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Monterey, California. Naval Postgraduate School

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**NAVAL  
POSTGRADUATE  
SCHOOL**

**MONTEREY, CALIFORNIA**

**THESIS**

**A CASE STUDY ON THE NEED FOR AND AVAILABILITY  
OF PATIENT TRACKING SYSTEMS**

by

William R. Berg

June 2007

Thesis Advisor:  
Second Reader:

Orin Marvel  
Albert Baretto

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**A CASE STUDY ON THE NEED FOR AND AVAILABILITY OF PATIENT  
TRACKING SYSTEMS**

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**MASTER OF SCIENCE IN INFORMATION TECHNOLOGY MANAGEMENT**

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## **ABSTRACT**

This thesis analyzes the feasibility, efficiency and usability of patient tracking systems in support of military and Humanitarian Assistance/Disaster Relief (HA/DR) operations by reviewing the implications for implementing a medical technology into the field. The initial focus of this research is on determining the need for such a system. Research was conducted that discusses the strengths and weaknesses of each of the currently available systems. This will be followed by combining the strengths of each system into a single, “best of breed” system. This thesis will also investigate the suitability of currently available COTS hardware and software components for medical operations.



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## LIST OF ACRONYMS

BMIS-J	The Battlefield Medical Information System- Joint
BMIS-T	The Battlefield Medical Information System- Tactical
Calit2's	The California Institute for Telecommunications and Information Technology
COTS	Commercial off-the-shelf
DIAD	Delivery Information Acquisition Device
DMAT	Disaster Medical Assistance Teams
FH-3	Fleet Hospital 3
GPS	Global Positioning System
HA/DR	Humanitarian Assistance/Disaster Relief
HIPPA	Health Information Privacy and Portability Act
IPTI	The Integrated Patient Tracking Initiative
MVS	The Medical Visualization System
PDA's	Personal Data Assistants
PIC	Personal Information Carrier
RFID	Radio Frequency Infrared Device
TacMedCS	The Tactical Medical Coordination System
TATRC	Army's Telemedicine and Advanced Technology Research Center
UCSD	The University of California, San Diego
UPS	United Parcel Service
VHHA	The Virginia Hospital and Health Care Association



WISARD The Wireless Internet Information System for Medical Response in  
Disasters

WMD Weapon of mass destruction

## ACKNOWLEDGMENTS

This was a long and painful process which included many late nights. I know that it has all been worth while though and will benefit me greatly in the future. I would like to take this opportunity to thank those that have made this possible.

First and foremost I must thank my wife, Skye. She took over the daily running of our household, which included running our son to all the things that six year old boys like to do. She did this while working part time and completing her own degree. Did I mention she was also pregnant? Without her help and encouragement I would have never made it through.

I would like to thank my fellow Medical Service Corps officers. This topic was one of many that I considered researching. Having the ability to “bounce” ideas off of them saved me many hours of talking to myself, and ultimately let me find something that was not only important to me but also to my community.

Thank you to my academic advisor, Mr. Glenn Cook for allowing me to customize my class schedule so that I was able to get the most out of my educational experience while at the Naval Postgraduate School.

Writing a thesis is not an ease task that you can complete in a weekend. Many times advisors can add to the stress by micro managing your work. Dr. Marvel gave me free reign to research and write my thesis as I felt necessary. He turned me onto many resources that aided my research and offered advice when asked. This allowed me to keep my stress level manageable. He helped make this a learning experience for me and I want to thank him for that.

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# **I. INTRODUCTION**

## **A. PURPOSE**

The world that we live in is an ever changing and volatile environment. Wide scale natural disasters, such as the Eastern Asia Tsunami of 2004, are becoming more frequent. Military engagements, such as the War on Terror and the Iraqi War, are occurring more often and in more places. Technology is advancing at an alarming rate. One of the areas being affected by the advances in technology is the medical arena. The purpose of this thesis is to conduct a review of the available Patient Tracking Systems currently in use in both the military and civilian communities.

## **B. RESEARCH QUESTIONS**

The following questions were used to guide the research and development of this thesis:

1. Why is there a need for patient tracking systems?
2. What are the major systems that are currently available?
3. What are the strengths and weaknesses of the available systems?
4. Can we develop a “best of breed” system for patient tracking from the technology of these existing systems?

## **C. SCOPE OF RESEARCH**

This thesis will begin by identifying the need for patient tracking systems based upon past military and humanitarian missions. It will then familiarize the reader with four currently available systems, two civilian and two military. Familiarization of the systems will be accomplished by reviewing their fundamental features and components. Next, the study will identify the strengths and weaknesses of each system. This thesis will conclude by looking into the possibility of creating a “best system” from the existing strengths of each of the available systems.

## **D. METHODOLOGY**

The methodology used in this research will consist of the following four steps:

1. Conducting a literature search of books, journals, magazines, and other material from the Naval Postgraduate School's library as well as from the World Wide Web, regarding the need for and availability of the Patient Tracking Systems.
2. Identify and describe the functional components and features of currently available Patient Tracking Systems.
3. Explore and evaluate the strengths and weaknesses of each system.
4. Identify and create a "best of breed" system.

## II. BACKGROUND

### A. INTRODUCTION

Patient tracking systems are primarily used for three different situations. First, they can be used to track patients as they move from one department to another in a hospital type setting. Second, they can be used to track both patients and casualties as they are moved from disaster areas. Finally, they can be used to track wounded patients as they are moved out of military operational areas. In this section, I am going to focus on historical events and identify potential uses of patient tracking systems during these humanitarian missions.

### B. HUMANITARIAN MISSIONS

On Sunday, 26 December 2004, one of the largest earthquakes ever recorded occurred about 150 kilometers off the west coast of the Indonesian island of Sumatra. The quake, which according to scientists at Northwestern University measured 9.5 on the Richter magnitude scale created a tsunami which was recorded by tide gauge stations in both the Indian and Pacific Oceans. The areas hardest hit by the tsunami were in Indonesia, Thailand, India, Sri Lanka, Malaysia, Myanmar, Maldives and Somalia.<sup>1</sup> The death toll, which was a combination of reports from eleven different countries reached close to 250,000. This number is believed to be a gross underestimate of the actual total since there are still thousands of people unaccounted for, and many assumed deaths in the surrounding areas have not been reported.<sup>2</sup>

Following the tsunami, rescue workers came from all areas of the globe to offer assistance. They collected the bodies of the deceased and lined them side-by-side down the shore line. The only way to identify the bodies was to take a photograph and attach it to the body. Due to the intense heat and humidity the bodies were quickly decomposing, and within five days became unrecognizable. Time was of the essence when it came to taking the photographs. The only way to identify the remains after decomposition started

<sup>1</sup> G. Pararas-Carayannis, 2005. *The great earthquake and tsunami of 26 December 2004 in Southeast Asia and the Indian Ocean*. Retrieved January 23, 2007, from <http://www.drgeorgepc.com/Tsunami2004Indonesia.html>.

<sup>2</sup> Pararas-Carayannis, 2005.

was through the use of non-forensic techniques such as DNA-testing.<sup>3</sup> This type of testing could not be done by the locals because it required trained professionals with specialized equipment. Due to the sheer number of victims, it would be almost impossible to conduct testing on all the remains. To make the identification process even harder, in many areas the locals were beginning to bury large numbers of bodies in mass burial sites without any identification or documentation on who they were. They were doing this because the bodies were creating an environment that was conducive to disease, and causing long term traumatic effects on the children that saw the bodies everyday.

The use of a patient tracking system could have been employed with great results. Bodies would have been quickly registered into a system and then moved to a secure location. This would have cut down on the possibility of creating and/or spreading of disease. Also, the emotional distress caused by seeing the bodies lying around would have been eliminated.

Another example of a natural disaster that would have benefited from the use of a patient tracking system occurred on August 29, 2005. Hurricane Katrina made landfall as a Category 3 hurricane with sustained winds of 125 mph near Buras-Triumph, Louisiana.<sup>4</sup> At landfall, hurricane-force winds extended outward 120 miles from the center of the storm. Katrina maintained hurricane force winds to Meridian, Mississippi more than 150 miles inland. Katrina was downgraded to a tropical depression near Clarksville, Tennessee. On August 31, Katrina was absorbed by a frontal boundary in the eastern Great Lakes region and moved rapidly to the northeast where it affected Ontario and Quebec. Hurricane Katrina was the costliest and one of the deadliest hurricanes in the history of the United States. It was the sixth strongest Atlantic hurricane ever recorded and the third strongest U.S. hurricane on record.<sup>5</sup>

---

<sup>3</sup> M. Blackley, 2005. *Government 'too slow' to act identifying tsunami bodies*. Retrieved January 25, 2007, from <http://thescotsman.scotsman.com/index.cfm?id=26272005>.

<sup>4</sup> *Hurricane Katrina, 2007*. Retrieved January 27, 2007, from [http://en.wikipedia.org/wiki/Hurricane\\_Katrina](http://en.wikipedia.org/wiki/Hurricane_Katrina).

<sup>5</sup> *Hurricane Katrina, 2007*.

Most of the city of New Orleans was left under water from the storm, and many people spent days on rooftops waiting to be rescued. It was feared that hundreds or possibly even thousands had drowned due to the storm. Days after the storm, New Orleans Mayor Ray Nagin ordered the total evacuation of the city. It was believed that there were still 50,000 to 100,000 in the city that would need to be evacuated. Some of the remaining people included:<sup>6</sup>

- At least 20,000 people who took refuge in the city's Superdome stadium
- 10,000 people - patients, staff and refugees - from nine city hospitals
- At least 7,600 prison inmates

Relief organizations scrambled to locate suitable areas for relocating evacuees on a large scale. Many of the survivors in the Superdome were bussed to the Reliant Astrodome in Houston, Texas. By September 1, the Astrodome was declared full and could not accept any more evacuees.<sup>7</sup> The nearby George R. Brown Convention Center was opened to house additional evacuees. San Antonio, Texas also agreed to house refugees. Efforts began to relocate refugees in vacant office buildings on the grounds of a former air force base. The Reunion Arena in Dallas, Texas was mobilized to house evacuees, and smaller shelters were established in towns across Texas and Oklahoma. Arkansas also opened various shelters and state parks throughout the state for evacuees. Moving a large amount of people to a variety of different locations proved to be a logistical night mare. Children were split from their parents, elderly from their care givers, patients from their nurses, even babies from their nurseries. Trying to reunite family members or to simply locate a person after evacuation was sometimes harder than the actual evacuation.

The use of a patient tracking system would have made the evacuation much less of a night mare. People would have been tracked from the time they left New Orleans, until they reached their final destination. This would have eliminated people being “lost” or displaced. It also would have made it much easier to care for people who had special needs, such as infants or the elderly in that the facilities that they were being transported

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<sup>6</sup> *New Orleans evacuation under way 2005*. Retrieved January 27, 2007, from <http://news.bbc.co.uk/2/hi/americas/4203718.stm>.

<sup>7</sup> *Effect of Hurricane Katrina on New Orleans*. 2007. Retrieved January 27, 2007, from [http://en.wikipedia.org/wiki/Effect\\_of\\_Hurricane\\_Katrina\\_on\\_New\\_Orleans](http://en.wikipedia.org/wiki/Effect_of_Hurricane_Katrina_on_New_Orleans).



too would know that they were coming and been able to prepare for them. The Asian Tsunami and Hurricane Katrina are two examples that are very different in nature, but that both demonstrate a need for a patient tracking system during humanitarian missions.

### **C. MILITARY MISSIONS**

The second use for patient tracking systems covered in this paper is in the military. Patient tracking systems can be used in both the traditional “brick and mortar” facilities, and in operational settings. When in the line of battle of an operational setting, every second counts and being able to get an extra second is the difference between life and death. Traditionally, medics have carried a rolodex or medical references, and huge amounts of paper. Although well trained, medic’s sometimes come across illnesses that they are not familiar with, and need to be able to look them up. All of this researching and documenting can be very laborious, time-consuming, not to mention expensive and hard to manage. In some cases such as the special-forces that go into remote areas, it’s just not practical. In any type of operational setting, speed and accuracy do not go hand in hand. When faced with the choice of documenting the treatment and taking time away from caring for the patient, or treating the patient and disregarding the accuracy of the paper work for speed of treatment, the medic will always choose to treat the patient. Once treatment has been rendered, he can then attempt to go back and complete the paper work. However, as time passes it becomes harder and harder to remember what was done for the patient. Because of this, the documentation is not always complete or accurate.

Errors or lack of documentation has proven to be a problem for veterans. Many of them have inaccurate documentation of injuries or illness that occurred in operational settings. When the veteran then attempts to get follow-up treatment after his release from the service, he is often times denied. This is often the result of medical information not captured and documented while serving on active duty, then once off active duty there is no record to prove that it actually occurred. This was a major concern following the 1990 Persian Gulf War. Many veterans returned with undocumented illnesses, injuries, and

exposures.<sup>8</sup> When they attempted to get follow up treatment after their discharge, they were being refused because there was no documentation. This problem became so big, that in 1997 Congress mandated that the military services upgrade their medical documentation procedures.<sup>9</sup> Officials wanted to make sure that injured service members were able to receive the appropriate follow-up care that they needed and were entitled too.

The use of a patient tracking system would greatly enhance the military's ability to care for its patients in the field, in the military health care facility, and after their release from the service. Inside the hospital or treatment center, tracking systems will allow providers and administrators the ability to follow patients as they move from one department to another. This will allow administrators to conduct work flow analysis that will be used in an attempt to keep bottle necks from occurring. The use of tracking systems enables providers to see what treatment options are currently available for their use. Tracking systems also help to cut down on errors in documentation. By removing the chance for human error, the accuracy is immediately increased. They also make the process faster and when it comes to health care, each second that can be spared enhances a patient's chance of survival and decreases the cost of care.

In the field the use of a patient tracking system allows medics to cut back on the amount of references and paper work they have to carry. This would allow them to bring more supplies or combat essentials. Through the use of tracking systems, the medic can work faster. They will have the ability to immediately look up treatments that would take time to do if going through manuals. This extra time could be the difference between a patient's life and death. By using a tracking system, documentation can be more complete and contain fewer errors. This will not only aide the patient's ease of care in the future, but it will also save the government money that would have been spent on trying to determine what had happened to the patient in the past.

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<sup>8</sup> Microsoft Corporation, 2003. *U.S. military improves medical care, tactical advantage with wireless point-of-care handheld assistant* Microsoft Windows Mobile Customer Solution Case Study ed.

<sup>9</sup> R. Thormeyer, 2005. *Handheld tool gives army a quick look into a soldier's medical history*. Retrieved January 25, 2007, from [http://www.gen.com/print/24\\_30/37180-1.html](http://www.gen.com/print/24_30/37180-1.html).

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### III. CURRENT SYSTEMS

#### A. EXISTING SYSTEMS

Tracking systems can be used for many different purposes. They can track packages, automobiles, and even people. This paper will look at four different systems currently in use, United Parcel Service (UPS), The Wireless Internet Information System for Medical Response in Disasters (WIISARD), the Tactical Medical Coordination System (TacMedCS), and the Battlefield Medical Information System- Tactical (BMIS-T).

##### 1. United Parcel Service

During the late 1980's, UPS was delivering approximately 11.5 million packages and documents a day, for more than one million regular customers in over 200 countries and territories.<sup>10</sup> With such a huge volume UPS realized that they needed to develop a new method to track their packages. They also wanted to offer a new unique supply chain service to their customers which allowed them to track their packages, while at the same time keeping their prices competitive. In order to accomplish this, they began investing millions of dollars in research and development (R&D). In 1993, due to their hard work and intensive R&D, UPS introduced a new technology to the package transportation. This new technology was electronic tracking and it could be used to accomplish immediate data collection and transmission, digital signature capture and allow drivers to stay in contact with their headquarters keeping them abreast of changing schedules, traffic patterns and other important messages.

The most recent version of UPS's electronic tracking system functions around the fourth generation hand held device called the Delivery Information Acquisition Device (DIAD), Figure 1. The DIAD operates on multiple wireless technologies, including Wi-Fi, General Packet Radio Service (GPRS), Code division multiple access (CDMA), and Bluetooth.<sup>11</sup> Through the use of the DIAD, drivers are able to receive last minute

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<sup>10</sup> *Embracing technology 1991-1999*. Retrieved January 25, 2007, from <http://www.ups.com/content/us/en/about/history/1999.html>.

<sup>11</sup> A. Stone, 2005. *The Ups of Wireless for UPS*. Retrieved January 25, 2007, from <http://www.wi-fiplanet.com/columns/article.php/3511671>.

delivery changes or updates, while still within the UPS center. Once they are in the field, drivers are able to record and upload delivery information by simply scanning the package bar code, collecting the receiver's signature electronically, typing the receiver's last name and pushing a button which completes the transaction and sends the information directly to the UPS data repository. Once the information is in the data repository, customers are able to enter in a tracking number and see the status of their packages. Besides just connectivity, DIAD also contains 128 megabytes of memory.<sup>12</sup> UPS's electronic system tracks over 821,000 packages daily and eliminates an estimated 59 million sheets of paper per year.



Figure 1. Delivery Information Acquisition Device (DIAD).<sup>13</sup>

## 2. The Wireless Internet Information System for Medical Response in Disasters

How is tracking a patient any different than tracking a package? The current technologies supporting acute field care of victims of disasters are simply inadequate as shown in Figure 2, and new systems and technologies for care need to be developed. Following the recent Gulf Coast hurricanes and other natural disasters, many people began looking for an answer.

---

<sup>12</sup> *Fact sheets: The UPS Delivery Information Acquisition Device DIAD IV.*

<sup>13</sup> *Fact sheets: The UPS Delivery Information Acquisition Device DIAD IV.* Retrieved January 25, 2007, from <http://www.pressroom.ups.com/mediakits/factsheet/0,2305,1077,00.html>.

## Problems with Current Field Care

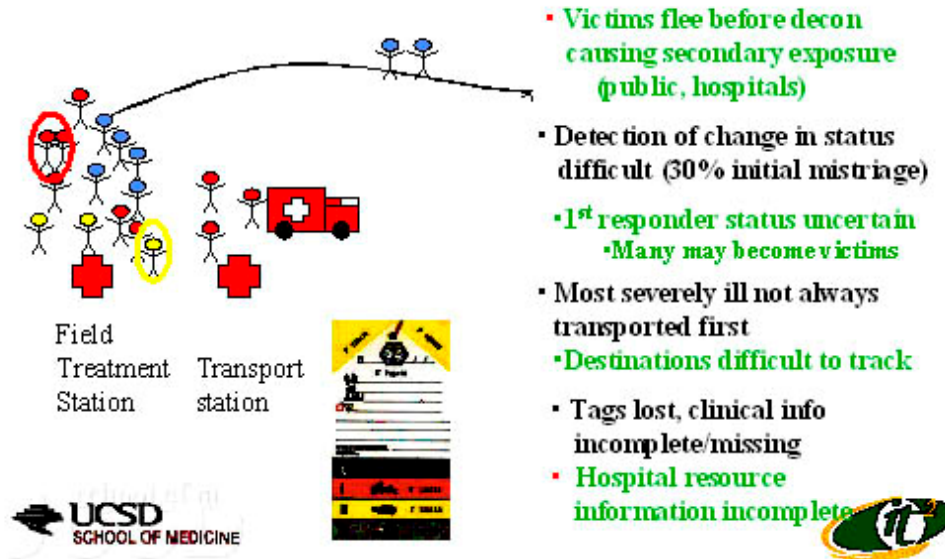


Figure 2. Problems with Current Field Care.<sup>14</sup>

In an attempt to find the answer, The Integrated Patient Tracking Initiative (IPTI) was developed. The IPTI was held at The George Washington University's Executive Center in Washington D.C., and was co-hosted by the Virginia Hospital and Healthcare Association (VHHA). It was a continuation of a series of nationwide conference calls among allied healthcare providers and groups of representative experts such as Emergency Medical Services, Hospital, Emergency Management, Academics, Public Health and Disaster Services personnel, the military, the Center for Disease Control, and the Department of Health and Human Services. A complete list of stakeholders is shown in Figure 3. The goal of the IPTI is to develop a list of requirements, best practices from previous deployments, technical solutions for data collection and exchange, and a framework for interoperability with other application systems.<sup>15</sup>

<sup>14</sup> UCSD, VA and Cal-IT<sup>2</sup> *Wireless Technology To Enhance Mass Casualty Treatment in Disasters*. 2003. Retrieved January 25, 2007, from [http://health.ucsd.edu/news/2003/10\\_23\\_WIISARD.html](http://health.ucsd.edu/news/2003/10_23_WIISARD.html).

<sup>15</sup> K. Robyn, 2006. EMS magazine's resource guide: Technology in EMS-patient tracking systems. April 2006.

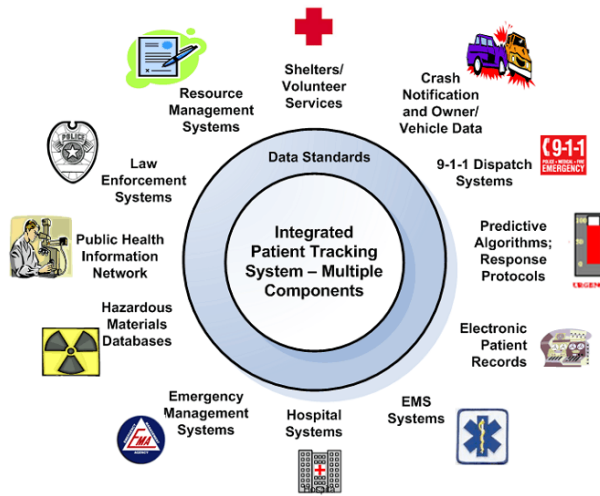


Figure 3. IPTI Stakeholders.<sup>16</sup>

The IPTI is comprised of three phases. Phase I focused on three areas: a) patient care perspective, b) emergency management and hospital planning perspective, and c) disaster service and public health perspective.<sup>17</sup> Phase II focuses on the identification and development of additional components needed to support communities in implementing patient tracking systems. Phase III is designed to “test drive” and refine the framework completed in Phase II. The project team will accomplish this by working with communities that have recently procured or implemented patient tracking systems to review their processes using the framework.<sup>18</sup> At the time of this research, Phase I had been completed and it was discovered that there were several systems already in use and more in the planning phase, most of which followed different standards and were not interoperable.

Due in part to the work of the IPTI, several new systems are being developed for use in the civilian population and the military that follow standards to include compatibility and interoperability, flexibility, clinically based data, secure data exchange, and automatic incident recording. One such system is a federally funded, \$4.1 million,

<sup>16</sup> UCSD, VA and Cal-IT<sup>2</sup> Wireless Technology To Enhance Mass Casualty Treatment in Disasters 2003.

<sup>17</sup> COMCARE Emergency Response Alliance. 2006. *Integrated Patient Tracking Initiative Phase I: Requirements Definition Proposal*. Retrieved 12 December 2006, from [www.comcare.org](http://www.comcare.org).

<sup>18</sup> *Welcome to the integrated patient tracking initiative website*. Retrieved March 21, 2007, from [http://www.comcare.org/Patient\\_Tracking/IPTI\\_Index.html](http://www.comcare.org/Patient_Tracking/IPTI_Index.html).

three-year contracted research project at the University of California, San Diego (UCSD). The project is being directed by Leslie Lenert, M.D., UCSD associate professor of medicine and chief of the Laboratory for the Study of Patients' Preferences at the Veterans Administration San Diego Healthcare System. Research has begun with controlled studies of individual components and will culminate with a randomized trial conducted during a simulated weapon of mass destruction (WMD) attack. The goal of WIISARD is to use sophisticated wireless technology to coordinate and enhance care of mass casualties in a terrorist attack or natural disaster for a period of hours to days, while national medical resources are being marshaled to aid in delivery of definitive care.<sup>19</sup> WIISARD will provide emergency personnel and disaster command centers with medical data to track and monitor the condition of hundreds to thousands of victims on a moment-to-moment basis, over a period of hours to days at the disaster site. In addition, WIISARD will use technology to enhance communication among emergency team members and ensure their safety by tracking the "hot zone," or location and wind drift of the chemical or radioactive matter used as a weapon of mass destruction against civilians. The system will operate using hand-held devices, commonly referred to as Personal Data Assistants (PDAs), and tablet systems which are based on modified and reconfigured off-the-shelf equipment. They will run on newly designed, cutting edge software called the Medical Visualization System (MVS). Figure 4 depicts the standard components of WIISARD.

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<sup>19</sup> UCSD, VA and Cal-IT<sup>2</sup> *Wireless Technology To Enhance Mass Casualty Treatment in Disasters*, 2003.



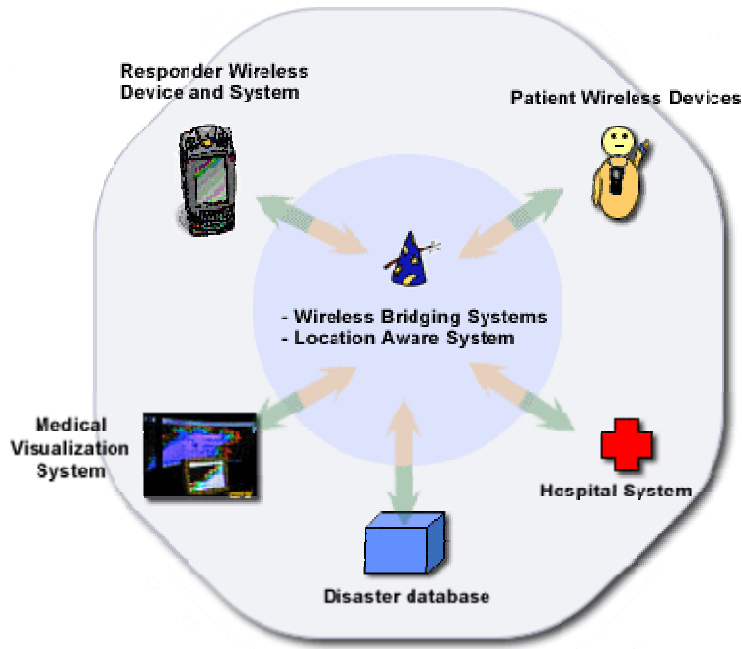


Figure 4. Standard components of WIISARD.<sup>20</sup>

WIISARD will operate by:<sup>21</sup>

- First creating a wireless 802.11 mesh network across the disaster site. Global Positioning Systems (GPS) units will be attached to the wireless network to enable estimation of people's position using signal strength triangulation.
- PDA-like units will be given to the first responders who will use them to enter reports of physical exam findings or treatments. Each one is equipped with a barcode scanner to accurately identify medications and accurately link patients with specific medication doses. Triage personnel can also enter additional patients with this device. The information is available and accessible to all other facets of the disaster response.
- First responders will hang electronic radio-frequency identification (RFID) tags around the neck of the patient. Responders will be able to enter the triage status of their patient on the tag; it will be recorded on the tag and also transmitted to the system's central database for tracking of that victim. Flashing triage lights will correspond to the triage status assigned. When the patients are transported, the triage tags will carry the electronic medical record of what has happened at the site with the patient.
- Figure 5 shows a pictorial representation of how WIISARD functions.

<sup>20</sup> UCSD, VA and Cal-IT<sup>2</sup> Wireless Technology To Enhance Mass Casualty Treatment in Disasters, 2003.

<sup>21</sup> M. C. Curran, 2006. *Tech specs: Specifics on WIISARD system set-up*. Retrieved March 6, 2007, from <http://www.calit2.net/newsroom/article.php?id=845>.

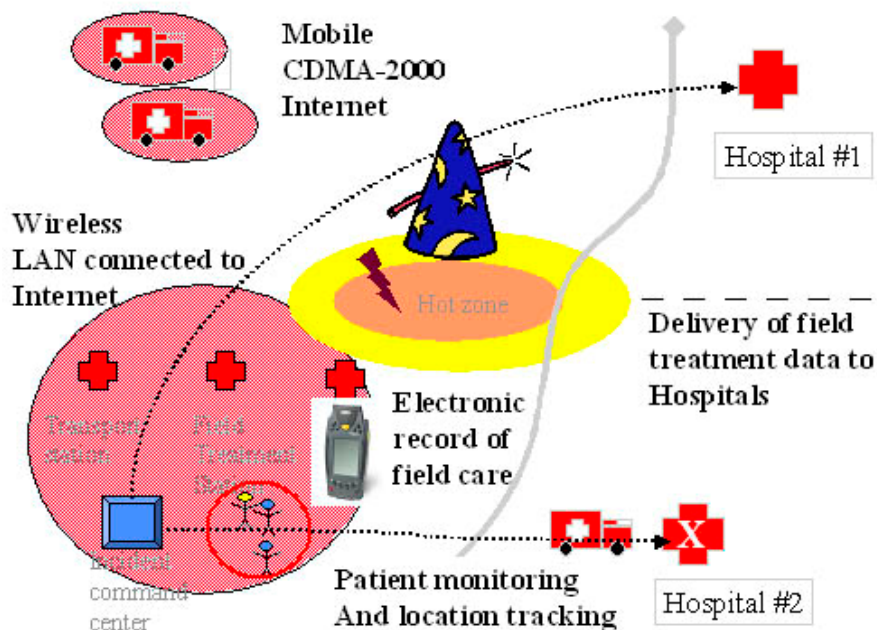


Figure 5. Demonstration of how WIISARD functions.<sup>22</sup>

### 3. The Tactical Medical Coordination System

When a medic is treating a patient, time is the enemy. Each second saved enhances a patient's chances of survival. A new system is being developed for the United States Navy at the Department of Energy's Pacific Northwest National Laboratory in collaboration with the Naval Aerospace Medical Research Laboratory of Pensacola, Florida, to help Navy Corpsman work more efficiently. The goal of the system, which is called the TacMedCS, is to improve upon the current paper tag system used for treatment information, by expediting the process Corpsman use to assess injuries, administer treatment, and transport patients. TacMedCS relies upon radio frequency technology, electronics, and GPS to quickly store, record and transmit data on patients. The system revolves around a wristband or dog tag, as shown in Figure 6, which contains an RF tag that is encapsulated in rubber. The tag, which was also developed by Pacific Northwest, consists of a tiny silicon chip and antenna, and can store up to 110 characters of data. The tag was designed to be read from up to four feet away in less than a second allowing

<sup>22</sup> UCSD, VA and Cal-IT<sup>2</sup> *Wireless Technology To Enhance Mass Casualty Treatment in Disasters*, 2003.

the Corpsman the freedom to move about. The purpose of the tag is to serve as a patient's electronic record holding medical conditions, blood type, and allergies.



Figure 6. RF tag.<sup>23</sup>

TacMedCS operates by:

- The first Corpsman on scene of a patient will slip a RF tag onto the patient's wrist.
- After rendering treatment, the Corpsman will scan the RF tag with a hand held electronic device called an "interrogator" as shown in Figure 7. The "interrogator" will automatically format the tag. After which, a screen will appear on the "interrogator" that the Corpsman will be able to simply click and point on to enter details about the patient's status. The information is then stored on both the RF tag and the "interrogator".
- Once all the information has been entered and saved, it is securely exported to the shared database, MedCOP.
- MedCOP can then give a detailed operational picture of the medical situation to providers, support personnel, and command staff.



Figure 7. Tactical Medical Coordination System.<sup>24</sup>

<sup>23</sup> *US dog tags: Past, present and future*. Retrieved April 14, 2007, from <http://www.military-dogtags.com/id19.htm>.

<sup>24</sup> *Virtual medical system beams navy into 21<sup>st</sup> century*. 2000. Retrieved January 25, 2007, from <http://www.pnl.gov/news/2000/00-26.htm>.

#### 4. The Battlefield Medical Information System-Joint/Tactical

As a former Army medic, Tommy Morris, Director of Mobile Computing at the Army's Telemedicine and Advanced Technology Research Center (TATRC), knew that there are no substitutes for speed and accuracy when treating patients on the battlefield. Using his past experiences, Mr. Morris and his team from TATRC received Congressional funding in 2001 to develop a new way for medics to treat wounded soldiers. BMIS-T was created to replace the inefficient medical forms and time-consuming paper files, by allowing medics to use a hand held device to store, retrieve, and transmit medical information electronically while on location. It provides an all-in-one suite of mobile applications that empower providers, via access to critical medical information and powerful clinical and decision support tools, to accurately create an electronic health record. BMIS-T also synchronizes with joint health surveillance and medical information systems from the earliest echelons through chronic care provided by the Veterans Administration.<sup>25</sup>

BMIS-T revolves around a Hewlett-Packard (HP) iPAQ Pocket PC, shown in Figure 8, and a Personal Information Carrier (PIC). A Microsoft Windows Mobile operating system allows it to transmit on a pre-existing wireless network while in the field to a back end infrastructure that is anchored by an array of hard wired HP Itanium servers.



Figure 8. Hewlett-Packard iPAQ Pocket PC.<sup>26</sup>

<sup>25</sup> *From the Front Lines: Mobile Healthcare Case Study. 2005.* Retrieved December 20, 2006, from <http://www.tatrc.org/>.

<sup>26</sup> *From the Front Lines: Mobile Healthcare Case Study. 2005.*

The iPAQ is used to access data that is contained on the PIC, shown in Figure 9, a flash memory device, similar to a soldier's dog tag that is carried on a chain. The PIC holds a service members complete medical history including immunizations, dental and ophthalmic records, and known drug allergies.<sup>27</sup>



Figure 9. Personal Information Carrier.<sup>28</sup>

Through the use of C++ and Microsoft Visual Studio 3.0, the iPAQ uses natural language processing to turn simple on screen point and click touches into XML based textual clinical notes in seconds. It standardizes how inputs are recorded through the use of embedded standard military text. It helps to ensure correct treatment is followed by the caregiver by suggesting a diagnosis and treatment plan which is based on the care giver's abilities. It also provides a full array of medical references.

BMIS-T operates by:

- Upon deployment a soldier is issued a PIC. His/her complete medical record is electronically uploaded to the PIC.
- Upon deployment, medical care providers are issued iPAQs.
- While in theatre, medical care providers can interface with the injured service members PIC through the use of their iPAQs.
- The iPAQs offer simple point and click screens and drop down menus for ease and standardization of entries. They also offer complete medical references and detailed treatment plans based on the information that is input.
- Once data has been written to the patients PIC, the iPAQ gives the option of wirelessly transmitting the data if a wireless network is accessible. If no

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<sup>27</sup> Microsoft Corporation, 2003.

<sup>28</sup> *From the Front Lines: Mobile Healthcare Case Study*, 2005.

wireless network is available it can save and hold the data. If available, the iPAQ can also be placed in a cradle and it will automatically sync with the network or it can be directly hard wired to the Internet. All transmissions are encrypted by secret-key block encryption algorithms.

- Upon transmission from the field, the patient's data is sent to the Battalion Aid Station or Theatre Hospital. From there it is transmitted to the Garrison Hospital and a central clearinghouse, as shown in Figure 10. Military commanders have the ability to access the data in the central clearinghouse which gives them the ability to assess potential threats at a theatre level

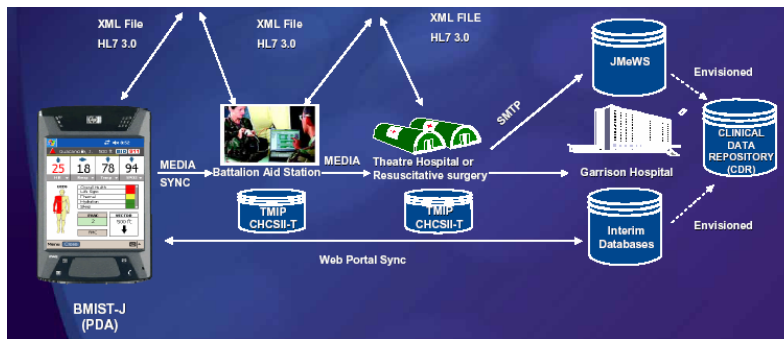


Figure 10. Data flow from BMIS-T.<sup>29</sup>

## B. STRENGTHS AND WEAKNESSES

### 1. WIISARD

On May 20, 2006, Researchers from the California Institute for Telecommunications and Information Technology (Calit2's) WIISARD project successfully demonstrated their mass-casualty patient tracking system during the California EMS Authority's annual Rough and Ready on May 7, 2006, which was held at NASA AMES Moffet Field, in Santa Clara County.<sup>30</sup> This was the first time that the team traveled outside of the San Diego area for a drill, and it was the first time that they have worked with Disaster Medical Assistance Teams (DMAT) in an exercise. The results were very successful. The system enabled the creation of real-time electronic medical records of victims/patients triaged at disaster scenes. The information both aggregated and individually, was available to medical personnel throughout the deployed WIISARD system to include supervisors at the scene, the command center and the

<sup>29</sup> *From the Front Lines: Mobile Healthcare Case Study*. 2005.

<sup>30</sup> Curran, 2006a.

receiving hospital. Medical and transport group supervisors were able to match the conditions and needs of patients with real-time data on available resources such as ambulance availability and location and hospital status. “WIISARD's patient tags worked well. I was impressed”, noted Ted Chan, medical director, Department of Emergency Medicine, UCSD Healthcare. “This system is useful both immediately after a disaster occurs and in the hours-to-days afterwards, where you are still tracking patients in the field. Patient tracking is a real challenge for any disaster situation where you have many victims.”<sup>31</sup>

## 2. TacMedCS

Testing of TacMedCS began in March of 2003. The system was implemented by Fleet Hospital 3 (FH-3), which is a 116 bed expeditionary medical facility stationed in Iraq. FH-3 utilized the system on approximately 242 wounded coalition personnel, prisoners of war, and civilians.<sup>32</sup> The point man for the testing was FH-3's nursing informatics officer, LT David Everhart. LT Everhart stated that, “As a real-time patient tracking device, TacMedCS has proven its worth. The Technology has enormous potential... As the data travels with the patient, an entire medical history can be assembled and stored...”.<sup>33</sup> He felt that being the first testing of the system, that it was very successful. It was noted though that the system was not complete and a few problems and areas of concern were encountered. These problems included: some of the RF tags being unable to be scanned, the ruggedness of the scanning units was questioned, and the size of the scanning units was sometimes considered to big and bulky.<sup>34</sup>

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<sup>31</sup> Curran, 2006a.

<sup>32</sup> C. Munsey, 2004. *New tracking system relays casualty data from battlefield*. Retrieved January 25, 2007, from [http://www.namrl.navy.mil/NAMRL\\_NEW\\_NEWS/TACMEDCS%20Navy%20Times%20March%202004.htm](http://www.namrl.navy.mil/NAMRL_NEW_NEWS/TACMEDCS%20Navy%20Times%20March%202004.htm).

<sup>33</sup> D. Ryan, 2003. *FH-3 tests patient tracking system in Iraq*. Retrieved January 25, 2007, from <http://www.globalsecurity.org/military/library/news/2003/05/mil-030524-nns01.htm>.

<sup>34</sup> B. Brewin, 2006. *Battlefield medical systems join Digital Age*. Retrieved January 25, 2007, from Coalition Warrior Interoperability Demonstration 2005 Final Report 2005. No. IT02.55.



### 3. BMIS-T

Since its invention, more than 1,000 BMIS-T devices have been utilized by the military, and disaster relief teams. A similar system, BMIS-J (Joint) has been developed for use with White House staff. BMIS-T gives medical providers an all in one tool for medical readiness, clinical information capture, diagnosis, and logistics to improve patient care and record keeping which contributes to a better informed, more efficient military force. Because of the proven durability and flexibility of the iPAQ, it has allowed for the use of a commercial off-the-shelf (COTS) product. This has greatly reduced the cost per unit. Power consumption has also been a great advantage of the system. “We get about 72 hours of normal use with 100 hours of standby with the iPAQ”, noted Morris.<sup>35</sup> Because it eliminates the carrying of volumes of medical reference books, boxes of patient histories, and stacks of paper, the use of BMIS-T allows the medic to document on the move in less time which means greater accuracy. Since it runs on a Microsoft based product, BMIS-T can be run on most government desktops, laptops and other devices without incurring significant additional costs. Due to the rapid capture and compilation of data, BMIS-T allows military commanders to get an almost real time snapshot of troop health and plan movements more effectively and efficiently which in turn gives them a tactical advantage. Since the device is POINTSEC FIPS 140-2 and PDA Defense FIPS 140-2 certified, as well as Health Information Privacy and Portability Act (HIPPA) compliant [18], it is also able to interface with minimal security risks. Some key challenges that face BMIS-T are hardware, software infrastructure, evolving business processes and interoperability and integration.

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<sup>35</sup> Hewlett-Packard, 2004. *Mobile point-of-care solutions support medics on the battlefield Hewlett-Packard Case Study* Retrieved January 27, 2007, from [http://www.tatrc.org/website\\_bmist/index.html](http://www.tatrc.org/website_bmist/index.html).



	<b>WIISARD</b>	<b>TacMedCS</b>	<b>BMIS-T</b>
primary users	Civilian	Military	Military
hardware availability	COTS	proprietary	COTS
software availability	proprietary	proprietary	COTS
wireless capability	yes	yes	yes
storage capability	yes	yes	yes
portable device	yes	yes	yes
pre-downloadable patient tag	no	no	yes
wristband	no	yes	no
dog tag	yes	yes	yes
point and click capability	yes	yes	yes
scanner capability	yes	yes	yes
voice capability	no	no	no

Table 1. Summary of capabilities

### C. BEST OF BREED

Over the past few years, there have been tremendous advances made in the area of patient tracking; however, there is still a long way to go. Currently there are three viable systems in use, BMIS-T, TacMedCS and WIISARD. The pros and cons of each have been listed in the previous section. One major factor that has not yet been mentioned is the fact that the three systems are not compatible with each other. The benefits of patient tracking systems have been documented in previous sections. If these benefits are to be truly recognized then there must be one system that is accepted and utilized, industry wide. If the systems are not compatible, there will be as much of a problem or possibly even bigger than not having a system at all. One way to overcome this obstacle is to take the pros from each system and use them to create a single, industry wide system. The focus of this research is to outline the capabilities of the “best of breed” system, not the obstacles that would be encountered in developing it.

First, as shown with all three previously mentioned systems, a hand held device is crucial. The HP iPAQ seems to be the best choice. It has already proven its durability and flexibility. It has the greatest transmission capabilities, being able to operate wirelessly, hard wired or through a cradle. It has the greatest storage capacity. It is

Microsoft compatible, which means that it will be able to interact with numerous types of hardware and software. It is also a COTS product, which means that it is easily available at a reasonable cost.

Next, there must be something for the iPAQ to interface with. In the case of the military, a dog tag size card with both RF and flash capabilities would be the best choice because of its ability to be loaded with the patient's previous medical history prior to entering the theatre of operations. Having the patient's medical record loaded on the device will greatly increase the medic's efficiency and effectiveness when treating the patient in a less than desirable situation. Offering both RF and flash capabilities on the device will give the medic the ability to be agile if needed, but also the option to directly download. The military should also strongly consider supplying medics with wristbands, similar to those that are used with TacMedCS that have embedded RF chips to use as backup devices. The reason for having a backup is so that if a dog tag was compromised or destroyed when a patient was injured the medic would still be able to utilize technology without having to revert to the cumbersome paper system. The iPAQ would communicate with the RF chip in the wristband the same way it would with the dog tag. This would allow it to still be able to write information, propose treatment plans, and forward information to commanders for analysis. In the case of disaster relief or humanitarian assistance the wristband would be the only way to go.

It is imperative that the user interface be familiar and user friendly. This will increase the speed in which the medic can input information which ultimately will give the medic more time to treat the patient. The more time the medic has to treat the patient, the better the chance of survival. An iPAQ running Microsoft Windows Mobile operating system with C++ and Microsoft Visual Studio 3.0 would be the best choice. The point and click screen and drop down menus are as user friendly as current technology allows. When in a combat situation, there are a lot of distractions and having the built in diagnosis and treatment plans make it easier to care for a patient by helping to minimize the thought and decision process.

Finally, the system must be compatible with other hardware and software. Utilizing a Microsoft based operating system with COTS hardware makes interoperability much easier since they are readily available and are much easier to implement than custom applications. Utilizing Microsoft also gives the ability to interact with other software. This allows military commanders the ability to utilize the data gathered for different functions such as planning troop movement, historical analysis, and medical readiness.

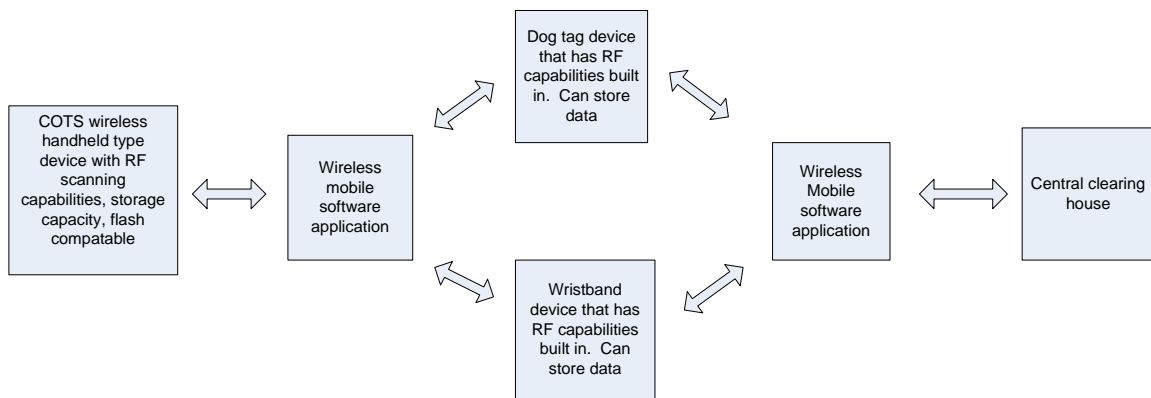


Figure 11. Best of Breed functionality figure.

## **IV. CONCLUSION**

### **A. SUMMARY**

The idea of a Patient Tracking System stems in part, from the vision used by technology developers and potential users in the package delivery services. Tracking systems can monitor the movement of a package, both material and human. Applications have been developed that enhance tracking in the supply chain, integration of inventory and logistics systems, automated monitoring of product availability and quality, control of critical infrastructure facilities, and improved security. Having proven its efficiency-enhancing capabilities in the package tracking industry, the same type of technology has begun to emerge in the area of medicine. When it comes to patients, the use of this technology can allow a medic to treat a patient more effectively and efficiently which translates into better care and a greater chance of survival.

Researching and choosing technologies that will function in both the military and civilian communities is a dynamic topic. This paper has only touched the surface of functionality. Research will need to be conducted into security issues and costs, as well as field testing to make sure the system operates as needed.

### **B. THESIS QUESTION REVIEW**

1. Why is there a need for patient tracking systems?

This study began by reviewing past historical and military events to determine if there was a need for Patient Tracking Systems.

2. What are the different systems that are currently available?

Tracking systems have been used in the package tracking industry since the early 1990s and have proven to be extremely efficient and usable. This success has begun to transfer into the medical field with the implementation of patient tracking systems. Even though tracking systems in the health care environment are a new idea and have not been widely used to date, research and documentation have shown that they also can be very efficient and useful.

3. What are the strengths and weaknesses of the available systems?

Research has identified four available systems, two military and two civilian. Each system is different in its own aspect, but they all are designed to accomplish a similar task. One of the key strengths demonstrated in each system is the ability to read and write information to a chip that the patient will keep with him at all time. This tremendously reduces the amount of time it takes to get a patients history which allows the medic more time to do his primary job, saving lives. Another strength of the patient tracking system is the ability to transmit wirelessly. This allows medics the ability to move around so they can tend to more then one patient at a time. As with any technology there are some weaknesses. The greatest weakness found in this research was the interoperability of the existing systems. Although each system works great in their own network, none of them possess the ability to work in systems outside theirs which significantly hampers the ability of organizations to work together.

4. Can we develop a “best of breed” system for patient tracking from the technology of these available systems?

Each system has its own strengths and weaknesses. This paper has taken the strengths from each and tried to combine them into one functioning system. This “best of breed” system would be based around a wireless hand held device. This device would be able to wirelessly read and write to a patient’s id chip. It would be able to wirelessly transmit data from the field back to a treatment facility or a central clearing house. It would also contain a built in reference section that would allow the medic the ability to quickly research injuries and illnesses that they were not accustomed to seeing.

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