STUDY PROJECT

UPDATING THE JOINT COMMON USER COMMUNICATIONS ARCHITECTURE-- A CASE FOR THE ARMY'S VIEW

BY

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In 1984 the senior leadership of the Army made a decision of huge proportions when they accepted the findings of the Battlefield Communications Review (BCR) II committee and authorized the acquisition of the Mobile Subscriber Equipment (MSE) communications system. This $4.8 billion investment in the digital future gave the Army a world-wide upgrade of its corps and divisions across the Active, Guard, and Reserve components, and ended nearly thirty years of patchwork system architectures.

The rapid outfitting of the Army's echelons Corps and Below (ECB) with MSE enabled the Signal Corps, in 1986, to pursue a second, lesser known, but equally important decision effecting Echelons Above Corps (EAC): the modification of its large fleet of Tri-Service Tactical Communications System (TRI-TAC) digital circuit switches to an MSE compatible routing system and channel rate. The Army had the vision to recognize the synergy of mobile, self-organizing communications systems and AirLand Battle doctrine, and the initiative to modify the long standing TRI-TAC architecture when it was no longer relevant in its current form.

The Army's decision has raised objections by the staffs of the Commanders-in-Chief (CINCs) and other services that the Army is unilaterally abandoning a joint communications architecture, with severe operational impacts. Was the Army's decision an ill-advised change to an architecture already prepared to support the present and the future, or are the CINCs and other services stagnated in an outmoded architecture, rooted in the 1970's standards and technology? The purpose of this paper is to discuss that decision and demonstrate its validity.

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USAWC MILITARY STUDIES PROGRAM PAPER

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AN INDIVIDUAL STUDY PROJECT

by

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United States Army

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INTRODUCTION

"The Gulf War clearly demonstrated that intelligent high-technology systems could integrate complex 'AirLand' operations in both time and space. Combat operations - many conducted at night - involved control of swift maneuvers, standoff engagements, precision targeting, and precise attacks. The US Army leads the world in designing military capabilities in this period called the *Third Wave* or the *Information Age*. Desert Storm forces have been characterized in terms of two different military modes of operation. The Iraqis fielded a conventional military machine, powerful but with very limited automation. The Allied Force was '...not a machine, but a system with far greater internal feedback, communication, and self-regulatory adjustment capability. It was a Third Wave 'thinking system' right down to the lowest ranked soldiers in the field.' Automation allowed our commanders - the Warfighters - at all echelons to exploit every advantage of command and control to outplan, outmaneuver, and outshoot the enemy."[1]

The above quote is significant in its linkage of the stunning success of the Army's AirLand Battle doctrine and the advances in command and control through communications tailored to the Army's way of doing business. This success was the result of building and modifying a command, control, and communications (C3) backbone system that supported rather than limited the warfighter. The Army had the vision to depart from years of investment in successive generations of communications equipment that were conceived in an older paradigm. Generations with names like Army Area Communications System (AACOMS), Army Tactical Communications System (ATACS), and Improved ATACS (IATACS) were each built upon successor systems in a slow, evolutionary fashion, so that even the latest family of equipment, the Tri-Service Tactical

Communications (TRI-TAC) system and its corresponding Integrated Tactical Communications System (INTACS) architecture had its roots firmly planted in technology and doctrine dating from the 1970s. The Army realized that "The rapid evolution of tactical doctrine over the past decade to the AirLand Battle concept dictated a significant change in communications doctrine and the means to support the deeper, expanded and integrated battlefield. The need for increased flexibility, dispersibility, mobility, and transportability is concurrent with the established requirement for automated simplicity and accompanying reduction in manpower."[2] This vision became clear in the findings of the Battlefield Communications Review (BCR) process, conducted in 1982-85.[3] Concurrent requirements for manpower savings in the Army Signal Corps of approximately 5000 personnel led the Army leadership to approve the Mobile Subscriber Equipment (MSE) concept in January 1984. This action came at a time when the Commanders in Chief (CINCs) and other services remained locked in the framework of the original TRI-TAC architecture and the standards of the 1970s.

The MSE acquisition assured modernization of the Army's Echelons Corps and Below (ECB), and enabled the Signal Corps to make the crucial decision to modify the Army fleet of TRI-TAC switching equipment to MSE compatibility. That decision raised objections by the staffs of the Commanders-in-Chief (CINCs) and other services that the Army is unilaterally abandoning the joint INTACS communications architecture, with severe operational impacts. Was the Army's decision an ill-advised departure from an architecture prepared to support the present and the future, or are the CINCs and other services stagnated in an outmoded architecture, rooted in the 1970's standards and technology? The purpose of this paper is to discuss that decision and demonstrate its validity.

The issues revolve around the two major changes the Army made to the INTACS architecture:

1. Non-deterministic routing (frequently referred to as "flood search"[4]) vice the practice of deterministic routing used by the commercial telephone industry and the TRI-TAC world.

2. Adoption of 16 kilobit (kbs) digital channel rates, vice the TRI-TAC interim rate of 32 kbs.[5]

Both of these issues will be discussed in depth in the succeeding pages. This paper will cover briefly the technical makeup of the INTACS, MSE, and TRI-TAC Block III architectures, including a discussion of the major interoperability issues involving 16/32 kbs data rates and flood search/deterministic routing. The conclusion will discuss the validity of the Army's actions and propose a solution to the CINCs' greatest concern, which is the integration of Army switching assets within a Joint Task Force (JTF) common user network.

The scope of this paper has been deliberately limited to the common user switching system because of its importance to the Joint commander, his staff, and his service components across the board. The Area Communications system is the heart of the JTF. It is understood that many different forms of communications media, including single channel terrestrial and satellite systems, make up the whole of joint communications. However, these systems by their nature tend to be used at a level below the Joint headquarters. Concerns over the Army's perceived departure from the joint standard are relevant because the Army owns the bulk of the switching fleet and could reasonably be expected to provide a corresponding share of the joint network, and to provide switching systems to a JTF headquarters when the four switches of the Joint Communications Support Element (JCSE) are committed or otherwise unavailable. Because of the nature of this issue, it involved members of the communications community of all services. Some of the documents, briefings, and interviews used in this paper were received even as the first draft was in progress.

BACKGROUND

TRI-TAC/INTACS: The TRI-TAC/INTACS architecture dates from the mid 1970s and was an outgrowth of the early Project Mallard efforts to modernize military tactical communications and digitize those communications across the battlefield. The TRI-TAC system, under the management of the Project Manager, Multi-Service Communications System (PM,SCS) was a complete family of switching, transmission, technical control, and user equipment. The INTACS architecture drew heavily from the practices of the commercial telephone industry, and this was reflected in the design of a system which provided area coverage, as opposed to previous military tactical systems which were command oriented. The difference was significant.

Command systems, as found in division level operations even today (the 1st Infantry Division is the last MSE conversion unit and is currently fielding), required the installation of multichannel communications systems from the commander to each of his subordinates. Figure 1. shows a typical arrangement as any Signal Corps lieutenant of the 1970s might recognize from FM 11-50. Although the diagram is simplified, it can be seen that this type of system creates critical nodes at command centers, in this case the Division Main CP. It was not uncommon for Main and Alternate CPs to have as many as 14 radio systems emitting from their sites. The use of the radio spectrum and the large quantity of vehicles increased the signature of the Main CP both electrically and visually. Alternate routing does not exist

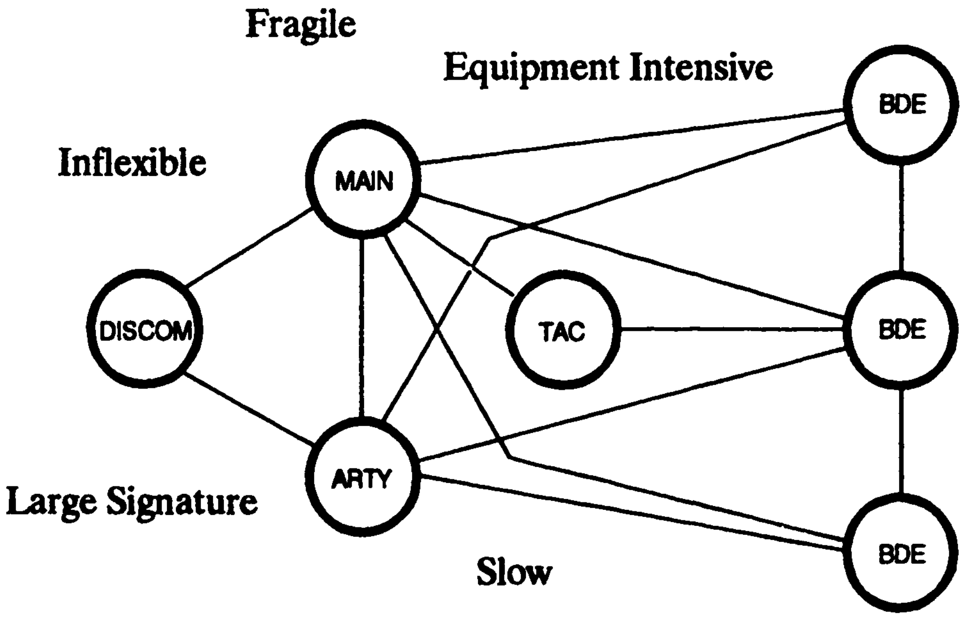

Figure 1. Command Type Multichannel System

unless specifically planned for and installed. This practice is terribly demanding of tactical system engineers because every communications needline at a given location requires its own communications link, regardless of the existance at that location of indirect linkage to desired destinations, e.g. lateral connectivity between brigades. The command system also placed siting constraints on tactical command posts which were not at all appreciated by the combat commander but which were required because of the necessity to install line-of-site systems to all other critical sites. This explains the enormous quantity of dedicated radio relay equipment (14 terminals) found in the Tables of Organization and Equipment (TO&E) of the ATACS era.

Compounding the problem, the switching and transmission equipment found in the AACOMS and ATACS generations were all analog in nature. The switches were not capable of tandem (through) routing, and circuit quality degraded with every switch and every transmission path transited. Under the AACOMS generation, all calls were handled with operator assistance, since the switchboards were manual, and only the system operator could understand the possible routings available. ATACS switches at division level were somewhat improved with direct dialing capabilities, but they still could not be programed for tandem operation. A smart user could route himself over the network if he knew the present system configuration, and knew the switch prefix number for every switch he had to transit. This was rarely useful for more than three links. The communications personnel compensated by installing even more direct links between nodes, (skip-node operations) further complicating the network. Corps level switches such as the TTC-25 and TTC-38 entered the inventory in the early 1970s and were the first true tandem, albeit still analog, switches. Overall, the command system architecture was an OPSEC nightmare, was time consuming to install, essentially immobile in the eyes of mechanized commanders, and had little or no robustness without exorbitant use of redundant equipment. In short, it did not support the commander.

The area system approach of the INTACS architecture provided a grid of major switching centers and transmission equipment that covered a given geographical area. Short extension links were installed from the closest area signal center to the

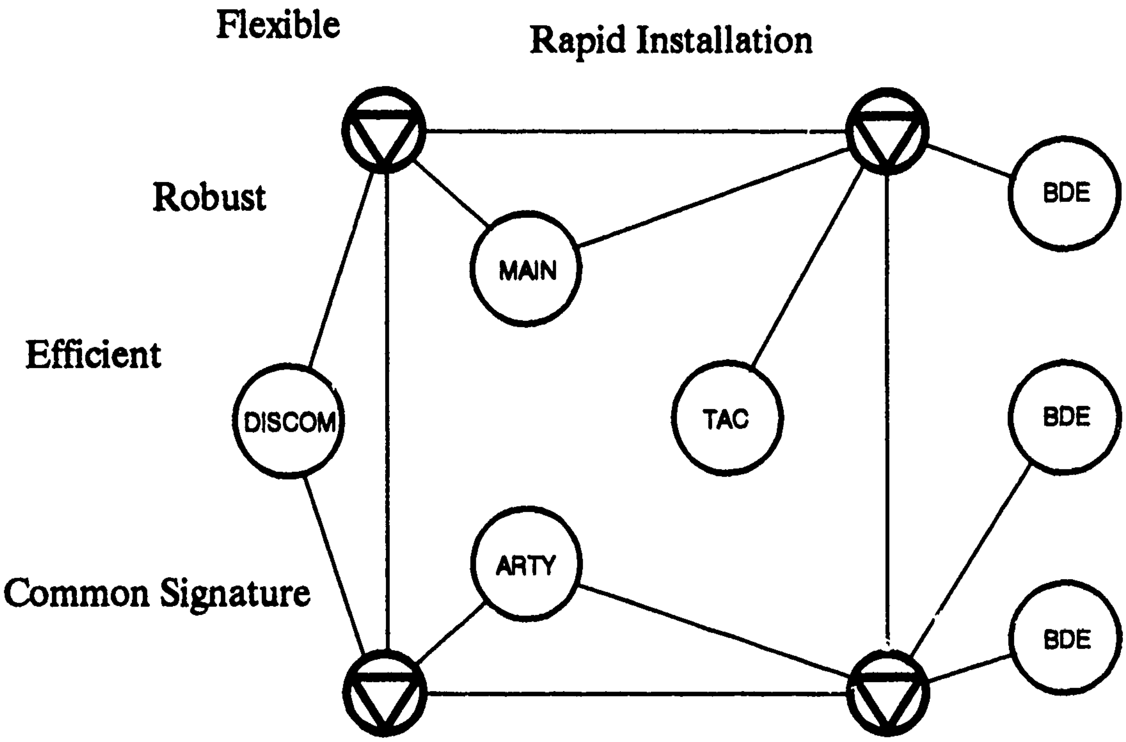

Figure 2. Area Type Multichannel System.

site of a newly arrived unit, and terminated on a small extension or terminal switch. Figure 2. shows this arrangement. The benefits of the area system were significant. The grid, or backbone system was installed separately, but in support of, tactical operations. Once a mature backbone system was operating, only relatively small parts of it were ever out of service due to movement. A properly sited major switching node could support successive locations of several different units as they passed through the area. More importantly, the burden of good electronic site selection was passed to switching centers and not tactical command posts. Although the combat commander didn't have carte blanc to locate his CP, his options were significantly increased.

Alternate routing was achieved by the installation of a second link to a second major switching center. Robustness was enhanced by the lattice or grid nature of the system. Use of equipment, frequencies, and engineering time was more efficient.

The benefits of the area or grid system were possible because of two key features of the INTACS generation: The programmable, automatic tandeming digital switch; and digital transmission systems. Subscriber calls were entered at the originating switch and routed based on stored databases containing all possible routes available to the destination. Digital transmission systems enabled calls to transit multiple links with little degradation. Primary and alternate routings that would have provided unintelligible conversations in an analog system were routinely possible in a digital network because of the reconstitution of the binary digital signal in every transmission link. An additional benefit was increased trunk capacity due to reduced channel data rates. The ATACS standard channel rate was 48 kbs, using Pulse Code Modulation (PCM), while the interim INTACS standard was 32 kbs, using Continuously Variable Slope Delta (CVSD) modulation. The objective INTACS channel rate, to be achieved in a mature network was 16 kbs.[6] Another benefit of the TRI-TAC/INTACS digital generation was the advent of end-to-end security for selected subscribers, using the KY-68 Digital Secure Voice Terminal (DSVT). The DSVT incorporated National Security Agency (NSA) approved Communications Security (COMSEC) devices in the telephone instrument itself, thereby providing speech and data encryption at the user level.

The TRI-TAC generation of switches started testing in the late 1970s, and began to enter the inventory of the Army, Air Force, and Marine Corps in 1981. The bulk of these switches were variants of the AN\TTC-39, with some smaller AN\TTC-42s and unit level SB-3865s acquired by the Air Force and Marine Corps. The original AN\TTC-39 and the improved TTC-39A(V)1 were hybrid switches with both analog and digital switching matrices. These switches were capable of handling up to 96 analog terminations of all types, including 2-wire and 4-wire field telephones, 2-wire and 4-wire commercial office interfaces, and 4-wire trunking to the analog ATACS/IATACS echelons. The digital side of the TTC-39 and TTC-39A(V)1 consisted of two time division multiplexed (TDM) matrices, capable of terminating 708 digital loops or trunks. These versions of the TTC-39 family, along with TRI-TAC Digital Group Multiplex (DGM) family of transmission equipment were entering the Army's III, V, and VII Corps during the period 1982 through 1985. Their unique dual analog/digital capability was to be of great importance during the MSE fielding process later.

As the TRI-TAC transmission system inventory matured, the Air Force began to transition its inventory of TTC-39A(V)1 to the (V)4 configuration. This version of the TTC-39 eliminated the analog matrix and became an all digital switch. Connectivity with selected analog circuits was handled with Line Termination Unit (LTU) cards, inserted as required for interface with commercial offices, AUTOVON, etc.[7] An additional variant of the TTC-39, the TTC-39A(V)3 was developed for the Joint Communications Support Element (JCSE). This switch was essentially a TTC-39A(V)4 in a downsized configuration for rapid deployment in support of JTF Hqs. The JCSE is equipped with two 39A(V)3s and two 39A(V)4s.

For all of it benefits, the INTACS architecture had some serious flaws that were not readily apparent in the mid 70s. First, the equipment was large and expensive and therefore it was determined early on that TRI-TAC equipment would not extend below Corps level. This left Army divisions - with the greatest need for maneuverability and flexibility - with a mix of ATACS and IATACS analog equipment.

Second, and more importantly, the INTACS architecture continued the practice of previous generations of equipment and of the commercial world as well when it followed a deterministic routing plan. Deterministic routing means that a subscriber's telephone number is determined by his location on the battlefield and the prefix and line termination number of the switch he is connected to. Movement to another location, serviced by another switch would require a new number. Figure 3. shows the routing of a typical call across a deterministic network. The first two digits of the telephone number are determined by the major switching center number. The remainder of the telephone number is determined by the port or matrix entry on the switch itself. Network engineers must calculate the routes for a primary and alternate path through the system and store this information in every switch along those paths. In the network shown in Figure 3. the primary path is 01, 02, 07, 10. A possible alternate route is 01, 03, 05, 08, 10. Notice that although other connectivity exists, the call cannot take any path that is not defined in

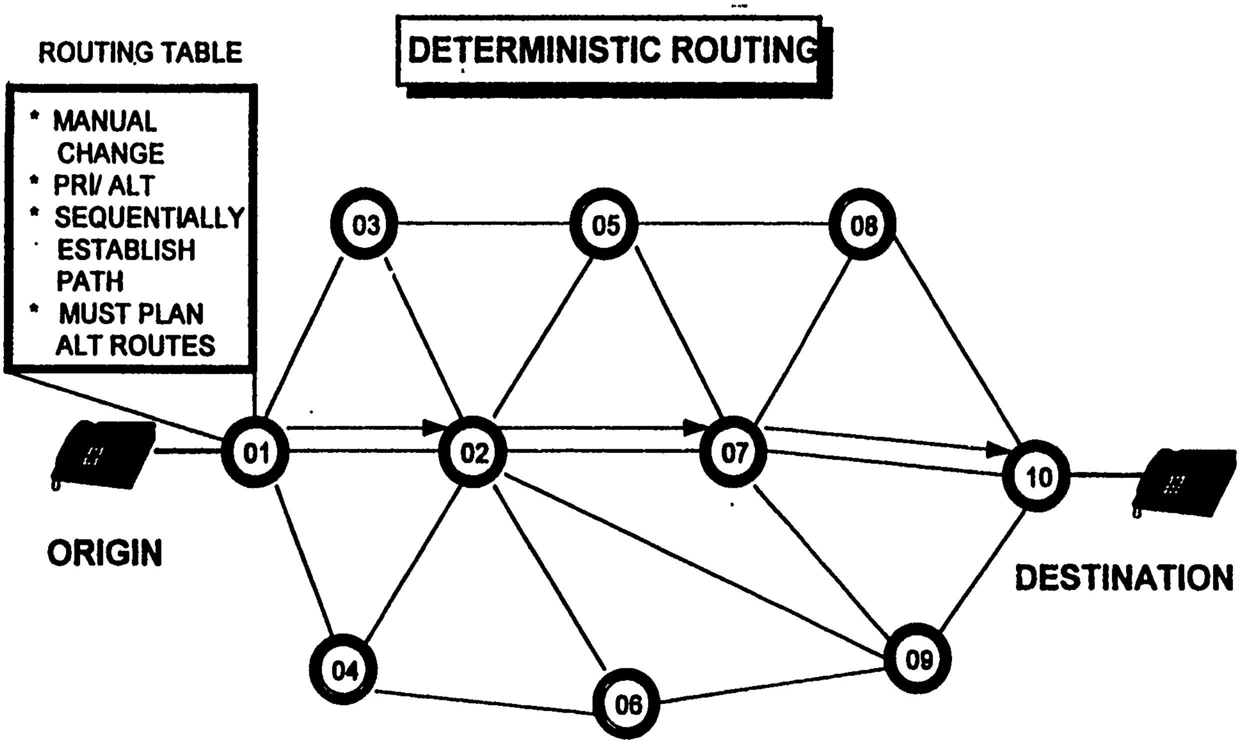

Figure 3. Deterministic Routing.

advance. This is a very time consuming job for network engineers, and it requires great attention to detail on the part of every switch operator. Routing information must be recalculated and reloaded into *every* affected switch whenever the network reconfigures, or a unit and its extension switch move. Subscriber telephone numbers can change faster in a tactical environment than telephone directories can be published and issued.

Deterministic routing is well understood by the designers of military telephone systems. After all, its the way the commercial world operates. The relatively infrequent movement of the civilian population makes this a very practical method of routing. The reliance on stored databases makes the system operate very efficiently when the network is static. Unfortunately it did not support the direction our doctrine was taking in the early 1980s. The fluidity of the battlefield, and the demands of mobility were diametrically opposed to the constraints of deterministic routing.

MSE: The Army leadership found, through the BCR II and III process, that there was a need for a tactical communications system in the corps and division echelons that reflected the tenants of the emerging AirLand Battle doctrine. This system had to have greater mobility, be more capable, use less manpower, and cost less than the projected communications architecture mix of TRI-TAC at Corps and IATACS at division.[8] The history of the MSE program as the Army's most successful Non-developmental Item (NDI) program will not be covered here. It is sufficient to note that the contract was awarded in December of 1985, and fielding began at Ft. Hood in February 1988, an unprecedented accomplishment in military acquisition of a major system.[9]

MSE was purchased as a complete communications system. It incorporated switching technology from GTE-Sylvania, the prime contractor on the TTC-39 family, and a non-deterministic routing algorithm using hardware from the French RITA system. The system is comprised of switching assemblages, VHF and UHF Line-of-Sight (LOS) radio vans, technical control centers, and user devices. Like TRI-TAC, it is an area system. Figure 4 is a diagram of a typical MSE area system for a two division corps.[10] The significance of this figure is to demonstrate the freedom of tactical units to ignore the identity of their supporting

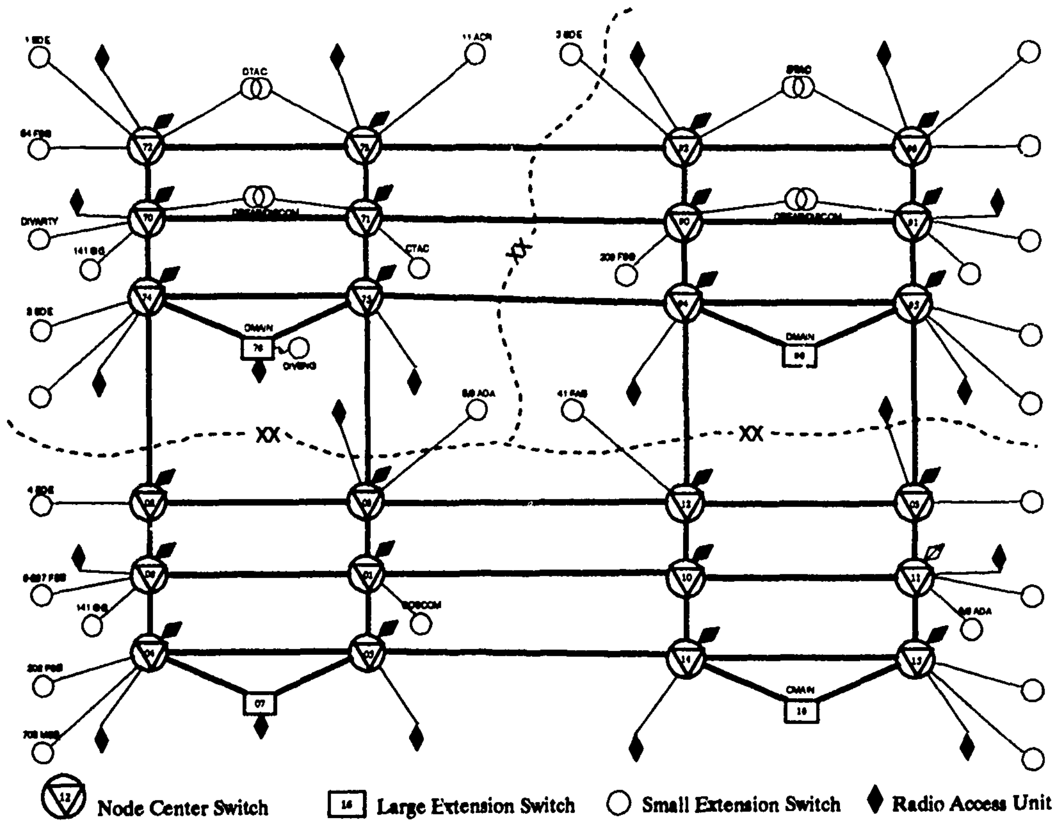

Figure 4. Mobile Subscriber Area System.

communications node. Because of 100% commonality, radio systems cross corps and division boundaries at will. The Corps Signal Officer is capable of "maneuvering" the communications assets in support of the tactical commanders plan without concern over equipment matchups.

The AN\TTC-47 Nodal Central Switch (NCS) and the AN\TTC-48 Large Extension Switch (LES) are both derivatives of the TTC-39 family hardware. They both incorporate the same Litton processor (L-3212), DGM multiplexer technology (conditioned diphase), Communications Security (COMSEC) equipment (KG-94 TED), and group rates (256, 512, 1024 kbs) as the TRI-TAC generation. On the channel level, MSE used a 16 kbs channel rate. This rate complied with both the objective TRI-TAC/INTACS channel standard, and NATO Standard Agreement (STANAG) 4206. Not surprisingly, MSE was fully interoperable with the TRI-TAC family of switches when connected via a separate Area Code to a gateway switch. The Area Code and gateway were required to provide a boundary between the deterministic, 32 kbs Echelon Above Corps (EAC), and the non-deterministic, 16 kbs Corps and below.

Non-deterministic routing, sometimes referred to as "Flood Search", or "Fixed Directory", is a routing method which uses both of these descriptive features. Using this routing method, every subscriber in the tactical organization is assigned a "fixed" or permanent seven digit telephone number. This number is part of a master database called a Pre-Affiliation List (PAL). This telephone number defines all the call features and privileges that the subscriber is authorized. The PAL telephone number essentially describes everything the switching system needs to know about the subscriber. It is his electronic identity. The PAL list is resident in every TTC-46 and TTC-47 switch. It is loaded when the switch is first initialized. When a subscriber arrives at a given switch site, he connects his user device and "Affiliates", i.e. he electronically informs the switch of his presence by dialing his own telephone number, followed by a unique Personal Identity Code (PIN). The switch checks the subscriber number against the PAL list, and if valid, marks the subscriber as "active" at its location, and provides the subscriber with all authorized privileges. When the subscriber wishes to leave the area, he informs the switch of his departure. The switch marks his PAL entry as "inactive" and provides a recorded message to all attempts to reach that number. Since MSE provides services like Call Forwarding, the subscriber can elect to remain affiliated, forward his calls to another number, and depart the area with his instrument with him. The act of affiliating at the next location will automatically terminate the call forwarding and mark him active at the new location. The process of affiliation and disaffiliation takes place continuously as subscribers move about the MSE battlefield. At any given time, only one switch will carry a subscriber as "active", and this is how the system completes the calls. Figure 5. is a diagram of a typical call completion using "flood search". When the call is made, the originating switch sends an electronic query to all connected switches in the network using Common Channel Interswitch Signaling (CCIS) on one of the two channels reserved for this use. Each switch passes on the request. Only one switch in the network can respond positively to the query and that is the switch where the called party is currently "active". The responding switch sends a message back over the CCIS channels with information on the route traveled, and the originating switch sets the call up. The strength of this routing method is that the system is self-organizing. No a-priori knowledge of the network is required. Network engineering is simplified. Additionally, the MSE network is "self-healing". Since all routes are valid, the loss of one or more links will not prevent call completion until there are no more paths remaining between origin and destination.

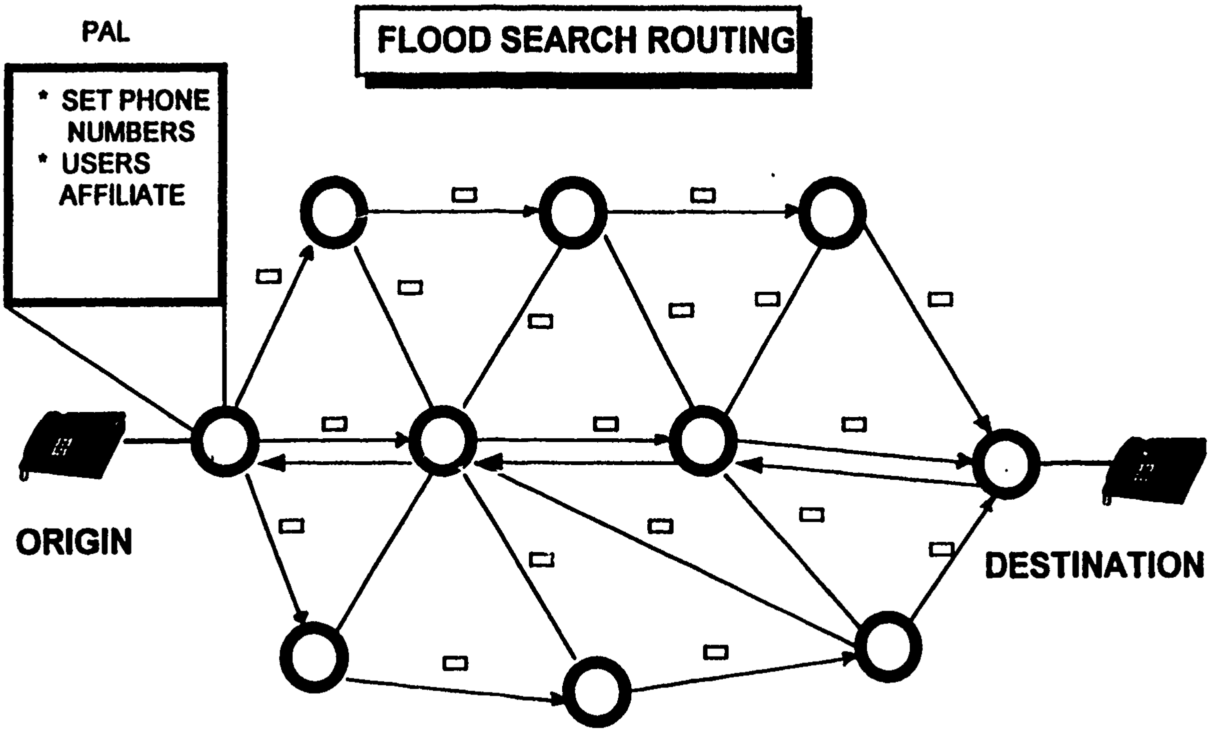

Figure 5. Non-deterministic Routing.

PAL lists were originally written for each Coı‸ ﹐ as it was fielded. Based on lessons learned on successive fieldings, and to take advantage of the fact that the world-wide MSE fielding is nearly completed, the U.S. Army Signal Center is involved in the generation of an Army-wide PAL, which will deconflict earlier problems with number duplications and feature mismatches.

The fielding of MSE to Army corps and divisions totally eliminates the artificial boundaries between those echelons. The equipment employed in signal units at both corps and division are identical. It is not an insignificant statement that one must check bumper numbers to determine where support is coming from. MSE subscribers at every level can travel anywhere within a corps

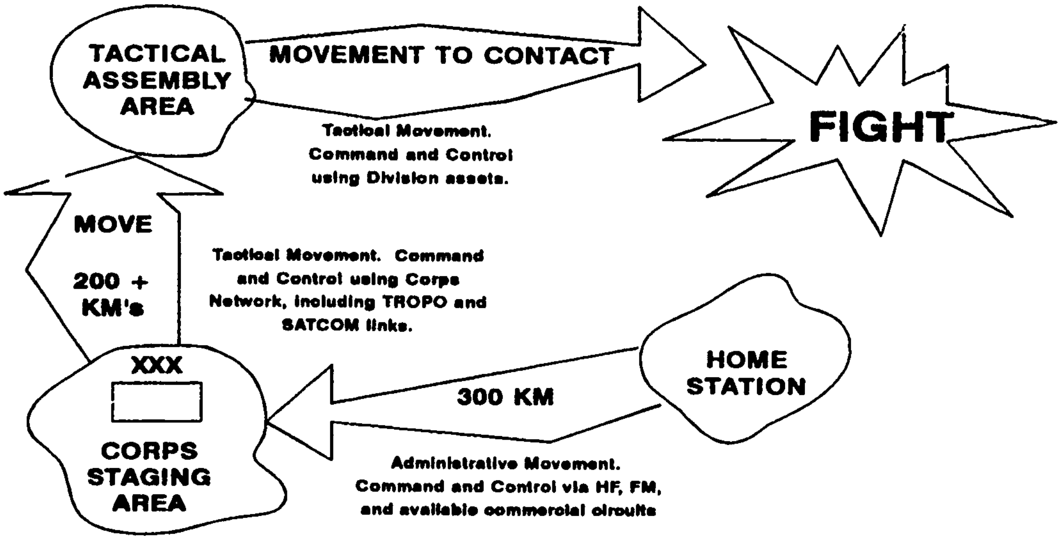

Figure 6. MSE Support of Maneuver.

area and be assured of seamless communications support. If that subscriber is an individual equipped with the Mobile Secure Radio Telephone (MSRT), then he need not even stop to affiliate. The fleet of MSRT users in the MSE network are supported by overlapping zones of radio coverage provided by Radio Access Units (RAU). The RAUs provide cellular-like secure telephone service to all MSRTs in range.

With MSE, the Army at last had a tactical communications system capable of supporting the AirLand Battle doctrine, a system capable of being "maneuvered" like combat arms systems. Figure 6. demonstrates the use of MSE in a movement to contact over long distances.[11] Acting in support of the corps or division commander, the senior signal officer (usually the commander of the corps signal brigade) could shift NCS and RAU assets to "weight the battlefield" with communications. This capability was demonstrated several times in USAREUR by the 8th Signal Bn, following the first fielding in that theater. Eighteen months later, techniques such as this were used with great success by the 143rd Signal Bn in Operation Desert Storm.

A DIVERGENT VIEW

Far Better it is to Dare
Something Mighty than to
Rank with Those Timid
Souls Who Know Neither
Victory or Defeat.

Teddy Roosevelt

<u>TRI-TAC BLOCK III:</u> The above quote on the cover of a study done at the U.S. Army Signal Center was auspicious. That study was to take the Army on a divergent course from that followed by the other services. Up to now, the Army had followed the INTACS architecture in its role as executive manager of the TRI-TAC programs, through the office of the Project Manager, MSCS. The MSE acquisition for division and corps kept faith with the master plan because, as has been pointed out, TRI-TAC equipment was not planned for at the division level, and the introduction of MSE at corps level was logical in order to maintain a homogeneous maneuver echelon. EAC, with TRI-TAC equipment, with which MSE was 100% compatible, formed a buffer zone between the unique direction the Army had taken with MSE and the joint world of INTACS. EAC was the gateway to the joint environment that was taking on increasing importance in tactical communications. Army changes within this echelon would be noticed.

In May of 1986, the Vice Chief of Staff of the Army approved a tentative approach to a new EAC communications concept and the Signal Center began to staff a document called the <u>TRI-TAC Block III Echelons Above Corps Tactical Communications</u>

Architecture.[12] Referred to generically as TRI-TAC Block III, this document sought to examine the current architecture with a view toward potential enhancements. The plan recognized that the existing architecture had resource implications on both funding and force structure. Also, the current investment in equipment had to be protected while taking advantage of new technology. Lastly, the need for increased flexibility, mobility, and robustness at EAC was concurrent with the AirLand Battle concept of a deeper, expanded, and integrated battlefield.[13] The Block III study held the following assumptions:

- Total Army Analysis - 92 (TAA-92) force structure cap could not be exceeded.
- The need for dedicated communications units at EAC must be examined in light of wartime requirements and efficient use of resources.
- The current investment in TRI-TAC hardware must be considered.

The study also considered the following facts:

- TRI-TAC TTC-39 switching systems could be product improved to be functional equivalents of the TTC-47 (MSE).
- TRI-TAC switches already maintained full interoperability with the MSE network, via area code gateways.
- The Army investment in TRI-TAC already amounted to $1.9 billion in equipment and R&D.
- TRI-TAC transmission systems were adequate as designed, in conjunction with tropospheric scatter and tactical satellite systems for extended geographical ranges.

The Block III study found that is was possible, through modifications to the existing Army fleet of TTC-39A(V)1 switches to build a digital, automatic, common user switching network at EAC that provided mobile subscriber capabilities identical to those found at (ECB). As shown is Figure 7, incorporating the French RITA processor and elements of MSE software code back into the TTC-39A(V)1 (from which much of the code had come), provided a seamless, integrated network for all elements of an Army Force (ARFOR). Characteristics of the original TRI-TAC/INTACS architecture, including joint service interoperability, commercial interfaces, and high volume common user transmission paths were retained.[14] The Army leadership approved Block III and its acquisition strategy on 5 May 1987.[15]

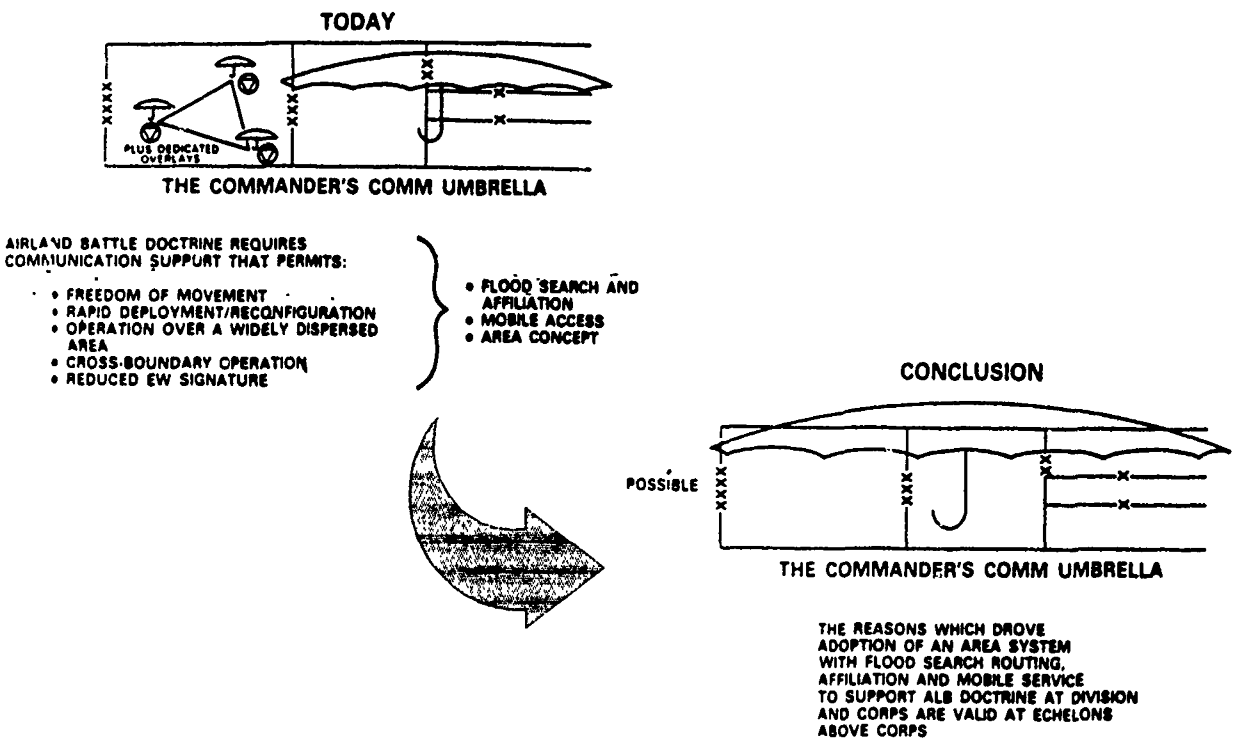

Figure 7. TRI-TAC Block III Study Conclusions.

The JCS J-6, and working panels of the Joint Tactical Command, Control, and Communications Agency (JTC3A),[16] were briefed by the author on the TRI-TAC Block III architecture on various dates in 1987. The reception was positive, mainly due to the resource issues that the concept resolved, thereby keeping the Army funding profile for TTC-39 healthy. Although the Marine Corps expressed some interest in the program, there was no indication that any service would actively participate in the Block III changes. It was during this period that the PM-MSCS made the program changes required to retrofit the Army fleet of TTC-39A(V)1s to the new configuration, the TTC-39D.

CINCs and Services Reaction: This state of relative ambivalence towards the Army's course changed dramatically with the onset of Operations DESERT SHIELD and DESERT STORM. The unprecedented magnitude of the communications network installed in support of the operation, and the obvious implications that joint operations were of increasing importance caused the CINCs and Services, specifically the Air Force, to raise concerns about the Army's apparent deviation from the established INTACS architecture. This concern was formalized in August 1992 by CINCFORSCOM, and the issue was placed on the agenda of the Military Communications Electronics Board (MCEB) Interoperability Improvement Panel (IIP).[17] The issue statement read "The Army is replacing the AN/TTC-39A(V)1 with the AN/TTC-39D Army-wide. This is a divergence of commonality from the other Services TRI-TAC switches and results in fundamental differences in joint network design and functionality. The CINC planners feel that this mixed network will constrain a JTF's flexibility, reduce network robustness and impede interoperability".[18] The CINCs were primarily concerned by the small size of the JCSE (four TTC-39A(V)4 switches). The JCSE mission is to directly support a JTF headquarters and provide connectivity downward to service components. The increasing possibility of multiple regional conflicts would create scenarios where JSCE assets were exhausted and Army-owned switches might be pressed into service in JTF or major component HQs. Specific problems which could occur include the following:[19]

- The TTC-39D cannot act as a tandem switch between two deterministic switches in the same area code. This situation could arise if a JCSE TTC-39A(V)4, supporting a CINC, tried to route a call through an Army TTC-39D. to an Air Force TTC-39A(V)4, as per figure 8.[20]

- Separate area codes are required to allow a TTC-39D to route to directly connected extension switches, directly connected TYC-39 message switches, and directly connected switch networks which use deterministic routing. The net effect is to proliferate area codes which are in short supply. See figure 9.[21]

- The TTC-39 cannot tandem from one area code to a different area code and back into the original area code. The effect is to require separate area codes for any non-contiguous TTC-39D networks. Problems such as this could arise if the Army was providing a TTC-39D as the JTF switch and the direct link to the ARFOR was inoperative. Calls could not be routed through the AFFOR TTC-39A(V)4 even though the path exists. See figure 9.

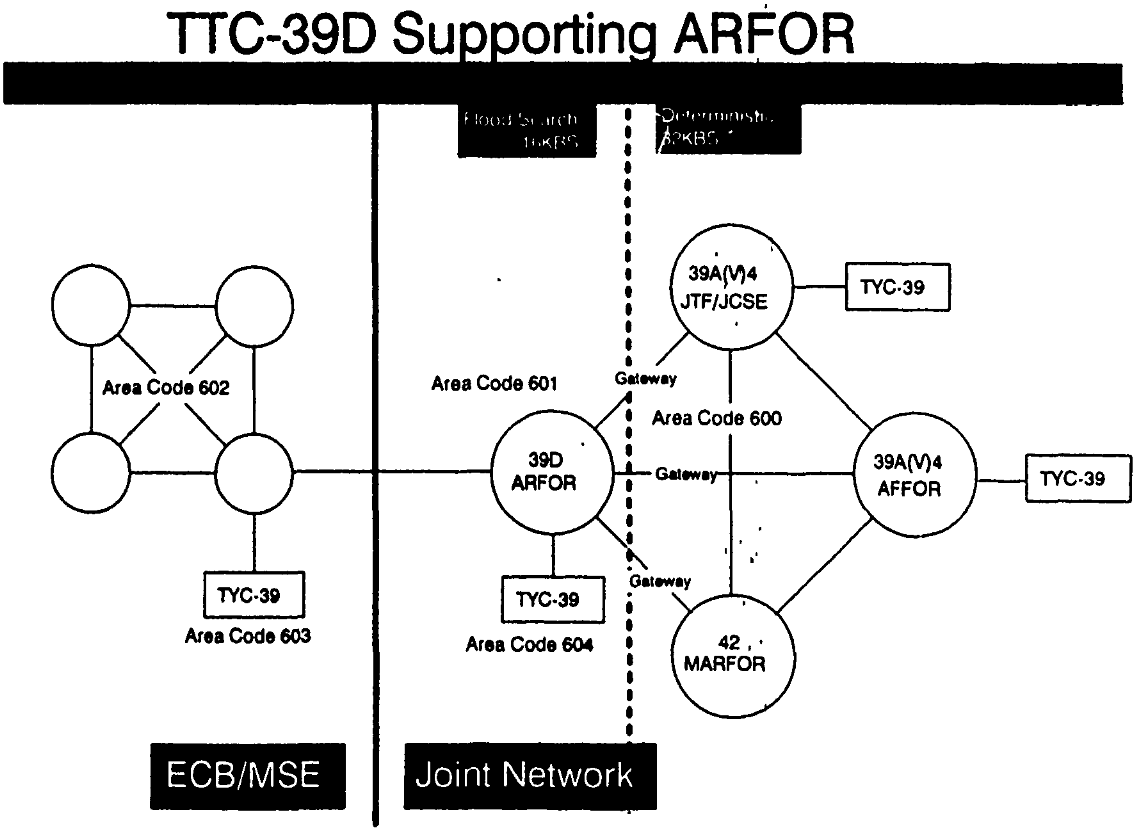

Figure 8. AN\TTC-39D Supporting ARFOR.

- The TTC-39D operates only at 16 kbs. The effect is to eliminate any possibility of operating some trunks at 32 kbs to take advantage of the greater capacity of the higher speed channels.

The Issues: The issue of mixed deterministic/non-deterministic routing in the joint network is a serious concern. The issue should not, however, be addressed in terms of should the Army return to the fold, but rather should the CINCs and services follow the Army lead in breaking out of the TRI-TAC mold of the 70s. The stunning success of the ground maneuver in DESERT STORM validated the AirLand Battle doctrine and the steps the Army took to build a communications architecture to support it.

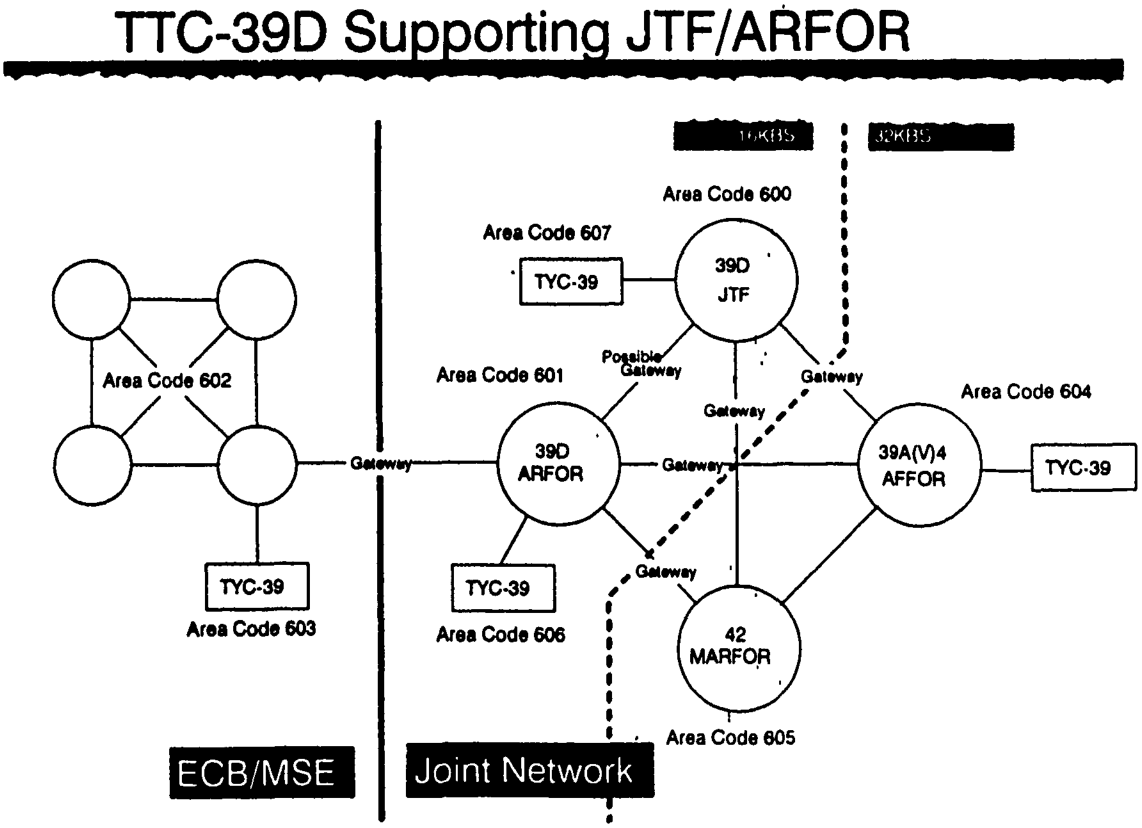

Figure 9. TTC-39D Supporting JTF/ARFOR.

The Army cannot retreat from the gains in mobility, flexibility, robustness and force structure efficiency gained the combination of MSE and TRI-TAC Block III. Disregarding the advantages of mobile MSRT service for selected users, the real power of the MSE/TRI-TAC Block III combination is the self-organizing, self-repairing nature of the system. The Army triad of M-1 Abrams tanks, M-3 Bradley fighting vehicle, and UH-60 Blackhawk helicopter brought the speed and agility to the battlefield that AirLand Battle demands. The investment in that triad would be negated by the loss of the communications speed and agility that MSE and like systems provide. The Marine Corps, as the other ground maneuver component of a JTF would equally benefit from

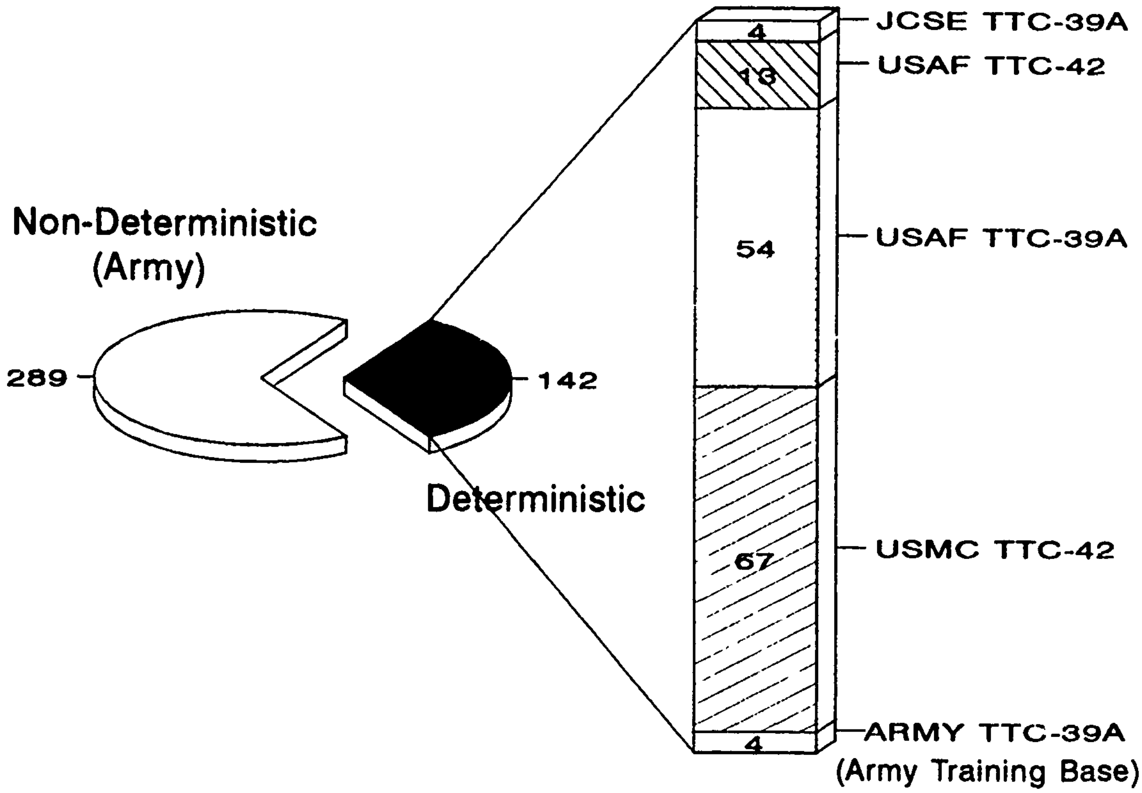

Figure 10. Defense Tactical Switching Distribution.

TRI-TAC Block III. The nature of CINC JTF headquarters and Air Force base operations dictate that conventional, deterministic routing is adequate for their use. The Air Force in particular has always operated with large engineering staffs that are capable of installing and maintaining the deterministic networks for large, static installations.[22] Future force structure cutbacks may change that. For the time being, they have little to gain from a change to a non-deterministic system. On the other hand, they have little to lose. They have much to gain in sharing a common architecture with the ground maneuver components for whom this architecture is critical. Figure 10 shows the distribution of large switches within the services. The Army holds the bulk of the switching assets. All are MSE or TRI-TAC Block III, non-deterministic switches. The minority shareholders need to make the investment in their fleet to reach a common baseline.

The issue of retaining 32 kbs channel rates is an attempt to maintain a bandwidth large enough to provide service for older analog and quasi-analog terminal devices. Due to sampling errors caused by CVSD modulation, 32 kbs channel rates are required to support the operation of 4800/9600 baud devices such as facsimiles and older data terminals. 16 kbs rates, while providing excellent voice quality with digital telephones, can only reliably support 2400 baud analog or frequency shift keyed devices. Since trunk group rates in the INTACS architecture remain constant at 256/512/1024 kbs, the effect of operating at 32 kbs channel rates is to provide 50% of the channel capacity of 16 kbs operation. In a tactical environment, channel capacity is critical. It should not be exchanged for the purpose of retaining analog terminals, or continuing the outmoded concept of handling data requirements with dedicated circuits. The packet switching overlay systems contained in MSE and TTC-39D switches have allowed the Army to practically abolish dedicated data circuits. Packet switching would remove much of the need for dedicated 32 kbs circuits. In those instances where increased bandwidth is critical it is possible to develop and field channel banks which would allow ganging individual 16 kbs channels together to satisfy larger requirements.

The Secure Telephone Unit (STU) III is a subset of the channel rate issue. The use of the STU-III in secure mode over tactical systems is an emerging joint requirement. There were no STU-III interface requirements identified for the TRI-TAC switches prior to DESERT STORM. During that operation the STU-III was operated over the analog matrix of the TTC-39A(V)1. Since all TTC-39D, TTC-39A(V)4, and MSE switches use the same Digital Line Termination Unit (DLTU), the reliable operation of the STU-III over digital channels is subject to the baud rate limitations stated above. Various informal testing indicates that the STU-III can reliably operate secure at 2400 baud on 16 kbs channels.[23] This baud rate is adequate for speech intelligibility, but not voice recognition. Requirement developers will have to analyze the cost benefit of trading bandwidth for voice recognition.

A final issue relates to the tactical/strategic interface. Interoperability issues concerning TRI-TAC and MSE connectivity to the Defense Switched Network (DSN) have raised a requirement for centralized management of area codes, subscriber number plans, PAL lists, data rates, etc. This configuration management is in addition to the need spelled out in preceding pages for control of tactical and strategic hardware and software baselines. Such a function has been directed by the JCS. The Defense Information Systems Agency has been appointed integration manager for strategic switching, and the Army Communications-Electronics Command (CECOM) has been made executive agent for all tactical switches.[24] These taskings form the framework for the centralized management of the joint tactical architecture.

CONCLUSION

The PM-MSCS has a proposal, called the Task Execution Plan (TEP) that would unify the diverging TRI-TAC switch family and addresses the concerns raised by the CINC community. The proposal provides a series of options:[25]

1. The basic implementation would change the AN/TTC-39D to implement functions of the French Routing Subsystem (RSS) processor (part of the MSE program) directly in the switch main processor.

2. Option 1 would add the capability of the TTC-39D to operate at 16 or 32 kbs channel rates in the same network. This would allow switches servicing subscribers with older, quasi-analog terminal devices to operate at 32 kbs and still communicate with the warfighting network.

3. Option 2 would migrate the unique TTC-39A(V)4 requirements into the software baseline of Option 1 to produce a single TTC-39 software version. This single version would operate on the TTC-39D, TTC-39A(V)3, TTC-39A(V)4, and the Next Generation Switch (NGS) being proposed by GTE.

4. Option 3 adds unique MSE functions to the Option 2 baseline and provides a single software version for all switches listed in Option 2, and the MSE TTC-46 and TTC-47.

Figure 11. is a pictorial presentation of the net effect of incorporating options 1 and 2 of the TEP.

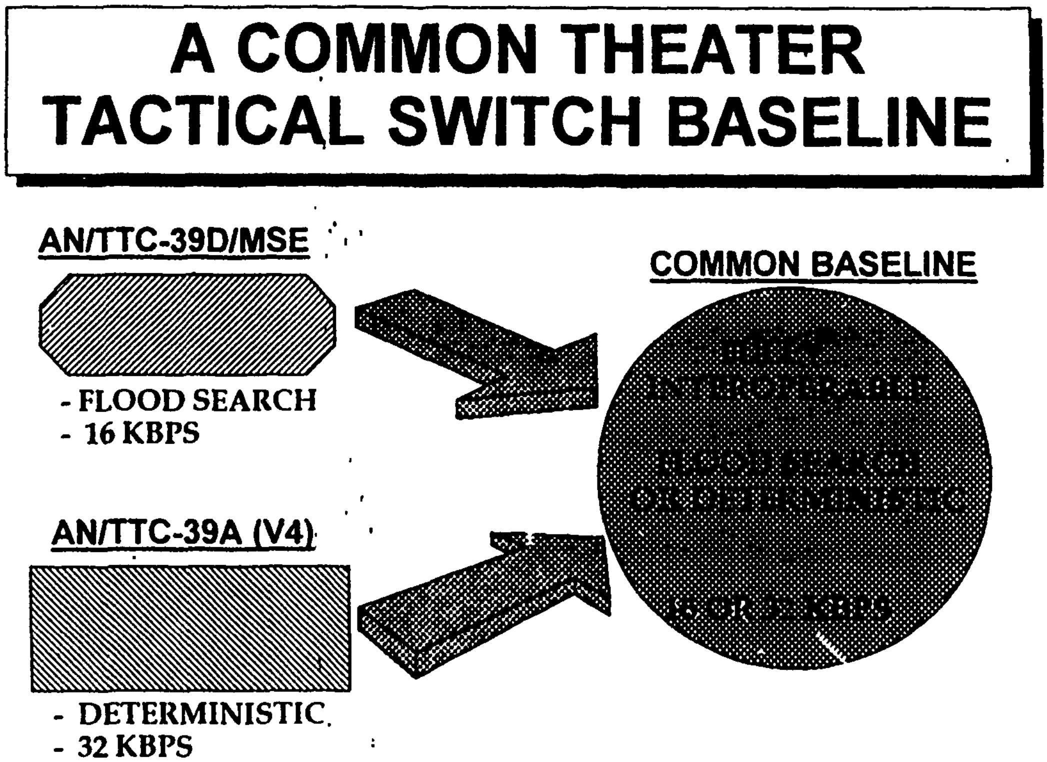

Figure 11. A Common Theater Tactical Switch Baseline.

The implementation of this TEP and all three options have the following impact:

1. The Army would be completely converted to a non-deterministic system with all subscribers preassigned on a global PAL list.

2. The JCSE and Air Force TTC-39A(V)3/4 fleet would use non-deterministic routing between any other TTC-39, and deterministic routing with TTC-42 and SB-3865 extension switches.

Advantages:

1. Software support would be simplified as all TTC-39 based switches would have the same baseline. This would result in considerable life-cycle cost savings.

2. The entire TRI-TAC fleet of switches would be capable of non-deterministic routing and 16 or 32 kbs channel rates. JTF routing would be simplified along the Army experience.

3. Tactical theaters could have one area code, as desired by the CINC community and DISA, for the JTF and major component commands.

4. Hardware and software would be backward compatible to existing TTC-39D and MSE switches, allowing a phased transition.

5. A "fixed" JCS telephone directory, based on a global PAL would be developed and prepositioned in all switches.

Disadvantages:[26]

1. There would be some training impacts to JCSE and Air Force personnel to become proficient in operating in both types of network routing.

2. Subscribers off of a deterministic extension switch such as the SB-3865 would have to use separately assigned telephone numbers, rather than their permanent number on the global PAL

3. The generation and management of the joint directory and PAL list would require a centralized JCS entity. The basis for this organization has been established by the JCS directive to the Army, assigning executive proponency for tactical switching systems.

This paper has attempted to illustrate the advantages that the Army reaped from its timely modifications to the INTACS architecture to provide a truly tactical communications system that *supports* the warfighter, rather than the commercial telephone industry. There were no fewer than three different generations of tactical communications equipment in the theater during Operation DESERT STORM. That they performed as well as they did is a tribute to the dedicated men and women communicators of all services. The fact remains however that only one system, MSE, was designed from the ground up for communications on the move, rapid reconfiguration and automatic self-organization. The Joint community has the opportunity to reunite the tactical communications hardware and software baselines once again by endorsing the PM,MSCS TEP and bringing all of the services' switching fleet under one umbrella.

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2 U.S. Army Signal School and Fort Gordon, *Final Draft Operational and Organizational Plan for Mobile Subscriber Equipment System*, 6 October 1986, 1-1.

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4 This is technically incorrect. "Flood search" is one method of implementing non-deterministic routing.

5 This action was not so much a change on the Army's part, but rather an acceleration of the shift to the INTACS objective rate of 16 kbs. 32 kbs was always considered an interim rate.

6 United States Army and Signal School, *The TRI-TAC Block III Echelons Above Corps (EAC) Communications Architecture Operational and Organizational (O&O) Plan*, 23 April 1987, 3.

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20 This diagram courtesy of an undated briefing by Mr. Mike Rulo, HQs FORSCOM, Fort McPherson, GA, Automatic Switching in a JTF Environment.

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