

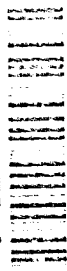
Naval Command,
Control and Ocean
Surveillance Center San Diego, CA
RDT&E Division 92162-5000

Technical Document 2359
January 1993

Space and Electronic
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Technical Document 2359
January 1993

U.S. Marine Corps
MTACCS/COPERNICUS INTEGRATION

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**NAVAL COMMAND, CONTROL AND
OCEAN SURVEILLANCE CENTER
RDT&E DIVISION
San Diego, California 92152-5000**

J. D. FONTANA, CAPT, USN
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ADMINISTRATIVE INFORMATION

This study, performed during fiscal year 1992, was funded by the Amphibious Warfare Technology Directorate of the Marine Corps Systems Command to identify architectural/technical issues associated with integrating components of Marine Corps C4I systems into the Navy's Copernicus architecture. The work was performed under the direction of Chuck Mirabile (Code 405) of the Naval Command, Control and Ocean Surveillance Center's RDT&E Division (NRaD), San Diego, California 92152-5000.

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RBT

FOREWORD

BACKGROUND

The Naval Command, Control and Ocean Surveillance Center's RDT&E Division (NRaD) supports the Marine Corps through the Battlefield Electronic Support Technology Program. The principal objective of this program is to enable the Marine Corps to develop technology leading to high-performance, portable Command, Control, Communications and Intelligence (C3I) systems.

OVERALL OBJECTIVES

In the 3900/AW/4 Feb 92 letter from the Marine Corps Research, Development and Acquisition Command (now the Marine Corps Systems Command), tasking was given to NRaD's Copernicus program office. Subsequent meetings between NRaD and the Systems Command resulted in the following specific tasks addressed in this report:

Identify architectural/technical issues associated with—and, when possible, provide solution/options for—

1. The Marine Air-Ground Task Force (MAGTF) Command Element (CE) to function as a Tactical Command Center (TCC) within the Navy's Copernicus architecture.
2. A shipboard interface between the Marine Tactical Command and Control System (MTACCS) and the Navy Tactical Command System-Afloat (NTCS-A) C3I system.
3. Use of "Communications Support System (CSS)-like" architecture and technology to support the communications resource-allocation requirements of a MAGTF CE ashore.

Note that the systems and concepts discussed here (Copernicus, NTCS-A, et al.) will likely be subject to significant changes over time, particularly in this present environment of budgetary constraint and changing threats. For this reason, some of the assumptions made in this document about these programs are "best guesses," and issues/solutions based on them may have to be modified in the future.

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SCOPE/DOCUMENT STRUCTURE

As indicated by the task objectives just described, the treatment of the elements covered in this report varies from considering near-term solution/options to an existing communications problem—to a very much more theoretical identification of issues associated with treating the MAGTF CE as a TCC in Copernicus.

To accommodate this variation and the differing operational context of each task, this report addresses the task elements in the following order:

1. MTACCS/NTCS-A Shipboard Interface (Section 1)
2. MAGTF CE to Function as a TCC (Section 2)
3. "CSS" to Support MAGTF CE Ashore (Section 3)

Recommendations and conclusions are provided separately for each task element at the end of each section.

Appendix A provides a succinct description of the Navy-developed C3I systems mentioned in this report, Appendix B presents an overview of Copernicus and its relationship with MTACCS, and Appendix C lists some CSS-related terms and definitions.

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1. MTACCS/NTCS-A SHIPBOARD INTERFACE TASK

1.1 ARCHITECTURAL LAYOUT

1.1.1 Operational Context

Amphibious operations are acknowledged to be among the most complex and difficult of military operations. To be successfully accomplished, an ongoing dialogue must exist between the Marine Air-Ground Task Force (MAGTF) Command Element (CE) and the Navy's Command Element represented by the Commander, Amphibious Task Force (CATF) throughout the entire assault operation. The requisite information and data-exchange requirements and resources will clearly vary during the phases of the operation. While both the Commander, Landing Force (CLF) and the CATF are embarked, prior to the start of an assault, the communications and data-exchange requirements between the Navy and the Marine Corps must be identified. Once identified, many or all of these requirements could be accommodated by an interface between the Marine Corps' MTACCS and the Navy's NTCS-A systems. This section addresses this interface (figure 1-1) and the architectural and/or technical issues associated with it.

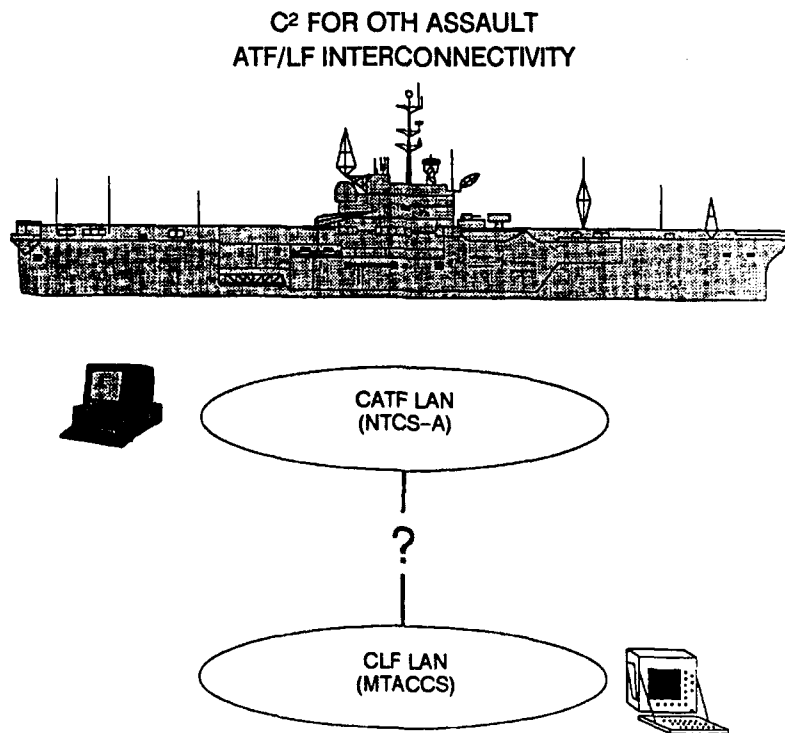


Figure 1-1. MTACCS/NTCS-A interface.

1.1.2 NTCS-A Configuration (See Appendix A.)

The NTCS-A hardware configurations in figures 1-2 and 1-3, taken from the NTCS-A Program Handbook of 21 October 1991, reflected current planning for amphibious assault (LHA/LHD) ship equipment locations and are the system architectures considered in this study. (These figures illustrate the density of the hardware in the two configurations.) The following list comprises the Navy Tactical Command Systems-Afloat (NTCS-A) standards that are assumed with these architectures and that define the system's "Common Operating Environment" are

Operating System	UNIX (POSIX)
Database	RDBMS, SQL
Languages	C, Ada
Local Area Network	Ethernet 802.3
Protocols	TCP/IP (GOSIP)
Graphics	GKS, PHIGS
Man-Machine Interface	X-WINDOWS (MOTIF)

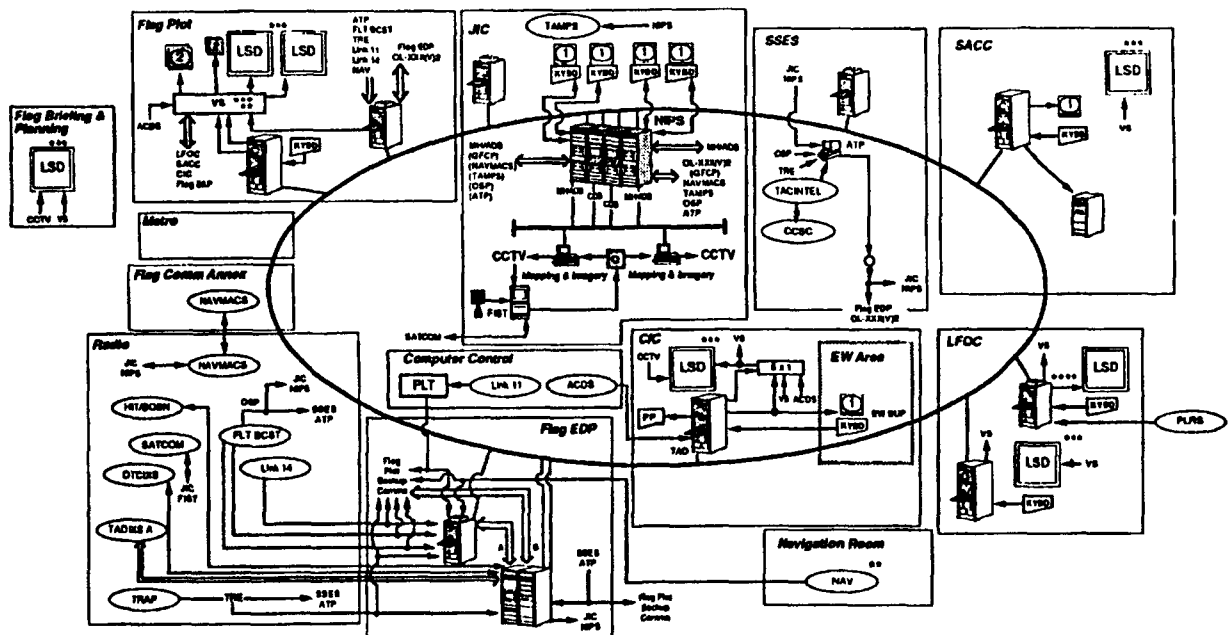


Figure 1-2. NTCS-A hardware configuration, LHD.

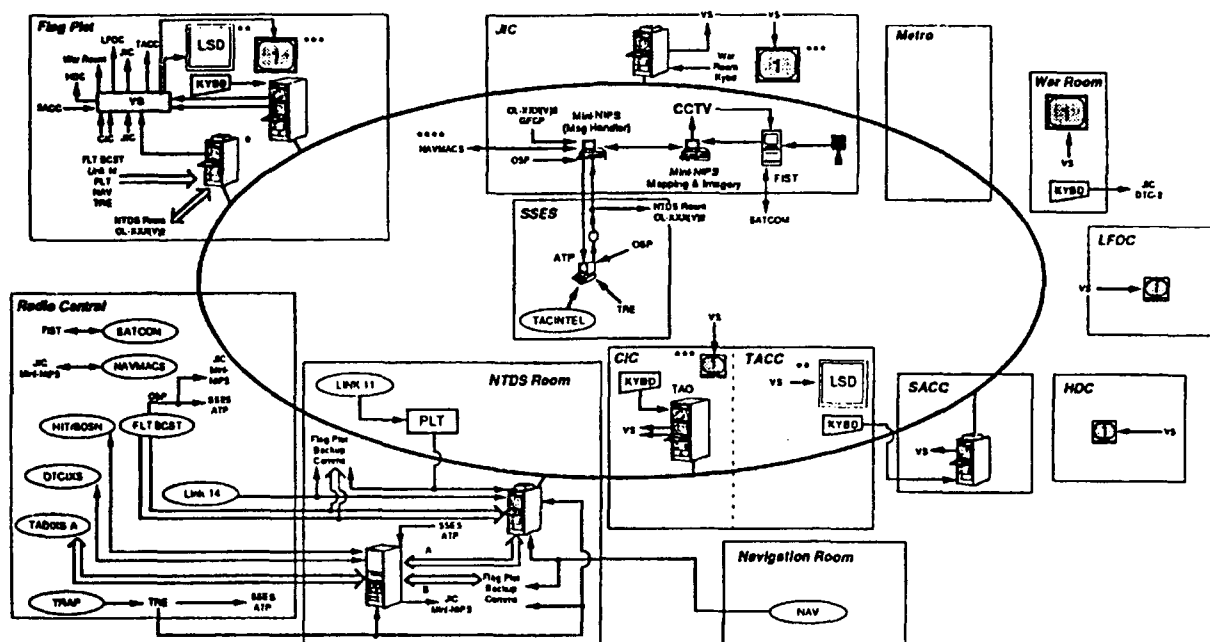


Figure 1-3. NTCS-A hardware configuration, LHA.

1.1.3 Specific MTACCS Configuration

The specific MTACCS-hardware configuration and architecture used in this study are based on the recommendations in the Hardware/Software Architecture Recommendations for Marine Corps Tactical Command and Control System (MTACCS) Report of May 1991 by Pacific Northwest Laboratory. It presumes the elements of MTACCS (TCO, MILOGS, IAS, etc.) are running as applications on the four-layered structure as shown on figure 1-4. Specific LHA/LHD architectures like those shown for the NTCS-A above are not available at this time, but certainly one can assume that MTACCS could be similarly configured in a shipboard environment. The revised Operational Requirement for the Intelligence Analysis System, for example, describes a configuration consisting of a data storage device, several workstations, and printers, tied together by a local area network. It states that the Integrated Avionics System (IAS) shall be interoperable with U.S. Navy intelligence systems aboard amphibious shipping, with Intelligence Support to Strike/Amphibious Forces (ISS/AF), and with Tactical Flag Command Center (TFCC) intelligence systems, thus keeping the MAGTF database current through all phases of an amphibious operation. The requirement also postulates that the equipment will be used in Joint Intelligence Center (JIC) spaces when possible. Other MTACCS elements are even less specific about their particular architecture aboard ship.

1.1.4 Other Concerns About Architecture

Issue—Proliferation of Marine Corps-related NTCS-A interfaces.

As the individual components of MTACCS continue in their separate development programs, each element has stated a requirement to interface with NTCS-A. Additionally,

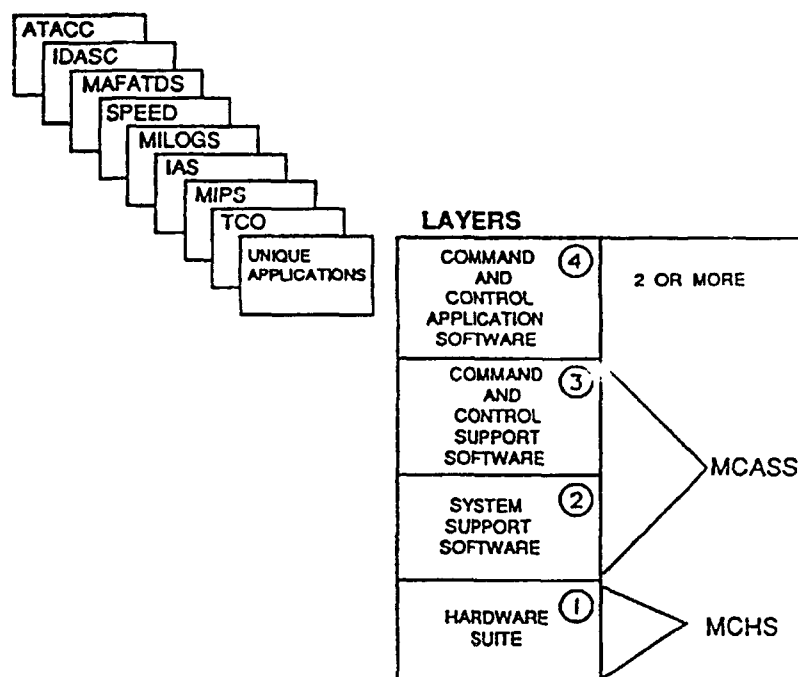


Figure 1-4. Elements of MTACCS running as applications on four-layered structure.

Marine Corps-related Navy-developed C2 systems (discussed ahead) plan to interface as well. Unless the interface development is done in a planned/coordinated manner, Marine Corps requirements probably will not be met in a cost-effective manner, if at all.

Three other ongoing system-development programs involve shipboard amphibious operation information and data-exchange needs and methods. Two of these are being developed by the Navy: the AN/KSQ-1 Amphibious Assault Direction System and the Tactical Information Processing System (TIPS), both described in Appendix A. The other, being developed by the Marine Corps, is the Amphibious Assault Planner (AAP). These systems are designed to provide support for the CATF/CLF and thus directly affect the requirements and design of an MTACCS/NTCS-A interface.

1.1.5 Architectural Layout

These paragraphs present basically two different architectural concepts for the shipboard Marine/Navy Command and Control Interface. Each concept implies a different philosophy involving responsibility for meeting Marine Corps C2 requirements during an amphibious operation, leading to a significantly different Concept of Operations. Technical pros and cons concerning each of these concepts are discussed in the Conclusion and Recommendations part of this section.

Concept 1—Integrate Marine Corps Shipboard Needs Within NTCS-A and Other Navy Systems

This architecture, reflected in figure 1-5, postulates that MTACCS-unique hardware would not be required shipboard to support Marine Corps C2I needs. Their command and

control assets would be handled similarly as communications assets are now treated, the Navy being responsible. Specific Marine Corps C2 requirements would be met by Marine Corps-developed software (i.e., MTACCS software) that runs as application programs in the NTCS-A software and hardware environments. Additional workstations could be added as required.

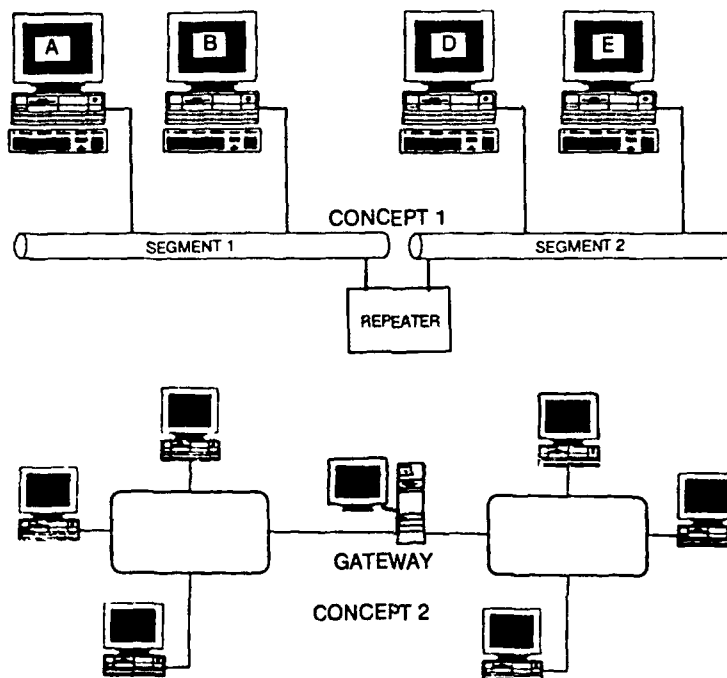


Figure 1-5. Gateway concept for interface shipboard.

Concept 2—NTCS-A and MTACCS Shipboard System Interface

This architecture, also shown notionally in figure 1-5, postulates an independently developed MTACCS used shipboard. The illustration should not imply that either NTCS-A or MTACCS will exist in a ring architecture, but that it illustrates the "gateway" concept for the interface shipboard. The complexity of the gateway depends upon the amount of information flow through it, the type of information, and the differences in architecture between NTCS-A and MTACCS. Using this structure, the networks may employ different message formats, maximum message sizes, and character sets. They may use completely different addressing methods. This would allow major differences in protocols and standards to exist between MTACCS and NTCS-A.

Selecting Concept 1 would be a significant change from the current direction of "independent" MTACCS-component development. This could significantly affect the ongoing design work of MTACCS systems.

Issue—How would selection of the architecture impact existing development work of MTACCS component systems?

1.2 TASK ANALYSIS/ISSUES IDENTIFIED

1.2.1 Information Requirements Between CATF/CLF in a Shipboard Environment

Information needs between CATF/CLF on the ship fall generally into three distinct but not fully independent categories. These are Planning, Communications, and Tactical.

Marine Corps planning needs in the shipboard environment will involve preparing and updating databases for both administrative and tactical use, as well as modifying previously developed operational procedures and plans, and updating intelligence and logistic information. To define information flow needed between NTCS-A and MTACCS in the planning area, however, assumes that a previously arranged understanding has existed about the location of planning data between the Navy and Marine Corps system. This understanding is a "Concept of Operations for Afloat Planning," using MTACCS and NTCS-A/KSQ-1/TIPS systems. It has not been addressed by either the Navy or the Marine Corps and has led to parallel system requirements. Generalizing even further, a Concept of Operations for the Marine Corps/Navy amphibious operation is required to rationally determine system and system-interface requirements. The Concept of Operations would map Marine Corps and Navy operational requirements in all those areas just discussed to the particular equipment that the services have available.

Issue—Concept Of Operations Development

1. Run Marine Corps C² as applications in the NTCS-A environment, i.e., complete integration shipboard.
2. Run Marine Corps C² in MTACCS-developed hardware and software. Interface (gateway) for any desired information transfer.

The Concept of Operations just discussed follow directly from the architecture options previously mentioned.

1.2.2 Issues Associated With Meeting Requirements

Based on the issues just discussed, requirements for Marine Corps C²I can be viewed in two ways, each reflecting the alternative Concept of Operations/architectures for the shipboard interface.

Issue—What additional information and/or capability is needed in NTCS-A to support the Marine Corps?—or—What information is NTCS-A holding that requires the Marine Corps (MTACCS) to support MC-C²I functions shipboard?

Another "architectural"-related requirement relevant to discuss here is the need to transition from NTCS-A support to MTACCS support during the later portion of the assault

and subsequent operations-ashore phases of an amphibious operation. MTACCS tactical and intelligence databases must be initialized promptly and accurately for a successful mission. This is a much less significant technical issue if the Concept of Operations reflects the "gateway" interface architecture, since this architecture would cause these databases to update automatically.

Issue—How much common software architecture will exist between MTACCS and NTCS-A?

The complexity of the interface between NTCS-A and MTACCS local area networks will be driven by the differences in their software architecture. When viewed in terms of the open-system interconnection (OSI) reference model (figure 1-6), the use of a simple repeater as an interface is possible when protocols associated with all seven layers are the same. A gateway, on the other hand, would be necessary if these protocols were different. If the "applications" architecture were chosen for the shipboard NTCS-A/MTACCS interface, the concern of the unique needs of the Marine Corps becomes a major design driver; particularly those requirements associated with presentation to the user.

Issue—How stable are the standards and protocols that define the NTCS-A operating environment?

This issue could significantly affect all developers of applications programs for NTCS-A.

1.3 CONCLUSIONS AND RECOMMENDATIONS

Six issues have been identified that must be addressed when considering the design of a shipboard interface between MTACCS and NTCS-A. They are

1. Proliferation of Marine Corps-related NTCS-A interfaces.
2. Impact on current MTACCS-component software development depending on the choice of future shipboard architecture.
3. Concept of Operations development.
4. Identification of specific Marine Corps information requirements and needs in NTCS-A.
5. Common software architecture and operating environment between MTACCS and NTCS-A.
6. Stability of the NTCS-A operating environment.

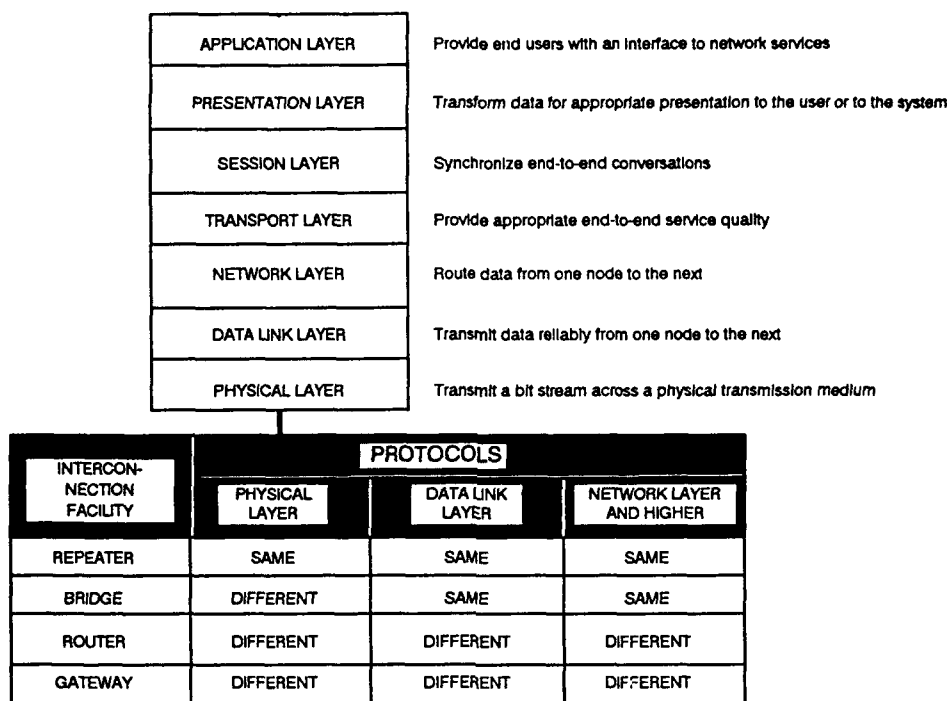


Figure 1-6. OSI reference model.

Issues 1 and 2 pertain to present Marine Corps and Navy systems developments. TCO, IAS, AAP, and other systems, like AN/KSQ-1 and TIPS, have specified the need to interface with NTCS-A. Independent development of these interfaces, as is now happening, cannot be the most cost-effective and efficient means to provide for them. We recommend that steps be taken now to coordinate/standardize NTCS-A interface design across ongoing Marine Corps C2 system developments.

Investigation of Issue 2, which would determine how much of current MTACCS-component software development would be transportable into the future MTACCS, should be addressed upon resolving the following issue discussed.

Issue 3 discusses what is the most significant decision at present, since its resolution defines the philosophy and framework for future MTACCS development. The following discussion deals with the pros and cons associated with designing and developing MTACCS software for the NTCS-A operating environment.

A common MTACCS/NTCS-A operating environment provides these advantages:

1. Allows the Marine Corps maximum leverage from Navy developments.
2. Provides a truly "seamless transition" from garrison to ship-to-shore evolution of an amphibious assault.
3. Does not require complex design for shipboard interface.

4. Provides inherent interoperability with Navy C2 and makes design issues—associated with interoperability among the other services—common to the Navy/Marine Corps.

The disadvantages of a common MTACCS/NTCS-A operating environment are as follows:

1. Difficult evolution from current MTACCS development.
2. Larger and more difficult Marine Corps/Navy coordination.
3. Loss of “independent” development.
4. Greater difficulty in treating Marine Corps-unique requirements.
5. Competition with the Navy for priority for upgrades to NTCS-A.

We believe that the advantages associated with a common environment outweigh the disadvantages and recommend that a Concept of Operations based on that architecture be developed. This concept would detail specific Marine Corps/Navy C2 system-interface requirements and would additionally clarify the role of the MTACCS- and Navy-developed C2I systems through the stages of an assault.

Issues 4 and 5 would be addressed in the Concept of Operations development.

To adequately resolve Issue 6 requires close liaison between the Navy and Marine Corps. A closer interface should be maintained than that currently provided by the Fleet Requirements Working Group, focused on design versus operational issues. We recommend that a mechanism be established to maintain an ongoing dialogue between MTACCS and NTCS-A developers.

Table 1-1 summarizes the identified issues and recommendations.

Table 1-1. MTACCS/NTCS-A interface, issues and recommendations.

Issue	Recommendations
1. Proliferation of MTACCS interfaces to NTCS-A.	Standardize the interface. (Use Recommendation 6.)
2. Impact on current MTACCS by choice of long-term software architecture.	Pending Concept of Operations development.
3. Concept of Operations development.	Define concept with common MTACCS/NTCS-A environment.
4. Marine Corps information requirements in NTCS-A.	Part of Concept of Operations.
5. Common software architecture and operating environment.	Addressed in Concept of Operations.
6. Stability of NTCS-A operating environment.	Establish a Marine Corps/Navy (MTACCS/NTCS-A) design group.

2. MARINE AIR-GROUND TASK FORCE COMMAND ELEMENT AS A TACTICAL COMMAND CENTER

2.1 TASK DESCRIPTION

2.1.1 Operational Context of Task

Figure 2-1 depicts the connectivity requirements of this task.

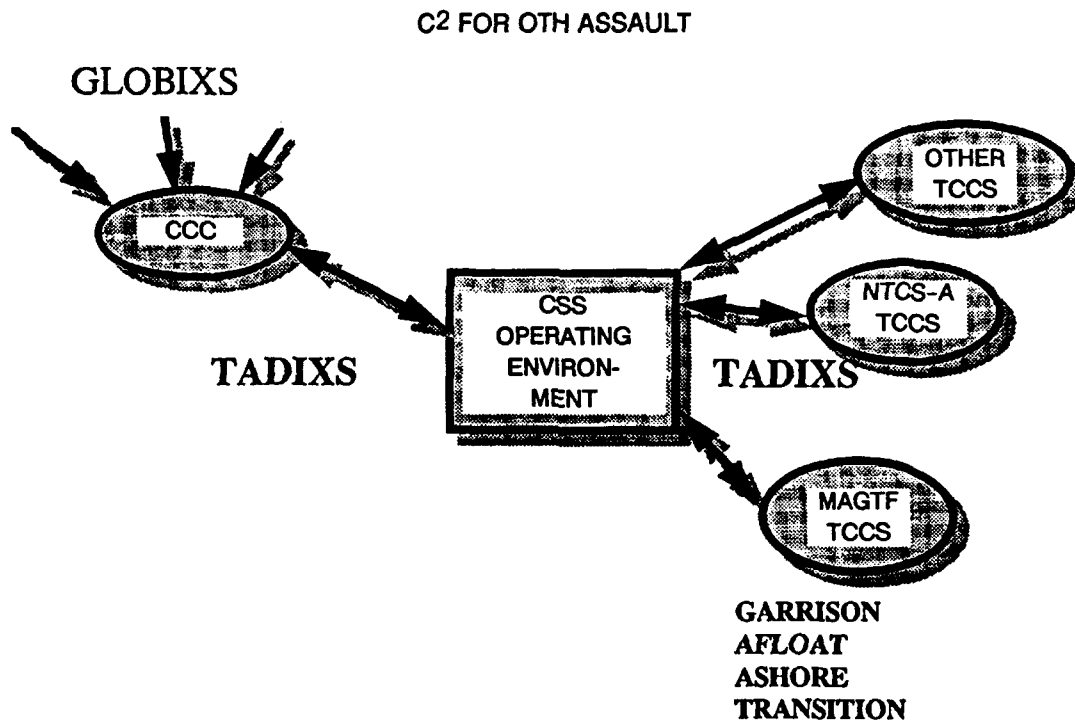


Figure 2-1. Operational context of the task.

The physical MAGTF TCC, in its four operational states (Garrison, Afloat, Ashore, and Transition), is connected via the Tactical Data Information Exchange Systems (TADIXS) to the CINC Command Center (CCC), to Afloat NTCS-A configured TCCs (CATF, CLF, Battle Force), and to other TCCs (Joint, Army, Air Force). These connectivities are required to perform the MAGTF mission.

As in any tactical information-processing system, time will tend to be the critical factor for the MAGTF TCC and the supporting information networks. MTACCS and Copernicus will be required to support a combination of planning and execution functions. The former is less time-constrained, tending to be completed separately from the realtime battle, while the latter requires near realtime performance.

2.1.2 Baseline MTACCS Configuration (MCTCA-Midterm)

The baseline MTACCS configuration and required connectivities for purposes of this study are the Marine Corps Tactical Communications Architecture-Midterm (MCTCA-Midterm).

2.1.3 Detailed Task Description

This subtask lays out the MAGTF architecture in terms of Copernicus pillars, and identifies the architectural and technical issues that must be resolved to enable the MAGTF CE to function as a TCC within the Copernicus architecture.

Figure 2-2 depicts the MAGTF architecture, including current connectivity (TADIXS) requirements among the CE and other MAGTF components—and with external Command and Control Facilities (C2FACS).

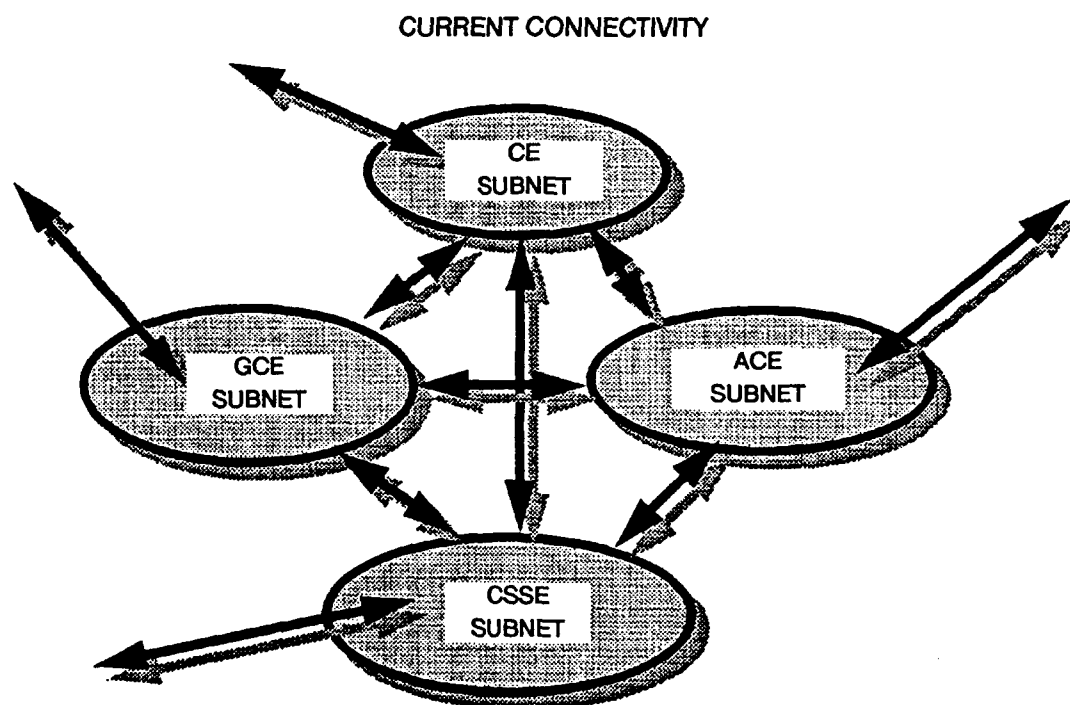


Figure 2-2. MAGTF architecture under Copernicus.

2.1.4 Copernicus Pillars

For this discussion, the following pillars are relevant:

1. CCC—The CINC Command Center is the shore-based termination of the individual Global Information Exchange Systems (GLOBIXS) networks that allows the command center to access information among data fusion and

correlation centers, as well as the technical information centers. A component of the CCC is the "Anchor Desk," which represents the users at this termination. Users can register their information requirements with the Anchor Desk to ensure that this information is captured and passed to them over the TADIXS.

2. GLOBIXS—These are individual information networks established among the CCC and the various data fusion/correlation centers and technical information centers.
3. TADIXS—These are the networks between the CCC and the user TCCs. They are a collection of bearer services that expedite the flow of information.
4. CSS—This is not a pillar of Copernicus, but a means to implement the TADIXS and GLOBIXS pillars that allow information to flow within the networks. A portion of CSS (COMPLAN) allows TCC users to register their information requirements with the Anchor Desk to extract needed information from the system. Another portion of CSS governs the flow of information among CSS and non-CSS participants (e.g., Joint/Allied TCCs), and among TCCs over TADIXS.

2.1.5 Comparison of C2MP/MTACCS and Copernicus

Both Copernicus and the Command and Control Communications Master Plan (C2MP), along with its implementation, the Marine Corps Tactical Command and Control System (MTACCS), are designed to provide flexibility within the volatile world-political environment that has arisen following the breakup of the Soviet Union. Both satisfy the need to rapidly move information from where it exists to where it is required, while allowing maximum flexibility. MTACCS is a functional and mission-area implementation of the Command and Control Communications Master Plan.

Both Copernicus and MTACCS stress open-systems interconnection (OSI) architecture, with modular and reusable software, provided either as Commercial Off the Shelf (COTS) or Government Off the Shelf (GOTS).

While on the surface, the two architectures should be compatible, underlying factors exist that must be addressed before such an assessment can be made. First, the emphasis of Copernicus has been to provide access to shore-based major command centers, tapping into a large amount of information that has not yet been effectively exploited in Naval Warfare. This information is then made available to the principal striking arm of the Navy, which is the afloat Battle Group Tactical Command Center (TCC). Thus far, the emphasis has not been extended below this Battle Group TCC. Unfortunately, this connectivity is about one-step above where MTACCS begins. The MTACCS system requires information from some of the GLOBIXS sources, through the CCC, but must

also extend to joint sources, to cross-echelon (e.g., Air Force Wings and Army Corps), and to down-echelon (to field units), in order to perform its mission. Thus far, the emphasis in Copernicus has been with rather large information systems and computing systems, while the MTACCS must deal not only with these large systems, but also with man-portable devices operating in a hostile combat environment. Unlike Copernicus, which focuses on information transfer from computer to computer as the primary media, the Marine Corps, in down- and cross-echelon communications, must deal with a significant percentage of information transfer by voice communications. A significant percentage of up-echelon communications for the Marine Corps will benefit from evolutionary development provided by Copernicus. However, cross-echelon and down-echelon communications will not benefit substantially from Copernicus system developments until data systems assume a larger role at tactical echelons.

The proliferation of software subsystems and databases should cause concern for both Copernicus and MTACCS. Previous experiences in subsystem integration indicate that close control must be established early in the design stage of software development to ensure interoperation.

Another issue exists that is a product of implementing open-systems architecture and diverse, somewhat-incompatible systems in the open environment. The traditional network tends to be hardware oriented, stressing interface design specifications that describe the physical connectivity between systems. In the open system, the emphasis should be upon information, rather than the specific hardware interfaces that are simply pipelines for information. Copernicus suggests "user pull" for getting information as opposed to the broadcast (that tends to overload the bearer services or results in a user receiving information who does not require the information). In order to accomplish a true open system with information exchange based on access rules or context registration with a controller (Anchor Desk), each piece of information within the system should be considered to be a separate object. This allows introduction of object-oriented information structures within the system. These are not object-oriented databases or database-management systems that have not yet achieved full functionality and are emergent technology that operates at extremely slow speeds today. Instead, these information structures have considerable utility in information management and in transitioning existing systems to an open-system environment. The first utility gained by object-oriented information structures is data integrity. Each information object has ownership that is an attribute of the information. One problem of information use is that the same information can arrive at a system via separate paths. This could result in "double counting" or in a single event resulting in more than one track (a common problem in data fusion). A second utility is the capability to use information from existing systems without an immediate requirement to transition the existing system to an open-system environment. An applique or "data tap" is placed on the existing system that translates the existing information into information objects that are then registered within the

global-information pool as being available. This technique has been used to allow access to information from older systems, when cost or scheduling prevents their being rehosted on newer hardware. For the Marine Corps, this might be an option for MS-DOS based logistics-support software packages, ensuring their interoperability with other MTACCS systems while waiting for their recoding.

The final utility of an object-oriented data structure is its capability to perform distributed processing and to modify—or customize—information in a flexible manner. Each information is registered with the global pool as a pointer to where the information exists. User systems are not required to store the information unless it is needed. If needed, it is copied from the source into the user system, where it can be used or modified to fit the need of the user. If the information is modified, it is “owned” by the user systems with appropriate ownership attributes set as the new information becomes a new object in the global pool. User systems will have access (when access requirements are met) to a large amount of information without having to store the information. Information accounting is accomplished through a pointer that indicates where the information exists, and access/recovery of the information is accomplished transparently to the user or user system. The modification capability, inherent in object-oriented software languages, allows users to combine objects into single, complex objects or to redefine the object attributes according to their need. An example of this would be a simple tracking problem. Each detection or observation of a target becomes an object. These objects can also be combined, through fusion/correlation/association, to form a single object that is a track. Each observation object that forms the track is uniquely named. If later it is observed that an observation does not fit with the composite track object, it can be easily removed from the track and reassigned. This is an improvement over relational structures in which individual observations tend to become lost when combined to form a track. Another improvement enables the user or user system to redefine the attributes associated with an object. This is not easily accomplished under a relational structure but is inherent in the object-oriented structure.

In order to implement these utilities, a transition is needed to an object-oriented data structure. To make this transition requires formulating an information dictionary that describes what the information looks like. While this seems like a considerable task, it is nothing more than good software engineering that allows information interoperability. Development of the information dictionary will be essential for transition to an open-systems environment, both for MTACCS and Copernicus.

Other fundamental differences exist between Copernicus and MTACCS that relate specifically to system specifications and implementation of the two architectures. These will be discussed as issues in the remainder of this study.

Both MTACCS and Copernicus contain event-driven networks, requiring a definite response time for the user, contingent on the tactical scenario. This point will be critical in addressing bearer-service bandwidth and information-transfer considerations.

2.2 TASK ANALYSIS/ISSUES IDENTIFIED

2.2.1 GLOBIX Sources/Information

Figure 2-3 depicts the GLOBIXS-to-MAGTF-TCC connectivity, over TADIXS, and uses the CCC Anchor Desk to control the two-way flow of information.

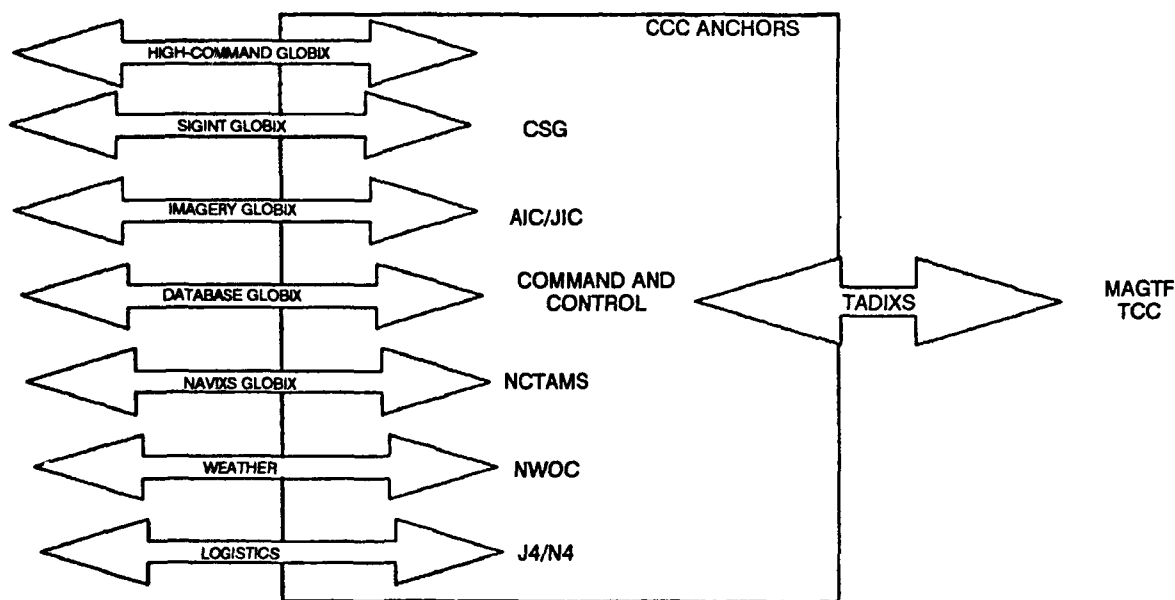


Figure 2-3. CINC Command Center and MAGTF-TCC connectivity.

The description of the individual GLOBIXS indicates the nature of information that would reside in the network.

The preliminary documentation for the Communications Support System (CSS) and the Copernicus Implementation Plan demonstrates how the information transfer will occur, from the MAGTF-TCC perspective. The MAGTF TCC, through the communications planning (COMPLAN) software of CSS, will register the context of the desired information with the CCC Anchor Desk. The MAGTF-TCC personnel can specify the nature of information that is of interest to them, resulting in transfer of only desirable information. One of the premises of the Copernicus architecture is that it is user driven,

rather than being originator driven. As an example, MAGTF-TCC personnel could indicate, through the COMPLAN, that they want to see intelligence and weather information relevant to a particular, operator-bounded, geographic area; and as a result of this registration, they would only see the requested information.

Another significant issue relating to the GLOBIXS network involves "what" information is to be passed from the MAGTF TCC to the GLOBIXS. Part of the Copernicus and open-system architecture allows access to information residing within the system, so long as access criteria are met. The primary source of tactical information that would interest the GLOBIXS would be the Commander's Situation Report (SITREP).

The nature of information exchanged indicates how well the aggregate system will operate under stress. The GLOBIXS participants comprise shore-based facilities connected by high-speed bearer services that enable rapid information exchange. Sometimes this information is in the form of Binary Large Objects (BLOBS), which could be large databases, maps, or detailed graphics. Even without the transfer overhead caused by the standardized protocol or packetizing technique, the time required to transfer these BLOBS is not insignificant. As an example, consider the case of an average graphics file (about 1.5 MB). The capacity of a normal T1 line—which allows the current state of the art transfer bandwidth—is 1.544 Mbps. This will take about 8 seconds for transfer, ignoring overhead and loading. The problem arises when this 1.5-MB file is placed on lower bandwidth bearer services, comprising the TADIXS. At a 2400-bps transfer rate, the same 1.5-MB file will take approximately 5000 seconds (83 minutes), again ignoring transfer overhead. While the high-bandwidth GLOBIXS will be able to handle transfers of this order, the lowest capacity TADIXS bearer services will quickly become clogged under this loading. The first step for assessing sufficiency of the Copernicus network lies in identifying the information residing in the GLOBIXS that is of interest to the MAGTF TCC.

2.2.2 TADIXS Issues

One of the issues concerning the TADIXS has already been discussed under GLOBIXS. In addition to identifying the information to be exchanged with GLOBIXS, a similar approach must be taken for TCC-to-TCC communications within TADIXS. To accomplish this, we must identify the current requirements for TADIXS participants from the MAGTF-TCC perspective. What are the Joint and Allied components of the Navy, Army, Air Force, and Coast Guard that must reside on the TADIXS? Once the participants and nature of information are identified, the next step is to define the TADIXS in terms of current-bearer services (and eventually future-bearer services).

A distinction must be made between TADIXS, which supports up-echelon or TCC-to-TCC communications, and organic MAGTF networks, which are not considered in this study.

When the MAGTF TCC is in a garrison state (ashore at a fixed site), establishing TADIXS connectivity via high-capacity (T1 line or equivalent) bearer services could be advantageous. This might also be a prudent strategy for developing a prototype, since it would provide data for evaluating use (and extend afloat/deployed requirements), while providing needed training to Command Center operators.

2.2.3 Afloat Support and Transition to Ashore

Afloat support is covered in the NTCS-A/MTACCS subtask. During transition from the afloat environment to the ashore (deployed) environment, afloat connectivity should probably not be broken until ashore connectivity is positively established. This transition procedure is doctrinal and not included in this study.

What will be included in the study are the hypothesized requirements for information in both the afloat and ashore (deployed) states. Most tactical functions in the afloat state will support planning and assessment, with some near realtime support provided for executing amphibious assault.

2.2.4 Organic/Nonorganic Bearer Services

Nonorganic-bearer services include only those that are external to the MAGTF. These are comprised primarily of Copernicus-TADIXS bearer services. Organic-bearer services include those networks, designated within MCTCA-Midterm, that provide intra-MAGTF communications services. These organic-bearer services include some communications channels and networks that would be classified as Joint or multiservice channels or networks. An example of this would be an air-coordination network, on which Marine Corps aircraft and ground controllers could reside, but that also might be used for controlling Navy, Air Force, or Army aircraft.

Organic-bearer services are not addressed in this study, although the impact of CSS implementation on organic-bearer services, and potential gains of implementation should be assessed.

2.2.5 Prioritization of Voice-Media Communications

MAGTF/MTACCS long-term plans call for reducing the percentage of voice-media communications to a level of about 10 percent of total communications. Review of nonorganic circuits indicates that a significant portion of communications is conducted using other than voice media, and that reduction of levels to about 10 percent should be attainable. The same statement cannot be made for organic voice-media communications. Review of organic-communications channels and usages indicates that a significant percentage of intra-MAGTF communications is accomplished using voice media. If a decision is made to implement CSS for intra-MAGTF communications to exploit some of the queuing and circuit-usage features of CSS, the CSS development team should assess the impact of placing a low priority on voice-media communications capabilities.

2.2.6 Standards

Review of Marine Corps and Copernicus system-development standards and architectural design standards show that the Marine Corps provides far more rigorous direction and guidance, while the Copernicus and NTCS-A standards tend to be less rigorous under the guise of evolutionary development. Two possible courses of action are suggested:

1. Continue MTACCS development* while monitoring evolving Navy-directed standards and concentrating on the principal interface (TADIXS/NTCS-A) with the Copernicus system—and react to evolving standards.
2. Take a more active role in selecting Navy standards for Copernicus and NTCS-A.

2.3 OPTIONS/RECOMMENDATIONS

Copernicus will become the de facto standard for Navy Communications, Command and Control, Computing, and Intelligence (C4I).

Copernicus is an evolutionary architecture, which, in the future, could potentially provide enhanced capabilities for the Marine Corps. Of particular importance to the Marine Corps should be (1) the improved bandwidth of the TADIXS, (2) the capability of the command center to quickly transfer information from the GLOBIXS, and (3) the scheduling/resource sharing and interoperability guarantees of CSS. Unfortunately, the thrust of the CSS is toward the afloat command center, rather than the mobile ashore command center—which could cause some hardware difficulties for the Marine Corps.

Copernicus could also solve some questions about MAGTF Master-Plan priority capabilities by establishing connectivity with GLOBIXS subscribers and through potential bandwidth improvements that would come from TADIXS development. This could particularly benefit Marine Corps users of large-volume databases (such as logistics).

To transition to the open-systems environment and to implement user-pull and distributed-information processing, the Marine Corps should begin transitioning to an object-oriented information structure. The first step of this transition will be to develop an information dictionary.

An option for transitioning MS-DOS based logistics-support systems to the open-system environment is to place a passive tap applique within the logistics-support system that translates information to object-oriented information. Recoding and rehosting software is an expensive proposition that sometimes results in providing a lesser capability than exists with the current system. Often this is a fix to something that is not really broken. The information taps, placed on top of the existing system, further provide

short-term interoperability between POSIX and MS-DOS based systems, allowing the Marine Corps to spend code-conversion money where and when they want to.

Issue One—The first issue identified relates to the physical MAGTF TCC to the CE only. Each of the MAGTF components accomplishes a considerable amount of external communications. The options are to retain the definition of the MAGTF TCC as the CE only and route all external communications through the CE, or to redefine the MAGTF TCC as embracing the CE and all other component elements (CE, ACE, GCE, and CSSE). The thought here is that constraining the definition of the MAGTF TCC to only the CE will result in cost savings; i.e., only having to make one component compatible with Copernicus, instead of four.

Conversations with CSS program developers indicate that each of the four MAGTF components will require CSS equipment to be compatible, regardless of the routing scheme. At least at this point in the development, constraining the definition of the physical TCC to the MAGTF CE will not result in any cost savings and might create a bottleneck for communications. Redefining the physical TCC to incorporate all MAGTF components might allow each of the components direct access to TADIXS, thus relieving the potential bottleneck.

We recommend expanding the physical TCC boundaries to include all MAGTF components, with each one allowed direct access to TADIXS.

Issue Two—The second issue relates to proliferation of software and databases, both in Copernicus and MTACCS. While some of these problems can be corrected through configuration management, some consistent and concrete plan must be adopted that addresses how these component software and databases fit together in the context of the MAGTF mission. This is normally accomplished through a Concept of Operations. In our research, we could find nothing that approximates a Concept of Operations for the MAGTF TCC. (This does not mean that such a document does not exist, but rather that we did not find it in our investigation.) Such a document would be helpful for system designers and integrators, since it would describe how each of the individual components will fit together in an operational context. We recommend that such a document be prepared. A sample Concept of Operations/Standard Operating Procedures is included in the GLOBIXS B Early Implementation Concept of Operations/Standard Operating Procedures, dated 10 June 1992. A portion of this Concept of Operations/Standard Operating Procedures document should focus on developing an information dictionary that defines information used and generated by MTACCS systems. This will assist in transitioning to an object-oriented open-system environment.

Another portion of the issue relates to creating an object-oriented information structure for existing and developmental MTACCS systems, and options for transitioning from what exists, today, to the future open-systems environment. The first option would be to expedite recoding all existing MTACCS systems. The second option would be to

invoke an applique that would translate the existing system's information so it can reside in an object-oriented structure. We recommend the second option, because it allows the Marine Corps to retain all available information, while also allowing a more relaxed rate of recoding. In addition, this option does not fix something that is not broken.

We do not recommend immediate transition to an object-oriented data-management system (OODMS). Available OODMS do not perform well enough to provide near realtime operation in event-driven networks requiring a guaranteed response time for the user. Object-oriented languages (such as C++) and existing relational database-management systems have performed adequately to operate within the event-driven network environment and should suffice until OODMS technology evolves into a responsive alternative. When this occurs, transitioning to an OODMS would be advantageous, simply because it provides a more flexible option to users and user systems. OODMS must be monitored as an emergent technology that could be used with MTACCS and Copernicus.

Issue Three—This issue relates to physically controlling information flow from the GLOBIXS, via the TADIXS, to the MAGTF TCC. The concern here is that Marine Corps requirements for information from the GLOBIXS source are adequately represented at the Anchor Desk. In the description of the Copernicus architecture, this is accomplished through the COMPLAN, that indicates the specific information the user wants to see. Current development of Copernicus emphasizes afloat concerns. We must be cautious to ensure that ashore concerns of the MAGTF TCC are represented in the development.

We recommend close coordination with Copernicus and CSS system designers and engineers to ensure that MAGTF-TCC information requirements are met and that sufficient mechanisms are in place to ensure the expeditious flow of required information from CCC-GLOBIXS sources to the MAGTF-TCC users.

Additional recommendations are made within paragraph 2.4 concerning an opportunity for developing a MAGTF-TCC prototype.

Issue Four—This issue relates specifically to the physical capabilities of GLOBIXS and TADIXS as information-transfer pipelines. This is in response to the attitude that eventually sufficient bandwidth will exist within the system to handle all of the requirements. To ensure that sufficient bandwidth will be available, we must first identify, specifically, the current (and to some degree the future) requirements for information transfer. The first step is to identify the size, content, and format of information that the MAGTF TCC will extract and input to the system over the TADIXS. We must then determine transfer rates of existing bearer services to estimate the timeliness of information. This must reflect the stress factor of a combat environment. When this is accomplished, we can determine the required bandwidth and compare this with existing bandwidth to ensure that Copernicus will provide sufficient capability to perform the MAGTF mission.

Some of the information needed will be gathered in this initial study. Additional effort should be taken to finish this portion.

Several of these issues can be resolved by developing a MAGTF-TCC prototype and by connecting the TCC to a CCC and other TCCs. The details of developing such a prototype are contained in paragraph 2.4 that appears after the issues and recommendations synopsized in the following matrices.

ISSUE/RECOMMENDATION MATRIX

ISSUE NUMBER	NARRATIVE	RECOMMENDATION
One	MAGTF-TCC Definition	Define the physical MAGTF TCC as encompassing all MAGTF components (CE, GCE, ACE, and CSSE).
Two	Proliferation of software and databases	Develop a Concept of Operations to define how all components fit together. Centrally control development of sub-systems starting at the design phase. Centrally control databases and ensure sufficient, detailed documentation to ensure information consistency. Validate replication among databases. Begin migration to object-oriented information structure (information dictionary). Investigate object-oriented "data-tap" appliques as an alternative to recoding existing systems that are performing suitably, but that are not in the UNIX/POSIX operating environment, or that have not been converted to Ada. Monitor evolution of object-oriented data-management systems. When these systems are sufficiently responsive to operate in an event-driven environment with guaranteed response times (near realtime), convert from relational data-management systems to OODMS.

ISSUE/RECOMMENDATION MATRIX

ISSUE NUMBER	NARRATIVE	RECOMMENDATION
Three	CCC Anchor Desk to MAGTF TCC	Coordinate closely with CSS and Copernicus system designers and engineers to ensure that 1. MAGTF-TCC information requirements are met. 2. Sufficient mechanisms are in place to expedite flow of required information from CCC-GLOBIXS sources to MAGTF-TCC users.
Four	Information transfer Prioritization of Voice-Media Communications Standards Development of MAGTF-TCC Prototype	Define information to be extracted from GLOBIXS. Define transfer rate acceptable for TADIXS information transfer based on mission requirements. Assess capability of existing bearer services. If a decision is made to implement CSS for intra-MAGTF communications, push CSS development to upgrade the priority of voice-media communications capabilities. Continue development of MTACCS while monitoring evolving Navy-directed standards, concentrating on the principal interface (TADIXS/NTCS-A) with the Copernicus system. As a minimum, provide representation to CINCPAC JT2CM board and C2I working group to resolve many CCC to MAGTF-TCC issues raised in this study. Build a prototype testbed at MCTSSA, containing existing and developmental pieces of MTACCS to support an MEF. Site would be deployable in a contingency (hence, a prototype versus a testbed).

ISSUE/RECOMMENDATION MATRIX

ISSUE NUMBER	NARRATIVE	RECOMMENDATION
Four	Development of MAGTF-TCC Prototype (contd)	Establish connectivity with CINCPAC CCC and JTFC. Testbed portion of site would support both NTCS-A and TADIXS terminations. Design a site for potential deployment, coordinate with operational forces to ensure deployability in a contingency, but continue to use as a testbed to support design and procurement decisions. Assess fiscal impact.

2.4 DEVELOPMENT OF MAGTF-TCC PROTOTYPE

The four states of the MAGTF TCC (Garrison, Afloat, Ashore, and Transition) provide some particular challenges to the designers, and some unique opportunities for test and evaluation. The maturity of MTACCS, and its documentation, suggests that perhaps developing a prototype and demonstrating its capability would be quite valuable. From experience in prototyping ASW GLOBIXS and ASW TADIXS, we learned that many of the issues relating to interoperability and design can be resolved through physically constructing a system. Marine Corps MTACCS-development plans and Navy/Joint command-center development plans seem to offer an opportunity to develop a prototype.

In the Atlantic Fleet, a GLOBIXS network exists at CINCLANTFLT. Unfortunately, this GLOBIXS is an ASW GLOBIXS, which is of little concern to the Marine Corps. The GLOBIXS has, however, tapped into a notional CCC at the CINCLANTFLT complex in Norfolk. The ASW GLOBIXS is using CINCLANTFLT-provided JOTS information and is not, as yet, tied into the intelligence network. Figure 2-4 is a connectivity representation of the existing GLOBIXS B and the Norfolk Metropolitan Area Network (MAN), which is a candidate for MAGTF-TCC prototype development.

As part of the GLOBIXS implementation, the Norfolk MAN was tied to a new wide area network (WAN) by means of a router, indicated by a circle and "R" between the networks. Conceptually, all information available to the Norfolk MAN is available on the GLOBIXS-B WAN (which could include intelligence information). Input from the Fleet Numerical Oceanography Command (FNOC) is made at COMUNDERSEALANT and NAVOCEANPROFAC through local area networks, meaning that some environmental information is available on the GLOBIXS.

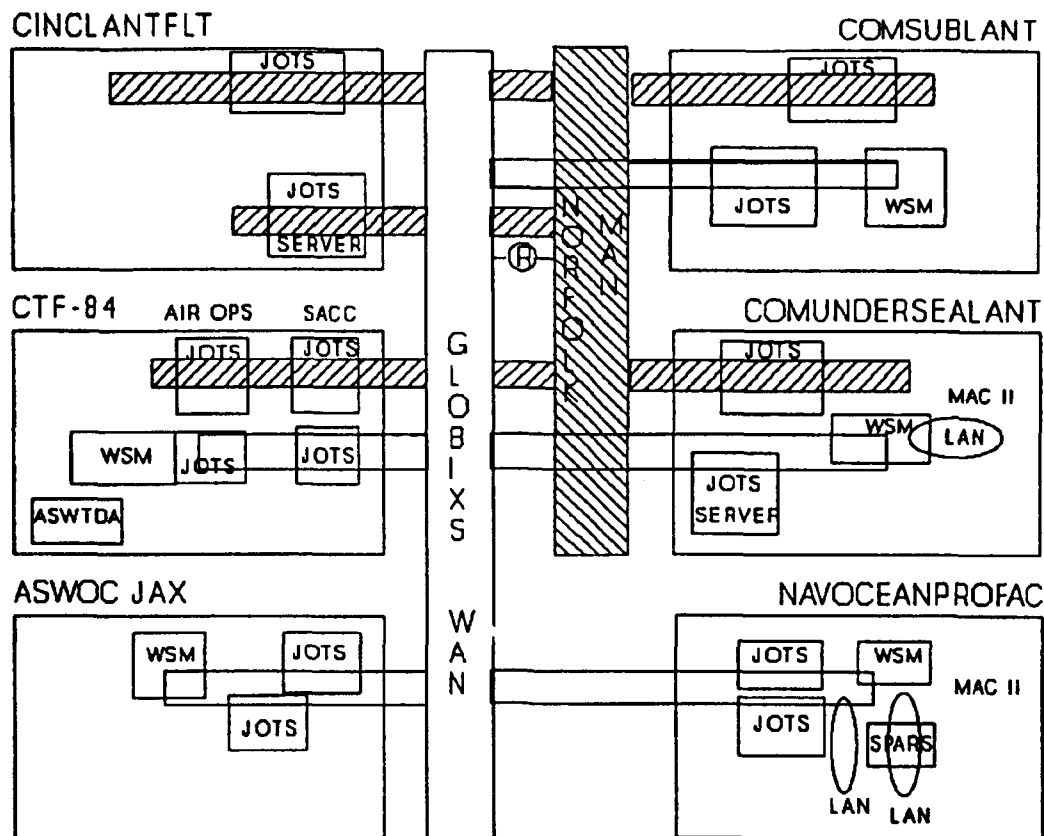


Figure 2-4. Existing GLOBIXS B.

The plan for establishing connectivity would be to connect with the GLOBIXS WAN, as depicted in figure 2-5, with the USMC MAGTF TCC located at Quantico. Connectivity and information access would have to be negotiated with CINCLANTFLT and CTF-84. While the depiction indicates that CTF-84 has an air-operations function; this is specifically ASW oriented and largely Maritime Air Patrol.

Many lessons have been learned as a result of developing this prototype. Note the number of JOTS terminals on the network. These are two separate releases of JOTS, with some of the terminals functioning as file servers. Connectivity with the GLOBIXS would be established via bridge/router, through a JOTS, and would approximate a TADIXS. Establishing connectivity through the LANTFLT GLOBIXS might have some advantages, but these appear to be outweighed by the disadvantages of limited information (of interest to the Marine Corps) availability. On the plus side, the linkages used within the LANTFLT GLOBIXS B are almost purely NTCS-A linkages, with the various versions of JOTS used to establish connectivity among members.

We do not recommend this option.

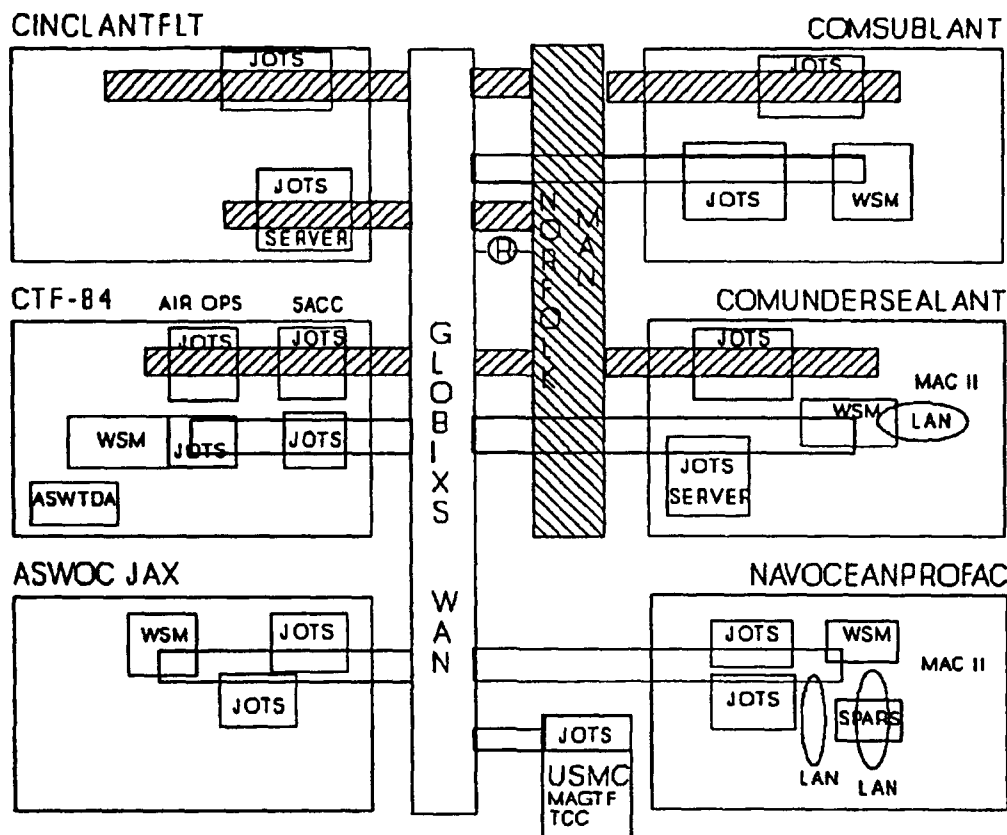


Figure 2-5. LANTFLT USMC to GLOBIXS-WAN connectivity.

The second option is provided by developmental efforts in the Pacific at CINCPAC. The thrust of this effort is to construct a Joint Command Center that supports CINCPAC and a Joint Task Force Commander (JTFC). The effort, which CINCPAC and DARPA support, will have to bridge between Copernicus and other service C2I architectures. Within the Copernicus world, project capabilities will include (1) Intel Anchor Desk, (2) Environmental Anchor Desk, (3) ASW Anchor Desk, (4) Strike Anchor Desk, and (5) Amphib/Specops Anchor Desk. Most of these are of interest to MTACCS and their establishing connectivity with Copernicus. Figure 2-6 depicts the development and joint test and evaluation strategy, and also depicts where the Marine Corps could potentially fit in.

In concept, the effort would combine the CINCPAC/DARPA-development effort with the efforts of NRAD (CSS prototype development) and MCTSSA (MTACCS), as well as a broad range of 6.2 and 6.3 joint-programs sponsored by the Marine Corps. The MCTSSA site would also provide a testbed for interoperable systems that are required to survive in NTCS-A, Copernicus, and Joint worlds.

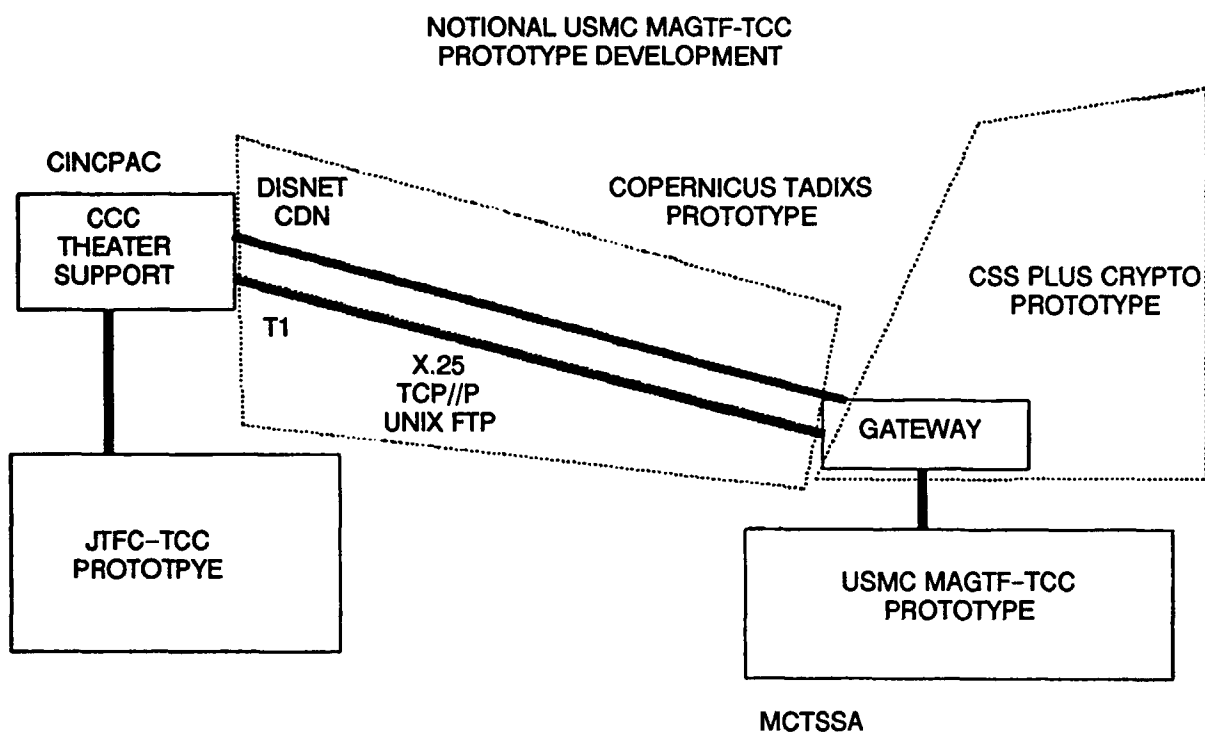


Figure 2-6. Candidate PACFLT USMC MAGTF-TCC prototype development.

The manager for the CINPAC effort is the Joint Theater/Task Force Crisis Management (JT2CM) Board and their various working groups. The purpose of the effort is to evaluate the ability of task-force component C4I systems to interoperate between themselves and with the C4I systems of the Joint Task Force Commander (JTFC) and rear-echelon supporting commands. This plan is consistent with the long-term goals and objectives of the Marine Corps.

A relationship with JT2CM, and particularly with the C2I working group, would benefit the Marine Corps significantly. First, the C2I working group is beginning to address some of the issues raised in this study relevant to CCC-to-MAGTF-TCC connectivity. Second, the JT2CM and C2I working group is living in the Joint world, which is the domain in which the Marine Corps must reside because of its mission. Answers to issues that affect the Joint world would logically affect Marine Corps operations. For these reasons, we recommend, as a minimum, that liaison be established with the JT2CM and C2I working group. The Marine Corps brings to the table a relatively mature C2 system (MTACCS) and considerable experience in Joint operations, as well as a wealth of excellent documentation covering requirements and systems.

Beyond this minimum level of participation, a broad range of options exists for the Marine Corps. A preferred option, along with the basic liaison, is establishing connectivity

with the Joint and CCC prototypes constructed by CINCPAC. The termination of this connectivity would be at MCTSSA, which would be a prototype MAGTF TCC simulating functions in garrison and afloat modes. The pipeline to the prototypes would be through T1 lines and existing bearer services, with bridge/router functions at MCTSSA. This particular proposal would require establishing a MTACCS LAN at MCTSSA that could also support MTACCS test and evaluation. The LAN would immediately assemble all existing pieces of MTACCS and would add new pieces as they became available. Prototype development would also provide a testbed for hardware and software that will be required to operate in a deployable Joint or Copernicus environment.

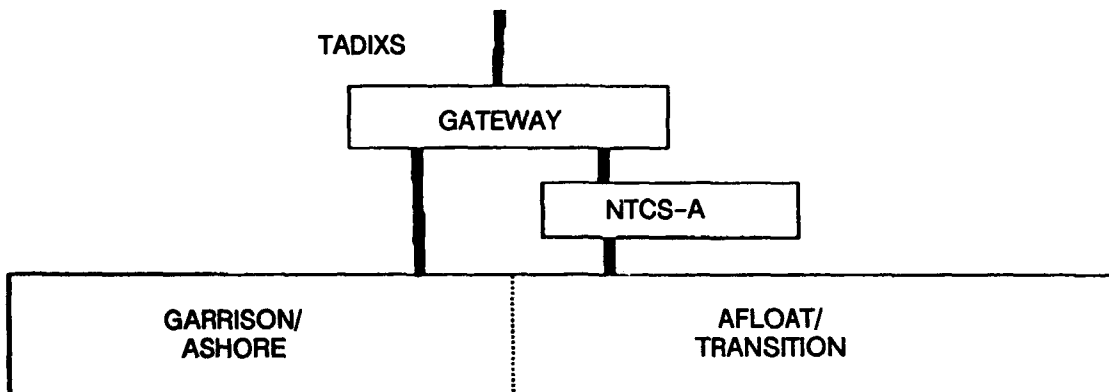
Figures 2-7 and 2-8 depict a hypothesized connectivity and the functioning of such a prototype. This includes a speculated functional arrangement of the facility at MCTSSA, which should be capable of supporting both afloat and garrison MAGTF-TCC states.

There is a concern over establishing connectivity between operational (CCC) and test facilities (MCTSSA MAGTF TCC). This concern is the reason for classifying the site and system for prototype development rather than as a testbed. The site would mimic current capabilities, being a collection of existing equipment and software that supports an MEF. An aspect of the effort that should be enforced is that the site could be deployed to support an operation, if required; and to ensure that this is the case, there should be frequent interaction between MCTSSA and operating forces. The site should also be an active participant in FDS exercises as a baseline and evolutionary C2FAC. These exercises can be augmented by command-post exercises conducted at the CINC or Joint level. While the initial implementation will clearly provide a significant resource for enabling the Marine Corps to perform development and test and evaluation to support procurement decisions, it will also provide a significant capability to field a tested system in response to short-fused requirements. The architectural and design philosophy of the site should reflect this requirement.

This is the recommended option because of (1) the obvious benefits to system development and test and evaluation in support of procurement decisions and (2) the capability to deploy the site on short notice, along with the interaction between MCTSSA and operating forces.

Many particulars are left to be worked out for each of the options. To be specific, the fiscal aspects of each option must be identified. The first step required of this preferred (connectivity) option is the step required of the previous recommendation, which is to establish an active liaison with the JT2CM and C2I working groups. This will be the vehicle needed to establish the connection and to perform the negotiations to make it happen. Once the connection is established, the operating environment for Copernicus, Joint, and NTCS-A information networks will be created, allowing the evolutionary development process to continue.

MAGTF-TCC PROTOTYPE



All MAGTF-TCC hardware and software (MTACCS) will be the same except for the NTCS-A interfaces. The prototype will be able to software configure to represent all four MAGTF-TCC states.

The distinction among states is representational only.

Figure 2-7. MAGTF-TCC connectivity.

MAGTF-TCC PROTOTYPE PHYSICAL REPRESENTATION

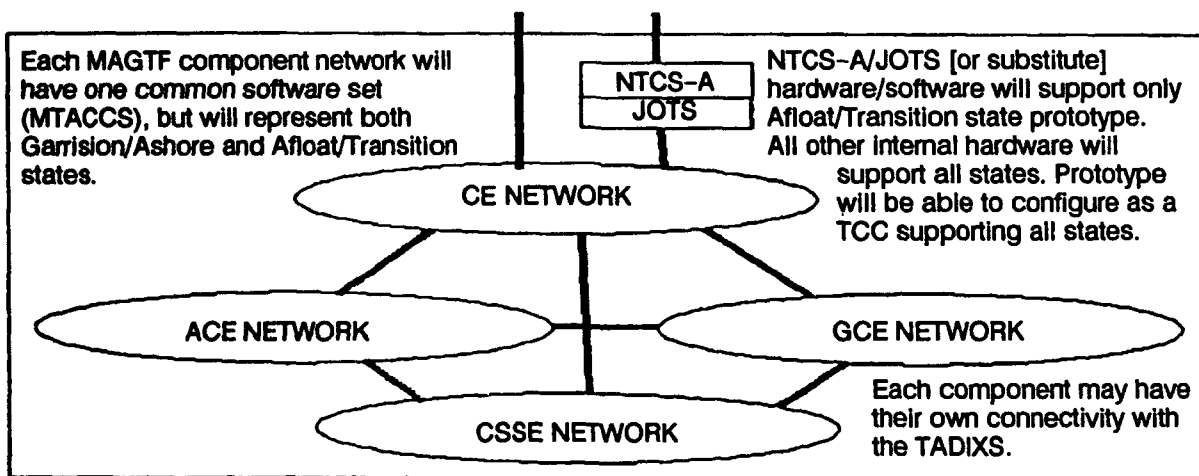


Figure 2-8. MAGTF-MTACCS architecture.

3. CSS TO SUPPORT MAGTF-CE ASHORE

3.1 TASK DESCRIPTION

Investigate the feasibility of designing the MAGTF CE ashore according to Copernicus principles to provide the MAGTF-CE Communications/Electronics Staff Section a digital system and technical control (SYSCON/TECHCON) capability.

3.1.1 Operational Context of Task

The purpose of the following paragraphs is to describe the operational context of an MEF-size MAGTF CE in the field.

The commander of the MAGTF is designated by appropriate authority, normally from a source outside the MAGTF. The commander is supported from a Command Element (CE) made up of personnel and material resources from outside the other three elements of the MAGTF.

The capabilities of the CE extend and complement the command and control capabilities of the other three elements of the MAGTF. They do not duplicate them under normal circumstances. Liaison teams are heavily deployed to ensure coordination of all four elements of the MAGTF.

The separate CE allows the other three elements of the MAGTF to concentrate their C2 efforts on commanding the respective element. The MAGTF commander may authorize direct liaison between the other elements of the MAGTF with commands external to the MAGTF for specific activities that do not require intervention of the MAGTF CE.

In amphibious operations, the MAGTF CE serves concurrently as the Landing Force headquarters.

3.1.1.1 Types of MAGTF. MAGTFs are self-contained, combined-arms, task-organized organizations specifically tailored to their mission or anticipated mission assignment. There are three basic MAGTFs: the MEF, the MEB, and the MEV. Forward-deployed MEUs, those with special training and capabilities, when certified by higher Marine Corps authorities, are designated as MEU(SOC). Special purpose MAGTFs (SPMAGTF), smaller in size than an MEU, are employed on specific missions, usually of very limited duration. Additionally, Marine task forces that do not meet the strict definition of a MAGTF will carry a different designation, such as Battalion Landing Team (BLT) 3/9 or their lineal or organizational designation, e.g., 3rd Battalion, 9th Marines.

3.1.1.2 MEU. The MEU is a task organization, usually commanded by a colonel, that can perform limited combat operations. A MEU is normally forward-deployed to fulfill

specific-afloat deployment requirements. When committed to operations ashore, it is normally commanded and supported from its sea base, e.g., most of the CE remains embarked. The CATF provides the MEU with its entry into the Naval Telecommunications System. CATF and MEU (CLF) communications planning is performed concurrently and in concert. Marine Communications Detachments, assigned as ship's company, at least to LHA and LHD type ships, are trained and organized to provide comm-elec support to the embarked landing force commander and his staff. MARCOMMDET's are augmented with MAGTF communications personnel.

3.1.1.3 MEB. The MEB, also task organized, is normally commanded by a brigadier general. Its mission is also limited. MEB combat operations may be supported from the sea base, from facilities ashore, or from a combination of both. A reinforced communications company from a Communications Battalion, FMF, support the CE. If the MEB is operating from the sea base, the CATF provides entry into the Naval Telecommunications System. If operating from ashore, CommCo provides this service. Limited amphibious shipping and major elements of combat-support and combat-service-support units must be allocated to forming an MEB CE (no longer a standing organization). Because of this, current thinking is that, if an MEB or MEB-like MAGTF is constituted, the CE will be made up of elements of the standing MEF CE and designed as an MEF(FWD).

3.1.1.4 MEF. The MEF, commanded by a major or lieutenant general, depending on the mission and size, is capable of conducting a wide range of sustained operations ashore. Like the other MAGTFs, the MEF is task organized and its structure is tailored to the assigned mission. Communications support for the MEF CE requires the full capabilities of a CommBn FMF, augmented with communications assets from joint resources such as the JCSE.

A MEF-size MAGTF CE and its field command post will require the full capability of a force Communications Battalion, that is, a CommBn FMF. These resources will enable MEF-internal communication with the GCE (at least one MarDiv), the ACE (at least one Marine Aircraft Wing (MAW)), and the CSSE (a FSSG), each of which will have established a separately located command post (CP). The COMMBN FMF also provides the communications that are operated within the physical confines of the MEF CP, itself, where the MAGTF CE is located. The MEF G-6 (CEO) must also plan for external communications with the CJTF; the Marine Component Commander of a JTF, if one is designated; adjacent commands of the same echelon; and the amphibious task force, if one is present. (Note: If the MEF is embarked, the CATF is responsible for external communications services for the MEF.)

The following communications resources are used to provide MEF internal communications and external communications.

1. Radio. This term refers to all wireless communications assets, such as single-channel voice, radio telegraph, RATT, and multichannel.
2. Wire/cable. Wire and cable systems are used to interconnect activities in close proximity to each other. The systems use field wire, fiber optics, cable (multiple pair), and telephones and switchboards for person-to-person communications; and interconnections for Teletypewriters, Teletype switches, End-User Computing Equipment (EUCE), such as the AN/UGC-83 and AN/UGC-85, and related switching systems.
3. Radio Wire Integration. This is the interconnection of radios to switchboards to enable telephone subscribers to send messages over mobile-radio circuits.
4. Multichannel. Multichannel radio systems extend the wirelines by providing multiplexed transmission paths via point-to-point microwave relay paths over areas where it is not practical to lay wire.
5. Satellite Communications. These provide for worldwide voice and data communications for forces in the field. The Marine Corps uses UHF FLTSAT/LEASAT and SHF systems that are part of the GMF system that accesses DSCS. These systems provide for entry into AUTODIN, WWMCCS, and other national communications systems.
6. Visual, Sound, Mail, and Courier. These resources supplement and complement the assets just discussed.

The CP of an MEF-size MAGTF CE that is planning to remain in the field for some time is in reality a small city that could be spread over 1 or 2 square kilometers or more. It has an external security force to protect against physical attack, internal security forces to control access to sensitive parts of the CP, berthing areas, sanitary facilities, messing facilities, and transportation and supply facilities needed for efficient operation of the command, control, and communications activities of the command. Central to the C3 functions of the CP is the Combat Operations Center (COC), in which representatives of the principal staff sections (Operations and Intelligence) exercise control over current operations of the forces in the field. (Other services and joint commands call their COC-like facilities the Tactical Operations Center (TOC) or the Command Center (CC).) The COC for an MEF-size MAGTF CE is fairly large, especially when it accommodates the Fire Support Coordination Center (FSCC) liaison officers from adjacent and supporting units—and some communicators who operate selected tactical and command radio nets. The COC could be located in a group of interconnected tents, in a large bunker, or in a building that may be commandeered for the purpose. The communications facilities to support the entire CP surround the COC and the area in which the MEF staff sections operate.

Command posts are normally organized into echelons to effectively control the force. All command posts displace periodically and this displacement must take place in an orderly fashion so that control by the commander and his staff is not interrupted.

The Main CP is the principal headquarters and C2 element of the commander and his supporting staff. It has the facilities, equipment, personnel, and communications needed to fully control and support the force. The Main CP is where future operations are planned and, unless a Forward CP is established, where current operations are monitored and controlled. The Combat Operations Center, responsible for controlling current operations, is located in this CP complex.

The Forward CP, if established, is concerned with current operations and their control. Sometimes, particularly in the case of battalion-size units, this CP echelon is called a "Tactical CP." In the small-unit (battalion or company) vernacular, it is also known as a "Jump CP" or "Hip-Pocket CP," because operations are run literally from the map in the hip pocket of the commander or his operations officer.

The Rear CP contains such headquarters functions as administration and logistics that should not be conducted in the Main CP. As its name implies, it is located well to the rear in the area of operations. It is far less mobile and displaces far less frequently than the Main CP or Forward CP, if established.

3.1.2 Baseline MAGTF-CE Configuration

The Marine Corps, under the direction of the Program Managers for Marine Air Ground Task Force (MAGTF) Command and Control Systems (PM, MAGTF C2), is developing a Marine Corps Tactical Automated Command and Control System (MTACCS). The MTACCS will enable desired information from individual systems to be combined into an integrated system. Interoperability among automated systems will be achieved by utilizing a common family of data-processing hardware, a common operating system and software, and coordinated functional applications software. All of the systems will implement either Marine Tactical Systems (MTS) broadcast protocol or MTS switched protocol standards.

The primary programmatic goal of CSS is to meet the operational goals first through integration of existing basic-communications capabilities; and secondly, through newly developed capabilities. Consequently, the CSS architecture will follow the principles of open-system design and evolutionary development. These are important considerations in developing the architecture. This implies a hybrid approach—a mix of new modern design and existing "stand-alone" designs—that is fully backward interoperable; that allows interoperability with non-CSS, joint, and allied systems; that is expandable to include emerging new requirements over time; and, most of all, that is affordable.

From a joint-operations point-of-view, Navy/Marine Corps tactical systems should interoperate and intercommunicate during amphibious operations (transition of command responsibilities) and to a lesser extent during ashore operations. Therefore, there is a need to demonstrate the capability for Marine Corps users of MTACCS operating afloat to use CSS/SCE communications assets during an amphibious assault and follow-on operations ashore. CSS provides communications services in the Navy, joint, and allied-tactical environment. Communications services are only part of the command and control, communications, computer, and intelligence (C4I) capability needed. CSS communications services must fit within an open-system environment of other joint- and allied-communications services, and within an open-system environment of application programs, information architectures, and hardware and software.

3.1.3 CSS/SCE SPECIFICATION

The CSS is a communications architecture that enhances battle-force communications connectivity, flexibility, and survivability through multimedia access and media sharing. The CSS permits users to share total network capacity on a priority-demand basis according to a predefined communications plan. Automated network monitoring and management capabilities are also provided by the CSS to assist operators in realtime allocation of communications resources.

CSS must define its own information architecture for interplatform coordination of CSS communication services. This will be done in the CSS Level "A" Specification, and implementing programs will design specific information architectures for their requirements within the architecture and top-level design of the Level "A" Specification. CSS imposes minimum architecture restraints on implementing program managers to permit maximum flexibility in responding to program requirements within the open-system environment. When CSS has imposed "building codes," it was because they were considered necessary for attaining CSS operational and programmatic goals.

The Standard Communications Environment (SCE) is an implementation of CSS concepts. The SCE includes Initialization and Recovery, System Control, Communications Services, Subscriber Security, Subscriber Management, and Resource Management.

The CSS communications architecture is designed for a naval battle group. This architecture will allow multiple shipboard users to communicate among themselves using a variety of communications resources. To accomplish this dynamic allocation, a modular design is incorporated in the design of the CSS Standard Communications Environment.

Naval warfare inherently gives commanders maximum latitude. The separation of platforms and multimission nature of most platforms require that commanders act with a high degree of initiative. The distributed architecture of CSS network management

supports this requirement. Interplatform management functions of the System and Site-Control Segment provide coordination among multiple CSS (and disadvantaged or non-CSS) platforms.

The CSS/SCE modular design with standard interfaces allows technological improvements to be incorporated into specific areas of the system without redesigning the whole system. For example, new COTS modems with standard CSS interfaces can easily be added to an existing CSS system. The SCE is modular and constructed using open-system components. Major open systems components include VME, 680X0, SPARC, UNIX, Motif, and TCP/IP.

In addition, development and integration of new and existing subscriber and radio-communications resources into the CSS/SCE is simplified by the modular architecture and adherence to open-systems principles. Integration of a new subscriber requires only developing a Subscriber Interface Controller (SIC) interface and incorporating that subscriber into the Connection Plan. Integration of a new radio communications resource requires only developing a Subnet Access Controller (SAC) and incorporating that communications resource into the Connection Plan.

NECC, TACINTEL II, and SHF IXS are the first three systems slated for incorporation into the CSS architecture. A modified CSS software package allows NAVMACS II to operate with some CSS functionality.

CSS is described in the Communications Support System (CSS) Overview, 26 July 1990, CSS-10001-01. A more thorough explanation of the CSS/SCE is available in the Communications Support System (CSS)/Standard Communications Environment (SCE) Prototype Description, 6 May 1992, CSSSCE-RDT-BASE-U-BIVI-ROCO. Several acronyms are often used in describing CSS. These acronyms, with definitions, are included in Appendix C.

3.1.4 CSS Functional Description

CSS provides the Navy with a communications service that is responsive to user needs, survivable against electronic warfare and physical attacks, and efficiently uses available communications channel capacity. CSS provides a set of automated mechanisms that provides communications resource sharing and multimedia access for CSS subscribers.

The CSS/SCE includes Initialization and Recovery, System Control, Communications Services, Subscriber Security, Subscriber Management, and Resource Management.

This paragraph describes flow of data through the CSS/SCE. The Subscriber Interface Controller (SIC) provides access to the CSS/SCE for Tactical Data Processor (TDP) subscribers. TDP subscriber data is encrypted on its way to the SIC. Control information

is wrapped around the crypto and passed unencrypted to the SIC. A packet is formed containing the encrypted data and the unencrypted control information. Within the SCE, the packet is sent to the appropriate Resource Access Controller (RAC) according to the predefined rules established in the Connection Plan. The Connection Plan is installed and tailored in the Communications Plan Generator/Security Manager (CPG/SM). The packet is queued in the RAC until the appropriate SAC can process it and ultimately send it out over one of the Link Access Radio Group (LARG) components. Figure 3-1 is a function diagram of the CSS SCE.

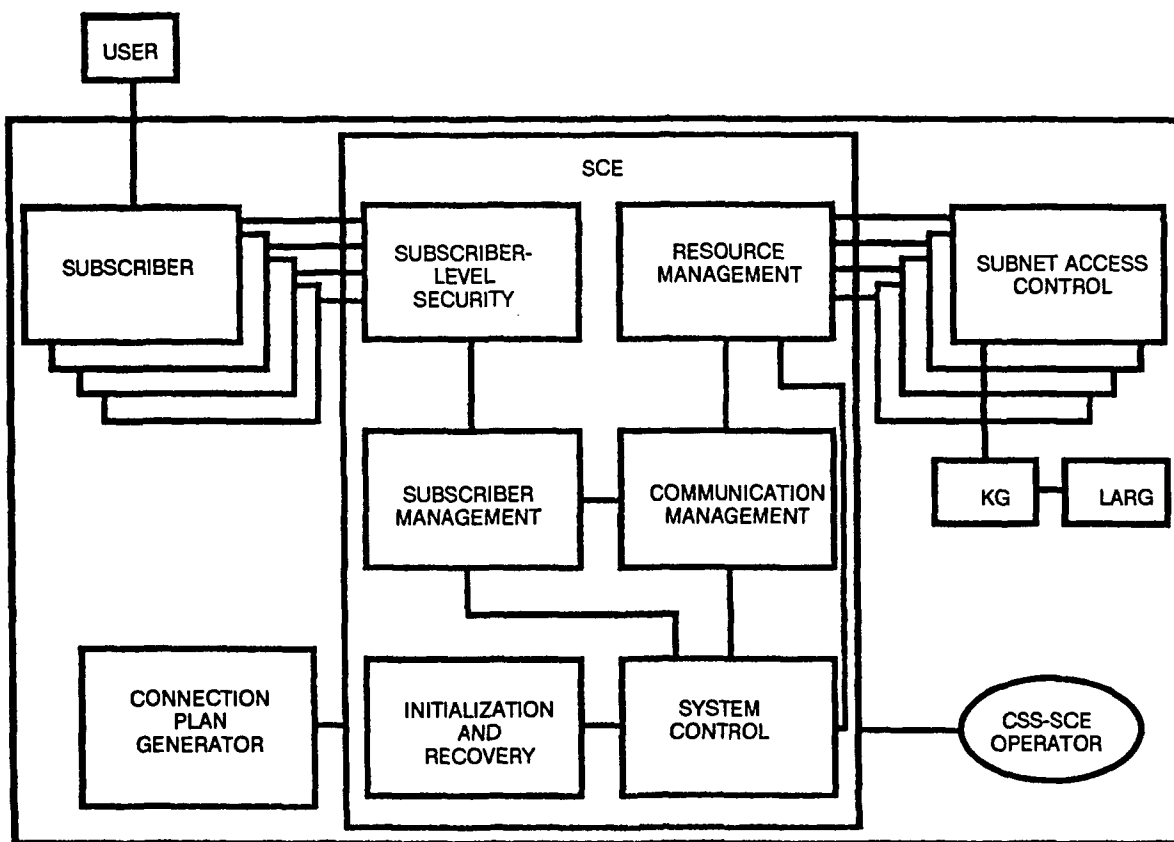


Figure 3-1. Communications Support System (CSS)/Standard Communications Environment (SCE).

3.2 POTENTIAL ARCHITECTURAL DESIGNS

The current implementation of the CSS/SCE is designed for a Navy shipboard communications system. Figure 3-2 illustrates this architecture for a CSS MAGTF-CE LAN.

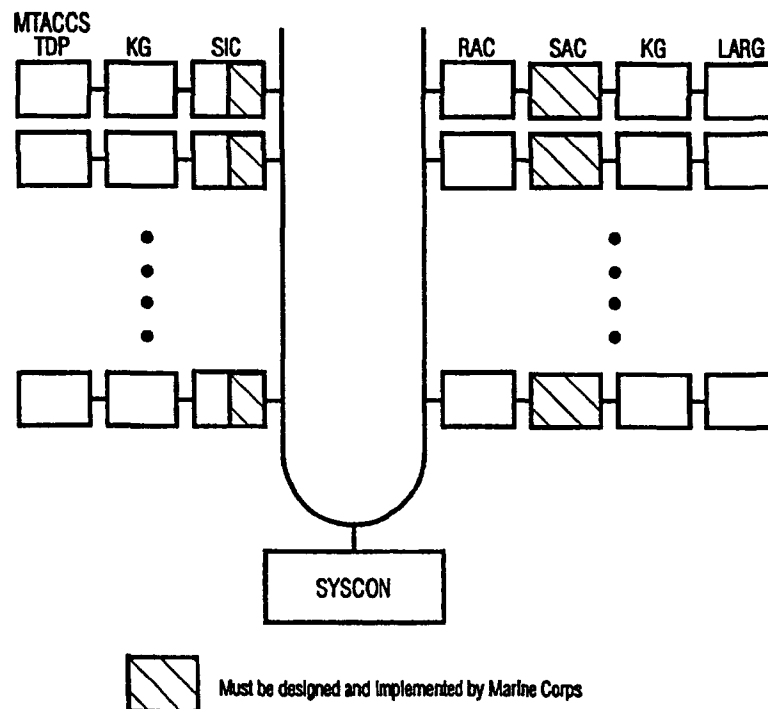


Figure 3-2. CSS MAGTF-CE LAN configuration.

3.3 ISSUES

The current implementation of CSS/SCE

- Handles tactical data and record messages.

- Does not have voice capability.

- Monitors message-queue sizes.

- Does not troubleshoot any communications link problems.

- Shows developmental costs for SAC and SIC software to be risky, time-consuming, and costly.

3.4 RECOMMENDATIONS

The current CSS implementation is well suited to a MAGTF CE and could easily be tailored to meet Marine Corps needs.

The communications requirements of a MAGTF CE are more analogous to the requirements supported by a Navy Computer and Telecommunications Area Master

Station (NCTAMS). Although the number of circuits of a MAGTF is not near the number at the NCTAMS (5000 on the black side), the number of circuits is certainly much larger than those in Navy-numbered Fleet flagships. Consider the use of the MAGTF Command Element as a hub for the SHF SATCOM GMF net to DISA and the Air, Ground, and Support Command Elements with a parallel architecture of wire and terrestrial microwave links. This is analogous to the architecture at NCTAMS EASTPAC in Hawaii, where the Navy recently installed an Automated Network Control Center.

This is a true implementation of a Digital Techcon on a larger scale. It consists of a 8196-by-8196 true nonblocking black switch and a 4096-by-4096 red switch with switch servers and control workstations on an ethernet-based control LAN (figure 3-3). The switch architecture is modular, based on a 512-by-512 switch and a 64-port Remote Interface Unit (RIU); it can be scaled and packaged to meet the MAGTF/CE deployed requirements. The RIU uses a fixed 32-channel TDM scheme of 32 channels at 64 kbps for a 2.048-Mbps aggregate that can be run 2000 feet on twisted pair or 2 kilometers on fiber optic. An analysis is required to consider the cost and benefits of integrating this architecture into new shelters, existing shelters, and consolidating the resulting shelters and equipment to achieve the following: optimize functionality, enhance survivability, provide an overall space and weight savings, and reduce the amount and weight of cable required to support the deployed MAGTF CE.

Of the three data types (record message, TACINTEL data, and voice), Marine Corps record-message traffic is the most straightforward to implement in a CSS architecture.

Currently, record messages are handled primarily by the Rapid Information Management (RIM) Communications System deployed in an AN/MSC-63A Mobile Comm Shelter. A Navy NAVMACS (V)2 is used as a backup delivery system, and as the primary system when the MAGTF receives its record traffic over UHF Single-Channel SATCOM as a CUDIXS subscriber.

3.4.1 Copernicus Architecture for the Common Evolution of Navy and Marine Corps Record-Message Traffic Delivery Systems

One system currently under development is the NAVMACS Model II. This system will eventually replace the current NAVMACS (V)5 down through and including the NAVMACS (V)2, which is deployed throughout the Navy and Marine Corps. The system is evolving using a phased approach, which, if followed properly, could be tailored as appropriate to maximize benefits and minimize cost to the Marine Corps.

The NAVMACS II uses inexpensive hardware and open-system architecture. It currently uses a DTC-2 with VME backplane and the UNIX operating system and will use follow-on standard hardware and software contracts as appropriate for time of delivery under the Copernicus architecture.

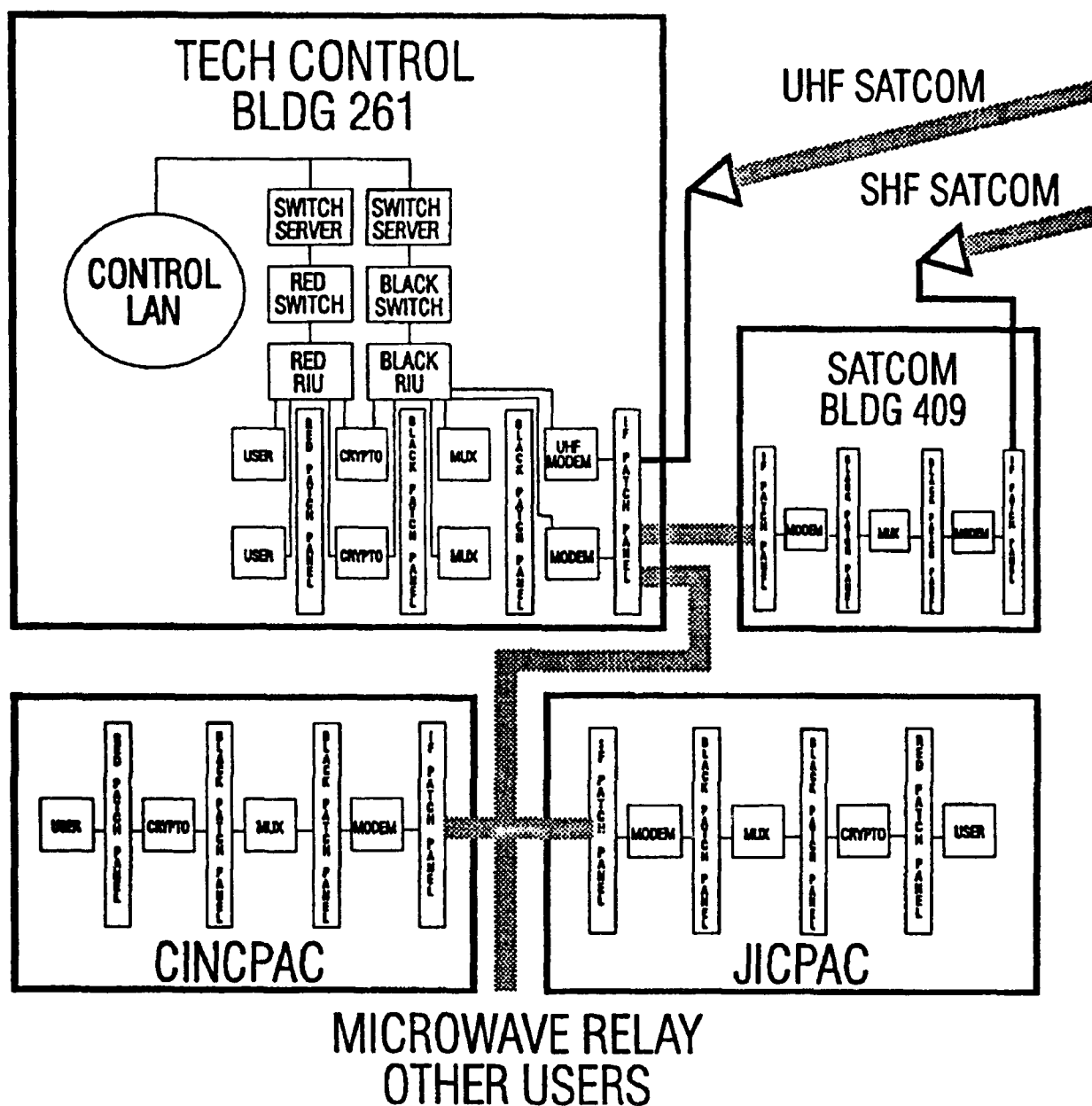


Figure 3-3. Automated Network Control Center (ANCC) at NCTAMS EASTPAC.

The starting point for the NAVMACS II is the MNFEP for use at Navy Antisubmarine Operations Centers (ASWOC) nominally delivered in October 1991. Phase 0 of NAVMACS Model II was successfully demonstrated in USS *America* in early 1992. This consists of using the NAVMACS Model II as a front-end processor for the NAVMACS (V)5 on the CUDIXS link running at 9600 bps instead of the usual 2400 bps. NAVMACS

Model II allows 9600-bps operation of CUDIXS on both UHF single channel or UHF DAMA SATCOM.

The next milestone will be to deploy the NAVMACS Model II as a front-end processor for all the ships in the USS *John F Kennedy* Battle Group to allow efficient use of the assigned 9600-bps SATCOM channel.

Delivery of the Phase-II software is scheduled for October 1992. This is the nominal point at which all the functionality of the NAVMACS (V)5 is supported by the NAVMACS Model II. This includes guarding circuits other than CUDIXS (HF full-period termination, UHF SATCOM Broadcast, HF single-channel full duplex) that is provided by the NAVMACS (V)5. Phase II also includes a dedicated local area network (LAN) for delivery, storage, and user-initiated random-access retrieval. This capability is not present in the NAVMACS (V)5, and this aspect of the system will revolutionize the nature of record traffic to Fleet users.

NAVMACS Model II is being developed by SPAWARS PMW 152. The primary field activity is NTSIC at Cheltenham, Maryland. The development milestones have been aggressive, and sometimes the plan has slipped due to technical difficulties and ship schedules. Although the Model II was not developed here at NRD, the Marine Corps would benefit from having NRD serve as its agent; i.e., NRD could accept a copy of deliverables for the Navy as they become available and evaluate them for modification in a laboratory setting and for later demonstration at a Marine Corps site. We feel that minimal modifications would be required for the circuit side of the NAVMACS II. However, the Marine Corps might want the delivery system rehosted on a common-equipment LAN of its choice, and they would definitely need to tailor the message routing and internal communications functions of the LAN to its own command and communications structure.

APPENDIX A

NAVY-DEVELOPED C³I SYSTEMS

A.1 NAVY TACTICAL COMMAND SYSTEM-AFLOAT (NTCS-A)

NTCS-A, the Navy's primary afloat Command, Control, and Intelligence System, provides the architectural framework for initially implementing the Copernicus concept into the Fleet. The requirements of previously separated C²I programs are planned to be satisfied by a single engineering solution, using the evolutionary acquisition approach. Examples of these previously separated programs are JOTS, TIMS, POST, EWCS, NIPS, and FDDS; and tactical decision aids like ASWTDA. Features associated with the NTCS-A program include

- a. Standard workstations—DTC-2 and TAC 3.
- b. Common software on all platforms.
- c. Maximum use of Non-Developmental Items (NDI) hardware and Contractor-Off-The-Shelf (COTS) software.
- d. Planned formal integration of functionally related prototypes.
- e. Periodic upgrades of baseline systems based on Fleet/user inputs. (A Fleet Requirements Working Group has been established.)

Current planning indicates that integration of the system elements mentioned above will be completed by 1994, the end of Phase II of the NTCS-A program.

Note: While additional information on Navy Command and Control Systems of interest to the Marine Corps is available in Chapter 4 of the U.S. Marine Corps Command and Control Master Plan, be very careful when using this information, since many programs have changed significantly since the document was published.

A.2 TACTICAL INFORMATION PROCESSING SYSTEM (TIPS)

TIPS is a general-purpose information storage and retrieval system designed to support the needs of the Marine Landing Force and Amphibious Force staffs aboard amphibious assault (LHA, LHD) ships. The TIPS component of the ship's Combat Direction System (CDS) Tactical Data System (TDS) supports both interactive and background processing to meet tactical, intelligence, logistic, and administrative requirements. It consists of terminals and printers located in strategic areas throughout the ship to provide access to its predefined databases. These databases support development of landing-plan

documents, supporting-arms reports, and management of embarkation data. Additionally, TIPS is to be used to create and manage tactically oriented databases to coordinate operational data, including aircraft and intelligence data, during an amphibious operation. The future of this program is questionable because of both funding and technical issues concerning overlap with other Navy and Marine Corps system developments—particularly with the Marine Corps Amphibious Assault Planner (AAP) development program.

A.3 AMPHIBIOUS ASSAULT DIRECTION SYSTEM (AN/KSQ-1)

The AN/KSQ-1 system program, managed by NAVSEA PMS 377, is designed to provide timely three-dimensional position information for tactical use. The system is designed to provide accurate information in realtime to the command and control ships of an amphibious task force on the position and movement of all surface landing craft. In addition to its ability to display and disseminate information between ships, the KSQ-1 will provide both a secure-voice and digital-data communications link for these ships. This system incorporates the Navy's Position Location Reporting System (PLRS) capability and is being designed to be interoperable with PLRS—being developed by the Marine Corps. The program plans TECH/OPEVAL in late FY 94 – early FY 95, with a Milestone IIIB full-production approval decision to be made in mid-FY 95.

APPENDIX B

OVERVIEW OF COPERNICUS ARCHITECTURE

The basic strategy of the Copernicus architecture is to make information available where and when it is needed. This is a significant departure from the "broadcast" way of conducting communications and it requires a supporting structure and set of capabilities to make it work. The structure is provided by the four major pillars of the architecture: (1) the Global Information Exchange Systems (GLOBIXS), (2) the CINC Command Center (CCC), (3) the Tactical Data Information Exchange Systems (TADIXS), and (4) the Tactical Command Center (TCC). The GLOBIXS are virtual networks that are essentially very high-capacity, high data-rate pipelines of information that are shared among the various GLOBIXS subscribers. The CCC is another virtual network of subscribers, tying together existing command and staff organizations, and acting (through the CCC "Anchor Desk") as a switch from the GLOBIXS to the end user of information. The TADIXS are other pipelines (again high capacity and virtual networks) between the CCC and the end user of information. The TCC is a decision center for the warfighting commander. This TCC should be designed with open-systems architecture standards and modularity that can be configured for many missions, not just one. The Copernicus architecture requirements designate a MAGTF as a TCC. Likewise, Corps, Air Wings, and JTF are designated as TCCs.

The TADIXS and GLOBIXS should not be confused with existing communications circuits and networks that are essentially bearer services. Instead, they should be viewed as high-speed and high-capacity switching networks that facilitate movement of information from where it exists, to where it is needed, when it is needed.

APPENDIX C

CSS TERMS AND DEFINITIONS

CPG/SM—Communications Plan Generator/Security Manager

Has an interface to the CSS-SCE LAN.

LARG—Link Access Radio Group

A generic term that represents the entire suite of radio communications terminals and equipment: HF, UHF, EHF, and SHF

RAC—Resource Access Controller

Provides an interface to the SCE LAN and to the SAC, and handles queueing of outgoing data

SAC—Subnetwork Access Controller

Provides an interface to the RAC and a particular subnetwork link, and handles link protocols

SCE—Standard Communications Environment

SCE components include a portion of the SIC, the SPC/SM, the RAC, and the network that ties these components together. Non-SCE components include the TDP Subscriber, the TDP subscriber interface of the SIC, the SAC, the cryptos, and the LARG.

SIC—Subscriber Interface Controller

Provides an interface to a particular TDP Subscriber and to the SCE LAN.

TDP Subscriber—Tactical Data Processor Subscriber

Some Marine Corps examples will be included here.

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