IDEA GROUP PUBLISHING
701 E. Chocolate Avenue, Hershey PA 17033, USA
Tel: 717/533-8845; Fax 717/533-8661; URL-http://www.idea-group.com
ITP4426

MOBILE COMPUTING AT THE DEPARTMENT OF DEFENSE

James A. Rodger
Indiana University of Pennsylvania, MIS and Decision Sciences Dept, 203 Eberly
College of Business, Indiana PA 15705 Tel.: *724/357-5944;* Fax: 724/357-4831; jrodger@grove.iup.edu

Parag C Pendharkar and Mehdi Khosrowpour
School of Business, Penn State Harrisburg, 777 W Harrisburg Pike, Middletown PA 17057
Tel: *717/948-6028;* Fax: 717/948-6456; pxp19@psu.edu; mlk@psu.edu

ABSTRACT

This paper is designed to relate the rationale used by the Department of Defense, to utilize Telemedicine, to meet increasing global crises, and for the U.S. military to find ways to more effectively manage manpower and time. A mobile Telemedicine package has been developed by the Department of Defense (DOD) to collect and transmit near-real-time, far-forward medical data and to assess how this improved capability enhances medical management of the battlespace. Telemedicine has been successful in resolving uncertain organizational and technological military deficiencies and in improving medical communications and information management. The deployable, mobile Teams are the centerpieces of this Telemedicine package. These teams have the capability of inserting essential networking and communications capabilities into austere theaters and establishing an immediate means for enhancing health protection, collaborative planning, situational awareness, and strategic decision-making.

INTRODUCTION

Telemedicine is an approach of providing care for patients that are geographically separated from a doctor. Telemedicine allows a doctor and a patient to interact with each other using computer networks. Telemedicine, when used in military, has a potential to heal patients in the war zone where doctors may not be readily available. The U.S. national strategy for military pre-eminence is based on technological superiority. Through new discoveries in advanced science and technology, the goal of the Department of Defense (DoD) under Joint Vision 2010 (JV 2010) is to develop the ability to directly and decisively influence events ashore and at sea—anytime, anywhere—to meet current and future challenges.

To successfully counter these challenges, the DoD must continue to move forward in its effort to incorporate telemedicine into its prime mission—to keep every service member healthy and on the job, anywhere in the world, to support combat operations, as well as humanitarian, peacekeeping, and disaster relief missions.

Telemedicine supports the DoD's goal by electronically bringing the specialist to the primary provider who directly cares for service members in austere, remote, and isolated environments (Floro, Nelson, and Garshnek, 1998). Telemedicine also creates an opportunity to provide rapid, accurate diagnosis and therapeutic recommendations (Garshnek and Burkle, 1998). The end result is that telemedicine helps to maintain the health of service personnel and their ability to quickly return to duty, minimizing logistically burdensome, inconvenient, and expensive transportation to distant specialty care (Bangert, Doktor, and Warren, 1998).

For telemedicine methods to be successful, however, their operational effectiveness, suitability, and importance to the warfighters' mission must continuously be tested, evaluated, and proven (Oliver, Sheng, Paul and Chih, 1999). In 1997, the U.S. Army, in partnership with the Navy and Air Force, was tasked to develop exercises to explore the integration of advanced technologies with existing systems and architectures to meet the requirements established under JV2010.

These technologies are all aligned with the Joint Vision 2010 concepts of Dominant Maneuver, Precision Engagement, Focused Logistics and Full Dimensional Protection. The technology initiatives utilize dedicated, small mobile teams, with a sophisticated IT infrastructure, to provide telemedicine capabilities wherever they are needed in the medical battlespace (Mann, 1997). This IT Infrastructure includes novel Medical Equipment Sets (MES) with digital capture devices such as digital cameras, digital scopes, digital blood and urine laboratories, physiological monitors, advanced digital radiography, and digital ultrasound (Perednia and Allen, 1995). Other, associated items of equipment include novel software, such as the Pacific Virtual Health Care System. This package offers electronic medical record archiving capability that enables automated, standardized teleconsultation by forward medics to higher echelon physicians (Rodger and Pendharkar, 2000).

This ACTD has charged itself with operating within the concept of Focused Logistics and Full Dimensional Protection. It is, therefore, pertinent to understand just how this ACTD can accomplish its missions/objectives and meet the operational concepts of JV2010. This operationalization is embodied in the following quote. "To protect the force, the Army will rely on a technically advanced, operationally simple network of multi-component intelligence sources capable of detecting and locating forces, active and passive obstacles, in-flight aircraft, ballistic and cruise missiles and their launch sites, chemical and biological agents, electronic jamming sources and a host of still-developing threats."

One technology that is mentioned in the document that applies to this ACTD is the use of "advanced soldier technologies." It is necessary for this ACTD to fit within this concept and provide the warfighter with information that identifies, early on, those countermeasures that can be used to defeat medical threats (Dardelet, 1998). It is also important to recognize other action that may be used to defeat enemy deployment of weapons of mass destruction (WMD), especially biological agent dispersal.

Focused Logistics makes only one mention of "telemedicine." "For the Army, Focused Logistics will be the fusion of logistics and information technologies, flexible and agile combat service support organizations, and new doctrinal support concepts to provide rapid crisis response to deliver precisely tailored logistics pack-

This paper appears in *Managing Information Technology in a Global Economy,* the proceedings of the Information Resources Management Association International Conference.

ages directly to each level of military operation." The document portrays medical support to Focused Logistics in the form of "internet triage" and "telemedicine" in order to enhance the survivability of the joint force (Zajtchuk, 1995).

Achieving 21st century medical support capability demands significant advances in the military's ability to provide force health care and medical protection and to deploy medical communications and information management in tactical operations (Institute of Medicine, 1996). The broad mission of Telemedicine in the military, is to assess advanced mobile applications that can potentially meet such demands (Paul, Pearson, and McDaniel, 1999).

US military has adapted a suite of software, databases, and architecture standards to provide deployable medical information management (Tanriverdi and Venkatraman, 1998). The Theater Medical Core Services (TMCS) is a database that stores data locally and is capable of sending encrypted e-mail to several redundant database servers via store-and-forward (Rasberry, 1998). The database servers aggregate information and store it in databases for distribution. Web servers supply data to medical personnel as customized encrypted reports.

The Medical Workstation (MeWS) is a network-based workstation equipped with portable medical devices, clinical support capabilities, medical information support, and a graphical user interface. The MeWS will support multi-patient monitoring, interface with the patient's clinical record, and provide access to a searchable database. It will also provide full Personal Information Carrier (PIC) read and write implementation. MeWS collect, store, and forward medical device data and images. By utilizing a Global Positioning System (GPS), MeWS have the capability to enter the patient's geographical location. The various software components of the MeWS help to facilitate clinical data entry, acquisition and retrieval. MeWS enable the generation of medical facility status reports, the monitoring of disease surveillance, the updating of supplies, and tracking of evacuation requirements.

The Field Medical Surveillance System (FMSS) is an expert system that systematically detects and monitors epidemiological trends and profiles patient populations. FMSS integrates patient information to the Global Infectious Disease and Epidemiology Network (GIDEON) knowledge base. Demographic and symptomatic information is used to arrive at a presumptive diagnosis or classify the patient using discriminate analysis. FMSS is also capable of providing incidence and prevalence trends for infectious diseases.

The Libretto is a commercial-off-the-shelf (COTS) hand held computer, manufactured by Toshiba. It has the capability to automate field medic PIC card software by reading service member's demographic information from the PIC into the software. It can also write GPS medical encounter information to the PIC and store the information as a pre-formatted message for transmission.

Tactical medical communications require updating of the existing IT infrastructure. The previously mentioned novel hardware, software, and interfaces were implemented in order to enable this change and facilitate the transmission of medical-unique information over the existing communications hardware and command, control, communication, computers, intelligence, surveillance, and reconnaissance (C4ISR) networks. However, telecommunications from the operational area of responsibility (AOR) to the medical sustaining base uses the existing Defense Information Systems Network (DISN).

The technologies described above have been assembled into an exportable capability that is specifically tailored to meet the medical Information Management (IM) and Information Technology (IT) needs of the unit it is supporting. This assemblage of technologies is referred to as the Capability Package. The capability package must work in concert with the unit's infrastructure, communications, tactical situation, and logistical constraints if the military is to realize its full potential in meeting today's global crises.

For such technologies to be successful, however, their operational effectiveness, suitability, and importance to the Telemedicine mission must continuously be tested, evaluated, and proven. To perform this task, the military established a Test and Evaluation Integrated Product Team (T&E-IPT) to evaluate candidate mobile models and architectures. These technologies are examined in a rigorous test and evaluation (T&E) environment with extensive user participation as a means of assessing their mobile applications. The T&E-IPT have leveraged and optimized existing communications technologies to transmit medical data. Database technologies for mobile technologies are utilized for epidemiological and trend analyses utilizing data mining of these data warehouses.

The initial concept of operations (CONOPS) was to employ a tailored Joint Task Force (JTF) to accomplish missions in controlled environment demonstrations. The first series of demonstrations, tested communication methodologies, functionality, and the field utility of collecting and sending patient data from the forward edge of the battlefield. As the information and results were obtained the CONOPS was expanded to use additional activities. These activities are as follows:

- The deployment of mobile technologies and agents, called Theater Telemedicine Teams (TTTs), to medical treatment facilities (MTFs) to establish and conduct telemedicine operations; coordinate with signal and Command, Control, Communications, Computers, and Intelligence (C4I) assets to establish and maintain tactical medical networks; receive, verify, and log Command information provided from lower echelons
- The use of advanced mobile information management models and technologies, such as software, databases, and architecture standards, that were adapted to provide deployable medical information management for advanced mobile applications
- Two radio frequency (RF) networking technologies that were enhanced for user interface design in a battlefield setting
- Modeling and simulation (M&S) capabilities provided through advanced mobile application software during training exercises.

All of these capabilities are being evaluated by the military. The goal of this approach is to first establish effective, interoperable mobile communications in the early stages of the exercises and to then implement more robust mobile database technology capabilities as the application matures. This paper will provide the following details of this advanced mobile application.

- Types of mobile technologies that were identified and tested as potential candidates for enhancing Telemedicine capabilities
- Objectives of each mobile agents in the field
- Methods and applications of these mobile technologies
- Performance results of these mobile database technologies
- Recommendations, lessons learned, and feedback received from actual mobile users
- Overall findings and results of Telemedicine mobile field agents.

MEASUREMENT OF ISSUES AND FINDINGS

A series of measurements were conducted to test mobile communications methodologies and functionality. The field utility of collecting and transmitting near-real-time, far-forward medical data was examined and assessed as to how this improved capability enhanced medical management of the battlespace. This phase was also used to expand and improve the techniques for testing and evaluating the proposed mobile technologies and software enhancements.

The mobile technologies were operated by typical users who performed their intended mission tasks at the projected levels of workload within a realistic operational environment. Included were the use of dedicated, small, mobile teams with associated items of equipment to provide telemedicine capabilities when and where needed in the medical battlespace. These items included novel medical equipment sets (MES) with digital data capture devices, as well as novel software that enables automated, standardized teleconsultation by forward medics and corpsmen to rearward physicians with an electronic medical record archiving capability. A suite of software, medical databases, and architecture standards were adapted to provide deployable medical information management.

In addition, two radio frequency (RF) networking technologies were also tested and fielded. These included the Lucent Wireless WaveLAN II system, a commercial wireless networking capability that was enhanced for military applications, and the Joint Internet Controller (JINC), a tailored set of software and firmware that is geared toward providing lower bandwidth data networking capabilities to existing military field radio systems.

The medical play in several of the demonstrations was robust enough to provide a rich opportunity to observe how these mobile technologies provided support to the user in an operational setting. These results were then used as a baseline for follow-on demonstrations and exercises.

Both the WaveLAN and JINC demonstrated their primary intended functions of mobile tactical networking capacity. The WaveLAN system provided superior bandwidth and full wireless local area network (LAN) capabilities, and the JINC provided tactical networking over low bandwidth military radio systems.

Among the outcomes, it was found that mobile technologies could successfully replace wired LANs with wireless LANs and that mobile database technology software development and refinement should be continued.

The exercises demonstrated the following capabilities:

- Theater Medical Core Services (TMCS) system – a mobile database application used to provide medical reports
- Medical workstation (MeWS) – a mobile, functionally configured, network-based workstation designed to support the clinical and information support requirements of forward echelon providers ashore and afloat
- Toshiba Libretto end user terminal (EUT) – a lightweight, handheld computer capable of reading, storing, and transmitting the soldiers' demographic information in the field
- Desert Care II (DC II) Theater Clinical Encounter Application (TCEA) – a Web-based application that facilitates the user interface design, on the browser workstation, for mobile providers or medical technicians to record, view, and report patient encounter information in the field
- Personal information carrier (PIC) – a small, portable storage device containing demographic and medical information pertaining to the soldier who is wearing or carrying the device
- Theater Telemedicine Prototype Program (T2P2) – a Web-based delivery system of consultive care that gives healthcare providers from remote locations the ability to access the expertise of a regional facility for medical specialty consultations
- Theater Telemedicine Team (TTT) – a mobile team composed of a leader with a clinical background, a visual systems operator, and an information systems operator who provide telemedicine capability to select, deployed MTFs
- Aeromedical Evacuation (AE) Suitcase – a mobile system that provides critical voice and data communications to the AE mission of the U.S. Air Force (USAF) Air Mobility Command (AMC)

The tasks needed to achieve the objectives of the demonstration were carried out. These included the ability to collect and forward healthcare data in DC II and TMCS Lightweight Data Entry Tool (LDET), transmit it over existing communications [high frequency (HF) and International Maritime Satellite (INMARSAT)], extract it to a medical situational awareness system (TMCS), view those data in a Web environment on the TMCS server at Systems Center, San Diego (SSC SD), and conduct long-range clinical consultations. Although technical difficulties were experienced, the lessons learned from these exercises were evaluated, and solutions to these problems were incorporated into the next exercise. One good example of a lesson learned was the use of the wireless LAN to track patients within the MTF.

The exercises also indicated that essential data transport requirements of these mobile technologies can be met consistently, reliably, and cost effectively. Specific technologies were examined relative to each other for specific operational requirements of data throughput, transmission distance, time to setup, time to train, and actual costs to acquire, maintain and dispose. Among the significant achievements was the employment of the five-person mobile TTT, which successfully conducted clinical reachback capability.

Several parameters were not measured directly by the field exercise. These parameters can be determined through future exercises and battle laboratory testing and evaluation methods. For example, analysis still is not complete on the availability of mobile HF and very high frequency (VHF) radios, the overall reliability of the mobile laptops demonstrated, the software reliability of several of the communication modules, and the sustainability of several of the software database applications, hardware components, networks, and databases used in the exercise. As new data becomes available through future exercises and battle laboratory testing, a more complete picture of these advanced mobile applications of telemedicine will evolve.

Testing and evaluation of mobile Telemedicine applications have produced tangible evidence for the military utility of these technologies. Results from the field indicate that the essential data collection and dissemination requirements of these mobile technologies can be met consistently, reliably, and cost effectively.

The mobile models and architectures demonstrate the potential to enhance data collection and dissemination of information through the use of quality database software and robust, mobile communications infrastructure. Through its efforts, these mobile agents have developed a consistent pattern of progression. From an initial state of uncoordinated, service-unique solutions to the building of an overall mobile framework, this architectural solution is being developed and refined by several different technological concepts. These concepts have been and will continue to be assessed for operational and technical feasibility. The results from these operational and technical assessments will ultimately lead to the development and insertion of an emerging architecture, which will encompass these advanced mobile applications.

This first series of phases was conducted to test communications methodologies, functionality, and the field utility of collecting and transmitting near-real-time, far-forward medical data and to assess how this improved capability enhanced medical management of the battlespace. This phase was also used to expand and improve the techniques for testing and evaluating the proposed technologies and software enhancements specified in the exercises.

The technologies demonstrated were operated by typical users who performed their intended mission tasks at the projected levels of workload within a realistic operational environment. These technologies included the use of dedicated, small, mobile teams with associated items of equipment to provide telemedicine capabilities when and where needed in the medical battlespace. Associated items of equipment included novel MES with digital data capture devices (e.g., digital cameras/scopes, physiological monitors, and advanced digital radiography), as well as novel software (e.g., Theater Telemedicine Prototype Project) that enables automated, standardized teleconsultation by forward medics and corpsmen to rearward physicians with an electronic medical record archiving capability. A suite of software, medical databases, and architecture standards were adapted to provide deployable medical IM.

In addition, two RF networking technologies were also tested and fielded during the exercises. These included:

- Lucent Wireless WaveLAN II system
- JINC.

WIRELESS WAVELAN

The WaveLAN system was developed and maintained from commercial-off-the-shelf (COTS) wireless networking capabilities for the exercise. All JMO-T participation in this exercise was predicated on the work accomplished by the engineers to enhance the Lucent WaveLAN II system for military applications. In this regard, the WaveLAN represented an extension of a LAN via wireless means at data rates in excess of 2 million bits per second (Mbps).

JINC

The JINC system is a tailored set of software and firmware that is geared toward providing lower bandwidth (i.e., 2.4–64 kilobytes per second (Kbps) data networking capabilities to existing military field radio systems. The basic concept behind JINC system development was to field a "programmable," mobile tactical networking system capable of exchanging digital data between ships, aircraft, combat vehicles, and individual soldiers in the field. The JINC system was enhanced from an existing COTS product to allow data connectivity between any two existing military radio systems without reliance on satellite communications (SATCOM). The intent behind this configuration was to avoid having the ACTD become involved in procuring and installing new generation radio systems.

The JINC is composed of three elements operating together – the host computer, Team Care Automation System (TCAS) software, and a Micro-INC data controller device.

TCAS

The TCAS software installed on the JINC computer host provided automated network connectivity for distributed facilities, remote users, and individual units all interconnected using existing military communications media. TCAS software is based on object-oriented technology to enhance data exchange at low bandwidths. Fundamentally, TCAS software operates in two basic modes. The first mode emulates any specified data package as an "object" in an object-oriented database structure. Using a common database distributed throughout the entire JINC network, the software takes the "objects" and compresses them using a proprietary compression scheme and then transmits the "object" across the RF network. At the receiving node, the object is decompressed and translated back into its original protocol stack prior to delivery; thus, hosts on either end of a JINC-supported RF network see the expected data format in the form it was transmitted. Using this object compression scheme, JINC is able to deliver near full use of available low bandwidth data links with very little administrative network overhead.

MICRO-INC DATA CONTROLLER

The Micro-INC (MINC) data controller provided the conversion from RS-232 serial data to a synchronous MIL-STD-1880-114 data stream. Each Micro-INC data controller can support up to two radio systems simultaneously. This data controller is normally located near the Single-Channel Ground and Airborne Radio System (SINCGARS) radio installation to reduce the length of the synchronous cable run. The controller requires no external or manual operation to function. All MINC functions are controlled by TCAS software.

TECHNOLOGIES DEMONSTRATED

For this demonstration, a Mobile Medical Monitor (B) (M3B) computer system simulating a MeWS, was connected to a SINCGARS via the TCAS. A Libretto system running TCAS was connected to a second Libretto via the WaveLAN Personal Computer Memory Card International Association (PCMCIA) wireless networking devices. Abbreviated discharge summary documents in Microsoft Word format were prepared on the M3B based on input from the various sensors attached to the M3B. This message was transmitted as a file attachment to a TCAS freetext email from the M3B to the first Libretto via SINCGARS. The Libretto then ported the data, via preset forwarding rules, from the SINCGARS net over the WaveLAN net to the second Libretto using the socket interface.

The computer systems selected for the exercise consisted of Libretto 110CT-NT computers, which were similar to the 100CT Libretto EUTs. The principal difference was that JMO-T Librettos required the Windows NT 4.0 operating system to support the TMCS system. The Librettos used in the exercise generally used Windows 95/98. In addition to the basic computer system, each JMO-T EUT was provided with a Quatech four-port serial expander PCMCIA card, which allowed the connection of the PIC reader along with the Garmin 12XL Global Positioning System (GPS) device. The second PCMCIA slot on the Libretto was occupied by the WaveLAN II 803.11 PCMCIA wireless network card.

During this exercise, far-forward Hospital Corpsman (HM) transmitted medical information from four far-forward first responder sites to the medical command onboard the USS Coronado. Data was entered via the Libretto 110CT-NT, which was equipped with a PIC Reader and TMCS LDET software. Three stationary sites were located at Area 41 in Camp Pendleton, California, and one mobile platform, a High-Mobility, Multipurpose Wheeled Vehicle (HMMWV), traveled to Yuma, Arizona. Because no specific medical exercise took place during the ELB phase, each user was given a set of preprogrammed PICs to scan into the system. The data were then periodically transmitted.

Initially, the Joint Medical Semi-Automated Forces (JMedSAF) simulation was to be used in conjunction with the scenario played out on the ground to give the staff onboard the USS Coronado a more robust "picture" of the battlespace; however, early in the exercise, it became apparent that bandwidth was at a premium on the network. The demonstration manager, therefore, elected to "shut down" the JMedSAF feed to the USS Coronado to keep essential data feeds open to the Enhanced Combat Operations Center (ECOC). As a result, very little data generated from the simulation runs eventually made its way to the TMCS database. Furthermore, the scenario of the "real" battlespace was disconnected from the "virtual" battlespace.

RESULTS

JMO-T operations consisted of sending over 120 patient encounters via the TMCS LDET to the TMCS server located in the ECOC on the USS Coronado. Three nodes were operated by JMO-T personnel during ELB:

· HMMWV Mobile Node

· Area 41 Node

· Yuma Node.

Two basic WaveLAN modes of operation were used. The first (and most commonly used) was the "standard" mode, which allowed the EUTs to communicate with the rest of the WaveLAN network via a WavePoint router connection, which translated the packets for use by the rest of the network. Because the power output of the individual WaveLAN card was only 25 milliwatts, the JMO-T EUT had to be located within 1,000 feet of a WavePoint in order to access the network. In practice, this range was extended to as much as 2,000 feet at Area 41, but this was due primarily to a high antenna mast (about 40 feet) for the Area 41 WavePoint antenna.

The other method of operation was called the "ad hoc demo" mode, which was accessed by selecting an option on the WaveLAN card "properties" window. When activated, this allowed the EUTs to communicate with each other (i.e., for training) without the need for a WavePoint.

OPERATIONAL OBSERVATIONS BY SYSTEM NODE

HMMWV Mobile Node

The intent behind JMO-T operations from the HMMWV node was to demonstrate the ability to send medical data from a highly mobile platform. In practice, this actually involved JMO-T personnel going to the location where the HMMWV was parked and joining the net from that location. One corpsman from 1/5 Marines accompanied JMO-T engineering personnel to the HMMWV location at Green Beach. The corpsman transmitted nine patient records with transmission times as follows in Table 1.

Patient Number	Transmission Time (min:sec)
1	1:45
2	2:30
3	17:00
4	1:00
5	0:20
6	1:10
7-9	0:25

Table 1. HMMWV Transmission Times

Although additional periods of JMO-T participation were scheduled with the HMMWV node, revisions to the exercise schedule resulted in postponement and eventual cancellation of other HMMWV JMO-T operations because the HMMWV, was needed elsewhere in the exercise.

Area 41 Node

The majority of JMO-T operations occurred at the main exercise Area 41 operations center and relay node. Results of patient record transmissions are provided in Table 2 and 3.

Table 2. Area 41 Transmission Times

MSEL Event	Number of Patients Sent	Time to Send (min:sec)
401	8	19:40 (VTC was ongoing)
341	8	Various time (sent individually)
408	1	0:19 (about 500 ft from WavePoint in field)
	1	1:24 (about 1000 ft from WavePoint in field)
	1	1:13 (back in shelter)

MSEL Event	Number of Patients Sent	Time to Send (min:sec)
	1	5:19
	1	0:55
	1	1:44 (sent by 1/5 Corpsmen)
	1	1:23 (sent by 1/5 Corpsmen)
	1	1:54 (sent by 1/5 Corpsmen)
359	5	2:30 (sent by 1/5 Corpsmen)
406	5	Various
412	4	7:03
368	7	Not sent (repeated time-out alerts). This was around 1200 and other videoconferencing events were ongoing. We made 5 attempts with no joy.

Table 3. Area 41 Transmission Times (continued)

After the completion of the videoconference, JMO-T personnel and 1/5 Marines corpsmen experienced dramatically improved network performance. LDET transmission times for all patient encounters were in the 3-5-second range. In addition, the ECOC TMCS server was able to be viewed and browsed from the Libretto EUTs (something that had not been possible previously due to videoconferencing network delays). The corpsmen passed all required MSEL data and then resent) all previous MSEL data at the request of ELB authorities. The entire evolution was smooth and successful. In addition, all required imagery files, including four 2.35-megabyte (MB) images, were successfully transmitted. The 2.35-MB files took 2-3 minutes to transmit, and all were viewed on the ECOC TMCS server.

YUMA NODE

JMO-T participation at Yuma demonstrated far-forward message reach-back capability. JMO-T was assigned to operate from a WavePoint assigned to a Naval Research Lab (NRL) mobile commercial SATCOM system mounted in a HMMWV. This

SATCOM link provided a 2-Mbps relay directly back to Area 41 at Camp Pendleton. EUT operational modification only required an IP change.

As in Area 41, all JMO-T messaging was handled by a 1/5 Marines corpsman. The system was operated from the back of a vehicle within 200 feet of the NRL SATCOM HMMWV. Individual patient encounter messages were transmitted within 5-10 seconds. The ECOC TMCS server was able to be browsed to confirm delivery.

Five additional images, including two 1.35-MB images, were transmitted via File Transfer Protocol (FTP). Small files were transmitted in 10-20 seconds, and large files took 2:20 each. The only operational problem noted was a tendency for the Global Positioning System unit to stop sending position information when requested. This was traced to a loose cable on the Quatech serial port card; however, the cable was tightened, and the system returned to normal operation.

RESULTS

ELB technology provided a number of excellent options for medical communications. When the network was not overwhelmed by the demands of Videoconferencing, it provided an excellent method of collecting medical data-both TMCS textual data and images. During these times, Engineering Integrated Product Team (E-IPT) personnel working with data senders reported that TMCS data was sent in milliseconds, and the large files were transmitted in no more than 5 seconds. Data senders were able to use the handheld computers with ease. JMO-T participated in the longest leg of the exercise network by successfully sending TMCS and large data files from Yuma, Arizona.

The Libretto systems running Windows NT using 64 MB RAM performed satisfactorily; however, when the LDET, TCAS, Serial TCAS, and Medical Messaging Service (MMS) server were all running on one computer, the operation slowed significantly. One solution was to allow TCAS to speak TMCS (or Wave or any other medical software) in its native mode as a C++ object. Based on this experience, a more effective device for Echelon I use is a Windows CE computer, which weighs less than one pound, can easily fit into a Battle Dress Utilities (BDU) pocket, and provides resident software, a user friendly screen, and a long-life, inexpensive battery.

KB Prime (CG-1)

KB Prime (CG-1) consisted of an amphibious assault exercise with a robust medical activity imbedded inside the main training action. The deployed forces consisted of three Regimental landing force size units supported by appropriate Level III medical care both ashore and afloat. The medical force during the CG-1 phase included two BASs, two STPs, one SC, the USS Essex (LHD-2), which served as a Casualty Receiving Treatment Ship (CRTS), the USNS Mercy (AH-19) hospital ship, and a Fleet Hospital (FH). Plans were for roughly 500 total casualties in 5 days.

The medical play in KB Prime was robust enough to provide a rich opportunity to observe how the technologies provided support to the user in an operational setting. These results were then used as a baseline for follow-on exercises. Both the WaveLAN and JINC demonstrated their primary intended functions of mobile tactical networking capacity. The WaveLAN system provided superior bandwidth and full wireless LAN capabilities. The JINC provided tactical networking over low bandwidth military radio systems. The primary objectives and results are provided in Table 4 and 5.

Objective	Result
Achieve medical in-transit patient visibility through the use of the WaveLAN network	Achieved. When the WaveLAN network was in full operation, the delivery of LDET messages occurred in 3–5 seconds. Other ELB functions (i.e., VTC) significantly slowed network operations.
Achieve medical imagery file transfer using WaveLAN technology	Achieved. Multiple images were transferred using standard FTP programs.
Achieve medical in-transit patient visibility through the use of JINC network and tactical radio systems	Not achieved. While LDET messages were delivered between units on the network, LDET input did not reach the TMCS master server at Space and Warfare (SPAWAR). As a result, full patient in-transit visibility was not achieved.
Achieve MeWS medical messaging and file transfer capability through the use of JINC network and tactical radio systems	Achieved. Two test files were transferred between SC and USNS Mercy.

Table 4. Networking Objectives and Results for KB 99

Objective	Result
Demonstrate internetting for units on different RFs	Partially achieved. Messages received over SINCGARS net were forwarded via HF net but required intervention for delivery. SINCGARS-to-WaveLAN automated delivery was accomplished during the UW exercise.

Table 5. Networking Objectives and Results for KB 99 (continued)

OPERATIONAL EFFECTIVENESS

The effectiveness of the systems used in the exercise was demonstrated by typical users, who operated them in a realistic operational environment. The Capability Package demonstrated the ability to collect both patient encounter and Annex Q-type information; however, it did not meet the threshold values established by the Performance Integrated Product Team (P-IPT) for transmitting that information to the theater medical command. The purpose of the exercise was to move patients through the evacuation system, and most decisions that needed to be made could be made without referring to the information stored on the TMCS server. In fact, most of the decisions did not require the type of information that was reported, and therefore, the staff instead used other data. As stated in the feedback questionnaires, the Marine Expeditionary Force (MEF) and Third Fleet Surgeons neither relied on the data provided by TMCS nor trusted its timeliness or reliability.

SUMMARY OF LESSONS LEARNED

The following were lessons learned from the exercise:

- To perform net-centric communications, it is necessary to have network management and good engineering support.
- All engineering initiatives during JMO-T assessments should be directed and coordinated by the E-IPT chairman based on requirements developed by the P-IPT using a Good Idea Cut-Off Date (GICOD).
- The Libretto configuration was too heavy and complex for the end users, and battery power was insufficient.
- A combination of PIC with chip and a simple bar code would read faster. A photo identification card would be helpful. These issues need to be coordinated with the Joint SMART Card and PIC offices.
- TMCS was not used by target JTF Surgeon Headquarters (HQ); its configuration and report makeup must be examined.
- Ship-to-ship communications of TMCS data works well with HF/SINCGARS.

- Land-based units had significant communications challenges because natural barriers (not in line of sight) shut down the ability to communicate outside of the unit.
- Estimated power requirements must be part of the articulated Technology Plan. Coordination with supported units must discuss power requirements.
- More detailed overall training packages and materials will be needed prior to future exercises. Training at the leadership level and documented training materials should be part of the deployed system.
- Baseline business processes must be assessed to identify change requirements of new technology.
- Liaison with participating units is required to ensure adequately trained users, informed leaders, and tested technology support.

RECOMMENDATIONS

Based on achievement of the stated objectives, the following recommendations are provided for continued wireless networking development:

- WaveLAN technology appears sufficiently mature to warrant use as a replacement for wired networking at field MTFs.
- A prototype network configuration to support an SC should be devised and prepared for testing.

The following recommendations are provided for continued TCAS software development:

- As demonstrated in the exercise, TCAS was based on a C++ Windows 95/98/NT executable program. Operational experience with the Libretto NT system at Echelon I showed the need for a smaller, lighter computing system to support this highly mobile group. The Windows CE operating environment appears most suited to this requirement. Port TCAS software into the CE environment is recommended.
- The greatest asset (and liability) of the TCAS/J software is its flexibility. Programming the various communications servers, forwarding rules, and message formats is similar to programming a full-featured network router. This implies that a TCAS operator must be both computer literate and network knowledgeable. Simplification of the user interface, perhaps with more graphical network connection screens, appears necessary. In addition, the software should feature some type of "system lock" that will keep all settings under a password-controlled environment so that an inexperienced operator cannot change them by accident.
- Continued developmental work is needed to incorporate the full range of medical database-specific messages into TCAS. Message delivery in the exercise was achieved via a complicated process involving multiple serial port data exchange and encoding. This process can be streamlined by the provision of a medical system communications server to the TCAS software developers so that they can test their message servers directly.

CONCLUSIONS

Testing and evaluation of the JMO-T ACTD have produced tangible evidence for the military utility of telemedicine. Results from Demonstration I indicate that the essential data collection and dissemination requirements of JMO-T can be met consistently, reliably, and cost effectively.

The ACTD promises the potential to demonstrate technology-enhanced data collection and dissemination of information through the use of quality software and robust communications infrastructure. Through its efforts, the JMO-T ACTD has developed a consistent pattern of progression. From an initial state of uncoordinated, service-unique solutions to the building of an overall architectural framework, this architectural solution is being developed and refined by several different concepts. These concepts have been and will continue to be assessed for operational and technical feasibility throughout Demonstration II, which begins with Cobra Gold in April–May 2000 and FOAL Eagle in the Fall. The results from these operational and technical assessments will ultimately lead to the development and insertion of an emerging JMO-T architecture, which will encompass the "run" phase of the JMO-T ACTD.

REFERENCES

Bangert, D. Doktor, R. & Warren, J.(1998). Introducing Telemedicine as a Strategic Intent. Proceedings of the 31st Hawaii International Conference on System Sciences (HICSS-31), Maui, Hawaii.

Dardelet, B. (1998). Breaking the Wall: The Rise of Telemedicine as the New Collaborative Interface. Proceedings of the 31st Hawaii International Conference on System Sciences (HICSS-31), Maui, Hawaii.

Floro, F.C. Nelson, R. & Garshnek, V. (1998). An Overview of the AKAMAI Telemedicine Project: A Pacific Perspective. Proceedings of the 31st Hawaii International Conference on System Sciences (HICSS-31), Maui, Hawaii.

Garshnek, V & Burkle, F.M. (1998) Telemedicine Applied to Disaster Medicine and Humanitarian Response: History and Future. HICSS. 10(6).

Institute of Medicine. (1996). Telemedicine: A Guide to Assessing Telecommunications in Health Care. National Academy Press: Washington, D.C.

Mann, S. (1997) Wearable Computing. Computer. 30(2), 25-32.

Oliver, R. Sheng, L. Paul, J.H. & Chih, P.W. (1999). Organizational Management of Telemedicine Technology: Conquering Time and Space Boundaries in Health Care Services. IEEE Transactions on Engineering Management, 46(3), 279-288.

Paul, D.L. Pearlson, K.E. & McDaniel, R.R. (1999). Assessing Technological Barrieres to Telemedicine: Technology-Management Implications. IEEE Transactions on Engineering Management, 46(3), 279-288.

Perednia, D.A. & Allen A.(1995). Telemedicine Technology and Clinical Applications. Journal of the American Medical Association. 273 (6), 383-388.

Rasberry, M.S. (1998) The Theater Telemedicine Prototype Project: Multimedia E-Mail in the Pacific. Proceedings of the 31st Hawaii International Conference on System Sciences (HICSS-31), Maui, Hawaii.

Rodger, J.A. & Pendharkar, P.C. (2000). Telemedicine and the Department of Defense. Communications of the ACM, 43(2).

Tanriverdi, H. & Venkatraman, N. (1998). Creation of Professional Networks: An Emergent Model Using Telemedicine as a Case. Proceedings of the 31st Hawaii International Conference on System Sciences (HICSS-31), Maui, Hawaii.

Zajtchuk, R.S. (1995). Battlefield Trauma Care. Military Medicine. 160, 1-7.

The views expressed in this paper are those of the authors and do not reflect the official policy or position of the Department of the Army, Department of the Navy, Department of Defense, or the U.S. Government.