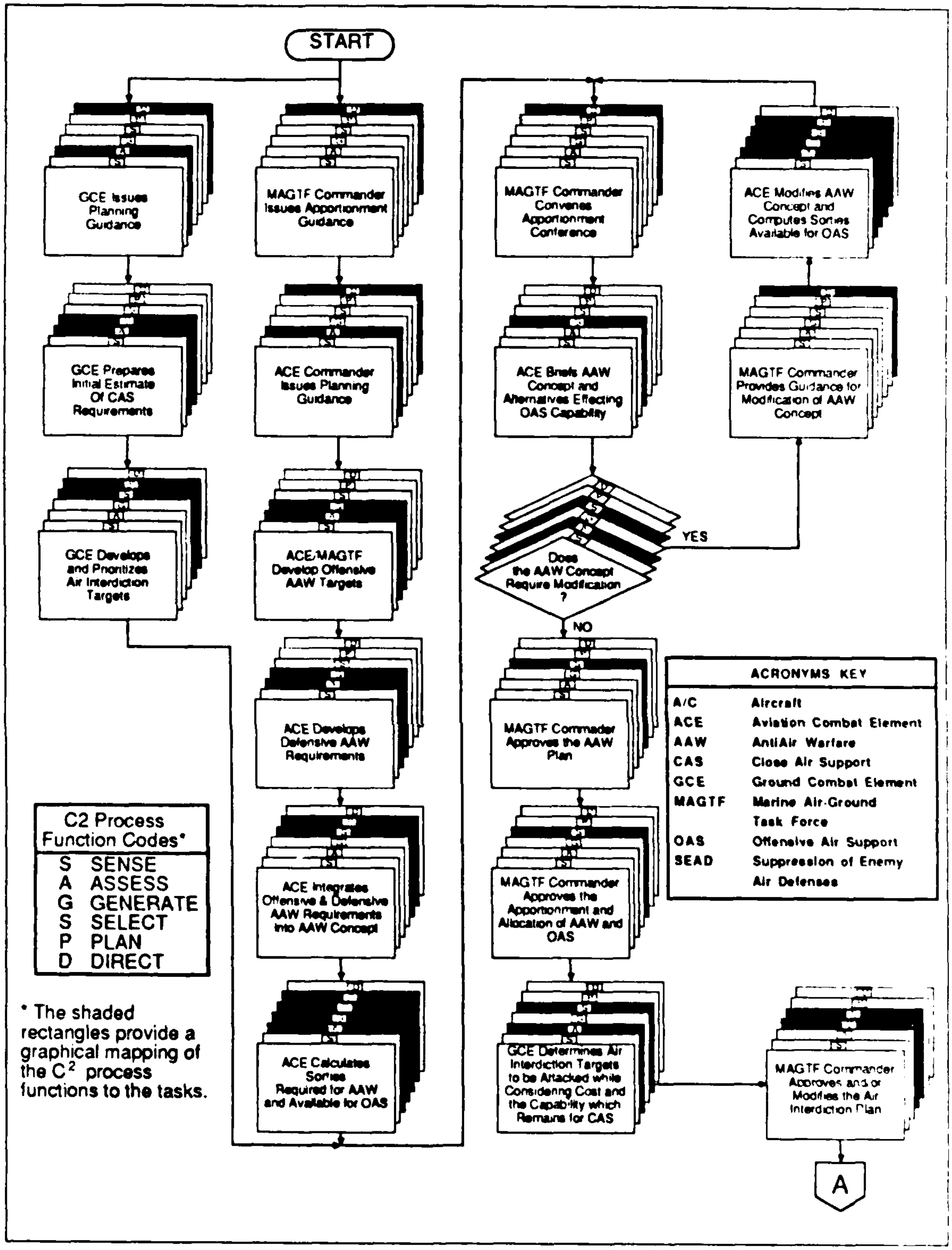

Figure 3.6. MAGTF Fixed Wing Air Tasking Process.

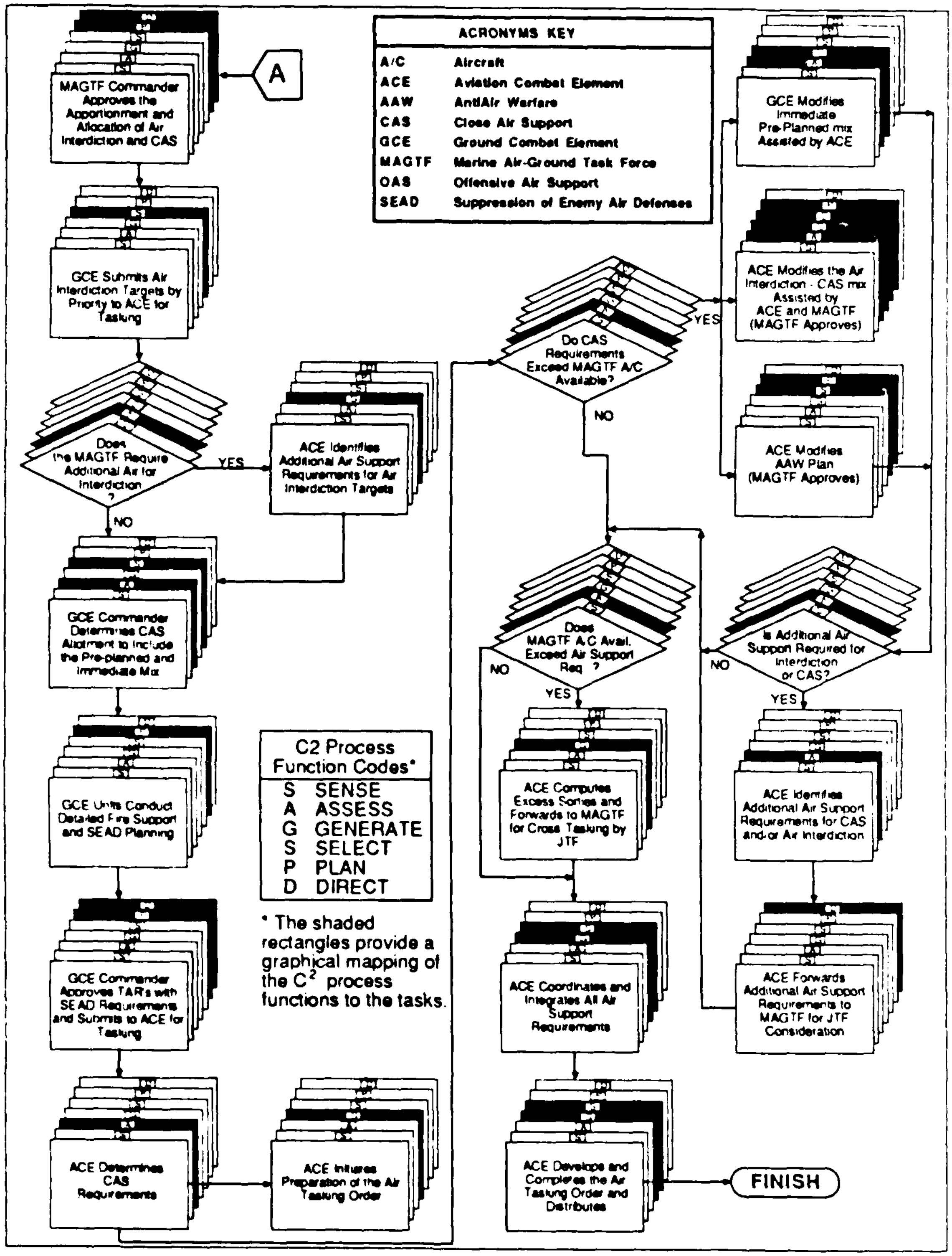

Figure 3.6. MAGTF Fixed Wing Air Tasking Process (cont.).

b. Mapping C2 Functions

One of the MORS working groups provided a basic model that represents the basic arrangement of most C2 processes. This conceptual C2 model is shown in Figure 3.7. This model is generally characterized by six C2 process functions which have a direct or indirect influence on the friendly (own) forces operating in the environment. [Ref. 3: p. 5-3]

(1) Definitions of Functions

The six C2 process functions as defined in the text titled Command and Control Evaluation Workshop [Ref. 3: p. 5-5] are quoted below:

> Sense--That function which collects data necessary to describe and forecast the environment, which includes:
>
> - The enemy forces' disposition and actions.
> - The friendly forces' disposition.
> - Those aspects of the environment that are common to both forces, e.g., weather, terrain, and neutrals.
>
> Assess--That function which transforms data from the function into information about intentions and capabilities for enemy forces and about capabilities of friendly forces for the purpose of determining if division from the Desired States warrants further action.
>
> Generate--That function which develops alternative courses of action to correct deviations from the Desired State.
>
> Select--That function which selects a preferred alternative from among the available options. It includes evaluation of each option in terms of criteria necessary to achieve the Desired State.
>
> Plan--That function which develops implementaton details necessary to execute the selected course of action.
>
> Direct--That function which distributes decisions to the forces charged with execution of the decision.

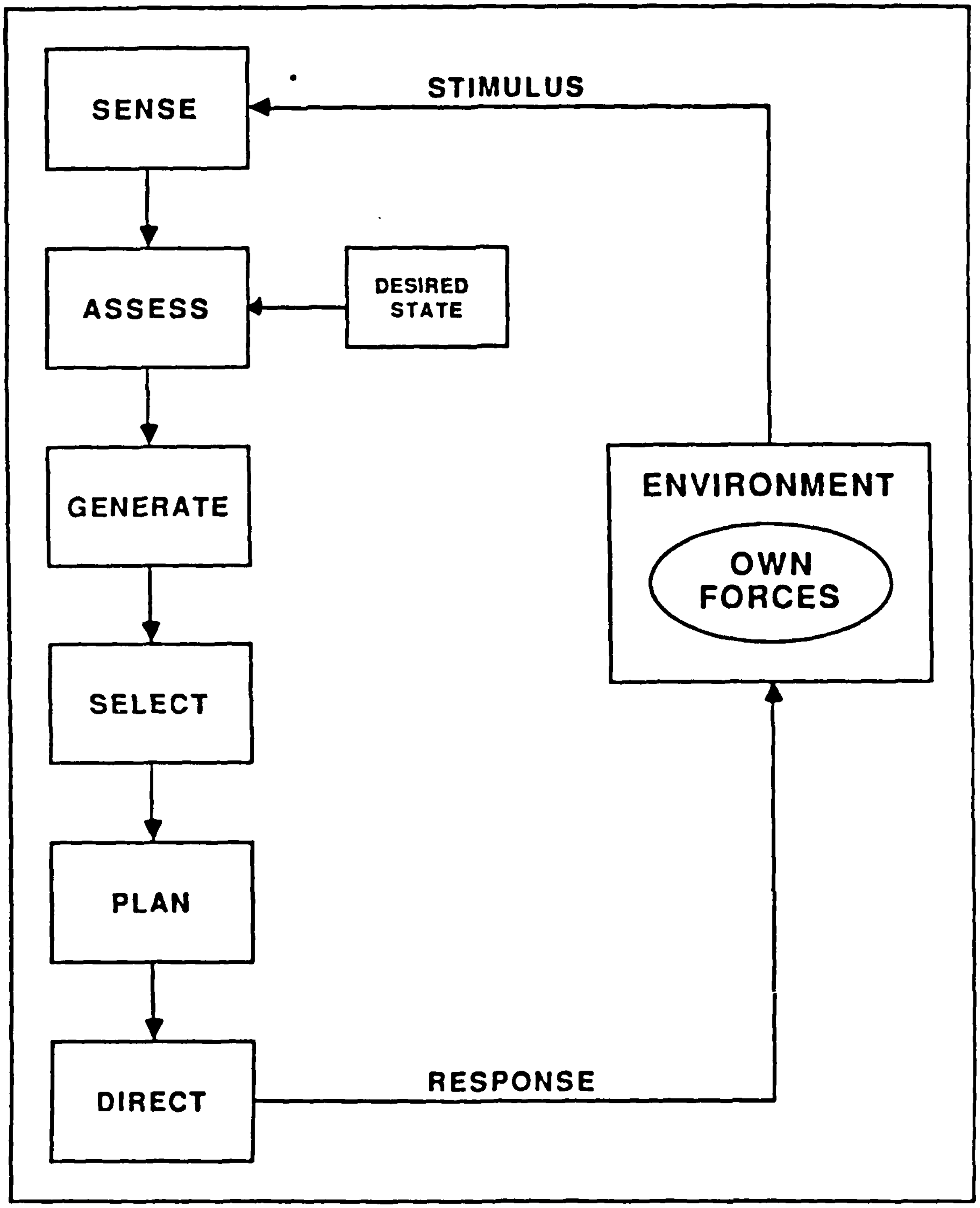

Figure 3.7. Lawson-Like C^2 Process Model.

(2) Description of C2 Process

A single OPFAC performing a single isolated task, which requires no interaction or feedback considerations, can be modeled by Figure 3.7. [Ref. 3: p. 5-5] This C2 process is summarized below:

> . . . there are interactions with the environment. These interactions are represented by a stimulus input and a response output. The output can only cause and action through our own forces, which results in a change to the overall environment. External inputs are shown coming from the environment and are susceptible to both natural and human-initiated environment effects. The only other direct input to the process, the desired State, establishes an error function inside the loop. This error function causes processing activity to continue, or, at the other extreme, halts processing activity when the Desired State is believed to be reached. [Ref. 3: pp. (5-3) - (5-5)]
>
> The process is initiated when a sensed input is assessed and is determined or is believed to be in error with a Desired State or when our requirements for the Desired State change. These errors cause the generation and selection of options, which results in a plan intended to change the environment. The object is to minimize the difference between the assessed and desired environment. [Ref. 3: p. 5-5]

The C2 process involving the COC MAGTF, COC GE, and TACC OPFACs producing an air tasking order is much more complicated than the process described above. This point will be addressed further in the following section.

c. Application of Air Tasking Order

Relying on doctrinal and operational experience, the author mapped the C2 functions to the tasks required to produce an air tasking order.[3] The flow chart in

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[3] The air tasking order tasks were obtained from the Operational Handbook (OH) 5-3, <u>Tasking USMC Fixed Wing Tactical Aviation</u>, Appendix A.

Figure 3.6 (the shaded rectangles) provides a graphical mapping of the C2 process functions to the tasks, while in Table 3.1 a tabular mapping is presented. Mapping C2 functions to tasks was not straightforward. As can be seen from the graphical mapping of C2 functions to tasks in Figure 3.6, the C2 functions do not follow a sequential flow as depicted in Lawson-like conceptual model in Figure 3.7.

A single OPFAC for the air tasking order is better represented by the conceptual model designed by the author in Figure 3.8. This model designed by the author is the same as the one in Figure 3.7, except that it includes feedback options for each function. An OPFAC does not have to progress sequentially from the "sense" function through to the "direct" function. This is evident as seen in the flow chart of Figure 3.6. Theoretically there are an infinite number of ways that an OPFAC can perform the functions to control its own forces. This model is fine for a single OPFAC working autonomously; however, three OPFACs interacting together are required to produce an air tasking order. Figure 3.8 is inadequate to model the coordination among three independent OPFACs.

In Figure 3.9 the author expanded the functional feedback option concept to the hierarchical-interactive relationship of the COC MAGTF, COC GE, and TACC. The principles of operation for the model in Figure 3.9 are identical to that of the model in Figure 3.8, with two additional main points: (1) the COC MAGTF establishes the Desired State for

TABLE 3.1

C^2 PROCESS FUNCTIONS MAPPED TO AIR TASKING ORDER TASKS

TASK NUMBER		TASK DESCRIPTION	C^2 FUNCTIONS
1	1.1	MAGTF CDR ISSUES APPORTIONMENT GUIDANCE	DIRECT
1	1.2	MAGTF CDR ISSUES APPORTIONMENT GUIDANCE	DIRECT
2	1.1	ACE CDR ISSUES PLANNING GUIDANCE	ASSESS
2	1.2	ACE CDR ISSUES PLANNING GUIDANCE	DIRECT
2	2.1	ACE/MAGTF DEVELOP OFFENSIVE AAW TARGETS	ASSESS
2	2.2	ACE/MAGTF DEVELOP OFFENSIVE AAW TARGETS	GENERATE
3	1.1	ACE DEVELOP DEFENSIVE AAW REQUIREMENTS	ASSESS
3	1.2	ACE DEVELOP DEFENSIVE AAW REQUIREMENTS	GENERATE
3	2.1	ACE INTEGRATES OFFENSIVE AND DEFENSIVE AAW REQUIREMENTS INTO AAW CONCEPT	SELECT
3	2.2	ACE INTEGRATES OFFENSIVE AND DEFENSIVE AAW REQUIREMENTS INTO AAW CONCEPT	PLAN

TABLE 3.1

C^2 PROCESS FUNCTIONS MAPPED TO AIR TASKING ORDER TASKS (CONTINUED)

TASK NUMBER		TASK DESCRIPTION	C_2 FUNCTIONS
3	3.1	ACE CALCULATES SORTIES REQUIRED FOR AAW AND AVAILABLE FOR OAS	ASSESS
3	3.2	ACE CALCULATES SORTIES REQUIRED FOR AAW AND AVAILABLE FOR OAS	GENERATE
3	3.3	ACE CALCULATES SORTIES REQUIRED FOR AAW AND AVAILABLE FOR OAS	SELECT
3	3.4	ACE CALCULATES SORTIES REQUIRED FOR AAW AND AVAILABLE FOR OAS	PLAN
4	1.1	GCE ISSUES PLANNING GUIDANCE	ASSESS
4	1.2	GCE ISSUES PLANNING GUIDANCE	DIRECT
4	2.1	GCE PREPARES INITIAL ESTIMATES OF CLOSE AIR SUPPORT REQUIREMENTS	ASSESS
4	2.2	GCE PREPARES INITIAL ESTIMATES OF CLOSE AIR SUPPORT REQUIREMENTS	GENERATE
5	1.1	GCE DEVELOP AND PRIORITIES AIR INTERDICTION TARGETS	SELECT

TABLE 3.1

C^2 PROCESS FUNCTIONS MAPPED TO AIR TASKING ORDER TASKS (CONTINUED)

TASK NUMBER		TASK DESCRIPTION	C2 FUNCTIONS
5	1.2	GCE DEVELOP AND PRIORITIES AIR INTERDICTION TARGETS	PLAN
6	1.1	MAGTF CDR CONVENES APPORTIONMENT CONFERENCE	DIRECT
6	1.2	MAGTF CDR CONVENES APPORTIONMENT CONFERENCE	DIRECT
7	1.1	ACE BRIEFS AAW CONCEPT AND ALTERNATIVES EFFECTING OAS CAPABILITY	GENERATE
7	2.1	DOES THE AAW CONCEPT REQUIRE MODIFICATION	SELECT
7	2.2	DOES THE AAW CONCEPT REQUIRE MODIFICATION	ASSESS
7	3.1	MAGTF CDR PROVIDES GUIDANCE FOR MODIFICATION OF AAW CONCEPT	DIRECT
7	4.1	ACE MODIFIES AAW CONCEPT AND COMPUTES SORTIES AVAILABLE FOR OAS	ASSESS
7	4.2	ACE MODIFIES AAW CONCEPT AND COMPUTES SORTIES AVAILABLE FOR OAS	GENERATE

TABLE 3.1

C^2 PROCESS FUNCTIONS MAPPED TO AIR TASKING ORDER TASKS (CONTINUED)

TASK NUMBER		TASK DESCRIPTION	C^2 FUNCTIONS
7	4.3	ACE MODIFIES AAW CONCEPT AND COMPUTES SORTIES AVAILABLE FOR OAS	SELECT
7	4.4	ACE MODIFIES AAW CONCEPT AND COMPUTES SORTIES AVAILABLE FOR OAS	PLAN
8	1.1	MAGTF CDR APPROVES THE AAW PLAN	SELECT
9	1.1	MAGTF CDR APPROVES THE APPORTIONMENT AND ALLOCA-TION OF AAW AND OAS	SELECT
10	1.1	GCE DETERMINES AIR INTER-DICTION TARGETS TO BE ATTACKED WHILE CONSIDER-ING THEIR COST AND THAT CAPABILITY WHICH REMAINS FOR CAS	SELECT
1C	1.2	GCE DETERMINES AIR INTER-DICTION TARGETS TO BE ATTACKED WHILE CONSIDER-ING THEIR COST AND TH. CAPABILITY WHICH REMAINS FOR CAS	ASSESS
10	2.1	MAGTF COMMANDER APPROVES AND/OR MODIFIES THE AIR INTERDICTION	SELECT

TABLE 3.1

C^2 PROCESS FUNCTIONS MAPPED TO AIR TASKING ORDER TASKS (CONTINUED)

TASK NUMBER	TASK DESCRIPTION	C^2 FUNCTIONS
10 2.2	MAGTF COMMANDER APPROVES AND/OR MODIFIES THE AIR INTERDICTION	GENERATE
11 1.1	MAGTF CMD APPROVES THE APPORTIONMENT AND ALLOCATION OF AIR INTERDICTION AND CAS	PLAN
11 1.2	MAGTF CMD APPROVES THE APPORTIONMENT AND ALLOCATION OF AIR INTERDICTION AND CAS	DIRECT
12 1.1	GCE SUBMITS AIR INTERDICTION TARGETS BY PRIORITY TO ACE FOR TASKING	SELECT
13 1.1	DOES THE MAGTF REQUIRE ADDITIONAL AIR SUPPORT ASSETS FOR AIR INTERDICTION?	ASSESS
13 2.1	ACE IDENTIFIES ADDITIONAL AIR SUPPORT REQUIREMENTS FOR AIR INTERDICTION TARGETS	GENERATE
13 2.2	ACE IDENTIFIES ADDITIONAL AIR SUPPORT REQUIREMENTS FOR AIR INTERDICTION TARGETS	GENERATE

TABLE 3.1

C^2 PROCESS FUNCTIONS MAPPED TO AIR TASKING ORDER TASKS (CONTINUED)

TASK NUMBER		TASK DESCRIPTION	C^2 FUNCTIONS
13	3.1	GCE CDR DETERMINES CAS ALLOTMENT TO INCLUDE THE PREPLANNED AND IMMEDIATE MIX	ASSESS
13	3.2	GCE CDR DETERMINES CAS ALLOTMENT TO INCLUDE THE PREPLANNED AND IMMEDIATE MIX	SELECT
14	1.1	GCE UNITS CONDUCT DETAILED FIRE SUPPORT AND SEAD PLANNING	PLAN
14	2.1	GCE CDR APPROVES TAR'S W/SEAD REQUIREMENTS AND SUBMITS TO ACE FOR TASKING	PLAN
14	2.2	GCE CDR APPROVES TAR'S W/SEAD REQUIREMENTS AND SUBMITS TO ACE FOR TASKING	DIRECT
15	1.1	ACE DETERMINES CAS REQUIREMENTS	ASSESS
15	2.1	ACE INITIATES PREPARATION OF THE AIR TASKING ORDER	GENERATE

TABLE 3.1

C^2 PROCESS FUNCTIONS MAPPED TO AIR TASKING ORDER TASKS (CONTINUED)

TASK NUMBER	TASK DESCRIPTION	C^2 FUNCTIONS
15 3.1	DO OAS REQUIREMENTS EXCEED MAGTF A/C AVAILABLE?	ASSESS
15 3.2	DO OAS REQUIREMENTS EXCEED MAGTF A/C AVAILABLE?	ASSESS
15 4.1	GCE MODIFIES IMMEDIATE-PREPLANNED MIX ASSISTED BY ACE	ASSESS
15 4.2	GCE MODIFIES IMMEDIATE-PREPLANNED MIX ASSISTED BY ACE	ASSESS
15 4.3	GCE MODIFIES IMMEDIATE-PREPLANNED MIX ASSISTED BY ACE	GENERATE
15 5.1	GCE MODIFIES THE AIR-INTERDICTION-CAS MIX ASSISTED BY ACE/MAGTF (MAGTF APPROVES)	PLAN
15 5.2	GCE MODIFIES THE AIR-INTERDICTION-CAS MIX ASSISTED BY ACE/MAGTF (MAGTF APPROVES)	ASSESS
15 5.3	GCE MODIFIES THE AIR-INTERDICTION-CAS MIX ASSISTED BY ACE/MAGTF (MAGTF APPROVES)	GENERATE

TABLE 3.1

C^2 PROCESS FUNCTIONS MAPPED TO AIR TASKING ORDER TASKS (CONTINUED)

TASK NUMBER		TASK DESCRIPTION	C^2 FUNCTIONS
15	5.4	GCE MODIFIES THE AIR INTERDICTION-CAS MIX ASSISTED BY ACE/MAGTF (MAGTF APPROVES)	SELECT
15	6.1	ACE MODIFIES AAW PLAN (MAGTF APPROVES)	PLAN
15	6.2	ACE MODIFIES AAW PLAN (MAGTF APPROVES)	SELECT
15	7.1	IS ADDITIONAL AIR SUPPORT REQUIRED FOR AIR INTERDICTION OR CAS?	ASSESS
15	8.1	ACE IDENTIFIES ADDITIONAL AIR SUPPORT REQUIREMENTS FOR CAS-AND/OR AIR INTERDICTION	ASSESS
15	9.1	ACE FORWARDS ADDITIONAL AIR SUPPORT REQUIREMENTS TO MAGTF FOR JTF CONSIDERATION	DIRECT
15	10.1	DOES MAGTF A/C AVAIL-ABILITY EXCEED THE AIR SUPPORT REQUIREMENTS	ASSESS

TABLE 3.1

C^2 PROCESS FUNCTIONS MAPPED TO AIR TASKING ORDER TASKS (CONTINUED)

TASK NUMBER	TASK DESCRIPTION	C^2 FUNCTIONS
15 11.1	ACE COMPUTES EXCESS SORTIES AND FORWARDS TO MAGTF FOR CROSS-TASKING BY JTF	GENERATE
15 12.1	ACE COORDINATES AND INTEGRATES ALL AIR SUPPORT REQUIREMENTS	GENERATE
15 12.2	ACE COORDINATES AND INTEGRATES ALL AIR SUPPORT REQUIREMENTS	SELECT
15 13.1	ACE DEVELOPS AND COMPLETES THE AIR TASKING ORDER AND DISTRIBUTES	PLAN
15 13.2	ACE DEVELOPS AND COMPLETES THE AIR TASKING ORDER AND DISTRIBUTES	DIRECT
15 13.3	ACE DEVELOPS AND COMPLETES THE AIR TASKING ORDER AND DISTRIBUTES	DIRECT

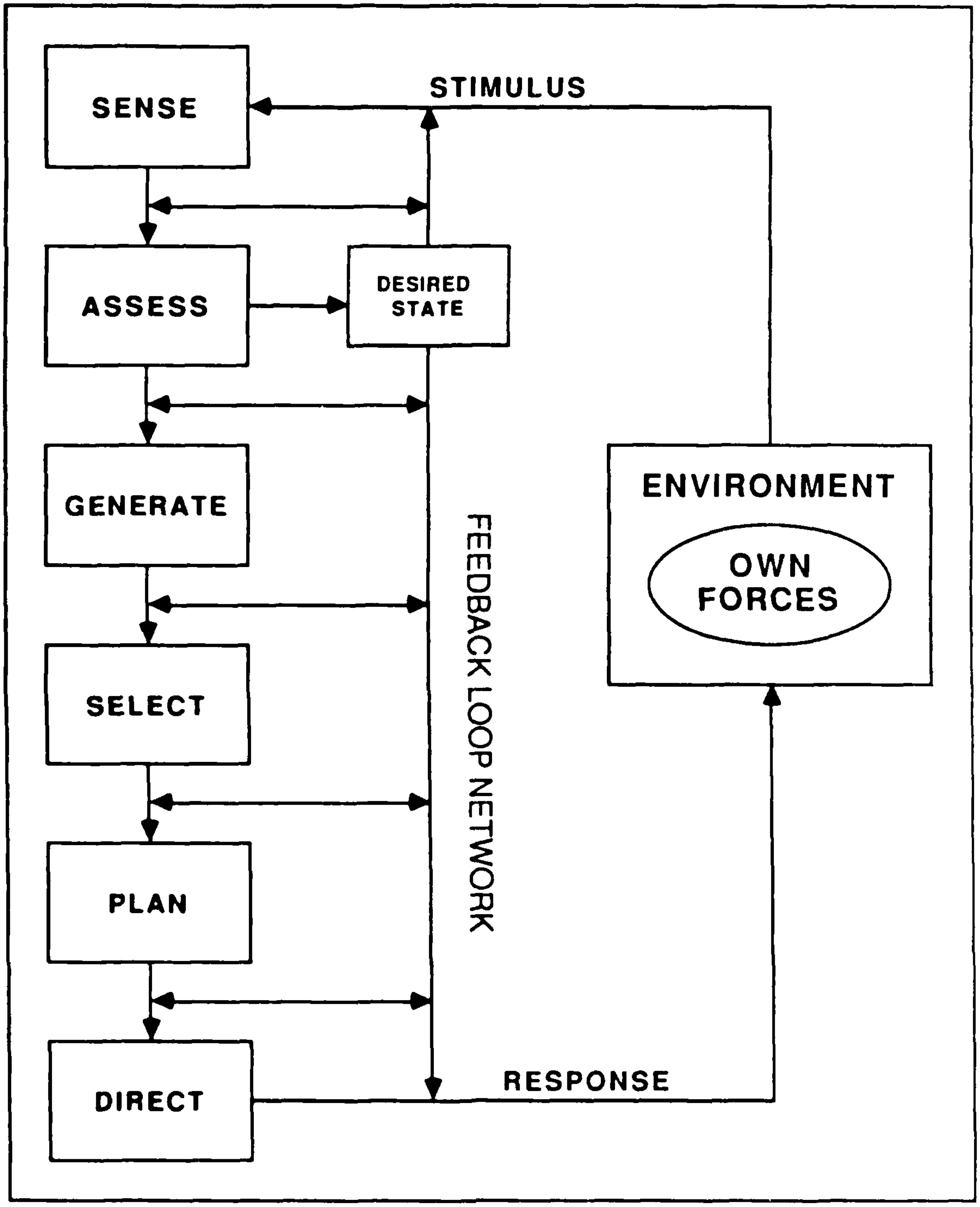

Figure 3.8. Lawson-Like C^2 Process Model Expanded.

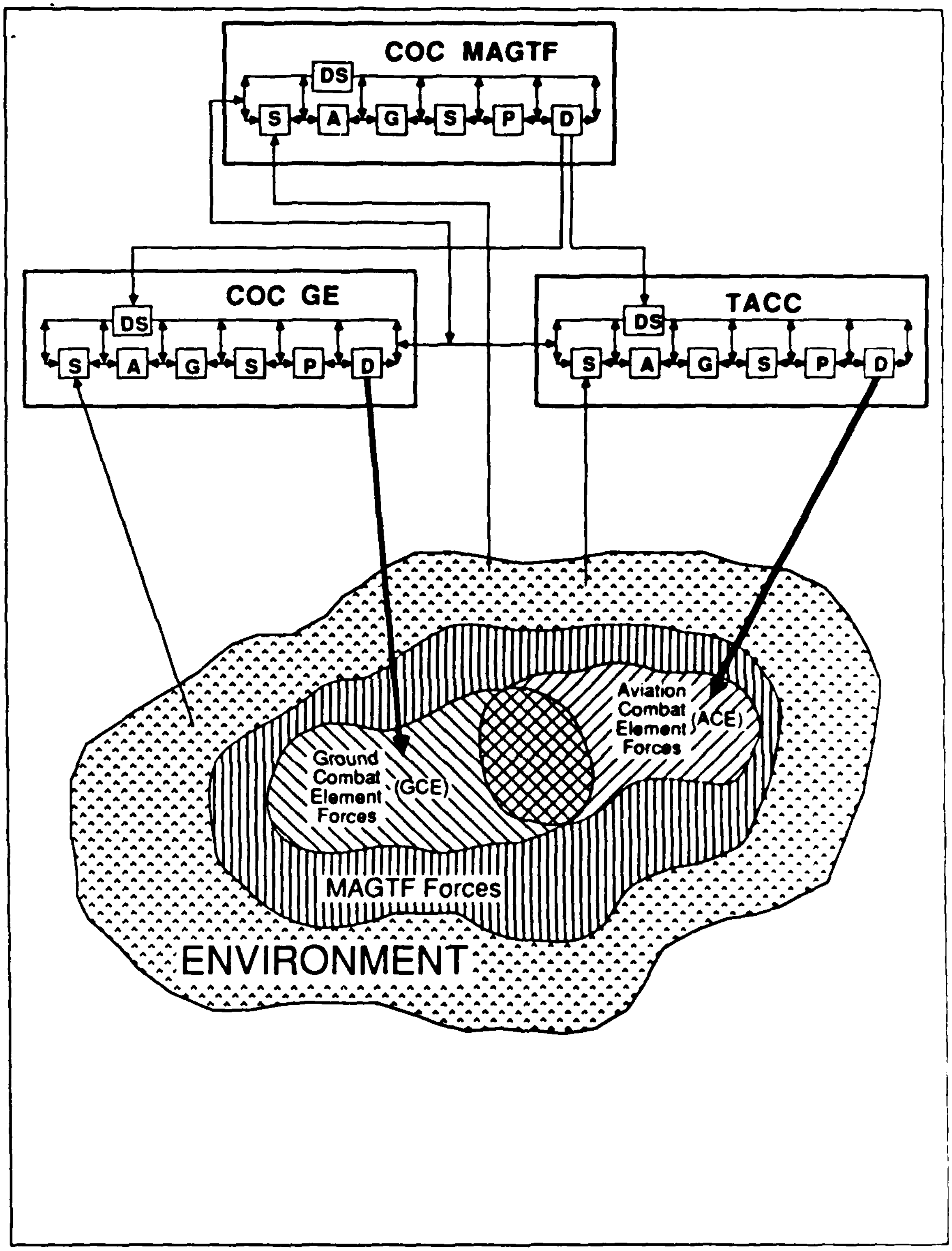

Figure 3.9. Expanded C^2 Process Model to Show Interaction Among Three Individual OPFACs.

the COC GE and TACC through Directions. Both the COC GE and TACC have the option to compare any point (C2 function) of the C2 processing to the Desired State; and (2) Each of the three OPFACs can have an interaction with another OPFAC during any point in the C2 process.

4. <u>Integration of System Elements and Functions</u>

"The JINTACCS program has derived 12 categories of information exchange requirements among and between various OPFACs. When an individual information category is applied to each of the 12 operational tasks, the content of the category varies according to the task. This application refines the basic 12 information categories in defining information exchange requirements." [Ref. 10: p. 3-5] The bounded system (OPFACs and the air tasking order tasks) coupled with the information category codes (ICC) (See Appendix [illegible]) provide the basis for the integration of system elements and funct[illegible] Table 3.2 portrays the integration of the OPFACs and tasks required to produce an air tasking order. The tasks [illegible] 2 are reproduced from the <u>Tasking [illegible] Fixed-Wing [illegible]</u> <u>Aviation</u>, Operational Handbook. Then, using the [illegible] table for C2 functions [illegible] Table [illegible] completed. This cross-reference table was based [illegible] experience. Information from the environment [illegible] status and friendly status [illegible] sense function. Analyzing the enemy [illegible]

TABLE 3.2

INTEGRATION OF SYSTEM ELEMENTS
AND FUNCTIONS

TASK NUMBER	TASK DESCRIPTION	* ICC	** SOURCE XOPFAC	SINK ROPFAC	** OPFAC TASKS
[illegible]	MAGTF CDR ISSUES APPORTIONMENT GUIDANCE	RI	MAGTF CDR 600	ACE CDR 650	60000,65001
[illegible]	MAGTF CDR ISSUES APPORTIONMENT GUIDANCE	RI	MAGTF CDR 600	GCE CDR 601	60000,60101

*INFORMATION CATEGORY CODES (ICC)

1. ALLOCATION/APPORTIONMENT (AL)
2. ENEMY CAPABILITIES (EC)
3. ENEMY STATUS (ES)
4. FRIENDLY CAPABILITIES (FC)
5. FRIENDLY STATUS (FS)
6. [illegible]
7. PLANS (PL)
8. PRIORITIES (PR)
9. REQUEST FOR INFORMATION (RI)
10. REQUEST FOR SUPPORT (RS)
11. TERRAIN/GEOGRAPHIC INFORMATION (TG)
12. WEATHER (WX)

*INFORMATION CATEGORIES ARE DEFINED IN APPENDIX C.

** [illegible] AND OPFAC TASKS ARE DEFINED IN APPENDIX A.

TABLE 3.2

INTEGRATION OF SYSTEM ELEMENTS
AND FUNCTIONS (CONTINUED)

TASK NUMBER	TASK DESCRIPTION	* ICC	** SOURCE XOPFAC	SINK ROPFAC	** OPFAC TASKS
2 1.1	ACE CDR ISSUES PLANNING GUIDANCE	EC,FC	ACE STAFF 650	ACE STAFF 650	65001
2 1.2	ACE CDR ISSUES PLANNING GUIDANCE	RI	ACE CDR 650	ACE STAFF 650	65001
2 2.1	ACE/MAGTF DEVELOP OFFENSIVE AAW TARGETS	EC,FC	ACE CDR 650	ACE STAFF 650	65001
2 2.2	ACE/MAGTF DEVELOP OFFENSIVE AAW TARGETS	AL	ACE STAFF 650	ACE CDR 650	65001
3 1.1	ACE DEVELOP DEFENSIVE AAW REQUIREMENTS	EC,FC	ACE CDR 650	ACE STAFF 650	65001
3 1.2	ACE DEVELOP DEFENSIVE AAW REQUIREMENTS	AL	ACE STAFF 650	ACE CDR 650	65055

TABLE 3.2
INTEGRATION OF SYSTEM ELEMENTS
AND FUNCTIONS (CONTINUED)

TASK NUMBER	TASK DESCRIPTION	* ICC	** SOURCE XOPFAC	SINK ROPFAC	** OPFAC TASKS
3 2.1	ACE INTEGRATES OFFENSIVE AND DEFENSIVE AAW REQUIREMENTS INTO AAW CONCEPT	PR	ACE STAFF 650	ACE CDR 650	65001
3 2.2	ACE INTEGRATES OFFENSIVE AND DEFENSIVE AAW REQUIREMENTS INTO AAW CONCEPT	PL	ACE STAFF 650	ACE CDR 650	65001
3 3.1	ACE CALCULATES SORTIES REQUIRED FOR AAW AND AVAILABLE FOR OAS	EC,FC	ACE STAFF 650	ACE CDR 650	65041
3 3.2	ACE CALCULATES SORTIES REQUIRED FOR AAW AND AVAILABLE FOR OAS	AL	ACE STAFF 650	ACE CDR 650	65041

TABLE 3.2

INTEGRATION OF SYSTEM ELEMENTS
AND FUNCTIONS (CONTINUED)

TASK NUMBER	TASK DESCRIPTION	* ICC	** SOURCE XOPFAC	SINK ROPFAC	** OPFAC TASKS
[illegible]	ACE CALCULATES SORTIES REQUIRED FOR AAW AND AVAILABLE FOR OAS	PR	ACE STAFF 650	ACE CDR 650	65041
[illegible].4	ACE CALCULATES SORTIES REQUIRED FOR AAW AND AVAILABLE FOR OAS	PL	ACE STAFF 650	ACE CDR 650	65041
4 1.1	GCE ISSUES PLANNING GUIDANCE	EC,FC	GCE CDR 601	GCE STAFF 601	60100
4 1.[illegible]	GCE ISSUES PLANNING GUIDANCE	RI	GCE CDR 601	GCE STAFF 601	60100
4 [illegible]	GCE PREPARES INITIAL ESTIMATES OF CLOSE AIR SUPPORT REQUIREMENTS	EC,FC	GCE CDR 601	GCE STAFF 601	60100,60101 60111

TABLE 3.2

INTEGRATION OF SYSTEM ELEMENTS AND FUNCTIONS (CONTINUED)

TASK NUMBER	TASK DESCRIPTION	* ICC	** SOURCE XOPFAC	SINK ROPFAC	** OPFAC TASKS
[illegible]	GCE PREPARES INITIAL ESTIMATES OF CLOSE AIR SUPPORT REQUIREMENTS	AL	GCE CDR 601	GCE STAFF 601	60100,60101 60111
[illegible]	GCE DEVELOP AND PRIORITIES AIR INTERDICTION TARGETS	PR	GCE STAFF 601	GCE CDR 601	60101 60100
[illegible]	GCE DEVELOP AND PRIORITIES AIR INTERDICTION TARGETS	PL	GCE CDR 601	GCE STAFF 601	60101 60111
[illegible]	MAGTF CDR CONVENES APPORTIONMENT CONFERENCE	RI	MAGTF CDR 600	ACE CDR 650	60001,65001
[illegible]	MAGTF CDR CONVENES APPORTIONMENT CONFERENCE	RI	MAGTF CDR 600	GCE CDR 601	60001,60000

TABLE 3.2

INTEGRATION OF SYSTEM ELEMENTS
AND FUNCTIONS (CONTINUED)

TASK NUMBER	TASK DESCRIPTION	* ICC	** SOURCE XOPFAC	SINK ROPFAC	** OPFAC TASKS
[illegible].1	ACE BRIEFS AAW CONCEPT AND ALTERNATIVES EFFECTING OAS CAPABILITY	AL	ACE CDR 650	MAGTF CDR 600	65001
[illegible].1	DOES THE AAW CONCEPT REQUIRE MODIFICATION	PR	ACE CDR 650	MAGTF CDR 600	65001
[illegible]	DOES THE AAW CONCEPT REQUIRE MODIFICATION	EC,FC	MAGTF 600	MAGTF 600	60001
[illegible].1	MAGTF CDR PROVIDES GUIDANCE FOR MODIFICATION OF AAW CONCEPT	RI	MAGTF 600	ACE CDR 650	60001
4.1	ACE MODIFIES AAW CONCEPT AND COMPUTES SORTIES AVAILABLE FOR OAS	EC,FC	ACE CDR 650	ACE STAFF 650	65001

TABLE 3.2

INTEGRATION OF SYSTEM ELEMENTS
AND FUNCTIONS (CONTINUED)

TASK NUMBER		TASK DESCRIPTION	* ICC	** SOURCE XOPFAC	SINK ROPFAC	** OPFAC TASKS
7	4.2	ACE MODIFIES AAW CONCEPT AND COMPUTES SORTIES AVAILABLE FOR OAS	AL	ACE STAFF 650	ACE STAFF 650	65055
7	4.3	ACE MODIFIES AAW CONCEPT AND COMPUTES SORTIES AVAILABLE FOR OAS	PR	ACE CDR 650	ACE STAFF 650	65001,65041
7	4.4	ACE MODIFIES AAW CONCEPT AND COMPUTES SORTIES AVAILABLE FOR OAS	PL	ACE STAFF 650	ACE STAFF 650	65001
8	1.1	MAGTF CDR APPROVES THE AAW PLAN	PR	ACE CDR 650	MAGTF CDR 600	60000

TABLE 3.2

INTEGRATION OF SYSTEM ELEMENTS
AND FUNCTIONS (CONTINUED)

TASK NUMBER		TASK DESCRIPTION	* ICC	** SOURCE XOPFAC	SINK ROPFAC	** OPFAC TASKS
9	1.1	MAGTF CDR APPROVES THE APPORTIONMENT AND ALLOCATION OF AAW AND OAS	PR	MAGTF STAFF 600	MAGTF CDR 600	60012
10	1.1	GCE DETERMINES AIR INTERDICTION TARGETS TO BE ATTACKED WHILE CONSIDERING THEIR COST AND THAT CAPABILITY WHICH REMAINS FOR CAS	PR	GCE STAFF 601	GCE STAFF 601	60111
10	1.2	GCE DETERMINES AIR INTERDICTION TARGETS TO BE ATTACKED WHILE CONSIDERING THEIR COST AND THAT CAPABILITY WHICH REMAINS FOR CAS	EC,FC	GCE STAFF 601	GCE CDR 601	60101

TABLE 3.2

INTEGRATION OF SYSTEM ELEMENTS
AND FUNCTIONS (CONTINUED)

TASK NUMBER	TASK DESCRIPTION	* ICC	** SOURCE XOPFAC	SINK ROPFAC	** OPFAC TASKS
10 2.1	MAGTF COMMANDER APPROVES AND/OR MODIFIES THE AIR INTERDICTION	PR	GCE CDR 601	MAGTF CDR 600	60001
10 2.2	MAGTF COMMANDER APPROVES AND/OR MODIFIES THE AIR INTERDICTION	AL	MAGTF CDR 600	MAGTF STAFF 600	60001
11 1.1	MAGTF CMD APPPROVES THE APPORTIONMENT AND ALLOCATION OF AIR INTERDICTION AND CAS	PL	MAGTF CDR 600	ACE CDR 650	60001
11 1.2	MAGTF CMD APPPROVES THE APPORTIONMENT AND ALLOCATION OF AIR INTERDICTION AND CAS	RS	MAGTF CDR	ACE CDR	60001

TABLE 3.2

INTEGRATION OF SYSTEM ELEMENTS
AND FUNCTIONS (CONTINUED)

TASK NUMBER	TASK DESCRIPTION	* ICC	** SOURCE XOPFAC	SINK ROPFAC	** OPFAC TASKS
[illegible].1	GCE SUBMITS AIR INTERDICTION TARGETS BY PRIORITY TO ACE FOR TASKING	PR	GCE CDR 601	ACE CDR 650	60112,65001
[illegible]	[illegible] THE MA[illegible]TE REQUIRE ADDITIONAL AIR SUPPORT A[illegible]ETS FOR AIR INTERDICTION	FC,FC	ACE STAFF 650	ACE CDR 650	65015,65041
[illegible]	ACE IDENTIFIES ADDITIONAL AIR SUPPORT REQUIREMENTS FOR AIR INTERDICTION TARGETS	AL	ACE STAFF 650	ACE CDR 650	65001
[illegible]	A[illegible] ADDITIONAL A[illegible] REQUIREMENTS [illegible] A[illegible]	AL	ACE CDR 650	GCE CDR 601	65001,60101

TABLE [illegible]

INTEGRATION OF SYSTEM ELEMENTS
AND FUNCTIONS (CONTINUED)

[illegible]	* [illegible]	** SOURCE ROPFAC	LINK ROPFAC	** OPFAC TASKS
[illegible] A [illegible]	[illegible]	SEE TABLE [illegible]	SEE CDR [illegible]	60115,60101
[illegible] A [illegible]	[illegible]	[illegible] TABLE [illegible]	[illegible]	60111
[illegible]	[illegible]	[illegible] TABLE [illegible]	[illegible]	[illegible]0111
[illegible]	[illegible]	[illegible] TABLE [illegible]	[illegible]	[illegible]

TABLE [illegible]

INTEGRATION OF SYSTEM ELEMENTS
AND FUNCTIONS (CONTINUED)

TASK NUMBER	TASK DESCRIPTION	* ICC	** SOURCE XOPFAC	SINK ROPFAC	** OPFAC TASKS
14 2.2	GCE CDR APPROVES TAR'S W/SEAD REQUIREMENTS AND SUBMITS TO ACE FOR TASKING	RS	GCE CDR 601	ACE CDR 650	60112,65015
15 1.1	ACE DETERMINES CAS REQUIRE-MENTS	EC,FC	GCE CDR 601	ACE CDR 650	60101,60115 65001,65015
15 2.1	ACE INITIATES PREPARATION OF THE AIR TASKING ORDER	AL	ACE CDR 650	ACE STAFF 650	65001,65043
15 3.1	DO OAS REQUIREMENTS EXCEED MAGTF A/C AVAILABLE?	EC,FC	ACE CDR 650	GCE CDR 601	65001,65015

TABLE 3.2

INTEGRATION OF SYSTEM ELEMENTS
AND FUNCTIONS (CONTINUED)

TASK NUMBER	TASK DESCRIPTION	* ICC	** SOURCE XOPFAC	SINK ROPFAC	** OPFAC TASKS
15 3.2	DO OAS REQUIREMENTS EXCEED MAGTF A/C AVAILABLE?	EC,FC	GCE CDR 601	GCE STAFF 601	60101,60115
15 4.1	GCE MODIFIES IMMEDIATE-PREPLANNED MIX ASSISTED BY ACE	EC,FC	GCE STAFF 601	GCE CDR 601	60101,60111
15 4.2	GCE MODIFIES IMMEDIATE-PREPLANNED MIX ASSISTED BY ACE	EC,FC	GCE STAFF 601	ACE CDR 650	60101,60111 65001,65041
15 4.3	GCE MODIFIES IMMEDIATE-PREPLANNED MIX ASSISTED BY ACE	AL	GCE STAFF 601	ACE STAFF 650	60101,60111 65001

TABLE 3.2

INTEGRATION OF SYSTEM ELEMENTS
AND FUNCTIONS (CONTINUED)

TASK NUMBER		TASK DESCRIPTION	* ICC	** SOURCE XOPFAC	SINK ROPFAC	** OPFAC TASKS
15	5.1	GCE MODIFIES THE AIR-INTERDICTION-CAS MIX ASSISTED BY ACE/MAGTF (MAGTF APPROVES)	PL	ACE STAFF 650	GCE STAFF 601	65001,65015
15	5.2	GCE MODIFIES THE AIR-INTERDICTION-CAS MIX ASSISTED BY ACE/MAGTF (MAGTF APPROVES)	EC,FC	GCE STAFF 601	GCE STAFF 601	60100,60101, 60111
15	5.3	GCE MODIFIES THE AIR-INTERDICTION-CAS MIX ASSISTED BY ACE/MAGTF (MAGTF APPROVES)	AL	GCE STAFF 601	GCE STAFF 601	60100,60101 60111
15	5.4	GCE MODIFIES THE AIR INTERDICTION-CAS MIX ASSISTED BY ACE/MAGTF (MAGTF APPROVES)	PR	GCE STAFF 601	MAGTF 600	6000[illegible]

TABLE 3.2

INTEGRATION OF SYSTEM ELEMENTS
AND FUNCTIONS (CONTINUED)

TASK NUMBER	TASK DESCRIPTION	* ICC	** SOURCE XOPFAC	SINK RCPFAC	** CPFAC TASKS
15 6.1	ACE MODIFIES AAW PLAN (MAGTF APPROVES)	PL	ACE STAFF 650	ACE STAFF 650	65001,65041
15 6.2	ACE MODIFIES AAW PLAN (MAGTF APPROVES)	PR	ACE CDR 650	MAGTF CDR 600	60001
15 7.1	IS ADDITIONAL AIR SUPPORT REQUIRED FOR AIR INTERDICTION OR CAS?	EC,FC	ACE STAFF 650	ACE STAFF 650	65015,65041
15 8.1	ACE IDENTIFIES ADDITIONAL AIR SUPPORT REQUIREMENTS FOR CAS-AND/OR AIR INTERDICTION	EC,FC	GCE CDR 601	ACE CDR 650	65041,65015 65001

TABLE 3.2

INTEGRATION OF SYSTEM ELEMENTS AND FUNCTIONS (CONTINUED)

TASK NUMBER	TASK DESCRIPTION	* ICC	** SOURCE XOPFAC	SINK ROPFAC	** OPFAC TASKS
15 9.1	ACE FORWARDS ADDITIONAL AIR SUPPORT REQUIREMENTS TO MAGTF FOR JTF CONSIDERATION	RS	ACE CDR 650	MAGTF CDR 600	65015,65041
15 10.1	DOES MAGTF A/C AVAILABILITY EXCEED THE AIR SUPPORT REQUIREMENTS	EC,FC	MAGTF STAFF 600	MAGTF CDR 600	60000
15 11.1	ACE COMPUTES EXCESS SORTIES AND FORWARDS TO MAGTF FOR CROSS-TASKING BY JTF	AL	ACE CDR 650	MAGTF CDR 600	65015,65041 65001
15 12.1	ACE COORDINATES AND INTEGRATES ALL AIR SUPPORT REQUIREMENTS	AL	GCE STAFF 601	ACE STAFF 650	65001

TABLE 3.2

INTEGRATION OF SYSTEM ELEMENTS
AND FUNCTIONS (CONTINUED)

TASK NUMBER	TASK DESCRIPTION	* ICC	** SOURCE XOPFAC	SINK ROPFAC	** OPFAC TASKS
15 12.2	ACE COORDINATES AND INTEGRATES ALL AIR SUPPORT REQUIREMENTS	PR	ACE STAFF 650	ACE STAFF 650	65041,65015
15 13.1	ACE DEVELOPS AND COMPLETES THE AIR TASKING ORDER AND DISTRIBUTES	PL	ACE CDR 650	MAGTF CDR 600	65043,65001
15 13.2	ACE DEVELOPS AND COMPLETES THE AIR TASKING ORDER AND DISTRIBUTES	OR	ACE CDR 650	AIRCRAFT GROUPS	65043,65001
15 13.3	ACE DEVELOPS AND COMPLETES THE AIR TASKING ORDER AND DISTRIBUTES	OR	ACE CDR 650	GCE CDR 601	65043,65001

TABLE 3.3

C^2 PROCESS FUNCTIONS CROSS-REFERENCED TO INFORMATION CATEGORIES

C^2 FUNCTION	INFORMATION CATEGORIES
SENSE	ENEMY STATUS (ES) FRIENDLY STATUS (FS) WEATHER (WS)
ASSESS	ENEMY CAPABILITIES (EC) FRIENDLY CAPABILITIES (FC)
GENERATE	ALLOCATION/APPORTIONMENT (AL)
SELECT	PRIORITIES (PR)
PLAN	PLANS (PL)
DIRECT	ORDERS (OR) REQUEST FOR SUPPORT (RS) REQUEST FOR INFORMATION (RI)

capabilities is the same as assessing the situation. When a commander allocates, he is refining his apportionment decision. In consideration of the apportionment, the commander prepares the allocation by generating specific alternatives and making this process analogous to the generate function. When the commander assigns priorities to his options he is selecting among his alternatives, which is similar to the select function. The plans category is straightforward and relates directly to plan function. Request for information, request for support and orders are results of a commander directing a specific response from a subordinate command; they are therefore equivalent to the direct function.

Having cross-referenced the C2 functions to the ICC in Table 3.3, the author relied upon doctrine and his operational experience to select the appropriate ICC for each task. Columns 4 and 5 of Figure 3.2, the transmitting OPFAC (XOPFAC) and the receiving OPFAC (ROPFAC), were chosen by the tasks described. If the tasks statement mentioned the "ACE," then the TACC (OPFAC #650) would be considered as the source and/or sink. The MAGTF commander would correspond to the COC MAGTF (OPFAC #600) and the GCE would correspond to the COC GE (OPFAC #601). Again the author had to rely heavily on operational experience when determining the second OPFAC. The second OPFAC may or may not have been the same as the first. When both the XOPFAC and ROPFAC were the same, this implied intraoperability as opposed to interoperability. The final column titled "OPFAC task" was completed by comparing the first five columns to the OPFAC tasks narrative summaries contained in the TIC, and selecting the "most" appropriate OPFAC task(s). Appendix A provides a narrative summary from each of the OPFAC tasks involved.

5. Specifications of Measures, Data Generation and Aggregation of Measures

The last three MCES modules (Specification of Measures, Data Generation, and Aggregation of Measures) are beyond the scope of this thesis. However, the author recommends that remaining modules be developed further.

D. ANALYSIS OF THE APPLICATION

Recall that a MEO is defined by a unique arrangement of (1) source C2E, (2) Sink C2E, (3) message standard, and (4) link standard. The better the characterization of the components of a MEO, the easier it is to construct MEOs. The C2Es are easy to characterize by their descriptive elements (See Figure 3.2), but message standards are not. The application of this thesis provides some insight on how to refine and expand the characterization of tasks which determine message standards.

The author has shown that the tasks associated with producing an air tasking order can be characterized in terms of (1) C2 functions, (2) information category codes, (3) C2Es, and (4) tasks associated with a C2E (OPFAC task) (See Table 3.2 and Figure 3.10). These characteristics of a task can be used to

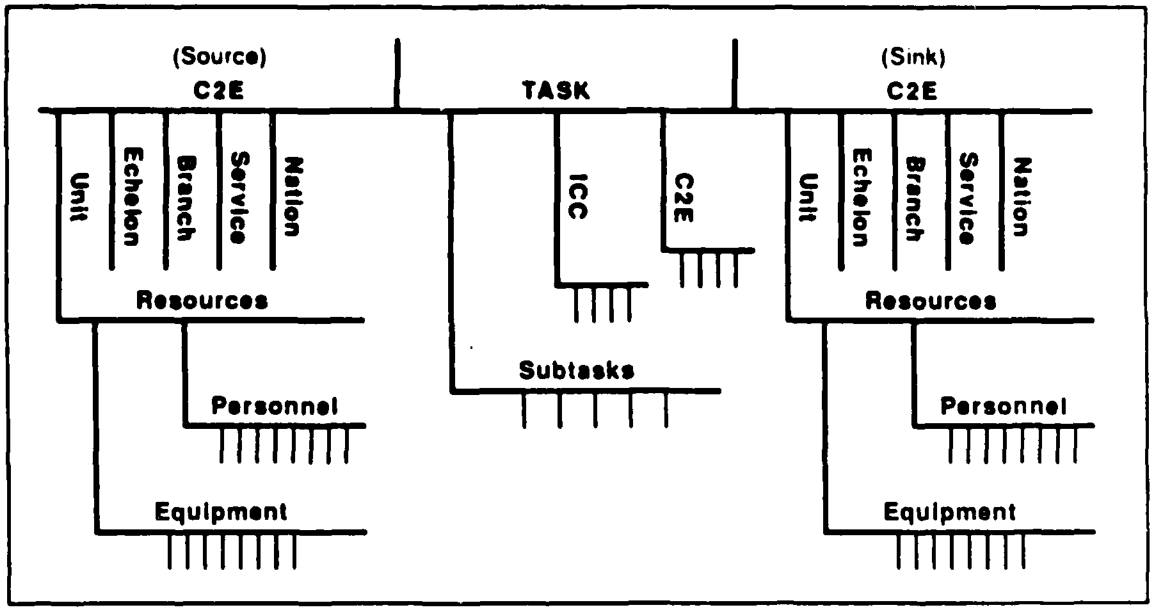

Figure 3.10. Structure of C^2Es and their Associated Task.

identify what type of information that is required to be exchanged between two OPFAC. C2 planners can use information requirements to define standardized message exchanges between two OPFACs, which define message standards. Once message standards are defined, C2 planners can decide what kind and how many data elements are required to adequately identify the information needed in the message standard. The number of data elements and the speed of which they must be exchanged between OPFACs would be used to define the link standard. The author has identified a more precise way to define the components of a MEO, which should be used to construct MEOs.

Once all potential MEOs and their descriptive characteristics have been identified, coded and recorded in an integrated interoperability database (IIDB), C2 planners could use this vast amount of information to manage interoperability problems. For instance, a planner may want to know what communications equipment is required to support an air defense mission. He could enter the IIDB and ask for all MEOs associated with an air defense mission. Then he could request the communications equipment which could support the particular link standards associated with those MEOs. Or he may desire to know what tasks are performed within an air defense mission. If so, he would ask for the message standards of the MEOs associated with air defense. Then he would ask for the tasks relating to the message standard. Also, the C2 planner could manage interoperability requirements by using the

IIDB and asking a question such as: given units "A," "B," "C," and "D," what types of communications equipment is required to support them in a particular exercise and does all the equipment exist? And if not, given the available resources what MEOs are involved and what tasks can be supported? One can begin to see that almost any question about interoperability/intraoperability can be addressed and answered using an IIDB. [Ref. 11]

IV. CONCLUSIONS AND RECOMMENDATIONS

A. OPERATIONAL CONSIDERATIONS

1. Weaknesses

The concept of defining interoperability and intraoperability requirements of C2 architectures in terms of MOEs is not a trivial matter. The actual method by which the Marine Corps and other services operate must be accurately verified and documented. Doctrinal publications are required to distinctly reflect the actual ways in which the services may operate. This effort will call for the services to think and plan in a broader perspective. They will have to reorganize their thinking in order to implement and adhere to a "truly" systematic approach when addressing operational considerations.

2. Strengths

The overall concept of distinctly defining the tasks which are involved in operational missions is a sound idea. This concept will enable military commanders to train their force in a more realistic way. The services will have a better grasp on what things they can do and can not do. They will have a methodology that will permit them to view the tasks necessary to support an operation, along with the resources required. This methodology gives the commander a tool to effectively and efficiently manage his assets.

3. New Insights Gained

With the concepts presented in this thesis, [illegible] interoperability managers [illegible] better manage interoperability requirements. The [illegible] provide the basis for the development [illegible] the design of future [illegible]. In essence, the MEO concept provides the [illegible] for development of interoperability standards. By distinctly characterizing the components which define a MEO, interoperability issues on several different levels can be addressed. Below are three interoperability standards referenced in the "Marine Corps Interoperability Management Plan" [Ref. 13: p. 2-10]:

> (a) Operational Interoperability Standards that specify military objectives/operational requirements, tactical doctrine/procedures, standard military language, and specific information exchange plan.
>
> (b) Procedural Interoperability Standards that specify procedures related to the forms in which information is transferred, standards reporting language, and operating procedures for data . . . links.
>
> (c) Technical Interoperability Standards that specify functional, electrical, and physical characteristics necessary to allow the exchange of information between different equipment systems.

Characterizing interoperability standards is simple in concept, but far reaching in terms of future applications.

4. Future Directions

C2 planners can use the tools contained in the MEO concept, this thesis, TIC, and MCES to identify the necessary information for an IIDB. In his paper titled, "CUTTING THE GORDIAN KNOT OF INTEROPERABILITY: . . ." Pipho states:

> The Marine Corps is currently in the early stages of developing a C2 interoperability database that embodies the MEO concept. Figure [4.1] is a diagram of the data model for this database as it now stands. The heavy lines indicate where the basic components of the MEO are found. Implementation of this database is scheduled to occur over the next two years. Completion of this project will validate and provide the Marine Corps with an effective tool to achieve interoperability among its C2 systems. [Ref. 2]

Also, needed will be a way to tie measures to the IIDB. MCES would be an excellent methodology to apply developing these measures and in analyzing interoperability requirements.

C2 planners could ask such questions as: (1) "given several implementation of a potential C2 communications architecture, which one is significantly better or worse than the others?" Or (2) "given a particular collection of resources (personnel and equipment), what type of missions can be performed and how well can they be executed?"

B. METHODOLOGICAL ISSUES

1. Weaknesses

As stated previously, the basic idea of the TI[illegible]
But trying to implement the concepts contained in the [illegible]
difficult at best. Some of the OPFAC tasks contained [illegible]
TIC are ill defined and in many cases it is [illegible]
ciate the "most" appropriate OPFAC task to [illegible]
were many cases where several OPFAC tasks [illegible]

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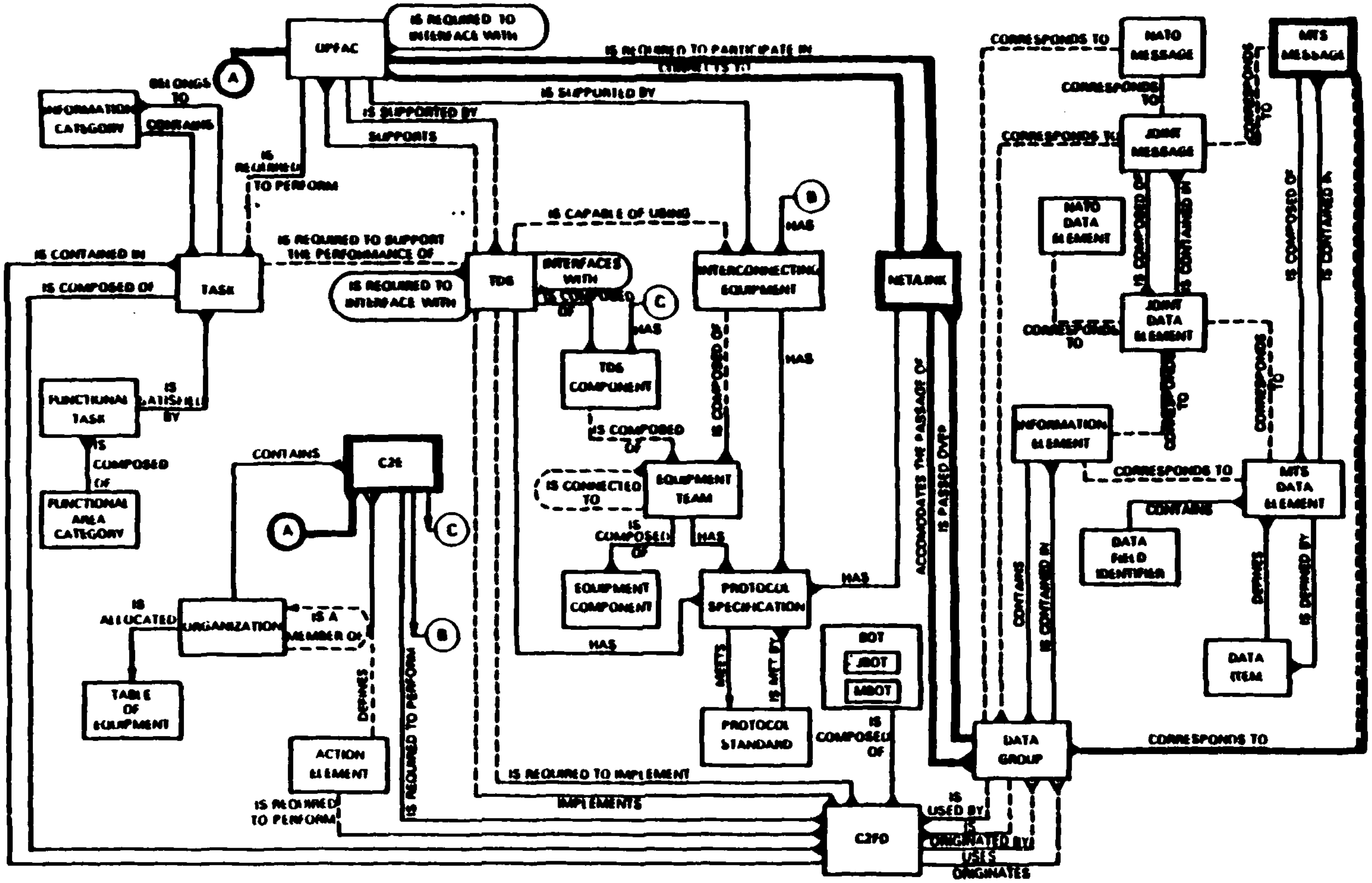

Figure 4.1. Data Model Diagram for the C2 Interoperability Data Base.

to capture the essence of the task being performed, although only portions of each OPFAC task actually related to the given task. Figure 4.2 illustrates this point. In this figure one can graphically see that, if each of the four OPFAC tasks' narrative descriptions were reduced to the size of the accented areas, the OPFAC tasks would be better defined. And as a result, C2 planners would not have to wade through unnecessary information. Simply eliminating text from an OPFACs narrative summary would not necessarily result in a better defined OPFAC task. Omitting text would more likely change the connotation of the narrative summary, rather than creating a better defined OPFAC task. In essence, the functional area category codes which are the fourth and fifth digits of an OPFAC tasks number should be defined so that they relate to only one task. Then C2 planners would not have to wade through unnecessary information to identify the relationship between tasks and OPFAC tasks.

2. Strengths

The overall concept of this thesis, of distinctly characterizing OPFAC tasks, is "usable." Air tasking is performed by all services and the author has used an available set of tools by combining MCES and the MEO methodology to demonstrate this point. By combining these tools the author has provided an approach supported by a substantial database to address the issue of interoperability management. This was not previously possible.

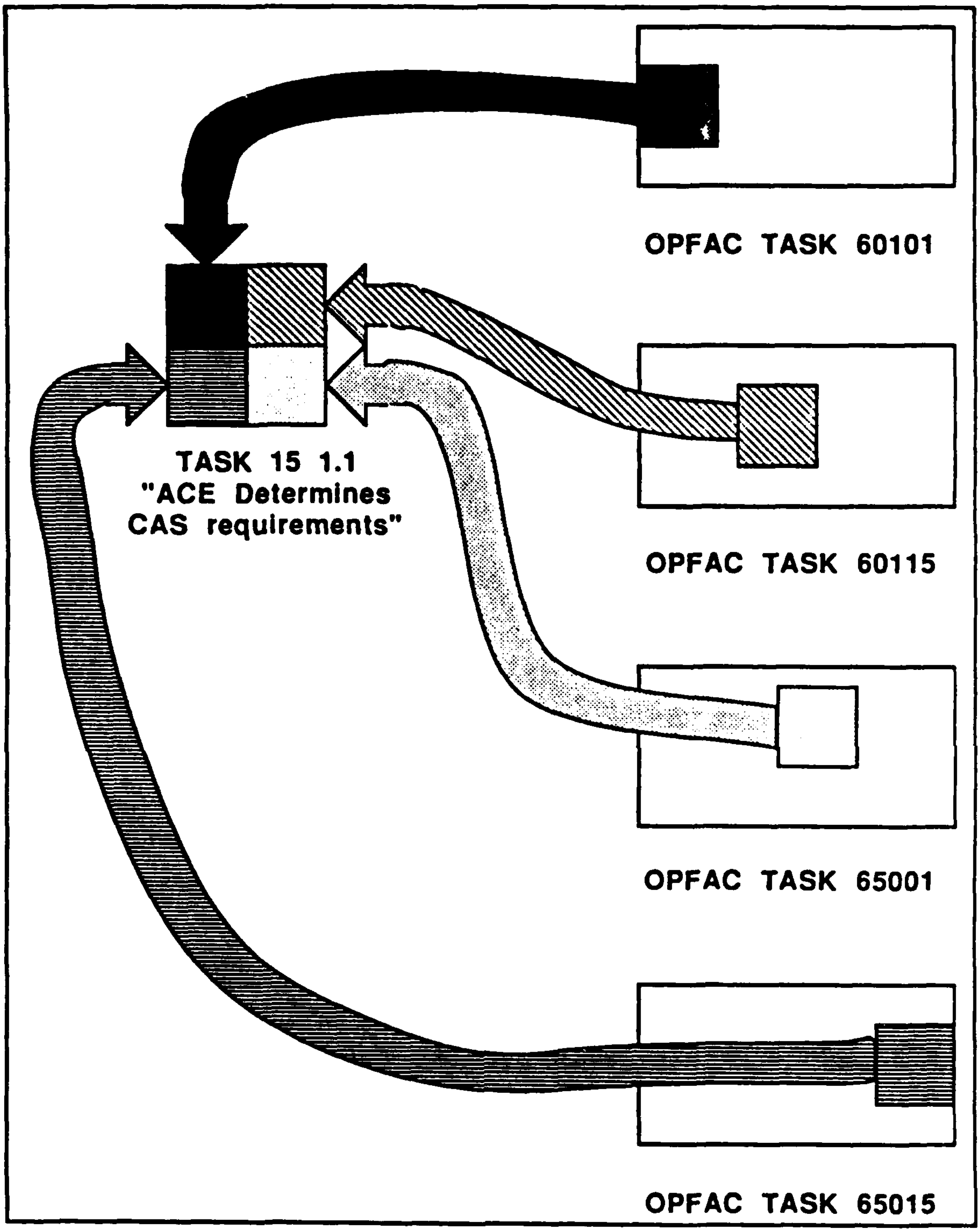

Figure 4.2. Mapping OPFAC Tasks to a Given Task.

3. New Insights Gained

Given that C2Es and message standards are both contained in a MEO, and that C2Es can be characterized by the organizations that are associated with them, message standards should be characterized by the tasks associated with them. Along the same reasoning, if C2Es are on different organizational levels, they should be classified hierarchically. If tasks (functional area categories) are structured hierarchically, they create a perfect vehicle to architecturally translate a given task into organizational units. But if tasks (functional area categories) are not structured hierarchically, then it is implied that a given task should be treated the same regardless of what level in an organization it pertains to. [Ref. 11]

An additional insight gained from this thesis is captured by the illustration in Figure 4.3. Intuitively, the author suggests that the six C2 process functions not only have a nonsequential execution through feedback loops (as depicted in Figure 3.8 and Figure 3.9) but the six C2 functions are not mutually exclusive. Essentially all six C2 function are involved throughout any C2 process. However, not all C2 functions may be involved with the same degree of intensity, and therefore they may be disregarded.

4. Future Directions

It is clearly evident that there is still much work to be done in order to have a useful IIDB. The author recommends

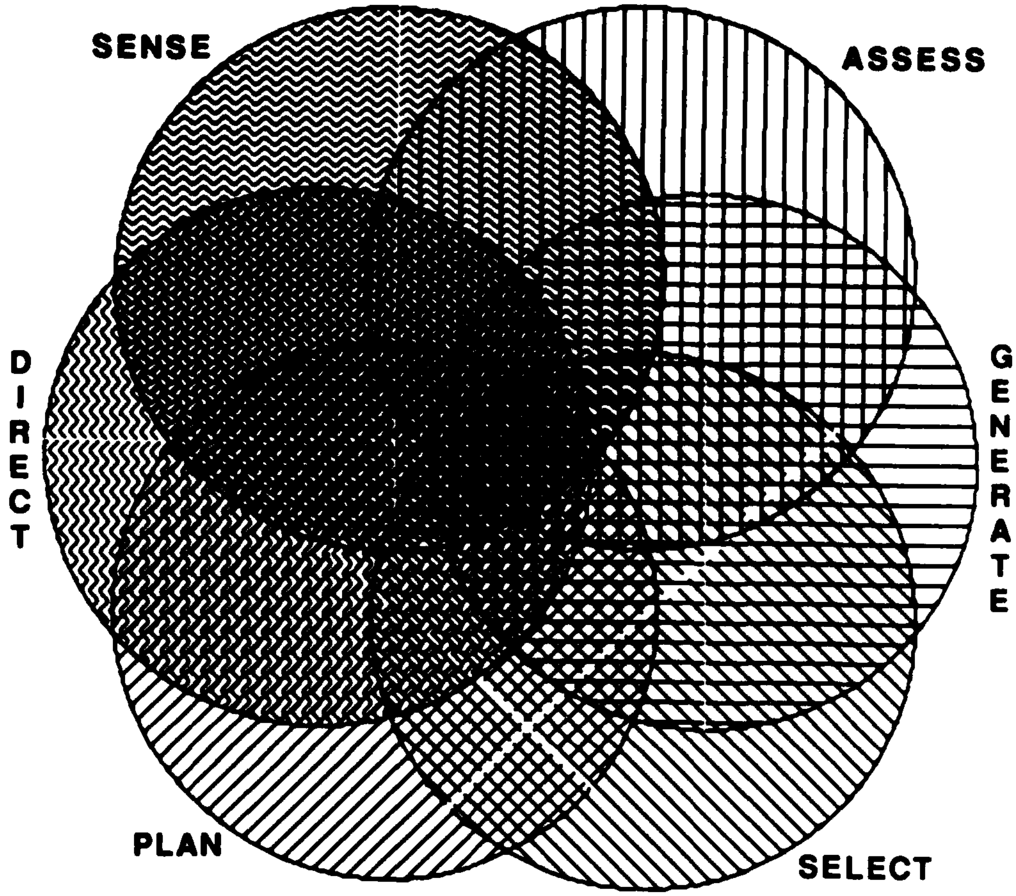

Figure 4.3. Intersection of C^2 Process Functions.

the five efforts listed below be undertaken, as soon as possible:

(a) Refine the functional area categories in the TIC, so that they more closely relate to the actual tasks performed for a given mission area. This includes organizing and coding the functional area categories on a hierarchical structure.

(b) Identify information requirements for each newly defined OPFAC task, based on the information category codes.

(c) Construct MEOs for all mission areas.

(d) Once MEOs have been defined, store them, along with their components which characterize them, into an IIDB.

(e) Run queries on the IIDB and use MCES as a tool to analyze the MEO concept to improve interoperability management.

MCES can be expanded to address questions on an architectural level, such as: given architecture A and architecture B which system can best support a specific combat mission? Once the IIDB is operational, it will speed up the analysis of the types of problems stated in the previous section (IV.A.4) titled "OPERATIONAL CONSIDERATIONS, Future Directions."

This thesis points out to the C2 community an existing approach that the Marine Corps is embarking upon. The C2 community has not used and does not use this approach, but should be aware of it because they can model their own service's unique tools after it.

APPENDIX A

OPERATIONAL FACILITIES (OPFAC) TASKS

The functional tasks are presented in the following paragraphs under the appropriate OPFAC. These OPFAC tasks were extracted from the TIC [Ref. 10: pp. D-3 - D-17]. The tasks are listed in generally the same order as OPFACs are presented in the TIC.

Combat Operations Center - Marine-Air-Ground Task Force Tasks

- COC MAGTF(M) Task 60000. Receive initiating directive from higher authority; receive planning information from all mission planning agencies; develop mission plans and operation orders for the conduct of operations by subordinate and supporting units of the Marine Air/Ground Task Force (MAGTF). Submit plans/ orders to supporting agencies for coordination and guidance, and to subordinate agencies/units for execution.

- COC MAGTF(M) Task 60001. Supervise and coordinate the operational planning and tactical execution thereof by subordinate and supporting agencies to preserve economy and unity of effort, while ensuring the accomplishment of objectives of the MAGTF; modify the tasking of supporting agencies as required.

- COC MAGTF(M) 60011. Ensure, during the planning and execution stages, the integration of all air, artillery, mortar, and naval gunfire in support of the scheme of maneuver of the ground forces.

- COC MAGTF(M) Task 60012. Allocate assets to subordinate and supporting agencies for the operation when approved plans have been promulgated. Request allocation of support from higher headquarters when support requirements cannot be met from organic assets.

- COC MAGTF(M) Task 60015. Maintain the status of the capabilities of friendly and enemy forces. Receive operational reports and intelligence data from supporting agencies; consolidate and forward to cognizant headquarters, keeping them advised of progress toward meeting objectives.

- <u>COC MAGTF(M) Task 60065</u>. Receive/initiate and disseminate tactical alerts and warnings concerning enemy activity and delivery of chemical or nuclear munitions by friendly forces, to ensure the safety and tactical integrity of force units.

- <u>COC MAGTF(M) Task 60070</u>. Establish the EMCON/EW policy for the MAGTF.

- <u>COC MAGTF(M) Task 60075</u>. Receive, evaluate, and disseminate combat information to support MAGTF operations, utilizing reconnaissance and surveillance reports, and other reports from units in contact with the enemy.

<u>Combat Operations Center Ground Element Tasks</u>

- <u>COC GE(M) Task 60100</u>. Receive initiating directive from higher authority; receive planning information from all mission planning agencies; develop mission plans and operation orders for the conduct of operations by subordinate and supporting units of the ground element (GE). Submit plans/orders to senior headquarters for approval, to supporting agencies for coordination and guidance, and to subordinate agencies/units for execution.

- <u>COC GE(M) Task 60101</u>. Supervise and coordinate the operational planning and tactical execution thereof by subordinate and supporting agencies to preserve economy and unity of effort, while ensuring the accomplishment of the objectives of the GE; modify the tasking of the supporting agencies as required.

- <u>COC GE(M) Task 60111</u>. Ensure, during the planning and execution stages, the integration of all air, artillery, mortar, and naval gunfire in support of the scheme of maneuver of the ground forces.

- <u>COC GE(M) Task 60112</u>. Allocate assets to subordinate and supporting agencies for the operation when approved plans have been promulgated. Request allocation for support from higher headquarters when support requirements cannot be met from organic assets.

- <u>COC GE(M) Task 60115</u>. Maintain the status and capabilities of friendly and enemy forces. Receive operational reports and intelligence data from supporting agencies; consolidate and forward to cognizant headquarters, keeping them advised of progress toward meeting objectives.

- COC GE(M) Task 60165. Receive/initiate and disseminate tactical alerts and warnings of enemy activity, and delivery of chemical or nuclear munitions by friendly forces, to ensure the safety and tactical integrity of force units.

Tactical Air Command Center Tasks

- TACC(M) Task 65001. Supervise and coordinate the operational planning and tactical execution thereof by subordinate and supporting agencies to preserve economy and unity of effort, while ensuring the accomplishment of the missions of the TACC in support of the MAGTF objectives; modify the tasking of supporting agencies as required.

- TACC(M) Task 65015. Maintain complete information on the air situation, including that ground combat information essential to the air effort. Keep cognizant agencies advised.

- TACC(M) Task 65041. Manage all aircraft in the AOA to ensure the most balanced and properly weighted utilization of assets for tactical air operations.

- TACC(M) Task 65043. Develop detailed FRAG orders to support the operations of the assault forces. Advise supporting arms agencies of the air support schedule in order to integrate air support with artillery and naval gunfire support. Disseminate the FRAG orders to air units and control agencies for execution.

- TACC(M) Task 65052. Divert aircraft from scheduled missions to meet other priority requirements; notify affected agencies and brief pilots as required.

- TACC(M) Task 65055. Establish and promulgate procedures for employment of air defense weapons in overlapping sectors of responsibility.

- TACC(M) Task 65061. Coordinate search and rescue operations for the MAGTF.

- TACC(M) Task 65065. Provide appropriate air defense alert conditions to all major elements of the MAGTF.

- TACC(M) Task 65068. Establish alert conditions for ground alert aircraft.

- TACC(M) Task 65070. Prescribe electronic emission control (EMCON) conditions and electronic warfare (EW) procedures for MACCS agencies in the objective area.

- TACC(M) Task 65072. Coordinate the gathering of sensor information, including radar contacts and electronic emissions, and report the information to command elements and air control agencies.

APPENDIX B

FUNCTIONAL AREA CATEGORIES

The functional area categories listed below are quoted directly from the TIC. [Ref. 10: pp. D-4 - D-5]

PLANS

- 00 Basic Plans and OPORDs
- 01 Supervise and Coordinate Planning and Execution of Plans and Orders
- 02 Supporting Arms Plans
- 03 Naval Gunfire Plans
- 10 Information Collection Plans
- 04 Nuclear and Chemical Fire Plans
- 05 Fire Support Plan Assistance
- 06 Artillery Fire Plans
- 07 Counterfire Plans
- 08 Air Support Plans

ASSETS

- 11 Integration of Assets
- 12 Allocation of Assets

SITUATION OR STATUS

- 15 Friendly and Enemy Status
- 16 Supporting Arms Situation
- 17 Aircraft Status and Capabilities
- 18 Status Displays/Dissemination
- 19 Status of Landings
- 20 Unit Location and Status
- 21 Friendly Aircraft Location

FIRE SUPPORT

- 25 Provide Supporting Arms Support
- 26 Monitor Fires/Safety
- 27 Limiting Measures
- 28 Coordinate NGF, Artillery, Mortar Support
- 29 Requests for NGF, Artillery, Mortar Support
- 30 Receive Calls for Fire
- 31 Call for and Adjust Fires
- 32 Control NGF and Artillery Fire
- 33 Registration Fires
- 34 Fire Direction
- 35 Fire Commands/Safety
- 36 Target Information

AIR SUPPORT

- 40 Command Subordinate Agencies
- 41 Manage Aircraft
- 42 Coordinate with External Agencies
- 43 Schedules/FRAG Orders
- 44 Coordinate Friendly Aircraft
- 45 Coordinate/Act for Control Agencies
- 55 Coordinate Air Defense
- 56 Identify and Track Aircraft
- 57 Landing Zone Operations
- 46 Provide Air Support
- 47 Direct Air Strikes
- 48 Control Aircraft
- 49 Assign A/C to Control Agencies
- 50 Requests for Air Support
- 51 Air Support Requirements
- 52 Adjust/Divert
- 53 Coordinate DAS Execution
- 54 Coordinate FAAD Teams
- 58 Movement Into and Out of Landing Zone
- 59 Provide Air Defense

APPENDIX B

FUNCTIONAL AREA CATEGORIES (CONT'D)

FLIGHT ASSISTANCE	60 Flight Advisories 61 SAR Operations 62 Radar Handover	63 GCA/Radar/Navigation Assistance 64 Air Track Data
WARNINGS AND ALERTS	65 Receive/Disseminate 66 Nuclear and Chemical Delivery	67 Ordnance Release 68 Strip Alert Data
SENSOR	70 EMCON/EW Policy 71 Coordinate/Monitor EMCON/EW	72 Coordinate Sensor Data 73 Provide Sensor Data
INTELLIGENCE/OPERATIONAL	74 Collect Information 75 Process Intelligence Data	76 Reconnaissance and Surveillance 77 Results
ROUTES AND POINTS	80 Approach and Retirement 81 Alteration	
BRIEFINGS	85 Brief Aircrews 86 Brief Observers	87 Brief Agencies on Status
CONFLICTS	90 Supporting Arms Conflicts 91 Safety Conflicts	92 Priorities
METEOROLOGICAL AND SURVEY	95 Meteorological Data 96 Survey Data	

APPENDIX C

INFORMATION CATEGORIES

The information contained in this appendix is quoted from the TIC [Ref. 10: pp. 3-5 - 3-7].

Information Categories. The JINTACCS program has derived 12 categories of information from JCS Pub 12 to identify the information exchange requirements among and between various OPFACs. When an individual information category is applied to each of the 12 operational tasks, the content of the category varies according to the task. This application provides for a refinement of the basic 12 information categories in defining information exchange requirements.

a. Allocation/Apportionment(AL). An allocation is refinement of the apportionment decision made by the force commander. An example is the apportionment decision made by the division of the total tactical air capabilities among air strike tasks to be performed for a specific period. In consideration of the apportionment, the commander prepares the allocation by designating specific numbers and types of aircraft sorties for use during the specified time period. Necessary allocation information is transmitted from the commander(s) to the components included in the apportionment and to the joint task force headquarters.

b. Enemy Capabilities (EC). This category provides intelligence on possible future courses of action by the enemy which may affect the accomplishment of the assigned joint task force mission. The term "capability" includes not only the general courses of action open to the enemy, such as attack, defense, or withdrawal, but also all specific courses of action possible under each general course of action. Enemy capabilities are considered in light of all known factors affecting military operations, including time, space, weather, terrain, and the strength and disposition of enemy forces. It does not involve the current situation of the enemy, but deals with possible future actions of the enemy. As used in this document, information in this categoryo is generated by an operational facility as a result of analyzing and evaluating information obtained from its own resources and/or of information obtained from other operational facilities, including a reassessment of enemy capabilities generated by other operational facilities.

c. Enemy Status (ES). This category provides information and/or finished intelligence on the enemy situation as it currently exists. It may include historical intelligence, but it excludes possible future actions by the enemy from all sources, including order of battle, location and disposition, movement speeds and direction, target and installations, scientific and technical, biographic, nuclear, biological, and chemical and other information classified as current or combat intelligence (e.g., contacts and sightings, electronic warfare, imagery and imagery readouts, prisoner-of-war exploitation, and captured documents and material) are included in this category, except weather (WX) and terrain (TG).

d. Friendly Capabilities (FC). This category provides the commander's evaluation of what his unit(s) can or cannot do in the future. It does not involve the present situation of friendly forces, but deals only with possible future actions and conditions of these forces. Information in this category includes potential courses of action by friendly units which, if adopted, will contribute to the accomplishment of the assigned mission. It also includes projected status and availability of units, or their weapons systems or other material, and estimated future strength and location of friendly units. It does not include the intention of the commander, but may describe the future friendly situation resulting from the pursuit of those intentions.

e. Friendly Status (FS). This category provides information about friendly forces as they currently exist. It includes such elements as strength, composition, location and dispositon, status and availability of resources, movements and activities, movement speeds and direction, logistics, significant strengths and weaknesses, nuclear, biological, and chemical weapons, and/or technical characteristics of equipment. It describes the friendly situation as it currently exists, not as it may exist in the future.

f. Orders (OR). This category involves directives to take action. It does not include information concerning what the commander intends to do in the future, but may tell the recipient what the commander requires to be done in the future. For weapons systems, it may include instructions such as fire, cease fire, track, drop track, vector, attack, etc. It also includes such directives as operations orders, warning orders, fragmentary orders, etc.

g. Plans (PL). This category consists of a method or scheme for a future military action. It represents the commander's translation of his decisions and concepts of operation into preparing for action in a specific area to meet a particular event, and it conveys the commander's intentions for accomplishing this event. A plan will not become an order without appropriate implementing instructions.

h. Priorities (PR). This category involves the commander's ranking the elements of any situation in the order of each element's importance to the accomplishment of the mission. Priority information may involve establishing the precedence of elements relative to time, space, or any number of other limiting factors. The ranking indicates relative importance; it is not an exclusive and final designation of the order of accomplishment. For example, the DASC assigns a priority to each request for close air support submitted by ground agencies; the TACC assigns priorities for air defense protection to specific areas, facilities, units, or activities within the area of operations.

i. Request for Information (RI). This category tells the recipient that information is needed for use in decision making. This category does not include requests for support (RS). It is not used to obtain information which is otherwise required to be transmitted as a result of orders or of execution of plans, but is used to obtain information for amplification or clarification, or information that is otherwise excepted from reporting. Such requests may be general or specific in nature, and may or may not require recurrent responses. It may be used to obtain information on enemy or friendly status or capabilities, weather or terrain. It may also be used to request further orders from a superior, or to interrogate other commanders about their plans or priorities.

j. Request for Support (RS). This category is part of the process of allocating and reallocating combat resources. The support requested encompasses any action on the part of an agency which aids, protects, complements, or sustains another agency when engaged in tactical operations.

k. Terrain/Geographic/Oceanographic/Hydrographic Information (TG). This category of information pertains to all aspects of the environment, natural or manmade, other than weather. It includes the configuration, composition, fauna, flora, cultural features, and hyudrological and geophysical characteristics of the land and all aspects of the sea. It includes navigational information, fallout, effects of chemical weapons, induced radiation data, and such mand-made obstacles as minefields, barbed wire, concertinas, and underwater barriers.

l. Weather (WX). This category of information pertains to all past, current, and forecasted meteorological, climatological, and sea conditions.

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