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THESIS

A PROPOSED BATTALION AND BELOW COMMAND AND CONTROL (B2C2) SYSTEM ARCHITECTURE FOR THE ARMOR BATTALION

by

Michael D. Landers

June, 1993

Principal Advisor:
Associate Advisor:

Dan C. Boger
Carl R. Jones

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A Proposed Battalion and Below Command and
Control (B2C2) System Architecture for
the Armor Battalion

by

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Submitted in partial fulfillment
of the requirements for the degree of

MASTER OF SCIENCE IN SYSTEMS TECHNOLOGY
(Command, Control, and Communications)

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Command, Control, and Communications Academic Group

ABSTRACT

The Army Command and Control System (ACCS) is the system of systems for Army command and control. The tactical portion of ACCS is the Army Tactical Command and Control System (ATCCS). ATCCS applies to Echelons Corps and Below and presently extends down to the brigade level. Efforts within the Army are ongoing to extend the ATCCS to the battalion level but have not yet been completed. This thesis proposes a battalion and below command and control (B2C2) system architecture for the armor battalion. The architecture defines the necessary component systems to be included within the architectural framework and how those component systems should be integrated within a B2C2 framework.

The component systems involved are the Intervehicular Information System (IVIS), the Combat Vehicle Command and Control (CVC2) System, the Command and Control Vehicle (C2V), the Common Ground Station, the Single Channel Ground and Airborne Radio System (SINGARS), Mobile Subscriber Equipment (MSE), Enhanced Position Location and Reporting System (EPLRS), and Common Hardware Software (CHS).

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TABLE OF CONTENTS

I.	INTRODUCTION	1
A.	FOCUS OF THIS STUDY	1
B.	OBJECTIVE OF THE STUDY	2
C.	RESEARCH QUESTIONS	3
	1. Primary Research Question	3
	2. Secondary Research Questions	3
D.	RESEARCH METHODOLOGY	4
E.	SCOPE OF THIS STUDY	5
F.	ORGANIZATION OF THE STUDY	6
II.	FRAMEWORK AND BACKGROUND	7
A.	INTRODUCTION	7
B.	AIRLAND BATTLE DOCTRINE	10
	1. Doctrinal Tenets	10
	2. AirLand Battle Doctrine Communications	11
C.	FRAMEWORK	13
	1. ACCS	13
	2. ATCCS	14
	a. MCS	16
	b. ASAS	17
	c. CSSCS	17
	d. FAAD C2I	17

e. AFATDS	18
3. B2C2	19
4. IVIS	20
D. SUMMARY	21
III. DESCRIPTION OF SYSTEMS	24
A. IVIS	25
1. Functional Description	25
2. Physical Description	27
a. The Core Tank	27
(1) Data management system (MIL STD 1553B Data Bus).	28
(2) Power management (RS 485 electrical interface)	28
(3) Modified Slipring Assembly.	28
(4) Hull Electronics Unit (HEU).	28
(5) Turret Electronics Unit (TEU).	28
(6) Fire Control Electronics Unit (FCEU).	29
(7) Hull-Turret Position Sensor (HTPS).	29
(8) Digital Engine Control Unit (DECU).	29
(9) Commander's Integrated Display (CID).	29
(10) Gunner's Control and Display Panel (GCDP).	29
(11) Driver's Integrated Display (DID).	30

b.	Commanders Independent Thermal Viewer (CITV)	31
B.	CVC2	31
1.	Functional Description	34
2.	Physical Description	35
C.	B2C2	36
1.	Functional Description	36
2.	Physical Description	37
D.	C2V	38
1.	Functional Description	38
a.	Capabilities and Configuration	38
b.	C2V Deployment	41
2.	Physical Description	41
E.	COMMON GROUND STATION (WARRIOR)	44
1.	Functional Description	44
2.	Physical Description	48
F.	COMBAT NET RADIO (SINGGARS)	49
1.	Functional Description	49
2.	Physical Description	50
G.	AREA COMMON USER SYSTEM (MSE)	51
1.	Functional Description	51
2.	Physical Description	52
H.	ADDS (EPLRS)	53
1.	Functional Description	53
a.	Capabilities	53
b.	Deployment	55

2.	Physical Description	55
a.	Net Control Station	55
b.	Radio Set (RS)	57
3.	Technical Description	59
I.	CHS	61
1.	Functional Description	61
2.	Physical Description	62
a.	Block II CHS	62
b.	MCS Block IV	63
J.	SUMMARY	65
IV.	PROPOSED ARCHITECTURE	66
A.	EXISTING ARCHITECTURE	67
1.	TOC	69
2.	TAC	70
3.	ALOC	71
4.	Field Trains	71
5.	Companies	71
6.	Attachments	72
7.	Deficiencies of the existing architecture	72
B.	PROPOSED ARCHITECTURE	73
1.	TOC	75
2.	TAC	78
3.	ALOC	79
4.	Field Trains	80
5.	Companies	81

6. Attachments	82
7. Solutions To Current Deficiencies	82
V. SUMMARY, CONCLUSIONS, RECOMMENDATIONS	85
A. SUMMARY	85
B. CONCLUSIONS	86
C. RECOMMENDATIONS	86
1. Future research areas	86
2. Possible continuation of the architecture with future systems.	86
LIST OF REFERENCES	88
INITIAL DISTRIBUTION LIST	90

LIST OF FIGURES

Figure 1 Army Command and Control System 14

Figure 2 ATCCS Architecture 19

Figure 3 IVIS internal information flow and
interfaces 30

Figure 4 M1A2 Core Tank 32

Figure 5 M1A2 Core Tank with IVIS and RIU
Interfaces 33

Figure 6 C2V view of Common Hardware Software
Locations 43

Figure 7 C2V view of Battle Staff Workstations . . . 44

Figure 8 Common Ground Station 46

Figure 9 CGS information paths 49

Figure 10 EPLRS Net Control Station Configuration . . 57

Figure 11 Enhanced PLRS User Unit (EPUU) 58

Figure 12 Common Hardware Software 65

Figure 13 Existing battalion command and control
structure 68

Figure 14 Proposed battalion TOC 77

Figure 15 Proposed TAC 79

Figure 16 Proposed ALOC 80

Figure 17 Proposed company architecture 81

Figure 18 Proposed battalion command and control
architecture 84

I. INTRODUCTION

A. FOCUS OF THIS STUDY

The Army Command and Control System (ACCS) is the system of command and control systems for Army command and control.

It is:

the aggregate means by which Army commanders employ and sustain military forces in a theater of operations. ACCS consists of the organizations (comprised of personnel, facilities, equipment, communications and other materiel), training (standards, SOPs) and C2 doctrine (e.g., processes, organization of staffs and CPs). ACCS is a web of C2 systems across the theater of operations. [Ref. 1:p. 1-1]

Within this umbrella is the Army Tactical Command and Control System (ATCCS). The Army Tactical Command and Control System is the tactical portion of ACCS and applies to Echelons Corps and Below. The ATCCS is a hierarchy of systems operating within five Battlefield Functional Areas (BFAs). The five BFAs are Maneuver, Fire Support, Intelligence and Electronic Warfare, Air Defense, and Combat Service Support. These component functional areas process three categories of information: technical, staff, and command. [Ref. 2:p.1-1] Originally ATCCS was designed to operate from Corps to Brigade. Plans are to extend ATCCS to the Battalion using the Battlefield Functional Area Control Systems (BFACS) for the Fire Support, Maneuver, and Air Defense BFAs. The extension is called Battalion and Below Command and Control (B2C2) and

will extend ATCCS to the platoon level. The focus of this study is on the B2C2 level.

The emphasis in this thesis is on horizontally integrating the battlefield to provide battlefield synchronization to the battalion commander. The effects of synchronization can serve to multiply the combat effects of a force.

Because of the strategies of deception, maneuver and speed employed by coalition forces in Desert Storm, knowledge came to rival weapons and tactics in importance, giving credence to the notion that an enemy might be brought to its knees principally through destruction and disruption of the means for command and control [Ref. 3:p. x].

Fast, accurate synchronization across the combined arms team through mission planning, battlefield reporting, and sustaining combat power with on board fault isolation tools become combat multipliers for the commander. This thesis proposes the architecture to provide a Battalion and Below Command and Control system with these capabilities to the commander.

B. OBJECTIVE OF THE STUDY

The objective of this thesis is to describe an architecture for the M1A2 equipped Armor Battalion/Task Force Commander. The architecture will utilize concepts, systems, hardware and software already in existence, as well as systems under development. This will center around the B2C2 system and related hardware and software systems that support B2C2. The systems involved are the Command and Control Vehicle (C2V),

the Intervehicular Information System (IVIS), and the Common Ground Station (Warrior). The C2V is a command post vehicle based on a Bradley suspension and Multiple Rocket Launcher System (MLRS) chassis which will transport the command posts at a speed roughly equivalent to the M1 Abrams tank and M2/M3 Bradley Infantry and Cavalry vehicles. The IVIS is the conceptual sharing of information and system connections of specific hardware components included in the M1A2 Abrams tank. The future IVIS system is the Combat Vehicle Command and Control System (CVC2). The Common Ground Station (CGS) is an intelligence system being developed at Ft. Huachuca, AZ.

C. RESEARCH QUESTIONS

1. Primary Research Question

What functional and physical architecture can be developed using existing systems, and how can the systems being investigated be integrated within the Army Tactical Command and Control System?

2. Secondary Research Questions

What physical system limitations exist to prevent ATCCS, B2C2 and IVIS integration, as well as integration of the IVIS and Common Ground Station (Warrior)? What is the existing architecture and what architecture should be proposed as a Battalion and Below Command and Control System?

D. RESEARCH METHODOLOGY

Sources of information were literature searches through Defense Technical Information Center (DTIC), the thesis section of the Knox Library at the Naval Postgraduate School, and existing publications in full or draft form from various Program Management offices. Trips to development locations to confer with those organizations, activities, and personnel developing leading edge systems gained more undocumented information. These visits were a collection of interviews and observations of the systems in action or through exercises in simulators.

Information about the Common Ground Station (Warrior) was collected by reviewing a thesis [Ref. 4] prior to visiting the development site at Ft. Huachuca, AZ. There the system was observed in a capabilities demonstration. Documentation about the CGS is extremely limited and not available at this writing.

Information about IVIS and CVC2 was collected through observations of the system in use and hands on experience with the simulators at the Mounted Warfare Test Bed, Ft. Knox, KY. Additional information was gained through documentation.

Information concerning Single Channel Ground and Airborne Radio System (SINCGARS), Common Hardware Software (CHS) and Mobile Subscriber Equipment (MSE) was obtained through document searches with further information provided by the Program Management Offices (PMOs). Information about EPLRS

was obtained by documentation from the PMO and a visit to the equipment technical test site at FT. Huachuca, AZ.

Research efforts centered around identifying the capabilities and external interfaces of each specific system. The capabilities are examined to determine possible placement in the architecture. The external interfaces are evaluated to determine connectivity with other systems, host vehicles and host hardware. This information was used to construct the architecture in terms of meeting the users functional needs yet being physically possible.

E. SCOPE OF THIS STUDY

This study is limited to Army systems. It is further limited to those systems to be utilized by a Battalion Commander in his Command and Control (C2) System. Attention has been paid to developmental as well as existing systems. Systems already fielded or in manufacturing are the IVIS (in development for the M1A2) which has not been fielded, the SINCGARS radio, the MSE area common user system, the CHS, EPLRS and the C2V (the transport vehicle only). Developmental systems are the Combat Vehicle Command and Control (CVC2) system, the Common Ground Station (Warrior), and the Situational Awareness software for EPLRS.

F. ORGANIZATION OF THE STUDY

Chapter II provides the framework of command and control systems, with specifics about the Army Tactical Command and Control System (ATCCS). The five battlefield functional areas (BFAs) are described in terms of what function they serve in the overall tactical command and control system. Chapter III examines in depth the capabilities and interfaces of each of the specific systems used in the proposed architecture. The proposed architecture is described in Chapter IV in forms of both functional and physical architectures. Recommendations and conclusions are in Chapter V.

II. FRAMEWORK AND BACKGROUND

A. INTRODUCTION

The battalion commander of the future will command a combined arms team encompassing armored and infantry companies, scouts, field artillery support teams, engineers, air defense artillery assets and organic logistical support assets, all aimed at focusing combat power at a specific location on the battlefield. He could therefore have representatives of all Battlefield Functional Areas (BFAs) within his command structure at one time. The battalion is the lowest echelon where a dedicated staff exists to assist the commander in the management of these BFAs. This staff must assist the commander with information collection, management, decision making and dissemination.

The commander's decision process requires accurate and timely information with which to focus his combat power. Future conflicts or crises are anticipated to be no-notice, come-as-you-are in regional locations possibly lacking existing local communications infrastructure. The battalion commander fights the Near Term and Immediate battle with an environment characterized by "increased confusion, conflicting

information, decreased time for planning, and an overall sense of immediacy and increased pressure".¹

The pace of future conflicts will be faster, decisions must be quicker yet based upon highly accurate information, and the environment in which the commander operates will be ever-changing. As such, the commander must have organic to his unit those systems necessary to provide the picture of the battlefield necessary to make optimum decisions. He must also have the common picture of his higher and subordinate commanders and units. Imperative to future success on the battlefield is the ability to react faster than the opponent with greater and more accurate information than the enemy. Obviously the faster the processes of sense, detect, process, decide, act can be accomplished, the more time is available to the commander for supervision and plans refinement. He must therefore have a C2 system geared to this end. The battalion commander, while controlling a combined arms team, does not operate independently. He must rely on horizontal and vertical integration of his forces and C2 systems to

¹"Near Term" and "Immediate" battle management are terms created by the U. S. Army Research Institute for the Behavioral and Social Sciences Field Unit at Fort Leavenworth, Kansas to describe the phases of battle management. Planning that occurs well (from weeks to years) before the battle is "Long Term". Near term planning takes place just prior to the commencement of battle (as far out as weeks and as near as a few days). The planning and execution of the battle during its actual conduct is Immediate planning.

operate as part of a larger force. Therefore he must be able to communicate with subordinate units, adjacent units and superiors. His C2 systems must integrate with these other forces, creating a command and control architecture that allows for timely transfer of information and a common picture of the battlefield.

Based upon Desert Storm, the National Training Center at Ft. Irwin, CA, and European experiences, the commander needs better tools for command and control. He needs the ability to:

1. Command and control on the move
2. Have accurate position and navigation (POS/NAV)
3. Identify friendly vehicles
4. Conduct target acquisition and engagement in a coordinated fashion
5. Rapidly employ supporting fires from artillery, mortars, close air and helicopters.

As recently as 25 March 1993 a demonstration was held at the Mounted Warfare Battle Lab demonstrating the linkability of several systems and the potential to help provide these tools to the commander. A separate demonstration of the Common Ground Station (Warrior) was held in late April 1993 for providing enemy information and the Intelligence Preparation of the Battlefield. All systems however, must support the Army C2 structure and doctrine.

B. AIRLAND BATTLE DOCTRINE

1. Doctrinal Tenets

The current doctrine for the U.S. Army requires U.S. forces to maintain the initiative on the battlefield, look and fight in depth, and demonstrate agility against a numerically superior enemy force. All of this must be accomplished in a synchronized fashion for it to be most effective. The synergistic effects of a unified force are much greater than the sum of the effects of individual units. The doctrine requires action on our part instead of reaction to enemy actions. The doctrine also presupposes an efficient and effective communications system with which to share the information gained, and to do so quicker than our adversary. Agility, Initiative, Synchronization and Depth are the four tenets of the AirLand Battle Doctrine. These tenets provide an action oriented doctrine that is designed to win.

Agility is the ability to think, process information and act faster than the enemy. Initiative, in AirLand Battle terms, is setting the tone of the fight by an offensive spirit. Gaining the upper hand through analysis of information provides a means to seize the initiative. Synchronization requires all participants to know what is going on around them (by possessing a "situational awareness"). This requires a common picture of the battlefield with which to work from. The inclusion of a C2

system that promotes this common picture for all participants allows synchronization of assets by the commander to the central point of battle. Depth refers to the extension of the battlefield in time, distance, and resources. Depth in terms of time is the organization of efforts by commanders of different levels to separate the time frames in which they plan to fight. Depth of distance requires commanders to strike at near, as well as far locations on the battlefield. Higher level commanders look and strike deeper into the enemy's rear area.

An uncoordinated strike across the battlefield does not maximize the combat potential of a unit or collection of units. Poor timing and haphazard actions across the battlefield might inadvertently disrupt friendly advantages or plans. From Corps to Battalions, commanders are faced with differing time and space allocation problems. Yet all must understand the relationship to each other and what responsibilities they each have. Thus, we need an architecture capable of delivering these tenets in a usable form, while integrating all BFAs.

2. AirLand Battle Doctrine Communications

Presently, analog voice circuits serve as the communications medium at the battalion level. Currently the Single Channel Ground and Airborne Radio System (SINCGARS) is being incorporated into the U.S. Army. This will provide a

secure, digital voice and data transmission medium. The present transfer of information at the battalion level is done by voice transmissions following unit standard message formats. The amount of time taken to transmit the information and the accuracy of transmission are functions of tropospheric conditions, enemy countermeasures, unit proximity, and awareness of the units.

Incorporation of digitally transmitted information provides advantages to the using unit. The transmissions are much quicker and more accurate with automatic transfer of standard reports. This also frees the unit and vehicle commanders from time consuming tasks of routine or lengthy transmissions. Side benefits of the use of digitally transmitted reports are the storing and later forwarding of the reports, accuracy of information, and the ability to track the source of the information. Features incorporated into many existing systems allow senders to know when receivers actually receive the messages and when they read them. The presupposition of effective communications for an effective doctrine demands communications means commensurate with the doctrine's tenets. An antiquated communications system without the means to send the volumes of required information hinders the potential of the unit.

C. FRAMEWORK

In this section we examine the command and control framework or hierarchy of systems that allows the commander rapid and accurate transfer of information. The Army Command and Control System (ACCS) provides the overall structure for command and control. Contained within the ACCS is the Army Tactical Command and Control System (ATCCS) which is the tactical system of the ACCS (see figure 1). ATCCS presently extends only to the brigade level. An ongoing development plan is the B2C2 which extends the ATCCS architecture to battalion and below. B2C2 is, in essence, ATCCS extended to the lowest levels of command and control. This serves to vertically integrate the battalion but provides no assurances of horizontally integrating all BFAs at the battalion level. A subordinate system of the Maneuver Control System (one of the ATCCS Battlefield Functional Area Control Systems) is IVIS. The IVIS was developed independently of ATCCS from the bottom up as an Armor School initiative for internal and platoon level information transfer for the M1A2 tank. IVIS was not initially integrated to ATCCS. These four systems comprise the command and control framework. An overview of each C2 system follows.

1. ACCS

The Army Command and Control System is the "aggregate means by which Army commanders employ and sustain forces in a

theater of operations". [Ref. 1:p. 1-1] It is the system of systems consisting of organizations, training and doctrine. This thesis will look at only the tactical portion of the ACCS. Figure 1 depicts the organization of the ACCS and its links to joint and combined operations as well as ATCCS.

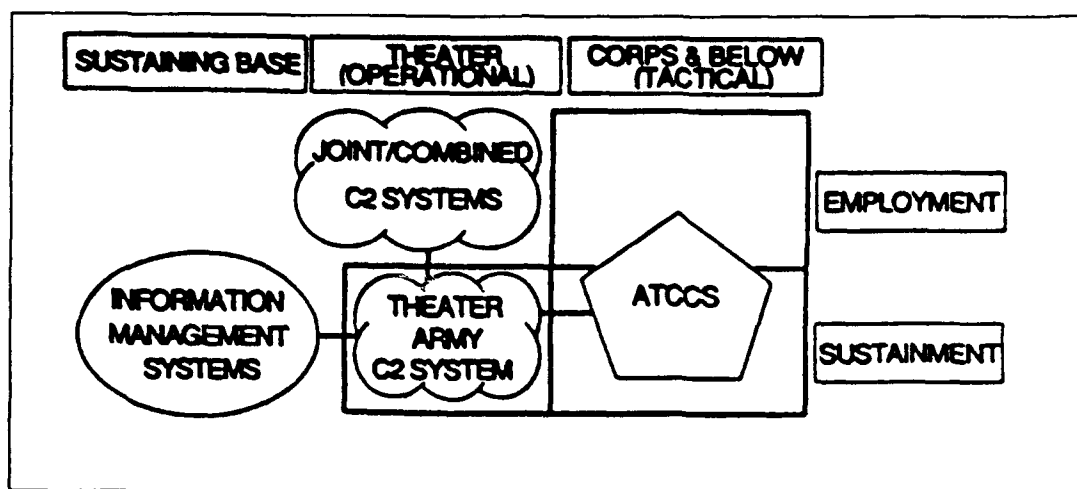


Figure 1 Army Command and Control System

2. ATCCS

The ATCCS is an ACCS tactical system composed of three levels of systems. They are the force level, the functional level and the subordinate systems. The force level is the common application of software that all Battlefield Functional Areas (BFAs) use. The functional level systems are those systems unique to the BFAs and are connected by four types of communications systems. The communications systems are the Area Common User Systems (ACUS), Army Data Distribution Systems (ADDS), Combat Net Radios (CNR) and

Broadcast Systems (BDCST). We will not address Broadcast Systems in this thesis. ATCCS also utilizes the ATCCS Common Hardware Software (CHS) and command and control facilities at various echelons. The subordinate systems are those systems performing specific functions within the BFAs. ATCCS will process technical, staff and command information from data sources across the battlefield. [Ref. 2:p. 1-1]

By integrating the distribution of data, commanders and staff can rapidly collect, process, analyze, display, coordinate and exchange timely battlefield information, thus providing a common battlefield picture [Ref. 2:p. 1-1]. Each BFA has a battlefield functional area control system (BFACS). ATCCS will employ Common Hardware Software (CHS) as the means to interoperate and host these control systems. The functional areas and their control systems are:

BFA	Control System
1. Maneuver	Maneuver Control System (MCS)
2. Intelligence & Electronic Warfare	All Source Analysis System(ASAS)
3. Combat Service Support	Combat Service Support Control System (CSSCS)
4. Air Defense	Forward Area Air Defense Command Control and Intelligence System (FAAD C2I)
5. Fire Support	Advanced Field Artillery Tactical Data System (AFATDS)

At the commander's level he has a system composed of the BFACSS interconnected by communications systems. This is known as force level control (FLC). FLC provides vertical as well as horizontal integration of C2 information. A basic requirement of each BFACS is to be capable of implementing the FLC software. In this way information and data common to the BFACS as well as the FLC can be stored in a common database accessible by the BFACS and FLC software.

FLC provides a networked, distributed system which permits the commander to exercise C2 from any of his echelon's command facilities or from other BFA command facilities. The objective of total interoperability among the BFACS will allow real time access and updating of the FLC database from any BFACS command post (CP) location. [Ref. 2:p. 1-9]

a. MCS

This system gives force-level commanders and their staffs the capability to collect, sort, retrieve, disseminate, and display combat information more effectively, thereby shortening the decision making cycle and enhancing the synchronization of combat action or planning. The MCS is critical to the success of ATCCS as its software will implement the initial FLC capability. [Ref. 1:p. 4-16] Versions of MCS are already fielded and were used in Desert Storm².

²Versions 10.03 and 10.031 of MCS have been used.

b. ASAS

ASAS is the tactical **intelligence** system with the capability of processing data from several different sources. ASAS will provide collection management, intelligence and electronic warfare (IEW) sensor management, information processing, and dissemination of all source intelligence to support U.S. forces. A key feature is the capability of nominating high value targets on an immediate basis.

ASAS is modular and functionally grouped, capable of multiple configurations to support various echelons [Ref. 2:p. 1-10].

c. CSSCS

CSSCS will provide the necessary logistical support information through automated processing of data from Standard Army Management Information Systems (STAMIS). This will give the commander critical information about the status of ammunition and fuel supplies, medical and personnel status, and overall resource accounting.

d. FAAD C2I

This BFACS will provide commanders with a consolidated air defense picture. It will provide alerts and cueing to air defense assets of enemy aircraft in their area, rapid dissemination of air battle management information, and exchanges of commander's essential information with the command facilities. This serves to protect maneuver units,

critical command and control facilities and support forces from low-altitude air attack.

e. AFATDS

The Fire Support BFA system will support Joint, Combined and Allied operations. It is a totally integrated fire support C2 system that will provide automated fire support for execution of close air support, counterfire, interdiction, and suppression of enemy air defense (SEAD). It is a modular software executed on a stand alone Local Area Network (LAN) connected to ATCCS common hardware. AFATDS will provide an integrated processing capability from the Platoon Fire Direction Center to Corps for all fire support assets from naval gunfire, close air support, mortars, as well as ground support. [Ref. 2:p. 1-10,11]

Within each of the BFACS are subordinate systems. Theoretically, subordinate systems within a BFACS are integrated horizontally at the force level control as well as vertically to lower and higher echelon command facilities. Additionally, subordinate systems within a particular BFACS can be integrated with subordinate systems in another BFACS. We will be looking at systems located within the MCS and ASAS BFACS. The communications systems specific to this thesis providing the connectivity are described in later sections.

Figure 2 illustrates graphically the five BFAs linked by the communications systems. The force level control

system is the software system that links the five BFA control systems at that commanders particular level. The BFACS is the **functional** level control system for a particular BFA. For example, the Maneuver Control System is the BFACS for the Maneuver BFA, and therefore is a **functional** level control system.

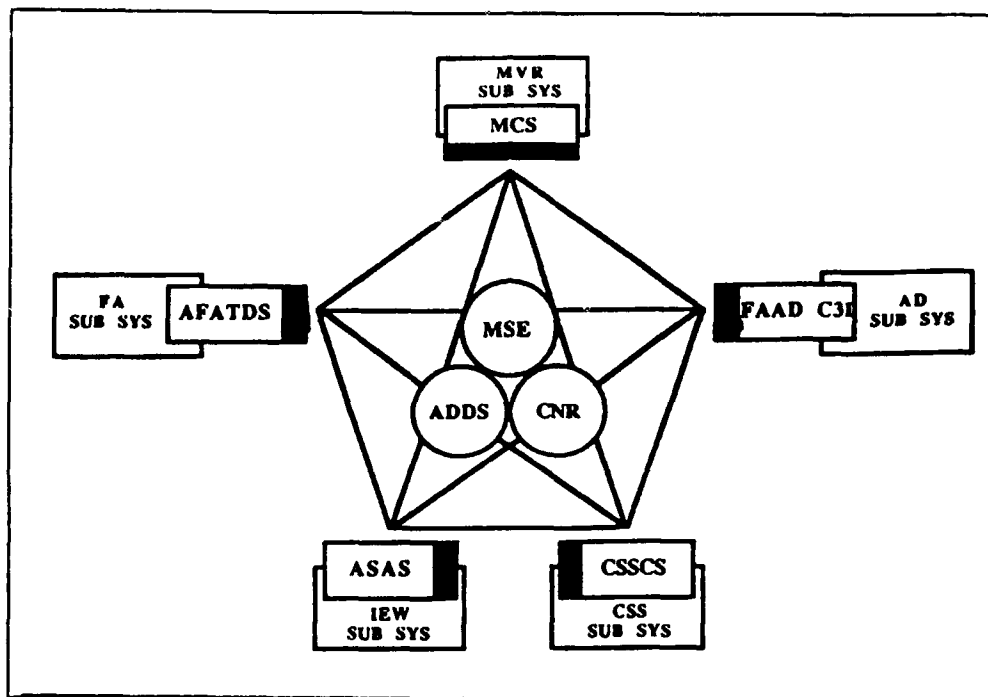


Figure 2 ATCCS Architecture

3. B2C2

B2C2 is a battalion and below command and control system developed by the Armor school to extend ATCCS to lower levels. However, as the following quote indicates, ATCCS has had difficulty incorporating the battalion level system.

In recent years the Force Level Commander's portion of ATCCS has been focused from Corps down through Brigade,

while the proponents of the Battlefield Functional Areas have developed command and control systems to automate their individual battlefield functional area requirements. This approach has created a situation in which several BFA systems have pushed C2 automation to lower echelons (Battalion and Below), providing vertical or "Stove Pipe" information flow and integration. The missing link, at the lower echelons, has been an effective capability to integrate/interface across the BFA boundaries to support the Commander's Critical Information Requirements. [Ref. 6:p. 1-1]

The extension of BFACS to the battalion level helps to vertically integrate the battalion, but does little for the horizontal integration the commander must have to exercise force level control. Presently, only three BFACS extend to battalion. These BFACS existence at the battalion level require common hardware and software capabilities. The Maneuver Control System Block IV architecture plans for the incorporation of common hardware and software for the battalion S-1, S-2, S-3, and S-4 sections, as well as the commander and S-3. [Ref. 7:p. 11]

4. IVIS

IVIS is as much a capability as it is a system or collection of components into a system. It is the organization of M1A2 components into an architecture that shares the information available from the tank's components and presents it to the Tank Commander. It is also the tank to tank information sharing system. Information sharing external to the tank is accomplished using the Single Channel Ground and Air Radio System (SINCGARS) for digital transfer of

information. The 1553B data bus accomplishes the internal information sharing. The vehicle commander can use IVIS to prepare combat orders, plans, graphics, reports, and transmit them to other IVIS or IVIS compatible systems. The objective is to take today's tools of paper maps, plastic overlays, and analog voice communications for information transfer to a higher level of digital map displays, messages, and overlays, and interoperability with other IVIS or IVIS compatible systems in a synchronized manner. This system was originally designed for the platoon level, but has been demonstrated (in a limited proof of principle) at a battalion level. The demonstration linked an OH58D Kiowa Warrior helicopter, a Bradley Fighting Vehicle, a FIST-V, communications base stations, and five M1A2 tanks during a live fire display. (Ft. Knox, 25 March 1993) This capability has lent credence to using IVIS as a baseline Battalion and Below Command and Control (B2C2) system. IVIS also forms the basis for a follow-on system known as Combat Vehicle Command and Control (CVC2).

D. SUMMARY

This chapter has described the four C2 systems around which we will build the proposed architecture. ACCS provides the overall structure for Army command and control. ATCCS addresses the tactical command and control system. B2C2 and IVIS fill the void at battalion level which is not being fully

addressed by ATCCS. Each of these C2 systems have subordinate systems that make the overall system operate. What must be avoided however, is a system that provides too much data to the commander and overwhelms his thought processes. He must avoid using the increased levels of information to micro-manage, and he must not overly depend upon the technology available. [Ref. 7:p. 4]

The battalion is the lowest level at which a designated staff operates in support of a commander. The staff assists the commander by planning for future operations and monitoring current operations. Their purpose is to reduce the administrative burden on the commander and provide him with critical information with which to make decisions. The staff requires tools to reduce the volume of data into information. They also require a structure and a set of systems to reduce their own time demands while maximizing the combat potential of the unit. The command and control facilities at the battalion level are the tactical command post, the tactical operations center (the main command post, known as the TOC) and the administrative and logistics center (sometimes referred to as the ALOC or rear command post). The ALOC has a secondary mission of assuming the TOC's responsibilities should the TOC not be operational. The tactical command post (TAC) normally incorporates the command group. Chapter III will discuss the specific subordinate systems to be incorporated into this thesis's proposed architecture within

the existing C2 framework. The C2 systems, together with the subordinated systems, form the proposed C2 architecture in Chapter IV.

III. DESCRIPTION OF SYSTEMS

This chapter contains more explicit and more complete descriptions of each specific system being used in this architecture. This will allow the reader to better understand the components of the proposed architecture. These descriptions contain the functional, physical, and (when available) technical descriptions of each system. Included as well are the connectivity limitations or advantages of each system. Some systems are not yet fully developed and the capabilities described are those envisioned for the product.

The systems covered within this chapter are;

1. Intervehicular Information System (IVIS)
2. Combat Vehicle Command and Control (CVC2) System
3. Battalion and Below Command and Control (B2C2)
4. Command and Control Vehicle (C2V)
5. Common Ground Station (Warrrior) (CGS)
6. Combat Net Radio (CNR) specifically the Single Channel Ground and Airborne Radio System (SINCGARS)
7. Area Common User System (ACUS), specifically Mobile Subscriber Equipment (MSE)
8. Army Data Distribution System (ADDS), specifically the Enhanced Position Location and Reporting System (EPLRS)
9. Common Hardware Software (CHS)

A. IVIS

1. Functional Description

IVIS is the conceptual and physical sharing of information within the components and systems of the M1A2 as well as information and data sharing with other tanks and IVIS compatible systems. The central operating principle of IVIS is the mutual sharing of tactical information and data with other members of the combined arms team. An IVIS compatible system is one equipped with compatible software, processing systems, and output devices. It does not mean the system must be an IVIS. It will provide near real-time target acquisition, information processing and data distribution to integrate the combat, combat support, and combat service support assets of an armor battalion/task force. [Ref. 8:p. 1]

During the review of Mission Area Analysis in 1982 for Close Combat Heavy functional area, deficiencies were identified that reduced the combat capability at battalion and below levels. These centered around the performance of time consuming, repetitive, manual activities. The commanders were prevented from utilizing their time effectively by performing these resource draining tasks. The Battlefield Management System (BMS) was developed to correct the problem. IVIS was initiated as a starter BMS. [Ref. 1:p. 4-23]

IVIS was originally designed to be a tank to tank system for automatically displaying critical information allowing tank platoons to automate those time consuming or repetitive tasks that monopolize air time. It is a systems monitoring and communication system incorporated within the M1A2 tank. Connectivity between tanks is provided through the SINCGARS radio.

The vehicle commander can use IVIS to prepare combat orders, plans, reports, and graphics, and transmit them to other combat vehicles or platforms as secure data. He has three modes (pre/post combat, combat, and diagnostics) to operate in. All modes provide different levels of reports, graphics and messages. Presently the system has the capability to display four reports and messages, and five overlays in a baseline configuration. They are:

1. Contact Report
2. Spot Report
3. Situation Report
4. Call for Fire Message
5. Two Operations Overlays
6. Fire Support Overlay
7. Obstacle Overlay

There are planned enhancements to the system for a combined 42 reports, messages, and overlays. The vehicle commander can also use IVIS to prepare, distribute, and

execute his fire and obstacle plans. IVIS provides the vehicle commander with the locations of friendly and enemy vehicles. Friendly vehicles are automatically displayed, whereas enemy vehicle data must be entered. IVIS facilitates navigation and tactical movement. IVIS allows the commander to store, process, and distribute a wide variety of tactical and administrative/logistical data. Commanders will use IVIS to:

1. Speed the plans and orders cycle
2. Maneuver units and combat power quicker to the decisive point on the battlefield
3. Improve the speed and accuracy of indirect fires
4. Enhance situational awareness by knowing where all vehicles and their targets are on a real time basis
5. Reduce fratricide through situational awareness.

2. Physical Description

The IVIS architecture on the M1A2 tank is composed of four major components:

1. Commander's Independent Thermal Viewer
2. Improved Commander's Weapons Station
3. Position Navigation System (POSNAV)
4. The core tank/data bus architecture.

a. The Core Tank

The core tank is the term used to describe the collection of hardware, software and firmware that constitute

IVIS, and contain the four major components of IVIS. It is also a technical means for system integration of the M1A2 [Ref. 8:p. A-1]. The components and their functions are listed in the following sections.

(1) *Data management system (MIL STD 1553B Data Bus)*. The data bus is the primary command and control means on the M1A2 electronic system. This provides central control of the data traffic on the bus.

(2) *Power management (RS 485 electrical interface)*. The power bus allows the use of electrical power by the components on a decentralized basis.

(3) *Modified Slipring Assembly*. The slipring provides the link between the hull and turret. This assembly includes a redundant data bus and power bus and shielding added to some circuits.

(4) *Hull Electronics Unit (HEU)*. The HEU provides the control, communications, and processing core for the hull electronics system. It also serves as a backup bus to the 1553B data bus. The HEU also provides POSNAV computation and management and engine diagnostics reporting. The HEU communicates with the turret electronics unit (TEU) and will perform the TEUs critical functions.

(5) *Turret Electronics Unit (TEU)*. The TEU is the primary system supervisor and manages the data bus. It provides critical HEU functions if needed.

(6) *Fire Control Electronics Unit (FCEU)*. This system provides the capability for the hunter/killer mode of the Commanders Independent Thermal Viewer (CITV). It integrates the CITV with the fire control system and provides all ballistic computer functions.

(7) *Hull-Turret Position Sensor (HTPS)*. This provides the signal to the FCEU to indicate the position and relative angle of the hull and turret. This allows the concept of "far-targeting"³.

(8) *Digital Engine Control Unit (DECU)*. The DECU provides control and monitoring of the engine system as well as engine diagnostics information.

(9) *Commander's Integrated Display (CID)*. This is the primary man-machine interface to the tank for the commander. The CID is the single display and CITV control for the C3 functions on the tank.

(10) *Gunner's Control and Display Panel (GCDP)*. The GCDP provides the interface needed by the TEU's fire control function. This panel provides information to the gunner as well as data to the FCEU and TEU for ballistics calculations and resolutions.

³"Far-Targeting" is the concept where the commander lazes to a target, thus determining the range, while knowing his own vehicle location and direction to the target. This produces an 8-digit grid coordinate to an enemy location.

(11) *Driver's Integrated Display (DID)*. The DID provides display of information to the driver about engine status, fuel status, navigation information and "steer-to" information [Ref. 8:p. A-3].

While not a component of the core tank a critical component to IVIS is the Radio Inerface Unit (RIU). The RIU serves as the interface for remote radio control and net protocol management. Additionally, it provides, packet processing, control and formatting/deformatting of transmitted and received digital data and voice traffic. It allows the transmission and reception of alphanumeric and graphic data without impacting current voice communications. Figure 3 describes the interfaces and information flow for IVIS.

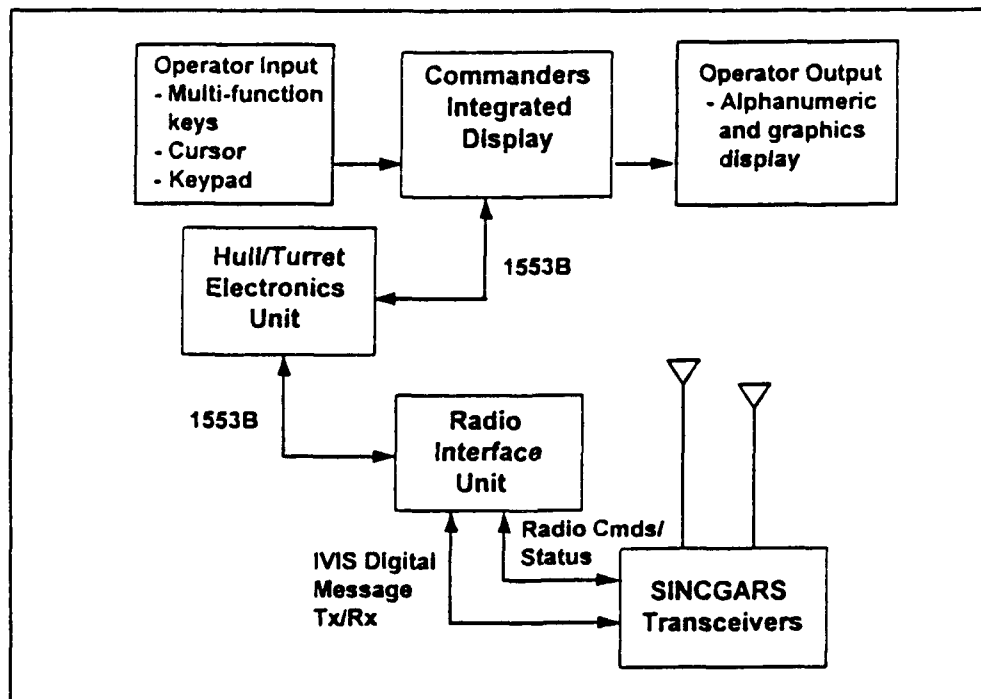


Figure 3 IVIS internal information flow and interfaces.

b. Commanders Independent Thermal Viewer (CITV)

The CITV provides a means for the commander to (independently of the gun) search for other targets, conduct far-targeting, or scan a sector automatically.

IVIS hardware is composed of sensors, displays/controls and a communications means. The sensors are Position Location, Target Location, and Turret Hull Indicator. The displays/controls are the Commanders Integrated Display, the Drivers Integrated Display, the Mission Computer, and the Radio Interface Unit. "Display hardware can range from the M1A2's CID to any Army Command and Control System (ACCS) common hardware device or terminal" [Ref. 8:p. 3]. In this way the IVIS system can be displayed on the C2V common hardware (see Figures 4 and 5 for interface diagrams). Communications is accomplished by all components riding on the 1553B data bus, and SINCGARS. The software is an Ada distributed software that controls digital communication within and between vehicles. The proposed architecture will focus on existing overlays, reports, and messages available to the IVIS equipped vehicle commander.

B. CVC2

The Combat Vehicle Command and Control (CVC2) System is the follow-on version of IVIS. Presently the system resides only as a prototype software on the automated TOC at the

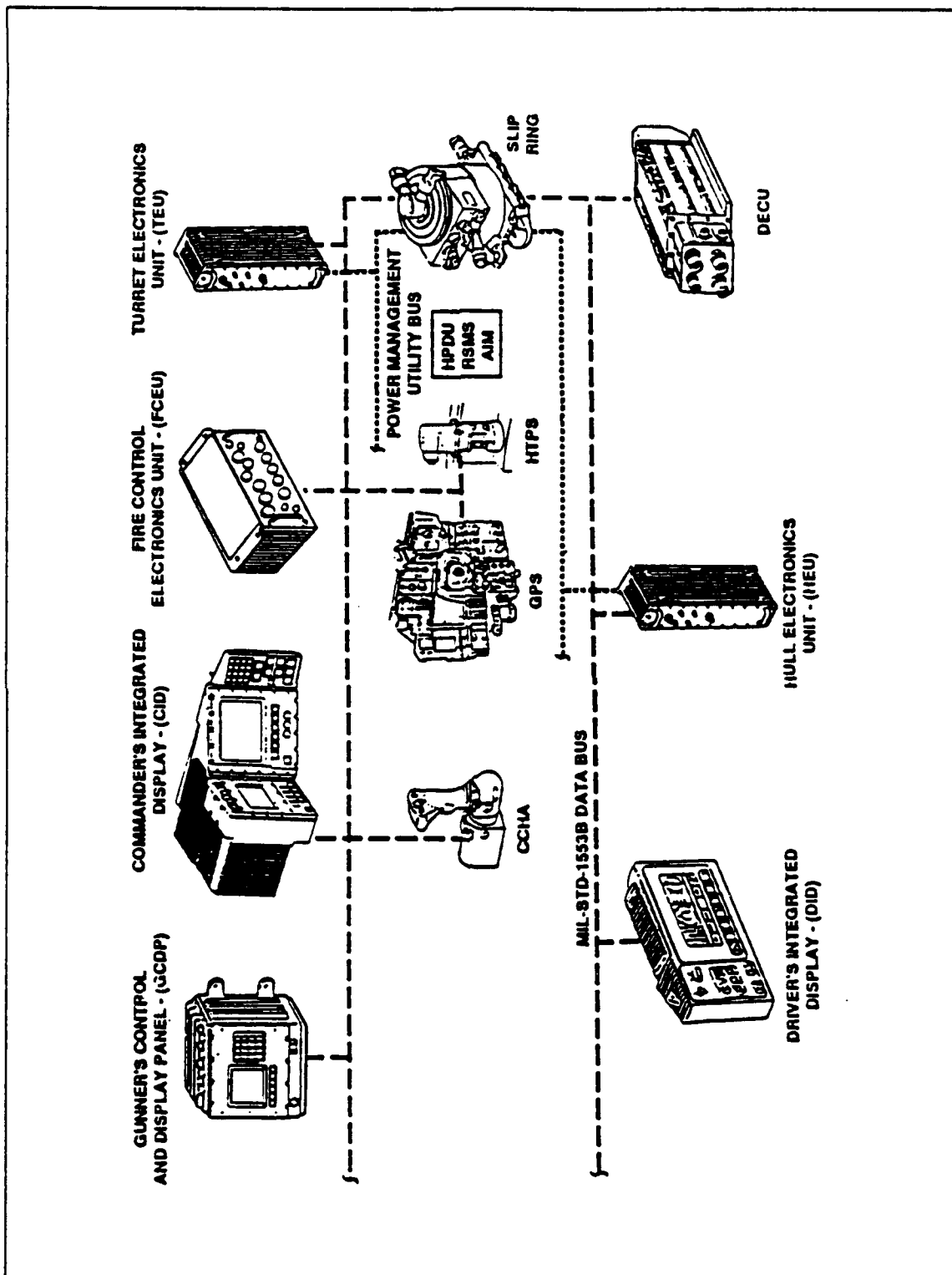


Figure 4 M1A2 Core Tank

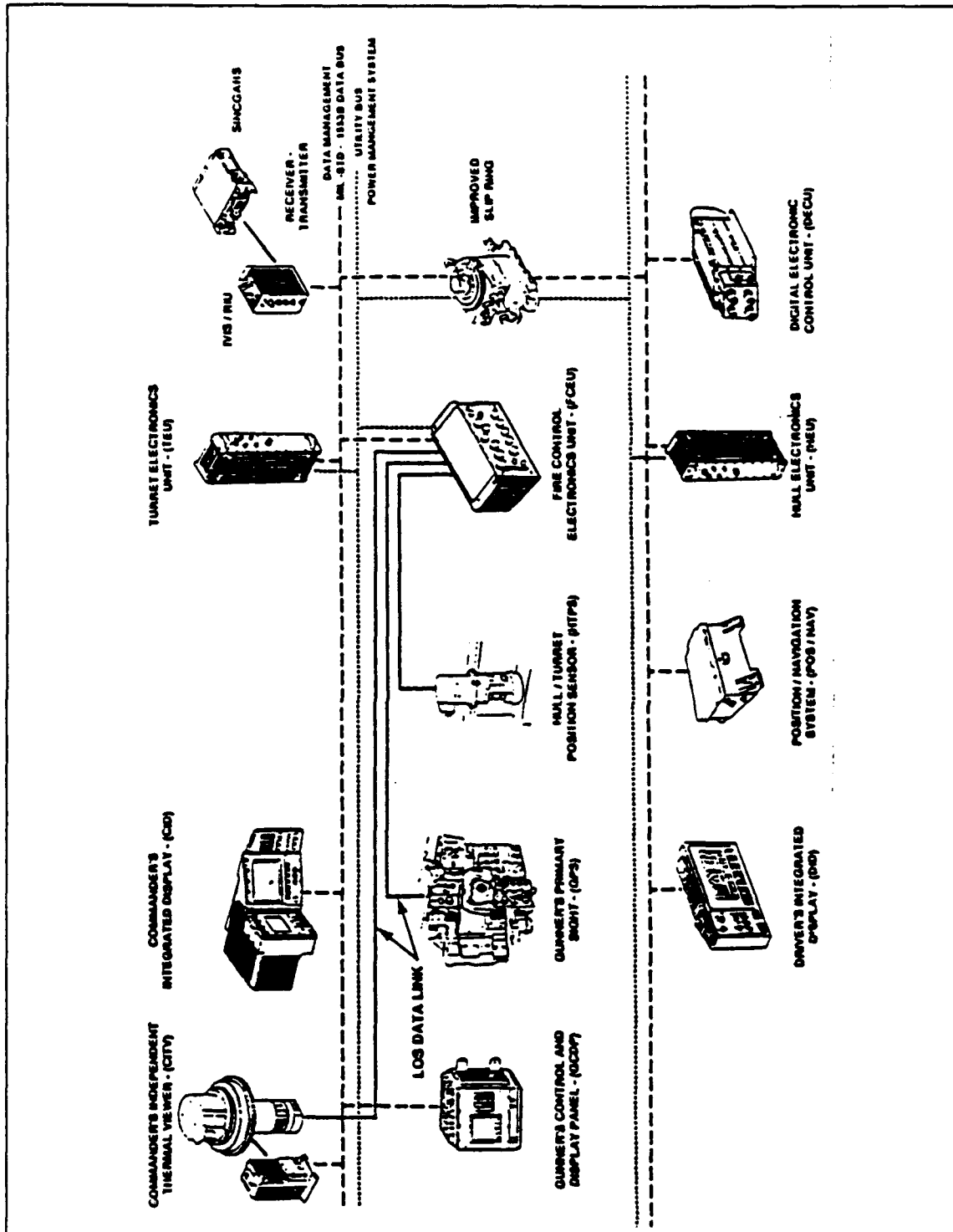


Figure 5 M1A2 Core Tank with IVIS and RIU Interfaces

Mounted Warfare Test Bed, Fort Knox, KY. The CVC2 is limited to control of maneuver forces and is a subset of B2C2. Presently the CVC2 system does not interface with any other BFACS or subordinate system.

1. Functional Description

The CVC2 system consists of vehicle embedded functions to perform command and control and communications network management tasks. It serves as a distributed communications network for the combat vehicles in the battalion. Communications network interfaces are accomplished through the combat net radio (SINGARS). The CVC2 system provides digital voice and data transmission of information and data much the way IVIS does. The CVC2 system node is the collection of equipment located in the combat vehicle to provide CVC2 capabilities to the vehicle. Many existing components of the vehicles will likely be incorporated into the overall CVC2 system. System nodes will be tailored by the vehicle commander and located with the following positions:

1. Battalion Commander
2. Battalion S3
3. Company Commanders
4. Company Executive Officers
5. Platoon Leaders
6. Platoon Sergeants
7. Wingmen

The CVC2 system will interface to the non-combat vehicles by an as yet undetermined system. The TOC and ALOC will also have system nodes. The CVC2 system augments the existing command and control structure of a battalion by providing near-real-time assistance to the command structure to speed the plans and orders cycle and generate combat power. The system is actually an improved IVIS (IVIS in a generic sense). Just as IVIS is designed to automate repetitive or time consuming tasks, CVC2 will help reduce the stress of the commander using the system.

The CVC2 will provide tactical situation displays on a color screen. The touch screen will allow a color map of varying sizes to display friendly and enemy data. This information may be in the form of icons, overlays, messages and reports. This information will be transmitted digitally using combat net radio.

2. Physical Description

The protocol for the CVC2 will be a unique formatting protocol. A tailored version of ASAS Tactical Net Radio Protocol and the SINCGARS radio will combine to send digital traffic over the CVC2 system.

Reports, messages, and overlays will be sent over the CVC2 network. These 38 messages, reports, and data are a combination of overlays about friendly plans and locations, enemy locations, alerts, logistics information, and replies.

C. B2C2

B2C2 is not a system. B2C2 is:

the exercise of battle command by properly designated commanders or leaders at battalion through section level, over assigned forces in the accomplishment of the mission. [Ref. 9:p. 1]

The concept of B2C2 is to provide decision support, graphics, and automated C2 support through an integrated seamless C2 architecture. B2C2 is to be a tool or collection of tools available to the commander for implementation. This will occur through the current CHS developments or local area networks. As early as 1988 the Armored Family of Vehicles Task Force wrote the Armored Family of Vehicles (AFV) Concept Exploration Definition Automation-Communication Work Plan describing the B2C2 concept. That concept was similar in that it horizontally integrated the components and tools available to the battalion commander for C2. The AFV concept also included a vehicular command operating system (VCOS)⁴.

1. Functional Description

B2C2 is the continuation of ATCCS to the battalion and below force levels. This will allow for the vertical integration and automatic transfer of information from higher to lower and lower to higher. The Block B Force Level Control System (FLCS, and earlier referred to as the FLC) is scheduled to be implemented in the mid 1990s. This will be an integrating

⁴The VCOS was not defined, but has literally become IVIS.

software capability resident on the Maneuver Control System. With this reality, the Block B will operate at each BFA operational facility on each of the BFACS down to battalion level BFA.

The B2C2 concept will include Armor, Infantry, Aviation, Field Artillery, Air Defense Artillery, Signal, Engineer, Military Police and Chemical Units. It will have interfaces with all five BFAs and their control systems. It will interoperate with all BFACS and BFA operational facilities (like the TOC for example), selected national intelligence means, selected Joint Command, Control, Communications, and Intelligence systems, and any allied systems as appropriate. [Ref. 9:p. 6]

2. Physical Description

The CHS or CHS compatible systems will be utilized for data and information storage, manipulation and transfer. With this in mind, the C2V mission module equipment (CHS) will be capable of implementing the B2C2 concept. Decision aids such as the Brigade Planner will assist the staff in integrating the data and information available for presentation to the commander and other recipients.

ATCCS CHS Transportable Computer Units (TCU) with the Maneuver Control System (MCS) are presently planned for the S-1, S-2, S-3, and S-4 sections. These systems will be operating on the MCS at the battalion level. Companies and platoons will be

operating on IVIS, or IVIS type system (which is a subordinate system of MCS) Digital transfer of information is accomplished with a Lightweight Computer Unit (LCU) or a Transportable Computer Unit (TCU) running B2C2 software, a PLGR for positioning and navigation, and the SINCGARS radio for communication and data distribution. It is expected these systems will be on the Command and Control Vehicle as well as the commander's and other critical participant's vehicles in the C2 system.

D. C2V

The Command and Control Vehicle is designed to replace existing M577 series vehicles and the Standard Integrated Command Post Shelter (SICPS) known as the 1068. These vehicles currently house the battalion battle staff for the Tactical Operations Center (TOC), and the Administrative and Logistics Center (ALOC).

1. Functional Description

a. Capabilities and Configuration

There are presently three versions of the C2V planned. They are a tracked C2V, to be part of the rapid shock action of the heavy force; the wheeled C2V, to enhance the agility of the light forces; and the airborne variant which will be in both heavy and light forces [Ref. 10:p. 2]. This thesis will address only the tracked version.

This vehicle will provide the commander the means to move the battle staff across his area of interest at a pace commensurate to the maneuver units. The staff will then be able to maintain contact with the maneuver forces and maintain the commander's critical information requirements while moving. The battle staff will require the means to:

1. Receive information and data during the battle
2. Prepare and transmit the commander's critical information
3. Control the forces and functions of the battle based on the commander's intent and direction

All staff actions will eventually be accomplished on the move.

[Ref. 11:p. 3]

The vehicle will provide mobility, power, intra-vehicular data connectivity, electrical power control and distribution from an on board primary power unit (PPU) and mounting provisions for on board and ancillary equipment. The intercom system will provide point to point, group, and broadcast communications to each work station position and crew member. Each position will be able to access all radios. [Ref. 11:p. 3] Future concepts include providing mounting provisions for a tactical satellite antenna. It will be NBC survivable with overpressurization, incorporate military standard distribution capability, and provide a status display of the functioning of critical vehicle components. Additionally, the vehicle must not require a large logistics burden, thus reducing the visual and electronic signature of large numbers of support

vehicles around the C2V's operations. The C2V will house ATCCS CHS and other automation and IEW assets as required. [Ref. 11:p. 5,6]

The vehicle will provide seating for four workstations and two extra seats for observation or non-workstation related activities. The chairs will have safety harnesses allowing the staff to operate during cross country movement, yet still be comfortable enough for sleeping or long term operations.

A full objective workstation will consist of computers and communications devices that will allow maximum networking between computers and staff functions. This equipment must transmit and receive voice and data information. There must also be an intercom system that allows the operators to communicate with each workstation in the mission module, the vehicle cab, and adjacent C2Vs within the range of the LAN or the wireless LAN. A workstation may consist of any combination of automation and communication equipment based on Table of Organization and Equipment (TO&E) allocation and the mission. [Ref. 10:p.2]

The concept continues by requiring a spooled LAN to be used when the vehicles are stationary yet locally dispersed for security and survivability reasons. The C2V platform and related work stations will be fully automated and integrated through Common Hardware Software (CHS) and Army communications equipment. Future concepts include providing mounting provisions for a tactical satellite antenna. After the CHS capabilities are upgraded, a greater capability will allow the staff to quickly originate and manipulate information and graphic displays to provide data to the commander for decision, synchronization, and planning. [Ref. 10:p. 9]

b. C2V Deployment

Presently the determination of the fielding plan for the battalion level has not been decided. The proposed architecture in Chapter IV will recommend a deployment plan. One concept being investigated by the Army is for the armor battalion/task force to receive three C2Vs. Two will operate in the Tactical Operations Center (TOC) and one in the Administrative and Logistics Center (ALOC). The TOC C2Vs will operate with one vehicle having the S3 (Operations) primary personnel and S2 (Intelligence) alternate personnel and the other vehicle with the S2 primary and S3 alternate personnel. The ALOC C2V will serve as a coordinating center for the S1 (Personnel) and S4 (Logistics).

Since the C2V will serve as the central command facility for planning, monitoring, and reporting the battle to the commander it must possess the capabilities to interface with superior, adjacent, and subordinate units. This vehicle is in development and is tentatively scheduled for First Unit Equipped Date in FY99.

2. Physical Description

There are two major parts to the C2V. They are the XM4 vehicle, and the integration of the mission hardware. The XM4 vehicle is a Bradley derivative vehicle composed of the Bradley suspension system and the MLRS chassis. The objective C2V mission hardware architecture is the ATCCS Block IV Common

Hardware architecture composed of the Transportable Computer Unit (TCU), the Lightweight Computer Unit (LCU), and the Handheld Terminal Unit (HTU). Refer to the CHS section for more information on CHS. The workstations however must not be software specific to allow for future growth and flexibility of operations. Communications capabilities on the vehicle will be CNR, ACUS, ADDS, and BRDCST.

The command suite is an on board shelter where the communications and Common Hardware Software is located. Additionally it has several features included in the vehicle for enhanced crew and staff performance.

The Army communications equipment and ATCCS will provide the backbone of commonality among C2V's command and control mission modules. [Ref. 11:p. 1]

The driver and vehicle commander in the cab will be provided position/navigation and night vision capabilities. The objective night vision is through thermal viewing devices [Ref. 11:p. 3]. Other objectives for the vehicle include a self erecting antenna, inherent camouflage, external self defense weapon, and a water and individual ration heating device. Figures 6 and 7 depict all components of the vehicle including crew workstations. Figure 6 displays the side of the mission module where the Common Hardware Software location and the mission map. Of particular note, one of the goals of the system is to eventually replace the CHS TCU computers with the LCU versions. Figure 7 displays the battle staff workstations.

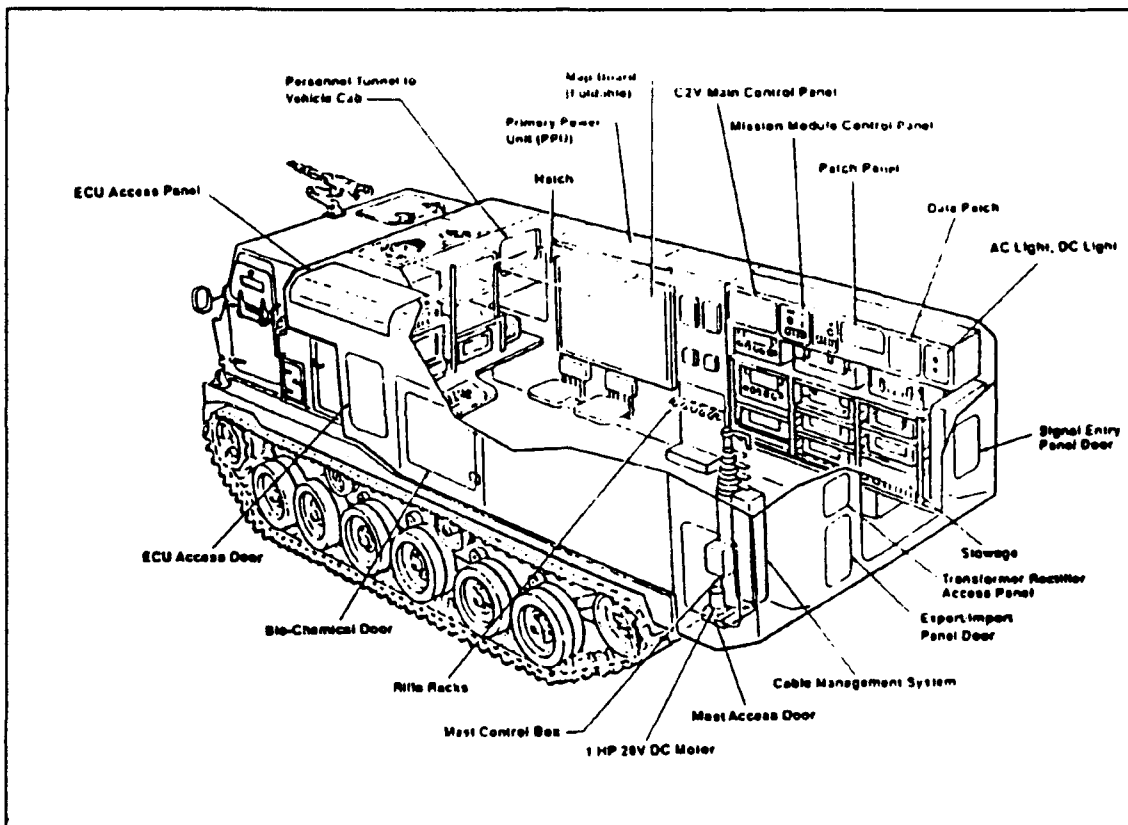


Figure 6 C2V view of Common Hardware Software Locations

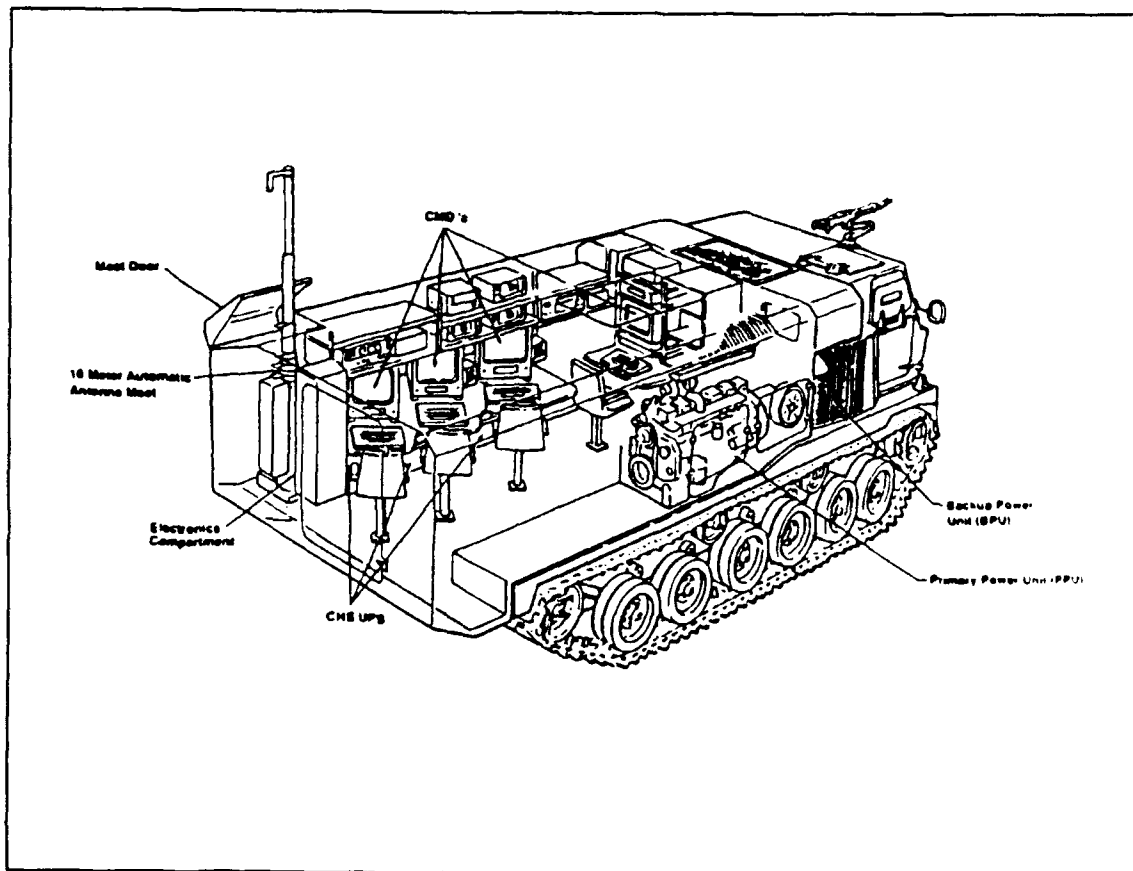


Figure 7 C2V view of Battle Staff Workstations

E. COMMON GROUND STATION (WARRIOR)

The Common Ground Station is designed to alleviate the problem of sensor data and other intelligence not being provided to the brigade level warfighter in a timely manner.

1. Functional Description

The purpose of the CGS is to provide information and intelligence to the commander. Information includes terrain and weather data. The Common Ground Station was initially envisioned to be a subordinate system of the ASAS BFACS. The

system referred to here is a system presently being developed outside of ASAS. Its current name is Warrior. Warrior as a system exists as a prototype software application hosted by a portable computer. Its capabilities are not fully documented as it is in development. Warrior, for terminology clarification, is the ongoing software application to provide intelligence to the commander. Warrior as a system has been held in a fixed state of development and termed "Hawkeye". Further developments of Warrior produced the Common Ground Station version of Warrior (we will call that version CGS Warrior). Warrior has been developed to its most recent fixed design and called Warlord. On a time line of development, Warrior began, was fixed as Hawkeye, continued to develop, and was fixed as CGS Warrior, continued to develop and has been fixed as Warlord. Warrior continues to be the prototype software for development purposes.

The ultimate goal of the program is for CGS (with a to-be-determined Warrior Software version) to be a capability software resident on CHS terminals that can be located on a number of operational facilities or vehicles. For example, CGS could operate as an application on the Ground Station Module (GSM) of the JSTARS system or as an application on the commander's vehicle and TOC (for our purposes, the C2V). Currently, the CGS is composed of the Warrior software, Unmanned Aerial Vehicle software system module, and the JSTARS software system module (Figure 8).

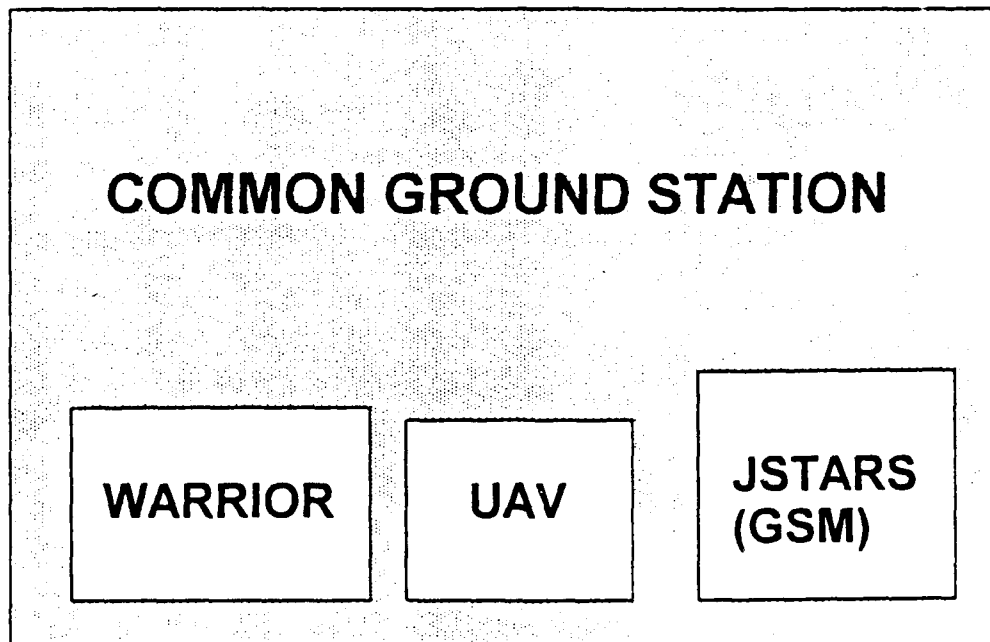


Figure 8 Common Ground Station

The Common Ground Station is to be included in ASAS Block II as a subordinate system. Warrior will continue to be developed over time, and is envisioned to extend its capabilities. However, the system as currently demonstrated has several of the following capabilities.

CGS receives information and intelligence from national technical means, sensors, JSTARS, and UAVs. This information is processed on the Warrior software. The software is used to develop a number of products. Utilizing the Defense Mapping Agency digital map data, an overlay can be built using information gained from the collection assets. This could be an enemy overlay developed from using the assets to identify actual locations of enemy vehicles, personnel and

equipment. After identifying the locations (an 8-digit grid coordinate) of the target, the digital map data can be better utilized. An example follows.

The S-2 section determines, through templating, the likely enemy locations. These likely locations become "zones of consideration" for intelligence collection. Sensors would then be utilized to pinpoint the enemy locations at progressively finer resolution. After identifying the location of a tank for instance, the software can determine line of sight for the enemy tank. Combining all tanks in the areas line of sight can produce an obvious kill zone being observed, and an enemy overlay developed. Obstacle data collected from the sensors can be incorporated into the overlay. Using the terrain data in the DMA data base, routes of ingress or potential overwatch positions can be determined. This information will be drawn (using the Warrior software) on an enemy overlay. The overlay will be sent digitally to those requiring the information.

The databases developed over time are available for analysis using tools built into the software for tracking specific units around the battlefield. What this all does is provide an heretofore unheard of capability to generate, maintain, and manipulate information about the enemy, and send that information in a fraction of the current time frames.

Although the system is still in development, this capability was demonstrated at Operation Desert Capture in

November and December 1992 at the National Training Center, Fort Irwin, CA.

Deployment considerations are to make the CGS a software application on a yet to be determined S-2 workstation at the brigade level. The Military Intelligence battalion at the division level receives the raw information from the sources. That information is sent unchanged via MSE to the brigade short extension node (SEN). The SEN is connected to the CGS on the S-2 workstation via ethernet. All transmissions take slightly longer than 16 nanoseconds. The division CGS can be used to develop the division picture, and the brigade CGS can develop the brigade's area of interest intelligence picture. The division and brigade, after development of the data, can exchange information, thus creating a common picture of the battlefield. The brigade will then pass the information to its subordinate units.

2. Physical Description

Warrior is a software hosted on a CODAR Sun architecture. The components of the computer are a hardened Sun SPARC II system weighing 250 lbs with two 1.2 gigabyte hard drives, a monitor, a CPU, and interface connections.

Interfaces to other systems are through ethernet, RS 232, and X.25. The ethernet interface can be connected to other computers (useful in the C2V or CHS), Mobile Subscriber Equipment (MSE), and a Computer Information Management (CIM)

device that can connect to SINCGARS. The RS 232 interface can connect to a STU III, MSE, and SATCOM via Trojan Spirit. The X.25 interface can connect to EPLRS. See Figure 9 for a visual representation of the interfaces and information flows within CGS.

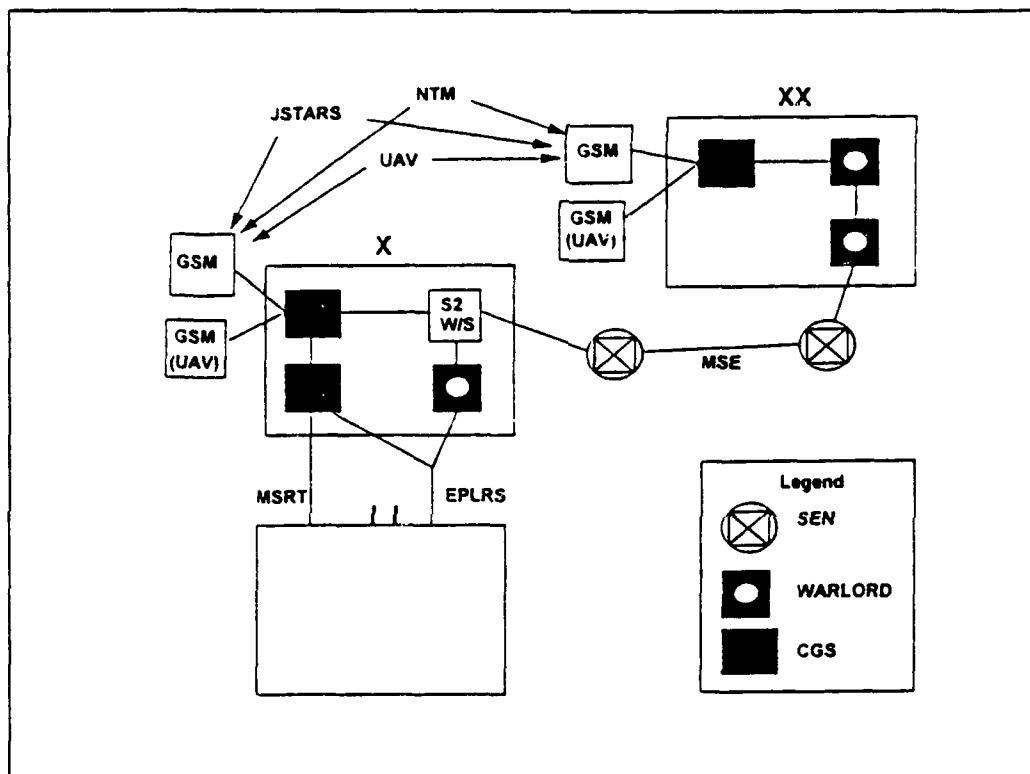


Figure 9 CGS information paths.

F. COMBAT NET RADIO (SINCGARS)

1. Functional Description

SINCGARS is a secure single channel or frequency hopping VHF-FM radio designed to provide the primary means of command and control in combat, combat support and combat service support units. [Ref. 12:p. 1-15] It is one

component of the family of combat net radio (CNR) systems. SINCGARS supports voice as well as data transmissions with the capability of preprogramming eight channels for single channel transmission or six channels for frequency hopping mode. It operates on 2320 frequencies in the VHF band (30-87.975 MHz). The vehicular configuration we are interested in has an estimated range of 35 kilometers. SINCGARS has automatic data transmission via a data device and automatic retransmission capability. Each M1A2 tank in the battalion will have SINCGARS capability as will the C2V. SINCGARS can also be used to transmit information to Tactical Fire Direction System, or TACFIRE (a field artillery system used for fire missions), analog data terminals, and electronic remote fills (ERF) for synchronizing the sync pulses necessary for frequency hopping transmission. This ERF is accomplished by a Net Control Station (NCS).

"SINCGARS equipment can interface with ACUS (MSE and TRI-TAC) equipment, thus providing ATCCS users who are not normally supported by ACUS with a gateway into the ATCCS network" [Ref. 13:p. 6].

2. Physical Description

The SINCGARS family of radios has several configurations. We are concerned with the Short Range (SR) (AN/VRC-87 or AN/VRC-88), the Long Range (LR) (AN/VRC-90), the Long Range/Short Range (LR/SR) (AN/VRC-89 or AN/VRC-91) and

the Long Range/Long Range (LR/LR) (AN/VRC-92) radio configurations. Components of the systems are:

1. Vehicular Antenna: This radiates/receives RF signals for the Receiver/Transmitter (RT) and is mounted on the vehicle.
2. Power Amplifier: This provides 50 watts of power during transmission. It slides into the mounting adapter.
3. Power Amplifier Mount: This provides control interface and support to a second power amplifier.
4. Armored Vehicle Crewman Helmet: The helmet connects to the control-monitor and is used for voice communication.
5. Control-Monitor (CM): This is used to remotely control the RT. One CM can control up to three RTs.
6. Handset: This is used for voice communications.
7. Mounting Adapter: the adapter provides interface and support to the RT and power amplifier in the LR radios.
8. Loudspeaker
9. Mounting Base: The base supports the mounting adapter.
10. Receiver-Transmitter (RT)

G. AREA COMMON USER SYSTEM (MSE)

1. Functional Description

The Area Common User System provides telephone, facsimile, and data transmission services from the maneuver battalion through echelons above corps (EAC). It is primarily designed to support user-to-user voice and message center-to-message center record (teletype) traffic. The ACUS does support data transmissions. At corps and below, the "Mobile Subscriber Equipment (MSE) provides the capabilities for both

circuit switched (i.e., dial-up) and packet switched data transmission" [Ref. 13:p. 5,6]. ACUS supports two networks, the Tactical Packet Network (TPN) and Circuit Switched Network. The TPN is the primary medium for data exchange from maneuver brigade through EAC. Access to this network is provided either by extending the command post (CP) local area network to connect to the supporting MSE switch, or through a direct wire connection from the ATCCS device to the supporting switch. The circuit switched network is the primary voice medium from the brigade through EAC. It also permits ATCCS users who are not normally supported by an MSE switch (e.g. maneuver battalions) to enter the ATCCS network using the Mobile Subscriber Radio Terminal (MSRT). [Ref. 13:p 7,8] MSE provides area common user communications for Army corps and divisions, but has been extended to brigade. It is capable of handling voice and data communications in an area of up to 37,000 square kilometers.

2. Physical Description

An MSE interface entails a direct connection from a MSE gateway node to packet switch within the MSE Packet-switched Network (MPN). In this configuration, the gateway node will serve as host data terminal equipment (DTE) for the MPN. The node may be referred to as a gateway, because the bridge between the networks may take place within the user applications or within a common Application Layer. The MPN

communications protocols (TCP, IP, X.25) are used to communicate on the MSE network. From the MSE communications protocol stack, a connection is made to a packet switch within the MPN. The packet switch functions as the data circuit-terminating equipment (DCE) for the MPN. Thus, the link between the gateway node and the packet switch constitutes a DTE-DCE interface.

H. ADDS (EPLRS)

EPLRS is the tactical data distribution workhorse and was developed to fill the data communications need. This provides each BFACS a reliable, on-time data service with standard interfaces. EPLRS links the ATCCS BFACSS and architecture with a robust, automatic relaying, and automatic rerouting network.

1. Functional Description

a. Capabilities

EPLRS provides the means of distributing data about the location of units or vehicles with EPLRS radios, as well as sending overlays and text messages (in the new Situational Awareness Software). EPLRS is a multifunctional system that integrates data from all BFAs, allows on the move C2, facilitates all-source integration of Position/Navigation (POS/NAV) and near-real-time C2 data. It accomplishes this by providing networks POS/NAV data from EPLRS, SINCGARS/GPS, Ground Combat Identification, etc. and provides reliable

intra/inter BFA C2 data communications links. It operates with an inter/intra division-wide network servicing all BFA communications needs to multiple destinations. It bridges the CNR local net structure and interfaces with other control/communications systems. The network is self healing in that should one Radio Station (RS) not be able to forward or receive a message, the system will identify, then use other RSs to automatically relay the message to the correct RS. Additional capabilities are Operations Security (OPSEC) controls, and over the air re-key of the password or code of the day.

Each EPLRS system is a multiple Net Control Station (NCS) community of up to four single NCS communities to support a Division. Each community would consist of between 100 to 250 RSs (approximately 500 to 1000 terminals in division deployment). Communications techniques include using spread spectrum, frequency hopping, error detection and correction, and automatic rerouting.

Command and control information useful to the battalion is provided by the NCS. These include information about zones, corridors, lanes, unit information, RS information, POSNAV and messaging. For example, a unit may be operating near an area contaminated by a chemical agent. The NCS can (with the situational awareness software) draw lines around the area. Should a vehicle with a RS cross the limiting boundary, they would hear an audible alarm. The

vehicle commander is now alerted to the hazard and can take appropriate action. This feature can be incorporated in terms of any fire control, boundary, or limiting control measures.

Extended communications ranges can be accomplished by the system. Data or messages sent from one RS to another will automatically route along other RSs to reach its destination. Once the needlines are set and a message is sent, only the destination RS(s) may receive the message. The transfer is transparent to other RSs involved in the transfer but not eligible to receive.

b. Deployment

EPLRS planned asset assignment is four Net Control Stations (NCSs) assigned to the Heavy Division with 335 Radio Stations (RSs) [Ref. 14:p. 2-2,2-12]

2. Physical Description

The EPLRS contains two major elements, the Network Control Stations and the EPLRS Radio Sets. "The NCSs provide overall network management, service the operator interface, and monitor/report network performance" [Ref. 14:p. 1-5]. The Radio Sets implement commands from the NCSs, report status, and information about which RSs can hear whom to the NCS.

a. Net Control Station

The NCS is a tactically shelterized computer facility providing technical control and monitoring of an RS community. It performs dynamic network management of all RSs

under its control. The NCS shelter is mounted on a five ton truck. It has a generator behind it for power. NCSs are linked with other NCSs through an EPLRS radio set with 1553B interface. Linkage from one division to another division is a HUMMWV with two Enhanced PLRS User Units (EPUUs) and a cable from one radio set to the other. Each EPUU is set for its respective division NCS system. A Downsized NCS (currently in development) will provide all the functions of the current NCS, yet be positioned on the back of a HUMMWV. Future desires are to reduce the size requirements allowing it to be placed in 19" wide racks (which are the size of C2V racks).

The components of the NCS in figure 10 are:

1. NCS Display Control Console (DCC)
2. Keyboard (KBD)
3. Printer (PTR)
4. Three AN/UYK-44 Computers (running the EPLRS real-time software)
5. One AN/UYK-7 Computer (also running the software)
6. Enhanced Command Response Unit (ECRU, for interface to the Radio Frequency network)
7. 1553B Radio Set to communicate and coordinate data bases between NCSs

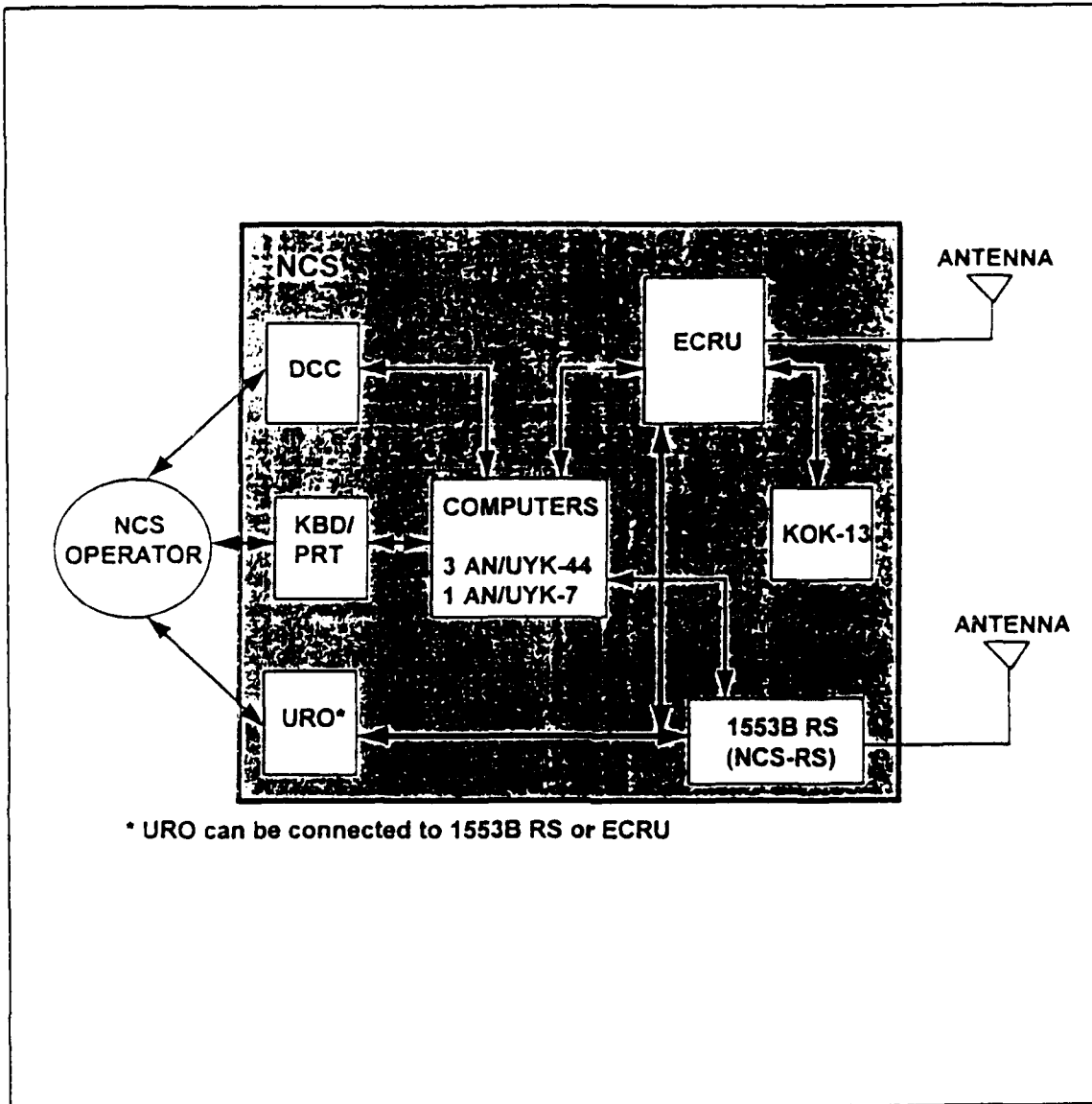


Figure 10 EPLRS Net Control Station Configuration

b. Radio Set (RS)

The RS is composed of an Enhanced PLRS User Unit (EPUU), a User Readout (URO) device or a Pilot Control and Display Panel (PCDP) and an installation kit.

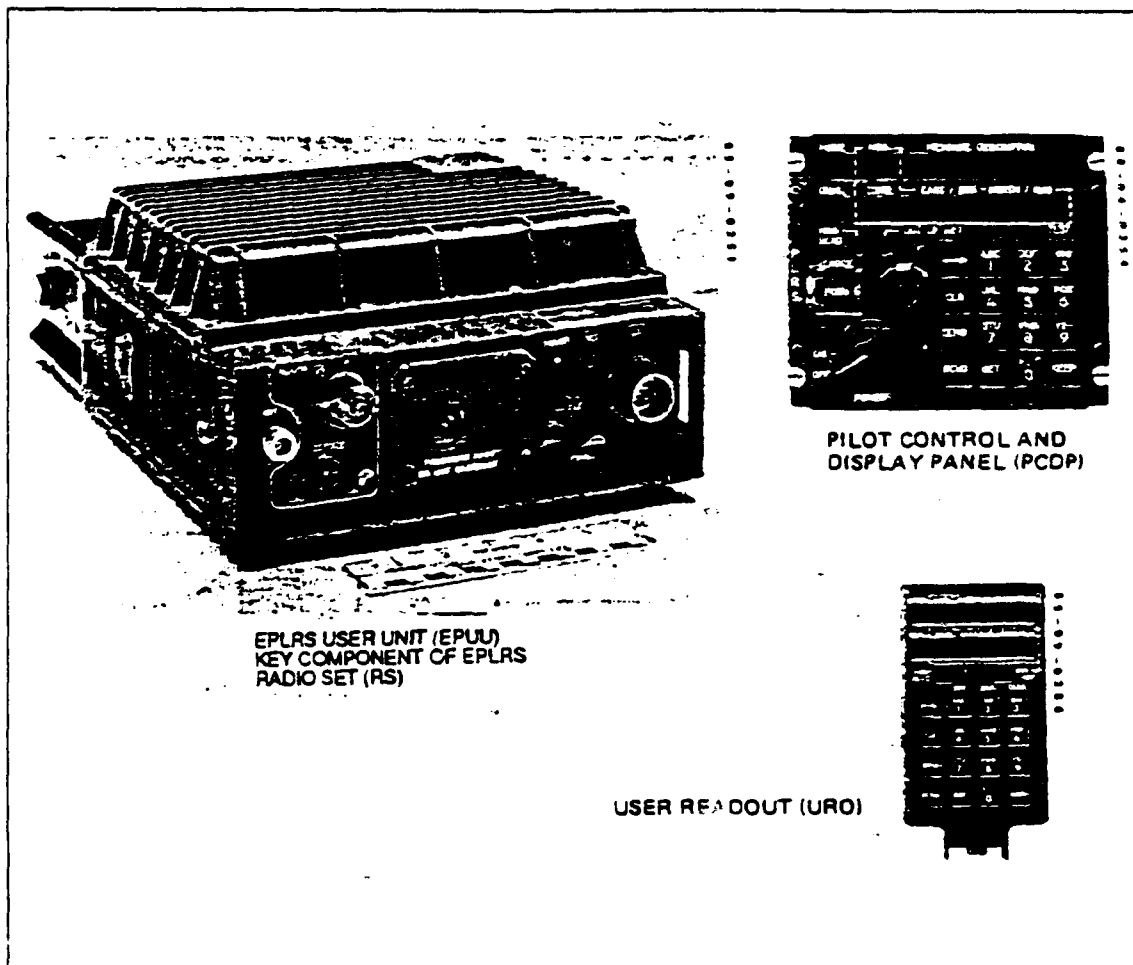


Figure 11 Enhanced PLRS User Unit (EPUU)

The EPUU can be configured with either an ADDS Interface (ADDSI) or a 1553B Interface. The ADDSI is a CCITT X.25 type interface. As a point of interest the M1A2 tank utilizes the 1553B data bus. The URO is used with surface vehicles, airborne vehicles, or manpack. It presents information requested and lets the operators send/receive free-text messages. The PCDP provides everything the URO does, as well as allow remote operation of the EPUU. The PCDP

also provides bearing and altitude information to the aircraft instrumentation system.

The radio set performs user to user data communications and generates ranging information for position location/navigation. It also serves as an automatic relay of opportunity, without interfering with other user data functions. This extends the communications range and keeps communications links (called "needlines"⁵) operable during jamming and changes in user location. The user can also use the interface capability for direct host-to-host communications on the BFACS associated with the respective BFA.

3. Technical Description

EPLRS operates on UHF over eight frequency channels in the 420 to 450 MHz range, using synchronous time division multiple access, frequency and code division multiplexed. EPLRS has automatic central resource and relay assignment and maintenance. This adaptive automatic relay capability "accounts for the ability to satisfy relatively long range needlines, without each RS having to be in line with every other RS" [Ref. 14:p. 2-18]. The tactical uses of this system method is very helpful for tanks and other maneuver units trying to avoid high terrain.

⁵"A needline is the data communication requirement/circuit between EPLRS radio sets" [EPLRS Technical Report, p 1-11, 26 Feb 93]

EPLRS contains embedded cryptological capabilities, and terminal data rates of multiple circuits with selectable rates up to 1,200 BPS simplex and 600 BPS duplex⁶. The data rate for each circuit is reduced as more circuits are assigned to a network. [Ref. 14:p. 2-32]

The POS/NAV circular error of probability for the system is 15 meters. The key to the POS/NAV is having the correct basis of location, which must be provided by another source like Global Positioning System (GPS), survey points, benchmarks and map information. [Ref. 14:p. 2-18]

Each Enhanced PLRS User Unit (EPUU) can be configured with either an ADDSI Interface Module Assembly (IMA) or a MIL-STD-1553B IMA. The ADDSI interface is the packet that contains up to 1024 bits of information. The unit of transfer for the 1553B Interface is the block containing 31 words at 16 bits per word. The IMA is the part of the EPUU that provides the interface to a host system equipped with either IMA. This way the 1553B or ADDSI IMAs can be used to exchange protocols to transport data between the host system and the EPUU. These may vary depending upon the number of circuits assigned.

⁶Simplex means information travels in only one direction, duplex means information travels in both directions.

I. CHS

1. Functional Description

Common Hardware Software (CHS) is the goal of utilizing the same hardware or software capabilities to gain interoperability of command and control systems. "A key feature of the ATCCS program is the goal of using CHS for the five tactical BFA control systems, wherever possible" [Ref. 15:p. 22]. CHS is a family of commercial off-the-shelf (COTS)-based computer hardware, peripherals, and software. The software would be developed or procured to operate on the common hardware. The Maneuver Control System Block II CHS is the current system. It consists of the Portable Computer Unit (PCU) and the Tactical Computer Processor (TCP) and is also known as CHS-1.

Block IV CHS consists of the Transportable Computer Unit (TCU) for the mid-to-upper end tactical computer user, the Lightweight Computer Unit (LCU) for the majority of the tactical computer users, the High Capacity Computer Unit (HCU) for the high end tactical user with computation intensive requirements, and the Handheld Terminal Unit (HTU) for low-to moderate computer users and is also known as CHS-2. [Ref. 13:p. 57,58]

2. Physical Description

a. Block II CHS

There are four layers associated with the CHS. Layer 1 is the common hardware. The ATCCS computers (the PCU and the TCU) are based on a 32 bit Motorola 68020 microprocessor supporting up to 8 MIPS (at a 33 MHz clock rate), a 32 bit, 5 Mbits/s data bus in a 3.5 floppy disk drive, and a 40 or 100 Mbyte removable hard disk cartridge. The PCU supports 1-2 million instructions per second (MIPS) and 4-20 Mbytes of random access memory RAM, whereas the TCU supports 2-4 MIPS with 4-16 Mbytes of RAM. The Stand-Alone Display Unit (SDU) is a 16-inch monitor with two configurations: monochrome display with direct (RS-232) connection to a portable computer or TCU or color monitor device (CMD) with keyboard and connection to the standard (ISO 8802.3) local area network LAN. The PCU has a 25-line (9-in) built-in display. The stand-alone Hard Programmable Interface Unit (HDU) is a 152 Mbyte disk drive with an Institute of Electrical and Electronics Engineers (IEEE) 488 interface. The Adaptive Programmable Interface Unit (APIU) provides four modems with multiple interface options (e.g., wire, RS-232, RS-449, COMSEC, combat net radio, packet switching). The Handheld Terminal Unit (HTU), designed as a digital entry device for forward units, weighs 7-10 lb and supports up to four modems.

Common software is planned for system support (Layer 2), common applications software support (CASS, Layer 3), and C2 applications software (Layer 4). Layer 2 software is provided with the NDI hardware and includes both and MS DOS environments (the HTU supports only MS DOS). [Ref. 15:p. 22]

CHS1 will provide a suite of CHS-1 items for use by the BFACS. The aim is to field modern computer equipment through a consolidated acquisition of compatible hardware and software. Common software consists of the common BFACS applications and Common ATCCS Support Software (CASS). CASS contains common functionality which will be implemented in software developed by selected ATCCS developers and includes the common support software entities for ATCCS that are not commercially available. CHS-1 consists of an NDI suite of computer hardware in handheld and transportable configurations. Peripheral equipment includes external hard disk, external compact disk ROM and floppy drive, power unit, mass storage expansion unit, monitor, communications interface device and printer. [Ref. 2:p. 1-11]

b. MCS Block IV

This equipment is referred to in the previous section as CHS-2. The present contract is for CHS 1. The CHS 2 acquisition is a follow-on contract and will be competitively awarded in early FY 94 to meet the BFACS

continuing requirement for a family of common hardware and software. CHS 2 will improve hardware capability and reduce cost and will come in handheld and transportable configurations. Peripheral equipment will include large color monitor, large screen display, printer, mass storage device and tactical scanner.

The TCU (see Figure 12) is a two piece digital computer ruggedized for tactical use. It consists of a computer unit and an external monitor and can be transported in a vehicle. The operating system is UNIX based and runs COTS software. Baseline peripherals include a printer, secondary storage device, and a keyboard.

The LCU (see Figure 12) is a portable one-piece digital computer resembling a laptop computer. It is DOS based and will also run COTS software. Basic features are a built in display, a 32-bit microprocessor, internal RAM and a removable rechargeable battery backup. Peripherals include a printer, and communications interface device.

The HCU consists of a CPU, keyboard, trackball, and a monitor. It is UNIX based and will run COTS software. It has the RS-232C interface.

The HTU (see Figure 12) is a one-piece unit and features a built in display, keypad, removable/rechargeable battery, and 28 VDC vehicle powered operation. It is DOS based. [Ref. 13:p. 57,58]

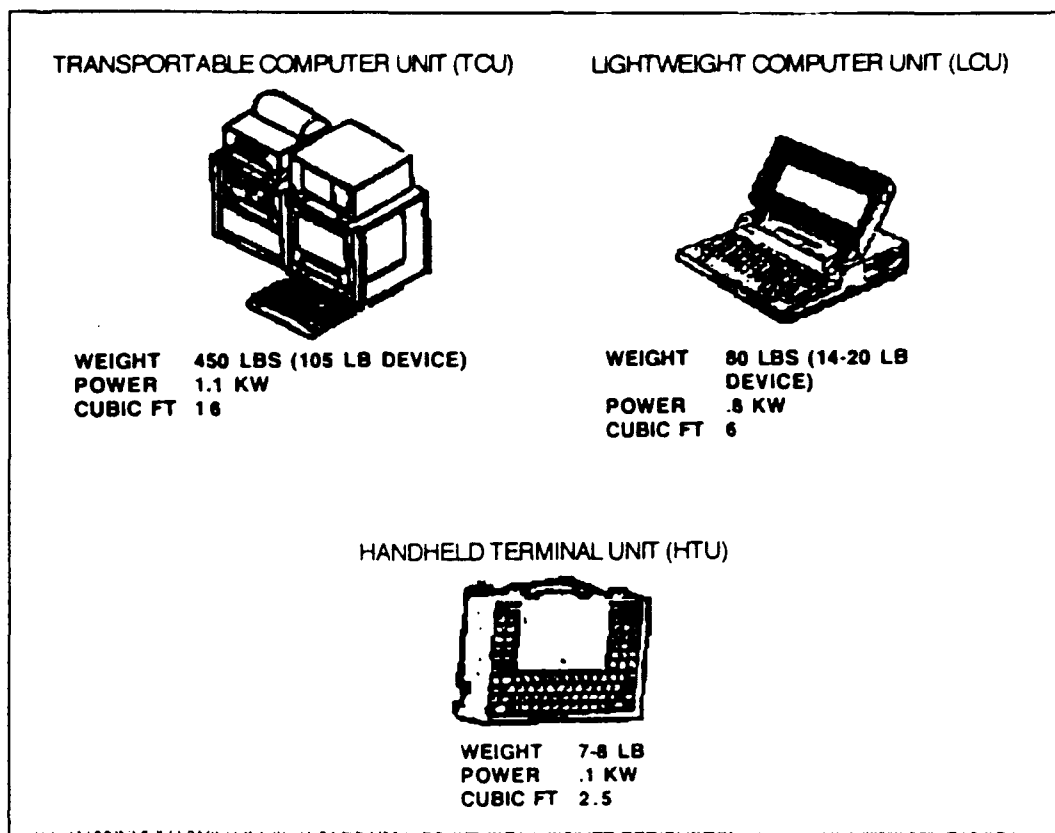


Figure 12 Common Hardware Software

J. SUMMARY

These nine systems comprise the major additions and substitutions to an existing maneuver battalion command and control structure. The descriptions of the systems help the reader understand the capabilities and limitations as they are included in the proposed architecture in Chapter IV.

IV. PROPOSED ARCHITECTURE

Chapters II and III described existing or developmental systems available to construct a command and control architecture. This chapter will formulate an architecture consisting of those components, yet pointed towards a high intensity conflict. A review of an existing battalion level architecture serves as a basis and comparison for the proposed functional and physical architecture.

The architecture is developed by first identifying the capabilities and external interfaces of each specific system. The capabilities are evaluated to determine where in the architecture the system will be used. The external interfaces are evaluated to determine connectivity with other systems, host vehicles and host hardware. These functional needs and physical capabilities and interfaces are then matched to the needs of the organizational structure. Where no system exists to fill a need in the architecture the capabilities necessary for a proposed system are discussed. Systems that provide duplicate capabilities to transfer necessary data are evaluated to determine which system will best fit the unit needs.

A. EXISTING ARCHITECTURE

The command and control structure for an armor battalion forms the functional framework for the existing battalion architecture. Additional units and other members of the combined arms task force are incorporated into the C2 structure based upon what elements of that structure either provide or require information and data. The battalion commander orchestrates the preparation, conduct, and reconstitution of the battle using his subordinate commanders and staff. He also receives from and provides information to other elements such as the brigade commander, brigade main command post and rear command post. Through his staff, he maintains communication and information flow with other members and operational facilities of the brigade.

Figure 13 illustrates the connections that provide the communications network and information flow in a typical battalion. The operational facilities in the battalion are the Tactical Operations Center (TOC), the Tactical Command Post (TAC), the Administrative and Logistics Center (ALOC) and the Field Trains. The Battalion Executive Officer (BN XO) is located at the TOC for battle management. The TAC is actually the command group composed of the Battalion Commander (BN CO) and the Fire Support Officer (FSO). The FSO

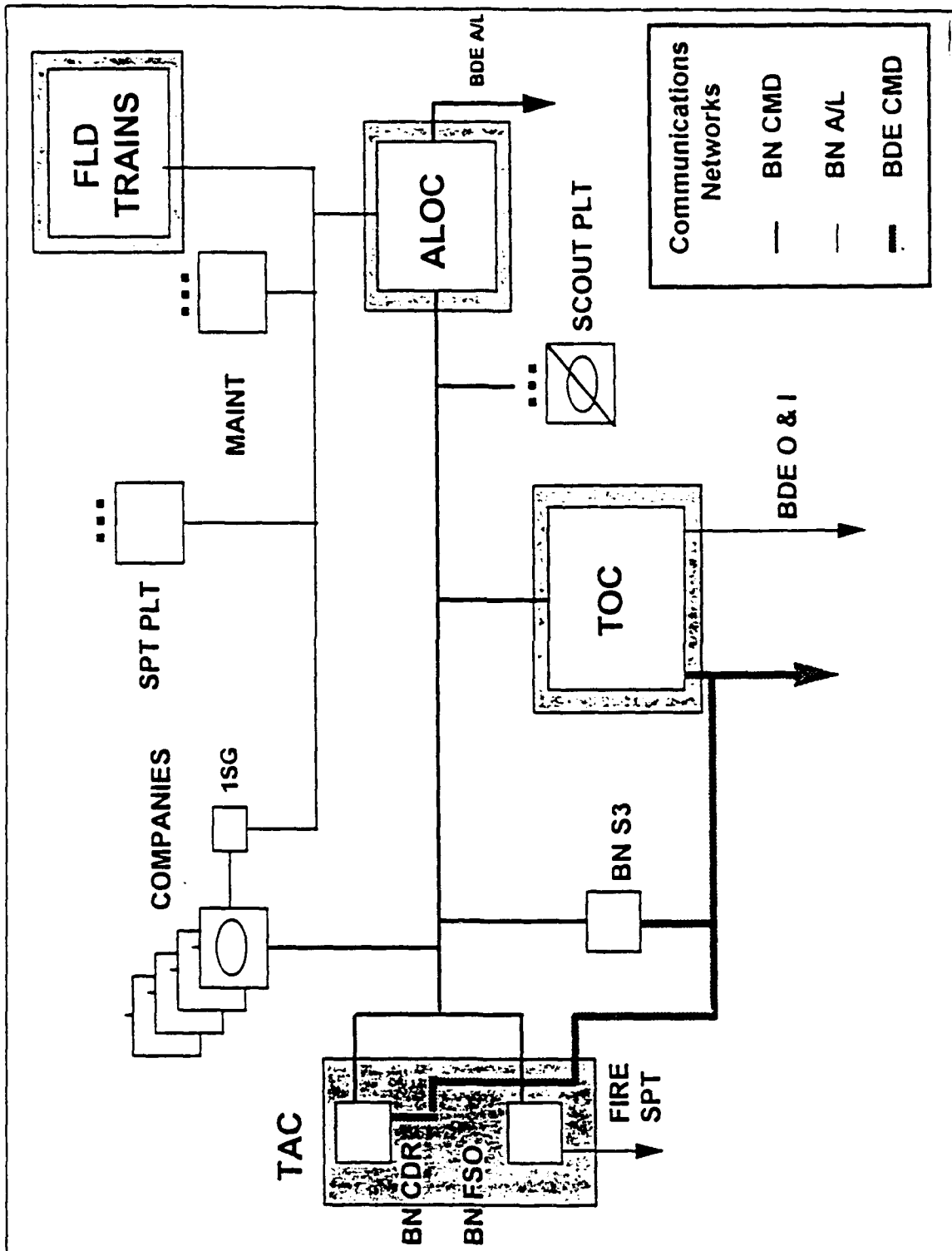


Figure 13 Existing battalion command and control structure

controls all indirect fires and close air support. The Battalion S-3 (BN S3) is usually located at another critical location in the battalion area.

Physically, all operational and intelligence information is exchanged via voice or hard copy products delivered by hand. The only exception is the fire support TACFIRE system and it's capacity is exhausted with fire support traffic only. Messages and reports are also voice communications or hard copy. Operational or intelligence graphics and overlays are hard copy only and must be delivered by hand or described over the radio. Radio descriptions of graphics and overlays can be confusing and often lead to the parties concerned not having the same graphics. Quite often, the overlays are distorted by hand copying and passing from one level or organization to another. Stress due to lack of time or situation also contributes to graphics or symbols being deleted or distorted. Gaining the common picture can be difficult.

The following sections describe the existing components of the overall structure.

1. TOC

The TOC consists of the S2 section, S3 section, Engineer Company CP, and Fire Support Element (FSE) each housed in an M577 (possibly a 1068 Standard Integrated Command Post System) with analog radios or updated with SINCGARS. The

FSE has TACFIRE net capability in addition to its analog or SINCGARS radios. TACFIRE presents the capability to send digital traffic (in message sets or free text). If the task force has an engineer company attached, the engineer CP housed in an M577 with analog or SINCGARS radios will also be present. These vehicles are located next to each other in the TOC.

The pace of the vehicles is well below the pace of the combat vehicles. Periodically the vehicles must stop to allow the battle staff the opportunity to record information, draw graphics or re-establish lost communications. Additionally, the physical set-up of the TOC takes anywhere from 30 minutes to an hour. The TOC may maintain radio communications immediately after stopping, but must unload map boards, radio remotes, and other equipment to become fully operational. Each halt to operate causes the TOC to fall farther and farther behind the combat forces. The range of the radios force the TOC to locate between the forces it is controlling and the brigade operational facilities.

2. TAC

The TAC consists of the FSOs M113 vehicle and the battalion commander's M1 series tank. The FSO vehicle has digital capability connected to the TACFIRE system, and analog or SINCGARS radios. The battalion commander has analog or SINCGARS radios. The S3 has the identical capabilities as the

commander. While the TAC does not face as great a challenge maintaining the pace of the battle, limitations of radio ranges impair the commander.

3. ALOC

The ALOC consists of the S1 section and S4 section housed in an M577 vehicle with analog or SINCGARS radios. These vehicles are located next to each other. The battalion aid station is in an M577 as well with analog or SINCGARS radios. The aid station may be located next to or in the vicinity of the S1 and S4 vehicles. The ALOC faces similar problems as the TOC.

4. Field Trains

Located approximately 25 kilometers to the rear of the front line of troops are the field trains. Again, analog or SINCGARS radios provide communications to the other operational facilities. The primary radio station is the Headquarters Company Commander's on a soft skinned vehicle. Movement of the field trains is less frequent than the other battalion operational facilities as they are co-located with the brigade support area.

5. Companies

Companies may be armor or infantry. The armor companies' vehicles are equipped with M1 series tanks and analog or SINCGARS radios. The infantry units are equipped with Bradley Fighting Vehicles (BFVs) with similar radios.

6. Attachments

Depending upon the task organization of the task force, other units may include air defense (STINGER) sections, Improved TOW sections, temporarily assigned attack helicopters, and engineers. Communications is either analog or SINGARS.

7. Deficiencies of the existing architecture

The existing battalion command and control systems has problems that can be corrected by adopting the proposed architecture. They are:

1. Accuracy and clarity of information transfer
2. Speed of information and data transfer
3. Susceptibility to enemy electronic countermeasures
4. TOC and ALOC vehicles are too slow to maintain the physical pace of the battle
5. Communication distances are heavily restricted by equipment limitations

Too often information in the form of reports, messages and graphics are "garbled and unreadable" to the point the information is discarded for fear of using wrong data. Messages and spot reports sent at 0200 are often transcribed by sleepy, overworked soldiers with bad handwriting no one can read. Key grid coordinates are misread when the '2' looks like a '7'. A report of '2' tanks may infer a possible platoon of tanks at a grid coordinate. If the number looks like a '7' analysts could infer a possible company of tanks at

that location and advise the commander as such. Graphics drawn with a large marker cover 300 meters of a 1:50,000 scale map. The difference on the map is small, on the ground is another matter. IVIS or CVC2 can fix this.

Liason officers at the TOC deliver battalion graphics to the supporting brigade and return with the brigade graphics and orders. The time taken to receive the information is time lost, and there is still the problem of reproducing 50 copies of an overlay and maintaining the accuracy of information.

Analog radios without frequency hopping and spread spectrum techniques are vulnerable to electronic countermeasures. SINCGARS, with its capabilities, thwarts this problem and has the ability to send voice and digitized data over greater distances.

TOC and ALOC vehicles are much slower than the combat vehicles such as the M1 series tank and the M2 and M3 Bradleys. The vehicles are also cramped with the items necessary to make the overlays, orders, and reports. The vehicles must be stopped and set up to become fully operational. The C2V will solve this problem.

B. PROPOSED ARCHITECTURE

The proposed architecture is constructed to eliminate the existing architecture's deficiencies listed on page 72. This entails incorporation of the nine systems described in Chapter III into the command and control structure of the battalion.

In a functional sense operational information and intelligence will be exchanged over the same communications paths to the same elements or operational facilities. The quantum improvement, however, will be the speed and accuracy of the information distributed. All the same players must still communicate with each other. The same information must still be collected and disseminated. The advantage gained by the commander is the addition of greater and more timely intelligence information. Coupling the sources and receptors of information and having the means to fuse the data into more useful intelligence should give the commander the advantage necessary to win on the battlefield. This will give the commander the means to function faster and more effectively than the enemy.

Physically, each operational facility has undergone a transformation of capabilities. Not all systems within this architecture are presently operational. In many cases, only the concept of what capabilities the systems will have can be determined.

In addition to passing data and information, the presence of computational means will provide an archival capability that can be drawn upon throughout the course of a conflict or stored for future use. Computer software such as

the Brigade Planner⁷ provide the means for a commander to "war game" a particular action, or develop several courses of action, all within a fraction of the time used today.

Digital communications allow the possibility of sending the information to other facilities or unit leaders that for tactical reasons cannot come face to face. Digital communications also provide the flexibility and potential for future growth necessary to keep pace with a changing world and changing situational environment.

What follows is a description of the component's utilization in each of the operational facilities and the correction of existing deficiencies.

1. TOC

The TOC still consists of the S2 section, S3 section, Engineer Company CP, and Fire Support Element (FSE) (see Figure 14). The vehicle now used is the C2V described in Chapter III with SINCGARS, EPLRS, CHS, and an MSRT at the S2 and S3 vehicles. The C2V will allow the TOC to maintain the pace of the battle both physically and operationally. The vehicles are no longer required to be located next to each other. They will be connected by wireless Local Area Network (LAN) or send information over SINCGARS to CHS. The TOC

⁷ The Brigade Planner is a computer-assisted planning aid capable of running closed as well as man in the loop simulations, terrain evaluation, and enemy tactics and actions [Ref. 17:p. 21, 22].

benefits from the dispersion with increased survivability and reduced radio spectrum disturbance.

The FSE will have either TACFIRE net capability or AFATDS. This integrates the Fire Support BFA. The S2 primary vehicle (and backup S3) will have connections to the CGS by an MSRT or EPLRS. Warrior software resident on CHS will allow the battalion to analyze their area of operation and area of influence. This will integrate the IEW BFA. The engineer C2V will have connectivity to IVIS/CVC2 for providing immediate status to the force of obstacles, mobility, survivability actions. The S3 (and S2 backup) will have IVIS/CVC2 and the B2C2 specific software force level control system capability on the CHS, thus integrating the Maneuver and Air Defense BFA.

The pace of the vehicles, and capability of the C2V to operate on the move eliminates the need for the vehicle to stop to become fully operational. SINCGARS radios and EPLRS and MSE extend the range of operations for the TOC. Eventually, touch screens and voice controlled computers will replace manual keyboard entry. The C2V set up time is less than two minutes (required to raise the 10 foot antenna) to become fully operational. Rapid reaction to a changing situation is now much easier.

Each of the battalion TOC sections is equipped with an MSRT. Because of the MSRTs ethernet interface, it can be linked to the TOCs CHS (Figure 14). EPLRS ethernet, X.25, and ADDSI interfaces are also easily connected to the CHS.

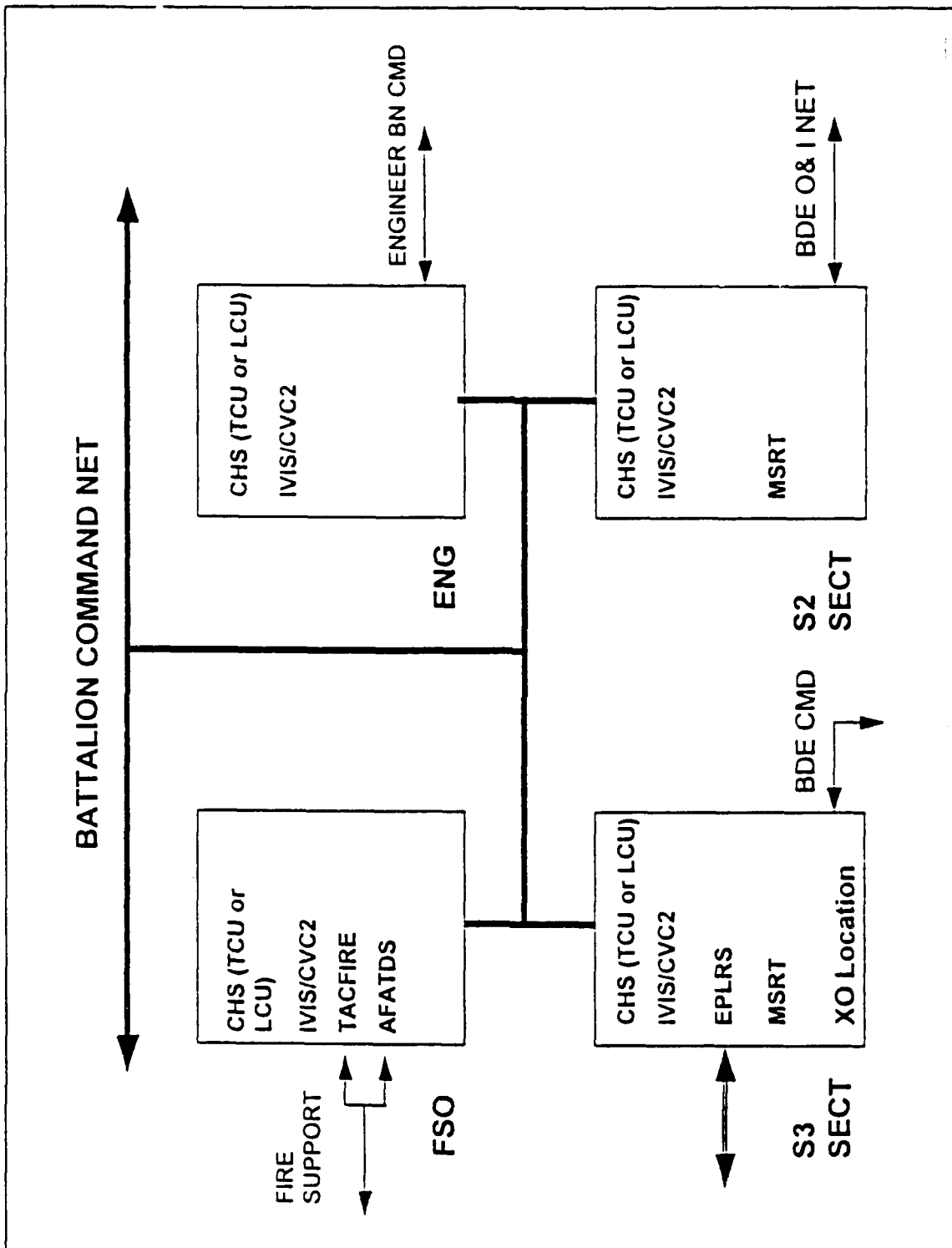


Figure 14 Proposed battalion TOC

2. TAC

The TAC consists of the FSO's Bradley Fighting Vehicle⁸ and the battalion commander's M1 series tank. The FSO vehicle has digital capability connected to the TACFIRE system (possibly AFATDS) and SINCGARS radios. The battalion commander has SINCGARS, EPLRS and an MSRT. What is necessary, but has not been yet developed, is the integrating software for the radio interface unit. This software will be required to determine what type of message, voice, and data on the tank should be routed over which communications means. For example, the commander may have developed graphics on an integrated display for an upcoming operation. When he sends that set of graphics the information is routed to the Radio Interface Unit (RIU). The software in the RIU evaluates the information to be sent for size, classification level and type of graphic. The software then decides to send the information via SINCGARS or EPLRS and routes the data to that communications device⁹.

The S3 has the identical capabilities as the commander and all vehicles have IVIS/CVC2 capability. Figure 15 illustrates the proposed TAC configuration.

⁸ This would be a modified BFV for the FSO, and has not yet been developed.

⁹This is purely a conceptual idea. Presently no software application exists to perform this task and must be developed.

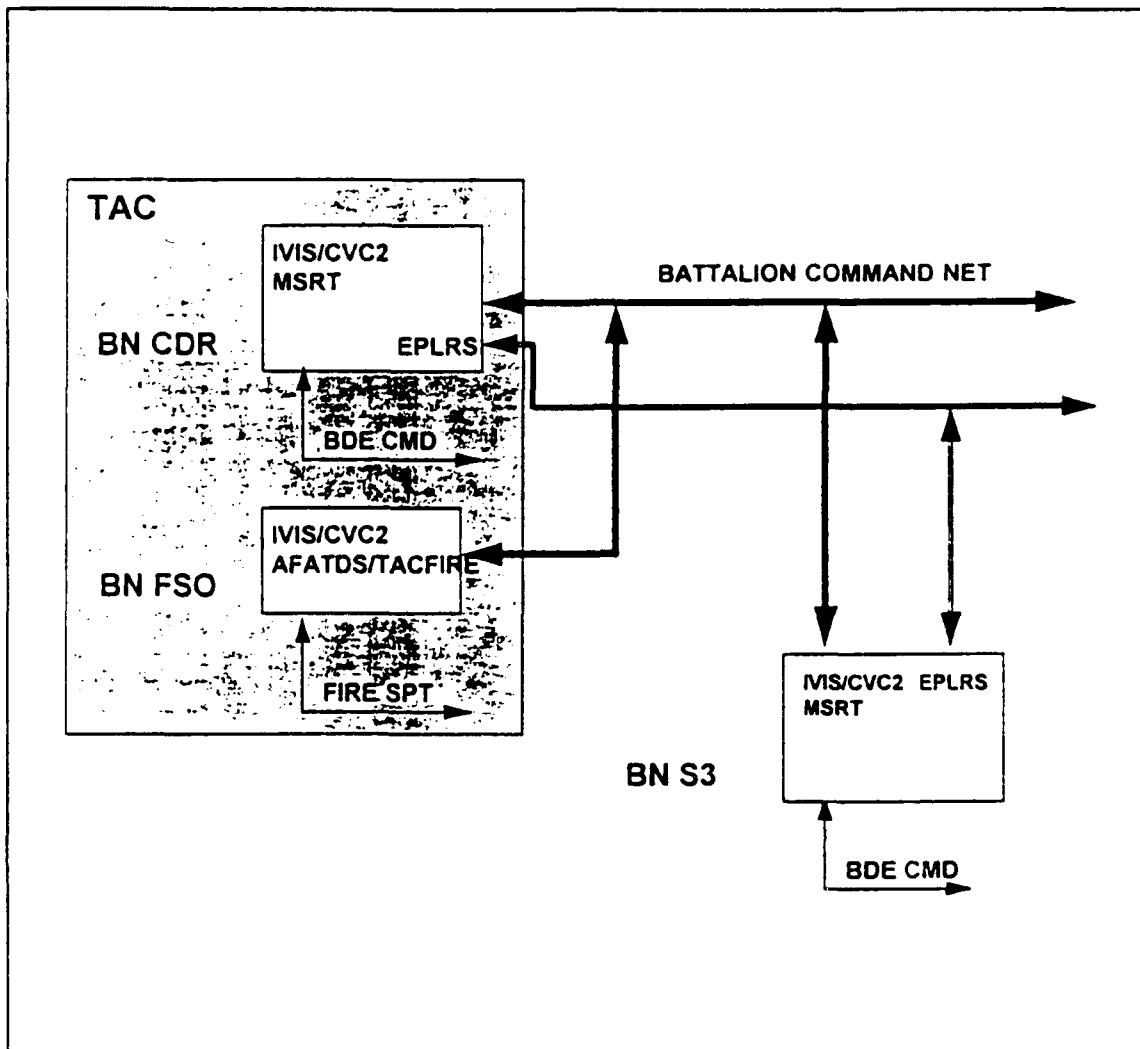


Figure 15 Proposed TAC

3. ALOC

The ALOC consists of the S1 section and S4 section housed in two C2Vs with CHS, and the battalion aid station. Current thought is to co-locate the S1 and the S4 in the same C2V. This practice does not allow for contingencies,

maintenance problems, combat losses, and the ALOC's supplemental mission of alternate TOC. The ALOC will be dispersed in a manner similar to the TOC. SINGARS, EPLRS, and an MSRT provide connectivity to higher level CSSCS as well as integration with the battalion force level control system. IVIS/CVC2 capability also serves to integrate the Combat Service Support BFA at the battalion force level. Figure 16 depicts the ALOC.

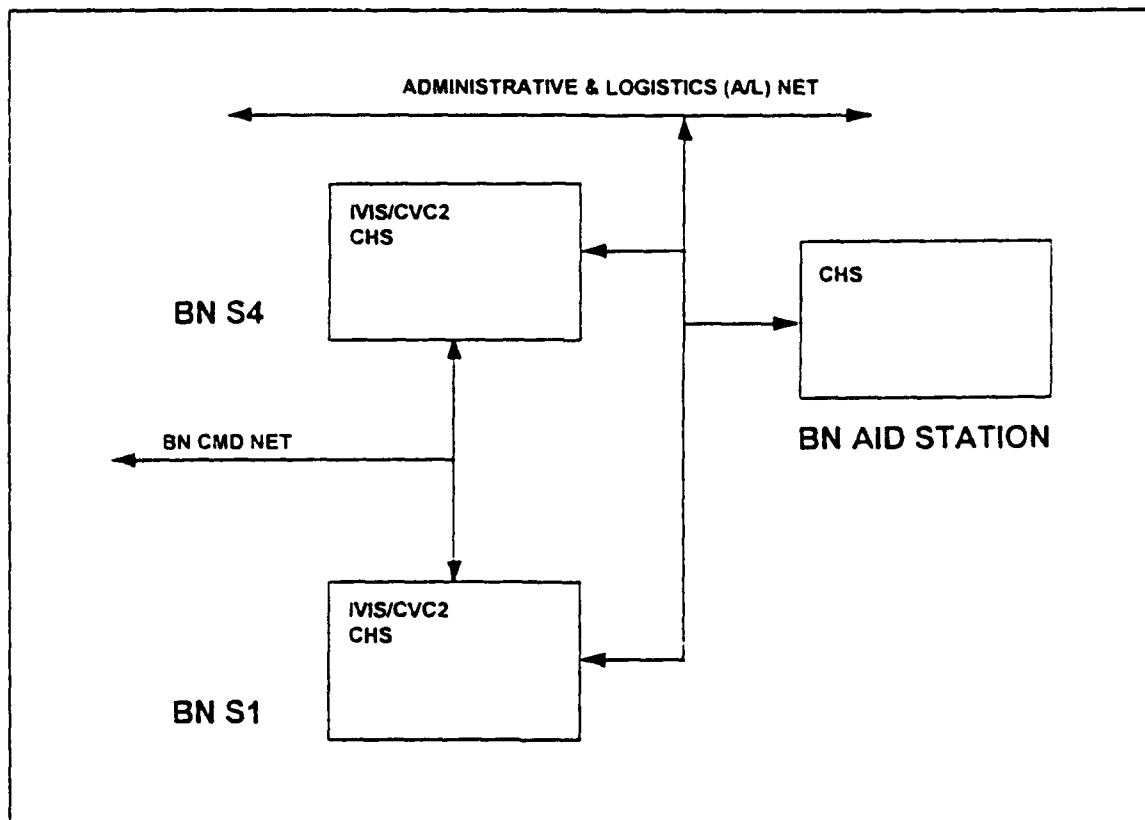


Figure 16 Proposed ALOC

4. Field Trains

The field trains will be connected via LR/LR SINGARS over an IVIS compatible system resident on a CHS LCU. Current

transport means for the field trains will require the use of the LCU.

5. Companies

Companies will use IVIS/CVC2 entirely within the company organization (see Figure 17). Attachments to the company must have IVIS compatible capabilities. The company commander will have an EPLRS radio set incorporated into his vehicle in the same way the battalion commander will. This will allow for greater message and overlay transmission without interrupting voice communications.

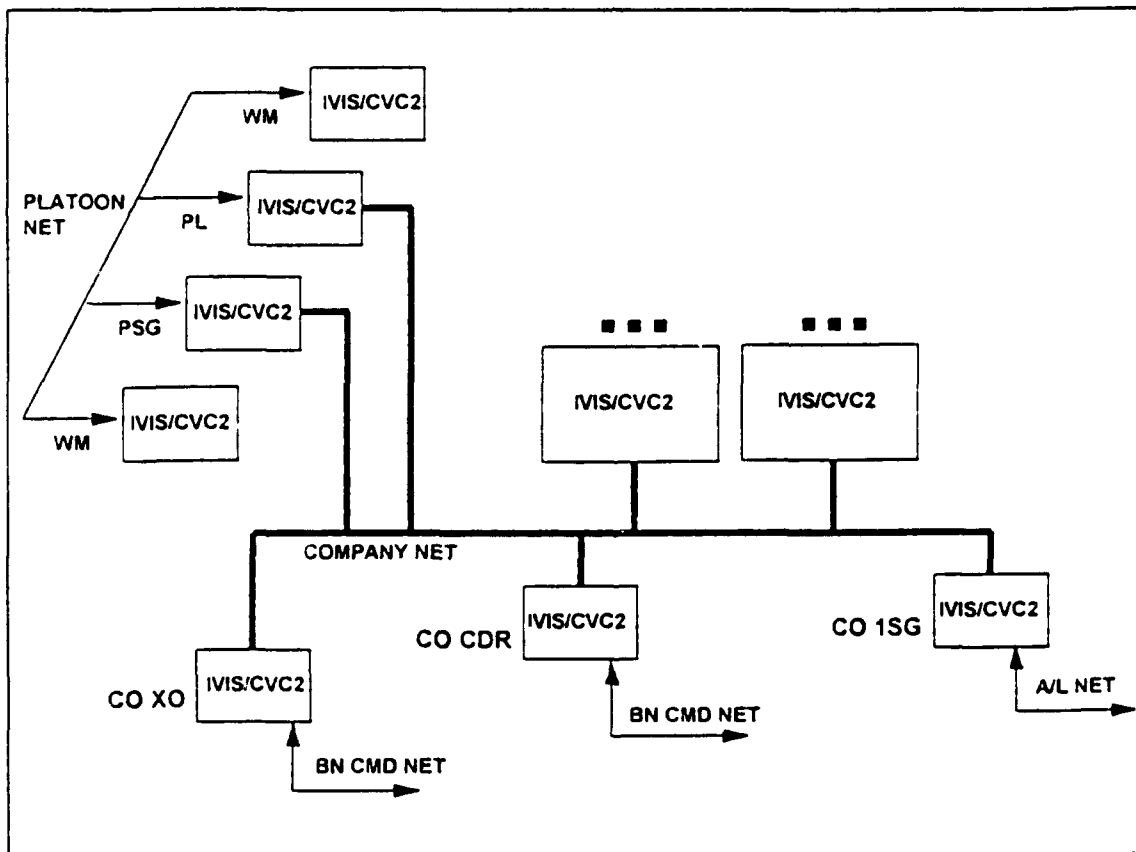


Figure 17 Proposed company architecture

6. Attachments

Attachments to the task force must have IVIS compatible systems. Attached elements such as engineer, air defense, and chemical units do not yet have this capability. While this thesis is ambitious in its assumption that the structure is buildable with a limited number of developments, the real difficulty is connectivity to other combat, combat support and combat service support assets.

7. Solutions To Current Deficiencies

Figure 18 is the overall architecture of the proposed battalion and below command and control system. The components to this C2 system have been reviewed in previous sections.

With this structure, information and data can be sent in fractions of the time currently required. The accuracy and clarity of the data will improve simply because there are fewer interpretations as the information passes from the source to the commander. SINCGARS and EPLRS do not eliminate enemy electronic countermeasures, but they do improve communications in that environment.

The C2V dramatically improves the TOC's and ALOC's abilities to maintain the physical and operational pace of the battle. Having a self contained vehicle that requires very little set up time, can maintain the speed of operations, and has the software and hardware tools necessary to support the

commander in a greater fashion are quantum improvements in synchronizing the battle.

With SINCGARS increased transmission and reception range, and EPLRS capacity to route messages and graphics through passive EPUU systems over greater distances, the range of communications is also greatly improved.

This architecture provides the commander with the means to solve the problems in the current system.

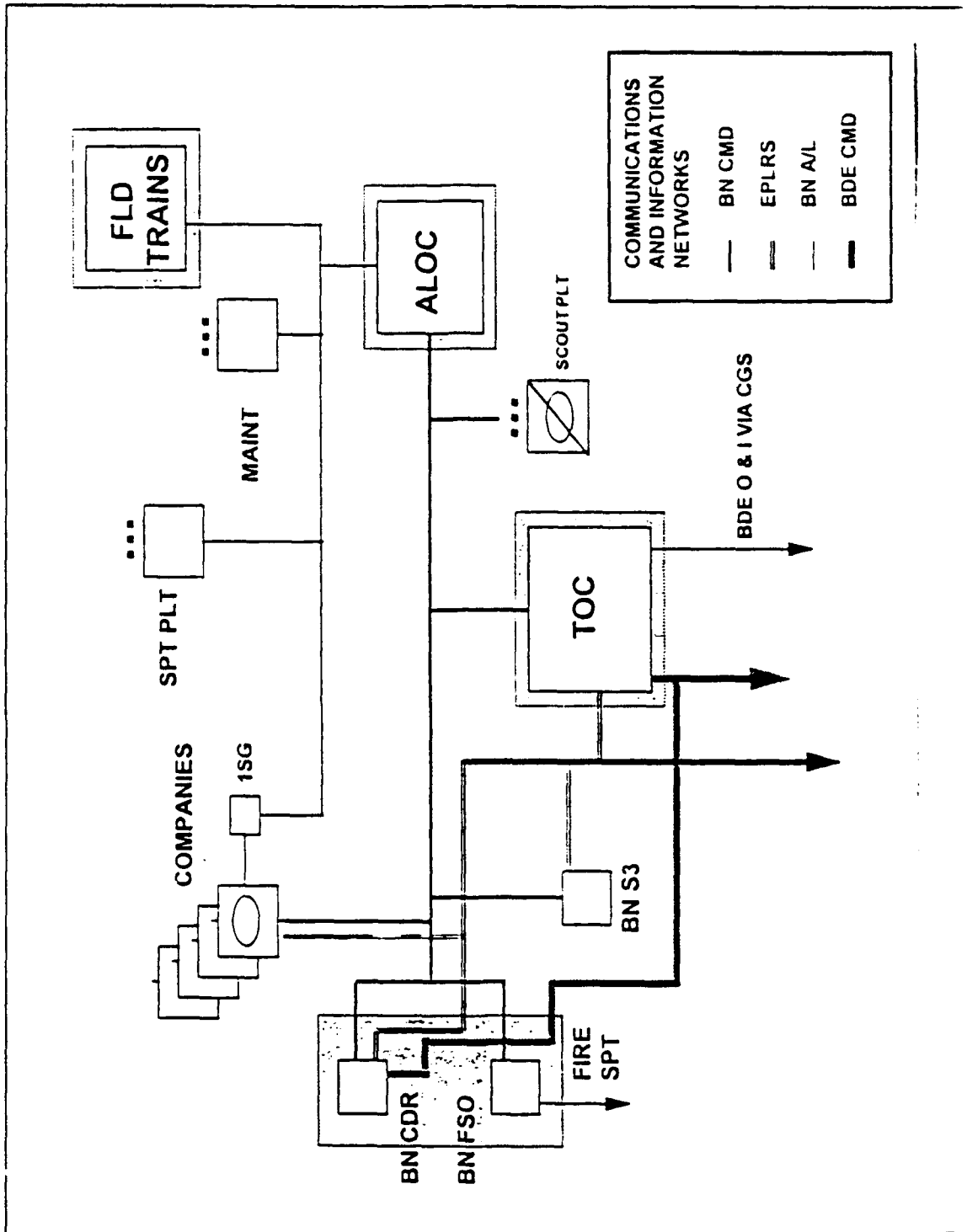


Figure 18 Proposed battalion command and control architecture

V. SUMMARY, CONCLUSIONS, RECOMMENDATIONS

A. SUMMARY

The Near Term and Immediate battle management environments are characterized by increased confusion, conflicting information, decreased time for planning, and an overall sense of immediacy and increased pressure. This is also a highly distributed decision-making environment involving numerous individuals, each with a functional area of responsibility, and all charged with working together to produce a coordinated plan. [Ref. 16:p. 2]

Ideally the information requirements and communications needs would be developed first. Following that, the hardware software and firmware would be developed to establish the means of transfer. However, equipment and systems exist today to bring to fruition the means to digitally integrate the battlefield. The architecture proposed in this thesis will connect the battalion commander to the sources of information as well as those nodes he wishes to inform of decisions or other information processed at the battalion TOC. It also provides the situational awareness for all members of the battalion or task force.

B. CONCLUSIONS

Ultimately the measure of a command and control system is one which aids the unit in functioning more effectively and faster than the enemy he faces. AirLand Battle Doctrine hinges on our ability to think, act, and move faster than the enemy. The architecture proposed here will give the battalion commander the means with which to control his forces and maximize their capabilities. All this is not without cost. The addition of an extra vehicle in each armor battalion during these economic times poses a problem. The cost, however, of reduced capability and ability to display greater Agility, Initiative, and Synchronization could mean the difference in a future conflict.

C. RECOMMENDATIONS

1. Future research areas

Future research in the area of this thesis should concentrate on testing the architecture using the Network Assessment Model or a similar model. The investigation of necessary software capabilities assumed in this thesis should also be done.

2. Possible continuation of the architecture with future systems.

There are systems in concept exploration and development that could further enhance the utility of the proposed architecture. Multimode, multiband digital radios

will increase the communications means and reduce the number and size of radios needed. The flexibility to use computer cards to emulate several different radios will give the potential of connecting every element on the battlefield.

Wireless LANs provide the means to protect the force through dispersion. Helmet mounted displays and voice controlled computers free users from time consuming manual distractions. Virtual reality systems displaying terrain over the multimode radio give the potential of rehearsing every move on the battlefield.

Future systems like these can be incorporated within this proposed architecture to give the commander the tools necessary to better command and control the force.

LIST OF REFERENCES

1. United States Army Combined Arms Combat Developments Activity, *Army Command and Control Master Plan*, v. 1, Desktop Reference, 1990.
2. Army Tactical Command and Control System Test and Evaluation Master Plan, 1992.
3. Campen, A. D., *The First Information War*, AFCEA International Press, Fairfax, VA.
4. Weigeshoff, W. R., *An Automated Reconnaissance and Surveillance Planning Tool*, Masters Thesis, Naval Postgraduate School, Monterey, CA., September 1992.
5. Thordsen M., and others, *A Knowledge Elicitation Study of Military Planning*, p. 2, U. S. Army Research Institute for the Behavioral and Social Sciences, 1990.
6. U.S. Army Combined Arms Command, *Combat Developments, Army Tactical Command and Control System (ATCCS) Umbrella Concept for Battalion and Below Command and Control (B2C2) (3rd Draft)*, Fort Leavenworth, Kansas, 7 July 1992.
7. Lee, F.A., MAJ, USA, *Should the Army Tactical Command And Control System (ATCCS) Provide Command And Control Automation To The Heavy Maneuver Battalion/Task Force?*, Masters Thesis, U. S. Army Command and General Staff College, Fort Leavenworth, Kansas, 1993.
8. Department of the Army United States Armor Center . Directorate of Combat Developments, *IVIS Operational Concept*, Fort Knox, Kentucky, July 92.
9. U. S. Army Combined Arms Command, *U. S. Army Operations Concept for Battalion and Below Command and Control (B2C2)*, Draft, Fort Leavenworth, KS.
10. U. S. Army Battle Command Battle Lab, *Draft Concept Paper (C2V)* Fort Leavenworth, KS. 1993.
11. Office of the Deputy Chief of Staff for Operations and Plans Memorandum to Commander, U. S. Army Training and Doctrine Command, Subject: *Operational Requirements Document (ORD) for Command and Control Vehicle (C2V)*, 26 March 1993].

12. Headquarters, Department of the Army, *Operator's Manual, SINCGARS Ground Combat Net Radio, Non-ICOM, (TM 11-5820-890-10-3)*, May 1991.
13. Headquarters Combined Arms Command, *Army Tactical Command and Control System (ATCCS) Systems Management Techniques (FM 24-7), Preliminary Draft*, 1 May 1993.
14. Hughes Aircraft Company, *Scientific and Technical Report System Technical Description for Enhanced Position Location Reporting System (EPLRS) Lrip Program*, 26 February 1993.
15. Walker, R. P. et al, *Assessment of Potential for Commonality of ADP for Army and Marine Corps*, Institute for Defense Analysis, December 1989.
16. Thordsen M. et al, *A Knowledge Elicitation Study of Military Planning*, Klein Associates, Yellow Springs, Ohio, February 1990.
17. Ralph, J. R., *Decision Support Systems for Mobile Subscriber Equipment Communications Managers*, September 1988

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