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Combat Service Support Computer System
Advanced Experimental Demonstrations

by

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1. Introduction

This document has been prepared as a technical report on work done under project G36-633 at the Georgia Institute of Technology surrounding the development and implementation of the Combat Service Support Control System (CSSCS) and the Command and Control (C²) Database. In order to fully explore these issues, prototype CSSCS and C² Database systems were designed and implemented. Descriptions of these prototypes along with instructions for installation and operation of the prototype systems may be found in a companion report, Considerations in the Design and Development of a Combat Service Support Computer System, which was written as a technical specification for the prototype systems developed.

In the year ending in September 1985 the project group made good progress in investigating the issues surrounding the development of the Combat Service Support Control System. In these endeavors, fundamental issues such as dynamic network configuration, automatic routing, failure management, database backup and recovery, JINTACCS message processing, and network control were addressed. The year was concluded with a successful demonstration of a network incorporating the above features and a presentation of results to AIRMICS and assembled AIRMICS contractors.

The demonstration network consisted of a Honeywell DPS/6 running GCOS Mod 400, two Burroughs B26 TACCS systems running DISTRIX and XENIX, two IBM PC/AT systems running XENIX, and two ONYX computers running UNIX† System V.

The Honeywell DPS/6 is designated as the DAS3 in the ACCS network plan. The Burroughs B26 machines are beta test versions of the TACCS. The PC/AT and ONYX systems were used to simulate more TACCS systems and to provide a wider variety of hardware and software systems for testing.

The project began with the results of previous work undertaken to study the issues of communications and message passing in the environment of the CSSCS. These results were expanded upon and incorporated into the development of the prototype CSSCS system. In addition to message passing and failure detection, the prototype system addresses the issues of automatic message routing, dynamic network reconfiguration, remote node identification, network security, message generation and processing, C² database interactions, and database backup/recovery.

† UNIX is a trademark of AT&T Bell Laboratories.
The CSSCS environment is described as a loosely coupled occasionally connected network of independently operating computers. By occasionally connected, we mean that nodes in the network may come and go at will under normal operating conditions. In addition, the CSSCS environment is conducive to catastrophic node failures of network nodes. The necessity of mobility and risk of destruction are unavoidable features of the battlefield environment in which the CSSCS will operate. Node failures must be detected and handled by the system with a minimum of human intervention.

Development of the prototype system was done under the UNIX operating system. UNIX was chosen because of its wide availability in the class of small machines being considered for use by the Army as the TACCS. UNIX provides a full featured multi-tasking, multi-user environment conducive to the development of software. It is well supported in a variety of hardware environments including personal computers, minicomputers, and mainframes. The C programming language, standard on all UNIX systems, is a powerful, high level language incorporating structured programming features, flexible data structures of almost any desired level of complexity, and systems programming features for simple access to UNIX or to other processes.

Because the CSSCS environment requires real-time response to changing conditions and due to the unpredictable nature of communications in that environment, a robust, flexible, timesharing system is desirable. The UNIX operating system provides these qualities and offers a greater degree of portability among different types and sizes of machines than any other system currently available.

During the course of the project a series of Advanced Experimental Demonstrations (AED) were conducted. These are described fully in section 6. AED 1 demonstrated backup and recovery of the C² database via TACCNET. AED 2 demonstrated the C language TACCNET implementation on the Honeywell DSP/6 under GCOS. A copy of the scenario set used for the demonstrations is provided in Appendix 2.

Copies of all presentation materials developed during the project are provided in Appendix 3.

A set of data flow diagrams for the main components of the TACCNET system is provided in Appendix 4.
2. Overview

The CSSCS is intended to perform a prescribed set of functions in a designated environment. The details of these functions and the nature of this environment impose certain constraints on the system. In this section we will define the functions to be performed by the CSSCS and describe the CSSCS environment.

The CSSCS is intended to support the CSS commander on the battlefield at the corps, division, and brigade levels. The term "CSS commander" is refers to the officer responsible for managing the CSS function at any particular site. CSS is defined as the functional areas of supply, maintenance, field services, transportation, personnel, and health services found in the divisions, corps, and theater Army.

2.1. CSSCS Functions

The CSSCS is an information system for the Combat Service Support (CSS) node of the Army Command and Control System (ACCS). As such, the CSSCS will interface will the other four nodes of the ACCS as well as with other functional systems within CSS (e.g. STAMMIS). The interface to external nodes will be via JINTACCS messages, both sent and received. The interface to STAMMIS will be limited to the extraction of data which will be posted to the Command and Control (C^2) database which will be an integral part of the CSSCS.

The basic functions of the CSSCS are:

- to provide a transport and communications network for information exchange among CSS units, primarily in the form of JINTACCS messages;
- to provide a database of information for use by CSS commanders and personnel in the performance of CSS functions;
- provide decision support functions to the CSS commanders on the battlefield.

2.2. CSSCS Environment

The CSSCS will operate in the battlefield environment of the modern Army. This requires mobility and portability of all systems as well as transparency with respect to communications media. CSS units will appear as nodes in a loosely connected network capable of frequently changing topology. Nodes may join and leave the network at will as they change locations in the battlefield environment. Nodes are also subject to catastrophic failure due to enemy activity.
These elements of the environment require a network which is able to detect arrivals, departures, and failures and adjust operations accordingly.

The CSSCS must be able to detect errors in the routing or delivery of a message and reroute the message as necessary to ensure timely delivery to an appropriate CSS unit. In the event that a CSS node is rendered inoperative, it will be necessary to recover its C² database from a backup (at another node) and reconstitute the database by collecting all messages sent to the node after the backup and before the failure. It may be necessary for one CSS node to perform the function of a down node, taking its place in the network and carrying out the function of the down node until that node can be replaced.

The modern battlefield will offer a variety of communications media including existing telephone networks, microwave links, optical links, packet radio, and other more traditional media. Since it may not be possible to determine in advance the media available for CSSCS data transfer, it is desirable to have a system which is independent of communications medium. Limited bandwidth for digital communications encourages reduction of data redundancy in message formats and message redundancy in reporting systems.

The CSSCS environment places the following constraints on the CSSCS:

- restricted bandwidth for communications
- media transparent communications
- nodes join and depart the network at will
- nodes subject to catastrophic failure
- must provide distributed backup and recovery of C² databases
- must automatically route messages for timely delivery
- must detect failures and reroute messages accordingly
- messages in JINTACCS format

The system must observe these constraints and carry out its functions with a minimum of operator intervention.
3. Design Issues

The design issues involved in the development of the TACCNET system are discussed fully in the technical specification and will not be repeated here. We will, however, highlight the major design decisions made in the course of the system development. The design issues to be discussed in this section are those which impact the system at the top level. These decisions had a major impact on the nature of the software developed and on its functionality.

3.1. Network Topology

The Army is organized in a hierarchical fashion with responsibilities distributed among various internal organizations. These organizations are related through the chain of command in a formally defined hierarchical manner. The organizations within CSS which use the CSSCS will have a defined hierarchy, and it is reasonable to assume that their reporting and communications will observe this hierarchy. For our purposes, communications will be in the form of JINTACCS messages transmitted among CSSCS nodes.

3.1.1. Connectivity

Two types of networks are possible: a fully connected network in which any node can contact any other node as needed, or a polled network in which some nodes are only contacted by other nodes at specified intervals. The TACCNET prototype is a fully connected system. This choice was made to insure that important messages of high priority would not have to wait for a higher-echelon node to call in order to be transmitted and processed. In the prototype, nodes call one another whenever they have messages to deliver. They first check to be sure that a conversation with the desired system is not already in progress. Priority messages get fastest possible service, preempting routine messages or conversations if necessary. In a polled system, messages would have to wait (half the polling interval, on the average) for the next call from the master system regardless of priority.

The cost of a fully connected system is redundancy of capability, increased system complexity, greater overhead in communications, and increased usage of communications bandwidth. A polled system would tend to cut down the number of calls and increase the size of the transmissions as larger batches of messages would accumulate between contacts. The cost is mainly in the area of increased delay in propagating information through the system. In the battle field environment, timeliness of information can often be critical. There is also the matter of deciding who polls whom, how often to call, and how to handle high priority messages. It is possible to envision a compromise, where some nodes are polled and others communicate at will. This type of system could take advantage of the inherent hierarchical relationships between superior and
subordinate elements within CSS.

Store and forward message passing could be used to allow nodes which do not
know how to contact each other directly to communicate through intermediate
nodes. A modified "post office" scheme can be used to handle messages for
unknown destinations - they are passed on to a designated node which may
know how to deliver them (or may pass them on to another designated node,
and so on). This would allow nodes to restrict their database of network con-
tacts to those needed for routine operations.

3.1.2. Priority Message Handling

During the development of TACCNET we were unable to find information
detailing the exact messages used within CSS and the frequencies of transmis-
sion of those messages. We did encounter some documentation which indi-
cated that there would be response time criteria associated with some JIN-
TACCS messages. The expected response times ranged from less than one
minute to over a week. This implies a need for different classes of service for
messages with different response time requirements. It is also reasonable to
expect that there will be messages of different priorities (flash, immediate,
secret, etc.) requiring different levels of service.

The question then arises: what types of special services are required for these
types of messages? We may expect, at least, that there will be a requirement
for immediate or fastest possible delivery and processing. There may also be a
need for immediate reply while the sending node remains on the line waiting.
Processing of database queries could be stratified to provide immediate service
for queries at top priority levels. Ports and connections which are busy with
routine transmissions may be preempted for priority transmissions. The incor-
poration of these capabilities complicates the system and can introduce the pos-
sibility of deadlocks or race conditions as processes of different priority compete
for resources.

There is also the matter of node failures. What is to be done when there is a
priority message for a site that cannot be contacted? Should the message be
immediately rerouted to a designated backup node for prompt action? Does
the type of message affect the action to be taken? If so, a knowledge base for
the messages will be required for the system to determine the correct action for
each type of message and each priority level. Obviously, this can become quite
a serious consideration in the design of the system. The bottom line is that the
system should give fastest possible service to important messages; preferably
without degrading the performance of the network with respect to routine
traffic.
The TACCNET prototype provides preemptive service for priority messages, inserting them into active conversation streams where possible, preempting routine transmission if necessary, and scheduling calls and resources to give fastest possible service to priority messages. Only two levels of messages are recognized: priority messages and routine messages. Priority messages get fastest possible service while routine messages are served on a first-come-first-served basis. In a fielded system there will probably be a need for more different levels of priority, but we do not know at this time how many or what types of service they would require.

3.1.3. Alternate Sites

In the event that a node is down and cannot be reached, what is to be done with messages for that node? Some messages are routine reports and can wait until the site returns to action and calls for them, but others (especially priority messages) may require fast or even immediate action. With this in mind, the TACCNET prototype uses a table of designated alternate sites for each node in the network to re-route messages targeted for inactive sites. The method used is to keep a list of sites which can take over the processing of important messages during the node's absence. The list is traversed in order; if the first alternate site is also unavailable, the next one on the list is tried. Courtesy copies of all message sent to alternate sites should be kept and delivered to the original destination site once it has returned to operation.

This method implies a hierarchy of alternate sites in case of failure. This is consistent with the organization of CSS and the military chain of command. Without more information on the internal operation of CSS and the usage of JINTACCS messages for CSS functions we cannot determine what the hierarchy (and therefore the ordering of alternate sites) should be. There is also the question of how many alternate sites to put on the list. Should the chain stop at some point or should it continue all the way up the CSS chain of command. What is to be done with a message when no alternate sites are available?

3.2. Routing

We have already discussed the issues surrounding the topology of a CSSCS network. Regardless of the type of network proposed, it must be able to route message efficiently and automatically through the network. The user should be relieved of the details of selecting a path and should only need to know the desired destination of his message. In the case of routine or automated reports and queries, the system should keep track of message origins and destinations, leaving the operator responsible only for message composition or auditing.

Due to the dynamic nature of the CSSCS network environment, there are advantages to implementing a store and forward message passing system.
When a message cannot be delivered directly to the desired site, it can be routed through an intermediate site which may have an active link to the desired site. Messages labeled for unknown destinations could be passed on to a designated "post office" site responsible for maintaining a complete database of network nodes and addresses. New nodes or nodes returning to action could call in to the post office to register and pick up waiting mail. The post office site could then distribute the new node's address to the rest of the network.

A side effect of the store and forward capability is the ability to route a message through a chain of intermediate sites to a final destination. Message paths would be composed of a sequence of node names. This could be used to broadcast messages of general importance to related groups of nodes or to use a specific set of links so as to avoid down or unreliable links. Ordinarily the user would supply only the final destination node name and the system would choose the shortest available path to that system, probably a direct connection via dialup. The user would, however, have the ability to override the system choice and specify a particular path. Aliases could be maintained by the system for complex or lengthy paths allowing the user to send a message to a designated group of nodes without remembering all of the nodes and their order or connectivity.

The TACCNET prototype provides store and forward message passing, automated path selection with optional user override, and path aliasing. It does not provide the post office method of dealing with undeliverable messages but does provide mail holding for departed or inactive sites.

3.2.1. Message Forwarding

We have already discussed alternate sites and message passing. In a network where nodes are expected to be mobile and to enter and leave the network at random we must provide a means for forwarding messages to appropriate nodes in the event that the designated recipient cannot be reached. This means that the system must have a set of criteria for use in evaluating the state of a node in the network. These criteria will be used to decide whether a node is down, temporarily unavailable, active, or destroyed. They system must be able to automatically decide whether to hold messages and keep trying to contact the remote site or to forward the messages to another site for delivery or processing.

The system must monitor the state of each node and take appropriate actions to maintain connectivity and continued operability. This may require the automatic rerouting of messages to insure prompt processing. It may require generation and maintenance of courtesy copies of messages for bypassed nodes so that they may be brought up to date when they return to action. It may require special handling of priority messages for down nodes when it is not
acceptable to wait through the retry process.

The TACCNET prototype provides the capability to determine the state of a site and to automatically route messages around a down site while keeping courtesy copies of all messages for bypassed sites. The courtesy copies are delivered when the site is successfully contacted and the site is restored to active status. The system keeps track of the current state of each node and keeps a record of the last successful contact as well as the number of failed attempts to contact a down site. Sites are declared to be down when the number of failed contact attempts exceeds a user determined threshold.

3.3. Failure Management

The discussion of message rerouting brings up the topic of link failure. There are different classes of failures which the system must be able to recognize and handle. The system may be limited in its ability to recognize some types of failures by the limitations of the communications equipment. In any event, the system must be smart enough to distinguish between local failures (e.g., can't dial out) and remote failures (e.g., no answer or no login at remote modem).

3.3.1. Classes of Failures

The first class of failure is the local failure. This includes conditions such as no available ports, no response from local modem, modem unable to dial out, and inactive phone line. These conditions indicate local hardware or system problems and should not count against the remote site's connection history. They should not be considered when trying to determine whether a remote site is up or down. The proper response to these conditions will usually be to notify the operator and wait for correction of the situation. The incident should be logged automatically so that patterns of performance may be analyzed.

The second class of failure is the remote failure. This includes no answer from remote modem, busy signal, no carrier, no login prompt from remote system, and login or startup failure. These conditions span a range of problems from malfunctioning hardware to invalid login id or password. When the remote system answers the phone but does not allow login and synchronization we know that the site is operational and not destroyed. The correct action may be to keep calling or to change the login id or password for that system. When there is no answer to the call, the site may be down or destroyed and the messages may need to be rerouted. If there was a busy signal, it may be sufficient to wait

† For example: the D. C. Hayes Smartmodem employed in the TACCNET prototype does not distinguish between the "busy signal" and the "no answer" condition. The Cermetek Infomate does.
a while and call back. If the call is answered but there is no carrier, there may be a problem with the modems (possible hardware incompatibility). In each case, a note must be kept in a log file describing the result of the attempted call and the possible cause of failure.

The third class of failure is the transmission interruption. This includes link failure during transmission, cancellation of transmission, and preemption for priority messages. These types of failures do not usually indicate that the site has gone down. It will usually be sufficient to retry the connection after a short delay and continue transmission at the point of interruption. If the remote site has in fact gone down, the failure will be detected and handled as a class 2 failure as described above.

The TACCNET prototype detects and handle each of these classes of failures. Because of certain hardware limitations, it does not have the desired degree of resolution for class 2 failure diagnosis. It does recognize login and startup failures as well as transmission interruptions. Log files are maintained for each site showing the history of contacts and messages transferred. A system table is kept for the sites to monitor site status and contact times. Another table is used to monitor local port activity.

3.4. \( C^2 \) Database Backup and Recovery

Since the CSS environment can be volatile and nodes may be destroyed, it is desirable to build into the network the capability to back up and restore important information. Examples of such information include network configuration tables and the unit commander's \( C^2 \) database. This requires the designation of backup sites for each node. These need not necessarily be the same as the alternate processing sites for the node, but that would be a logical choice.

To increase the possibility of being able to recover a lost site's information, the database should be backed up on more than one remote site, each at a different location. The system designer must decide how many backup sites to allow or provide and how to insure that they are kept current. Another issue is frequency of backups: how often do we take a snapshot of the data for backup?

When the failure occurs and recovery is desired, how will it be initiated? A message may be sent to one of the backup sites to request an upload of the last database backup. It will be important to know and validate the time of that backup. It will probably be desirable to request retransmission of any messages sent to the destroyed node after the date of the last backup. The method for requesting these retransmissions must not flood the network with redundant messages, but must make sure that all relevant information is obtained. It may be possible to avoid retransmission of old messages by restoring a snapshot.
backup and updating it from a higher level node.

3.5. Node Emulation

The TACCNET prototype system provides the capability to run more than one copy of the system on a single physical machine. This allows a node to perform the functions of a down or departed node in addition to its own work. Other nodes in the network do not need to know that the down node is being emulated.

All that is required to set up an emulated node is to create a root directory for TACCNET to use to handle the emulated node's work, disseminate the new phone number for the emulated node, adjust the site tables of the local and emulated node to show that they are in fact resident on a single machine, and invoke TACCNET in the new root directory.

This capability can be used to maintain a logical configuration even when network nodes are destroyed.
4. TACCNET Prototype Features

The TACCNET system is fully described in the technical specification referenced earlier and we will not attempt to repeat that description here. In this section we will highlight the principal features of the prototype CSSCS and provide a general overview of the system and its capabilities.

4.1. Heterogeneous Communications

The system provides media transparent communications between machines of different types and sizes, requiring only that the TACCNET software be present on each machine. The TACCNET system will run on any machine which can run the UNIX operating system. This encompasses a broad range of hardware classes including personal computers, microcomputers, minicomputers, and mainframes. The TACCNET system has run on the following machines: ONYX, IBM PC/XT, IBM PC/AT, Burroughs B26 (TACCS), ATT 3B2, DEC VAX 11/780, Honeywell DPS/6. The system normally operates at 1200 bps over voice grade phone lines, but will operate over other media at any speed. The system is completely automated and uses auto-dial, auto-answer modems.

4.2. Binary data transfer

The TACCNET system transfers a file exactly as it is stored. Full 8-bit binary data transfer is assured by the protocol. In tests the system has been used to transfer executable programs between machines for remote execution.

4.3. Error detection and recovery

The system uses a 16 bit checksum to detect errors in transmission. Packets containing errors are retransmitted. Repeated errors are logged and notification is sent to the system operator.

4.4. Transaction logging and archiving

All messages passing through each node are logged and copied to an archive. Administrative operations and database transactions are also logged. If necessary, the archives can be searched and saved messages can be retransmitted. This is done when it is necessary to reconstitute the C2 database for a unit whose database has been lost.

4.5. Bidirectional on-demand links

All communication links between nodes in the TACCNET network are bidirectional. Any machine can call any other machine. There are no delays due to
polling. It is possible to configure the system so that a site is polled and does not call other sites, but the normal configuration allows full connectivity. Sites call one another whenever they have messages to transmit. If two sites call each other at the same time, the collision is detected and one of the sites will back off. A site can converse with many sites simultaneously (depending on the number of available communications lines) but only one conversation at a time is allowed between any two given sites.

4.6. Tunable parameters

The performance of the TACCNET system on a given machine depends on a number of factors, including available memory, disk space, work load, and processor type. The TACCNET system has a number of adjustable parameters which can be used to tailor a configuration to the needs or limits of a particular site. These include: message forwarding, retry delays, error detection thresholds, archiving, courtesy copies, and scanning intervals.

4.7. Broadcast messages

The system allows one site to broadcast a message to all the sites it knows about from its own site table. Such a message is the propagated throughout the network until every node has received a copy. The system has the ability to check for and reject messages which have already been received so that unnecessary transmissions are minimized. It is also possible to send copies of a message to other designated sites or to route messages through specific sites or paths in the network.

4.8. Failure detection and management

The TACCNET system is designed to operate in a failure prone environment. In fact, node failures are considered to be routine, expected events and the system will detect such failures automatically and route messages around failed nodes. The system will automatically bypass a failed node and will keep a copy of the any messages for that node to be delivered when the node returns to service. Also, the system will monitor down nodes and call them at regular intervals to attempt to regain contact. Nodes may leave the system in a more controlled manner by notifying other nodes of their departure. In that case, mail for the departed nodes will be held until they return to service. Nodes can add, change, delete, and query information in the site tables of other nodes without operator intervention.

4.9. File transfer

The basic function of the system is file transfer between machines. The system transfers JINTACCS messages in text files and can also be used to transfer any
other text, data, or programs files between machines. Files are transferred through the system by the store-and-forward method. Multi-node paths through the system and multiple recipient transfers are possible.

4.10. Electronic mail

The TACCNET system has a gateway into the UNIX electronic mail system. It can therefore be used to send mail to users or processes at other sites in the network. The use of TACCNET is transparent to the user.

4.11. Priority message scheduling

The TACCNET system is designed to allow different classes of service for messages of different priorities. For demonstration purposes, messages were assumed to belong to one of two classes: priority messages requiring fastest possible delivery, or routine messages to be delivered on a first come first served basis. The system processes all messages as received and tries to deliver them as soon as possible. Priority messages, however, can cause the delay or interruption of routine messages in order to receive fastest possible service. The system detects the arrival of priority messages and will insert them into the communications stream ahead of remaining routine messages if possible. If necessary, the system will automatically preempt a communications port from a routine transmission in order to send off a priority message.

4.12. On-line JINTACCS message dictionary

The TACCNET prototype offers a JINTACCS message composition aid based on an on-line JINTACCS message dictionary. The dictionary is contained in a set of database relations stored under the UNIFY relational database management system. The system can generate messages directly from the C2 database on command or can be used to prompt the user in sequence for the data to be formatted into a JINTACCS message. This frees the user from the task of remembering all the rules of JINTACCS.

4.13. Password security

The TACCNET features three levels of password security. First, users must supply a password at login time to gain access to a node in the system. Second, each node must supply a password whenever it logs in to another node to initiate communications. Third, each node can enable or disable access to the network administrative functions and to the C2 database server by defining the appropriate userid in the system password file.
4.14. Portability

The TACCNET software is written in the C programming language under the UNIX operating system. Great care has been taken to avoid hardware dependencies and operating system version dependent features. The system has been compiled and run under the following different operating systems: IBM PC/IX, IBM XENIX 1.0, IBM XENIX 2.0, ATT UNIX System III, ATT UNIX System Vr2, GCOS, ONYX.

4.15. JINTACCS messages to and from C^2 database

The system provides the capability to generate JINTACCS messages automatically from data contained in the prototype C^2 database. The system can also receive JINATCCS messages and used them to automatically update information the the C^2 database. The C^2 database is a collection of relations in a UNIFY relational database schema.

4.16. Automated JINTACCS message composition interface

The system provides a JINTACCS message composition interface to assist users in composing JINTACCS messages for transmission by the system. The tool uses the on-line JINTACCS message dictionary to prompt the user for the necessary data and format the data into a valid JINTACCS message. The user may view the message at any stage of the composition. Upon completion the message may be edited, transmitted, or saved in a file.

4.17. Distributed C^2 database backup and recovery

The TACCNET system provides backup and recovery functions for the C^2 database. A set of command files may be used to send a copy of the database files to other nodes in the network for storage. The stored copy may be retrieved later in the event of a system failure. Transactions occurring after the saving of the database may be recovered by broadcasting a message requesting retransmission of all messages sent to the failed site after the database backup was made. This message is propagated through the network and all relevant messages are recovered from node archives and retransmitted. These transactions are then run against the backup copy of the database and an up to date database results.

4.18. Single machine emulation of multiple nodes

A feature is provided to allow a single machine to emulate multiple nodes in the network. This is useful in the event that a node is taken down for some period of time. The network functionality can be maintained without extensive
reconfiguration until the down node returns to service. It may also be used for testing purposes. All that is requires is that the operator create a set of directories for use by the emulated system and then start a copy of the TACCNET software running in those directories.

4.19. Automated network management via messages

Network modifications are made easy through the use of network administrative messages. These special messages allow an operator at one node to obtain or modify the network configuration information at other nodes. Messages are provided to add, delete, change, and query information at remote nodes. Operators may enable or disable the processing of these messages for security reasons.

4.20. Screen oriented menu interface for user

The TACCNET system is controlled through a screen oriented menu interface on the system console. The interface provides command menus and graphic displays to show the state of the system. Windows into system log files may be opened and closed as needed. Special commands for system initiation, termination, monitoring, and maintenance are provided.

4.21. Path definitions

Operators can define special paths through the network and can assign names to these paths. These path aliases can be used for commonly used paths and destinations to save time and typing.
5. Summary of Activities

In this section the efforts and activities of the project are summarized. The term of the project was from September 1895 to May 1986, but the project was a continuation of work from a previous project, G36-610. Furthermore, work from this project was continued into project G36-655 which began in May 1986 and extends through September 1987.

5.1. September 1985

In September the project group worked to maintain and expand the TACCNET prototype system. Improved login handling and broadcast message handling were developed. Error logging and message tracking systems were improved. Other planned improvements to TACCNET included: screen editing capability for JINTACCS messages, console monitoring facilities for network observation, message display utilities for demonstrations, robust login procedures, and administrative utilities.

The Honeywell GCOS C compiler was ordered and was expected to arrive in October. Preparations were made to transfer all TACCNET source code from the IBM PC/AT to the Honeywell DPS/6. Substantial changes were expected to be required in the I/O routines due to differences between UNIX and GCOS.

Design work began for the database backup and recovery system. It was expected to involve a combination of shell scripts and C functions. Modifications to the Message Processing system were required.

5.2. October 1985

A task plan for the project was prepared and presented to AIRMICS. Work areas included UNIX/GCOS conversion of TACCNET, JINTACCS message preparation facilities, C² database backup and recovery, and TACCNET user interface development.

Design work continued on the database backup and recovery system. The system was to use a prototype C² database implemented using the UNIFY relational database management system. The system was intended to allow a CSSCS node to transmit a copy of its C² database to another node for storage and then retrieve that copy on demand without operator intervention on the remote system. All messages processed after the date of the backup would then be retransmitted upon receipt of a special broadcast message.
A TACCS computer was received by AIRMICS. It was installed and brought up under a version of UNIX called DISTRIX 1.0. Plans were made to port TACCNET to the new system as soon as possible.

An advance copy of the Honeywell GCOS C Compiler arrived but was not accompanied by any documentation. AIRMICS personnel worked on getting manuals and on expediting our order.

5.3. November 1985

Three work areas were identified: TACCNET improvements, Honeywell C conversion, and database backup and recovery. The conversion of Honeywell DPS/6 code from PASCAL to C were to begin as soon as the Honeywell DPS/6 C compiler was received and installed. The other work was begun immediately.

The planned improvements to TACCNET included: screen editing capability for JINTACCS messages, console monitoring facilities for network observation, message display utilities for demonstrations, robust login procedures, and administrative utilities. These improvements are primarily of a cosmetic nature and will improve the clarity and impact of TACCNET demonstrations.

While the DAS3 described in the CSSCS environment was not required to receive JINTACCS messages from the TACCS at that time, it was expected that that capability could be provided during the C code conversion. Some groundwork was required so that existing C code from the UNIX based TACCS environment could be transferred to the Honeywell DPS/6 and retrofitted to run under GCOS. Numerous changes were required due to the disparate nature of the GCOS and UNIX operating systems, but the interfaces and operations of the programs were designed to be the same under both systems.

An examination of DISTRIX 1.0 uncovered or confirmed numerous deficiencies which were reported. DISTRIX 2.0 was reported to fix some of the bugs. Jim Kearns worked on getting a pre-release copy for the project.

A presentation based on the final report of the previous contract (g-36-610) was given. In addition, a briefing on TACCNET was scheduled for December 18.

5.4. December 1985

Documentation for the Honeywell C compiler was received in December. Work began on transferring the UNIX-based C code for TACCNET from the PC/AT to the DPS/6. The transfer was completed without incident using
simple terminal emulation and file transfer programs. Initial attempts to compile the C code were moderately successful with most routines compiled on the first try. Some compiler differences were encountered and corrections made, resulting in the successful compilation of approximately 95% of the C code.

A problem emerged when we attempted to link the compiled code into an executable program. The linker for the C compiler contains a bug which prevents programs larger than a few Kbytes from linking. We called in to Honeywell and spoke with them about a fix. In the mean time, we began making necessary changes that we already knew about in the device dependent parts of the system.

Work proceeded on the database backup and recovery system for TACCNET. The system was designed to allow the C² database files (used by UNIFY) to be transferred via TACCNET to a designated backup site for safekeeping. The files were to be stored in a special "backup" directory on the remote machine and retrieved automatically by sending a special network administrative message.

The user was to be insulated from the actual administrative messages required to back up and recover the files by a set of shell scripts which would be invoked as command files.

The briefing scheduled for Dec. 18 was canceled and rescheduled for a later date. Bill Putnam prepared a high level presentation on TACCNET to supplement the existing technical briefing.

5.5. January 1986

The C functions and shell scripts for the database backup function were installed and tested. Code to allow the distribution and handling of TACCNET broadcast messages was in development.

Broadcast messages are those which are sent from one site to all other sites in the network. This type of message was to be used to send out requests for database recovery from archived messages. It could also be used to distribute network wide routing information.

Shinn reported progress in the development of the screen editor interface for the JINTACCS message entry system. The system used the curses screen handling package. This package is supported on almost all UNIX systems with only minor differences among the different UNIX versions.
The interface as planned would prompt the user in a screen oriented (as opposed to line oriented) manner and use the responses to build a JINTACCS format message. The user would be able to examine the message at any point in the composition process.

The GCOS system conversion proceeded slowly. An apparent bug in the GCOS device handler caused the transmission of the DEL character as a filler in spite of configuration commands that should have disabled this "feature". The low level I/O routines of the IOCONTROL module were rewritten for GCOS while the DEL problem and the C Linker problems were being investigated.

A hard disk failure on the "xenair" PC/AT XENIX system rendered that system inoperative.

The TACCS DISTRIX 2.0 system was obtained and installed. The TACCNET software was ported over to the new system. The port was accomplished without incident, and the system functioned as a regular TACCNET node. We were unable to run the UNIFY dbms system on the TACCS (different cpu). This prevented the TACCS node from running the C^2 database and participating fully in the test scenarios involving database backup and recovery. We were able to use the TACCS node as a backup site for the other nodes, however.

A meeting was held to discuss the desired content of the TACCNET Technical Specification required for Task 3. It was decided that the spec should contain a high level design description, user manual, and an installation guide for the TACCNET system.

A briefing and demonstration were scheduled for February 19.

**5.6. February 1986**

The PC/AT with the hard disk problem was repaired and reinstalled. The latest version of TACCNET was installed on the two PC/AT systems (xenics and xenair), one ONYX system (sysa), and the TACCS (taccs) DISTRIX system. The new version contained a robust login procedure, database backup system, broadcast messages, and improved error logging.

The JINTACCS message composition tool was nearing completion. It allowed the user two operate in command or editing mode and to toggle between these modes at will. Input syntax checking and a help facility were under development.
A demonstration was presented on Feb. 26. Test scenario 3 was executed successfully. This is described in the next section, Demonstrations and Presentations. A request was made for better console monitoring utilities.

We had some trouble getting customer support for the Honeywell C compiler. The questions were eventually resolved.

5.7. March 1986

Work continued on the Honeywell PASCAL to C conversion. Modification of low level I/O routines was complete and testing began. The next phase involved the conversion of directory and file handling routines. Problems with the port configuration and the modems hampered progress, but were resolved.

The C program linker for GCOS still refused to link moderate to large programs. Help from Honeywell produced a "workaround" solution which required the user to interrupt the compilation and manually edit the linker control file to set certain link parameters before restarting the link process. This allowed us to link the programs, but was a severe inconvenience and was regarded as a temporary fix.

The database backup and recovery functions were completed and tested. Coding began for the incremental database recovery from archives. A scenario was devised to demonstrate the system.

Coding for the JINTACCS message composition tool was completed. The program was debugged and some cosmetic changes were made. The program was incorporated into the TACCNET system as the primary user interface for message creation.

5.8. April 1986

Development proceeded on the message processor routines to recover JINTACCS messages from site archives. These messages were to be re-queued for transmission to a specified site for use in reconstituting that site's C^2 database. Functions for the regular backup and recovery of the C^2 database were installed and validated by testing.

A draft outline for the TACCNET technical specification was prepared.

We decided to obtain a copy of the JINTACCS handbook, which would allow us to put more messages into the system.
We acquired a Kurzweil Voice System machine which capable of voice recognition with a 1000 word vocabulary. We considered ways to incorporate this machine into the research using voice recognition software to build JINTACCS messages.

We discovered that the Honeywell DPS/6 does not allow timeouts during read operations. Some rewriting of the code was required to allow for this. Other problems related to the configuration of ports were recorded. The system required some modification of UNIX based code to handle special timeout, DEL, and BEL situations arising from GCOS limitations on asynchronous reads and writes. These changes were bracketed by "#ifdef" statements in the C code so that they are compiled only as needed.

We became aware of a software product developed by Consultant's Choice, Inc. which purported to be able to read and parse JINTACCS messages. Arrangements were made to investigate the product and evaluate its suitability for use in the CSSCS environment. A presentation by CCI representatives was held at the AIRMICS office. A decision was made to examine the system further and to solicit sources for JINTACCS message processing systems for open evaluation.

5.9. Conclusion

The term of the project was concluded with successful demonstrations of the results of Tasks 1 and 2 and with a presentation at the August 1986 Joint IPR hosted by AIRMICS. These presentations are described below.
6. Demonstrations and Presentations

Two Advanced Experimental Demonstrations (AED) and one In Process Review (IPR) were conducted during the term of the project. In this section we will describe the activities and results presented.

6.1. Advanced Experimental Demonstration 1

Advanced Experimental Demonstration 1 was the culmination of Task 1 of the work statement. This demonstration presented the results of an examination of the issues of maintaining, updating, and restoring a distributed database in the presence of communications failures and node failures in the CSSCS network.

The previously defined TACCNET prototype system was expanded to allow interaction between a prototype Command and Control (C²) database and the JINTACCS messages being passed by the system. The prototype C² database was derived from the set of messages to be used in the demonstration scenarios. The database consisted of a set of relations in a schema defined under the UNIFY relational database management system. The relations were developed by studying the JINTACCS messages and normalizing the data elements from these messages into coherent relations. As there was no information available on the content or usage of the C² database it was necessary to define the relations in an ad hoc manner. The resulting prototype database should not be considered as a fieldable system; it is merely a tool for demonstration of certain capabilities. A complete description of the C² database is given in the TACCNET technical specification document referenced above.

The TACCNET system was expanded to allow the automated generation of JINTACCS messages from the prototype C² database and the automated posting of messages to the database. Incoming JINTACCS messages were scanned and their component data elements extracted and inserted into database relations. Existing database relations were updated with the new information.

The primary focus of this task was to demonstrate the ability to maintain copies of a unit C² database at several other sites in the network and to be able to access those copies and any relevant archived messages to reconstruct the C² database in the event of a node failure. TACCNET was used to transfer and retrieve the database backup files. Broadcast messages and archive scanning were implemented to allow a node to request retransmission of all messages sent since the last backup was made. A set of shell command files were generated to allow the user to easily make backups and retrieve them from other nodes.
In the AED, a unit database was successfully backed up on two other nodes in the testbed network. The original database was then deleted and recovery was effected from a remote node. Broadcast messages were sent to other nodes resulting in retransmission of JINTACCS messages sent to the failed node after the backup date. The desired messages were automatically recovered from remote system archives and retransmitted to the local system where they were posted to the $C^2$ database. The resulting database was then shown to be the same as the original database. The backup and recovery were accomplished by the use of three commands on the local system.

Finally, the TACCNET system was expanded to allow local emulation of remote units which have failed. This allowed a unit to replace a failed unit by starting up an emulated node using the database backup from the failed unit. Broadcast messages could be sent to get any subsequent messages for the failed unit and to inform other units that the substitution had taken place. In this manner a remote node could take over the function of a failed local node and continue to answer queries and provide updates during the local node downtime. Upon reactivation, the local node could retrieve the current database from the remote node and resume activity.

6.2. Advanced Experimental Demonstration 2

Task 2 entailed the conversion of TACCNET code on the Honeywell DPS/6 from PASCAL to C. This was completed and the resulting code was shown to have greater functionality than the original. The implementation in C was taken straight from the UNIX systems. The C source code was transferred from the PC/AT running XENIX to the Honeywell GCOS system using the original TACCNET system for file transfer. The C code was then modified to allow for GCOS file system dependencies and the resulting source was compiled. The complete source for the system compiled without error almost immediately, but some bugs required additional work.

A major handicap to progress on this task was presented by the Honeywell C compiler. The compiler was very green and contained a number of bugs and design deficiencies. The problems are described in the Summary of Activities below. The deficiencies were eventually overcome by means of workaround solutions and the problems were reported to Honeywell. It is the opinion of the project staff that the Honeywell C compiler needs some serious work before it is a viable program development tool.

In the end, the TACCNET implementation on the Honeywell was completed and the system was used as a node in the testbed network. Files and message were exchanged between the Honeywell and the other systems in the network. The IOCONTROL, CALLER, and GENMSG programs were implemented on the Honeywell system. This allowed the Honeywell to answer the calls from
other systems and to call other systems and initiate transfers when so com-
manded by the operator. The QMS program was not implemented on the
Honeywell since it is not expected that the DAS3 will require its capabilities.

6.3. In Process Review

In August 1986 a joint IPR for all AIRMICS contractors was hosted by AIRM-
ICS. The TACCNET project group presented four hours of briefings and
demonstrations on the project and on the TACCNET system. As a result,
TACCNET was installed on several other machines and is being used by some
other AIRMICS contractors on their projects.

The visual aids used in the IPR are provided in appendix 3 of this report.
7. TACCNET System Requirements

In this section the hardware and software requirements for the TACCNET software are defined. The system was designed and developed with portability as a major concern and should be easily ported to any machine using the UNIX operating system or one of its derivatives.

7.1. Hardware

The TACCNET software has been installed and tested on ONYX and IBM PC/AT computers. These machines were used to simulate the TACCS system. The system requires at least one 360K floppy disk and a minimum of 10 megabytes of hard disk storage. The minimum memory required to run the system is 512K bytes. The GCOS part of the system is installed on a Honeywell DPS Level 6 minicomputer.

7.2. Operating Systems

All software for the TACCS has been written in the C programming language and developed under the ONYX and XENIX operating systems. Each of these systems is a derivative of the UNIX operating system. The software will run without modification on any UNIX System III machine.

Software for the DAS3 has been written in C and developed under the GCOS Mod 400 operating system using the M4_CC compiler. While there are differences in implementation details between the GCOS and UNIX versions of TACCNET, the functionality at the communications and protocol level is the same. The message processing and network management levels have not been implemented in the GCOS version.

7.3. Communications Equipment

The modems employed in the development and demonstration of the prototype system are D. C. Hayes Smartmodem 1200 standalone modems. These modems are auto-dial, auto-answer, programmable asynchronous 1200 bps devices intended for use with voice grade telephone lines. The TACCNET software uses Smartmodem commands to program the modem and dial the phone, thus requiring the use of the Hayes Smartmodem on all dialout lines. Any auto-answer modem could be used for the dialin lines.

Each TACCS system must have at least one telephone line for dialin use and one line for dialout use. More lines may be allocated for each mode if available. Section 4.3 explains the configuration of phone lines for the system. The DAS3 must have one phone line for dialout use. The modem on this line must
be a Cermetek Infomate 1200 bps modem. The proper configuration of the Honeywell port is explained in section 4.3.

7.4. Software

The TACCNET prototype system provides automated database operations for a sample set of three JINTACCS messages. These messages may be generated from information stored in the prototype C² database or they may be used to update information in the database. These functions are provided by the database server program and are dependent on the presence of the UNIFY relational database management system. The dbms must be configured to include the relations defined for the C² database prototype which is described in section 4.2.4.
8. Recommendations and Conclusions

In this report we have summarized the issues encountered and work done by the project team during the development of the prototype TACCNET system for the CSSCS. Some of these considerations are general and will apply to any information and communications systems developed for use in the CSSCS environment. Others are dependent on the specific functional requirements of the proposed system. It is critical to define and describe the complete set of functions to be performed by the system so that such design considerations may be discussed and resolved before the system is built.

We also believe that the CSSCS information requirements are not yet sufficiently well defined for development of the CSSCS communications systems to begin. There seems to be little or no information available on the content and intended usage of the Command and Control Database in the CSS units. It is difficult to project communications requirements and to develop system interfaces without a good analysis of the nature of the C2 database and its role in the CSSCS.

One theme which has been present throughout our work and in this report is the importance of portability. At this time it appears likely that the CSSCS will run on a small computer using UNIX or one of its derivatives. The specific hardware and UNIX version are not yet defined. Since one of the prime features of UNIX and the C language is portability, it would be a serious mistake to write hardware or version dependent code in the development of CSSCS software. With a small amount of extra work one can develop code which is easily ported to any UNIX-derived system, regardless of the hardware chosen. The TACCNET system has been run successfully on seven different versions† of UNIX and on five different machines‡.

A number of issues remain for further investigation in this area. These are summarized in Appendix 1, "Areas for Further Investigation".

A separate document, "Considerations in the Design and Development of a Combat Service Support Computer System", has been provided as a description of the TACCNET prototype developed as part of the CSSCS AED program. This system is described to illustrate the main issues in CSSCS communications and is not to be considered as a fieldable system. It is a starting point for further development. It is not expected that the reader of this report will be

† The versions are: AT&T System Vr2; AT&T System III; IBM XENIX 1.0; SCO XENIX V; ONYX Onix V; PC/IX; DISTRIX 2.0 (and 1.0).
‡ The machines are: IBM PC/XT; IBM PC/AT; Burroughs B20; ONYX; AT&T 3b2
fully able to understand and operate the TACCNET system. It will probably be necessary to study the system source code in order to fully understand the system. The TACCNET development team at Georgia Tech will be happy to answer any questions and provide any assistance necessary.

Appendix 2 to this report contains the demonstration scenarios used in the Advanced Experimental Demonstrations presented during the project. Copies and descriptions of the JINTACCS messages used in the AEDs are provided.

Appendix 3 contains copies of viewgraphs used in a presentation about TACCNET. These will be helpful in understanding the system.

Appendix 4 contains high level data flow diagrams for the major TACCNET system components. These will aid in understanding the interactions of the TACCNET subsystems.
9. References


Appendix 1 - Areas for Further Investigation

Development of a JINTACCS Message Parser

Examine and develop a working version of a JINTACCS message grammar using a well defined subset of the ACCS COMS; Apply UNIX tools (e.g. yacc, lex) to develop a parser for messages; incorporate parser into a system which would use knowledge about the messages and their users (expert system) to aid in construction, routing, and processing of JINTACCS messages.

Analysis of DSS requirements and Applications

Identify users, sources, applications of information available in C2 database in the context of a DSS based on that database. Describe DSS<->C2DB interface.

C2 Database Analysis

Interview potential users and operators of TACCS systems (as well as other affected individuals), digest available documentation on C2DB, examine JINTACCS message set, and develop a basic description of the C2 database: its users, applications, contents, and interfaces.

TACCNET Security Analysis

Study and define security considerations in the TACCNET environment. Areas include: software protection; data security; access levels (software, hardware, and information); data transfer; encryption (information storage and transfer). Apply findings to current TACCNET software system.

Network Tracking

Interactive monitoring of network operations; compilation of statistics on message flow & usage, node interactions. Usage of such data in automatic configuration of network and individual systems. Examination of sources/destinations of messages, development of tools for network analysis and management.

Analysis of ACCS COM Usage

Identify stimulus/response patterns in usage of JINTACCS messages. Analyze and describe processing requirements and operations for automated handling of messages according to stimulus/response patterns. Develop scenarios for testing of JINTACCS message systems.
Technology Transfer and Integration

Integrate multiple related tasks and projects in the Command & Control and/or JINTACCS message processing areas into coherent prototype and demonstration systems. Develop and evaluate hardware, software, and documentation necessary for interfaces between existing and proposed systems. Support AIRMICS internal development teams in transfer of prototype systems to target environment and in development of operational systems. Application of Expert Systems, Voice Recognition, Human Factors Engineering, Intelligent Data Flow Analysis, and other advanced technologies to environment and operations of C² and JINTACCS messages.

STAMMIS extraction and the CSSCS interface

The extraction of information from STAMMIS for use in the CSSCS should be examined. Interfaces for information exchange should be developed and standardized. Transfer of information from a STAMMIS into the CSSCS prototype system via TACCNET could be demonstrated.
These scenarios are to be used in conjunction with Task 3 of Delivery Order 0018 for Contract DAAK70-73-D-0087 with the Georgia Institute of Technology. These scenarios were developed jointly by AIRMICS and the Georgia Institute of Technology. Attending the meeting were the following:

Professor A. P. Jensen, GIT
Mr. Bill Putnam, GIT
Maj(P) Thomas Rogers
Maj David R. Forinash
Maj Terry Hilderbrand
Cpt(P) Larry Frank
Dr. Jerry McCoyd

Description of task: The extensive data requirements of a command and control system will require some type of data base to store the information until it is needed for decision making or message creation. This data base must be capable of being posted automatically, answering automated queries, and responding to on-line queries. This task will require the analysis of the requirements for a C2 data base, establishment of the data base on the two TACCS computers of the CSS test-bed, and use of the data base to generate the data elements required for the messages passed in tasks 1 and 2. Messages must be received from the DAS3 system and both received from and passed to the other TACCS system. Any courtesy copies needing posting due to the TACCS being bypassed while it was non-operational shall be automatically posted to the data base. Data elements should be stored independent of message format allowing update of individual items. The demonstration performed as part of task 2 shall be rerun using these data bases as the source and destination of the messages' data elements.

Modification to task: Due to the delivery schedule of the TACCS computer systems, the two TACCS computers will be unavailable. Two Onyx C802 computer systems will be substituted for the specified TACCS systems. The specific equipment for the demonstration will be as follows:

1. Honeywell DPS6 Model 54 using GCOS400 to simulate the DAS3
2. Lnyx C802 using UNIX System III to simulate the TACCS
3. IBM PC/AT using Xenix to simulate the TACCS

Equipment Configuration: The following diagram shows the normal network routing that will be used in all scenarios. Communications links between systems will be over dial-up telephone lines without manual intervention. All connections will be computer initiated and terminated.
Test-Bed Configuration

Messages: The messages to be used in this demonstration are from the ACCS COM Message Standards. They are in JINTACCS format. The chosen messages are required to be passed at the force level (between combat service support and the other four nodes) as well as internally (as identified by the information requirements document supplied by LOGC). The force level interface will be simulated since the interim system has a remote interface. This simulation will consist of a screen display of the message in JINTACCS format (complete with slashes) that may be displayed upon demand as well as an on demand "operator readable" version that displays both the message data and identifying information (such as labels).

Message Features: (see incl 1 for message formats) The examples given are illustrative of the different types of features in the messages and are in no way exhaustive of all the features in the messages, i.e. all features are not listed in all messages, rather, new features are listed that differ from previous examples.
SO06 Casualty Information Report

The set KUNITCAS demonstrates the use of field descriptors. These descriptors are not required for machine interpretation of the data since the data is position dependent, however the descriptors do make the data human readable.

The sets KDTRGPTN, KUNITCAS, and 5KCASLTY are mandatory.

The set 5KMOSCAS is conditional. The condition that indicates whether the set is present is determined by the user and therefore the option must be given for the user to include the data or not.

The sets 5KCASLTY and 5KMOSCAS are columnar sets. This means that the fields in the set are repeatable even though the code does not indicate them as such. The first line will be the column headings. Subsequent lines will be the actual data as given by the fields in the set.

The set 5KCASLTY demonstrates a set where an arithmetic computation must be made to complete the set. The field "COUNT OF PERSONNEL" is the total of the preceding four fields. This same type of behavior is exhibited by sets 5KMOSCAS and KUNITCAS.

This message has some problems with machine interpretation. First, the set 5KMOSCAS has alternative fields without field descriptors. The fields have the same formats (5 AN) so there is no way to determine the actual MOS or SSI usage of the field. The interpretation we are giving to this is that MOS pertains only to enlisted while SSI pertains to warrant and commissioned officers. In this interpretation, the actual usage is immaterial and a unique identifier results and the information may be parsed without problem. Actual usage of these fields may be different and problems could be present that are not addressed by this demonstration. Another problem is the fact that columnar sets 5KCASLTY and 5KMOSCAS are related but there is no line-by-line key provided. A usage convention is needed to be able to cross check data values for validity. In this demonstration the data will be merely displayed and no attempt to validate the values in sets will be attempted.

SO26 POL Locations

The set 3KPOLLOC demonstrates alternative fields without field descriptors. This presents a problem in that field location has 5 alternative representations. Four of these have unique lengths that identify the format that is used. The fifth, UNIT LOCATION NAME, has a specification of 1-20 ANBS and therefore could be confused with any of the other four formats. In this demonstration, the only valid location that will be used will be the LOCATION, UTM 100-METER.

Sets 3KPOLLOC and 3KCLTHRE show columnar sets where the data entry fields in one set key the data back to the data in the previous set.

The AMPN set (page 2) in this message is conditional on the judgement of the operator that the set must be included to complete the
data.

**5034 Supply Shortages**

The set AMPN is conditional upon data entered in the previous set and therefore should be prompted for in cases where it is necessary to include the set.

**Data Bases:** Each TACCS device (look-alike) will incorporate a command and control data base. At this time there is no mandatory requirement for replication of data bases. Each data base will contain the information required by that node to conduct business (to include contingency plans such as rerouting messages).

**Scenarios:** There are three scenarios. Two scenarios are logistics oriented while the third is personnel oriented. The three scenarios could in fact be performed as one integrated scenario, however, breaking them into individual scenarios allows greater insight into the processing taking place.

**REFERENCES:**

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SCENARIO I

Scenario I uses the ACCS message S006 Casualty Information Report (CSS C2 Information Unit 130A1 PERSITREP). The force level interface documentation shows this message being transmitted to CSS by ADA, IEW, and FS. There is no requirement from MCS. The CSS C2 Information Requirements shows this message as being sent to G1, AG, and P&A by the units. These two usages are compatible.

1. The messages will originate at the DISCOM SPO. This manual origination is consistent with the interim system that uses a remote interface. Data entry is initiated through the keyboard of the TACCS. Data entry need not be in JINTACCS format.

2. The SPO places the data in its internal data base.

3. The SPO sends the message, in JINTACCS format, to the AG.

4. The AG places the data in its internal data base.

5. An on-line manual query verifies the arrival and storage of the data.
SCENARIO II

Scenario II uses the message S034 Supply Shortages. This message may be used in two ways. One way is to report status of selected supplies and the actions being taken to procure them. The other way is to request information on the status of selected supplies. The interface specifications show that this message is used across the interfaces to FS and IEW in a bidirectional mode and transmitted only to ADA. MCS has no requirement for this message. The internal usage of this message (O81A3) shows this message flowing from functional organization to FSB, DMMC, CORPS SPT GP, and COSCOM. In this scenario, the information on supply status is resident on the DAS3. The DAS3 periodically would update the command and control data base on the status of previously identified supply items. The command and control data base is resident on the DMMC TACCS. A message requesting supply status will be received by the SPO. This request for information must then be serviced.

1. Manually initiate on the DAS3 a message giving the status of selected supplies for various units.
2. Send the message to the DMMC.
3. DMMC places the information in the C2 data base.
4. SPO receives S034 Supply Shortage Request from Fire Support. This is simulated through the use of a screen display and data entry.
5. SPO forwards request to DMMC.
6. DMMC receives S034 Supply Shortage from SPO.
7. Human operator reviews S034 and makes appropriate queries of C2 data base.
8. Operator uses screen and keyboard to create return message with the desired status.
9. DMMC sends S034 message to SPO.
10. SPO, on manual request, displays message to simulate remote interface. Message should be displayed as both JINTACCS format (with all the slashes) and as human readable (a friendlier format than JINTACCS).
SCENARIO III

This scenario uses the force level message 5026 POL location (CSS C2 Information Requirement 061A1). The force level interface specification shows this as a message transmitted by CSS to all four nodes. The CSS C2 Information Requirements Document shows this as a message sent every four hours by supply companies and the POL battalion to the FSB, DMMC, and CMMC. Note: at this time it does not appear that there is a way to delete a POL location by use of a message. The scenario will assume that all POL locations, once active, will remain active. Quantities transmitted are current on-hand quantities and not changes to previous messages. Messages may be sent by 1) "pushing a button" that causes the message to be automatically formatted and sent, 2) the clock says "time to send a message" and the message is formatted and sent without operator intervention, 3) manually entering message data into a screen template, or 4) automatic response to an automated query (again without operator intervention).

1. Initially the network consists of the SPO, the DMMC, and the S&T Battalion. The FSB reaches its location and sends its message to the network to enter it into the appropriate routing tables and distribution lists.

2. S&T Battalion uses the "push a button" method to send the POL Location message to the DMMC. Data has been entered manually through on-line data base update. Location sent is for the division main fuel distribution point.

3. FSB uses screen template to format and send location of POL point to DMMC. Data is also stored in data base. Location sent is for forward fuel distribution point in the brigade area.

4. Messages are received by DMMC.

5. DMMC posts data to its data base.

6. DMMC uses clock method to formulate a consolidated list of POL locations and send to SPO and FSB.

7. SPO receives message from DMMC and posts it to its data base.

8. SPO simulates forwarding of message to MCS, IEW, ADA, and FS by displaying message on screen upon demand by operator. Message is displayed in JINTACCS format as one option and as human readable as a second option.

9. FSB receives the message from DMMC and, upon demand, displays it upon the screen.
10. FSB enters the POL location data in its data base.

11. Change the quantities of POL on hand at the division main fuel distribution point in the S&T Battalion data base using on-line update.

12. DMMC formulate on screen a request for update of POL locations using the POL Location message in a request mode.

13. Send the request message to the S&T Battalion.

14. S&T Battalion responds to DMMC automated query by automatically sending message with new locations.

15. DMMC receives the message from the S&T Battalion and changes its data base.


17. DMMC node goes down.

18. Change manually the POL location data at the S&T Battalion and the FSB.

19. S&T and FSB formulate their messages using "push a button" method and attempt to send to DMMC.

20. After determining that DMMC is down, FSB and S&T send their messages to SRO as an automatic reroute.

21. SPO receives messages.

22. SPO updates its data base.

23. SPO displays data on screen in response to on-line query by operator.

24. SPO determines that DMMC was bypassed and sends consolidated POL Location message to FSB.

25. FSB posts data to data base upon receipt.

26. FSB displays data on screen upon demand (on-line query).

27. DMMC returns to operational status.

28. FSB and S&T send courtesy copy of message to DMMC.

29. DMMC posts its data base automatically using new data.
30. On-line query verifies new data at DMMC.
INCLOSURE 1

JINTACCS MESSAGE FORMATS
MESSAGE NUMBER:  S006

TITLE: Casualty Information Report (CASSTATS)

GENERAL INSTRUCTIONS

This message reports casualty information in four categories broken down by unit total, military personnel class, and specialty skill or MOS. The four categories are KIA, WIA, MIA, and non-battle casualties.

The sets, EXER through NARR, are prepared in accordance with the message instructions for the initial main text sets.

SPECIAL INSTRUCTIONS

Set Identifier: KDTGRPTN [M].

Field 1, As of Date-Time [M]. Enter the as of date-time (day, hour, and minute) for the time of the report (DFI #C914, DUI A25).

Field 2, Report Serial Number [M]. Enter the appropriate report serial number (DFI #E487, DUI 048).

Set Identifier: KUNITCAS [M]. This set is used to report a unit's total number of casualties in four categories.

Field 1, Unit Identification [M]. Enter the unit identification or the transliterated unit name by unit number, organization type, and echelon level for the unit reporting casualties (DFI #E987, DUI 005) or (DFI #C095, DUI 001).

Field 2, Actual KIA [M]. Enter the field descriptor followed by the total number of unit personnel killed in action (DFI #E959, DUI 006).

Field 3, Actual WIA [M]. Enter the field descriptor followed by the total number of unit personnel wounded in action (DFI #E959, DUI 013).

Field 4, Actual MIA [M]. Enter the field descriptor followed by the total number of unit personnel missing in action (DFI #E959, DUI 014).

Field 5, Actual Non-Battle Casualties [M]. Enter the field descriptor followed by the total number of non-battle casualties for the unit (DFI #E959, DUI A04).

Field 6, Count of Personnel [M]. Enter the field descriptor followed by the total number of casualties from the entries in fields 2, 3, 4, and 5 for the unit entered in field 1 (DFI #E959, DUI 001).
MESSAGE INSTRUCTIONS

MESSAGE NUMBER: 5006

TITLE: Casualty Information Report (CASSTATS)

SPECIAL INSTRUCTIONS (Continued)

Set Identifier: 5KCASLTY [M]. This set is used to report unit casualties in four categories by military personnel class (i.e., officer, warrant officer, and enlisted) as well as the total number of casualties for each class.

Field 1, Military Personnel Class [M]. Enter the character code for the military personnel class to be reported (DFI #E168, DUI 001).

Field 2, Actual KIA [M]. Enter the number of personnel killed in action for the personnel class entered in field 1 (DFI #E959, DUI 006).

Field 3, Actual WIA [M]. Enter the number of personnel wounded in action for the personnel class entered in field 1 (DFI #E959, DUI 013).

Field 4, Actual MIA [M]. Enter the number of personnel missing in action for the personnel class entered in field 1 (DFI #E959, DUI 014).

Field 5, Actual Non-Battle Casualties [M]. Enter the number of non-battle casualties for the personnel class entered in field 1 (DFI #E959, DUI A01).

Field 6, Count of Personnel [M]. Enter the total number of casualties from the entries in fields 2, 3, 4, and 5 for the personnel class entered in field 1 (DFI #E959, DUI 001).

Set Identifier: 5KMOSCAS [C]. This set is mandatory if the casualties reported are to be further classified by specialty skill identifier/military occupational skill code.

Field 1, Specialty Skill Identifier: [M]. Enter the appropriate specialty skill identifier (DFI #E4027, DUI A02).

OR

Military Occupational Specialty. Enter the desired military occupational specialty code (DFI #E4027, DUI A01).

Field 2, Actual KIA [M]. Enter the number of personnel killed in action for the code entered in field 1 (DFI #E959, DUI 006).
MESSAGE NUMBER:  5006

TITLE: Casualty Information Report (CASSTATS)

SPECIAL INSTRUCTIONS (Continued)

Set Identifier: 5KMOSCAS [C]. (Continued)

Field 3, Actual WIA [M]. Enter the number of personnel wounded in action for the code entered in field 1 (DFI #E959, DUI 013).

Field 4, Actual MIA [M]. Enter the number of personnel missing in action for the code entered in field 1 (DFI #E959, DUI 014).

Field 5, Actual Non-Battle Casualties [M]. Enter the number of non-battle casualties for the code entered in field 1 (DFI #E959, DUI A01).

Field 6, Count of Personnel [M]. Enter the total number of casualties from the entries in fields 2, 3, 4, and 5 for the code entered in field 1 (DFI #E959, DUI 001).

Set Identifier: RMKS [O]. This set is used for any additional required information.

Set Identifier: DWNGRADE [C]. This set is mandatory when the message is classified.

Field 1, Downgrading and Declassification Markings [M]. Enter the appropriate downgrading and declassification markings if the message is classified (DFI #E679, DUI 001).
MESSAGE CONTENT

MESSAGE NUMBER: S006  PAGE 1 OF 2

TITLE: CASUALTY INFORMATION REPORT (CASSTATS)

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**MESSAGE CONTENT**

**MESSAGE NUMBER:** S006  
**PAGE 1 OF 2**

**TITLE:** CASUALTY INFORMATION REPORT (CASSTATS)

**PURPOSE:** TO REPORT CASUALTY INFORMATION IN FOUR CATEGORIES BROKEN DOWN BY UNIT TOTAL, MILITARY PERSONNEL CLASS, AND SPECIALTY SKILL OR MOS. THE FOUR CATEGORIES ARE KIA, WIA, MIA, AND NON-BATTLE CASUALTIES.

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TITLE: CASUALTY INFORMATION REPORT (CASSTATS)

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MESSAGE MAP

MESSAGE NUMBER: 5006

TITLE: CASUALTY INFORMATION REPORT (CASSTATS)

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OPER/xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

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/xxxxxxxxxxxxxxxxxxxxx/

2
/xxxxxxxxxxxxxxxxxxxxx/

3

MSG10/CASSTATS/xxxxxxxxxxxxxxxxxxxxx/nnnnnnnn/aaa/aaa/nnn/

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NNNNNNNN
AXXNN

REF/A/xxxxxxxxxxxxxxxxxxxxx/xxxxxxxxxxxxxxxxxxxxx/nnnnnnabaaanh/nnnnnn

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AMPH/
NARR/
**MESSAGE CONTENT**

**MESSAGE NUMBER:** S006

**TITLE:** CASUALTY INFORMATION REPORT (CASSTATS)

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**RMKS**

**DWNGRADE**

**JUNE 1984**

**ACCS-A3-500-003**
MESSAGE MAP

MESSAGE NUMBER: 5006

TITLE: CASUALTY INFORMATION REPORT

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  1       2       3       4
XXXXXXXXXXXXXXXXXXXXXXXX
XXXXXXXXXXXXXXXXXXXXXXXX
/ACTHBC:NNNX/CTPERS:NNNX/
  5       6
5KCASLY
/HILPERCL ACTKIA ACTWIA ACTMIA ACTHBC CTPERS
/A    NNNX NNNX NNNX NNNX NNNX NNNX//
  1    2    3    4    5    6
5XKOSCAS
/SS1-MOS ACTKIA ACTWIA ACTMIA ACTHBC CTPERS
/HHAXX NNNX NNNX NNNX NNNX NNNX NNNX//
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HHAXX
HHAXX
RMKS/
OUNGRADE/AAAXXXXXXXXXXXXXXXXXXXXX//
MESSAGE EXAMPLE

MESSAGE NUMBER: S006

TITLE: Casualty Information Report (CASSTATS)

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MSGID/CASSTATS/8 INF BN/
KDTGRPTN/180700/N01808/

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MESSAGE NUMBER: 5034

TITLE: Supply Shortages (SHORTSUP)

GENERAL INSTRUCTIONS

This message is used to report the identification of supplies which because of their shortage could affect the effectiveness of a unit. It can be used by both using units and logistics activities. Using units would report supply shortages to their supporting logistics activity. Logistics activities could also use this format to report critical shortages to command and higher level logistics activities.

The AMPN set can be related to individual items in the 6KSHTSUP set through correlation with the CMNT field. Special comments related to individual items can be conveyed in the AMPN set.

The sets, EXER through NARR, are prepared in accordance with the message instructions for the initial main text sets.

SPECIAL INSTRUCTIONS

Set Identifier: DTGM [M].

Field 1, As of Date-Time [M]. Enter the date-time (date, hour, and minute) of the effective time of the report (DFI #C914, DUI A25).

Set Identifier: UNITIDM [M].

Field 1, Unit Designator: [M]. Enter the unit designator of the unit making the report using either (DFI #C095, DUI 001) or (DFI #E987, DUI 005).

Set Identifier: 6KSHTSUP [M].

Field 1, Logistical Support Item [M]. Enter the logistical support item in short supply (DFI #C460, DUI 001).

Field 2, Report Comment [O]. This field is used to designate if the specific item is on requisition, to provide the requisition document number, and to identify a specific item for reference in the following AMPN set. Enter "A2" if the item is not on requisition. Enter "A1" if the item is on requisition. The requisition document number may be added immediately following the A1 entry (DFI #E150, DUI 022).
MESSAGE NUMBER: S034

TITLE: Supply Shortages (SHORTSUP)

SPECIAL INSTRUCTIONS (Continued)

Set Identifier: AMPN [C]. This set is mandatory if entries are made in the report comment field of set 6KSHTSUP. Enter free text explanation of entry made in report comment field of set 6KSHTSUP.

Set Identifier: RMKS [O]. This set is used for any additional required information.

Set Identifier: DWNGRADE [C]. This set is mandatory when the message is classified.

Field 1, Downgrading and Declassification Markings [M]. Enter the appropriate downgrading and declassification markings if the message is classified (DFI #E679, DUI 001).
MESSAGE CONTENT

MESSAGE NUMBER: 5034

TITLE: SUPPLY SHORTAGE (SHORTSUP)

PURPOSE: TO IDENTIFY SUPPLIES WHICH BECAUSE OF THEIR SHORTAGE COULD AFFECT THE COMBAT EFFECTIVENESS OF A UNIT.

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MESSAGE EXAMPLE

MESSAGE NUMBER: 5034

TITLE: Supply Shortages (SHCRTSUP)

UNCLAS
EXER/LOG RED 88/
MSGID/SHORTSUP/2BDE19ARDIV/2007004/
DTGM/200600/
UNITIDM/2BDE19ARDIV/
6KSHTSUP
/MAT-EQUIP-VEH CMNT
/20 ECH LWHEL M35A2 A18152-006
/12 ECH TANK M1 A2
/190 CSE MISC RATIONS A2A
/5K GAL FUEL DSL A2
/54 ECH LTMG M60 A2
/30 ECH MISC LITTER A18157-003/

AMPN/A1 DENOTES ITEM ON REQUISITION, NUMBER FOLLOWING A1 IS REQUISITION DOCUMENT NUMBER. A2 DENOTES ITEM NOT ON REQUISITION. ITEM 8152-006 URGENTLY REQUIRED FOR RESUPPLY VEHICLES TO FORWARD DEPLOYED UNITS. ITEM A2A IS MCI//
MESSAGE NUMBER: S026

TITLE: POL Locations (POLLOC)

GENERAL INSTRUCTIONS

The POL Locations message is used to announce the location, capabilities, and availability of Class III items. Actual quantities of fuel, oil, and lubricants are reported in set 3KCLTHRE. The servicing capability and other type of Class III items available at the specific CL III point are reported in the AMPN set.

The sets, EXER through NARR, are prepared in accordance with the message instructions for the initial main text sets.

SPECIAL INSTRUCTIONS

Set Identifier: DTGM [M].

Field 1, As of Date-Time [M]. Enter the as of time (date, hour, and minute) of the report (DFI #C914, DUI A25).

Set Identifier: 3KPOLLOC [M].

Field 1, Data Entry [M]. Enter the data entry number (DFI #E082, DUI 001).

Field 2, Point Name [M]. Enter the code name for the specific CL III point (DFI #E468, DUI 004).

Field 3, Location [M]. Enter the location of the specific CL III point using one of the following:

- Location, Seconds (DFI #C011, DUI 043)
- Location, UTM 10-Meter (DFI #C012, DUI 005)
- Location, Minutes (DFI #C469, DUI 011)
- Unit Location, Name (DFI #E500, DUI 043)
- Location, UTM 100-Meter (DFI #C542, DUI 012).

Set Identifier: 3KCLTHRE [M].

Field 1, Data Entry [M]. Enter the data entry number from set 3KPOLLOC which identifies the appropriate Class III point (DFI #E082, DUI 001).

Field 2, Fuel Quantity and Type [M]. Enter the quantity, unit of measurement, and fuel type on hand at the time of the report (DFI #C4007, DUI A01).
MESSAGE NUMBER: S026

TITLE: POL Locations (POLLOC)

SPECIAL INSTRUCTIONS (Continued)

Set Identifier: 3KCLTHRE [M]. (Continued)

Field 3, Oil Quantity and Type [M]. Enter the quantity, unit of measurement, and oil type on hand at the time of the report (DFI #C4032, DUI A01).

Field 4, Lubricant Quantity and Type [M]. Enter the quantity, unit of measurement, and lubricant type on hand at the time of the report (DFI #C4033, DUI A01).

Field 5, 3KCLTHRE Comments [0]. Enter any pertinent comments about the POL point in the space provided, or if more space is required, include a reference note or number and expand in the AMPN set below (DFI #E150, DUI A01).

Set Identifier: AMPN [C]. This set is mandatory if reporting additional information pertaining to set 3KCLTHRE. Information on additional type of Class III items available and POL servicing capability should be reported in this set.

Set Identifier: RMKS [O]. This set is used for any additional required information.

Set Identifier: DWNGRADE [C]. This set is mandatory when the message is classified.

Field 1, Downgrading and Declassification Markings [M]. Enter the appropriate downgrading and declassification markings if the message is classified (DFI #E679, DUI 001).
MESSAGE NUMBER: 5026

TITLE: POL LOCATIONS (POLLOC)

PURPOSE: TO ANNOUNCE THE LOCATION AND CAPABILITIES OF POL POINTS TO PROVIDE RESUPPLY.

<table>
<thead>
<tr>
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<th>FIELD</th>
<th>MANDATORY ENTRY/FLD DESC/COL HEADER</th>
<th>FIELD NAME</th>
<th>START COL</th>
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**MESSAGE NUMBER:** 5026

**TITLE:** POL LOCATIONS (POLLOC)

```
1234567890123456789012345678901234567890123456789
DTGM/HHHHHH//

3KPOLLOC
/DE PTNAME
/NN XXXXXXXXXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXXXXXXX//
  1 2

3KCLTHRE
/DE FUEL-QTY-TYP OIL-QTY-TYP LUB-QTY-TYP CMTS
/NN XXXXXXXXX XXXXXXXXXXXXX XXXXXXXXXXXXXXX XXXXXXXXXXXXXXXXX//
  1 2 3 4 5

AMPN/
RMKS/
DHWNGRADE/AAAXXXXXXXXXXXXXXXXXXXX//
```
MESSAGE EXAMPLE

MESSAGE NUMBER: 5026

TITLE: POL Locations (POLLOC)

CONFIDENTIAL**

EXER/DESERT GALE 88//
MSGID/POLLOC/9SPTCMD/1911825//
DTGM/240600//
3KPOLLOC
/DE PTNAME LOCATION
/01 PIPE END 3 62RST12345678
/02 BLUE STAR 62RST56781234//
3KCLTHRE
/DE FUEL-QTY-TYP OIL-QTY-TYP LUB-QTY-TYP CMTS
/01 25000GALMGS 550GALSAE40 200LBOG90 NOTE 1
/- 50000GALDSL 40BBLSAE10 - -
/02 50000GALDSL 100GALSAE40 - NOTE 2//
AMPN/(NOTE 1) 400 GALSGF AVAILABLE, CL III PT CAPABLE OF SERVICING 2 TANKERS AT THE SAME TIME. (NOTE 2) 2000STCOAL AVAILABLE IN 100LB SACKS, PT CAPABLE OF SERVICING 3 TANKERS AT THE SAME TIME, MGS EXPECTED TO BE AVAILABLE 241200//
DOWNGRADE/DECL 24 NOV 90//

** Information on this page is UNCLASSIFIED. Classification is shown for example purposes only.
Appendix 2 - TACCNET Demonstration Scenarios

The following pages contain the demonstration scenarios used for the Advanced Experimental Demonstrations presented during the project. These scenarios were developed jointly by AIRMICS and Georgia Tech personnel and are intended to be representative of actual field operations which might be performed by the CSSCS units.
Appendix 3 - TACCNET Presentation Materials

The following pages contain copies of the visual aids and presentation materials developed for the IPR and other presentations during the project.
CSSCS Advanced Experimental Demonstrations

1983 - 1986

Development of a Tactical Army Command and Control Network

(TACCNET)
Objectives:

To examine issues related to information transfer among loosely-coupled, occasionally connected, heterogeneous, asynchronous networks of networks.

To develop a prototype Combat Service Support Computer System and a prototype Command and Control Database to be used in the exploration of CSS information processing requirements.
Approach

Iterative Refinement

- Develop expertise
- Design and build prototype
- Demonstrate capabilities
- Examine and refine

Experimental Demonstrations

- Advanced Experimental Demonstration (AED)
- Demonstrate capabilities
- Highlight issues
- Incorporate previous work
- Provide recommendations for future work

End Product

- Working, portable, full-featured prototype
- Documentation of issues and concerns
- Specification for interim, fieldable system
Accomplishments

- Information transfer among network of widely differing machines (S/1, CDC, IBM 4300, Vax/Unix, PC) over a variety of links (3780, BISYNC, asynchronous dialup, token ring)

- Prototype TACCNET using PC/Unix and Honeywell/GCOS featuring automated routing, failure detection, and rerouting

- Extended TACCNET featuring database backup and recovery, file transfer, message processing, and screen-oriented user interface

- C² Database with automated JINTACCS interface

- JINTACCS screen-oriented, automated composition tool

- Source-level system portability

- Simulation of CSSCS network (SLAM)
Overview of Research

1983 - 1984
Heterogeneous communications
Low-speed asynchronous networks
Routing and identification

1984 - 1985
Development of TACCNET
Failure detection and management
Automatic routing
$C^2$ database analysis

1985 - 1986
Expansion of TACCNET
JINTACCS message composition
$C^2$ database interface
Database backup and recovery
User interface
Overview of Research

1986 - ?

JINTACCS message processing

- Analysis of interface between JINTACCS messages and C² database
- Functional model of JINTACCS messages
- Development of JINTACCS grammar or definition language
- Development of a generic JINTACCS message handler (parser?)
- JINTACCS message composition aid expansion to include editing capabilities
1983 - 1984

System Features

- Terminal on one system acts as a console on another system
- Files may be transferred between systems
- Asynchronous communication links
- Three or more machines in network (3 Series/1’s, 1 CDC Cyber)
- Positive identification of remote systems
1984 - 1985

System Features

- On-demand communications via asynchronous links
- Bidirectional communications
- Error-detecting and error-correcting packet-oriented protocol
- Failure detection and rerouting
- Queue-oriented message processing
- Positive identification of remote systems
Plans

- Finalize and document TACCNET prototype

- Explore JINTACCS message processing issues
  - JINTACCS grammar or definition language
  - Functional definition of messages
  - Message processing tools

- Design Command and Control Database
  - Top-down design approach
  - Analysis of intended usage/user requirements
  - Determine structure and content from usage requirements
  - Interface with JINTACCS

- Convert to ADA
Status

- Completed and installed a well-defined, fully featured prototype TACCNET for CSSCS environment

- Developing detailed specification of TACCNET system design and implementation

- Beginning first year of two-year investigation of automated JINTACCS message processing
CSSCS Environment

- Nodes subject to catastrophic failures
- Nodes are physically mobile but logically static
- Frequent, expected, but unpredictable reconfiguration
- Nodes are loosely coupled and occasionally connected
- Machines are physically small (microcomputers)
- Communications links are undetermined (media transparency required)
- On-demand communication links
- Time constraints/priority messages
- Most messages in JINTACCS format
- Well-defined hierarchy of nodes
Why TACCNET?

Why not use uucp, Kermit, or other widely available data transfer systems?

- No existing product conforms to CSSCS environmental constraints (rerouting, failure management, JINTACCS message handling, time constraints, priority messages, observance of node hierarchy, etc.)
Why UNIX?

Advantages:
- Availability on many different architectures
- Portability (many machines in desired size class)
- Good environment for software development
- Convenient file structure (i.e., directories as queues)
- Process control and inter-process communication
- Multi-user, multi-tasking system
- Standard, portable high-level language (C)

Disadvantages:
- Unix is a "moving boundary"
- Not "friendly" to naive user
- Many variants in distribution
- Missing features (such as file locking)
- Security
TACCNET Capabilities and Functions

- Heterogeneous communications
  - Media transparency
  - Error-detecting protocol with retransmission
  - Logging of connections, errors, and message transfers
  - Bidirectional, on-demand links
  - Tunable parameters (i.e., speed, packet size, retry delays)
  - Remote system identification
  - Broadcast and message rejection
  - Failure detection and management

- File transfer
- Electronic mail
- JINTACCS to and from C² database
- Automated JINTACCS message composition interface
- Distributed C² database backup and recovery
- Single machine emulation of multiple nodes
- Network management functions via messages
- Dynamic network configuration
- Screen-oriented, menu-driven user interface
- Message forwarding/holding
- Store-and-forward message transfer
- Automatic routing via shortest path
Objectives:

- Pass JINTACCS messages
- Detect and handle failures
- Automatic (re)routing
- Dynamic network configuration
- Messages to and from C² database
- Database backup and recovery
- User interface
- JINTACCS message composition aids
TACCN ET

Constraints:

- Ordinary telephone lines
- 1200 bps transmission rate
- Auto-dial / auto-answer modems
- Media transparency
- TACCS/UNIX, DAS3/GCOS
TACCNET

Additional Features:

- Error detection and recovery
- Data transparency
- Binary data transfer
- Store and forward capability
- Priority message scheduling
- On-line JINTACCS message dictionary
- Password security
- File transfer
- Electronic mail
- Multiple node emulation
- Tunable system parameters
- Portability (all code written in C language)
- Menu-driven system interface
TACCNET Composition

Communications

$qms$ - scheduling
$caller$ - connections
$iocontrol$ - transmission

Message Generation and Processing

$genmsg$ - generation
$msgproc$ - processing

Database Operations

$jms$ - message composition
$server$ - messages into $C^2$ DB
$build$ - messages from $C^2$ DB

User Interface

$console$ - system administration
Communications

$qms$
- Runs in background (sleep or cron)
- Scans priority queue first, then system queues in order taken from site table
- Invokes $caller$
- Handles preemption for priority messages
Communications

caller
- Validates site information
- Establishes connection
- Handles connection failures
- Starts *iocontrol* process
- Handles transmission failures
- Releases port and system queue
- Updates site table
Communications

**iocontrol**
- Transmits / receives files
- Gets files from system queue
- Puts files into message processor queue
- Error detection / correction
- Priority preemption
- Data transparency / binary data transfer
Communications

Transmission Protocol

- Similar to BSC (Stop & Wait, Window = 1)
- Data packets / control packets
- ASCII control codes
  - DLE - Data Link Escape
  - STX - Start of Text
  - ETX - End of Text
  - ETB - End Text Block
  - EM - End of Message
  - EOT - End of Transmission
  - ACK - Acknowledge
  - NAK - Negative Acknowledge
  - CAN - Cancel
- Packets “punctuated” with CR for GCOS
Communications

Packet Formats

- Data Packets
  12 bytes for frame, text block is variable length (tunable parameter)

- Control Packets
  Always 4 bytes

Data packet format:

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<tr>
<th>packet-number</th>
<th>STX</th>
<th>text</th>
<th>DLE</th>
<th>ETB</th>
<th>checksum</th>
<th>DLE</th>
<th>EM</th>
<th>CR</th>
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Control packet format:

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<tr>
<th>control code</th>
<th>DLE</th>
<th>EM</th>
<th>CR</th>
</tr>
</thead>
</table>
Message Processing

msgproc
- All messages pass through msgproc
- Processing is based on message type
- Routing is based on message header

Diagram:
- genmsg
- build
- msgproc
- msgprocq
- caller
- iocontrol
- UNIX Mail
- server
- serverq
- sysa
- qms
Message Processing

`msgproc`

- Message file name indicates type

Format:

```
TsysnameXXXXX
```

Where:

- `T` = message type
- `sysname` = originating node
- `XXXXX` = hex timestamp

- Valid message types:
  - A - Administrative
  - C - Courtesy copy
  - E - Undeliverable
  - H - Bad header
  - M - New message
  - N - Rejected message
  - P - Priority message
  - R - Routine message
  - S - Invalid path
  - U - User mail
Message Processing

*msgproc*

- Routing based on message header
  - priority [c-flag]
  - source path
  - destination path

- Path format:
  
  site![site!site...]![user]

Where:
- site is a valid node ID;
- user is either "net.adm", "server", or a valid user on the node

- Message may have multiple headers (first is current)
Message Dictionary

Hierarchical system may be preferred:

- JINTACCS message defined in hierarchical fashion
- Message database is primarily used as (static) message dictionary
- Information accessed hierarchically (fields within sets within messages)
- Speed of operation is desirable
- No need for relational query capability
- Reduced redundancy
Database Design

Command and Control ($C^2$)

Relational may be preferred:

- Information not defined in hierarchical manner
- Data items may be related in many-to-many fashion
- Database contents are dynamic
- Relational query capability desirable
- User-oriented interface necessary

First cut: extract from JINTACCS messages and normalize
Database Operations

*ims*

- User interface for message composition
- Uses message dictionary to build prompt panels
- Builds message in JINTACCS format and submits to *msgproc*
- User can review, edit, or save message during composition
- New messages are easily added for automated composition assistance
Database Operations

**server** (automated message posting)

- Reads JINTACCS messages
- Extracts variable data into file
- Builds UNIFY update in file
- Calls UNIFY to enter data update
- Old data overwritten by new

Limitations:

- C source module for each message
- Needs embedded query language
Database Operations

**build** (automated message generation)

- Given: message ID, destination, priority

- Executes UNIFY query, capturing data into file

- Reads data from file, puts into JINTACCS template in new file

- Submits new message file to *msgproc* for input to system

- Table-driven; does not use message dictionary

Limitations:

- C source module for each message

- Need embedded query language
Database Operations

Backup and Recovery

- Uses TACCNET to copy snapshot of database to remote node(s)
- Broadcast messages used to retrieve messages sent after snapshot
- Backup and recovery procedures initiated by user or cron

To recover from a failure:

- The snapshot is retrieved from one of the remote backup sites,
- A broadcast message is sent to the network requesting retransmission of all messages sent to the failed site after the snapshot was made.
Network Simulation

- SLAM simulation on CDC Cyber
- Low, moderate, and high traffic
- Assume basic network segment
- 1 - 3 ports (*dialin* and *dialout*)
Network Simulation

Results
- Bottleneck at DMMC
- 2 dialin, 2 dialout gives best results
- 1 dialin, 1 dialout is OK for leaf nodes

Response Time vs. Arrival Rate

<table>
<thead>
<tr>
<th>sec</th>
<th>msg/sec</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>0.12</td>
<td>0.12</td>
</tr>
</tbody>
</table>

Curves:
1. Bottleneck at DMMC
2. 2 dialin, 2 dialout
3. 1 dialin, 1 dialout
Further Investigation

JINTACCS processing
  Message grammar, parsing, functional description

Security
  Data and network security

Expert Systems
  Structured format with ambiguities; message processing

Voice Technology
  Voice / data interface for composition and display

User Interface / Tools
  Edit / display messages during creation; insulation from JINTACCS

Distributed Database
  Consistency, redundancy, fault tolerance
Appendix 4 - TACCNET Data Flow Diagrams

The following pages contain the high level data flow diagrams for all of the major systems and subsystems comprising the TACCNET software system. A legend is provided at the beginning.
Legend

Module entry and exit points

Flow of program control

Flow of data to/from disk files or program modules

Command line arguments from user or parent program

Program control statements

Flow of data to/from tables or messages (files)

Flow of data (files) to/from directories (queues)

Special entry and exit points for errors and procedure calls

start

---

end

---

scan mode

---

read in list of sites to monitor (in addition to priority queue)

---

system parameter file

---

msgprocq

---

Send Mode

---

error exit
Genmsg

1. Start
2. Get arguments from user command
3. Expand and validate destination paths
4. Build a message for each destination
5. Put messages into message processor input queue
6. End
QMS

start

masterq  
scan mode  
debug level

get arguments from user command; set working directory and operating parameters

system parameter file

read in list of sites to monitor (in addition to priority queue)

check for messages in priority queue

no messages

messages found

move messages to appropriate system queues and schedule priority callers for appropriate sites

check for messages in system queues

no messages

messages found

schedule a caller for each system with messages in its queue (routine priority)

check for shutdown command or scan mode = "one pass"

"one pass" mode or shutdown command received

end
Schedule

start

site name -> get site name and priority from qms

priority level -> check for existing conversation with desired site

conversation found

exit to qms

no available ports

get a port to use for caller

port table

port table

get a port

try to pre-empt a routine call and seize its port

priority messages routine message

no available ports

port table

invoke a caller for desired site with given priority level; update port table to show status of port

exit to qms

exit and wait for port

port table
get arguments from user command or qms invocation; lock site queue and reset modem on given port for dialout operation

get phone number and login information from site table

use modem to call the remote site and establish connection

log in to remote system

invoke 10Control with site name and port name

record successful call in site table

remove lock file and exit

check call history in site table to see if site should be declared down

declare site down

site table

failure

success

modem

lock file

site table

Caller

start

site name

port name

debug level
Msgproc

start

get arguments from user command; lock msgproc queue set working directory

read message from msgproc input queue

OK call PROCESS function to process message by type

error

move message to error queue

record error in log file

more messages in input queue to be processed?

yes

no

"one pass" mode or shutdown command received

yes

no

exit
Process

start

message name

open message file and read destination path from message header

message file

path table

expand path if necessary, then check for validity

invalid path

return error

site table

path OK

routine message for remote site

new message in system

put message in appropriate system queue

check priority level and mark message accordingly

user mail message for user at this site

message to be forwarded

give message to UNIX mail facility

make courtesy copy for original recipient and forward to alternate site

network administrative message

priority message

give message to network admin server

put message in priority queue

message for database server

unknown message type

give message to C2 database server

return OK

return OK

return error
IOControl

1. start

2. arguments from CALLER
   - check argument list to determine mode of operation
   - no arguments

3. site name, port name
   - read arguments and initialize in MASTER mode
   - fail
     - wait for ENQ and acknowledge
     - send ID packet and wait for ACK
     - error exit
   - succeed
     - send ENQ, then wait for ACK
     - succeed
       - get remote ID packet, send ACK
       - fail
         - error exit
       - succeed
         - update site table to show successful contact with remote
         - all done

4. send Mode
   - more files
     - exit
     - all done

5. Receive Mode
   - more files

6. Send Mode
   - more files
   - all done
Send Mode

start

check for INTERRUPT or ALL DONE conditions not found

get file from site queue empty queue

send file ID packet and wait for ACK got ACK

send file and wait for ACK got ACK

date file from site queue; update site table

check site queue for more files to send more files

signal EOT to remote system; set ALL DONE condition empty queue

Receive Mode

exit OK ALL DONE

INTERRUPT return error

got ACK

got NAK retry limit exceeded?

yes no

note error in log file
Receive Mode

start

check for INTERRUPT condition

got EOT

get file ID packet

got ID packet

see if file is already in the archives

archives

send ACK

receive file and send ACK

move file to msgproc queue

msgprocq

got EOT?

reset ALL DONE

Send Mode

not found

signal CANCEL

error exit

Send Mode

yes

send NAK (decline file)