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# DISTRIBUTION OF SOFTWARE CHANGES FOR BATTLEFIELD COMPUTER SYSTEMS: A LINGERING PROBLEM

A thesis presented to the Faculty of the U.S. Army Command and General Staff College in partial fulfillment of the requirement for the degree

MASTER OF MILITARY ART AND SCIENCE

by


WEBSTER E. FRANCIS, JR., MAJ, USA
B.S., University of Tampa, 1976





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To meet the demands of the tactical commander to rapidly increase the flow of information on the battlefield, automated command and control systems are being developed; thereby creating the possibility of catastrophic software failures which can render a computer useless or, even worse, provide erroneous information to the commander. When problems occur, software support must be provided immediately.

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The problem with employing AUTODIN is the limited media output capability at the Telecommunications Centers. Data receipt is restricted to a 7- or 9-track tape or 80 column cards, neither of which interface the majority of the media employed by command and control systems being fielded. To use AUTODIN for the distribution of software changes for battlefield computer systems, other terminal capabilities and/or interfaces must be developed to meet the multimedia requirements of the Army. (author)

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The opinions and conclusions expressed herein are those of the student author and do not necessarily represent the views of the U.S. Army Command and General Staff College or any other governmental agency. (References to this study should include the foregoing statement.)

## ABSTRACT PAGE

DISTRIBUTION OF SOFTWARE CHANGES FOR BATTLEFIELD COMPUTER SYSTEMS: A LINGERING PROBLEM, by Major Webster E. Francis, Jr., USA, 86 pages.

To meet the demands of the tactical commander to rapidly increase the flow of information on the battlefield, automated command and control systems are being developed; thereby creating the possibility of catastrophic software failures which can render a computer useless or, even worse, provide erroneous information to the commander. When problems occur, software support must be provided immediately.

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# CHAPTER I

## INTRODUCTION

As the turn of the century rapidly approaches, the influence of computers on the private, business, and government sectors has never been more evident. Whether maintaining the family monthly budget in the home or the huge payroll in the military pay system, the financial systems application of Automatic Data Processing (ADP) is merely one of the many uses of the computer. Virtually every aspect of daily life is affected by the computer, and no where has the impact been more evident than in the Army.

The early data processing capabilities within the Army were limited to manual methods for business-type applications such as financial, logistical and personnel record keeping. Although the first computers were used for scientific purposes, it was recognized early in their development that electronic computing devices would be an economical means of processing large volumes of data for the peacetime Army. Initially, ADP support focused on providing automation to the installation level with the Base Operations (BASOPS) environment rather than to tactical units. Because of the large physical size of the first and second-generation Automatic Data Processing Equipment (ADPE), the installation of computers in military vans for use at tactical unit level was generally not practical. Their large size and limited mobility necessitated that they be installed in a specific location and seldom, if ever, moved. Therefore, the majority of information and report processing was limited to manual means in tactical units.*

As technology improved, the vacuum tube was replaced by the transistor and computers became readily programable through software changes rather than the physical rewiring of the Central Processing Unit (CPU). These improvements led to the development of computer systems with considerably reduced physical dimensions. The reduced size of the ADPE provided the opportunity to install computer hardware in van mounted configurations for the mobile tactical users. The systems could then be introduced to corps and division level units to process the business-type information being accomplished in the BASOPS environment. These systems were the onset of a substantial automated information processing capability for tactical as well as garrison installation units.

The unrelenting technological improvements have not only increased the processing capabilities of the computer, but have also continued to reduce its size. With the advent of the micro-chip, mini- and micro-computers are being developed with virtually the same processing capability as the

*There actually were some early computer systems installed in military vans for use by tactical units. For example, the NCR 500 system was installed in a two van configuration for the direct support unit/general support unit (DSU/GSU) logistics supply system. They were, however, seldom if ever moved.

larger models. These newer more compact models have made possible the development of a number of extremely rugged and completely portable computer systems. The new ADPE is being adopted by the military to meet the ever increasing demand for ADP capabilities in the modern battlefield of the 1980s and beyond.

The Military Computer Family (MCF) project is underway to develop standard tactical computer hardware for universal applications by the Army. Also in development and separate from the MCF project are the Tactical Computer Terminal (TCT) and Tactical Computer System (TCS). The TCT and TCS currently in development, with a limited number of prototypes in the field, are fully militarized micro- and mini-computers respectively. They are designed to facilitate the real-time flow of vital information for command control operations by the commander and his staff on the battlefield. Both of the computers are completely portable and ruggedized for ease of mobility with high reliability in a tactical environment. Several applications systems are in development for use with them.

Along with the new TCT and TCS for the command and control systems, new ADPE has been developed for the information systems used in the logistical, financial and personnel area of combat service support. Mini-computer systems such as the Decentralized Automated Service Support System (DAS3) are being fielded in mobil tactical configurations to replace antiquated equipment in divisional and non-divisional units. With this rapid proliferation of computers on the battlefield, and the increased reliance on them for command and control and logistics support, timely software support to keep the systems operational has become critical.

Software support will be required for a variety of reasons. With any computer system, whether it is in the development or maintenance phase of its life cycle, it is necessary to continually monitor and, if required, make modifications to the software. Software changes could be required for the operating and/or applications system programs. Requests for program changes may be initiated by the system developer or the user in the form of an Engineering Change Proposal (ECP). However, regardless of who initiates the ECP, ther_ is the possibility that a change will introduce a new problem to the system. Even without change, a "bug" in the system could be discovered at any time during the life cycle. A problem in the software can render a computer useless or, even worse, provide erroneous information to the commander on the battlefield. Therefore, with the increasing dependency on computers to fight and win on the battlefield, it is critical that software changes be delivered expeditiously to field commands. The procedures for the rapid distribution of urgent software changes to the computers operating in divisional and non-divisional tactical units in the OCONUS (Outside Continental United States) Theaters is the focus of this study.

Production and distribution procedures now employed by the various software support and/or system design centers are inadequate to provide software changes either quickly or efficiently. Time delays of a few days to several weeks are the norm for the delivery of changes to Europe or the Pacific region from one of the CONUS based design centers. The difference in time is dependent on the perceived urgency by the agency involved since each has its own procedure which is often dependent on which project is "hot" at the time. The delay may be perceived to be tolerable for the service support systems, or even for command and control systems during peacetime; however, the failure to resolve these problems today during peacetime could ultimately lead to failure on the battlefield.

The purpose of this study is to investigate the feasibility of developing a standard means for the rapid distribution of urgent software changes to all divisional and non-divisional computer systems in tactical units located in OCONUS Theaters. The development and subsequent adherence to standard procedures should ultimately minimize the degradation of command and control due to software failures. The study was conducted by investigating various sources.

1. Current Department of the Army Regulations, plans,

studies, and other published documents concerning software support for the Army.

2. Recent articles in military and civilian periodicals and journals.

3. A software support questionnaire provided to the various Army design centers to determine their distribution procedures in effect.

4. The above questionnaire also provided to Department of the Navy agencies responsible for the distribution of software changes to the Atlantic and Pacific Fleets.

5. Interviews with personnel at the Project Manager (PM) level who are involved with the software development for the TCT and TCS.

6. Personal experience and knowledge of the author while assigned to the U.S. Army Computer Systems Command (USACSC) in various capacities from August 1979 to June 1982.

Through the use of the sources listed above, the study was developed through the succeeding chapters drawing final conclusions and recommendations. Chapter II explores the historical development of the computer; how it has evolved in the Army; and how this untenable situation has, through years of neglect, evolved into a major problem in the military computer community.

Chapter III analyzes the nature of software; reaffirms the need for continued software support throughout the system life cycle; and examines a questionnaire designed to identify the software support problems being experienced throughout the Army. Analysis includes the dynamic nature of software; the need for rapid software support; and how the questionnaire was designed to provide a comparison of present distribution methods employed by the agencies involved. The questionnaire results, the means and resources available, the distribution methods available, and future requirements and capabilities will be examined in Chapter IV. The Automatic Digital Network (AUTODIN), which is currently used for some data transmissions, will also be examined in the chapter to determine the feasibility of electronically distributing all software changes to divisional and non-divisional users.

The final chapter draws conclusions based on the analysis of the information gathered and recommends standard distribution procedures for adoption Army wide. It should be recognized that this is an initial attempt to resolve a lingering problem, and the examination is not an all inclusive investigation. Yet, this study may serve as the catalyst for further study to resolve this lingering and extremely serious problem which faces the ADP developers and managers of today and the years ahead. If the policy makers of the Army are stimulated in the least to further examine this problem, the purpose of this study will be realized.

## CHAPTER II

## THE COMPUTER IN THE ARMY

Prior to delving into the current practices for and inherent problems with software maintenance support, it is appropriate to review the development and evolution of computers in the Army. The review will encompass the evolutionary growth of data processing systems from the manual systems of World War II to the mini- and micro-computers employed on the modern battlefield of today. By examining the "growing pains" experienced by the Army during the development of tactical computers, it will become apparent in this chapter why attention has only recently been focused on timely software support. The impact of the "growing pains" on providing adequate software support is summed up in the findings of a study published in 1980:

> "...project managers receive little guidance in planning for the software support of systems after deployment and have little incentive to make decisions which might be detrimental to them individually but be of significant overall benefit to the Army."[1]

### BUSINESS-TYPE COMPUTER DEVELOPMENT IN THE ARMY

The computer in the Army had modest beginnings. Prior to World War II, the Army consisted of a small training force of less than 200,000 officers and enlisted men. The administration of personnel files, medical files, financial accounting, and logistical support was accomplished using primarily manual methods with the aid of desk calculators, adding machines, addressographs, and other desk top devices.[2] For a small force, these methods were acceptable with proven reliability and a relatively timely output.

As the United States drew closer to war, the Army began to rapidly build-up its forces and equipment. The administrative workload in the personnel, logistics and financial areas also began to increase. By early 1940, it was apparent that the manual administrative practices used so successfully in the past had to be augmented with some new method of data processing. The decision was made to explore the possibility of using punched card accounting machinery (PCAM) as an augmentation to the proven manual methods. The punched card method eliminated much of the human effort required in manual or mechanical data processing. The PCAM, or electric accounting machinery (EAM) as it was called, performed four of the six basic operations in data processing - sorting, calculating, summarizing, and recording. Its quick adoption resulted in a successful reduction in the administrative overhead generated by the growing Army. It also facilitated the rapid completion of complex calculations which greatly expanded the Army's capabilities in business-type operations. By war's end, the forerunner of our modern automatic data processing capability, the PCAM, was in use throughout the Army.[3]

Although the use of PCAM or EAM was a vast improvement over the previous methods of data processing, the drawbacks were many. In addition to lacking the celerity necessary to process the huge volumes of data generated on a daily basis, it required considerable human intervention at each step of the process. This intervention increased the manpower requirements and introduced the possibility of human error at each step of the data processing system. Even though sorting was a mechanical process, each machine was manually prepared for each operation. Punched cards - normally a considerable number to accommodate the large data volume - were transported manually between the various machines required to complete a given process. Operators were required to wait during the processing to transport the cards to a new location and to monitor the operation of the machine. Additionally, a different machine was required for each operation, necessitating the design and programming of a system for each task. A single electric computing device could perform all these information functions automatically at speeds that were to revolutionize the data processing capability of the world as well as the Army. More important, these devices were to perform tasks that were impossible for PCAM or EAM and they were error free.[4]

Although a punch card machine was far from being a computer or automatic calculating machine as early computers were generally known, their use continued to grow throughout the 1950's. From 1945 through 1956, the Army experienced a series of strength fluctuations as a result of shifting world-wide commitments initially with post World War II peace and then with the Korean conflict. Despite the fluctuant manpower of the Army, the growth in the use of EAM remained steady. In fiscal year 1951, EAM rentals were slightly below 6 million dollars.[5] By 1956, the annual rentals had risen to approximately 8 million dollars.[6] The punched card machines continued to be used into the early 1960's, when they were generally replaced by commercial-type computers.

During World War II, the Army cooperated with civilian universities on several research projects designed to develop an automatic calculating machine. While business-type data processing was enhanced by the PCAM, the research focused on new methods to automatically calculate huge volumes of data for scientific and mathematical applications for both commercial and military use. The research proved to have a deep-seated impact not only on the Army, but on the world as well. It led to the development of many of the rudiments of technology which contribute to the modern world of today. The use of the vacuum tube and electronic circuitry in machinery was the technological breakthrough which laid the foundation for the development of new automatic calculating machines. Between 1942 and 1947, two engineers from the University of

Pennsylvania, J. Presper Eckert and John W. Mauchley, used the new technology to develop and construct what is considered to be the first practical automatic digital electronic computer, the ENIAC (Electronic Numerical Integrator and Calculator).[7] In 1947, the ENIAC was installed at the Ballistics Research Laboratories, Aberdeen Proving Ground, Maryland, for use in the calculation of complex ballistics tables for the Army. It proved to be the fastest computing device developed up to that time with a capability to perform 5,000 additions per second using the decimal system of numbers.[8] It could solve the complex equations used in ballistics quicker than most people could state the problem.

In the scientific world of engineers, computers such as ENIAC and its immediate successors were developed strictly for their scientific and engineering applications. Through the first half of the 1950's, the computer was the province of the engineer and mathematician for scientific research and analysis. It was not until 1954 that a computer, the UNIVAC I, was built specifically for business applications.[9]

As the Army sought greater speed and accuracy in acquiring and processing information, EAM began to be rapidly replaced by Automatic Data Processing Systems (ADPS). After 1956, there was a significant increase in the rental of commerical, business oriented computers to facilitate the resource management of personnel, finance, and logistics matters in the Army. Personnel and financial operations were substantially improved with the ability to generate a wide variety of administrative reports, which simplified and aided resource management. ADPS were used in the logistics field for stock control, supply, and maintenance activities, which resulted in expeditious support and minimized inventory size with decreased errors. By fiscal year 1960, ADPS and EAM rentals amounted to 28.8 million dollars. However, the resulting benefits in both tangible and intangible savings counterbalanced the costs many times over.[10] The cost of data processing began to substantially decrease with the introduction of the second-generation computers.

The computers developed prior to 1959 are referred to as the "first-generation computers". They were characteristically large, bulky machines which used vacuum tubes requiring much air conditioning and relatively slow processing capability due to the limited internal program storage capacity. The computers used by the Army in the early 1960's generally fall into the category of the "second-generation computers". The transistor had replaced the vacuum tube enabling the manufacturers to build the computers smaller, requiring less air conditioning, and much less expensive. Computers developed after 1965 are generally considered to be "third-generation", which is when IBM introduced the System/360 family of computers.[11] Even with the introduction of mini- and micro-computers in the 1970's and into the 1980's, the term "fourth-generation" has yet to be universally applied to a new family of computers.

As the 1960's emerged with a new generation of computers, the business-type applications rapidly expanded as the cost effectiveness of ADPS increased with the improved technology. Reduced processing time for a large variety of applications increased the desirability to develop standard systems for Army wide adoption. It was recognized that centralized management of certain business-type applications would have a major impact on the conservation of appropriated funds dedicated to the resource management of personnel, finance, and logistics assets.

One of the first standard systems developed was the Army Subordinate Command Information System (ASMIS). The system was designed in 1962 for use on a commercially available RCA 501 computer with its primary application the Active Army Personnel Reporting System. The system proved to be extremely efficient in providing major Army commands with personnel accounting data.

Realizing the many benefits of standard systems, a project was begun in 1965 to standardize at the installation level Automatic Data Processing Equipment (ADPE), software systems, and management and reporting procedures. The system designed was Base Operations Information Systems (BASOPS). BASOPS was designed for the third generation IBM 360/30 computer system with personnel accounting, supply management, and financial management subsystems. Through the years since its initial design, the BASOPS subsystems* have undergone "enhancement" programs to complement and take advantage of the improvements in hardware and software as computer technology rapidly advanced. BASOPS remains today as the cornerstone of business-type applications in the Army.

## TACTICAL COMPUTER DEVELOPMENT IN THE ARMY

As the evolution of the computer was rapidly advancing from the one dimensional ENIAC to the programable systems of the mid 1950's, there began a significant effort to adapt computers to applications beneficial to the field Army commanders. Planners visualized the enormous advantage commanders would have if certain aspects of command and control were automated on the battlefield. The essentialness of ADPS on the modern nuclear battlefield was bolstered by the development of the PENTANA Army concept. The effort to support the tactical ADPS concept began with the formation of a joint Department of the Army/Continental Army Command (CONARC) Committee to define the problem, identify problem areas, and establish a priority of

*The initial BASOPS subsystems were: MPAS for personnal accounting, SMS for supply management, and STANFINS for financial management. Eventually, SIDPERS and SAILS replaced MPAS and SMS respectively. Other subsystems, such as IFS, MPMIS, and STARCIPS, were added to BASOPS over the years.

effort. The results of the committee were published in "Automatic Data Processing System for a Type Field Army" (February 1957). The major item of significance emanating from the committee findings was that DA gave CONARC the responsibility for identification of operational requirements and to develop technical requirements for an ADPS program for the field Army.[12]

Under the direction of CONARC, one of the earliest efforts to develop a family of militarized computers for use by the field Army was the FIELDATA system. Under development by the US Army Electronics Laboratories at Fort Monmouth, New Jersey,[13] FIELDATA proved to be a project too ambitious for the state-of-the-art technology existing at the time. The purpose of the project was to develop a militarized computer family that could handle a variety of applications. In addition to using the standard business-type applications associated with logistics and personnel and administrative functions, systems were to be designed for the automation of intelligence, operations, and fire support functions to provide a rapid flow of vital information to the field commander. Many of the problems associated with the FIELDATA system stemmed from its data communications orientation rather than information systems. An elaborate plan to network the system components from Theater Army to company level was never realized.

Though only a few of the applications computer systems were developed as prototypes, the FIELDATA project was not without its successes. It laid the groundwork for the development of tactical automatic data switches and terminals which are used throughout the Army today. Additionally, standards for the militarization of battlefield computer systems were established.

The U.S. Army Signal Research and Development Agency was given the responsibility for engineering the hardware for FIELDATA to meet the following requirements: (1) be miniaturized enough to be easily transported to meet mobility requirements; (2) be able to operate in extreme climatic and environmental conditions; (3) be sufficiently ruggedized to resist damage as a result of movement over rough terrain; and (4) have sufficient processing capability to meet the information needs of the field commander.[14]

In response to Department of the Army direction, in August 1960, CONARC tasked the US Army Command and General Staff College to develop a plan to automate field Army command information systems. The USAC&GSC, in coordination with various other organizations, developed a plan which identified five areas in the command and control framework as potential candidates for automation. The plan, "Command Control Information Systems 1970" (CCIS70), identified the candidates as: fire support, logistics, personnel and administration, operation, and intelligence. The CCIS70 plan, after formal approval by DA on 3 January 1962, became the basic planning document for the automation of command and control information systems in the field Army.[15]

The Army underwent a major reorganization in 1962 which necessitated the shift of responsibilities for the development of ADPS in the field Army from CONARC to the U.S. Army Combat Development Command (USACDC) and the U.S. Army Materiel Command (USAMC). In 1965, an effort to further consolidate and centralize the various agencies and efforts involved in the development of tactical ADPS was initiated with the organization of the Automatic Data Field Systems Command (ADFSC) under the control of USACDC as materiel developer and USAMC as a combat developer. The first priority of the new command was to assume the Project Manager (PM) responsibility for the development of three of the five original CCIS70 systems.[16]

In May 1965, the Department of the Army approved an updated version of CCIS70 which produced an implementation plan for the development of the Automatic Data Systems within the Army in the Field (ADSAF). The plan restructured the original five CCIS70 systems into three ADSAF systems: Tactical Fire Direction System (TACFIRE), Tactical Operations System (TOS), and Combat Service Support System (CS3).[17]

Although all three ADSAF systems were identified as command and control information systems, real-time inquiry capability was being planned for TACFIRE and TOS only. TACFIRE was to provide automated fire support and TOS, current intelligence and operations data to battlefield commanders. In contrast, CS3 was primarily designed as a batch processing business-type oriented system more closely associated with BASOPS rather than command and control functions. The subsystems of CS3 included: supply functions, maintenance reporting and and management, personnel and administration, and medical accounting and reporting.[18] These were not the only tactical systems being planned for development during that time period, but they collectively illustrate the difficulties and "growing pains" the Army has experienced in the tactical computer arena.

In 1969, the management of ADP in the Army again was changed with the creation of the U.S. Army Computer Systems Command (USACSC). The new organization used ADFSC as its nucleus and was given the mission "...to plan, direct, and control all aspects of multicommand data systems development, test, and installation and to provide operational support to the commands using the developed systems."[19] Thus the new command was given the responsibility of non-tactical multicommand data systems as well as those under the ADSAF program.

Initially, USACSC remained the Project Manager for all three ADSAF systems. However, in late 1970 and into 1971, the PM responsibilities for TACFIRE and TOS were transferred to a newly established agency within the Electronics Command, the

Office of the Project Manager for Army Tactical Data Systems (PM, ARTADS). ARTADS assumed overall project management, however, USACSC maintained the responsibility for the software development for the systems.[20] The many problems this split management arrangement caused were not resolved until the decision was finally made in 1976 to reassign the tactical systems software personnel of USACSC to ARTADS.[21]

Of the three ADSAF systems, CS3, which was the only system to remain under the developmental control of USACSC, became the first of the three to be fully fielded in 1975. It was designed for operation at Division and Corps level using commercial off-the-shelf third-generation IBM 360/30 hardware installed in two military vans. However, as is the major problem with all the early business-type systems built for the field Army, they fail to adhere to the militarization standards developed during the FIELDATA project. Generally they are not sufficiently ruggedized or miniaturized to meet the demand for highly mobile equipment on the modern battlefield. Although when built, they met the requirement to be transportable systems, the bulky dimensions and extreme weight of the 35 foot vans significantly limit off-road mobility. Additionally, the interconnectivity requirements of the systems necessitate that they be assembled close together in a large open area with relatively flat terrain. The time required to move the vans into position, level them, and lay the interconnecting cables makes setup a lengthy process. Consequently, systems such as CS3 are normally left operating in garrison when the unit participates in field training exercises.

The remaining two ADSAF systems, TACFIRE and TOS, took divergent routes. The decision was made early on in the development of TACFIRE that commercially available computer systems could not meet the specifications required for the system. Commercial use of real-time systems was only in its infancy with few applications, not to mention the requirement to operate in a battlefield environment. Therefore, an extensive research and development program was necessary to design a completely tactical real-time system with militarized hardware and unique software. When considering the state-of-the-art during the early design stages of the project, it is understandable why, not until 1980, approximately 15 years after DA approval and more than 20 years after its inception, did TACFIRE pass final Army acceptance for full production.

The final ADSAF system, TOS, did not realize the same final success as TACFIRE. Although a European (7th Army) version of TOS was tested in 1969, the system was never fielded. The early developers chose to design TOS for use on commercially available ADPS mounted in military vans, and they never successfully overcame the problems associated with developing real-time tactical systems with commercial hardware and software.

## BATTLEFIELD AUTOMATED SYSTEMS

Since the early days of the computer, when development and acquisition of automated systems plodded along, rapid technological advancements have quickly led to an ever increasing proliferation of computer systems on the battlefield. A recent study identified a total of 299 Battlefield Automated Systems (BAS) developed by the Army which are either presently fielded or scheduled to be fielded in the various theaters by 1988.[22] Recent projections demonstrate that if the proliferation continues, the Army computer requirements through the 1990 time period will be 250,000 micro-computers and 29,000 mini-computers.[23] To combat the proliferation, the Military Computer Family (MCF) project was initiated by the U.S. Army Communications Research and Development Command (CORADCOM).

The MCF project is intended to develop a hardware design for all embedded computer systems used throughout the Army. The basic approach chosen by CORADCOM was to develop modules which can be configured differently depending on the intended application within the Army. Each module performs a defined function along traditional lines. There are Central Processing Unit (CPU) modules, memory modules, power supply modules, Input and Output (I/O) interface modules and so forth to tailor a system for its unique function.[24]

On 1 May 1981, the U.S. Army Communications and Electronics Materiel Readiness Command and CORADCOM merged to form the U.S. Army Communications-Electronics Command (CECOM). In addition to the MCF project, CECOM inherited the responsibility for the research, development and acquisition of Army command, control and communications ($C^3$) systems. One of the major developmental managerial responsibilities of the organization is Project Manager for Operations Tactical Data Systems (PM, OPTADS).

The PM, OPTADS is tasked to develop and acquire command and control systems for use by the field commander and his operations staff to automate the flow of vital information on the battlefield. The major system currently under the PM is the Maneuver Control System (MCS).

MCS is designed to provide overall operations control from battalion through corps and provide the commander with real-time information from five battlefield control systems. The systems from which the information is integrated include operations control, intelligence control, air defense control, fire control, and admin/log control. The hardware used for MCS, in addition to some items from the MCF, is the AN/UYQ-19 Tactical Computer System (TCS) and the AN/UYQ-30 Tactical Computer Terminal (TCT). The TCS, an extremely rugged and transportable mini-computer system especially developed for the battlefield environment, was designed as a general purpose system for stand-alone or subsystem applications for various command and control functions. The TCT is also fully militarized and functions as an intelligent terminal utilizing three microprocessors. Both the TCS and the TCT are managed by the PM, OPTADS, but they are not a part of the MCS program.

Although CECOM has the responsibility for the research, development and acquisition of Army $C^3$ systems, all BAS are not the responsibility of CECOM. The business-type oriented systems, such as CS3, will remain the responsibility of the U.S. Army Computer Systems Command (USACSC). USACSC has been tasked to replace the third-generation van mounted IBM 360 series computers and the second-generation National Cash Register (NCR) 500 DSU/GSU systems with the Honeywell Level 6 mini-computer. The Level 6 has been installed in a military van to comprise the Decentralized Automated Service Support System (DAS3). This van mounted ADPS is more rugged and should prove to be more mobile than the antiquated systems it is replacing.

The responsibility for the development and acquisition of the DAS3 systems rests with the Program Manager for Tactical Management Information Systems (PM, TACMIS). In 1980, PM, TACMIS initiated the fielding of the DAS3 systems at the non-divisional maintenance company level for immediate replacement of the old NCR 500 systems. Processing, which took twelve hours to complete, can now be accomplished in two. During the next five years, over 400 DAS3 will be fielded to perform a variety of personnel, logistics and administrative functions for commanders in the field.

## ENDNOTES

[1]Department of the Army, Post-Deployment Software Support (PDSS) Concept Plan for Battlefield Automated Systems (Washington, D.C., May 1980), p. xii.

[2]United States of America War Office, Use of Automatic Data Processing Equipment in the Department of the Army (Washington, D.C., Department of Defense, 10 June 1963), pp. 1-4.

[3]Ibid.

[4]Automatic Data Processing Systems, Book - 1 Introduction (U.S. Army Signal School, Fort Monmouth, New Jersey, 15 January 1960), passim.

[5]Automatic Data Processing Systems, Book - 2 Army Use of ADPS (U.S. Army Signal School, Fort Monmouth, New Jersey, 15 October 1960), passim.

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[7]Edward O. Joslin, comp., Computer Readings: For Making It Count (Arlington, Virginia: College Readings, Inc., 1974), p. I-15.

[8]Ibid.

[9]Ibid., p. I-16.

[10]Systems, Book - 2, op. cit., passim.

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[12]Combat Service Support System, CS3, Introductory Manual (U.S. Army Computer Systems Command, Fort Belvoir, Virginia, June 1969), pp. 1-3.

[13]Alan B. Salisbury, The Making of a Weapon System: TACFIRE 1959-1978 (National Defense University Research Directorate, Washington, D.C., August 1978), p. 1

[14]Systems, Book - 2, op. cit., passim.

[15]Salisbury, op. cit., p. 2.

[16]CS3, op. cit., p. 3.

[17]Salisbury, op. cit., p. 3.

[18]CS3, op. cit., pp. 3-4.

[19]Ibid., p. 3.

[20]Salisbury, op. cit., p. 11.

[21]Ibid., p. 25.

[22]Theater Army Post Deployment Software Support Study (Draft), U.S. Army Battlefield Automated System (BAS) (Teledyne Brown Engineering, Huntsville, Alabama, November 1, 1982), pp. 1-1, 1-2.

[23]John S. Davis, MCF: Solution to Computer Proliferation (U.S. Army Institute for Research in Management, GIT, Atlanta, Georgia, 9 September 1980), p. 2.

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## CHAPTER III

## TACTICAL COMPUTER SYSTEM SOFTWARE SUPPORT

For the past thirty years, rapid technological advancements have enabled the Army to move from the single function simplicity of the first electric computing machine, ENIAC, to the highly sophisticated multifunction capabilities of the mini- and micro-computers of today. Due to its permanently wired circuitry, ENIAC's processing capability was initially limited to the one function of developing ballistic tables. However, a technique called "stored programming" was soon introduced which provided much needed flexibility to the computing machines. The ability to provide a programmed set of instructions for preplanned operations, called software, had a major impact on the evolutionary development of automatic data processing. As the expansion of technology led to vast improvements in computer hardware over the simplistic designs of the early machines, new sophisticated software was developed to instruct the computers to execute a vast array of new functions. Thus, with no physical change to the equipment, the function to be performed by the computer could be easily altered with the installation of new software. It can, therefore, be said that if the central processing unit (CPU) is the heart of the computer,[1] then the software can be categorized as the brain; for software dictates the processes that the electronic circuitry of the machine is to accomplish to complete the intended task. And like the brain, the full potential of software has yet to be realized.

## NATURE OF SOFTWARE

Computer software is highly structured and is generally considered in three categories: operating systems, utility programs and applications systems. The operating system consists of a set of instructions which, in basic terms, supervises the resources required to execute an application or utility program. It controls how the computer functions during a given operation. Utility programs are merely general use programs which can be called upon to do routine, recurring functions. They provide searching capability, file maintenance, program compilers and assemblers, computational subroutines, and the translation of program language into machine readable format. Application systems are a set of programs developed to perform specific functions for users. Where operating systems and utility programs generally provide universal capability across a set of hardware, applications systems are designed for processing a specific set of data using the hardware.

Historically, computer software has been written in numerous programming languages. From the inception of "stored programing", the instruction set directing the function of the computer has been written in many varying formats. Early languages were little more than basically digital instructions for mathematic and scientific calculations. As the number of users increased, languages were sought to improve the communications capability between the human and the computer. With the improvement of computer hardware, indepth software research led to the development of several levels of computer language. The least complex and simplest to use from a programer's point of view are the high-order languages such as FORTRAN, COBOL, and TACPOL. These languages provide programers with a common tool to develop applications programs which are easy to write and easy to correct if errors are detected.

Assembly language is the second level of software used to program computers. Considerably more complex than the high-order languages, it is used primarily in the development of operating systems rather than applications programs, and is a hardware unique language. While a language such as COBOL is written in relatively clear English text restricted by syntax rules, assembly is written in a series of discrete, monolithic instructions in mnemonic or symbolic form, which are tedious to write and even more difficult to change should program modificiations be required. Of even greater concern, the difficulty in identifying and correcting programing errors can result in critical delays in providing program corrections to users in the field. Also, with assembly language programs generally bound to a unique hardware system, it is not readily transportable to other hardware and, therefore, costly to develop and maintain.

The lowest level language is machine. Its instructions are communicated directly to the electric circuits of the CPU as a string of on-off conditions call bits. The string of bits - actually binary code - controls the computer's processing. All other languages are converted to binary code before they can be read by the computer.

When programs are initially written in either high-level or assembly language codes, they are in a nonexecutable source code format. In order to be reduced to an executable format - a sequence of instructions which can be understood by the machine - they must be translated by either a compiler for high-order languages or an assembler for assembly languages. The translation process results in the source code being reduced to a binary-based machine readable code which is identified as an object module. It is the linking together of object modules into a logical sequence of machine readable instructions that constitutes the nucleus of a software system.

## SOFTWARE SUPPORT REQUIREMENTS

As discussed in the previous chapters, the use of tactical computers at the divisional and non-divisional level is on the increase. There is a general consensus among military leaders that computers are becoming an inherent part of command and control systems. The increasing variety of essential elements of information required by the commander to reach sound decisions on the best course of action to initiate, can no longer be processed rapidly by manual methods. The flow on the battlefield has become so fluid that any delays in receiving vital information could result in loss of life and/or materiel.

To meet the demands of the commander to rapidly increase the flow of information, new and extremely intricate computer systems are being developed. With state-of-the-art hardware, such as the TCT and TCS, now in the Army inventory, it is the development of exceedingly complex software for more advanced applications of the hardware that is consuming development resources. This trend, noted several years ago in a study prepared for the Air Force, will continue in the years ahead:

> "The software to implement the various functions of tactical command and control and to integrate them into an effective system has been difficult and costly to develop. Indeed, software is expected to remain the critical factor in tactical command and control systems development."[2]

The increased reliance by commanders on computer systems with exceedingly complex software for command and control, has significantly increased the risks involved. Commanders must realize that computer systems are subject to failures that not only can, but will, occur. The planning, directing, and coordinating of tactical operations will be severely limited until the computer system is restored to full operation.

Coping with hardware problems will be relatively easy. Diagnostic test capability can quickly isolate the problem, and defective modules, or, if required, computers will be rapidly replaced. Downtime will be easily minimized.

The situation in dealing with the intricacies of software is quite different. When a software failure occurs, the operators or maintenance personnel in the field do not have the capability to resolve the problem. While a defective hardware module can be identified and physically replaced by a repairman, the object modules which constitute a software system cannot. System software programmers must try to identify which object module is causing the problem, and then review hundreds or thousands of instructions to determine which is in error. Once identified, the program instruction at fault must be corrected and a new software system/object modules distributed to the field. It is also important to note that hardware problems are generally isolated incidents restricted to one piece of hardware; software problems are not. If a problem is detected on one machine, new software correcting the problem must be installed on each computer which operates with that particular software system.

The sudden failure of software is sometimes incomprehensible to non-technically oriented ADP users. While there is a general acceptance that any machine, whether mechanical or electrical, will eventually experience some hardware malfunction, the feeling towards software is the converse. Once a software system has been tested and fielded for universal application, there is a tendency to believe that the software cannot "break". Unfortunately, this misconception is totally false. Regardless of the stringent testing conditions established for the software during the development phase, the only real test of the software will be operation under actual battlefield conditions. And while software will not "break" in the physical sense, a situation will inevitably occur which was unanticipated and went untested during system development. Therefore, software malfunctions should be anticipated for all ADPS. As one author noted when reviewing the development of the TACFIRE system:

> "The nature of the software beast is that a zero defects level is rarely achieved, and when claimed, more often than not is indicative of inadequate testing rather than superclean software."[3]

As more complex command and control systems are introduced, the possibility of experiencing software failures increases. However, even if the computer system does operate as designed, all may not yet be well. Under conditions of large-scale troop deployments as in actual war, the requirements for system input and output may be entirely different from that envisioned. The sudden surge from the increased number of users will result in unexpected system problems.

Throughout history, warring nations have continually adapted to the fluidity of the battlefield. There is nothing to suggest that the next war will not follow historical example. Human decision making is flexible and readily adapts to a fast changing environment; computer systems do not. System programs must be rapidly redesigned and reinstalled on the computers to meet the new requirement. Until the redesigned systems are distributed to the field, the debilitating effect of a major system design flaw will be capability-degrading, if not catastrophic, rather than providing the capability-enhancement for which it was designed.

The realization that the effectiveness of the Battlefield Automated Systems (BAS) being fielded will be dependent on the efficiency of software support received has led to an attempt to standardize the procedures throughout the Army. In July 1978, DARCOM (U.S. Army Materiel Development and Readiness Command) tasked CORADCOM to develop a Post-Deployment Software Support (PDSS) plan with other Army commands for Army-wide implementation. A task force was formed in August 1978 to investigate the problems of PDSS for battlefield systems that contained computers. The task force was made up of representatives of Army staff agencies, Army Commands, and Army project managers to:

> "...assist CORADCOM in defining the PDSS problem, identifying PDSS requirements, forming assumptions, and developing PDSS implementation alternatives, evaluation criteria, and a selection methodology."[4]

The major findings of the task force were not surprising. Numerous management and technical problems have plagued the development of adequate software support throughout the years. Specifically, the management structure in the Army has not dedicated the resources nor established firm policies to facilitate the development of a viable Army-wide software support program. Many of the problems begin with the development of the software and are compounded during the system life-cycle. Uniform procedures, guidelines, and standards for all BAS in development have not been identified. Specifically, in regard to software development, the task force found:

> "In general, a lack of concern during software development has produced BAS software with poor maintainability. The software in Army BASs is characterized by poorly defined functional and interface requirements and specifications, lack of proper modularization, too great a use of machine-oriented languages (MOLs) and inadequate documentation."[5]

Another significant finding of the task force was that there was a continuing proliferation of hardware/software. As previously discussed elsewhere in this study, many of the hardware proliferation problems will be resolved with the use of the MCF. The proliferation of software with the myriad of compilers, assemblers, subsystems, utilities, and operating systems will also be partially resolved with the MCF as well as the TCT and TCS. However, the current problems caused by the uniqueness of the assembly languages will take a significant amount of time to overcome. Software proliferation will be a hindrance to effective software support for years to come.

The proliferation of computer languages was another major problem identified during the study. Over 44 different computer languages, ranging from high-order, assembly, and machine languages to micro-process instructions, are in use on BAS. The many different languages increase the spectrum of software support requirements from additional training for programers to the availability of a large variety of test-bed systems. The adoption of the DOD standard language, Ada, for use on all Army BAS would be a major step to resolve the language proliferation problem.[6]

Having identified the major PDSS problems, the task force turned towards the development of a "software system structure" to define what elements of the fielded systems were to be supported. A work group from the task force defined subsystem elements of tactical software as: Operating System, Field Applications Software, Fielded Field-Training Software, and Fielded Hardware Diagnostic Software. The categories of system changes which would be generated to provide software support for the subsystems were: System Refinements, New Requirements, and Interoperability.[7]

The second two categories, New Requirements, which are program modifications as a result of routine engineering change proposals (ECP), and Interoperability interfaces, which are changes that affect the technical interface and interconnection of the systems, will not require rapid distribution of software program changes to the field. Those changes will be coordinated with the combat developers (CD) and released to the field at established intervals, generally on an annual or semi-annual basis.

The other category of system changes, System Refinements, encompasses program optimization, technological improvements, enhanced system performance and error correcting. These changes are generally not as a result of major application or operating system redesign. Changes in this category, which are not required for the immediate resolution of a major malfunction, are generally provided to the field as a new system version with a number of individual program changes normally embodied in the new version release. The number of changes in each release will be dependent on the urgency and/or complexity of the changes. However, when urgent software changes are required to resolve major software problems which have resulted in or have the potential to cause a system failure, software modifications will be quickly made to the affected modules and they will be expeditiously distributed to the tactical users in the field.[8]

Recognizing that the resolution of software problems is "...a function of complexity of the solutions and the priority of the problems", the task force established target goals for response time to resolve identified software problems. A system change would be provided to the user within 24 to 72 hours if the solution was urgently required and not extremely complex to resolve. Those extremely complex problems would be resolved "ASAP" with immediate consideration given to a "patch workaround". Routine problems would be taken care of from 90 to 360 days, depending on the degree of complexity.[9]

Upon completion of the task force investigation into the problems of and establishing the requirements for Army-wide PDSS for BAS, a management plan for PDSS was developed and recommended for adoption. To alleviate the management structure problems and define specific software support responsibilities, the plan calls for the establishment of eleven PDSS centers* on the basis of battlefield functional

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*The centers are scheduled for: (1) the U.S. Army Armament Research and Development Command (ARRADCOM) at Picatinny Arsenal, Dover, New Jersey; (2) the U.S. Army Communications-Electronics Command (CECOM) at Fort Monomouth, New Jersey; (3) the CECOM center at Fort Leavenworth, Kansas; (4) the CECOM center at Fort Sill, Oklahoma; (5) the U.S. Army Computer Systems Command (USACSC) at Fort Belvoir, Virginia; (6) the USACSC center at Fort Lee, Virginia; (7) the U.S. Army Missile Command (MICOM) at Fort Bliss, Texas; (8) the U.S. Army Electronics Research and Development Command (ERADCOM) at Fort Monmouth, New Jersey; (9) the ERADCOM center at Fort Huachuca, Arizona; (10) the MICOM center at Redstone Arsenal, Huntsville, Alabama; and (11) the U.S. Army Aviation Research and Development Command (AVRADCOM) at Fort Monmouth, New Jersey.

areas (BFA). Called the "hybrid" approach, it provides for the doctrinal sensitivity of certain systems while insuring that the technical complexity of the system design is met. PDSS centers are called for at both TRADOC centers/schools and the developing commands, as appropriate.[10]

In addition to calling for the establishment of the PDSS centers, other recommendations in the plan included the adoption of certain policies to improve PDSS. Chief among the recommendations was the reduction of the number of different types of computers by designating the MCF as the preferred hardware for use on future systems. Also, future software development would be restricted to the use of the Ada language. The adoption of both of these policies should significantly reduce the proliferation of hardware/software and computer languages.[11]

While an important aspect of the PDSS plan was the adoption of the "software system structure" and response time goals for system problems, the task force failed to develop or even to identify the problems of a distribution process for software change packages (SCP). Of particular importance are those urgently needed software changes for the Operating System and Field Applications Software subsystem elements of the BAS which must be provided under wartime conditions. Although it can be acknowledged that major system changes or enhancements cannot be provided within the response time goals of

24 to 72 hours, the unanswered question remains, "What procedure is available for the PDSS centers to provide urgently needed SCP within the established times to the BAS users in OCONUS Theaters?" The answer to that question will be pursued throughout the remainder of this study, for the complexities of the modern computer and the incertitude of software can be summed up thusly:

> "A 'perfect' software system of any magnitude with zero deficiencies has yet to be developed, either in the commercial world or within the military. Much research is ongoing aimed at formal proofs of software 'correctness' but state-of-the-art for the foreseeable future will fall short of this objective."[12]

## SOFTWARE CHANGE PACKAGE QUESTIONNAIRE

Since the question of how software change packages (SCP) are to be distributed in a timely manner to field commanders was left unanswered by the PDSS plan, a questionnaire was developed by the author to examine the current practices and procedures in use by various design centers. The questionnaire (Appendix) was designed to be applicable to the broad spectrum of software development and design centers to identify how each produces and distributes SCP for the ADPS supported by them. Although there is a distinct difference between the urgency required during war versus peacetime, the questionnaire was developed to determine what commonality or extreme differences exist between the centers as they operate now during peacetime. Also, what positive procedure accomplished by one may be adaptable to all.

The questionnaire was mailed to a total of twelve organizations. One was sent to each of the PDSS centers with the exception of the ERADCOM center scheduled for operation at Fort Huachuca. The center there has yet to be established. In addition to the PDSS centers, the questionnaire was also sent to the U.S. Navy software support activities for the Atlantic and Pacific Fleets to determine if they have a procedure which would be adaptable to the Army.

The criticality of providing timely software changes to the field commanders has been discussed in detail in the earlier sections of this chapter. However, the content and the physical nature of the SCP media has yet to be expounded. Therefore, before describing the contents of the questionnaire in detail, the elements of an SCP will be explained.

As elucidated earlier in the section entitled "Nature of Software", it is a binary based machine readable code which provides instructions to the computer. The machine code is divided into object modules which when linked together constitutes the nucleus of a software system. When an SCP is developed, it will consist of either an entire software system or merely one or more object modules which are only a part of a larger system. It is important to note that regardless of the number of object modules in a given SCP, the data is represented by a binary bit string that is intelligible only to the computer. A computer operator or repairman will be unable to determine by visual inspection if the SCP received for installation has been altered - obviously discounted is the identification of physical defects to the SCP media, such as damaged magnetic tape. It is, therefore, critical that the SCP be distributed to the users completely free of error. One bit of data that is incorrect will render the entire SCP unusable.*

The media used to send software changes to the field are generally magnetic tape on open reels or cassettes. The capability also exists for "floppy disc" or cards to be used on some systems. Another means to provide immediate software changes to users is through a patch workaround which is provided only in extreme emergencies where a catastrophic failure has occurred. A patch is a correction to the machine language instruction which must be entered directly into the system software. This type of change is extremely limited and should only be attempted when a software analyst is available to make the change. Therefore, for the purposes of this study which is limited to BAS which operate in a field environment without

*An SCP can contain from thousands to millions of bits of data depending on the number of object modules being modified. SCP containing 50 to 60 million bits of information are common.

software analysts immediately available, the capability to use patch workarounds were not explored in the questionnaire.

In addition to providing the obvious information dealing with the method of distribution, frequency and urgency of the SCP as well as the number of systems supported, the questionnaire was designed to provide other pertinent information. The organizational level that the changes are sent to, for example, is significant for two reasons. First, it indicates the type of outside support that will generally be available to the user. That is, the higher the organizational level, the more support that is generally available to the unit. Secondly, it provides an excellent indication of the difficulty involved with providing distribution directly to the unit. Distribution of SCP to company level divisional units is considerably more difficult and complex than to Theater and Corps units.

Another area of vital concern is the expertise of the personnel who operate the computers. If a computer is operated by the functional user rather than a trained ADP operator, there is a greater chance for a problem to develop during the installation of the software changes. Also, software maintenance personnel may be required by some organizations to rotate from computer to computer installing software changes. Contractor personnel may also be required to install changes on some systems.

The media used to send changes to the field are quite significant since they impact on the range of options available to make distribution. For example, if it is on floppy disc or cassette tape, the SCP cannot be transmitted via AUTODIN and must, therefore, be mailed or sent with a courier. Also, the media impact on where and how the reproduction process is accomplished. If an SCP is mailed to each site, the resources to copy the change once for each site must be available at the support center. If transmitted via AUTODIN, only one copy, regardless of the number of sites, is required. (The aspect of using AUTODIN for the distribution of SCP will be discussed further in Chapter IV.)

The remainder of the questionnaire is devoted to the type of system supported (i.e. developmental or fielded); why the present plan is in use; and the possible shortcomings or inadequacies of the system presently used. Any recommendations on how the distribution of SCP could be improved was also solicited.

The questionnaire was mailed under a cover letter dated 22 January 1982, to the twelve support centers previously identified. The response to the questionnaire was positive by all the organizations involved. While the quality of the responses was good, the information provided identified serious deficiencies in the timely distribution of SCP.

ENDNOTES

[1]Edward O. Joslin, comp., Computer Readings: For Making It Count (Arlington, Virginia: College Readings, Inc., 1974), p. II-36.

[2]R. Turn et al., Computers and Strategic Advantage: II. Capability-Enhancing Applications, A Report prepared for United States Air Force Project Rand, R-1643-PR (Rand, Santa Monica, California, August 1975), pp. 52-53.

[3]Alan B. Salisbury, The Making of a Weapon System: TACFIRE 1959-1978 (National Defense University Research Directorate, Washington, D.C., August 1978), p. 30.

[4]Department of the Army, Post-Deployment Software Support (PDSS) Concept Plan for Battlefield Automated Systems (Washington, D.C., May 1980), p. 1-7.

[5]Ibid., p. 2-5.

[6]Ibid., pp. 2-6, 2-11.

[7]Ibid., pp. 3-1, 3-3, 3-36.

[8]Ibid., p. 3-37.

[9]Ibid., p. 3-36.

[10]Ibid., p. 5-1.

[11]Ibid., pp. 5-26, 5-27.

[12]Salisbury, op. cit., p. 31.

## CHAPTER IV

## THE SCP DISTRIBUTION PROCESS

The previous chapters of this study were primarily concerned with building a foundation on which the reader could develop an appreciation for the critical nature of and the potential problems associated with tactical computer system software support. First, the evolution of the computer was described, and then the snail-like pace in the development of militarized computers for employment in the tactical arena was expounded. The numerous delays in the fielding of TACFIRE and the failures associated with TOS provided vivid examples as to why the focus of the Army has remained on the development, rather than the maintenance, of software. Next, to provide an understanding of the criticality of timely software support, the dynamic, and sometimes fragile nature of software was explained. And finally, after examining the Post-Deployment Software Support (PDSS) Plan, the questionnaire sent to various software support agencies to determine the level of software support currently available to the field commanders was described to the reader. With the need for timely software support firmly established, the study now shifts focus to the means and resources available to provide the required software support.

In this chapter, the questionnaire responses will be analyzed to compare the various distribution methods employed by the agencies involved. Capability shortfalls will be readily identifiable as the means available to accommodate timely software support are examined. Inadequacies of current distribution methods will then be evident when contrasted to the means and resources presently available to support centers. Software support problems identified by the support centers will be analyzed to determine if the Software Change Package (SCP) can be delivered in a timely manner to commanders during time of war. And due to the anticipated increase in the number of Battlefield Automated Systems (BAS) that will be employed in the battlefield, the future software support requirements will be identified to determine the improvement in capability required to accomplish rapid SCP distribution. Without improvements in the SCP distribution process, the ability to provide timely software support to field commanders is questionable.

## SCP QUESTIONNAIRE RESULTS

Of the twelve SCP Questionnaires mailed to the organizations identified earlier in the study, eight were completed and returned to the author. The eight received consisted of two from the Navy support agencies and six from the Army PDSS centers. The other four centers* are in their formative stages

*The four PDSS centers are: (1) the CECOM center at Fort Monmouth; (2) the USACSC center at Fort Lee; (3) the ARRADCOM center at Pecatinny Arsenal; and (4) the AVRADCOM center at Fort Monmouth.

of development and are not yet responsible for the distribution of software changes; therefore, limited information only could be provided based on projected requirements. The BAS covered by the questionnaires received spanned an array of Battlefield Functional Areas (BFA), to include Fire Support, Intelligence and Electronic Warfare, Air Defense, Combat Service Support, and Maneuver. With the exception of one PDSS center, the SCP Questionnaires were completed based on fielded, rather than developmental systems.* Rather than providing the specifics on each questionnaire in this portion of the study, a general summary only will be discussed. Overall responses to specific questions can be reviewed with the annotated sample questionnaire provided in the Appendix.

Although some of the responses provided vary significantly, there is a considerable degree of commonality among the various support centers. The dominant medium employed to distribute software changes to the field is magnetic tape, either on an open reel, cassette, or cartridge. No systems were reported to use "floppy" disc or card media for software distribution. The other medium identified as being used for a number of BAS is ROM (Read Only Memory). ROM is embodied on a microchip, and not as an object module of machine readable

*The questionnaire completed by the CECOM PDSS center at Fort Leavenworth, Kansas, was based on the Maneuver Control System (MCS) which is currently in development. A PDSS Implementation Plan is being developed for MCS as it is scheduled to enter the deployment stage of its life-cycle in July, 1983.

code stored in Random Access Memory (RAM). It is neither identifiable strictly as hardware or software and, therefore, normally identified as "firmware". As the nature of "software" was developed in Chapter III, ROM as "firmware" was not discussed, nor was it included on the questionnaire. However, while the reprogramming of non-software intensive systems using ROM firmware is not the focal point of this study, the impact of ROM on the distribution of programming changes to tactical computers cannot be totally ignored. The problems associated with the distribution of ROM will, therefore, be briefly discussed later in this study.

The following is a summary of the responses to the SCP Questionnaire:

1. For BAS distributing SCP on magnetic tape, the multiple copies required to provide one copy to each system are generally produced at the CONUS based PDSS centers. Some reproduction is accomplished at field sites, but normally only for local use. There are exceptions, however, such as when specific operator training must be conducted prior to the SCP being applied to all BAS. In such cases, reproduction and distribution are accomplished in theater after training is completed.

2. The primary methods of distributing SCP to tactical units is mail; followed closely by hand carrying the changes to each BAS site. Although the majority of software

changes are routine, and, therefore, not considered time sensitive, a significant number - approximately forty percent - are in response to time sensitive problems categorized as either urgent or emergency. Despite the time sensitive nature of urgent problems, the majority of urgent SCP are accorded the same distribution priority as routine changes when they are mailed to users in the field. There was no indication from any of the responses that emergency SCP are every mailed.

3. Emergency SCP and urgent SCP that require expeditious delivery are normally hand carried to the affected sites. SCP are also hand carried if operator training is to be conducted in conjunction with their loading. Usually, Department of Defense (DOD) civilians or contractor personnel from CONUS are the technicians who have the software knowledge necessary to hand carry and install the software changes at the computer sites. Few military personnel are assigned to PDSS centers, and if assigned, rarely are they sufficiently technically oriented to resolve software problems during SCP loads, and/or to conduct operator training on the system changes provided in an SCP. The only agency to identify a military courier as the means to distributed software changes was one of the Navy support centers. At that, it was limited to 18 percent of the time.

4. The only significant user of AUTODIN to provide changes to the field is the U.S. Army Computer Systems Command

(USACSC). Approximately fifty percent of their urgent software changes and virtually all of their emergency changes are distributed by transmitting SCP via AUTODIN to the field commanders.

5. The organizational level to which the SCP are distributed is normally division and lower with the functional user responsible for operating the computer rather than a trained ADP operator. Since relatively few software maintenance personnel are available on site to make the software changes, the SCP are applied either by the users when received by mail or AUTODIN, or by contractor or PDSS center personnel when they have hand carried the software changes to the site.

6. When queried as to why each organization was using the procedures identified, the majority of the questionnaire responses specified quick delivery, error-free transmittal, and Configuration Management (CM) control as the primary reasons. Few could identify any shortcomings or inadequacies in the system presently used and many were unable to provide suggested improvements in their procedures. Yet, in most cases, an urgent software change could not be distributed to all required BAS in the PDSS study goal of 24 to 72 hours.

7. Comparisons of the Navy software support agencies responses to those of the Army PDSS centers presented little contrast in procedures. They also mail or hand carry software changes to the ships at sea and are in the midst of studying alternative distribution methods.

While some information requested by the questionnaire may have required a written response, not all of the comments received were deemed relevant for the purpose of this study, and therefore, will not be considered for inclusion in the study. Narrative statements that were considered significantly relevant and/or required further analysis will be discussed throughout the remainder of this section. Also discussed will be information or comments received by the author when conducting telephonic interviews with representatives from the PDSS centers. The interviews were conducted initially to seek a clarification to some of the written responses received from the organization contacted. In many instances, in addition to receiving the clarification sought, new information not originally requested by the questionnaire was gained through the course of the conversation.

One such conversation revealed a new development in the Fire Support BFA. A soon to be released version of TACFIRE will have emergency patch capability for on site problem resolution. Although a movement in the right direction, only a limited capability to make emergency software changes will be available. More complex and/or extensive software modifications will remain limited to the PDSS center for distribution with mail or hand delivery.

Also revealed during the conversation was a problem with the delivery of cassette tapes through the mail. Rough handling in the postal system can cause a physical movement of the magnetic tape in the cassette. The tape header information is then no longer at the normal start position, and, therefore, the SCP cannot be loaded into the computer. To resolve the problem, maintenance personnel, if available in theater, must be contacted to reposition the tape, or an entirely new tape must be reproduced from the master and resent to the site. While this problem can be currently minimized with the relatively few systems now in the tactical arena, it will soon be compounded as systems such as the Battery Computer System are fielded. As the requirement to mail cassettes to the battery and company level increases, the volume of SCP damaged in the mail will significantly increase.

Another area of significance that was discussed with personnel from several PDSS centers is the large number of BAS that will be programmed using ROM. Systems such as those installed in the M-1 Tank and UH-1 Helicopter as well as many other weapons systems will require the rapid distribution of ROM for urgent or emergency programming changes for thousands of computers in the field. Most PDSS centers envision the distribution of the ROM being conducted using the existing supply system for repair parts. Urgent problems may not require an immediate fix and, therefore, could be adequately resolved in this manner; however, emergency problems cannot.

While emergency problems may be considered rare, an example of a problem with devistating consequences comes readily to mind. Emergency programming changes to a ROM in the Biological Detector System would be required if a new chemical or biological agent was suddenly introduced on the battlefield. Unless a programming change is rapidly distributed, the inability of the detectors to identify the new chemical and provide an alarm for the soldiers in the area would lead to a serious degradation in the fighting capability of the units on the battlefield.

Although the SCP Questionnaire did not provide any new insights into how to rapidly distribute urgent and emergency software changes, the responses reaffirmed the need to analyze existing methods, identify problems, and develop new procedures for adoption by PDSS centers Army wide. In the section that follows, existing distribution methods will be analyzed to determine their inadequacies, and the shortfalls of the distribution means currently available will be identified.

## SCP DISTRIBUTION METHODS AND CAPABILITY SHORTFALLS

When analyzing the results of the SCP Questionnaire, it is readily apparent that the majority of the PDSS centers have entrusted the capability to rapidly distribute software changes to resolve BAS software problems to the U.S. Government postal system. Admittedly, most of the SCP mailed to users are routine, but there are many that are urgent. However, whether urgent or simply routine, it is the failure to deliver SCP in a timely manner that highlights the major inadequacy of mailing changes to OCONUS users.

The time required for OCONUS addressees to receive mailed SCP is estimated by most centers to be between 15 and 30 days. While this delay may be tolerable in peacetime, urgent problem resolution that is delayed during wartime may have a significant impact on the field commanders. Certain problems, categorized as urgent simply because a system stoppage has not occurred, may have a considerable debilitating effect on the field commander's capability to process vital command and control information on the battlefield. The rapid resolution of this type of urgent problem will consume the aggregate of PDSS center time and personnel resources. It is inconceivable that such an intensive effort could be allowed to be negated by postal system delays of two weeks or more.

Another negative aspect of mailing software changes is the considerable drain on resources in the preparation of the packages for mailing. First, reproducing a copy of the SCP from the master for each computer requires a large number of blank tapes. While only a relatively few computers are in operation today for the majority of the tactical systems, hundreds and in many cases thousands of computers will soon be functioning on the battlefield with each requiring software support in the form of SCP.* To meet the support requirements, the number of copies of each SCP being reproduced will dramatically increase. Therefore, the cost of acquiring blank magnetic tape will proportionally increase. Also increasing will be the possibility of creating tapes with utility copy errors. Secondly, to provide an SCP to each site by mailing, the magnetic tapes, whether on open reel, cassette, or cartridge, must be packaged in a container with written instructions, labeled with addressing information, and transported to the local Post Office for mailing. And finally, as noted earlier with the physical movement of the tape in cassettes, SCP transmitted through the mail are subject to damage or loss.

Sending software changes to OCONUS Theaters employing the postal system during time of war is another area of major concern. While two to four weeks is the normal delay for mailed SCP in peacetime, the amount of delay that might be experienced during a major or even limited conflict could be extreme. They could easily be lost in the "shuffle" of materiel being delivered in Theater to support the war effort.

The next most popular method of delivering SCP to the BAS in the tactical arena is by hand carrying. While this method provides the greatest degree of surety against damage, loss, or alteration, the inadequacies of this method are many.

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*For example, current estimates show that as many as 3,000 TCS/TCT will require support by the year 1990.

Again, as noted earlier with regard to mailing, there are relatively few sites using a particular BAS today, and hand carrying of software changes to the individual computers can, therefore, be readily accommodated. However, as the number of sites increases, the resources required to rapidly deliver an SCP to each computer location would be exorbitant. In time of war, it would be virtually impossible. The problem of DOD civilian or contractor personnel, rather than military technicians, delivering software changes in a war zone is not the major obstacle since it has been done in past wars. The problem is the mere volume of personnel necessary to hand carry and install the required number of SCP in a timely manner.

The other major problem with hand carrying the changes is, as was illustrated when discussing the problems of mailing the software changes, the huge amount of reproduction that must be accomplished for each change. With more than a quarter of a million computers projected for employment in the Army by 1990, the severe drain on resources makes hand carrying of SCP to commanders in the field a questionable, if not an impossible, solution to the distribution problem.

The problems associated with the distribution of programming changes to BAS computers that use ROM (Read Only Memory) chips are many. First, consideration must be given to how they are produced for the Army PDSS centers. The government does not have the capability to produce ROM chips for the various BAS that are currently in the field or being developed for fielding sometime in the future. Therefore, the ROM must be produced by civilian contractors who have the capability to mass produce the required number for the Army systems. An obvious drawback to having civilian firms producing the ROM is their inability to quickly "retool" for necessary program changes. In addition to the problem of being unable to make urgent programming changes in a rapid manner, there is no capability to make emergency changes using patches applied by the computer maintenance personnel, or even operators. Both the "retooling" and emergency patch capability problems may be resolved by replacing the ROM with a FPROM (Field-Programable Read Only Memory). This replacement is currently under consideration by some of the Research and Development agencies.

In addition to the supply system, the other alternative methods of distributing ROM are the same as discussed for SCP distributed on magnetic tape through the mail or by hand carrying. As noted, neither of these alternatives are an acceptable solution to the problem.

The final method to distribute software changes is through the Automatic Digital Network (AUTODIN). AUTODIN is a general purpose Department of Defense communication system designed to transmit both narrative and data pattern traffic to subscribers throughout the world. Under the management of the Defense Communication Agency (DCA), the network is comprised of a series of AUTODIN Switching Centers (ASC) located in CONUS, and OCONUS Theaters. Both narrative and data pattern traffic is automatically routed through the ASC to Telecommunications Centers (TCC) which provide over-the-counter message service to customers located on a military installation and/or in a geographical area.

The TCC are configured with a number of different types of terminal equipment to meet the needs of the individual customers serviced. The majority of TCC providing service to ADP customers have the capability to transmit and receive data pattern traffic using either magnetic tape or eighty column cards. Since the use of cards is cumbersome and readily susceptible to errors, virtually all TCC that support Data Processing Installations (DPI) have tape capability, or are in the process of being upgraded to provide for it.

In addition to TCC, Standard Remote Terminals (SRT), are being installed at various locations to meet the increased demand for data transmissions via AUTODIN. The SRT are generally linked either through an Automated Multi-Media Exchange (AMME) or directly to the AUTODIN network with a configuration which provides magnetic tape capability to the user. An SRT was installed at the USACSC software support center in 1981 to afford immediate transmission capability for the distribution of urgently needed software changes. Having direct access to

AUTODIN through the SRT eliminated the normal delays that the USACSC had experienced when using the over-the-counter service provided by the supporting TCC. Also, the command was better able to account for SCP transmitted and respond more rapidly to problems in the field.

Whether employing an SRT or an installation TCC, data pattern transmissions via AUTODIN are restricted to generally the same format conventions as specified for narrative traffic; that is, the traffic must be formatted to adhere to governing DCA regulations and circulars which specify message contextures, such as length and addressee requirements. In order to use AUTODIN to distribute SCP or to transmit other data traffic, the USACSC developed a system that would automatically format the data to meet the DCA requirements. The system developed is the Standard Entry/Exit Service (SEES).

Designed as an interface between a DPI and its servicing TCC, SEES is composed of a series of utility programs that give the user the capability to receive or send data on cards or magnetic tape via AUTODIN. The sender uses the Exit portion of SEES to create valid addressee information and to separate the data into the valid message lengths to comply with AUTODIN requirements. The receiver uses the Entry utilities of SEES to separate the data from the message control information required by AUTODIN - described as header and trailer information - and reconstitutes the data into a machine loadable format for the targeted computer system.

The SEES process has been successfully employed by USACSC to transmit SCP via AUTODIN for more than a decade.

The advantages of employing AUTODIN to transmit software changes to users in the field are significant. Foremost, an SCP can be transmitted to a TCC or SRT thousands of miles away in a matter of minutes. It can then be rapidly provided to the serviced computer site for loading. To verify the velocious transmission and distribution capability of AUTODIN, a test was conducted by personnel from the USACSC in February 1982.[1] A test SCP, transmitted from the SRT installed at and operated by the USACSC in Falls Church, Virginia, was received by the TCC at Ziebruken, Federal Republic of Germany, with a total elapsed time, from time of transmission to time of receipt, of eight minutes. It was also received at virtually the same time - within a minute or two - at three other TCC in Europe.

The above described test also verified another major advantage of transmitting software changes using AUTODIN; the automatic SCP distribution capability built into the system. By transmitting one SCP with multiple addressees - currently SEES is limited to fifty addressees per transmission - AUTODIN uses its "store and forward" transmission capability to provide a separate data message to each addressee. Therefore, the considerable drain on resources required to reproduce numerous copies of an SCP and prepare it for either mailing or for hand carrying can be diverted to a more compelling software support requirement - problem solving.

To the user, the most important aspect of distributing SCP via AUTODIN is the assurance that the change received is undamaged by mail and free of utility copy errors. Also, SEES contains an extremely complex utility to guard against the introduction of errors by AUTODIN. The SEES utility is so precise in its determination that the data received is complete and the object code bit string is exactly as developed at the support center, that the surety of having an error-free SCP shipment is virtually 100 percent.* While SEES is not capable of detecting programming errors that may have been made at the support center, it assures that the SCP is completely free of transmission errors and ready for loading. If SEES does identify a problem to the intended user, a request for a retransmission can be quickly sent to the originator.

Although the advantages of employing AUTODIN for SCP distribution are significant, there are some serious disadvantages. The most severe problem is the inability to receive SCP transmitted via AUTODIN on any media other than 80 column cards or on 7- or 9-track magnetic tape. Software changes developed for distribution on cassettes or cartridges are not

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*As discussed earlier in this paper, an SCP must not be altered in any way. One data bit out of sequence will render the entire SCP useless. Also, in regards to the surety of SEES, to the knowledge of the author while assigned to USACSC, no SCP processed through SEES has contained any undetected transmission introduced error.

compatible with the equipment used at the TCC or SRT and, therefore, cannot be transmitted via AUTODIN.

Currently, the tactical units that are the primary beneficiaries of the capability to distribute changes using AUTODIN are the Division Data Centers (DDC) that operate the Combat Service Support System (CS3). The DDC use the van mounted IBM 360 series computers with 9-track magnetic tape drives which make them compatible with the tapes produced by the TCC and SRT. However, most of the DDC are supported by fixed station TCC that cannot be deployed to the tactical arena. Therefore, if required to tactically deploy, the DDC's capability to receive SCP via AUTODIN would be extremely limited. There are no tactical TCC employed within a division capable of receiving data transmissions via tactical communications systems.

Several other problems experienced with the transmission of software changes via AUTODIN can be attributed to people, rather than technical deficiencies. They range from a lack of understanding and/or coordination between the local DPI and TCC personnel, to problems with various publications that fail to provide adequate regulatory and technical guidance to the users in the field. Because of these problems, DPI personnel have been generally skeptical about the reliability of AUTODIN. Since the causes of many of the problems have been identified, action is now being actively pursued to resolve them. A Data Comm Work Group, composed of personnel from the USACSC and USACC (U.S. Army Communications Command), has been founded to work jointly at resolving DPI/TCC interface problems. Therefore, the major problems of AUTODIN remain the limitation of providing SCP only as 80 column cards or as 7- and 9-track magnetic tape, and the inability of division level TCC to receive data message traffic.

## FUTURE REQUIREMENTS AND CAPABILITIES

Throughout this study, the present and future requirements for software support of BAS have been continuously identified. Therefore, rather than reiterate the anticipated future requirements for each computer system, suffice it to say here, during the remainder of this decade, thousands of computers will be fielded in the tactical environment and each will require software support of one degree or another. Providing the required support will be a major challenge to all PDSS centers. Even with the relatively few tactical computer systems that are employed in the field today, adequate support for urgent SCP can scarcely be provided with the antiquated distribution methods currently practiced. And as the number of BAS increase to meet future requirements, current practices and procedures will prove woefully inadequate.

The software support shortfalls identified earlier in this chapter are not new, but with few exceptions, they have gone either unnoticed or possibly ignored by the majority of software support centers and the Army ADP community as a whole. Few leaders in the ADP field acknowledge that as the proliferation of hardware is checked with the development and fielding of standard hardware, such as the Military Computer Family (MCF), software support will move rapidly to the forefront as the major concern of system developers and be a severe drain on the Army's fiscal resources. As forecast by a Rand Corporation study conducted over a decade ago, "...by 1985 software will consume 95% of our defense computer system dollars."[2]

In general, the ADP system developers in the Army have been reluctant to expend the resources necessary to improve the SCP distribution capability to meet future software support requirements. A preoccupation with software development rather than software support throughout the years has only recently been reversed with the development of the PDSS Concept Plan. However, as previously noted, the plan is lacking in definitive solutions for the rapid distribution of SCP. In fact, adherence to certain aspects of the plan could delay the development of more responsive SCP distribution capabilities.

One aspect of the PDSS Concept Plan which has a major flaw is the requirement to establish a Contact Maintenance Team (CMT) at direct support/general support (DS/GS) level to provide "on-site support" and "install approved changes".[3]

If the intent is to have SCP delivered via mail or hand carried to the GS unit at theater level for reproduction on a computer test set for further distribution to the supported computer sites in theater, the CMT will not provide any improvement to current distribution practices. The time delay problems associated with sending SCP through the mail or hand carrying the software changes to each site will not be alleviated by employing a CMT. Additionally, the resources necessary to reproduce the required number of copies remains a major unresolved problem. If, however, the intent is to use the CMT for "on-site support" should a problem with an urgent SCP load occur, then the formation of the CMT is a step in the right direction.

Although the capability to transmit data via tactical multichannel communications systems has existed and been employed by field commanders for a number of years, little consideration has been given to developing the capability to transmit SCP using the same systems. The primary limitations have been the poor quality of circuits provided by tactical multichannel systems and the lack of data termination capability at the divisional TCC level.

A MITRE Corporation study published in October 1981 found that when tactical multichannel systems are properly deployed, data can be successfully transmitted over the communications links. In order to achieve quality communications links, however, the study recommended improvements to maintenance, training, operations, and supervision.[4] Poor quality circuits are unacceptable for high-speed data messages and, therefore, the quality of a tactical multichannel communications link must be superior to successfully transmit or receive SCP when interfaced with AUTODIN. Unless the recommended improvements are made, it is questionable whether SCP can be successfully transmitted via tactical systems.

A partial solution to the other limitation identified above is in the process of being accomplished. Data termination capability is not yet available at divisional TCC; however, an AUTODIN interface capability will soon be available in the Decentralized Automated Service Support System (DAS3). The DAS3 computers are being provided to divisional and nondivisional units as replacements for the IBM 360s and NCR 500 computer systems respectively. The AUTODIN interface will provide the DDC with the capability to receive SCP for the DAS3 supported Combat Service Support BFA directly from the USACSC software support center. Also eliminated will be the DPI/TCC interface problems previously identified.

An area in which the capability to transmit data messages in a tactical environment has already been improved is the automatic message switching capability. As a tactical interface with AUTODIN, the Army has developed and is in the process of fielding the AN/TYC-39 Message Switch (MS). The

MS operates on the same store and forward principle as AUTODIN and, therefore, provides the same automatic distribution capability for multiple addressed SCP in the tactical arena as in the fixed station environment. With the exception of the capability being provided to the DAS3 computers, the major limitation to the use of the MS for SCP distribution is the lack of data termination equipment currently available at division level.

Other study efforts to improve the capability to transmit data as input/output (I/O) from tactical computer systems has involved the use of Army tactical FM radios. One such study placed emphasis on improvement considerations for the AN/VRC-12 and the AN/PRC-77 radio sets.[5] The Maneuver Control System (MCS) is an example of how those tactical FM radios can be successfully employed to transmit data through a TCS and TCT interface. To date, no attempt has been made to transmit an SCP employing FM communications.

While there has been considerable thought and effort expended to develop the capability to rapidly distribute SCP for batch processed business-type systems operated on the DAS3, a comparable effort has not been given to developing the capability for real-time command and control systems. Unfortunately, it is the real-time BAS systems that the field commanders will rely on during time of war. It is on the real-time systems, therefore, where the effort should be placed.

## ENDNOTES

[1]Personal experiences of the author while assigned to the Executive Software Directorate, USACSC, during 1979-82.

[2]Edward Lieblien and Edith W. Martin, "MCF Part V: Software for Embedded Computers", Military Electronics/Countermeasures, Vol. 5, No. 7 (July 1979), p. 48.

[3]Department of the Army, Post-Deployment Software Support (PDSS) Concept Plan for Battlefield Automated Systems (Washington, D.C., May 1980), pp. 3-23, 3-24.

[4]George A. Simpson, Data Communications Over Tactical Multichannel Links (MITRE Corporation, McLean, Virginia, October 1981), p. 77.

[5]Michael S. Frankel et al., A Study to Determine the Feasibility of Improving the Data Distribution Capability of Army VHF/FM Radios, (SRI International, Menlo Park, California, May 1981), p. 3.

## CHAPTER V

## CONCLUSIONS AND RECOMMENDATIONS

### GENERAL

From the outset, the designed purpose of this study "...is to investigate the feasibility of developing a standard means for the rapid distribution of urgent software changes to all divisional and non-divisional computer systems in tactical units located in OCONUS Theaters. The development and subsequent adherence to standard procedures should ultimately minimize the degradation of command and control due to software failures." Unfortunately, even the need for a standard means for distributing SCP is doubtful in the minds of some members of the Army ADP community.

While conducting the research for this study, the author came in contact with some Army ADP personnel who expressed misgivings about the requirement to rapidly distribute software changes to the field. The sentiment was that software problems can be averted by thoroughly testing new software versions prior to fielding. These same people did, however, admit that the present mailing and hand carrying procedures employed during peacetime would be inadequate during war. Queries about plans to meet wartime contingencies invariably met with a negative response. Therefore, if readers of this study are skeptical about the need to have a standard Army-wide SCP distribution procedure, they need only to ask, "What are the alternatives?"

Undoubtedly, many administrative and technical problems will be experienced while establishing a standard procedure. Administratively, plans will have to be developed by the PDSS centers to provide the resources necessary to employ the means devised to meet the software support requirements. Technically, the means to provide the capability to rapidly distribute SCP must be developed. However, there is little doubt that the development of a standard means for the rapid distribution of urgent software changes to all divisional and non-divisional computer systems in tactical units located in OCONUS Theaters is feasible.

The study covered the aspects of reaffirming the need and examined the present capability to rapidly provide SCP to the field. Simple solutions were not sought and none can be provided. However, the author drew several conclusions from the research which provided the basis to present recommendations for the resolution of the problem.

## CONCLUSIONS

1. The dynamic nature of software dictates that regardless of the amount of testing, problems will arise or requirements will change that necessitate urgent software changes. The current trend to move to exceedingly more complex software increases the probability of software failures.

2. The increasing reliance on computers for command and control by field commanders requires that software changes be provided quickly lest a serious degradation in the decision making capability of the commander be experienced.

3. While the PDSS Concept Plan is a movement in the right direction, it is deficient in its failure to adequately address the SCP distribution requirements of software support.

4. The SCP Questionnaire verified that with no standard procedure available, software support throughout the Army is accomplished with a "shotgun" approach; that is, PDSS centers use the distribution method that happens to suit the project that is "hot" at the time.

5. There is an over-reliance on distributing software changes by mailing or hand carrying. Neither alternative would be an acceptable solution during time of war.

6. AUTODIN, with its current capabilities, cannot be used to electronically distribute SCP without extensive upgrading to provide the proper media interface capability. However, the use of SEES with AUTODIN transmissions does prove the capability and reliability of transmitting SCP electronically.

7. There is a major problem with the use of ROM in certain wartime systems if rapid programming changes must be made.

8. The capability to provide urgent SCP rapidly to

divisional and non-divisional BAS while tactically deployed during time of war does not exist, nor does it appear that the capability will exist in the near future unless an extensive effort to resolve the problems identified in this study is undertaken by the entire ADP community.

## RECOMMENDATIONS

The conclusions drawn from the research have led to several recommendations on how to accomplish the development of a standard software distribution procedure for adoption Army-wide.

1. The capability of AUTODIN must be expanded to provide the electronic means to distribute SCPs to all BAS in the field. Key to this requirement is providing terminal equipment and/or ADPE interfaces - similar to that currently being accomplished for the DAS3 - which allow receipt of the SCP on BAS specific medium. This expanded capability would not be limited to SCP distribution only, but would also facilitate the rapid movement of data throughout all echelons of the Army regardless of the geographical location of the unit.

2. If it is not feasible to expand AUTODIN to meet the growing data transmission requirements, a new world-wide network comparable to AUTODIN must be established to provide a means to rapidly distribute data. The network must operate employing a "store and forward" capability, rather than the

more restrictive "packet switching" design evisioned for the now cancelled AUTODIN II system. (Packet switching provides only a single addressee capability and, therefore, it would not be able to distribute data to multiple sites with a single transmission.) As with AUTODIN, the new network would be used for all data traffic, not solely restricted to SCP transmissions. Also required would be the capability to terminate transmissions at division level with multi-media capability, or possibly, a direct connection to support computers located at DS units in the division for further distribution to the battalions and/or separate companies if required.

3. A task force similar to the one established for the PDSS study should be formed to develop a viable solution to the problem. However, rather than restrict the membership to the Army ADP community, the task force should be composed of members from the communications community as well. Ultimately, the goal should be to have DOD-wide involvement.

4. To improve the quality of the tactical multichannel communications systems, the MITRE Corporation study recommendations must be vigorously pursued by the communications community. Regardless of the means chosen, the quality of the communications links in the tactical arena is the key to having the capability to electronically transmit the SCP to tactical BAS computers.

5. An effort must be made to replace the ROM used

in a variety of BAS with FPROM. Only then will the capability to provide immediate programming changes to those systems be realized. Changes to those systems could then be transmitted electrically from the PDSS center in CONUS to a support center in the OCONUS Theater.

Although this study suggests that a standard distribution procedure for adoption Army wide is feasible, only emphasis from the highest levels of the Army can result in the dedication of the resources necessary to develop the capability. Without that emphasis, the current antiquated practices of mailing or hand carrying software changes to the tactical BAS will continue to be the standard procedures for the PDSS centers. It can then be guaranteed that a catastrophic computer failure will occur in the early days of the next war, and we will be helpless to quickly resolve it.

APPENDIX

## Software Change Package Questionnaire

1. The following questions focus on how your organization currently produces and distributes software changes for the computer systems supported by you. Information in addition to that yielded by the questions and responses provided is welcome and solicited. The questionnaire was designed to be applicable to the broad spectrum of software development and design centers, and not to any one particular agency.

a. What method of distribution for software changes is used by your organization?

Mail XXXXXX

Military courier X

Commercial overnight service ____

AUTODIN XX

Other XXXX (Please explain)

Note: If more than one method is used, the above answers can be expressed as a percentage.

b. If mailed, what is the average time it takes to get to the addressee?

CONUS Addressee:
- 3-5 days X
- 6-14 days XXXX
- 15-30 days ____
- 30-90 days ____
- More than 90 days ____

OCONUS Addressee:
- 3-5 days X
- 6-14 days X
- 15-30 days XXXX
- 30-90 days ____
- More than 90 days ____

c. If sent via AUTODIN, what is the average time it takes for the addressee to receive it?

Same day __X__

1-3 days __X__

4 or more days ______

d. How often do you send changes to the field?

Monthly __1__

Semi-annually __1,2,1,2__

Annually __1,10__

Note: In answering the above question, put the average number of changes sent per system; i.e., if twice a month, enter a "2" after monthly.

e. Including all systems supported by you, what is the average number of changes sent per month? __1,1__

f. Are the problems which are being corrected by the software change considered to be:

Emergency (i.e. the system has quit functioning) __XX__

Urgent (i.e. the system is functioning, but serious problems exist) __XXXX__

Routine (i.e. changes are in response to a routine ECP) __XXXXXXX__

g. What is the organizational level your changes are sent to:

Installation __X__

Theater ______

Corps __X__

Division __XXXXX__

Battalion __XXXXX__

Company __XX__

Note: If sent to more than one organizational level, the response should be expressed as a percentage.

h. Are the systems supported by your organization operated by trained ADP operators or the functional users?

ADP operators __XX__

Functional users XXXXXXXX

i. Are software maintenance personnel available to make software changes on site?

Yes __XX__

No XXXXXX

j. If you answered no to the above question, who applies the software changes provided by you?

Operator __XX__

Contractor __XX__

Other __XX__ (Please explain)

k. What medium is used to send changes to the field?

Magnetic tape __XXXX__

Floppy disc ______

Cassette __XXX__

Cards ______

l. How are multiple copies of the changes produced for distribution to the users?

Multiple copies locally reproduced XXXXX (Adv number/system ______)

One copy sent via AUTODIN __X__ (i.e. distribution accomplished with AUTODIN)

Other __XX__ (Please explain)

m. Is any reproduction of changes accomplished at sites other than the CONUS based development and design centers?

No __XXX__

Yes XXXX (Please explain)

n. Are the responses provided for questions a through m above based on:

Developmental system(s) X

Fielded system(s) XXXXXXX

o. If the question above is answered with Developmental system(s), has a plan for the distribution of software changes been developed for the fully fielded system?

Yes X

No ____

p. If yes is the response to the above question, explain as concisely as possible how the plan differs from the responses provided for all of the above questions. None

2. The following questions focus on why your organization uses the procedures as outlined in paragraph 1 above.

a. Are the procedures used because they provide:

Quick delivery XXXXX

Error free transmittal XXXXX

Configuration Management (CM) control XXXXXXXX

Surety X

Other XXX (Please explain)

b. What are the shortcomings or inadequacies of the system presently used?

c. In your estimation, how can the system be improved?

3. Request that the name and telephone number of the individual responding to this questionnaire be provided below. For any questions concerning this questionnaire, contact MAJ W. E. Francis at AUTOVON 552-2748.

# LIST OF ABBREVIATIONS

LIST OF ABBREVIATIONS

ADP: Automatic Data Processing

ADPE: Automatic Data Processing Equipment

ADPS: Automatic Data Processing System

ADSAF: Automatic Data Systems within the Army in the Field

ASC: AUTODIN Switching Center

AUTODIN: Automatic Digital Network

BAS: Battlefield Automated Systems

BASOPS: Base Operations Informations Systems

BFA: Battlefield Functional Area

CCIS70: Command Control Information Systems 1970

CD: Combat Developer

CECOM: U.S. Army Communications-Electronics Command

CM: Configuration Management

CMT: Contact Maintenance Team

CONARC: Continental Army Command

CONUS: Continental United States

CORADCOM: U.S. Army Communications Research and Development Command

CPU: Central Processing Unit

CS3: Combat Service Support System

DAS3: Decentralized Automated Service Support System

DCA: Defense Communications Agency

DDC: Division Data Center

DOD: Department of Defense

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## D. OTHER SOURCES

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