Tactical Medical Coordination System (TacMedCS)

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Naval Health Research Center

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Abstract

The Tactical Medical Coordination System (TacMedCS) provides rapid casualty identification under adverse conditions, enables visibility of casualty status from the point of injury through medical treatment in higher echelons of care, maintains an electronic treatment record with the patient, utilizes non-physical-contact data transmission and storage media, and uplinks casualty information to a theater information network. Additionally, the current version of TacMedCS provides information to the corpsman in the field about patient location and status using a stand-along handheld device. This mature prototype (DoD Technology Readiness Level 7) was tested at Fleet Hospital 3 during Operation Iraqi Freedom in 2003, shipboard in the Health Services Support Exercise in 2004, in Coalition Warrior Interoperability Demonstration 2005 where it was determined to be a top performer, and during several Limited Technology Assessments conducted at the Marine Corps Warfighting Laboratory. Near real-time awareness of casualty status and location will allow medical personnel to respond with needed evacuation resources and will facilitate planning for treatment of incoming casualties by more quickly identifying the resources required to treat specific injury types and severity, while providing medical managers with advanced situational awareness.

Patient care can require many providers who may be in different locations either within a medical treatment facility (MTF), or at different MTFs. Even when medical care is provided in a fixed facility, such as a hospital, locating patients who are receiving care can be very difficult. These difficulties are magnified when the patient is seriously wounded in a combat zone, and may need to be evacuated through several levels of care while receiving treatment. Currently, there is a problem coordinating this care. Providers must guess what the previous medical treatment was, who they could contact to get more information, or even who the patient's name. Various data storage methodologies to communicate information about patient treatment in a timely manner have been tried, such as computer disks, thumb drives, cassette voice recorders, and paper records. To date, none has been consistently successful in communicating patient information to the next level of care. Some providers have resorted to making notes on the patient's body to coordinate care, as shown in Figure 1.

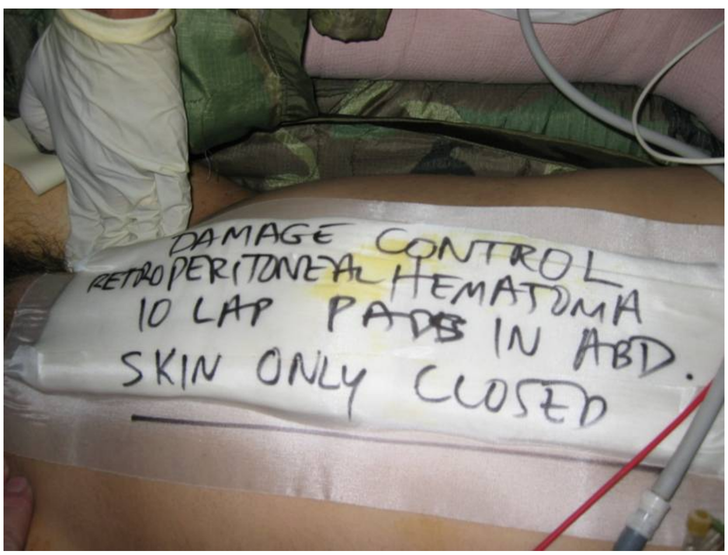

Figure 1. Example of medical provider communication: a note taped to the patient.

In addition to the problems faced by medical care providers coordinating care without being able to share information, there is the burden on the unit of not knowing the status and location of an injured warfighter. When a corpsman provides treatment in theater and takes the patient to the next level of care, that corpsman is responsible for knowing that person's status. The current system requires repeated inquiries, potentially over many days, to determine the casualty's health status. Automated patient tracking would both facilitate providing coordinated care and would enable the corpsman to determine the patient's location and status more quickly and with less effort than current methods.

The objective of the Tactical Medical Coordination System (TacMedCS) project was to identify and test a combination of technologies to facilitate patient tracking across all levels of medical care. The system needed to be rugged enough to function in austere environments, where it could be subjected to climatological extremes, and dirt, sand, and water. It needed to be flexible enough to support both combat and humanitarian missions and function in areas without mature communications, or when communication systems have been disabled. To contain costs, an additional goal was to make use of commercial-off-the-shelf (COTS) equipment as much as possible rather than using customized development.

System Specifications

TacMedCS designers decided to make use of emerging passive radio frequency identification (RFID) technology. This technology allowed automated patient identification, and offered substantial advantages to alternative technologies such as optical bar codes. RFID allowed patient data to be stored on a computer chip that can be contained within a plastic bracelet like those commonly used for patient identification in hospitals. This chip has roughly the computing power of the original IBM 8088 computer. The specific band chosen, which is 13.56 MHz, can hold 2k bytes of information and has the capability to protect some of the data from future overwriting while allowing other data sets to be updated. For example, the serial number of the band is protected from overwriting, while patient encounters information can be updated. RFID offered an inexpensive, durable, reliable, easy to use, and safe technology.

The passive RFID system chosen is inexpensive to implement. Active RFID systems have energized tags that have batteries that can last for up to a year. The passive RFID system uses tags that have only a circuit that is powered by energy from the RFID reader/writer. TacMedCS system designers chose to use passive tags because of the cost difference between the two types of tags. Active tags are more expensive, at roughly $150 per tag, compared with $1-$2 per tag for passive tags.

RFID systems are durable. The RFID chip is typically encased in a plastic casing to enhance durability. Unlike a bar code, the RFID chip is readable even when the tag is wet, dirty, or abraded. The tags can be written to and read from hundreds of times without failure. Compromising a tag requires the band be crimped through the circuit that forms the RFID chip, so that the circuit is disabled.

RFID systems are reliable. Data on the chips can be encrypted to protect them from compromise by being written to or read from by an unauthorized source. Information read from the band is not susceptible to transcription errors or difficulties from reading handwriting. Once the information is stored on the band, unless the band is badly damaged, the information will be available indefinitely.

RFID systems are easy to use. The tag can be read without physical or optical contact and can even be read through Mission-Oriented Protective Posture Level IV (MOPP-IV) protective clothing. Gathering accurate patient information requires a matter of seconds. Similarly, after recording a medical encounter, data transfer from the reader/writer to the band only requires seconds.

Passive RFID systems are safe to use. The RFID reader/writer communicates to the chip through the use of radio waves, which are believed to be harmless. The satellite transceiver used in the current version of the system has undergone and passed Hazards of Electromagnetic Radiation to Ordnance (HERO), Personnel (HERP), and Fuel (HERF) testing at Naval Surface Warfare Center Dahlgren. HERO refers to the danger of accidental activation of ordnance because of radio frequency

(RF) electromagnetic fields. HERP refers to the danger of RF electromagnetic fields to the health of personnel. HERF refers to the danger of RF electromagnetic fields accidentally igniting volatile materials (fuels). The entire unit, with the reader/writer, will be tested for HERO, HERP, and HERF as soon as it becomes available.

Concept of Operation

TacMedCS uses an RFID chip that resides in a band placed on the patient's wrist to store a small amount of patient information, such as the person's name, social security number or other identifying number, and codes for where the patient came from and the patient's expected disposition. This information can be written onto the tag either using a handheld, dedicated RFID reader/writer or using an RFID card inserted into a laptop or desktop computer. When the tag is read, this information can be uploaded to a local medical database by using an RFID-enabled computer. From there, the data can be sent elsewhere using established networks, such as the Internet, NIPRNet, or SIPRNet. In the absence of connectivity, or mature communication infrastructure, the data can be sent via satellite phone to a central server, and access can be provided to other locations—according to system design, as shown in Figure 2. Incorporation of satellite communication, using the Iridium network of satellites (Iridium Satellite LLC), enables over-the-horizon communications and may provide the only method of communication in austere conditions.

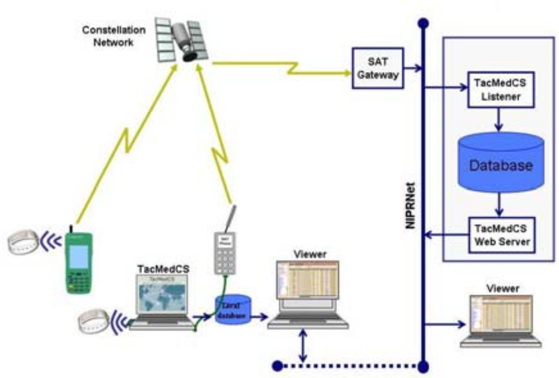

Figure 2. TacMedCS system architecture.

The incorporation of satellite communication capability into system design can dramatically increase system costs. Satellite phones can be an order of magnitude more expensive than cell phones, and the connection time is also expensive. However, satellite communication capabilities can provide patient tracking information in the absence of standard communication infrastructure, and it ensures that the system can operate under any conditions. Recent technological advances allow more-affordable satellite communication.

After the data are transmitted to a central server, the casualty information can be displayed using a graphical user interface (GUI) such as the Medical Common Operational Picture (MedCOP) or the Force Medical Tool Set (ForceMed; ScenPro Inc., Richardson, Texas). These interfaces allow the user to query the data so that patient status can be determined, which is demonstrated in Figure 3.

Figure 3. Operator using the TacMedCS laptop version during Fleet Hospital 3 trial.

If the data cannot be transmitted (e.g., because of a communication blackout), the patient's data are stored on the patient's tag. For Versions IV and V, patient information is encrypted at 192-bit or the advanced encryption standard (AES) level of encryption, also referred to as FIPS-197, to ensure the security of the information, and to facilitate obtaining Defense Information Assurance Certification and Accreditation Process approval for the system. With this level of encryption, the tag can hold information for the last three medical encounters.

Recording patient data on the tags ensures that some information travels with the patient to the next level of care, where these data can be uploaded into the system. This redundant data storage helps ensure that the patient tracking system will operate reliably—even when providers are unable to upload the data.

Initial versions of the system provided the capability to either use a prepopulated tag that had been issued to a Marine, or to create a tag for a person who did not have one. The concept behind the prepopulated tag was that each Marine in a unit would be issued a tag with his or her information on the tag, which he or she would carry. Doing this required the approval of and funding by the Marine Corps. This possibility was discussed, but was never adopted. Subsequent versions of the system allow the use of a prepopulated tag. However, there is no expectation that patients will have them.

Project History

The TacMedCS concept was first envisioned by researchers at the Naval Aerospace Medical Research Laboratory (NAMRL) in Pensacola, Florida. In response to the need for a technology that would easily and unobtrusively track casualties in a battlefield environment, they tried to develop this capability.

At the time they began this project, there was no commercially available RF identification chip, which was a crucial to the project. Within 2 years of NAMRL's inception of this project, RFID tags and reader/writer devices became commercially available. As COTS hardware became available, it was incorporated into system design. When COTS hardware could not do what was required, customized systems were designed and built.

The first system was a prototype, which was large and clumsy, but could fit into a suitcase. Version I provided a proof of concept that an RFID-based patient tracking system could work (Figure 4).

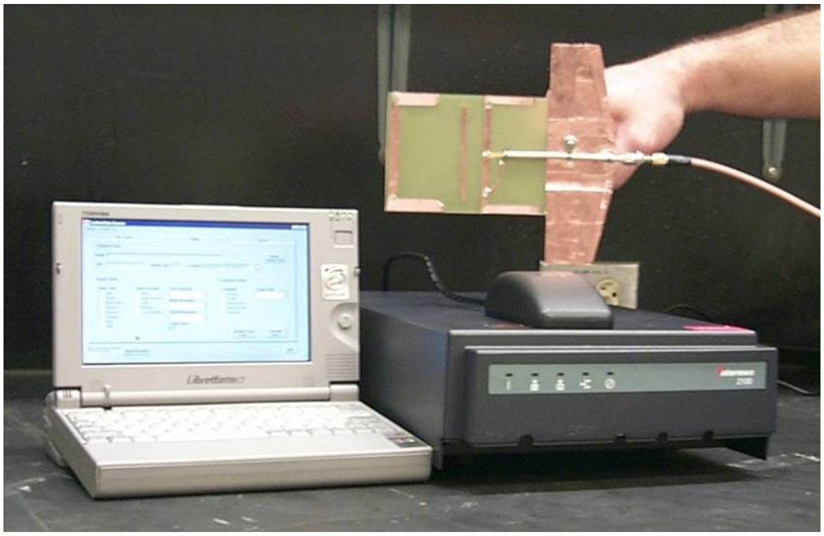

Figure 4. TacMedCS, Version I.

As the commercial sector provided more choices, the patient tracking system became more compact, more rugged, less expensive, and the project became more feasible. A second system was developed for the Marine Corps Chemical Biological Response Force (CBIRF; Figure 5). This system tracked the location of casualties as well as responders. It was tested during the first Limited Technology Assessment (LTA 1) conducted at the Marine Corps Warfighting Laboratory (MCWL) during the winter of 2003.

Figure 5. TacMedCS Version II, used by CBIRF.

The next version of the project took advantage of COTS. Version III had handheld reader/writers, the Minec 4x, and was a substantial advance over the first system in portability. This system is shown in Figure 6. This version and subsequent versions only tracked casualties rather than tracking both casualties and responders.

Figure 6. Version III during OIF field test.

Version III was successfully field tested at Fleet Hospital 3 during Operation Iraqi Freedom (OIF) to demonstrate concept feasibility. It was used to locate patients within the hospital, which consisted of an interconnected series of tents and buildings, as shown in Figure 7. The system architecture for this field test is shown in Figure 8. Patient information from casualty receiving, intensive care, wards, and evacuation was transmitted to a central server. This server could provide the data to other computers in the facility through a Local Area Network or LAN. This test did not involve any satellite communication.

The idea of automated patient identification and tracking was enthusiastically received by care providers. In this circumstance, not only did they have to locate injured Marines, but they also had to track indigenous people who had been wounded, and who might not be forthcoming about their identity (Figure 9). So TacMedCS provided a way of tracking patients with similar names, deceptive patients, and children who were unable to provide good information and history.

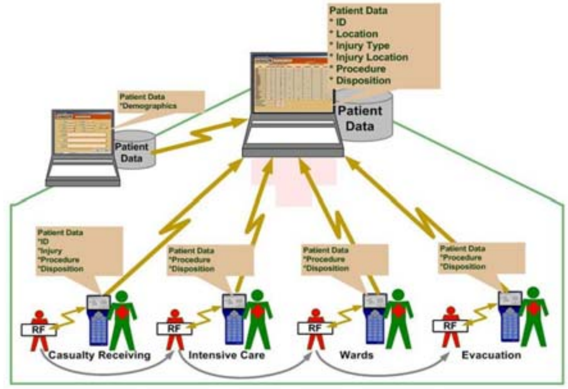

Figure 7. Fleet Hospital 3.

Figure 8. Architecture for Fleet Hospital 3 test.

Figure 9. A foreign patient who has been banded for identification.

The capabilities of the third system were later extended to accommodate data transfer using a satellite phone. Patient data were transmitted via satellite phone to the Iridium satellite system consisting of 72 satellites in low earth orbit. The signal was received by the closest satellite, and passed along until it was sent to a gateway in Wahiawa, Hawaii. There it was transmitted by the Defense Information Systems Agency to a server. From there, the data were provided to authorized users over the Internet. The Enhanced Version III was tested during LTA 2, which was conducted in the summer of 2004 (Wilson & Nebelkopf, 2005), and in LTA 3, which was conducted in the fall of 2004 (Wilson, 2005). Figure 10 shows Version III being tested during an LTA.

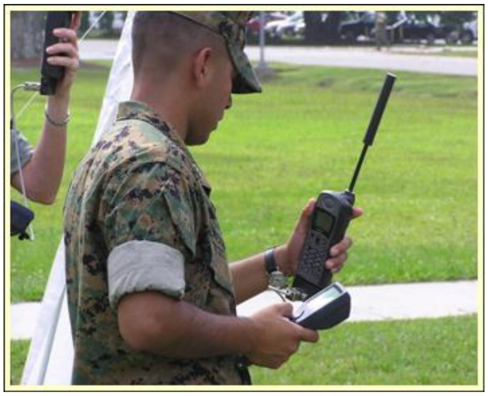

Figure 10. TacMedCS Enhanced Version III during an LTA.

This enhanced version was used during participation in a Health Services Support Exercise in 2004 aboard the HSV-2 *Swift*. During this test, system users were able to write to and read from the tag in the shipboard environment. Fictitious patient information was transmitted via satellite phone to a server in Johnstown, Pennsylvania. From there, the data were available over the Internet.

We were unable to send the data via satellite phone to the server. The TacMedCS data listener had been constructed to only accept characters that it expected. When it received unexpected characters, the listener stopped working, and the system had to be shut down and restarted. This problem was addressed by rewriting the listener to ignore unexpected characters, which helped ensure system reliability.

The enhanced version was also tested in the Coalition Warrior Interoperability Demonstration 2005 (CWID) at sites in Dahlgren, Colorado Springs, San Diego, and New Zealand, where the system was determined to be a top performer. The system architecture for CWID 2005 is shown in Figure 11. For this exercise, the server was housed at MCWL.

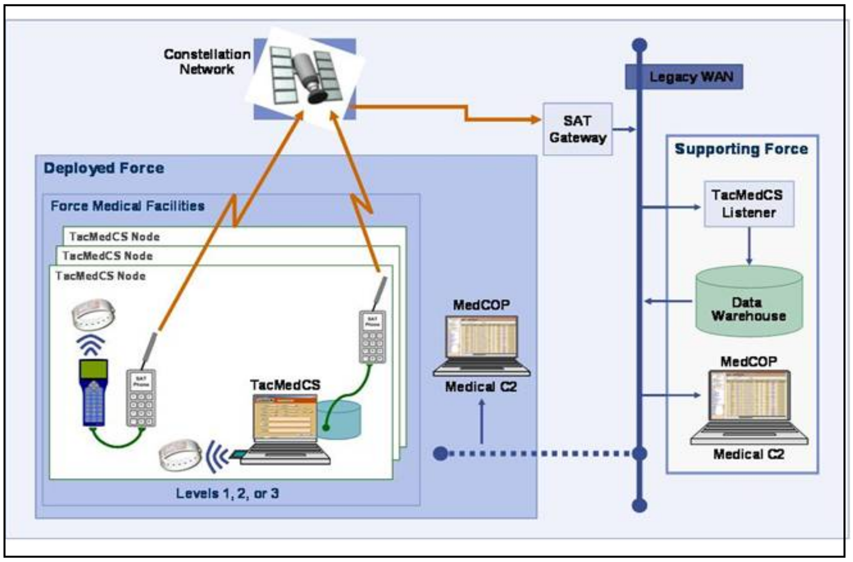

Figure 11. CWID 2005 system architecture.

The Enhanced Version III system had several advantages over previous systems, but it also had limitations. The advantages of the system were that all the hardware was COTS, making it less expensive and more reliable than customized development, and it was very portable. The disadvantages to the system were that the Minec scanner lacked a complete keyboard and required the operator to press two keys to enter each letter. This made data entry using the handheld unit quite burdensome. Data entry could be accomplished, but it could not be done quickly or easily. In addition, the satellite phone had to be physically connected to the scanner. If the two units were left connected, the phone had to be placed somewhere or held while entering the data into the handheld. If the satellite phone was disconnected, it was easier to enter the data into the Minec reader/writer. However, with repeated reconnection, the connection could become contaminated with fine sand, and fail. Estimates were that disconnection and reconnection could be done about 10 times before the connection would cease to function.

The fourth system, developed by MCWL, included a satellite phone built into the device. Version IV (the ACC 6100, shown in Figure 12) had the advantage that the satellite phone did not have to be cabled to the RFID reader/writer to communicate the data to a more central location. This feature was important during desert operation because of the problems produced by the fine sand. To create a reliable system, the satellite phone was incorporated into the box that housed the RFID reader/writer.

Figure 12. Version IV integrated handset.

Data transmission from the satellite modem to the satellite was also changed from sending a sequential signal to sending data in bursts. This method of communication does not support voice transmission, but it is more efficient for sending data, and allows faster transmission of data—which provides a greater margin of safety for the personnel transmitting the data. Use of a satellite phone requires a line of sight between the user and the satellite. Users sending a sequential signal are more vulnerable to detection.

As part of migrating the application to a new platform, the user interface was redesigned to make better use of the high-fidelity color display that was part of the new platform by providing redundant cues to facilitate user navigation of the complicated software system. The previous interface used black and white icons for different functions, such as initializing the system, reading or writing to tags, and communicating the information to the satellite phone. If a user selected the wrong icon, the system would present screens that could be confusing to the user. With new, inexperienced users, who would be expected to occasionally select the wrong icon, the system could seem too complicated to use, and might be rejected before the user had enough familiarity to learn to use it correctly.

In the revised interface, each function is shown in a colored stripe as seen in Figure 13. Selection of the function sequentially leads to more windows that had the same colored bar at the top of the window, with the name of the function at the top of the page. If the operator intended to select one function, and selected another function by mistake, there was feedback provided on the screen, both from the color and the name of the function showing the operator where he or she was within the program. This was intended to reduce confusion regarding why the system might be behaving differently from the operator’s expectations, increase user satisfaction with the system, and decrease the user’s belief that correct system operation was an undocumented error in the software.

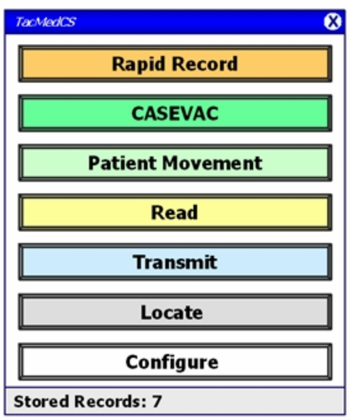

Figure 13. Sample screen shot from revised TacMedCS interface, Version IV.

As the product development team used the integrated handset, and sent the handsets to other team locations, we learned that the handsets were frequently broken during shipment. To repair these handsets, they had to be returned to the manufacturer, where the case was opened, the equipment was repaired, and the assembly had to be resealed into the case. Although this unit was impervious to sand and functioned, it was not sufficiently rugged to withstand the shock experienced during shipping. Presumably, it would not be able to withstand field conditions.

Additionally, we noticed that the battery life was not sufficient for field operations. The batteries did not support both the customized handheld unit and the integrated handheld unit as well as we had hoped.

Version IV was tested during LTA 4, which was conducted in the summer of 2005, and during LTA 5, which was conducted both at MCWL and at ScenPro Headquarters in Richardson, Texas, also in the summer of 2005 (Fye, 2006). The system architecture was comparable to the architecture used in CWID 2005.

Current Version

The fifth system resides on an iPAC Pocket PC (Hewlett-Packard Company; Figure 14). This device was chosen to be compatible with the Armed Forces Health Longitudinal Technology Application (AHLTA) Mobile development (formerly called BMIS-T) so that TacMedCS capability could be implemented at minimal cost. Given the tremendous number of AHLTA Mobile units that have been and continue to be deployed, and the overall success and acceptance of this project, having TacMedCS functionality on AHLTA Mobile hardware both increases the chances of system deployment and provides a transition plan for this project.

Figure 14. iPAQ Pocket PC using Tradewinds RFID card, running TacMedCS.

In addition to being compatible with AHLTA Mobile, there were several other goals of this development effort. We wanted to take advantage of improvements in satellite communication technology, which had dramatically decreased the purchase cost of this technology to about $300-$400 per unit and decreased the power consumption by about an order of magnitude. We wanted to maintain the short-burst transmission capability that was introduced in Version IV. Version V allows for satellite communication of data by inserting the Pocket PC device into a sled that has a customized circuitry to allow short-burst satellite communications (Figure 15). Version V was successfully tested during LTA 6 in May of 2007 (Fye, 2007).

Figure 15. TacMedCS Version V: a compact, fully integrated handset and satellite modem.

This construction allows use of COTS technology for the main unit of the system. The Pocket PC and the additional circuitry to support the satellite communication is housed in a vinyl casing to make it resistant to the elements and provide some protection from shock. It has a flip-up cover to protect the screen while still providing access to the user. The unit is powered by a separate power supply, housed in the unit, which uses three AA batteries.

A unit similar to Version V, Version V-Lite that does not have the satellite communication capability, could be fielded as soon as funding becomes available to supplement system capabilities. Although users in some locations may require satellite communications, users in areas with more mature communications infrastructure will not. For these users, satellite capability increases unit weight and cost. For units not requiring satellite communications, an AHLTA Mobile unit could be fitted with either an AWID RFID reader/writer card in the PCMCIA slot, or a Tradewinds RFID reader/writer card in the SDIO slot, for under $200 per unit. This substantially reduces the cost of additional units and allows more flexibility in system implementation. Similarly, this card can be used in existing laptops or desktop computers to provide TacMedCS functionality quite inexpensively.

Version V is designed for viewing using the ForceMed GUI, a proprietary software suite developed by ScenPro. The system architecture is shown in Figure 16.

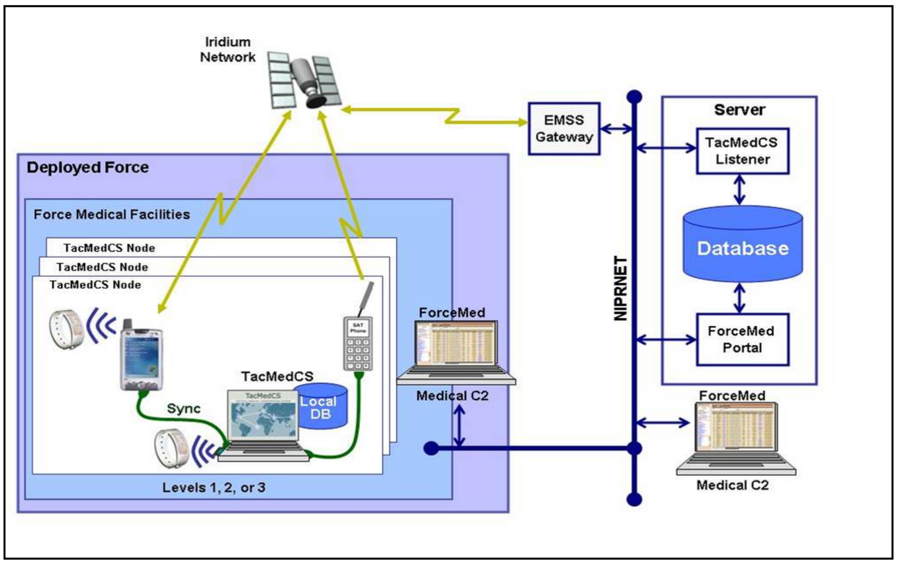

Figure 16. Version V components and communication architecture.

Future Development

The current version of TacMedCS can support patient tracking during combat situations. With minimal lead time, Version V-Lite could inexpensively provide some support for both humanitarian use and homeland defense. The standard Version V is not a COTS product. To use this capability, units would have to be procured and built, the software loaded, the units tested, and then stored. The satellite phone usage contracts would have to either be in place or rapidly completed. In contrast, Version V-Lite units would require only procurement, and loading the software.

The software for this application works on a cell phone (Figure 17). This allows an inexpensive implementation of RFID-enabled patient or provider tracking in any area with cell phone service.

Figure 17. TacMedCS on a cell phone equipped with Tradewinds RFID card.

In a disaster scenario without mature communications, cell phone capability can be provided using a Cell on Wheels (COW) for temporary cell phone capability when roads are passable. A COW is a mobile cell site that consists of a cellular antenna tower and electronic radio equipment on a truck or trailer. One system architecture is shown in Figure 18.

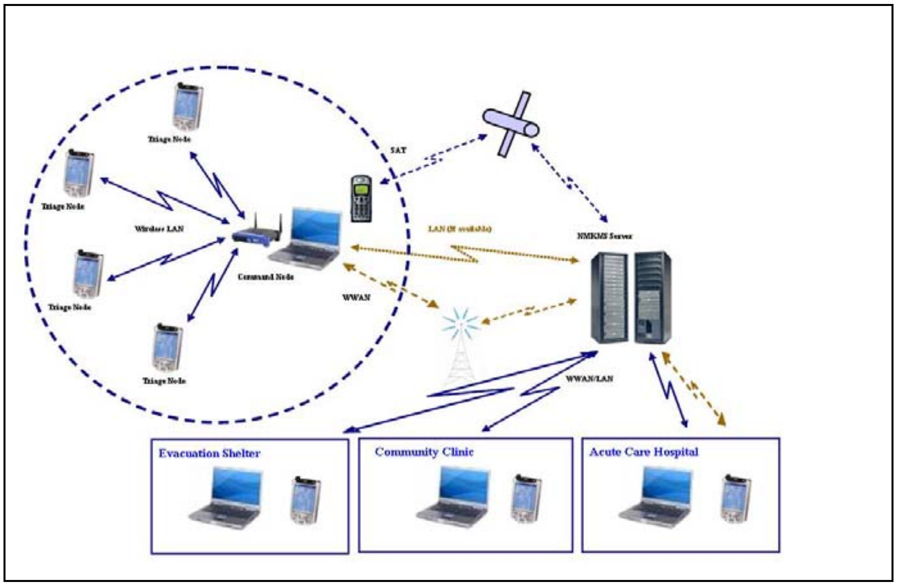

Figure 18. An ad hoc system architecture to deal with a mass casualty.

Transition Plan

We hope to transition the TacMedCS capability to the Theater Medical Information Program-Joint (TMIP-J), a Program of Record through our relationship with AHLTA Mobile and its developers. Over 30,000 AHLTA Mobile units have been fielded by Medical Communications for Combat Casualty Care, the Army's fielding agent for TMIP. The TacMedCS application runs on the AHLTA Mobile hardware as a separate application. There are plans for AHLTA Mobile developers to incorporate TacMedCS functionality into the AHLTA Mobile program. TMIP-J has adopted the AHLTA Mobile program.

Development Team

This project has been a collaborative effort among multiple commands and engineering firms. NAMRL started the project in 1999 and continued development of it for several years. NAMRL researchers chose to use contactless RFID technology to eliminate the problems that were experienced by systems relying on data transfer using the Personal Information Carrier (PIC) card, which did not perform well in field conditions. NAMRL originally partnered with Battelle to support this effort, which was funded by the Office of Naval Research. Funding was obtained from the Defense Advanced Research Projects Agency in 2001 as a part of a program called the Enhanced Consequence Management Planning and Support System (ENCOMPASS). The purpose of this program was to provide a suite of tools designed to help manage the response to catastrophes and to track the victims. Technical support for the ENCOMPASS effort and subsequent efforts were provided by ScenPro. ScenPro staff did the design and coding of the computer programs for the handheld RFID reader/writer, the laptop version, communication with the satellite phone, and the GUI, initially MedCOP, and then ForceMed, which was used to view the data. They conducted in-house testing, support for field tests, military exercises and demonstrations, created user guides, and provided project documentation.

The U.S Navy Bureau of Medicine and Surgery (BUMED) provided funding for further development and for field testing the unit during OIF. BUMED sponsored the project and provided technical direction.

In 2003, MCWL became involved by providing technical guidance and ongoing testing. The experimental test design for each LTA was provided by the Center for Naval Analysis staff, who analyzed and interpreted the resulting data, and wrote the test report. U.S. Marine Corps Headquarters, Health Services, provided project support and guidance.

Naval Health Research Center became involved in the project early in 2004. NHRC provided project management support, ergonomic and regulatory advice, and support for field testing and military exercises. To coordinate this project, NHRC hosted periodic video conferences and later teleconferences, which facilitated communication among the many different agencies involved.

NAL Research Corporation (Manassas, VA) constructed the satellite modem that replaced the satellite phone in Versions IV and V. A.C.C. Systems Inc. (Glen Head, NY) provided the tags and labeling, as well as fabricated Version IV and the sled for Version V.

MTS Technologies, Inc. (Arlington, VA) modified the data warehouse that holds the data gathered by the Naval Medical Knowledge Management System (NavMedKMS) to accommodate TacMedCS data. MTS also provided support for participation in CWID 2005, and engineering support and guidance.

Conclusion

TacMedCS can be used to display near real-time casualty data in the field, providing both medical and tactical benefits. Near real-time awareness of casualty status and location will allow medical personnel to respond with needed evacuation resources and will facilitate planning for treatment of incoming casualties by more quickly identifying the resources required to treat specific injury types and severity, while providing medical managers with advanced situational awareness. Additionally, the current TacMedCS version handset can provide information to the corpsman about patient location and status for the patients he or she has treated. This relieves the corpsman of the responsibility to track down casualty status.

This system has evolved from an improvised device to a mature prototype at Level 7 in the framework of the Department of Defense (DoD) Technology Readiness Levels (see Appendix 1). It has been repeatedly tested in LTAs, in military exercises, and during combat. It can currently support patient tracking during combat situations, and could support humanitarian use and homeland defense with minimal modification (Figure 18).

Figure 18. A child banded during Fleet Hospital 3 trial.

Automated patient tracking has a variety of benefits. It could enhance communication among medical care providers. This could affect not only the stream of patients being treated, but it could also influence best practices about how to treat patients in the future, which might be incorporated into new policies. As an example of how TacMedCS could improve patient care, patient tracking capability could allow providers to determine who last provided treatment to the patient, and could facilitate communication among providers to decrease the number of redundant surgeries performed.

Patient tracking capability could also help refine the provision of medical care during combat. Currently, given the lack of information about the medical care provided to patients, it is very difficult to do an outcomes-based analysis of various treatments. Some care providers are responding to evolving threats with innovative care. Some of these innovations are improvements over previously used techniques and some are not. Providing information about where the patient has been could be useful in determining what treatment each patient received. When combined with the patient's outcome, this information could allow medical analysts to determine the success of various treatments, which would be useful information for medical care providers.

TacMedCS is a mature technology that primarily uses COTS technology to provide a needed capability. TacMedCS is a good candidate for adoption into the TMIP suite of applications, and for consideration for both humanitarian use and homeland defense.

References

Defense Acquisition University. *Defense acquisition guidebook*. Retrieved July 27, 2007, from http://akss.dau.mil/dag/DoD5000.asp?view=document&rf=GuideBook\IG_c10.5.2.asp

Fye, R. (2006). *Tactical Medical Coordination System: Limited Technical Assessments 4 and 5*. (Analysis Report 06-05). Quantico, VA: Marine Corps Warfighting Laboratory.

Fye, R. (2007). *Tactical Medical Coordination System: Limited Technical Assessment 6.* (Analysis Report 07-09). Quantico, VA: Marine Corps Warfighting Laboratory.

Tactical Medical Coordinating System (TacMedCS) Warfighter Assessment. In *Coalition Warrior Interoperability Demonstration (CWID) 2005 Final Report IT02.55*. Retrieved April 11, 2007, from http://www.cwid.js.mil/public/htmlfiles/255war.html

Wilson, J. A. (2005). *Tactical Medical Coordination System Limited Technical Assessment 3* (Analysis Report 05-11) Quantico, VA: Marine Corps Warfighting Laboratory.

Wilson, J. A., & Nebelkopf, D. (2005). *Tactical Medical Coordination System Limited Technical Assessment 2* (Analysis Report 04-49) Quantico, VA: Marine Corps Warfighting Laboratory.

Appendix 1. Technology Readiness Levels in the Department of Defense

Technology Readiness Levels in the Department of Defense (DOD)
(Source: DOD (2006), *Defense Acquisition Guidebook*)

Technology Readiness Level	Description
1. Basic principles observed and reported	Lowest level of technology readiness. Scientific research begins to be translated into applied research and development. Example might include paper studies of a technology's basic properties.
2. Technology concept and/or application formulated	Invention begins. Once basic principles are observed, practical applications can be invented. The application is speculative and there is no proof or detailed analysis to support the assumption. Examples are still limited to paper studies.
3. Analytical and experimental critical function and/or characteristic proof of concept	Active research and development is initiated. This includes analytical studies and laboratory studies to physically validate analytical predictions of separate elements of the technology. Examples include components that are not yet integrated or representative.
4. Component and/or breadboard validation in laboratory environment	Basic technological components are integrated to establish that the pieces will work together. This is relatively "low fidelity" compared to the eventual system. Examples include integration of 'ad hoc' hardware in a laboratory.
5. Component and/or breadboard validation in relevant environment	Fidelity of breadboard technology increases significantly. The basic technological components are integrated with reasonably realistic supporting elements so that the technology can be tested in a simulated environment. Examples include 'high fidelity' laboratory integration of components.
6. System/subsystem model or prototype demonstration in a relevant environment	Representative model or prototype system, which is well beyond the breadboard tested for TRL 5, is tested in a relevant environment. Represents a major step up in a technology's demonstrated readiness. Examples include testing a prototype in a high fidelity laboratory environment or in simulated operational environment.
7. System prototype demonstration in an operational environment	Prototype near or at planned operational system. Represents a major step up from TRL 6, requiring the demonstration of an actual system prototype in an operational environment, such as in an aircraft, vehicle, or space. Examples include testing the prototype in a test bed aircraft.
8. Actual system completed and 'flight qualified' through test and demonstration	Technology has been proven to work in its final form and under expected conditions. In almost all cases, this TRL represents the end of true system development. Examples include developmental test and evaluation of the system in its intended weapon system to determine if it meets design specifications.
9. Actual system 'flight proven' through successful mission operations	Actual application of the technology in its final form and under mission conditions, such as those encountered in operational test and evaluation. In almost all cases, this is the end of the last "bug fixing" aspects of true system development. Examples include using the system under operational mission conditions.

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14. ABSTRACT (maximum 200 words)

The Tactical Medical Coordination System (TacMedCS) provides rapid casualty identification under adverse conditions, enables visibility of casualty status from the point of injury through medical treatment in higher echelons of care, maintains an electronic treatment record with the patient, utilizes non-physical-contact data transmission and storage media, and uplinks casualty information to a theater information network. This mature prototype (DoD Technology Readiness Level 7) was tested at Fleet Hospital 3 during Operation Iraqi Freedom in 2003, shipboard in the Health Services Support Exercise in 2004, in Coalition Warrior Interoperability Demonstration 2005 where it was determined to be a top performer, and during several Limited Technology Assessments conducted at the Marine Corps Warfighting Laboratory. Near real-time awareness of casualty status and location will allow medical personnel to respond with needed evacuation resources and will facilitate planning for treatment of incoming casualties by more quickly identifying the resources required to treat specific injury types and severity, while providing medical managers with advanced situational awareness. Additionally, the current version of TacMedCS provides information to the corpsman in the field about patient location and status using a stand-along handheld device.

15. SUBJECT TERMS
patient location, casualty tracking; radio frequency identification; Iridium satellite phones; graphical user interface; medical data display

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