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THESIS

TACTICAL LOCAL AREA
NETWORKS

by

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During Operation Desert Storm, the senior U.S. Marine Headquarters used a Local Area Network for Command and Control. Despite some limitations, the network was largely a success. The opportunities for employing the network to a greater extent for command and control are extensive. This requires careful examination of the functions of command and control and the capabilities of the system. Matching functional requirements to system capabilities will lead to optimum employment. Development of doctrine to use the network, education on how to use it, and improvements in its capability are all necessary. This technology is but one example of the available information technologies that must be harnessed for Marine Corps command and control to provide effective support to combat forces. A mechanism must be established for the Marine Corps to focus the efforts of experienced Marine leaders, information technology developers, and Fleet Marine Force system users to forge the vital link between our combat systems -- command and control.

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Tactical Local Area
Networks

by

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ABSTRACT

During Operation Desert Storm, the senior U.S. Marine Headquarters used a Local Area Network for command and control. Despite some limitations, the network was largely a success. The opportunities for employing the network to a greater extent for command and control are extensive. This requires careful examination of the functions of command and control and the capabilities of the system. Matching functional requirements to system capabilities will lead to optimum employment. Development of doctrine to use the network, education on how to use it, and improvements in its capability are all necessary. This technology is but one example of the available information technologies that must be harnessed for Marine Corps command and control to provide effective support to combat forces. A mechanism must be established for the Marine Corps to focus the efforts of experienced Marine leaders, information technology developers, and Fleet Marine Force system users to forge the vital link between our combat systems -- command and control.

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I. INTRODUCTION

A. C4 AND THE WARRIOR

The world has entered an era of phenomenal expansion of information technology. Such dramatic advances have taken place only a few times in history. Johann Gutenberg's printing press in 1436, Alexander Graham Bell's telephone in 1876, and Guglielmo Marconi's radio in 1895 each demonstrated the impact that an advance in information technology can have on the world. From faster computer chips to sophisticated computer software to greater capacity transmission media, information technology is providing fantastic opportunities for progress. These advances hold great promise for military command and control. A recent briefing by the J-6 of the Joint Chiefs of Staff highlighted the opportunity available to employ this technology to provide vital support to combat forces:

- "Intelligently and uniformly applied information technology has the ability to greatly facilitate the C4I support to the warrior" (Macke, 1992).
- "The technology explosion in information systems hardware and software has gifted the C4 Community with an enormous capability to provide warfighting aids to the warrior on the battlefield" (Macke, 1992).

Marine Corps doctrine summarizes both the basic functional purpose of this technology and its limitations:

- "Automated information system support, both tactical and administrative, must expedite the flow of the right information to the right place in a timely manner" (OH 2, p. 4-2, 1987).

- "Automated systems promote rapid processing, communicating and presenting information to enhance, but not replace, the manual warfighting process" (OH 6-1A, p. 6-1, 1988).

Change to time-tested ways is slow and sometimes costly in resources. Many people question spending scarce budget resources on unproven future systems that do not directly kill enemy forces. Yet already, some of those future enemies are beginning to employ the very technology in question:

- Previously unsophisticated enemies, including terrorists and drug trafficking organizations, are now employing sophisticated communication and computer technologies. (Breth, 1990).

Acquisition decisions for the right future technologies will require vision, leadership, commitment and a willingness to adjust to both the changing threat and the available tools.

B. SOME DEFINITIONS

Some basic definitions are given below to establish a foundation for the discussion that follows. Appendices A and B provide explanations for other abbreviations and terminology.

- LAN -- (Local Area Network) a group of computers connected by a communications channel covering a few km. or less.

- WAN -- (Wide Area Network) very similar to a LAN, but covering distances over a few km.

- Network Operating System -- the control program that allows all the computers on a network to communicate with each other.

- Command and Control -- a commander's responsibility to direct the efforts of his organization. Accomplished using many personnel, equipment, and procedures.

- Information Technology -- computer and communication industry products, hardware and software, that provide the means to process information more effectively.

- Automated Systems -- generally refers to groups of computers netted together to share information such as target resolution data, payroll statistics, or intelligence reports.

C. PURPOSE

This thesis has a four-fold purpose:

- To recount the success of the Marine Corps command and control data network in Desert Shield and Desert Storm.

- To explore further applications of the network for command and control.

- To recommend steps to expand employment of information technology in the Marine Corps.

- To propose a philosophy for future command and control development using advanced information technologies.

D. EXECUTIVE SUMMARY

Local Area Networks (LAN's) informally entered Marine Corps' communications sometime in the middle 1980's. By the latter part of the decade, several commands were using LAN's for non-critical command and control functions during exercises. This experimentation with LAN technology culminated in the selection of a standard network operating system for the Marine Corps in 1989. Just over a year later, the network was field-tested during Desert Storm. Those who used the network in Southwest Asia generally evaluated it as an enthusiastic success, despite some noted limitations.

That success suggests potential for more extensive employment. To employ the network optimally requires a close examination of both what the command and control requirements are and what the system capabilities are. The network has a significant cap city to focus information as demanded by Marine Corps command and control (C2) doctrine. However, its proper role in the C2 architecture must be carefully scripted to take advantage of its strengths while preserving the dominant position of the commander. Once the LAN's role is determined, a resolute and deliberate effort will be required to implement it throughout the Corps. Some issues to be addressed include doctrine for LAN employment, education for the users, and improvements to LAN capabilities.

This network represents the rush of new information technologies crowding the commercial market each year. Which ones have affordable military applications is a complex issue. Matching affordable, available technology to current and future requirements is a challenge that faces every business or military acquisition planner. In the light of declining manpower and budget resources, how can the Marine Corps find the right answer? Again, the formula is vision, leadership, and commitment with willingness to change.

E. SCOPE

This thesis includes a survey of Marine Corps local and wide area networks employed during Desert Shield and Desert Storm. A limited subjective evaluation of the system performance is also provided. Next are discussion of the command and control functions appropriate for the network and some suggestions about how the system might fulfill those functions. Some suggestions are also offered for putting the system into use, for documenting its functions, and for teaching its employment. Finally, future applications of information technology similar to this network are discussed.

F. ORGANIZATION OF THE THESIS

The next chapter is a case study of the employment of the Marine Corps LANs and WAN during Operations Desert Shield and Desert Storm. Chapter III then develops the future C4 potential of the system used in the war. The fourth chapter discusses procedures to reach the potential outlined in the previous chapter. The final chapter looks to the future to forecast where the rapidly expanding information technologies may lead.

II. THE CASE STUDY

A. CHRONOLOGY

1. Before the War

Before deploying to Southwest Asia, many Marine units had established Local Area Networks (LAN) as part of their command and control architecture. Particularly on the West Coast, LAN's had grown in popularity and were used in most exercises to send messages between major command headquarters. While LAN employment was not extensive or critical to pre-war command and control, the experience gained by the data processors and communicators in developing the system was to pay huge dividends in the desert. (Hall, 1991)

During Gallant Knight 88, a CENTCOM exercise, I Marine Expeditionary Force (MEF) directed all major subordinate commands to establish contact on the MEF LAN. This resulted in an attempt to field test several different LAN operating systems and highlighted Banyan Vines as the clearly superior software. (Hall, 1991)

This exercise also demonstrated some shortcomings of the system. First, it was limited to unclassified traffic so that very few operational messages could cross the network. Consequently, some important high-visibility uses for the network were absent. Secondly, there was some reluctance to use automation before the war. Old habits, skepticism of system reliability, and lack of education and training, were all causes for this reluctance. (Hall, 1991)

In July 1990, just before the war, the MEF had an opportunity to use the network in another CENTCOM exercise. This exercise became a rehearsal for many network functions used extensively in the war. However, the intelligence and operational use of the network remained limited because transmission security had not improved. Consequently, logisticians and administrators became more familiar with the network than other staff sections. Other combat uses of the system had to be learned by trial and error under pressure during Desert Shield. These exercises not only developed network familiarity, but also established the same standard for use of the network in the field as in garrison. Additionally, embark procedures were developed for even the non-tactical components. (Hall, 1991)

2. Initial Setup and Evolution in Southwest Asia

a. The Plan

During the planning stages of Desert Shield, Ground Mobile Forces (GMF) Systems (Joint Satellite System) were expected to provide primary connectivity for the Marine Air Ground Task Force (MAGTF) headquarters to its Main Subordinate Elements (MSE). Multichannel radio (AN/GRC-201) was to provide secondary connectivity to the MSE's and links to other widely dispersed units. As more forces arrived in theater, the demand for information channels rapidly out-paced the primary communication nets and the roles of GMF and multichannel radios were reversed. This reversal was the direct result of increased LAN use. (9th Comm Bn, 1991)

b. In the Beginning

The prewar exercise use of the network paid off. As headquarters were set up, the exercise routines for establishing the data nets were followed, though transmission security remained a problem. To overcome the security limitation, STU III secure telephones were used to provide slow data transfer at 2400 bits/sec. While this was not the most desirable arrangement, the system was at least operational and secure for the opening days of Desert Shield. As units arrived, they were added to the network and equipment was expanded to provide additional and improved capability. (Cheatam, 1991)

c. Improvements to the Network

To improve the data rate, Digital Subscriber Voice Terminals (DVST), KY-68, were substituted for the STU III's raising the rate to 9600 bits/sec. Eventually Dedicated Loop Encryption Devices (DLED), KG-84, were inserted to provide 32 K bits/sec service. A variety of computer terminals were used, including AN/UYK-83's and 85's and commercial PC's, both table top versions and laptops. The demand for terminals rapidly out-paced supply. The supply system responded in exemplary fashion, but could not keep up with the insatiable demand for access to the network. (Hall, 1991)

The communications links providing connectivity began with hardwire and developed into satellite and microwave applications. Ground Mobile Forces (GMF) networks using Satellite Communications Terminals, AN/TSC-85 and AN/TSC-93, linked units with the widest separation, while AN/GRC-201 and AN/TRC-170 Microwave Radio Sets provided shorter range multichannel links. Within headquarters, coaxial cable and fiber optic cable were the primary links. (9th Comm Bn, 1991)

d. Links Out of Theater

One of the most useful features of the system was the GMF satellite link between the Brigade Service Support Group (BSSG) Headquarters at the Port of Jubayl and Fort Buckner, Okinawa. Three 9.6 K bits/sec circuits were beamed via an Indian Ocean satellite to the Defense Communications System station at Fort Buckner. These three circuits allowed all the system users in Southwest Asia to access the Marine Corps Data Network through the Regional Automated Service Center (RASC) on Okinawa. This made many information resources at Marine Commands throughout the world available to LAN users. It also provided AUTOVON trunking and AUTODIN message service for the Force Service Support Group (FSSG). This roundabout routing capitalized on the processing power of the

RASC on Okinawa and avoided the heavy traffic on the Atlantic Ocean circuits. (9th Comm Bn, 1991 and Brewin, 1991)

e. Maintenance

Using equipment not intended for field use in the hot sandy desert environment of Saudi Arabia might well have developed into a maintenance disaster. However, a variety of ingenious methods were developed to keep the terminals cool and clean. Servers were typically shrouded in damp cheesecloth and burlap and serviced by a fan to reduce the heat. Other equipment was protected with panty hose to filter out the fine dust from the desert breeze. Operator maintenance took on a new meaning as clerks cleaned computers as often as their infantry brothers cleaned their rifles. This extra effort paid off as most equipment continued to operate throughout the campaign. (Levine, 1991)

f. Motivation for Use

A primary motivator to use the network was the backlog on other communication systems. Between five and ten thousand messages a day inundated the AUTODIN message center at I MEF, which meant that getting out a routine or even priority message was difficult. In addition, the capacity of the military phone system was strained to the limit as staffs who were accustomed to the extensive network in the U.S. were confined to a fraction of that connectivity. Waiting long periods for an available line and then finding the other end busy, or getting cut off in the middle of a conversation were the frustrations expressed by several staff officers.

The data network lacked such problems. It handled over one million messages a day, providing the paper-handling capacity demanded by modern coordination-intensive staff operations. In the hectic days preceding Desert Storm, most users found it to be a tremendous time saver. By using the network, they avoided the congestion on the phone system. Also, each addressee on a network message received a copy of the message on his terminal and could then print and distribute the ones he desired. However, no prioritization scheme was available and the network was limited to classifications of secret and below. (Early, 1991, sect 9)

> The use of LANs and WANs to augment, if not replace, the AUTODIN message system immeasurably aided in the prosecution of the war. (Early, 1991, sect 9)

g. Training

Marine units arriving from West Coast commands where LAN's had been used routinely in exercises before the war were readily assimilated into the network as they arrived. Units arriving from the East Coast were not as accustomed to networking and required some coaching to become familiar with the procedures and usefulness of the system. However, they soon realized the necessity of the network and began building their system, training their staff to use it, and overwhelming I MEF with requests for additional terminals. (Hall, 1991)

Though the network had been used by I MEF units before the war, it had not been tested under the volume of traffic and operational conditions that it faced in Southwest Asia. Because doctrine for using the data network had not yet been developed, even technically competent users could not make full use of the system. Table of Equipment (T/E) and Table of Organization (T/O) support had not been established so equipment and procedures to use it varied between units, thus hindering interoperability. Many other would-be-users found themselves untrained on this new information processing tool and had to learn under pressure. Even with these limitations, most users were enthusiastic about both its performance and its potential. Fortunately, the system was simple to comprehend and many without previous computer experience became overnight experts on e-mail. (Early, 1991, sect 9)

To get the system up and running in units where it had not been widely used, both I MEF and 1st Division organized teams of LAN trainers. The most effective instructional method, however, was one-on-one in front of a terminal. The objective was to leave at least one person in each staff section as a point of contact and as the limited local expert to trouble-shoot basic problems before calling the system managers in the G-6. Most new users of the system were motivated by peers who were using the system and getting more done as a result. (Imhof, 1991)

The system software was menu-driven allowing even individuals with little computer familiarity to quickly fathom the rudiments of sending electronic mail, which was the primary use of the system. In some staff sections, the staff officers themselves manned the keyboard to conduct personal liaison with other officers. In other sections, the clerks keyed in hand-written memos, AUTODIN messages excerpts, or verbal instructions passed from staff officers fully occupied on radio nets or in other planning requirements. (Imhof, 1991)

3. Final Setup

The final network configuration included all major Marine commands in Southwest Asia. In almost all cases, both primary and alternate connectivity was provided. It was comprised of approximately 40 servers, 750-800 devices, and thousands of users. Most links were over cable or microwave. Several high priority links were maintained over satellite. Figure 2-1 shows the configuration at the peak of usage, before the retrograde began. (Cheatam, 1991)

It is significant to note that the network included no other service. I MEF liaison officers with CENTCOM and with certain Army units operated dial-in nodes on the MEF network. CENTCOM established a separate network classified at the SCI

Source: I MEF ISMO

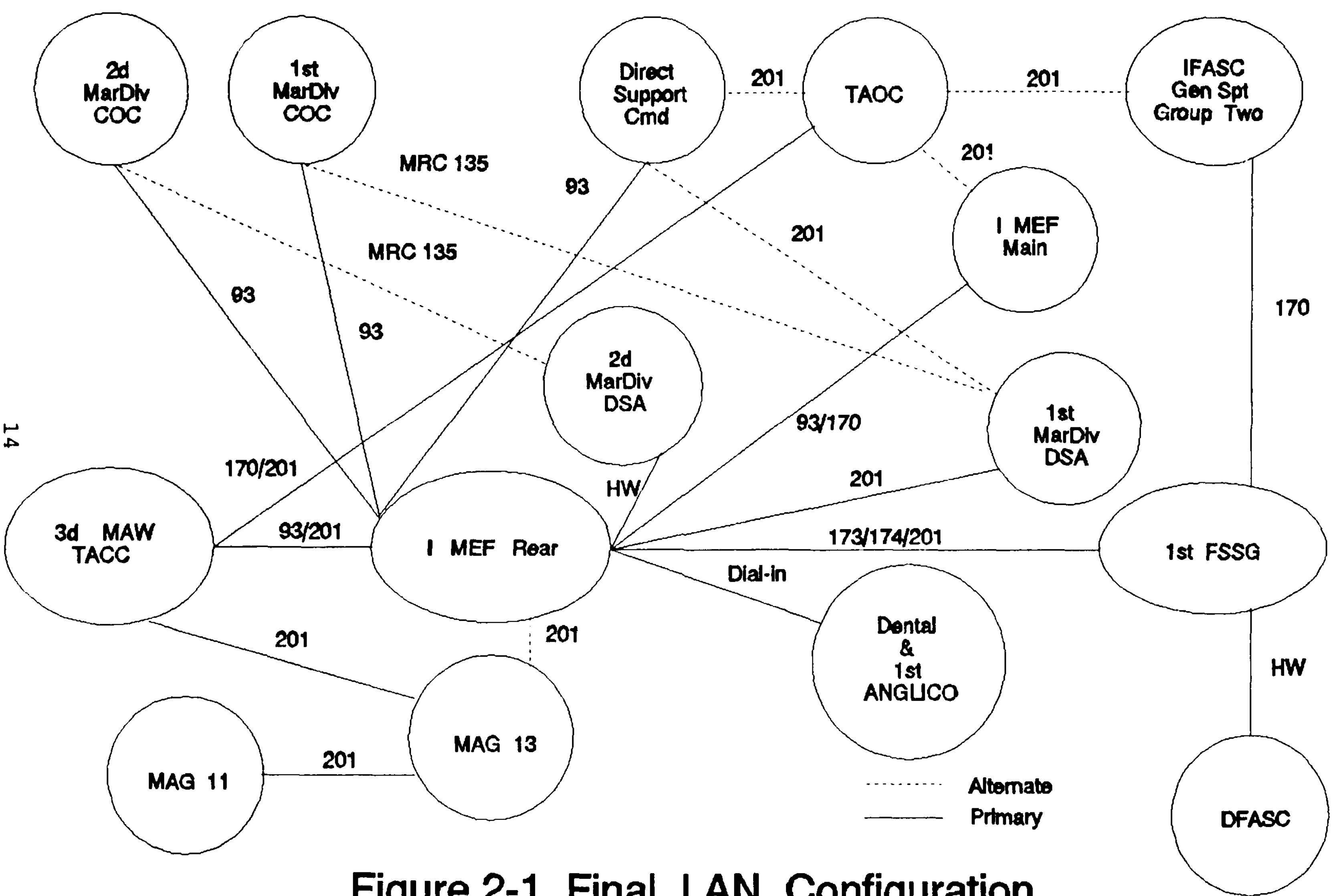

Figure 2-1 Final LAN Configuration

level that was used by the I MEF G-2. That was the limit of interoperability. (Hall, 1991)

B. HOW THE NETWORK WAS USED

While Banyan Vines has substantial capability, its primary use in I MEF during the war was electronic mail. It frequently became a substitute for phone conversations between staff officers. Rather than talking on the phone to a staff officer at another command, a I MEF action officer would sit at a keyboard and compose an e-mail message. In staff sections, such as the G-2 where large amounts of information were entered into the net, a clerk at the keyboard responded to the guidance of an officer engaged in generating the input to the network. Sometimes e-mail messages were used for historical reporting such as with daily status reports. On other occasions it was used as a real time alternate to the primary tactical nets. (Steed, 1991)

1. Logistical Use

Several staff sections used the LAN extensively for internal section coordination. For instance, the G-4 at the MEF ran a geographically split section, about 25 per cent with the section head in the forward command post, and the remainder in the main command post. This required extensive daily communication on the network to coordinate the tremendous logistics effort necessary to support the MEF. Logistics summaries and dump status reports were transmitted over the net daily for review by the section head and then compiled for submission to CENTCOM. External logistic agency reports were also handled in this manner whenever possible. Resupply matters to CONUS were frequently passed over the network, making the link through Okinawa particularly useful. Vehicle accident reports, resupply requests, transportation requests, and guidance to subsections were all routinely communicated over the local or wide area nets. (List, 1991)

The networks probably enjoyed their highest usage rate in the area of logistics. The personnel who were the most familiar with computer nets, and the type of information that was best suited for networking were both resident in the logistics section. It was estimated that 90 per cent of the G-4's critical business went over the network making it a vital tool in the prosecution of the war. (List, 1991)

> The Marine LAN was essential to the operation of the vast supply network managed by the 2nd FSSG. We could not have survived logistically without it. (Krulak as quoted by Brewin, 1991)

2. Intelligence Uses

Because the CENTCOM intelligence network was classified above secret at the SCI level and therefore couldn't be linked to the MEF network, only limited information flowed into the MEF G-2 on the MEF network. Instead many items from AUTODIN and other sources had to be inserted on the LAN at the MEF level for distribution to subordinate commands. The Division level G-2 consequently received a large volume of incoming traffic on the network from both the MEF and the 3d Marine Aircraft Wing. (Peterson, 1991)

In fact, it was estimated by the 1st Marine Division G-2A that 80 per cent of the incoming intelligence information to the division came across the network. Lengthy intelligence updates from I MEF would have been delayed significantly if sent through the AUTODIN system or by voice. Pilot observations from recently flown missions over the battlefield were received by the Division G-2 over the network and relayed immediately to the combat forces in contact. Other means of reporting and acting on this timely information would simply not have gained similar results. (Peterson, 1991)

Some incoming information was of a nature that it could be sorted immediately and passed to the G-3 and G-4. Most of the outgoing information was also passed to the G-3 and G-4 as information copies on the net. The network was also a convenient means to route targeting data from the G-2 to the G-3. Most of this traffic was keyed in by a clerk under the supervision of a staff officer. (Peterson, 1991)

3. Administration Uses

The G-1 found the network to be a useful tool in many ways, but it also created some new responsibilities for him.

Message preparation, personnel reports, and staff coordination were all made easier by the network, but message distribution became an additional burden. The G-1 was split between command posts making the network a convenient coordination tool. However, it also created a message sorting and distribution problem as the incoming AUTODIN traffic was passed to the forward command post via the network. Then, daily, the 300-500 messages received had to be reviewed and distributed by the primary staff officer, a liability for him, but a great service to the rest of the staff. (Franke, 1991)

A potentially invaluable network use was fortunately never fully tested. A liaison officer was established at the field hospital with a network node and the addresses of all major commands. When a casualty arrived, his identity and status was immediately reported back to his command to prompt personnel replacements as necessary and commence casualty reporting procedures. If the number of casualties anticipated before the war had occurred, this would have been a critically important tool. (Hall, 1991)

4. Operations Uses

Within the operations section, the network was routinely used as a substitute for both AUTODIN and voice traffic to transmit frag orders, sitreps, and air requests. Every network message coming into the combat operations center was treated as official traffic to preclude any lost information. The improved message responsiveness of the network reduced the number of staff officers and couriers travelling between the widely dispersed desert command posts. E-mail procedures were not difficult to learn or incorporate into operation center routine and undoubtedly increased the speed of the command and control process. A valuable tool was its ability to create a record of coordination otherwise conducted over a phone with little record kept. (Steed, 1991)

The most significant network use in the entire war was without doubt the transmission of the Air Tasking Order (ATO). Timely delivery of the ATO was critically important to the conduct of the war, but its size created a challenging problem. Originally the 500-700 page ATO was passed via AUTODIN message as a flash precedence message that occupied six to eight hours of transmission time simply to reach the main subordinate commands under CENTCOM. This meant that further dissemination to air crews and controllers and to the forces they supported, could take far too long for proper coordination and execution. Once the network was employed to send the ATO, hundreds of pages were reduced to those sections relevant to I MEF, and were then transmitted to Marine squadrons and controllers using a small fraction of the time previously required. Distribution of the Air Tasking Order was an outstanding example of the effectiveness of the LAN. This single capability made a clear difference in the way the war was fought. (Early, 1991, sect 9)

C. ADVANTAGES

Many Marines commented on the usefulness of the network during the war. The advantages can be summarized as follows:

1. Conservation of Assets

Because only the messages needed by each staff section were printed, much less paper and copy support was required. The congestion on many phone nets was reduced saving time and conserving available phone time for necessary voice communication.

This applied to AUTODIN as well. It would be impossible to quantify how much the network relieved the AUTODIN message system, but clearly, considering only the ATO, six to eight hours a day were saved. By allowing better anticipation of requirements, the network helped make more efficient use of many other resources. The faster flow of information improved the efficiency of the force as a whole.

2. Time Saved

The amount of time saved by using the network also would be difficult to estimate, but almost everyone agreed that it saved time on the phone, time just trying to reach someone on a phone or voice radio net, time in meetings, and time waiting in a queue to see the section head. When face-to-face contact was necessary, the section head was less likely to be on the phone or busy with someone else. In the hectic days preceding the war, efficiency was an important commodity.

3. Professionalism

There are some who believed that the network improved the professionalism of staff work. Phone conversations often wander and miss their objective and ill-conceived ideas are easier to propose verbally than in writing. Messages sent via the network however, were generally better organized and ultimately more valuable than phone conversations. In addition there was a hard copy record of the information transmitted.

D. FRUSTRATIONS

While the I MEF data network was a tremendous tool during the war, it did have some significant weaknesses.

1. Isolation

First, it was isolated to some extent both vertically and horizontally. Vertically, intelligence could not flow either to or from CENTCOM on the network. Such isolation from the next senior command was a serious limitation. Because of the rapid pace of the war, maneuver units reported only limited information up the chain of command. This forced the bulk of intelligence into I MEF to come from CENTCOM. The effort required to sort and insert it into the network was highly inefficient. Some isolation also existed below the division level since none of the maneuver elements had a networking capability. While there is no doctrine currently on how low in the organizational chain the network should extend, providing the capability to one step below the division received some support. (Lachowicz, 1991)

Horizontal isolation was not a problem within the Marine Corps, but it was between adjacent inter-service organizations. Only by providing liaison teams with networking capability could the MEF transfer data with other service organizations.

2. Classification

Another problem was the level of classification. Before leaving CONUS, the network was limited to unclassified traffic. Once in Southwest Asia, various means were used to raise the level of classification to secret. For most uses this was adequate, but some intelligence traffic was above this level and had to be transmitted by other means.

All the links within theater operated at the secret level while those on the wide area network outside the theater continued to operate unclassified. When the link to the Marine Corps Data Network was established, careful addressing was required to ensure no classified messages left the theater of operations.

3. Prioritization

There was no way to prioritize messages. The system worked on the first in, first out principle. During light usage that was not a problem since messages were transmitted when they were received. However, during periods of high usage in SWA the system became overloaded and high priority messages were held up in the queue with lower priority traffic.

4. Capacity

The message delay problem was related to the capacity of the system, which was of concern as well. Since the high volume of traffic across the net was unexpected, on several occasions the system became overloaded and crashed simply because server disk space was exceeded. This unfortunate result, though quickly remedied, caused some Marines to question the reliability of the system.

5. Distribution

Another problem involved message distribution. Each incoming message had to be screened, sorted, and distributed, all which was time consuming for the staff officer concerned. The volume of traffic was totally unexpected. The divisions were receiving 300-500 messages a day, each of which had to be individually read and evaluated.

6. Authority of Messages

The authority of network messages became an issue. While most Marines viewed a message as an alternative to a phone call with about the same level of authority, others chose to treat it like an AUTODIN message to preclude lost information. While that was a prudent choice for such a situation, the source of network messages was somewhat less official than the typical AUTODIN message.

7. Support Required

The network has been criticized for increasing certain requirements such as embark space, training, maintenance, command post support, etc., without replacing any other piece of equipment or personnel. In a busy environment, the addition of tasks without the subtraction of others does not go unnoticed.

8. Addressing

Finally, there was some confusion about the proper address of individuals on the network. Different conventions were used in each organization and some individuals were not aware of established standards within their command. This led to undelivered and mis-routed messages because delivery required exact addresses.

E. OPERATIONAL ILLUSTRATIONS

While the network was most frequently used for reporting past events and coordinating plans for future operations, there were some occasions when the network provided real-time support for Marines in contact with hostile forces. The MEF G-3 stated that during the ground campaign, while the forward thrust of the divisions was occupying everyone's attention, enemy prisoners of war became a growing concern. The first news that massive numbers of prisoners were stopping the tactical flow came over the network. Subsequently, coordination was effected over the network to get transportation and personnel to move and process the prisoners. (Steed, 1991)

The 1st Division G-2 recalled that the most reliable and accurate intelligence reports he received came across the network from the 3d Marine Aircraft Wing. Every night just before dark, a Marine fighter aircraft was tasked to fly along the forward edge of the enemy positions low enough to observe unit locations and activity. When he landed he was debriefed and his report was transmitted via the network to the G-2. These "last light fighter" observations, often relayed directly to maneuver units, were typical of the timely intelligence information made available by the network. (Peterson, 1991)

A reconnaissance unit scheduled for a mission within 24 hours submitted an urgent request for several sets of elbow and knee pads to the 1st Marine Division G-4. From the forward command post, filling that request seemed unlikely. However, the network allowed the request to be worked almost immediately in the main command post, and within the allotted time, the required items were in the hands of the Marines. (Spenser, 1991)

Just before the ground campaign began, the 1st Marine Division conducted a combined arms raid with an artillery battery firing at suspected enemy positions. Fighter aircraft were in support to attack enemy forces reacting to the artillery fires. As the attack progressed, the enemy response dictated the need for electronic jamming support. The division air officer quickly relayed the request to 3d MAW on the network in the chat mode and obtained the required support in time to complete the mission. (Hofley, 1991)

These are just a few examples of the real-time effectiveness of the network operating in the crisis. They clearly demonstrate the network's capability to provide effective operational connectivity.

F. CONCLUSION

The rapid development of procedures and the adapting of existing equipment to meet the needs of the mission in the Persian Gulf War present another stirring chapter in Marine Corps history. These Marines implemented a command and control system that provides the rudiments of what Marine Corps doctrine requires. In OH-2 The MAGTF, effective command and control is defined in terms of force effectiveness as "whether the force functions more effectively and quickly than the enemy." Clearly in the Persian Gulf War that goal was accomplished. The firepower advantage of the Coalition forces probably would have carried the day even without the command automation described above. However, it is readily apparent that without battlefield command automation, the war would have been much less efficient, requiring more time, material, and manpower.

Hidden within the success stories of command automation are some lessons learned about information flow. These require correction to ensure that we can continue to function inside a future enemy's observation-orientation-decision-action loop. Appendix C lists some information flow requirements that remain to be met by our current command and control architecture. So, where do we go from here to satisfy these additional requirements while continuing to meet the force effectiveness test with our C2 system?

III. LAN EMPLOYMENT OPPORTUNITIES

A. WHY DO WE NEED A LAN?

Before developing this new technology any further, it is prudent to ask some basic questions about what should be done to best use the LAN. Simply because it was successful in certain situations in Southwest Asia does not mean that it is the best solution to all command and control problems. Even if there is a worthwhile application in certain areas, there must be a plan to employ it.

In Command In War, Van Creveld has asked two pertinent questions concerning new technologies: "What is the effect of the new devices on existing methods, and how can the devices best be put to use?" He further suggests that an important issue is determining what the proper burden sharing should be between man and machines. That is, in which functions and to what extent should the data network be applied and what functions should remain the responsibility of a human or a less technical system? It is true that a data network cannot be instituted for all communications requirements at all levels. Nevertheless, a stated Marine Corps C4 goal as articulated by Brigadier General Breth is the "...exploitation of state-of-the-art information technology...." (Breth, 1990). Could the LAN be part of this exploitation?

It is also important that the network not further exacerbate the problem of the data explosion now overwhelming certain command functions, but assist in gathering, processing, and using the data in some constructive manner. If, as charged by some, the network adds complexity and bulk to the command system without shouldering a commensurate share of the functional tasks, then it is only an end in itself and is a liability instead of a capability. (Van Creveld, 1985, pp. 2-3)

B. FUNCTIONS REQUIRED

OH 6-1A, Ground Combat Element Command and Control, lists a good set of command functions that the network might fulfill. If the data network is to continue its trend toward improving command and control, it must satisfy these functions well enough to be perceived as an asset. The four basic functions are as follows:

- Provide the commander accurate, timely information and ideas for developing feasible courses of action and making logical decisions.
- Translate the commander's decisions into plans and orders.
- Communicate those plans and orders to subordinates.
- Supervise the execution of those plans and orders.

To analyze what role a data network may play in each of these functions requires that the following questions be answered: how can the system be employed in performing that function and does the network provide a clear advantage over current systems? Implicit in these questions are the issues of survivability, reliability, and flexibility. While the answers to these questions are theoretical at this point, they provide a framework for discussing command and control functionality in the years ahead.

C. ELECTRONIC MAIL DESCRIPTION

Before examining how the system might be employed to fulfill the command functions, it is necessary to understand what the system can do in a little more detail. The basic function of a data network is electronic mail (e-mail). While that may appear to reduce it to little more than a communication tool, e-mail has some unique capabilities that make it more than just a messaging system.

1. Definition

To see how e-mail can be an important tool in a command and control system, consider a proposed definition: "Electronic mail is the store-and-forward transport of electronic objects, across a heterogeneous environment, among people, among people and applications, and among applications." (Soft Switch, 1989, p. vii) The definition can be broken down and analyzed as follows:

2. Store-and-Forward Transport

Figure 3-1 shows the basic structure of all e-mail networks. The terminals of a group of users are connected to

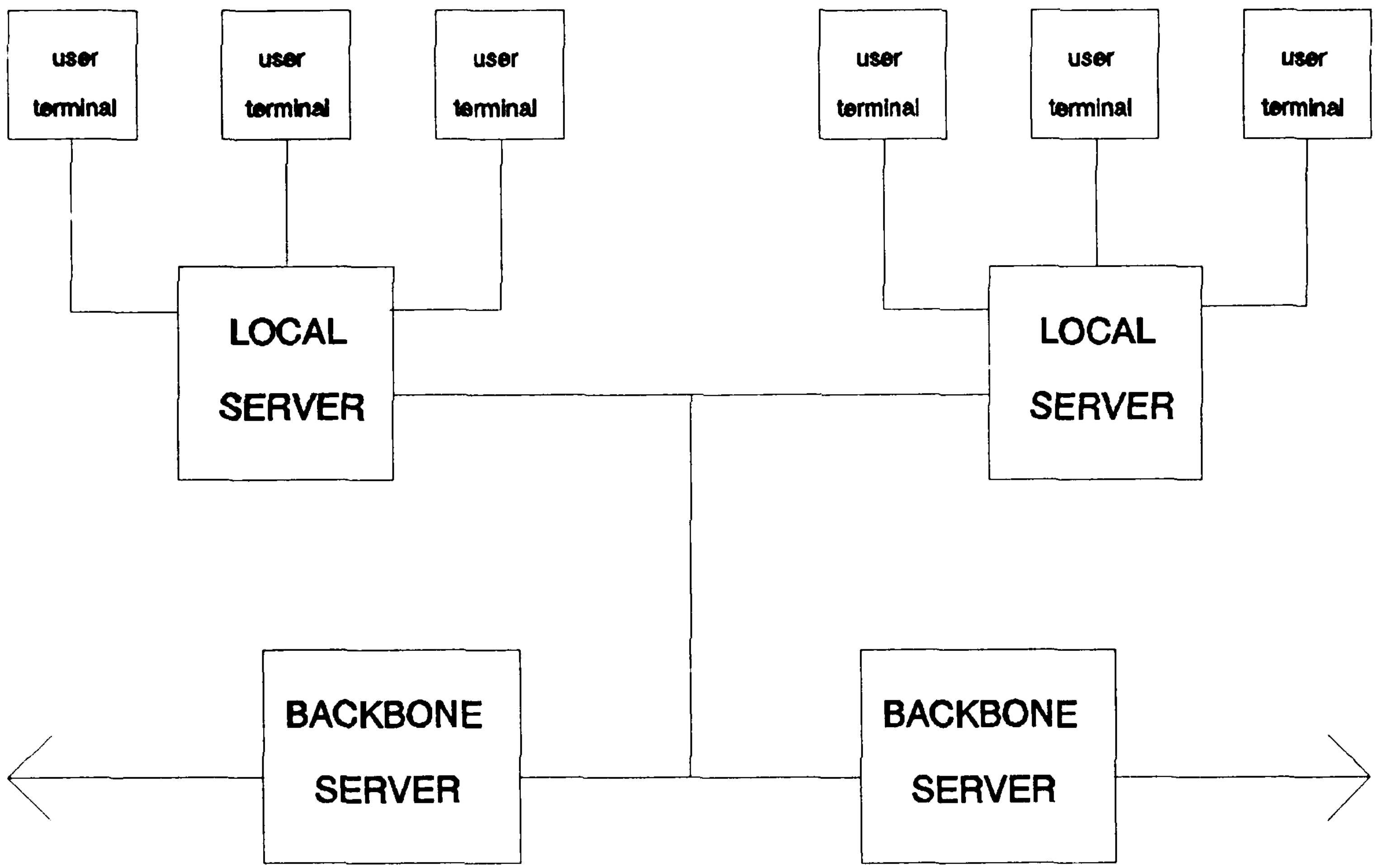

Figure 3-1 Worldwide Electronic Mail Network

a server and the server is connected to other servers over the network. The users can submit mail to the server, where it is stored for future delivery, either to other users' terminals connected to that server, or to other servers. The servers interact to deliver e-mail from one user to another across the network within a building, or around the world as required. Whereas real-time data communications simply transmit a file when directed to do so, an e-mail system can store messages and other digital objects to be delivered at some future time, when the receiver is available, for instance, or when another condition is met. This was a critical feature to the Marine Corps network use in Southwest Asia. (Miley, 1991)

> One of the Banyan Vines strengths was that it supported Marine units as they moved from position to position on the battlefield. That's absolutely critical to our operation because we displace so much. We have units with servers moving all the time. When you disconnect a Banyan server and move all the users identified with that server, the remaining network continues to collect mail for those users. As soon as the server is reconnected, the mail starts flowing again. (Hall as quoted by Olsen, 1991)

The server, then, can be thought of as the store-and-forward transport mechanism, and the user's terminal is a message center that can automatically process the data it receives. To automatically process data in a specific manner, the user may require specialized software besides e-mail.

This software is readily available and has received positive endorsements from data processing professionals. (Beyond Incorporated, 1991 and Ayre, 1991 and Needleman, 1991)

3. Electronic Objects

Electronic objects in the definition refer not only to text, but also to any other digital information such as images, voice, or numerical data. While the current C2 challenge is primarily processing text, fulfilling command functions may eventually require not only transporting these types of data, but integrating them as well into mixed media objects. (Miley, 1991)

4. People and Applications

People-to-people connectivity is simply passing messages between two or more individuals as well as using the system to transfer forms, reports, documents, or entire files to another individual. People-to-applications connectivity occurs when a rule based software program is inserted that allows the user to tell the application what information to acquire and under what conditions. An illustration might be an established daily requirement to post to a table the sunrise/sunset times taken from a database. The information to be acquired is the sunrise/sunset time and the condition is the specified time of day to retrieve it. Finally, application-to-application connectivity exists when one program, executing a previously directed instruction, queries another program for data to complete a specific task. For example, the G-2 might initiate a request via the G-2 terminal for enemy order of battle data not maintained in the local command. The G-2 terminal automatically queries other command databases for the required information and then updates the missing information in the G-2 status table.

Figure 3-2 shows the types of connectivity just discussed as they apply to a range of objects to be transmitted. On the vertical scale is shown the various connectivity combinations of people and applications, while the horizontal scale shows the different information types to be transmitted. The simplest communication is an e-mail text message in the upper left corner, while the most complex communication is files transmission between two applications in the lower right corner. With this range of communication capabilities in mind, the network ability to fulfill the command functions can be examined by associating them with an appropriate enabling connectivity. (Miley, 1991)

D. FULFILLING C2 FUNCTIONS WITH A LAN

While three of the four command functions involve information flow, clearly the first is the most complex and the basis for effectively accomplishing the other three.

1. Provide the Commander Accurate and Timely Information and Ideas for Developing Feasible Courses of Action and Making Logical Decisions

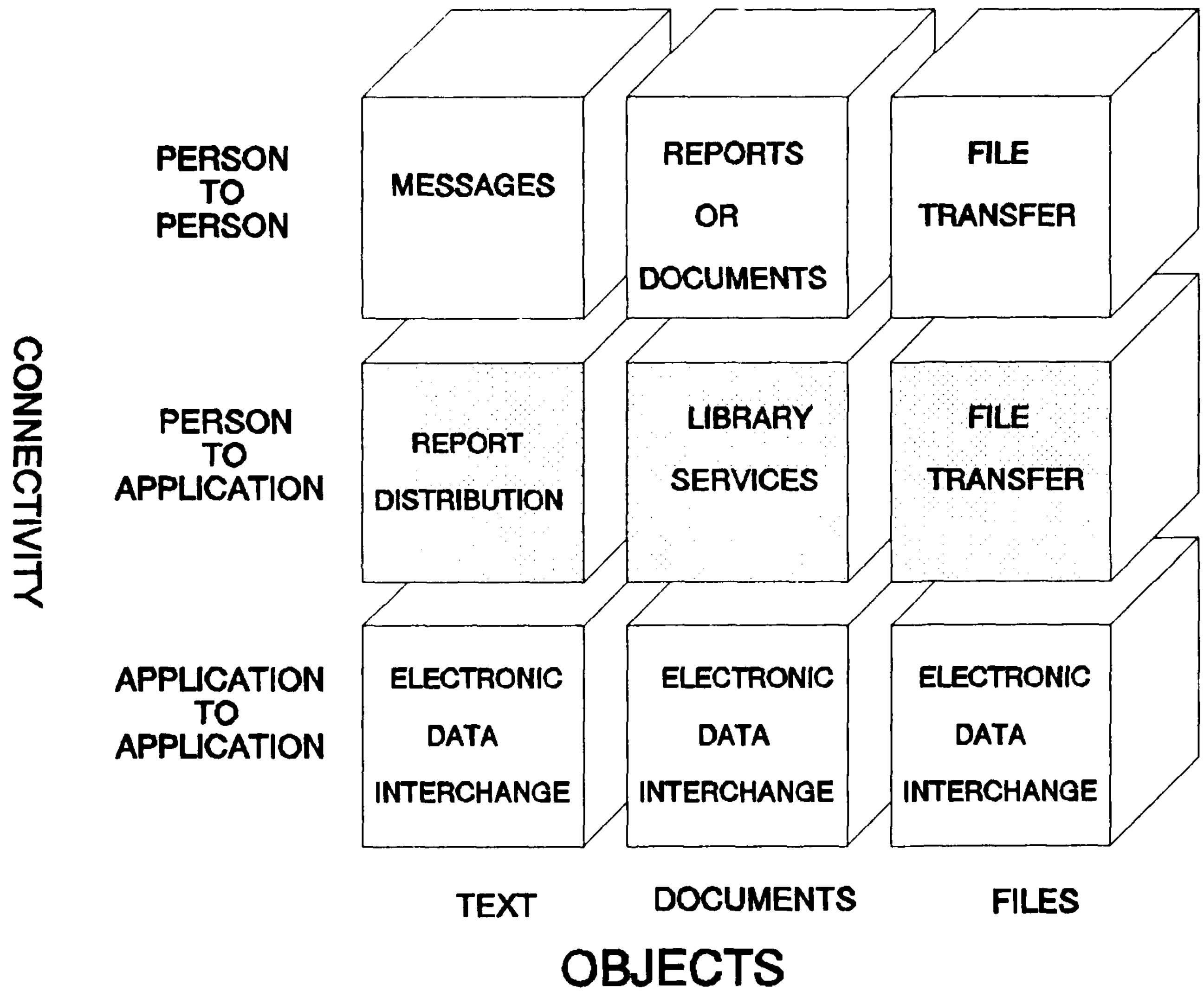

Figure 3-2 Range of E-Mail Capability

The acquisition capability of a data network is commonly understood because that is a communication function that communication tools have been fulfilling for centuries. The network used in Southwest Asia proved that it had some significant capability in this area to complement the more traditional forms of communication. However, providing information and ideas to the commander is more than simply obtaining data. It includes processing the data to make it useful. Therefore the key test for the network is not only to acquire data, but to focus information and ideas to be useful in decision-making.

a. Focusing Information

The major challenge for any commander, and therefore for the command system that he directs, is to make some useful sense of all the information that is available to him. From a historical perspective Van Creveld remarks,

> As the quantity of data rose, the difficulty of interpreting it in preparation for decision-making grew, causing staff to be piled upon staff and computer upon computer. New techniques, from operations research and systems analysis to cybernetics and games theory, were developed in order to cope with the flood of data. (Van Creveld, 1985, p. 3)

Modern technology has obliged to provide commanders with a plethora of raw data that may or may not have any significance to the commander's immediate situation. Even more to the point, only a limited amount of the available and possibly pertinent information can be acquired and processed in a timely manner. Consequently, the command system must focus it's information gathering and processing efforts on the commander's critical information requirements, which are "those items he considers critical to success on the battlefield." (OH 6-1A, 1988, p. 3-1)

(1) Critical Information Requirements. While every situation will have its own peculiar requirements, some information has been identified as critical in most tactical situations such as intelligence information concerning the enemy, environmental information concerning the terrain and weather, and astronomical data. See Appendix D for a more complete list of critical information requirements. Also of obvious importance is friendly force information such as current strength, location, activity, and weapons, communications, and logistics capabilities.

Each of the above categories represents only a general classification. Within each category are numerous groupings representing individual unit descriptions, capabilities, equipment, and status, in every area of military science. What should be obvious is that even carefully organizing both information acquisition and processing can be an overwhelming chore. Any tool that could effectively classify this information would be indispensable. If it is to be substantially useful in the C2 business, the LAN must demc. .rate the capability to do this.

(2) Sources. The source of this data is varied, including friendly force personnel, operational, and logistical status reports, all-source intelligence, encyclopedic databases, and staff analysis. Geographically speaking, the source of this information is potentially worldwide since intelligence gathering systems are often space-based and constructive analysis may be provided half a world away by a subject-matter expert. Here, the global reach of the data network is at its best, making accessible to the commander input from these sources from almost any spot on the globe with a linked terminal. This creates a virtual command center of almost limitless resources. These sources could come via any of the forms of connectivity shown in Figure 3-2.

(3) Sorting. To properly focus the mass of information reaching the command center requires that the identified critical information requirements be used to sort incoming messages into logical files for rapid analysis. This can be accomplished on the network using message-based rules suggested in paragraph C.4 above. To collect the desired information, the critical requirements must be expressed in terms of rules using key words, events, locations, or time, for instance. All incoming messages matching the given conditions will then be sorted as the message-based rules

direct. This information may be further processed to glean the exact intelligence needed and to update databases or any other report or display format. Either the person-to-application connectivity or the application-to-application connectivity is the system capability from Figure 3-2 in use here.

(4) Integration. Part of focusing information includes combining related information to provide a clear picture of the battlefield. This can be tailored to suit each commander's style and each situation, but it must continue the process of refining the volume of incoming data, not simply receiving and cataloging it. By continuing the rule set use on the system, sorted intelligence data can be integrated into files or formats that suit each situation and command style. A key enabling factor in this sorting is standard format intelligence reports. (Beyond Mail, pp. 10-12)

(5) Display. Once it is received, sorted, and integrated, the information must be displayed in a usable format for the commander to comprehend easily and act upon. An adequate display can be provided with a standard terminal monitor using readily available software to present charts, tables, and graphs. If deemed necessary, more sophisticated displays are possible, but they may require more complex hardware than currently available to the Fleet Marine Force.

(6) Update. The last focusing task is automatically updating critical requirements as new information is received in the command center. This is a classic application-to-application connectivity from Figure 3-2. Whether the incoming information comes as text, documents, or files, software acting in conjunction with e-mail continuously updates all the identified critical requirements and revises display elements.

(7) Executive Information System. What has been described above is essentially an executive information system (EIS). In the business world it is described as follows:

> EIS is a computer-based system that serves the information needs of top executives. It provides rapid access to timely information and direct access to management reports. It is very user-friendly, supported by graphics, and provides exceptions' reporting and "drill down" capabilities. It is also easily connected with on line information services and electronic mail. (Turban, 1990, p. 366)

This type of system is in use by successful leaders in business and industry as indicated by a study by the Center for Information Systems Research at MIT, which found that in 1989 over 50 per cent of large U.S. corporations had EIS programs installed or underway. (Turban, 1990, p. 366)

b. Focusing Ideas

Ideas and information have been separated here because although collecting both is similar, the focusing of ideas and information is accomplished differently by the network and therefore needs to be considered independently.

(1) Idea Development. Despite the tremendous progress made in recent years in computer technology, computers cannot replace the creativity of the human mind. Some technologies discussed below show some promise of eventually contributing to military decision-making, but the art of generalship is at this point still the domain of the human mind.

(2) Expert Systems. Tools referred to as expert systems (ES) are in use in a variety of business applications. "Typically, an expert system is a decision-making and/or problem-solving package of computer hardware and software that can reach a level of performance comparable to--or even exceeding that of--a human expert in some specialized and usually narrow problem area." (Turban, 1990, pp. 14) The ES has stored in its memory the task-specific knowledge of some human expert. Then, someone who needs the advice of the human expert can instead ask the computer specific questions and receive answers based on the stored information. The computer can provide conclusions and some limited inferences and even explain the logic on which the conclusion was based. While

there may be some applications for an ES in the more technically oriented aspects of military planning, it is no substitute for the bold imagination of the commander designing a campaign plan. In addition, an ES is a completely separate technology from a data network.

(3) Neural networks. At the forefront of computer software technology are neural networks. Designed to mimic the human brain, they are not programmed, but are trained by repeated exposure to similar problems and solutions. The network eventually determines what factors are important in reaching certain conclusions and can then solve similar problems by pattern analysis. Like ES, neural networks may eventually have an application in military science, but for the present, they cannot develop ideas for the commander perhaps because of inadequate training material to train the network neurons.

(4) Group Decision Support Systems (GDSS). Another potentially useful software in idea development is known as a group decision support system. This software is defined as "...an interactive, computer-based system that facilitates the solution of unstructured problems by a set of decision makers working together as a group" (Turban, 1990, p. 132). For example, a group of primary staff officers might gather in a room with linked terminals and a common display screen to brainstorm courses of action. They would have

similar information available to them as described above under focusing information. The commander might control the session by asking for ideas on specific issues or proposing alternatives. This arrangement is purported to improve both efficiency and effectiveness, particularly in large groups. It is most effective in tasks that involve generating ideas and solving problems without optimal solutions. (Turban, 1990, p. 139)

While this concept seems to have more potential for success in a military command system than the previous two, it has not had widespread success where it has been implemented in civilian organizations. Still, the concept is not well developed and has had only limited use, so perhaps the theoretical benefits may still be realized. (Kraemer and King, 1988, p. 140)

(5) Data Networks and GDSS. The three technologies just discussed are not integral elements of the typical data network and are not, at this point in their evolution, of great use in idea development. However, this type of exchange of ideas has already taken place on the data network.

Recently when tasked by the Commandant of the Marine Corps to produce a plan for the future of the Marine Corps, Brigadier General Krulak used the Marine Network to develop the plan, USMC 2001, with the help of other general officers not geographically present. "We built a file of all the (LAN) ID numbers of all the Marine generals and engaged in a great deal of give and take over the LAN." (Krulak as quoted by Brewin, 1991) This is a typical example of concept development on the network. It is not a substitute for face-to-face discussions in many instances where tone, emphasis, and personality are important. Nevertheless, it is a valuable tool to provide information that otherwise would be unreachable or untimely.

2. Translate the Commander's Decisions Into Plans and Orders

This command function requires the staff to develop the decision into a well-supported, carefully coordinated set of instructions. These instructions, in the form of a plan or an order, cannot hope to eliminate uncertainty nor should they deprive subordinate commanders the latitude of their initiative. Nevertheless, these instructions must focus the available intelligence, relate all aspects of available support to the operation, and provide coherent guidance about the commander's intent. An expertly meshed staff process is demanded.

a. *Staff Interaction*

The lack of readily decomposable staff functions dictates a parallel staff process be pursued for coherent instructions to be produced. Several data network capabilities support staff coordination.

b. Forms

Developing forms for off-the-shelf operation plans and frag orders can speed up the order issuing process considerably. Routing software on the network can merge data from each section onto appropriate forms as the forms travel from one terminal to another. This could be especially useful for standard supporting requests such as logistics and supporting arms. Referring to Figure 3-2, this is an example of person-to-person connectivity transferring documents.

Another staffing technique might have the frag order developed concurrently by separate sections while the whole document appears in its entirety on all terminals. The completed version could then be routed to the commander or chief of staff for final review and issue. This form of electronic brainstorming has been found to increase creativity and help generate alternate courses of action. It requires more than standard e-mail capability, but is readily available in software. (Turban, 1990, p. 137)

c. Information Requirements

The staff also will have critical information requirements. These requirements can be met by the network using the same rule-based scheme described for sorting the commander's traffic. Each staff section can sort traffic using its own rules, establishing files of information to facilitate reporting and plan development.

In addition, distributed data bases may be employed where each section and supporting agency maintains its own information in a data base readily accessible to anyone needing it. Just as with the commander's information, information from around the world is available to the staff in the virtual command center encompassing every known expert on an issue as well as every available historical file. This is not inundating confusing data, but carefully cataloged, available only when queried. In Figure 3-2, the connectivity is primarily person-to-application. This concept supports survivability by spreading out critical information in several different locations and on several different terminals.

3. Communicate Plans and Orders to Subordinates

Communicating messages and files is the forte of e-mail where the traffic is sent immediately to numerous addressees. Its receipt can be acknowledged automatically without action by the addressees by viewing the message on their terminal. At the subordinate command, it can be readily routed to necessary staff sections, printed where appropriate for study, and copied in part for forwarding.

4. Supervise the Execution of Plans and Orders

The extent and type of supervision is the commander's prerogative. Hopefully he does not use an improved information processing tool such as the network to micromanage subordinates. Used properly, the network can be employed to monitor critical situations effectively without interference, allowing the higher headquarters to provide timely support even before it is requested. With the confidence that the subordinate commander is seeing the same intelligence items that he is seeing, the senior commander may be better able to limit his guidance to his intent and his focus of effort.

E. REPORTING

Much of the basis for the information flow discussed above is effective reporting.

> A significant element in achieving the objective of acquiring and focusing information is the reporting system. An effective reporting system should provide the information the commander needs in a timely manner without unduly burdening subordinate units. (OH-6-1A, 1988, p. C-1)

Establishing effective rule-based message sorting, developing useful databases, and therefore focusing information and ideas at all levels is based on information flow in standard formats to permit efficient sorting. This is not a data network unique problem, however. The most difficult type of decision-making for any commander occurs when he is without his critical information requirements, regardless of their transmission medium. The strength of the network is in efficiently processing and focusing a massive amount of information flow. But the network cannot create the flow. It can simply make it easier for a source of information to get it to the commander.

Most commands have standard reporting procedures. Fielding the Digital Communications Terminal has provided excellent standard reports, which could form the basis for standard unit reporting. OH 6-1A (Appendix C) offers a sample reporting system that could also be emulated.

F. CONCLUSION

The evaluation questions at the beginning of this chapter have been answered only qualitatively. But clearly this technology demonstrates the potential for application in many aspects of command and control. How much of the control function it should absorb is not easy to say without experimentation. It cannot substitute for face-to-face contact or even voice contact in many crucial situations. The right and wrong time to use it must be understood by all users.

The network is not fully automated in that it requires a significant amount of user input to keep the information flow going. While that may be considered a weakness by some, it is also a strength, because a return to simpler methods is very easy when the network is unavailable for whatever reason.

The network must not be considered as an end in itself, but as a valuable technical tool to help manage the information explosion that the age of technology has created. Even as the radio made blitzkrieg possible, the data network may make some equally dominating stratagem a reality.

It will take forward thinking and imagination to break down the barriers of traditional organizational structure and information flow to allow this new tool to be exploited. Bonified criticism of its reliability, complexity, and efficiency must be met with objective evaluation. The ultimate goal, providing highly effective combat command and control to Marines at the point of attack, must remain the final test.

IV. RECOMMENDATIONS

A. CHALLENGE

In Command in War, Van Creveld states:

> ...the role that command may play in determining the outcome of present-day military conflict is crucial. By making possible a faster, clearer reading of the situation and a more effective distribution of resources, a superior command system may serve as a force multiplier and compensate for weaknesses in other fields.... (Van Creveld, 1985, p. 4)

The challenge then is to use the LAN to its full capacity to achieve the greatest force multiplication possible. All the e-mail capabilities described in the preceding chapter are available now, but are not being exploited. With over 700 servers around the Marine Corps linking all major commands, the e-mail system is here to stay (Green, 1991). The primary obstacle to full employment of the LAN is how it is viewed by individual Marines and consequently how they use it.

1. The Requirement

Before the war, as noted, a few commands at certain levels were using the LAN experimentally. During the war, its capability became vital in specific areas. Many who found the LAN to be so useful in Southwest Asia had to learn how to use it in the middle of wartime preparations. Some were simply too busy to take the time to learn and few used the system to full capacity.

Future crises will no doubt require similar capability stemming from the demand for increasing amounts of information of all kinds. Appendix C lists sample information Marines require for better command and control. "Not surprisingly, information has been called the 'most vital of all combat commodities' and the 'soul of morale in combat and the balancing force in successful tactics." (Stares, 1991, p.19)

2. Meeting the Requirement

The trend has been for staffs to grow and to be added upon one another with ever-increasing amounts of hardware to deal with the increasing demand for information. To manage the information deluge in Desert Storm, the I MEF staff, which before the war carried about 152 personnel, ballooned to about 1300 (MCLLS). Since 1945, the number of personnel in staff billets has grown fivefold and the amount of equipment to service them has expanded similarly. (Van Creveld, 1985, p. 267)

The prospect in the immediate future for further increasing staff size, or expanding the amount of equipment to enhance command and control is questionable. In the years ahead, personnel available to process information will no doubt shrink in number, and funding available for new equipment will remain an uncertainty. However, threat scenarios will continue to require rapid response. The increasing capability of potential enemies and the decreasing numbers of our own forces will present greater demands for timely and accurate information.

To meet this demand, the LAN must be used to its maximum capability. It may be well-suited to play the role of C2 force multiplier. However, many Marines will need to change the way they think about computers and automation in general.

B. HOW DO WE GET THERE?

1. System Development

The basic steps in information system evolution have been outlined by Lucas, Ginzberg, and Schultz as follows:

- Intervention: management recognizes a need for change in the way information is processed or decisions are made and activity to meet that need is initiated. e.g. The development of an information system to meet the evolving needs of Marine leaders.

- Implementation: information-processing or decision-making behavior is changed from what it was before the intervention.

- Improvement: successful implementation as improved information processing or decision-making. (Lucas, Ginzberg, and Schultz, 1990, p. 25)

In these terms, the LAN is a product of top level Marine Corps leadership recognizing a need for a change in the way information is processed in the Marine Corps. Intervention took place when the LAN was developed for use in command and control. Implementation progressed slowly until the war forced a change in behavior. The extent of implementation as well as the improvement level may be assessed using simple subjective measures.

2. Measures of Implementation

Measuring the change in how decisions are made is very difficult. On the other hand, measuring acceptance and LAN use is a more reasonable task, and these will be used as surrogate measures in the following analysis.

Acceptance is indicated by the tendency to use the LAN, while use is the actual level of system employment. Acceptance is based on several factors leading to the decision by an individual or an organization to use the system. Acceptance should result in use, except where the system is too difficult to employ extensively. (Lucas, Ginzberg, Schultz, 1990, p. 25)

System effectiveness also will impact acceptance and can be considered in two areas: performance and satisfaction. Performance is the processed information's objective value, while satisfaction is the user's subjective system evaluation. These two are also closely related; generally, good performance leads to high satisfaction. However, excellent performance that was difficult to obtain might result in poor user satisfaction. Figure 4-1 shows the entire flow of the process. (Lucas, Ginzberg, and Schultz, 1990, p. 26)

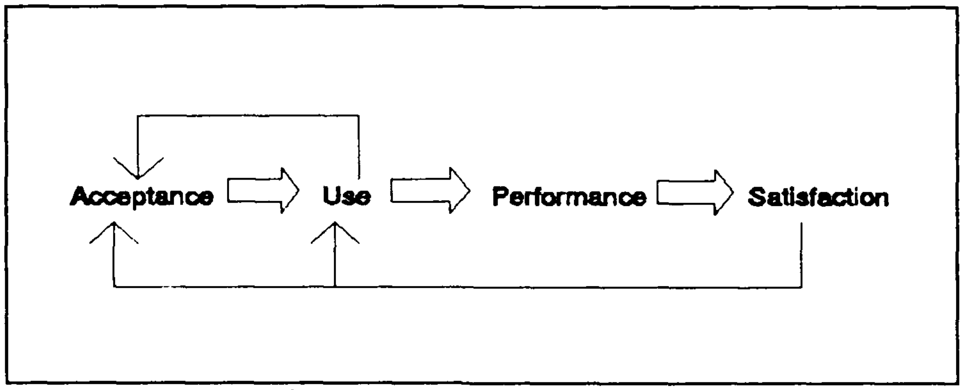

Figure 4.1 System Flow

Feedback loops show the element relationships pertinent to the Marine Corps LAN. Successful LAN use in the war resulted in increased acceptance. Satisfaction with the LAN performance in the war caused both increased use and acceptance. Figure 4-2 shows both the attained and the goal level of these measures, as estimated by the author.

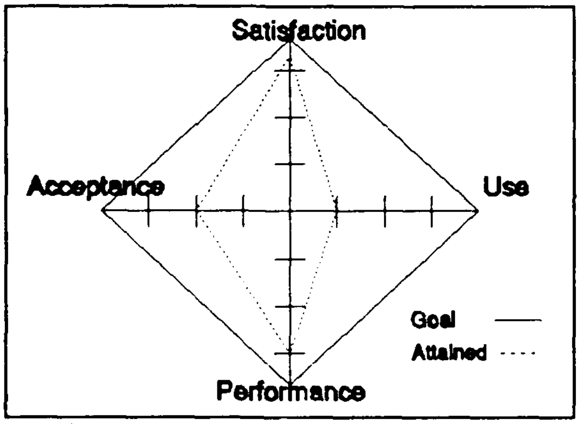

Figure 4.2 Implementation

The estimates in Figure 4-2 apply to use during the war by those who had access to the LAN. Satisfaction is rated very high because almost everyone who used the system was pleased with it. Performance is also marked high since users generally felt that the processed information had a high value. Acceptance is given a moderate score since many Marines did not use the LAN because of unfamiliarity or because they resisted computers in general. Finally, use is rated relatively low because the LAN was not fully employed.

3. Decision to Use

LAN use may be mandated for certain reports or documents, but if user acceptance is low, the system will remain under-used. If the system is not mandated, the decision to use the system to its capacity is contingent on three inter-related factors:

- Leader acceptance
- User acceptance
- Problem urgency

These three work together to bring organizational goals and the goals of the personnel involved into coincident focus. (Lucas, Ginzberg, Schultz, 1990, pp. 39-43)

a. *Leader Acceptance*

This is perhaps the key factor in implementing the system. If the unit leader believes in the LAN, he will sell its benefits in one fashion or another to his subordinates. His belief in the system can be based on several factors.

First is his understanding of the system's capabilities. If he has a thorough knowledge of how the LAN can be used to accomplish his unit's mission, he is very likely to encourage its use. If on the other hand, he has only a limited understanding of its capability, he probably will see it as a liability and not support implementation.

Another factor is the leader's assessment of system support. Although he may understand the LAN's potential, his perception of the available support may make him cautious to employ it. For instance, if he believes its reliability both in garrison and in the field is questionable, he will wisely not rely too heavily on it for mission-critical support.

A leader's decision style also plays a part. For instance, an intuitive leader generally has less use for an information processing system than an analytic type leader. Actually, the system's proper role of focusing information should support both leadership styles. An intuitive leader may find the system more useful if he avoids contacting it directly by having someone else provide him with system output.

The leader's job characteristics are also a factor in LAN acceptance. Some tasks such as tracking occurrences of specified events are well-suited for the LAN. Other tasks such as selecting a course of action, or counselling a subordinate may not be as appropriate. Some billets could find extensive uses for the LAN, while others might find little use at all. Understanding when to employ the system is as important as knowing how to employ it.

The leader's demographics also may affect how he perceives the LAN. Age, rank, education, previous tours and experiences will all have an impact on how willing one is to accept the LAN. Older and more senior Marines are generally less receptive to the system because they lack exposure to it. However, it is a widely held misconception that younger Marines are more computer literate simply because they have grown up in the computer age (Early, 1991, sect 9).

A final factor in system acceptance is the commander's perception of the availability of organizational support. Organizational support includes hardware and software, repair parts, trained maintenance personnel, trained operators and a command organization that has integrated the system into operational procedures. Can he be convinced that both hardware and software are available to make the LAN fully functional? Can he confidently follow the dictum to "fight as we train?" Can the system be deployed, be used in various field environments, and still perform reliably? Are personnel to maintain and operate it trained and available? And perhaps most importantly, are higher, adjacent, and supporting units implementing it too?

b. User Acceptance

User acceptance depends on the various factors described for leaders as well as two additional considerations. The first is *system characteristics* sometimes called *system friendliness.* Although the system may be supported by the unit leader and appeal to the user in all the areas described above, it may still not find high user acceptance. If the system is difficult to use, it probably will not be frequently employed.

A second factor is the user's personal stake in the system's success. His perception of the leader's acceptance and support may motive him to make it work. Additionally, the user's knowledge of the system's purpose can affect how much enthusiasm he has for it. How much time does it save and how important is the task that it accomplishes?

Finally, the user's view of organizational changes that will result from the system implementation may raise some questions. For instance, will the administrative section absorb some communication section duties when the LAN is installed? If so, the user's opinion of the system's usefulness could be biased depending on his particular section assignment.

c. Problem Urgency

A final factor that may spur both leader and user system acceptance is problem urgency. If both groups perceive that they are overwhelmed with information, or as in Southwest Asia, other systems prove inadequate, approval of a new system could come rapidly. Once the LAN was used in SWA, its excellent performance in handling problems caused its reputation to spread, resulting in even more users finding it to be useful.

4. Implementation Strategy

Successful implementation is based on the factors just discussed and may be pursued in three general phases (Lucas, Ginzberg, Schultz, 1990, p. 93).

a. Gain Commitment of User Leadership

Involve leaders as well as users in the implementation process. By helping to create the system, they learn about its advantages and accept it more readily. A leader must be committed enough to provide resources for the LAN and demand results from it. If a leader uses the LAN himself, particularly to contact subordinates, the subordinates soon find that the relationship with the leader works better if both use it (List, 1991).

b. Seek Out Potential High Stake Users

Anyone who has a potentially significant use for the LAN should be a target for early employment efforts. Primary staff officers and supervisors of tasks ideally suited for the LAN must be convinced that the system can improve their product and save them time.

c. *Concentrate on the User's Stake in the System*

Once the system is perceived as mandatory, user acceptance is of less concern for full system employment. The user should be encouraged to view the system as vital to his command's function and important to how his leader perceives his job performance. Then he will find new uses for the LAN, teach his peers how to use it, and make it an indispensable tool for command and control.

C. DOCUMENTATION REQUIRED

1. Doctrine

The Marine Corps should develop doctrine for the proper and effective installation and use of the LAN. Before the war, several commands experimented with LAN employment, and during the war, many ingenious uses were discovered. However, its capabilities need to be skillfully worked into the Marine Corps command and control structure.

> The lack of doctrine on installation and utilization of LAN's and WAN's has led to a number of difficulties that were only overcome by unnecessary additional effort. We now depend upon them on the battlefield, but we aren't familiar enough with them to make full use of their capabilities. (Early, 1991, sect 9)

The LAN can be applied to inappropriate tasks as well as ineffectively employed on worthy assignments. The following doctrinal issues should be addressed to ensure proper LAN employment:

- which nets can be eliminated by using the LAN?
- how low organizationally can the LAN be used?
- what should the table of equipment be to support the LAN?
- what standard procedures will be used on the LAN?
- which personnel will employ the LAN in different applications?

The expeditionary nature of the Marine Corps and the special requirements of the combat arms make the above questions particularly difficult to answer. Certainly, communication links and procedures suitable for fixed based forces will not be acceptable in their entirety for a Marine Air Ground Task Force conducting an amphibious assault on a hostile shore. Yet, for some purposes and at certain times, the LAN may prove invaluable to the sometimes complicated command structure of the amphibious force.

2. Employment Concepts

Developing employment techniques is perhaps as important as cataloging the doctrine for LAN usage. The widespread unfamiliarity with computers and their potential make this a particularly significant factor. Developing techniques to employ all the capabilities discussed in the preceding chapter, requires an understanding of how the system works. The LAN is not simply a substitute for a radio or a typewriter. Its potential reaches far beyond that. To employ it correctly demands skill in using the technology, the understanding of Marine command and control requirements, and imagination to bring the two together. Accomplishing this calls for a focused effort by knowledgeable leaders.

3. Demonstration Facility

Just as the best tactics are developed in the field, the best command and control doctrine and techniques are developed in a functioning command post. The doctrinal questions suggested above can best be answered by establishing a realistic C2 testbed where procedures and equipment can be evaluated and perfected. Such a facility would be ideal for teaching command and control once the doctrine and techniques have been developed. When discussing deficiencies in C2 during Desert Shield and Desert Storm, Brigadier General P.K. Van Riper suggested a similar requirement:

> Construct a functioning facility at Quantico that contains actual or surrogate communications and electronic equipment (radios, consoles, scopes, computers, etc.) for a MEF, division, regiment, wing, and FSSG command post. This would serve as a training facility for students and FMF staffs and as a concepts testing and evaluation facility for MCRDAC. (Van Riper, 1991)

Such a facility would not only be very useful in training currently assigned staff personnel and students, but also would prove useful in providing standard training for non-FMF personnel who will fill battle roster billets to complete wartime staffing requirements.

D. EDUCATION

Currently, the only instruction on LAN's within Marine Corps schools is found in the Computer Schools and in the Communications Schools. Both concentrate on network construction. Neither Amphibious Warfare School nor Command And Staff College include any instruction on LAN Employment. (Boeke, 1991)

Clearly, if the LAN is to become integral to Marine Corps command and control structure, instruction on its employment needs to be present in all formal schools that teach command and control. If a C2 training facility such as suggested by Brigadier General Van Riper were constructed, the students in all the formal schools at Quantico could participate in staff exercises as part of their course studies.

E. IMPROVEMENTS TO NETWORK CAPABILITIES

While the network has some significant capabilities as discussed in Chapter III, several critical areas need improvement.

1. Multi-level Security

In SWA, the network handled traffic classified at the secret level and below. In peacetime operations, it has carried no classified traffic at all. Some real-world traffic must be routed differently, a limitation that prevents fighting the way we train. In addition, any information classified above the secret level cannot be accessed even in wartime with the current capability. The LAN needs to provide multi-level security to reach its potential in command and control. This topic is under study by other agencies in the government as well as in the Marine Corps. (Weigand, 1991)

2. Internetworking Protocols

For obvious reasons, it is important for the LAN to be able to communicate with other defense department networks and other Marine Corps data systems. In SWA, the Marine Corps was unable to link the LAN to any other service because of interoperability problems. An interface also must be developed for the LAN and the Tactical Combat Operations (TCO) system of the Marine Tactical Command and Control System (MTACCS). These systems, which will integrate several other Marine Corps tactical automated systems, are currently under development. (Weigand, 1991)

3. Authentication

As with any communication system, a method must exit to identify intruders on the network. Passwords can be used to prevent unauthorized equipment use in friendly headquarters. However, when the LAN is linked by radio networks, enemy intrusion is possible. Currently the LAN lacks capability to prevent imitative deception. This issue is under study. (Weigand, 1991)

4. Remote Operation

Lower command levels may not have a need or the capability to support LAN operations within themselves. However, the incoming information flow from higher headquarters and the requirement to pass data up the chain of command would be better served if a remote station could be established on the higher headquarters LAN. (Weigand, 1991)

These are all areas that are under various stages of study or development for early resolution. Most are related to problems being tackled by other services or by the information technology industry.

F. COMMITMENT

To develop the doctrine for LAN use, to educate Marines with that doctrine, to correct system limitations, and to implement the LAN successfully require that Marines have an open mind and commitment to C2 excellence. The Marines in Desert Storm demonstrated that they had both and led the way toward a new concept of command and control. Those who follow them must build upon their efforts and find the right combination of tools and applications to carry Marine Corps C2 into the 21st century.

V. FUTURE COMMAND AND CONTROL

A. CHALLENGE

The purpose of this discussion of the Marine Corps LAN is not to promote a particular product or even a particular technology. The merits of any product and the usefulness of any technology must be considered in the context of the specific requirement. Those most familiar with the requirement must determine the best application.

1. Maximizing Combat Potential

The objective is to maximize the combat potential of a military force through efficient command and control. Efficiency in this sense means using fewer operating assets such as time, manpower, equipment, or supplies to accomplish the mission. <u>OH-2 The MAGTF</u> divides this efficiency into two parts, effectiveness and quickness. These two criteria may then be used to measure command and control efficiency.

2. Effectiveness and Quickness

It is tempting to assign equal importance to these two criteria, but in reality they have a partnership of unequal proportions. The partnership is illustrated by a quotation often attributed to General G.S. Patton, "A good plan violently executed now is better than a perfect plan executed next week." (Patton, 1979, p. 354) The proper planning balance in any combat situation between the quality of the plan and timeliness of the decision to execute the plan must be determined by the commander. Information technology can affect both the quality of the plan and the timeliness of the decision.

3. Quality Plans

The plan quality may be enhanced by improved information processing and activity coordination. In some cases, such as high technology surveillance, the information was not available in any form before the electronic age. In other cases, the information, while available from sources other than modern technology, could not be practically obtained in time to be used. For instance, in centuries past observation of enemy movements far behind the front lines of battle, often could not be relayed to the friendly commander in time to be worthwhile. Timeliness was the real issue.

4. Timely Decisions

FMFM 1 emphasizes the value of timely decision-making:

> Whoever can make and implement his decisions consistently faster gains a tremendous, often decisive advantage. Decision making thus becomes a time-competitive process, and timeliness of decisions becomes essential to generating tempo. Timely decisions demand rapid thinking, with consideration limited to essential factors. We should spare no effort to accelerate our decision-making ability. (FMFM 1, 1989, p. 69)

The opportunity for a rapid decision is generated when the commander quickly receives the information he needs to make a decision. The relative value of speed in the process is determined by comparison to the observation-orientation-decision-action (OODA) cycle speed of the enemy. The objective is to maintain consistently a shorter OODA cycle time than the enemy does. This is why FMFM 1 directs no effort be spared to accelerate that cycle.

B. INFORMATION TECHNOLOGY AND SPEED

Current commercial information technology products are emphasizing speed. Speed, sometimes called power, is the driving factor in processor development, networking, and even many application programs. These speed-enhancing products provide industry executives the same competitive advantages in the marketplace that the military commander's rapid decisions provide on the battlefield. One term for this advantage in the business community is *just-in-time business*. For military commanders, this is similar to staying inside the enemy's OODA loop. (Grove, 1991)

This analogous relationship may lead to improved military command and control through commercial product applications in the military. Military C2 has the opportunity to adapt for battlefield use the same technologies that industry is developing for commercial, competitive purposes. Not all these technologies are appropriate for military use, but many have very direct applications in military operations.

Military professionals must examine commercial products for applications within the military and then select and apply the most useful items. The products with the most obvious applications are often already being used in the fields of administration and logistics where the parallel between military and commercial functions is almost direct. The more difficult parallels in the intelligence and operations fields are not readily perceived and therefore not in widespread use.

The use of the Marine Corps LAN illustrates the application of a commercial product to military purpose. The most widespread LAN usage occurs in logistics and administration. Some operational and intelligence uses were suggested earlier as LAN Employment Opportunities. For Marine Corps command and control to "accelerate our decision-making ability," key leaders who know the operational decisions to be made, must get involved in evaluating and developing military information tools for the future. Those products will provide the basis for doctrinal procedures to give a decided battlefield C2 advantage much the way that radio and radar drastically altered military C2 in World War II (Stares, pp. 28-38, 1991).

C. SOME PROMISING TECHNOLOGIES

The following areas have potential for military application in command and control. All are at least under research, some are developed as prototype technologies.

1. Ubiquitous Computer

A ubiquitous computer is one that is omnipresent but also in the background so that it does its job without being noticed. The various electric motors of a typical automobile are a good example of technology that has disappeared into the background. The operator seldom thinks about activating the wiper motor, or the heater fan motor, or the starter motor or any of the other 20 or so motors in the car. Electricity has become ubiquitous. People flip light, TV, and appliance switches without a thought of the hundreds of volts flashing through the walls. (Weiser, 1991)

Computers will someday become so common-place that they will not be the focus of attention they are today. They will be programmed to accomplish automatically routine things like phone-call routing, updating data files, and providing the working software tools an individual normally uses at whatever remote terminal he operates. Paper size computer screens with pen-like writers will recognize handwriting and transmit information to a database or a large screen display. They also will recognize voice inputs for certain functions. Through handwriting and speech inputs, computers will be usable by those who can't type or by those who have never before used a computer. No longer will computers be approachable only in specialized jargon by trained operators. People will use them the way they use electricity today; they will use them constantly, but will cease to be aware of them. (Weiser, 1991)

2. Universal Networks

The computer networks that exist today are analogous to the thousands of winding dirt roads that made up the U.S. highway system in the early 1900's. Passing information on networks both commercially and in DOD is as slow and difficult as travelling cross-country 90 years ago. This situation is changing, however, and with the ubiquitous computer will come the universal network that will allow access to all manner of information and services. Transmission of high-quality pictures and videos integrated with voice and notations will be the norm. Real-time information exchange will take place over wireless nets. Instead of a web of slow and confusing communication channels, an easily accessible superhighway information system will emerge. (Dertouzos, 1991)

A current benefit of global networking is just-in-time business that is made possible by computer-supported collaboration (CSC). CSC is eliminating the barriers of space and time in working with shared information. Groups of decision-makers, sharing all forms of data in real-time, may change the way organizations, not just individuals, work. In the business community, it is being heralded as the most important source of competitive advantage in the near future. For the military, it also has the potential to change the way organizations work. (Grove, 1991)

3. Decision Support

Computer Supported Collaboration has begun the trend of computers providing decision support. Frequently, CSC allows several people to problem-solve using the same computerized picture from different terminals. Wireless networks with remote terminals such as the digitized chalkboard and high-performance laptop terminals are already demonstrating effective C2 in the laboratory (Grove, 1991). This long-distance coordination using computing tools is the beginning stage of a group decision support system (GDSS). GDSS's have not had much success in the past, perhaps because they were ahead of their time. Past GDSS efforts encouraged groups to change their normal relationships and work patterns without providing them the proper tools. In fact, until recently, computers have not changed the way individuals or groups work, but only allowed them to work more quickly or accurately. If, as forecast, CSC alters the way organizations work, GDSS may play a large part in the new procedures and relationships.

Another avenue to be explored is the employment of expert systems, programmed with the knowledge of one or more human experts, that can respond to both quantitative and qualitative questions with advice and logic. Expert systems may eventually lead to neural networks that can be trained much the way a human brain is trained by repetitive experiences, and may be used to solve problems too difficult for the human brain to understand or problems not appropriate for any other system. (Malone and Rockart, 1991)

D. SCENARIO 2010

The most difficult task for most planners is to look beyond the challenges of the present and immediate future to focus on the demands of the distant future. Futuristic enemies, weapons, and technologies can be very difficult to forecast with any certainty, and basing detailed development decisions on those forecasts would be unwise anyhow. However, forecasts are useful to chart general trends and to provide a scenario for examining alternate architectures. The further from the present the forecast reaches, the more important flexibility becomes in system capability. Even in the recent war in SWA, flexibility was the most important characteristic in C2 architecture (Starr, 1991).

Developing flexible information systems requires slipping free from the burden of current strategies and hurdling mind-set roadblocks to explore the possibilities of future technologies. It could be anywhere in the year 2010.

1. The Commander

The Brigade Commander on duty in the Southern Hemisphere has been monitoring activities in East Ghormel on the Worldwide Intelligence Broadcast (WIB). The WIB is a database of current information on a variety of topics that are continuously updated by every intelligence agency in the government. This all-source fusion is graded for accuracy and filed in multilevel categories for ease of sorting for any intelligence detail the commander requests. Based on comparison of State Department reports, Defense Intelligence Agency summaries, and Central Intelligence Agency accounts, he notices that today's evaluation of military activity in East Ghormel indicates an increased movement level in the Northern Province.

Sorting for specific weapon threats in this area, he notes the presence of PR-8 nuclear devices manufactured by an East European country. Hypertexting to related information reveals the date of delivery of the devices, their most recent employment, and material composition. Sorting the database again, he discovers the name of the province commander and is able to hypertext search for biographical information, and recent contacts in the U.S. A former ambassador to East

Ghormel, now serving in Switzerland is given as the best source of personal information on the province commander.

As the Brigade Commander leaves his quarters, his commander's badge signals the tenant computer to record his most recent planning activities in memory for immediate retrieval, to secure his wall display to prevent use by anyone else, and to distribute the results of his information searches to members of his staff whom he has previously designated as recipients. This technique keeps his staff thinking with him and saves them time conducting similar searches.

When the Brigade Commander Arrives in his Operations Center, the tenant computer, alerted by a signal from the commander's badge, automatically registers him. This routes all incoming calls to the nearest communications device, calls up his most recent planning activities from memory, and updates previously designated critical information requirements on displays in whatever area he moves into.

2. The Staff

The Brigade Staff, operating in a free-flow planning environment, have followed their commanders's intelligence search and have already taken action on several matters. The G-2 is arranging a video-conference with the former ambassador over broadband link, a secure communications channel with sufficient multiplexed capacity to be transparent to the user, *to discuss the Province Commander's personality and background. The G-3 has obtained still photos with analyst notations of the PR-8 sites from Washington D.C. The photos are almost immediately flashed to forward-based reconnaissance teams in the area for on-site observation. Their picture overlay reports will be transmitted back from their digitized chalkboards and integrated immediately into the developing intelligence picture. The weapons employment officer is working on a computer-animated operation plan for distribution to subordinate commands. The Operations Chief is almost finished integrating a three-dimensional display of the target area linking terrain database input with weather data and current enemy and friendly force distributions.*

The work of all staff members is meshed by the staff-planning network, which uses key-word indicators to provide intra-staff prompts to keep each staff member focused on the common goal. The status of each member's effort posts to a common wall-size screen where the Chief of Staff monitors the entire endeavor, providing guidance as necessary. Issues to be addressed by separate staff members are listed on the margins of the main screen by anyone who perceives a gap in the planning. All logistical implications are sorted automatically in each member's work area and forwarded to the G-4, who commences baseline tasking for a dozen different contingencies.

3. The Plan

Upon entering the operations center, the Brigade Commander confers with the Chief of Staff to discuss his intentions. The main display screen responds to voice commands while the two officers adjust planning priorities and answer staff queries. The Commander conducts a brief conference brainstorming session via the broadband net with subject matter experts in several agencies in CONUS. Their common planning screen is a section of the wall-size screen in the operations center.

With recently updated guidance from the NCA, the Commander's critical parameters are fed into the adaptive intelligence processor, affectionately known as Napoleon. Its expert system module produces recommended actions and alternatives. These are routed into the neural network module where, based on experience with similar parameters and recommended actions, the results are forecast. Napoleon is flexible enough to allow reprogramming of certain parameters to determine thresholds for pivotal outcomes. These wargaming scenarios are transmitted to subordinate commanders with annotated comments of the Brigade Commander. The subordinate units are small and armed with a limited amount of smart weapons, relying on the thoroughness of their plan, the accuracy of their weapons, and the quality of their training.

4. The Results

This scenario is certainly futuristic and most likely not accurate in many aspects concerning the information processing capabilities 20 years from now. The particular technology employed is not significant, but the shift in focus of the players. No longer will the crush of information overload be the primary contribution of the computer age. Instead, the ubiquitous computer will make obtaining and fusing information trivial. The computers will quickly and sometimes automatically handle the routine and currently time-consuming chores of information processing. Humans will be set free to use their brain power for the really important tasks of making judgments and determining priorities. People, not machines, will again become the focus in command and control. The full attention of the human brain may again be applied to conducting war.

> ...the conduct of war is ultimately an art, an activity of human creativity and intuition powered by the strength of the human will. The art of war requires the intuitive ability to grasp the essence of a unique battlefield situation, the creative ability to devise a practical solution, and the strength of purpose to execute the act. (FMFM 1, 1989, p. 15)

The part to by played by computers and communications in future C2 is a supporting role. It is a vital role, however. It is the role of freeing creative ability to again dominate the battlefield.

E. C2 FOR 2010

1. Forecasting Requirements

How can one forecast what C2 needs will be 20 years from now? How can one predict what technologies to develop to meet those needs? These are difficult, if not impossible questions to answer with any accuracy. Yet, that is precisely what current procurement practices attempt. The development schedule for a C2 system may span up to 10 years. With new generations of computer and communications technology appearing every 15-18 months, the unfortunate result is C2 systems that are planned 10 years ahead of their need with technology that will be 5-7 generations old by the time it is fielded. Given the shrinking defense budget and restrictive acquisition regulations, is there any solution?

2. A Proposal

a. Requirements and Technology

Shrinking budgets and restrictive regulations may make a solution difficult to determine, but an optimizing strategy is appropriate. Expense and long development times for new technologies have been suggested as the roadblocks to more modern and effective C2 equipment. This should not lead to the conclusion that technology should drive operational requirements. The opposite is true. Operational requirements must always drive the selection if not the development of technology. A sound strategy, then, would be to evaluate C2 functions and attempt to match available technologies to each function.

The Marine Corps LAN is a good example of this procedure. A major function of C2 is information processing. In recent years, the volume of information to process has overwhelmed the information system capacity. With limited research and development costs, the LAN, an application from the business world, was procured and employed with impressive results. It has some limitations that need to be addressed. However, its advantages are hard to ignore. It works relatively well and it is available now.

b. Planned Incremental Modernization

This procedure needs to be employed in a more general manner to command and control systems. A working group of knowledgeable Marines in the field of command and control functions should establish current requirements without concern for the equipment or procedures currently being used. Then, appropriate equipment and procedures can be matched to those requirements. This procedure should be repeated at least once within each generation of computer and communications technology. This allows rapid application of new technology to C2 systems. Not every new technology will be both applicable and affordable. Also, each new addition to the C2 architecture must be interoperable with existing systems. This strategy is called Planned Incremental Modernization (PIM) in the logistics world.

c. *Facility*

The demonstration facility suggested in Chapter 4 for use in training C2 staffs would be an excellent laboratory for evaluating C2 requirements. Additionally, new technologies could be demonstrated easily in a realistic environment to determine their value. This C2 laboratory could be the spawning ground for improved procedures to employ Marine forces more efficiently on future battlefields using the best suited equipment within the limited procurement dollars available.

3. Looking Ahead

Frequently the impact of new technology on warfare has not been immediately appreciated. Examples are numerous:

- the swiftness of the chariot
- the accuracy and range of the rifled musket
- the dominating shock effect of the tank
- the coordinating power of radio
- the accuracy and usefulness of radar
- the effectiveness of carrier aircraft
- the stealthful strike of the submarine

Could information technology be the smart weapon of the next war? While innovative leaders focus on the future to chart a course for the present, they must maintain an advantage in the C2 decision cycle. Let it not be said that Marines failed to understand the impact of this new technology during the period of relative peace at the end of the 20th century.

APPENDIX A: ABBREVIATIONS AND ACRONYMS

ANGLICO	Air Naval Gunfire Liaison Company
ATO	Air Tasking Order
BSSG	Brigade Service Support Group
C2	Command and Control
CENTCOM	Central Command
COC	Combat Operations Center
CSC	Computer Supported Collaboration
DFASC	Deployable Force Automated Service Center
DSA	Division Support Area
EIS	Executive Information System
ES	Expert System
FSSG	Force Service Support Group
GDSS	Group Decision Support System
GMF	Ground Mobile Forces
HW	Hardwire or Hardware
IFASC	Interim Force Automated Service Center
MAG	Marine Air Group
MAGTF	Marine Air Ground Task Force
MAW	Marine Air Wing
MCDN	Marine Corps Data Network
MEF	Marine Expeditionary Force
MSE	Main Subordinate Element
NCA	National Command Authority
OODA	Observation-Orientation-Decision-Action

RASC	Regional Automated Support Center
SCI	Sensitive Compartmented Intelligence
SWA	Southwest Asia
T/E	Table of Equipment
T/O	Table of Organization
TACC	Tactical Air Command Center
TAOC	Tactical Air Operations Center

APPENDIX B: DEFINITIONS

All taken from the U.S. Marine Corps Command and Control Master Plan, August 1987, Headquarters Marine Corps, Washington D.C.

AN/GRC-201 Radio Set	A 4.4 to 5.0 GHz communications system that receives and transmits voice and data signals in troposcatter and line of sight modes. It provides 12 channels of teletype, or 12/24 channels of time division multiplexed/pulse code modulated traffic.
AN/YK-83/85	Deployable, tempest-certified desktop and portable computers for field use.
AN/TSC-93 Satellite Communication Terminal	A nodal or point to point terminal capable of transmitting and receiving 6-24 channels on a single carrier. Uses eight foot ground-mount antenna.
AN/TSC-85 Satellite Communication Terminal	A nodal or point to point trunking terminal capable of transmitting a single, multiplexed, high-data-rate carrier frequencies (6-48 channels) and receiving up to four independent carrier frequencies (6-24 channels). As a hub terminal, can simultaneously communicate with four AN/TSC-93 spoke terminals. Uses eight foot ground-mount antenna.
AN/TRC-170 Troposcatter Radio Set	A 4.4 to 5.0 GHz line of sight or troposcatter, radio terminal set being developed under the TRI-TAC program. It provides the capability for transmission and reception of digital voice, analog voice, quasi-analog and digital data signals at ranges out to 100 miles. It is secured by the KG-58 (voice) and KG-84 (data) and will eventually replace the AN/GRC-201.
AUTODIN	A worldwide data communications network of the Defense Communications System; acronym for AUTOmatic Digital Network.
AUTOVON	A worldwide automatic communications system for end-to-end circuit-switched voice connections to the Defense Communications System. Acronym for AUTOmatic VOice Network.
Digital Communication Terminal	A lightweight, handheld, message processor for fixed or variable format messages. Provides netted or point to point communications over a variety of radios or wire.

MRC-135 Radio Set	Mobile, VHF/FM multi-channel analog radio. It provides eight 3 KHz voice channels to a distance of 20 miles.
STU III	Secure Telephone Unit with internal modem providing transmission rate of 2400 bps.
TSEC/KY-68 Digital Subscriber Voice Terminal (DSVT)	A terminal containing the audio-processing, signaling, and cryptographic functions necessary to provide secure and non-secure telephone and data access to the TRI-TAC family of digital circuit switches.
TSEC/KG-84 Dedicated Loop Encryption Device (DLED)	A device for encryption of TTY and data traffic on netted and point to point circuits.

Appendix C: INFORMATION REQUIREMENTS

1. "Often, the target intelligence received from higher-level sources at the division--necessary to conduct effective targeting--was outdated." "In general, our ability to disseminate targeting information efficiently requires closer scrutiny." (Mazzara, 1991)

2. "Battle damage assessment, however, was seldom available in a timely manner at the division level or below. We can fix this through increased emphasis on the downward push of this information at all levels, as well as with the assistance of digital command-and-control equipment." (Mazzara, 1991)

3. "We've reported 'unexplained' incidents and patrol contacts almost every night. No analysis, no support, no intel, just info." "Intelligence guys, take off your trench coats, put on your flak jackets and helmets, and get down." (Huddleston, 1991)

4. "Duplication of effort was widespread as several officers from different functional areas of the staff pursued the same piece of information, sometimes a day or more after an issue had been resolved. The result was a slow, overblown system that wasted hours of time and energy as information seekers and processors tried to feed the handful of decision-makers what was vital, while keeping everybody else in the information loop." (Armstrong, 1991)

5. "There is an increasing demand to transmit greater amounts of command and control, logistical, and intelligence data via the airwaves." (Ennis, 1991)

6. "Units designated as the POME (Point Of Main Effort) must be provided the means to rapidly report and receive information and intelligence. This includes communications, intelligence collection assets, and rapid access to all sources of intelligence, if necessary." (Moore, 1991)

7. "...the ability to fuse intelligence from all sources, identify that which is needed by various echelons of command, and rapidly disseminate that information in a usable form, both afloat and ashore, is critical to success." (Bierly and Seal, 1991)

8. During Desert Storm/Desert Shield, weather data such as winds, cloud cover, and visibility, took too long to obtain. (MCLLS)

9. During the war, dissemination of intelligence, once it was obtained, was a problem. (MCLLS)

10. Remotely Piloted Vehicle information flow needs to be improved in two areas: the flow of flight control information from the information users to the pilots and the flow of target location information from the pilots to the users. (MCLLS)

11. During the war, bomb damage assessment (BDA) choked communications channels largely because duplicate information was submitted by different sources. (MCLLS)

12. During Desert Shield/Desert Storm, information flow between operations and intelligence sections was less than desired. (MCLLS)

APPENDIX D: COMMANDER'S CRITICAL INFORMATION REQUIREMENTS

INTELLIGENCE

INFORMATION	SOURCE
UNIT (ORDER OF BATTLE)	
NAME	ORDER OF BATTLE HANDBOOK
TYPE	DIA FACTBOOK, SPOT REPS
SIZE	ITU REPS, SALUTE REPS
STRENGTH	SHELL REPS, DISUMS, INTSUMS
WEAPONS	CI REPS
EQUIPMENT	G-2 OB WORKBOOK
LOCATION	SALUTE REPS, SHELL REPS
ACTIVITY	SPOT REPS, DISUMS, INTSUMS CI REPS, ITU REPS
LOGISTICAL INTELLIGENCE	
TRANSPORTATION OF TROOPS- ROUTES	TERRAIN ANALYSIS, TACTICAL MAPS, SALUTE REP, SPOT REPS, SHELL REPS
VULNERABILITY ASSESSMENT OF REAR AREA	SALUTE REPS, SPOT REPS, CI REPS, ITU REPS, DISUMS, INTSUMS, OB HANDBOOK, G-2
VULNERABILITY ASSESSMENT OF CSSA STOCKPILES	ANALYSIS
VULNERABILITY TO LANDING SUPPORT OPS	
EXPLOITATION OF URBAN AREAS	
FACILITIES	DIA FACTBOOKS, TERRAIN ANALYSIS
COMMUNICATIONS	NIPS DATA BASE, AREA HANDBOOKS,
SUPPLY CLASSES I,II,IV	G-2 ANALYSIS
FACILITIES (CPs, AIRFIELDS, HLZs, VEH PARKS, ETC.)	
TYPE	SALUTE REPS, DISUMS, INTSUMS,
SIZE	CI REPS, ITU REPS, SPOT REPS
LOCATION	SAME
CAPABILITIES	
WHAT CAN HE DO?	G-2 ANALYSIS
WHEN CAN HE DO IT?	SAME
WHERE CAN HE DO IT?	SAME
IN WHAT STRENGTH?	SAME

INFORMATION	SOURCE
INTENTIONS	
COURSES OF ACTIONS (ATK, DEF, DEL, ETC.)	G-2 ANALYSIS, MEF INTSUM, DISUM
LOC OF MAIN ATK	SAME
TYPE OF UNITS/STRENGTH	SAME
TERRAIN	
TERRAIN FEATURES	TERRAIN, INTELL, & AMPHIB STUDIES
TERRAIN COMPARTMENTS	SAME
BARRIERS	SAME
AVENUES OF APPROACH	SAME
SURFACE MATERIALS	SAME
HYDROGRAPHY	SAME
VEGETATION	SAME
CULTURAL FEATURES	SAME
TRAFFICABILITY	TERRAIN, INTELL, & AMPHIB STUDIES & G-2 ANALYSIS
EFFECTS ON OPERATIONS	SAME
WEATHER	
TEMPERATURE	WEATHER REPORTS FROM CATF, MEF, LOCAL AGENCIES
WINDS	SAME
HUMIDITY	SAME
VISIBILITY	SAME
EFFECT ON OPERATIONS	G-2 ANALYSIS
ASTRONOMICAL DATA	
BMNT	ASTRONOMICAL STUDIES
SUNRISE	SAME
SUNSET	SAME
EENT	SAME
MOONRISE	SAME
MOONSET	SAME
PERCENT ILLUMINATION	SAME
EFFECT ON OPERATIONS	G-2 ANALYSIS

OPERATIONS

INFORMATION	SOURCE
CURRENT OPERATIONS	
TASK ORGANIZATION	DIV OPERATION & FRAG ORDERS
MISSION	SAME
TASKS	SAME
UNITS	
NAME	DIV TROOP LIST & TASK ORGANIZATION
TYPE	SAME
SIZE	SAME
LOCATION	SUBORDINATE UNIT FRAG ORDERS & SPOT REPS
ACTIVITY	SAME
COMBAT READINESS	SUBORDINATE UNIT SPOT REPS
MOPP ALERT STATUS	G-3 ANALYSIS AND SUBORDINATE UNIT SPOT REPS
CONTROL MEASURES	MEF & DIV OP AND FRAG ORDERS
UNITS (ADJACENT & SUPPORTING)	
NAME	MEF OPERATION & FRAG ORDERS
TYPE	SAME
SIZE	SAME
LOCATION	SAME
ACTIVITY	SAME
ENGAGEMENT RESULTS	
FRIENDLY LOSSES	SUBORDINATE UNIT SPOT & CAS REPS
KIAS	SAME
WIAS	SAME
MIAS	SAME
WEAPONS	SUBORDINATE UNIT SPOT REPS
EQUIPMENT	SAME
ENEMY LOSSES	SAME
KIAS	SAME
WIAS	SAME
PWS	SAME
WEAPONS	SAME
EQUIPMENT	SAME

INFORMATION	SOURCE
FUTURE OPERATIONS	
TASK ORGANIZATION	DIV OPERATION & FRAG ORDERS
MISSION	SAME
TASKS	SAME
UNITS	
NAME	DIV TROOP LIST & TASK ORGANIZATION
TYPE	SAME
SIZE	SAME
LOCATION	SUBORDINATE UNIT FRAG ORDERS AND SPOT REPS
ACTIVITY	SAME
COMBAT READINESS	SUBORDINATE UNIT SPOT REPS
MOPP ALERT STATUS	G-3 ANALYSIS AND SUBORDINATE UNIT SPOT REPS
CONTROL MEASURES	MEF & DIV OPERATION AND FRAG ORDERS
UNITS (ADJACENT & SUPPORTING)	
NAME	MEF OPERATION & FRAG ORDERS
TYPE	SAME
SIZE	SAME
LOCATION	SAME
ACTIVITY	SAME

FIRE SUPPORT

ARTILLERY	
UNITS	
DESIGNATION	DIVISION OPERATION & FRAG ORDERS
CALIBER	SAME
LOCATION	FIRE CAPS
ACTIVITY	SAME
MISSION	DIVISION OPERATION & FRAG ORDERS
WEAPONS STATUS	FIRE CAPS
AMMO STAT (BA & DOAS)	FIRE CAPS

INFORMATION	SOURCE
NAVAL GUNFIRE	
NAME	CATF & MEF OPERATION & FRAG ORDERS
TYPE OF GUNS	SAME
POSITION	SAME
MISSION	SAME
WEAPONS STATUS	SAME
AMMO STATUS	SAME
AIR FIRE SUPPORT	
SCHEDULED MISSIONS	ATO & DASC
ON CALL MISSIONS	ATO & DASC
AIR DEFENSE	
UNITS	
DESIGNATION	MEF & MAW OPERATION & FRAG ORDERS
TYPE	SAME
SIZE	SAME
LOCATION	DASC
MISSION	MEF & MAW OPERATION & FRAG ORDERS
ALERT STATUS	DASC
WEAPONS STATUS	DASC
AMMO STAT (BA & DOAS)	DASC
TARGET ACQUISITION ASSETS	
SYSTEM	DIVISION OPERATION ORDER
LOCATION	FSCC
CUING INSTRUCTIONS	FSCC
ENEMY INDIRECT FIRE WEAPONS	
CALIBER	SHELL REPS
TYPE	COUNTER-MORTAR RADAR, SHELL REPS
LOCATION	SPOT REPS
COORDINATION MEASURES & FRAG	MEF & DIVISION OPERATION ORDERS

PERSONNEL

INFORMATION	SOURCE
AUTHORIZED STRENGTH	PERSONNEL STATUS & EFFECTIVENESS REPORT
ACTUAL STRENGTH	SAME
GRADE AND MOS DATA	SAME
LOSSES	
BATTLE LOSSES	SPOT & CAS REPS
KIA	SPOT & CAS REPS
WIA	SPOT & CAS REPS
MIA	
NON-BATTLE LOSSES	
ILLNESS (MEDEVACED)	CAS REPS
INJURY(MEDEVACED)	CAS REPS
NON-BATTLE DEATHS	CAS REPS
PWS CAPTURED	SUBORDINATE UNIT SPOT REPS

LOGISTICS

INFORMATION	SOURCE
SUPPLY (ON HAND VS OBJ IN DOS)	
CLASS I (C)	FSSG LOGISTICS SUMMARY
CLASS III (W)	SAME
CLASS IV	SAME
CLASS V (W)	SAME
CLASS VIII	SAME
MAINTENANCE (NMCM/NMCS)	
M198 HOW	SPOT RES & DIVISION LOGISTICS SUMMARY
M1 TANK	SAME
AAV P7A1	SAME
AAV C7A1	SAME
TOW	SAME
COMMUNICATIONS	
COMM NET STATUS	ORAL REP FROM SYSCON
INFO SYSTEMS STATUS	SAME
VOICE CALL SIGNS	APPROPRIATE CMS MATERIAL
CALL SIGNS SUFFIXES	SAME
CLOCKS (LOCAL & "Z")	

Source: USMC OH 6-1A

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