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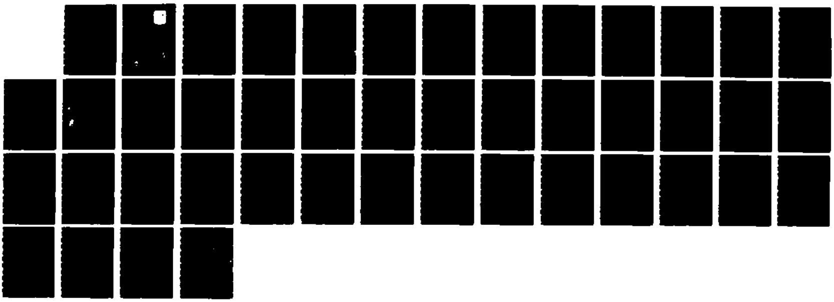

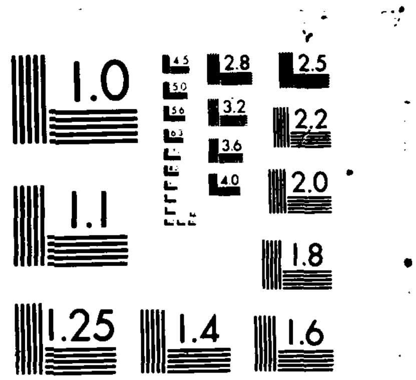

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STUDENT ESSAY

COMMAND AND CONTROL ARCHITECTURE OF THE FUTURE

BY

LIEUTENANT COLONEL JOHN T. WILDENBERG

23 MARCH 1987

US ARMY WAR COLLEGE, CARLISLE BARRACKS, PENNSYLVANIA

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The widening of the battlefield and decrease in the density of combatants have made it more and more difficult for the commander to "sense" the location and condition of his forces. Technological developments have increased the pace and fluidity of combat; and reduced the time available for sensing the situation, evaluating the situation, and taking actions necessary to thwart the enemy intentions and win the battle. The commander

must "see" the wider battlefield, "sense" the enemy's intention, and plan, direct and coordinate actions to defeat the enemy in the close, deep and rear Airland Battles. Automated Command and Control Systems need to capitalize on the same technology that widened the battlefield to provide the information necessary to "see" and "sense" without overwhelming information and provide a means to rapidly communicate the information necessary to carry out the commanders intention. This paper describes the switch from the revolutionary to the evolutionary approach to design of a command and control system, the proposed fielding program for the Maneuver Control System, and command and control initiative within the United States Army Europe. There have been many initiatives, formal and informal, to develop such a command and control system. Informal initiatives need to continue to place systems in the field now and provide user input to insure that an effective Maneuver Control System is fielded for use throughout the Army.

USAWC MILITARY STUDIES PROGRAM PAPER

COMMAND AND CONTROL ARCHITECTURE OF THE FUTURE

An Individual Essay
by

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ABSTRACT

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The widening of the battlefield and decrease in the density of combatants have made it more and more difficult for the commander to "sense" the location and condition of his forces. Technological developments have increased the pace and fluidity of combat; and reduced the time available for sensing the situation, evaluating the situation, and taking actions necessary to thwart the enemy intentions and win the battle. The commander must "see" the wider battlefield, "sense" the enemy's intention, and plan, direct and coordinate actions to defeat the enemy in the close, deep and rear Airland Battles. Automated Command and Control Systems need to capitalize on the same technology that widened the battlefield to provide the information necessary to "see" and "sense" without overwhelming information and provide a means to rapidly communicate the information necessary to carry out the commanders intention. This paper describes the switch from the revolutionary to the evolutionary approach to design of a command and control system, the proposed fielding program for the Maneuver Control System, and command and control initiative within the United States Army Europe. There have been many initiatives, formal and informal, to develop such a command and control system. Informal initiatives need to continue to place systems in the field now and provide user input to insure that an effective Maneuver Control System is fielded for use throughout the Army.

COMMAND AND CONTROL ARCHITECTURE OF THE FUTURE

Command and control has always been vitally important in the management of crisis and the employment of military power, and it has never been more important than now. If a command is to function as a coherent body, its command and control nervous system, and especially the displays which form the critical interfaces between these systems and decision makers they serve must be the best that we know how to provide. However, simply knowing about new techniques is not enough. Before the new techniques can be applied, there must be a thorough understanding of the operational requirements to be met. The fact that the potential of modern display technology and automatic data processing has not yet been fully exploited is not because there is a technical gap, but an application gap in bringing our technical know-how to bear on our vital requirements.

There appear to be three main reasons for this. First, our analysis of requirements have not been specific enough; second, we have failed to pinpoint which requirements are most vital; and third, we have not translated our requirements into feasible system concepts. We have been long on generalized statements about the need for better data processing systems and displays, but short on specific concepts of how they can help solve particular command and control problems. To close the application gap, we need to bring our requirements into sharper focus, to move from the general to the particular, from the abstract to the concrete.

At the same time we need to develop a wider perspective on the nature of the command and control process so that we can see more clearly which display applications are most likely to be most vital and therefore likely to make the most substantial contributions to our command and control capabilities.

The purpose of this paper is to illustrate how we can achieve focus and perspective in developing command and control requirements. It is not a comprehensive statement of all the requirements that exist; however, by illustrating the initiatives within the United States Army Europe (USAREUR) and the approach to developing the Engineer Command and Control System (ECCS) architecture, it may help to indicate some of the directions we need to go.

I will not take time here to develop another definition of command and control to add to those already in existence. We may have already spent too much time trying to define terms and too little trying to understand what the terms mean, and may have got on the wrong track altogether in trying to describe command and control in terms of facilities, personnel and procedures. Command and control is none of these, though it involves all of them. It is rather a set of related processes which help a decision maker perceive what is happening, decide what to do, and control weapons and forces so as to implement the desired strategies.

Each of the three basic processes - perceiving, decision planning and controlling - depends, in turn, on the effective performance of two specific command and control functions. The process of perception involves (1) situation reporting and (2) resource reporting. The process of decision planning involves (1) the evaluation of alternative courses of action and (2) consultation between decision makers and their staffs to compare plans and coordinate actions. The process of controlling involves (1) directing the actions of weapons and forces and (2) defining the necessary restraints on their actions.

All six of these vital functions have to be carried out continuously, in greater or less detail, and with greater or less urgency, at all levels of military and political decision making, under a wide range of crisis and conflict situations from low levels of conflict to all out nuclear war.

They are vital because they directly support decision makers and their staffs as they deal with crisis and conflicts, agree on the strategy too be followed, and take the actions required to implement it. They do not, of course, guarantee effective decision making or ensure the success of the strategy. But sound decisions and successful strategies are likely to be impossible unless these functions are carried out effectively.[1]

There are two levels where decisions are made: the tactical level and the division or higher level. The tactical level is up through brigade where the battle is. At this level, decisions are made on the spot and are made based on direct observations. These observations can lead to actions on the part of commanders who are in the position to see the actual combat or to move quickly to a position where they can see. At division or higher levels, commanders can see only pieces of the battle. The decisions made by these commanders do not have an immediate effect on the battle. At each echelon, moving up from the division, the time line between decisions and actions increase in length.

The principal decisions at these higher echelons normally involve moving units and allocating resources. Since it takes 48 hours to properly commit a division, a major task should be to forecast the situation 48 - 96 hours in the future. Thus there is a clear need for automatic data processing and simulation in support of the forecasting operations.

We can get an intuitive idea of which functions are likely to require and benefit from modern display and information processing techniques. Clearly, the two "seeing" functions; the perception of the current military situation and the availability of military resources head the list. To perform their mission, decision makers and their staffs must have timely and accurate information on the current ground and air situation and the forces and weapons that are or may be available. This information provides the basis for all subsequent planning, weighing of alternative strategies, decision making and action.

As already suggested, there are likely to be significant changes in the relative emphasis on various functional and performance requirements as we move across the spectrum of conflict. The basic command and control processes and the vital functions which support them do not change; but the level of effective decision, the amount and kind of information needed at various levels, and its required timeliness and accuracy are likely to vary depending on the kind of crisis and conflicts that are envisioned and the strategies that are planned.

Despite the most careful advanced planning, the exact circumstances and timing of the events which might trigger the decision process cannot be foreseen. All we can be certain of is that when the time comes for decisions to be made, they are likely to be needed quickly. There will probably not be enough time for the slow, sequential processing of information and decision planning at each echelon of command in turn. Instead, all echelons of command will need to work essentially in parallel.

At such times, the overriding requirement is likely too be for timely and accurate information on the current military situation. The decision makers and staffs at all levels of command will want to know what is happening where the fighting is going on and will want this information just as fast as they can possibly get it.

This desire for timely and accurate situation information at higher military and political decision levels does not imply a lack of trust in lower echelon commanders or a desire to interfere with their decisions. On the contrary, if higher level decision makers use the information wisely, they will use it for enlarging the lower level commanders' freedom of action, by getting ready to make the required political-military decisions promptly when they are needed. They are likely to be in a position to do this only if they are following the developing situation closely, continually evaluating alternative courses of action, and trying to anticipate possible decision points.

Failure to provide adequate information for this purpose results in less, not more, freedom of action for lower echelon commanders. Their ability to act is necessarily restricted during the interval that it takes higher level decision makers and their staffs to gather information that they consider essential, evaluate the situation, and reach a decision. It is therefore as much in the interest of lower echelon commanders and their staffs to provide timely, accurate situation information as it is in the interest of higher decision makers and their staffs to process, display, and use it effectively. This is the best, and perhaps the only, means of trying to ensure that when higher-level decisions are needed, they will be timely, sound and relevant.

If we were designing a command and control system from the ground up, we would therefore have to think not only of all the functional and performance requirements to be met, but of all the possible crisis and conflict situations under which these functions might have to be carried out. In practice the task is rarely this comprehensive. We almost always start with some existing or planned capabilities, we usually have some idea of the kinds of situations that are likely to occur, and we have usually developed some plans and strategies that we may want to implement. The task thus becomes one of evaluating the capabilities and limitations of the existing and programmed facilities, identifying specific potential capability gaps that appear to limit the feasibility and therefore the choice of strategies, and seeing how these deficiencies can be remedied.

This historical "broad systems approach" to the development of command and control systems cannot resolve the fundamental difficulties of obtaining valid user functional requirements. Futhermore, the local development of command and control systems relying entirely upon the capabilities of the user command, the "bits and pieces" approach is found to be wanting and tends to produce costly and repetitive trial and error cycles. An alternative evolutionary approach which would ensure that the valuable military service hardware and software expertise will be made available to any and all military users in an appropriate manner is required. This approach preserves, maintains and disseminates the useful and established knowledge and experience gained from military command and control development efforts. It recognizes the need to assign greater responsibility to user commands for the development of their own command and control systems, while at the same time providing for such commands a means of obtaining greater capabilities in this area.

The approach that attempts to stipulate several years in advance what the initial operational capability of a given command and control system should be "the broad systems approach" has lately tended to be discarded in favor of one involving gradual evolution. Futhermore, it is now recognized that command and control systems must evolve within the context of the user command.

Historically, the attempts to resolve the basic difficulties in obtaining operational requirements for command and control systems led to the creation of special agencies within the military services and Department of Defense. The over-all management responsibility for the development, acquisition, and delivery of command and control systems was located in such agencies. In general, the eventual system user had representatives in the appropriate agency and was thereby enabled to participate in the system design phase. In this manner, the system user could introduce up-dated functional requirements that often resulted in program design changes. However, compromise was inevitable. In order that the established delivery schedules might be met, great pressure was applied to freeze the system design early so that hardware procurement and development could begin. Soon after selection of the contractor there was a tendency to fix upon an initial operational capability, reserving changes for the second phase of complete operational capability. It was quickly discovered that most aspects of the system, both the hardware and software, soon became cast in concrete. At this point, introduction of even relatively small program design changes, however important these changes might be, proved costly in terms of both funding and delivery time. As this experience became the common pattern in the broad systems approach to command and control developments, the need for a change in developmental philosophy became apparent.

The recognition of the necessity for an evolutionary approach to the development of improved command and control capabilities is one thing; the establishment of appropriate management control responsibilities to ensure its successful accomplishment is another. How "evolutionary approach" is interpreted and how the approach is put into effect will significantly contribute to the success or failure of forthcoming command and control systems.[2]

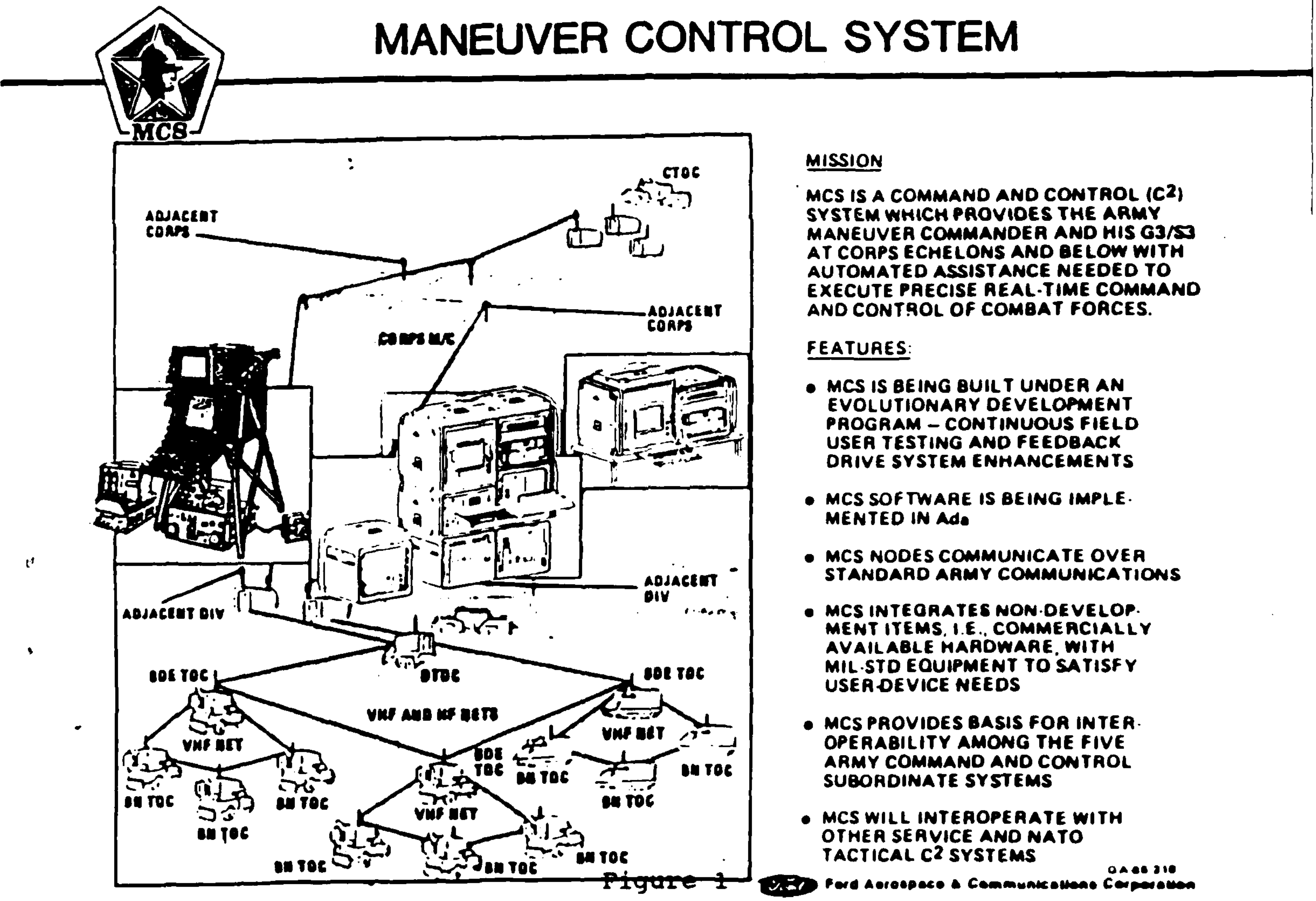

Figure 1

The Maneuver Control System (MCS) is part of the Army's tactical command and control system delineated as the Command and Control Subordinate System (CCS2) architecture. The CCS2 architecture was developed to organize and simplify the analysis and management of interoperability requirements for Battlefield Automated Systems (BAS) assigned to units at Corps and below, plus to improve the flow of information on the battlefield. It represents the Army's battlefield command and control system architecture. The CCS2 architecture subdivides the tactical command and control systems into five functional segments. The five functional segments are: Maneuver Control, Fire Support, Intelligence and Electronic Warfare, Air Defense and Combat Service Support. The MSC architecture, approved by the Army's Fifth Battlefield Automation Appraisal in 1980, represents the Army's initiative to automate primary functions of maneuver control under the direction of the maneuver force commander.

The MSC is being developed through the evolutionary process characterized by "Build a little - Test a little." As parts of the system are developed, the user participates in tests and evaluation. Thus valuable, immediate feedback is provided and refinements are made promptly. In addition, as user needs become more clear, MCS development adapts to meet them. The fielding of MCS computer hardware and software capabilities will be executed in four separate blocks. Each block will build on the hardware and software capabilities in the previous block (Figure 2).

MCS is a system of computer equipment, computer software, communications interface devices, facilities, personnel and

Maneuver Control System Implementation Concept

	Hardware	Software
BLOCK 1 4QFY86- 3QFY87	MCS mil spec: -Tactical Computer Terminal (TCT) -Tactical Computer Terminal Prime (TCT')	MCS version 9
BLOCK 2 4QFY87- 3QFY88	MCS mil spec: -TCT continue -Loacl Area Network (LAN) NDI: -Tactical Computer Processor (TCP) -Analyst Console (AC)	MCS version 10 -MCS/DCCS convergence -initial graphics -free format message
BLOCK 3 4QFY88-FY91	NDI: -graphics displays	MCS version 11 -Force level control -MCS/MTF lashup -enhanced graphics -embedded training programs -simulation exercise -initial artificial intelligence
BLOCK 4 early 90's- mid 90's	MCS mil spec: -Battalion Terminal (BT) -MCS to ACCS transition -Refurbished MCS to Reserve component	MCS to ACCS transition

Figure 2

procedures. It provides commanders and their staffs from Battalion through Division with an automated system for planning, directing, and controlling operations. MCS is designed to support sustained combat operations in all levels of conflict, to be operational 24 hours a day, and to be deployable worldwide. It makes maximum use of commercial off-the-shelf hardware and software integrated with existing Army tactical communications. This approach allows MCS to rapidly take advantage of technical advances in commercial equipment. Software is a mix of commercial packages and special applications necessitated by the military environment. Supplies are available through the computer stores worldwide and some are available through Army supply systems.

The MCS provides features that will greatly enhance Command and Control (C^2). By automating the processing and displaying of information, the large amount of data that is gathered from widely separated areas can be handled efficiently through the use of highly visual, user-friendly displays. These displays provide knowledge of the current situation, available resources and readiness status. The commander and staff can then accurately evaluate the information, rapidly issue orders and instructions, remotely monitor how well those orders and instructions are carried out, and rapidly alter plans as require by the changing situation. A primary benefit of this feature is the ability to work quickly. The cycle of acquiring information, making decisions, issuing orders, and ensuring actions move faster than the enemy's command and control system

Another feature of the MCS is the provision of reliable data regardless of the commander's or staffs location. As the data base is automatically updated, it is replicated at multiple locations. This feature has a number of benefits. MCS survivability is enhanced by placing the same critical information in many locations. Thus, the Division can sustain significant degradation before the ability to command and control is seriously impaired. Also, the commander is provided with battlefield mobility in that the same information is available in fourteen locations. In addition, the replicated data base provides all subordinate commanders with the same view of the battlefield.

MCS will be compatible with other Army force modernization programs such as the Position Locating and Reporting System (PLRS). MCS will provide the necessary interface to those programs, will allow access to common collateral-level databases and will provide the means to move data throughout the Division.

The MCS operates to insure the timely two-way flow of information among key elements of the Division. Individual information updates from all units may be transmitted two ways via tactical communications systems: electronic mail and data base updates. The commander may have the data displayed in a variety of formats including video maps with graphic overlays, pie charts, summaries, situation reports , and tables. As the commander's decisions are made, they are disseminated to units as applicable (Figure 3).

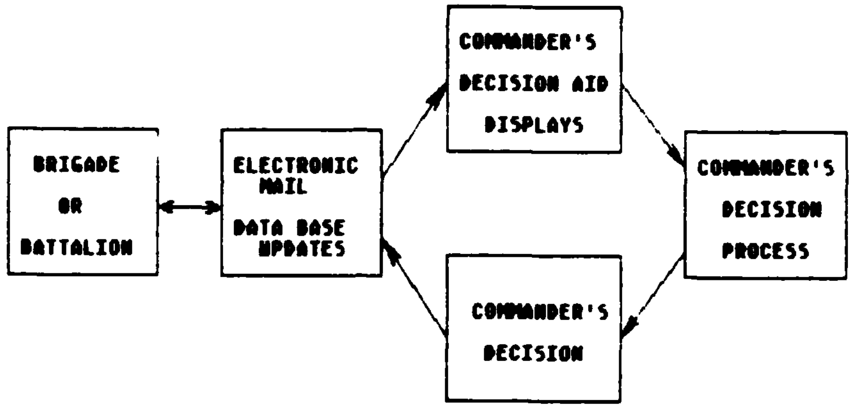

Figure 3 Flow of Information

MCS is organized to provide automation from Battalion through Division. In support of this, MCS organization within the Division, Major Subordinate Command (MSC) and Battalion is based on current principles calling for separation of the planning and directing functions when fighting battles. This separation is accomplished by means of Command Post (CP) configurations in which all the traditional elements are organized and physically located to support the decision-making and battle-making process (see Figure 4)

The Division CP provides the facilities and interfaces which allow the commander to see and direct the deep, close-in, and rear battles, allocate resources, plan future battles, and position combat support. The Division CP is composed of three echelons: the Tactical Command Post (TAC CP), the Main Command Post (MAIN CP), and the Rear Command Post (REAR CP).

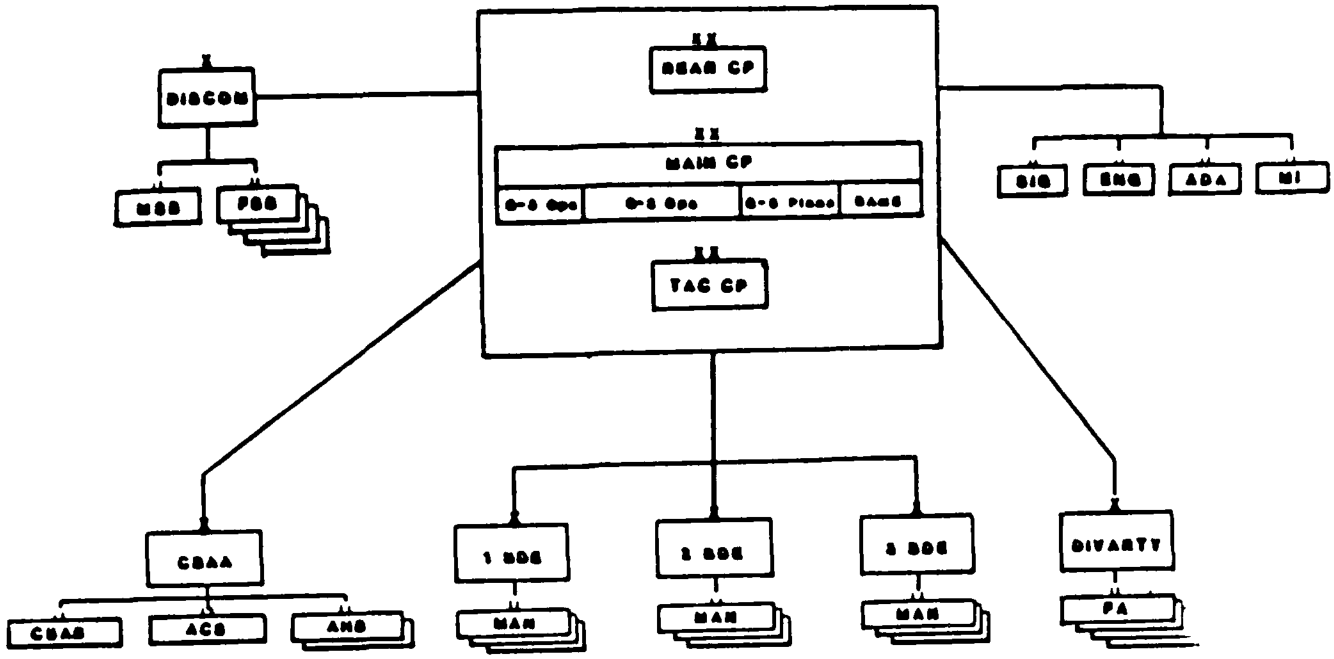

Figure 4 MCS Architecture

The TAC CP is the hub for the close-in battle. The TAC CP may merge with the MAIN CP and provide the command and control function for the MAIN CP when no forward presence is required. The TAC CP is capable of sending data to and receiving data from the other echelons of the Division CP and MSCs

The MAIN CP provides those functions essential to managing the total tactical situation, fighting the deep battle, and planning the future battle. The MAIN CP is the hub of Command and Control within the Division. It is organized into the following elements: G-3 Operations, G-2 Operations, G-3 Plans, and the Divisional Airspace Management Element (DAME).

The REAR CP contains those elements concerned with sustaining and restructuring the force. The G-1 and G-4 staffs are located here along with the Adjutant General, Judge Advocate General, Inspector General, Surgeon, Chaplain, and those associated with combat service support. It also has the same data distribution capability as the MAIN CP. The REAR CP habitually collocates with the DISCOM CP, which normally provides command and control for the rear battle.

Each Major Subordinate Command (MSC) along with the Division CPs, is capable of functioning as a Division Alternate Command Post (ALT CP). This capability is accomplished by means of appropriate communications links and the distributed MCS data base common to the echelons of the Division CP and the other MSCs. As a result, MCS provides several benefits. First, information essential to command and control of the Division is available to the commander at whatever CP he may currently be located. Second, only minimum essential personnel and equipment augmentation is needed to allow an MSC to be designated as an ALT Division CP. Third, as the tactical situation changes, the MSC designated as the current ALT Division CP can rapidly and easily be changed. Fourth, since all MSCs have access to the same data base, all have access to the same information covering the entire battlefield and, thus, share a common view of it (see Figure 5).

Rounding out the Division and MCS are the battalion tactical level units. These Lower Echelons consist of Main Support, Forward Support, Signal, Engineer, Combat Support

Aviation, Air Cavalry Squadron, Air Attack Helicopter, Maneuver, and Field Artillery Battalions. These units update the Upper Echelon data bases with the most current information. They also support the Battalion Commander's command and control

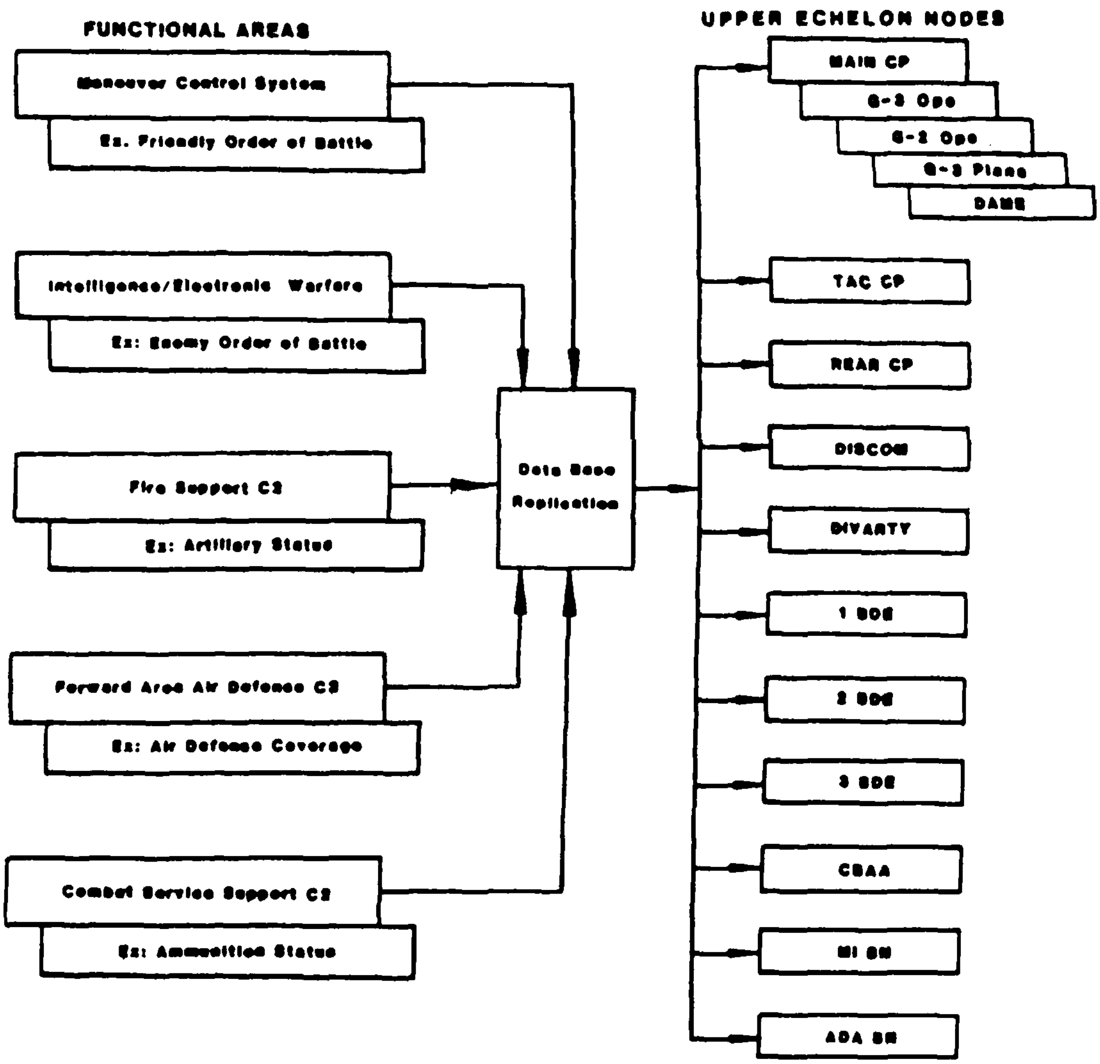

Figure 5 Replicated Data Base

requirements and his decision process. Each Lower Echelon node may be configured either as a single workstation or as several workstations linked together in a Local Area Network (LAN).

The typical single workstation is based on one portable computer. Connected to it are a printer and a storage device (either a hard disk system or a floppy disk system). The computer contains pre-set formats for records or reports and a mail system which enables the user to send information, updates and reports to other nodes. These single workstation nodes are usually found at battalion- and brigade- level TAC CPs, field trains and selected staff sections.

The typical multiple workstation nodes have several workstations linked in a LAN. Multiple workstations communicate through one main processing unit called a Server. The LAN makes peripherals, such as storage devices and printers, available to all users on the network. In other words, the LAN offers the following benefits. First, it allows users to operate without any peripheral equipment at their own workstation. Second, all users on the network can have access to the system's applications software and electronic mail. Third, it can limit the access of certain individuals to specific subjects or files. Fourth, the LAN allows users to store their programs and allow others that require a user's information to have access to it. The LAN configuration is usually found at the battalion-level MAIN CP.

Central to the LAN is the Server. It controls communication between itself and the peripheral equipment attached to it, communication between itself and the portable computers attached to it and communications among its internal processors. All user activities with the Server take place through the portable computer. As many as 48 of these computers may be supported by one Server. Information may be stored on hard of floppy disk systems.

Communications components also contribute to the typical Lower Echelon hardware configuration. The hardware at these nodes is capable of handling several means of communication at one time. This is done through a communications interface devise called the Data Communications Interface Unit II (DCIU II). The DCIU II is actually a computer that can process information as it is received or transmitted. It links the small computer with any combination of up to three single FM radios, and wire lines. It also allows information to be received on several channels simultaneously without losing any information and will determine if the FM radio network is free of transmission before it sends data. [3]

While the maneuver control system is an aggressive program, maximizing the use of commercial off-the-shelf hardware and software to provide an integrated command and control system, it does have three major shortcomings. First, ACCS hardware and software systems will not be available for several years. Second, the current design is modeled around a battalion with collocated companies, restricting UCLs to battalion and separate companies. Third, having been designed around a maneuver unit the data base does not accommodate the magnitude of Engineer data available throughout the Corps area.

There have been several initiative to provide a near term fix for these problems. The United States Army Europe (USAREUR) has recently complete a scrub of their battlefield automation requirements and defined a structure for automation within USAREUR and the Seventh Army that meshes with the proposed Army development program. It provides a basis for defining future automation development within the European Theater.

As part of their scrub, they have defined the requirements for a USAREUR Tactical Command and Control (UTACC) system that will tie together the USAREUR major commands and the USAREUR Headquarters and provide the essential automation until implementation of the Combat Service Support Control System (CSSCS) and the Army Command and Control System (ACCS) in the mid nineties. All USAREUR C^2 initiative have been rolled into this initiative under the UTACC label to reduce proliferation of hardware systems that have strained logistics and training capabilities in the past. Acquisition of equipment by tactical units is limited to Army standard systems or their approved surrogates. USAREUR will define the standard set of off-the-shelf software for use by tactical units.

The plan to overcome hardware shortfalls over the next four years includes using standard MS-DOS micro computers for the Unit Level Computer (ULC) and TACCS. The plan includes battalion, separated company and higher peacetime logistics and administration and, on a limited basis, use of ULC as a temporary filler for selected ACCS hardware until the ACCS systems are defined in Fiscal Year 88 and 89.

To insure that the initiative is not lost when the real ULCs are fielded, USAREUR has requested Army Material Command assistance in quickly developing a LAN that will allow the ULC, the ULC surrogate and other MS-DOS systems to be tied initially to the Tactical Control Terminal (TCT) for at least free text messages and then subsequently into the TCP for full-up netting. They also requested the software necessary to link the ULC to the TCT when the ULC is used as a battalion terminal.

This initiative does place hardware in the hand of the user in the near term, however, it does not address ULCs below Battalion level nor does it fully exploit information available within the Engineer community. The evolutionary process for [illegible] must be broadened to capture knowledge and experience gained [illegible]om attempts to develop an automated command and control system within the Engineer community.

Whether under the current Engineer structure or the future E-force structure, a Division commander can expect to see up to 9 Engineer Companies in support of his area of operation. That support equates to approximately 9 platoons or 27 squads working independently within a maneuver brigade sector. This dispersion of engineers throughout the division area provides the maneuver commander with a unique asset to analyze and report critical terrain data, obstacle data, MSR status, and river data as well as friendly and enemy activity across the division front.

The engineer structure must be responsive; on-site; integrated with the maneuver force at all times; ready, anticipating, and able to execute the commanders concept and requirements throughout the battle. [4] However, major shortcomings exist in the handling of the large amounts of critical terrain and obstacle data which must be maintained and analyzed by combat engineers and disseminated to engineer and maneuver force commanders and their staffs so that orders may be issued regarding future execution of tasks.

The need for an Engineer Command and Control System (ECCS) is dictated by this requirement to handle large amounts of data and the combat multiplier effect the combat engineers provide to the maneuver forces in the areas of mobility, counter-mobility, survivability and general engineering. The current manual system for acquiring and processing critical engineer data is extremely tedious and time consuming. The lack of accurate and timely processing of data may prevent the maneuver commander from reacting inside the enemy's decision cycle and result in the unnecessary loss of combat personnel and weapons systems. Commanders and their staffs require processed engineer information to plan their operations, execute those plans and modify the plans during execution. Automated systems are essential at every echelon, from engineer platoon to Corps commander, to collect, analyze, and report critical engineer information, and to disseminate it in a timely manner.

The ECCS hardware will be the standard hardware fielded with the MCS with the addition of a hand held device, configured for the platoon leader to pass information and receive orders from his company and higher headquarters. The software extends beyond the scope of the MCS. It includes the capabilities for engineer brigades, battalions, companies and platoons to perform mission related computations and data management. The software must run on MCS common hardware or surrogate hardware as is proposed in the UTACC system for USAREUR.

The equipment to run the software must include a source of data input, equipment to store, retrieve, analyze, and report the data, and the ability to transmit data and orders to higher and lower echelons of the engineer force in the form of database updates or message traffic. The equipment must tie into the MCS so that ECCS can pass pertinent information to force level commander and pull required information from that or other nodes as needed. This equipment must be available from the corps commander all the way down to the engineer platoon leader. The platoon leader's requirement is for a hand held device configured to allow him/her to pass information and receive orders from the company and appropriate higher commanders. All other engineer command and staff elements, from the company up, must have hardware that will permit the storage and manipulation of ever increasing amounts of data. These same organizations must also have a plotter available to them which will be capable of producing overlays of obstacle plans, and command and control graphics on map size sheets of acetate and paper.

The ECCS software must provide the engineer commander and all engineer staff elements with the ability to track the status of all pertinenty personnel, equipment and resources. The software must also give them the tools to analyze this data and balance it against various taskings in the form of engineer estimates, and publish OPORDERS and annexes. The software must also be able to send pertinent information to force level commanders, either as database updates or as message traffic. The ECCS software must be compatible with standard message formats, the Army Command and Control System (ACCS) and the Maneuver Control System (MCS). Only those portions of ECCS data and software that are pertinent to the force level commander will be resident on hardware that is dedicated for use by the maneuver commander. The full compliment of engineer technical data and engineer unique software will be located on the appropriate engineer staff officer's hardware. The software must present menus in a logical order, and the formats must be in a manned that allows non-engineer users to read the reports and messages without the use of a decoding aid. The transmittal of reports and messages must be simple for the user, flexible enough to modify what information is sent to whom as task organizations change. [5]

The feasibility and operational capability of the ECCS has been demonstrated in USAREUR. The Commander of the 7th Engineer Brigade, VII U.S. Corps, initiated a program, known as Automated Barrier and Terrain Information System (ABATIS) in May 1984 to provide timely engineer data to maneuver commanders. The initial objective was to field a system, using off-the-shelf hardware and software, in conjunction with existing tactical communication systems to provide timely engineer information for maneuver planners at the brigade, division and corps level.

While ABATIS did not test the full hardware architecture from platoon to corps level, it did demonstrate that the near term battlefield automation needs of USAREUR can be met. In addition to demonstrating the operational capability, tests of the system, during REFORGER 84 and REFORGER 85, provided valuable insight into the hardware architecture as discussed above.

ABATIS was also the first attempt in defining the information architecture for an engineer command and control system in USAREUR. The current system uses IBM compatible portable computers and MS-DOS software to track enemy order of battle, commander's SITREP, class V, friendly and enemy obstacles, bridge and river crossing data and main supply route (MSR) status.

The software is currently being updated to include the capabilities for engineer data reports, spot reports, and mission and barrier reports. The commercial software procured with the system also provides the capability for word processing, database management, and the preparation of spread sheets and visual presentations.

Concurrent with the hardware and software improvements for ABATIS, the 7th Engineer Brigade has initiated a thorough study to develop an information architecture to standardize all engineer reports within the VII Corps. While designed around the data entries used through the VII Corps engineer units, the architecture has direct application as a start point for the evolving Engineer Command and Control System. The information architecture was developed using the format prescribed by the IBM application Manual. The architecture is a tool that shows the relationship between data classes and military command processes.

The first step in the process is to identify all data entries used within the target community, in this case the engineer units within the VII Corps. A data entry is information of lasting interest to the organization and is categorized as either a person, place, thing, concept or event. The data entries in this case were determined to be the information reported by engineer units to their higher headquarters. The entries were obtained by interviewing separate company and battalion commanders and their staffs of engineer units throughout the Corps, and analyzing operational reports and Field Standard Operating Procedures. 147 unique and distinct data entries were identified.

The next step in the process is to identify data classes. A data class is a logical grouping of data related to things of lasting interest and available for decision making. The 147 data entries were broken into categories based on the type of information contained in each. Eventually 14 different data classes were identified. These data classes and their definitions are listed in Figure 6.

A process identification matrix was used (see Figure 7) to identify the military command process. The matrix lists the life cycle stages of a mission along the vertical axis. These stages are: (1) Requirements: Activities that determine the amount of a resource and number of missions required, (2) Acquisition /Stewardship: Activities to acquire and maintain resources and to

DATA CLASS DEFINITION

Equipment Type: Tracked vehicles, wheeled vehicles, bridge parts, construction equipment, special equipment.

Equipment Status: Amount of Equipment on hand, amount of equipment authorized, readiness status.

Mission Type: Mine field, point obstacle, tank ditch, construction, MSR repair, river crossing, assault breach, reorganization as infantry, reconnaissance.

Mission Status: Planned, executed, percent complete, start time, effective time, completion time.

Mission Goal: Mobility, countermobility, survivability.

Unit Type: Combat corps engineer, divisional engineer, bridge company, heavy equipment section, combat support equipment company.

Enemy Status: Disposition, unit type, type of enemy obstacle emplaced, estimated breaching time of enemy obstacle.

Material Type: Mines, POL, ammunition, lumber, sand, gravel.

Material Status: Amount of material on hand at unit or in field stock point.

Material Requirements: Amount of material required to accomplish mission.

Personnel Type: Officer, warrant officer, enlisted, MOS type.

Personnel Status: Number and type of personnel on hand, number and type authorized, KIAs, WIAs, MIAs.

Unit Status: Condition of unit with respect to morale, location, equipment, material and mission load.

MSR Status: MSR, trafficability, state of repair and capacity.

Figure 6.

	MISSION	MATERIAL	EQUIPMENT	PERSONNEL
REQUIREMENTS	DEVELOP MISSION REQUIREMENTS ANALYZE BATTLEFIELD ANALYZE ENEMY	DETERMINE MATERIAL REQUIREMENTS DETERMINE MSR REQUIREMENTS	DETERMINE EQUIPMENT REQUIREMENTS	DETERMINE PERSONNEL REQUIREMENTS
ACQUISITION/ STEWARDSHIP	MANAGE MISSIONS	MANAGE MATERIAL MANAGE MSR	MANAGE EQUIPMENT MAINTAIN EQUIPMENT	MANAGE PERSONNEL
DISPOSITION	ASSIGN MISSION	DISTRIBUTE MATERIAL	DISTRIBUTE EQUIPMENT	DISTRIBUTE PERSONNEL
	⟨:::::::: DEVELOP OVERALL STRATEGY ::::::::⟩			

Figure 7. Process Identification Matrix

track resources and missions, and (3) Disposition: Activities that bring resources and missions to the end user. Basic resources; product (mission), raw materials, facilities (equipment) and personnel are listed along the horizontal axis.

Utilizing the process identification matrix and unit interviews, 18 military command processes were derived. The processes and their definitions are listed in Figure 8.

The next step was to develop a process/data class matrix. The military processes were listed on the vertical axis and the data classes were listed on the horizontal axis (Figure 9). A "C" was used to indicate which process created the data class. Each data class can be created by one and only one process, although it may be used by many processes. Once each data class

PROCESS DEFINITION

Develop Overall Strategy: Determining the military activities and objectives of the Corps and its subordinate units.

Determine Personnel Requirements: Determination of what MOSs and ranks in what quantities are required for mission accomplishment.

Manage Personnel: Procurement and tracking of personnel as needs vary to battlefield losses and changes in mission requirements.

Distribute Personnel: Distribute personnel to units as required.

Analyze Battlefield: Determining what has occurred and is occurring on the battlefield, including what obstacles are emplaced and being emplaced.

Analyze Enemy: Determining enemy activity, disposition, and probable courses of action.

Develop Mission Requirements: Determine what missions must be accomplished to support overall strategy.

Manage Missions: Prioritizing and evaluating missions as they are accomplished.

Assign Missions: Assigning missions to units in a manner that best supports the overall strategy.

Determine Equipment Requirements: Determine what equipment types and quantities are required.

Manage Equipment: Procuring and tracking equipment as needs vary due to battlefield losses and changes in mission requirements.

Distribute Equipment: Distribute equipment to units as needed.

Maintain and Use Equipment: Utilizing and maintaining equipment in the course of mission accomplishment.

Determine Material Requirements: Determine what materials and quantities are required to support the overall mission strategy.

Manage Material: Procuring and tracking material as needs vary due to consumption and changes in mission requirements.

Distribute Material: Distribute material to units as required.

Plan MSR: Determine supply routes required to support the overall strategy.

Manage MSR: Utilizing and maintaining supply routes to support.

Figure 8. Process Definition

PROCESS \ DATA CLASS	Mission Goal	Mission Type	Mission Status	Unit Type	Enemy Status	Unit Status	Personnel Type	Personnel Status	Equipment Type	Equipment Status	Material Rqmt	Material Status	Material Type	MSR Status
Develop Overall Strat	C		U		U	U						U		U
Develop Mission Reqmt	U	C		U										
Manage Mission	U	U	C	C	U	U				U		U		U
Analyze Battlefield			U	U	U	U								
Analyze Enemy					C	U								
Assign Mission		U				C		U		U		U		
Determine Pers Rqmts	U			U			C	U						
Manage Personnel				U		U	U	C	U					
Distribute Personnel			U	U			U	U						
Determine Equip Rqmts	U			U					C	U				
Manage Equip		U							U	C				
Distribute Equip				U		U			U	U				
Maintain & Use Equip									U	U				
Determine Matl Rqmts		U							U		C	U	U	
Manage Material		U	U								U	C	C	U
Distribute Material						U			U		U	U	U	U
Plan MSRs	U										U		U	U
Manage MSRs			U								U		U	C

Figure 9   Process Data Class Matrix

had its creating process identified, data classes used by other processes were identified. The "using process" is identified by a "U".

Groups of processes were then identified by observing similar patterns of data usage. Figure 10 shows the processes and data classes broken down into four groups based on data usage patterns. These "process groups" can be identified by the processes they contain as operations management (S2 and S3), personnel management (S1), equipment management (BMO) and material management (S4).

PROCESS \ DATA CLASS	Mission Goal	Mission Type	Mission Status	Unit Type	Enemy Status	Unit Status	Personnel Type	Personnel Status	Equipment Type	Equipment Status	Material Rqmt	Material Status	Material Type	MSR Status
Develop Overall Strat	C		U		U	U						U		U
Develop Mission Reqmt	U	C		U										
Manage Mission	U	U	C	C	U	U				U		U		U
Analyze Battlefield			U	U	U	U								
Analyze Enemy					C	U								
Assign Mission		U				C		U		U		U		
Determine Pers Rqmts	U			U			C	U						
Manage Personnel				U		U	U	C	U					
Distribute Personnel			U	U			U	U						
Determine Equip Rqmts	U			U					C	U				
Manage Equip		U							U	C				
Distribute Equip				U		U			U	U				
Maintain & Use Equip									U	U				
Determine Matl Rqmts		U							U		C	U	U	
Manage Material		U	U								U	C	C	U
Distribute Material						U			U		U	U	U	U
Plan MSRs	U										U		U	U
Manage MSRs			U								U		U	C

Figure 10 Process Groups

Carrying the analysis one step forward it is observed that whenever data created by one process group is used by another process group, information must flow between the two groups. Each "U" located outside a box represents shared information between process groups. Figure 11 shows the information flow between process groups, known as the information architecture data flow. Removing the Cs and Us and rearranging the data classes produces the Information Architecture Flow Diagram (Figure 12). The Information Architecture Flow Diagram identifies systems that form the overall plan, identifies the data controlled by each information system, identifies the process supported by each system, and shows the flow of information between the information systems.

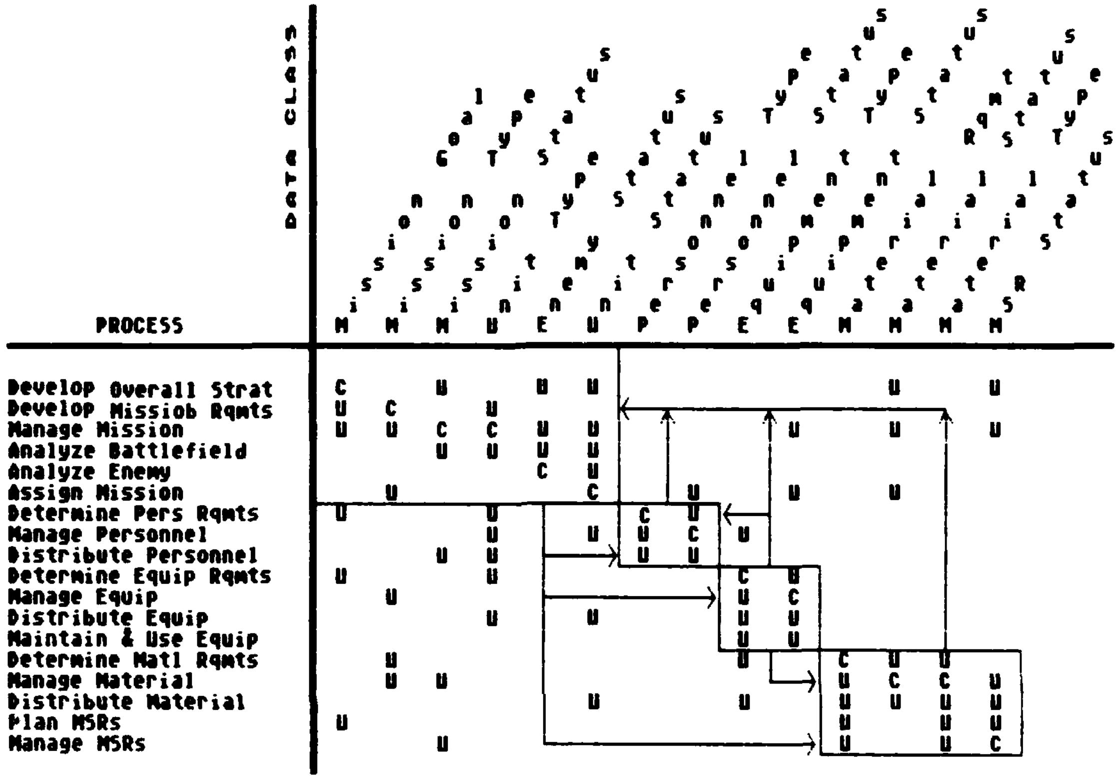

Figure 11 Information Flow

Commanders and Staffs face a significant challenge as the Army moves into the last decade of the Twentieth Century. The widening of the battlefield and decrease in the density of combatants which has marked combat operations since the beginning of this century have made it more and more difficult for the commander to "sense" the location and condition of his forces. Likewise, technological developments which have increased the

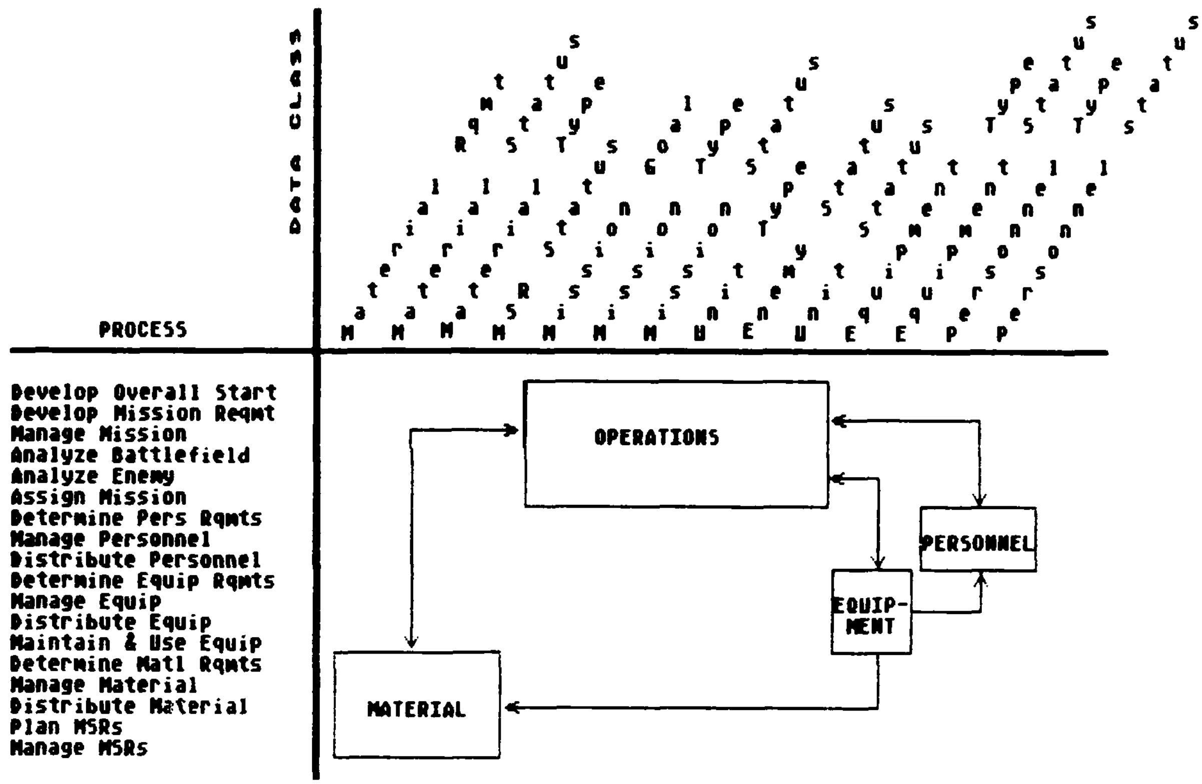

Figure 12 Information Architecture Flow Diagram

battlefield have increased the pace and fluidity of combat; and reduced the time available for sensing the situation, evaluating the situation, and taking actions necessary to thwart the enemy intentions and win the battle.

Our most likely enemy's forces and tactics are optimized to maintain rapid movement made possibly by technological advances. Our response to this threat, the Airland Battle, requires commanders to fight a wider, faster paced battle in three inter-related areas. The commander must "see" the wider battlefield, "sense" the enemy's intention, and plan, direct and coordinate actions to defeat the enemy in the close, deep and rear Airland Battles. The staff must provide the commander with the information necessary, without overwhelming him with detail.

Automated Command and Control Systems need to capitalize on the same technology that widened the battlefield to provide the commander and his staff with the information necessary to "see" and "sense" the battlefield and provide a means to rapidly communicate the information necessary to carry out the commanders intention.

There have been many initiatives, formal and informal, to develop such a command and control system. The evolutionary approach to development of the Army Command and Control System is a positive step toward fielding a system that takes advantage of the availably technology and incorporates user input in a timely manner. Informal initiatives, to define system and information architecture, need to continue in order to place systems in the field now and provide user input to insure that an effective Maneuver Control System is fielded for use throughout the Army.

ACRONYMS

ABATIS	Automated Battlefield & Terrain Information System
AC	Analyst Console
ACCS	Army Command and Control System
ADA BN	Air Defense Artillery Battalion
ALT CP	Alternate Command Post
BAS	Battlefield Automation System
BDE	Brigade
BFA	Battlefield Functional Area
BMO	Battalion Motor Officer
BT	Battallion Terminal
CCS2	Command and Control Subordinate System
CP	Command Post
CSSCS	Combat Service Support Control System
C^2	Command And Control
DAME	Division Airspace Management Element
DCCS	Distributed Commands and Control System
DCIU II	Data Communications Interface II
DISCOM	Division Support Command
DIVARTY	Division Artillery
ECCS	Engineer Command and Control System
E-Force	Engineer Force
IBM	International Business Machine
LAN	Local Area Net
MAIN CP	Main Command Post
MCS	Maneuver Control System

MI BN	Military Intelligence Battalion
MSC	Major Subordinate Command
MSR	Main Supply Route
MTF	Message Text Format
NDI	Non Developmental Item
PLRS	Position Locating and Reporting System
REAR CP	Rear Command Post
REFORGER	Return of Forces to Germany
SITREP	Situation Report
S1/G1	Personnel
S2/G2	Intelligence
S3/G3	Operations
S4/G4	Logistics
TAC CP	Tactical Command Post
TCP	Tactical Computer Program
TCT	Tactical Computer Terminal
TCT'	Tactical Computer Terminal Prime
ULC	Unit Level Computers
USAREUR	United States Army Europe
UTACC	USAREUR Tactical Command and Control

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