

Wireless Handheld Electronic Devices Assisting Emergency Medical Field Personnel

Final Report

Grant Agreement ME 99110

Submitted to:

Pennsylvania Department of Health
Emergency Medical Services Office

This project is funded, in part, under a contract with the Pennsylvania Department of Health. Basic data for use in this study were supplied by the Pennsylvania Department of Health, Harrisburg, Pennsylvania. The Department specifically disclaims responsibility for any analyses, interpretations or conclusions.

Submitted by:

The Pennsylvania State University
Applied Research Laboratory
P.O. Box 30
State College, PA 16804-0030

Ed Crow, Project Manager
(814) 863-9887
ecc1@psu.edu

Janet Jonson, Project Coordinator
(814) 863-4458
jlj6@psu.edu

PURPOSE

The Pennsylvania State University Applied Research Laboratory (ARL) has undertaken this project to help the Pennsylvania Department of Health Emergency Medical Services Office improve overall emergency medical response through more effective, timely collection and handling of critical patient data. Previous study investigated the viability of using a wireless, handheld electronic device to provide a critical information link between Emergency Response Service (EMS) providers and hospital emergency departments. (See *Final Report Grant Agreement ME 98175 "Pennsylvania Data Analysis and Strategy Development for Improving Emergency Response to Rural Highway Trauma."*) That effort, which spanned SFY 1998-99, resulted in the development of a data collection and communication system using wireless handheld devices.

In this current effort (SFY 1999-2000), the prototype system underwent field testing involving two ambulance companies to determine the practicality of using such devices at the scene of accidents and en route to the hospital. Software was integrated to enable patient data to be wirelessly transmitted and displayed in a fax format for emergency department physicians. Commercial reporting software was also integrated to enable the data collected by the EMS providers to be used for automated reporting to the State Department of Health. These upgrades have the potential to improve the timeliness and accuracy of communication, as well as streamline EMS providers' administrative duties.

SUMMARY

This phase of the research examined the use of technology in actual emergency situations. It identified and addressed additional operational or design needs required to maximize the beneficial aspects of the system and increase the likelihood of its acceptance by EMS providers. The following list summarizes the goals of this effort (in bold) and the results obtained.

1. **Integrate fax software to enable real-time communication with the emergency department via the handheld device.** System modifications were made to enable the units to wirelessly transmit critical patient data using conventional faxing technology. The software is operational and is undergoing minor changes to improve its effectiveness.
2. **Integrate commercial software into handheld application to automate PA pre-hospital trip report.** Software for the handheld was integrated with Medi-Media's EMStat, an approved commercial reporting software. The system was subsequently tested and shown to enable EMS providers to populate electronic reports required by the state on a desktop PC with data uploaded from the handheld devices.
3. **Perform field operational tests to assess the value of the wireless handheld devices in the field. Examine user interface requirements and the physical challenges of using the device in a time-critical situation under varying environmental conditions.**

Overall results:

- Use of the handheld in trauma situations was limited by the number and immediacy of tasks required of the EMS responders at the accident scene. Considerably more use occurred while en route to the hospital and during routine, non-emergency patient transport trips. Overall, user feedback was positive.
- Additional enhancements were identified, evaluated, and added to the system. These included physical (packaging) modifications and enhanced user interface screens.

- Various methods for measuring the value of the system—in terms of improved patient care and reduced administrative requirements—were identified and will be used in future field operational trials.

Specific Results:

- *Utility of the device (form factor, touch screen, battery life, durability, etc.)* – Overall utility of the device was determined to be high, although durability became an issue, requiring protective cradles to be added to the handheld devices. Some users exhibited a significant learning curve with regard to entering data; many such users exhibited signs of technophobia. A training manual was developed to aid in the learning process and hands-on training was provided to increase users’ comfort level with the technology.
 - *Layout and format of the graphical user interface (GUI)* – Based on user recommendations, ARL changed the order and method of entry of several GUI screens.
 - *Compatibility of the system in real-world field environment* – Achieving the small form factor and low cost of the handheld units has required a sacrifice in durability and ease of use. However, ongoing technological advances are overcoming these limitations and improving the readability of the screens, the battery life, and ease of data entry. Although the handhelds are somewhat fragile, allocating the units to EMS as a personal device (as opposed to issued equipment) seems to decrease unit breakage and mortality.
 - *Communication system (wireless modem) interface and functionality* – Testing of the communication system was limited, as a result of application limitations and server-related issues. The fax system was enhanced to handle multiple calls concurrently. Other “glitches” in the communication software were identified and corrected. This testing will resume in future field operational trials.
 - *Layout and format of the electronic fax bulletin* – At the request of the Emergency Department (ED) physicians, the fax sheet format was changed to improve readability and to accommodate multiple readings of vital signs. The system was designed to allow a flexible format for the fax in order to easily accommodate future changes.
 - *Integration and functionality with the desktop reporting software* – As described in item 2 (above), the software was integrated and tested. Deficiencies were noted and corrected. The interface is now robust.
4. **Identify opportunities for commercialization of the system to ensure ongoing system enhancements, widespread availability, and continuous user support.** The system is open database compliant (ODBC), meaning that it was designed in an open standard. ARL held a technical meeting with all state-approved trip sheet vendors to alert them to this project and entertain potential technology transfer relationships. Discussion is ensuing with a company that has expressed an interest in further developing the system and implementing it in the field.

BACKGROUND

Previous efforts to improve emergency response have focused on more quickly alerting emergency services to the existence of an accident. Considerable advancements have been made to improve identification of accident type and location and optimal dispatch of emergency services.

This effort addresses a second communication void, which exists between the EMS providers who respond to the accidents and the hospital emergency departments. Currently, EMS providers record field-collected information on notepads, bandages, or any other writing surface available (including the palms of their hands) at the scene of the accident. Additionally, voice communication with the hospital is subject to the availability of a radio signal and a free ED physician. When EMS providers arrive at the hospital with the patients, they must transfer pertinent patient information to ED personnel for consideration in patient treatment and for inclusion in patient records. Under current operating conditions, data accuracy and the timeliness of data submission are sub-optimal. Furthermore, the data submission task must be repeated by the EMS providers, who are required to file and transmit a report on each incident to the respective Department of Health Regional Center. Reporting is a time-consuming, secondary responsibility that can suffer from inaccuracies, given the lag time between when the EMS personnel treat a patient and when they have the time to file a report on the incident.

The need for an automated data collection and communication system is apparent. The prototype system developed under the previous effort offers potentially significant improvements in communication. This effort involved a looped system aimed at operationally testing the system, making the ensuing improvements, and testing those improvements. Although further refinements are needed, the system has proven its viability and acceptability to the emergency response community. See Figure 1 – System Diagram.

STUDY APPROACH

To implement handheld devices in the field and demonstrate their usefulness, ARL took the following steps to prepare for field testing:

1. Involved the user (EMS personnel, ED physicians) in determining what information is required to optimize patient care.
2. Synthesized the information requirements into an appropriate information architecture.
3. Selected the hardware, software, and cellular service necessary for implementing the system and achieving the goals of the program.
4. Integrated pre-existing handheld software with commercially available Pennsylvania pre-hospital trip report software. Integrated hardware and software into an operational system.
5. Developed a database management infrastructure to populate the pre-hospital trip report database and selected the data to be faxed to the ED.
6. Demonstrated the integration of the software and hardware in field tests in service areas within the Seven Mountains and Susquehanna Regional Councils. Modified the system during these field tests to improve user friendliness and usability of the technology.
7. Assessed the system's usefulness and defined the upgrades necessary to perform future field trials.

This approach is shown in Figure 2, Concept Integration and Field Tests.

Telemedicine Interface

Increase Effectiveness of Communicating Patient Health Status between EMS and Emergency Room Physicians

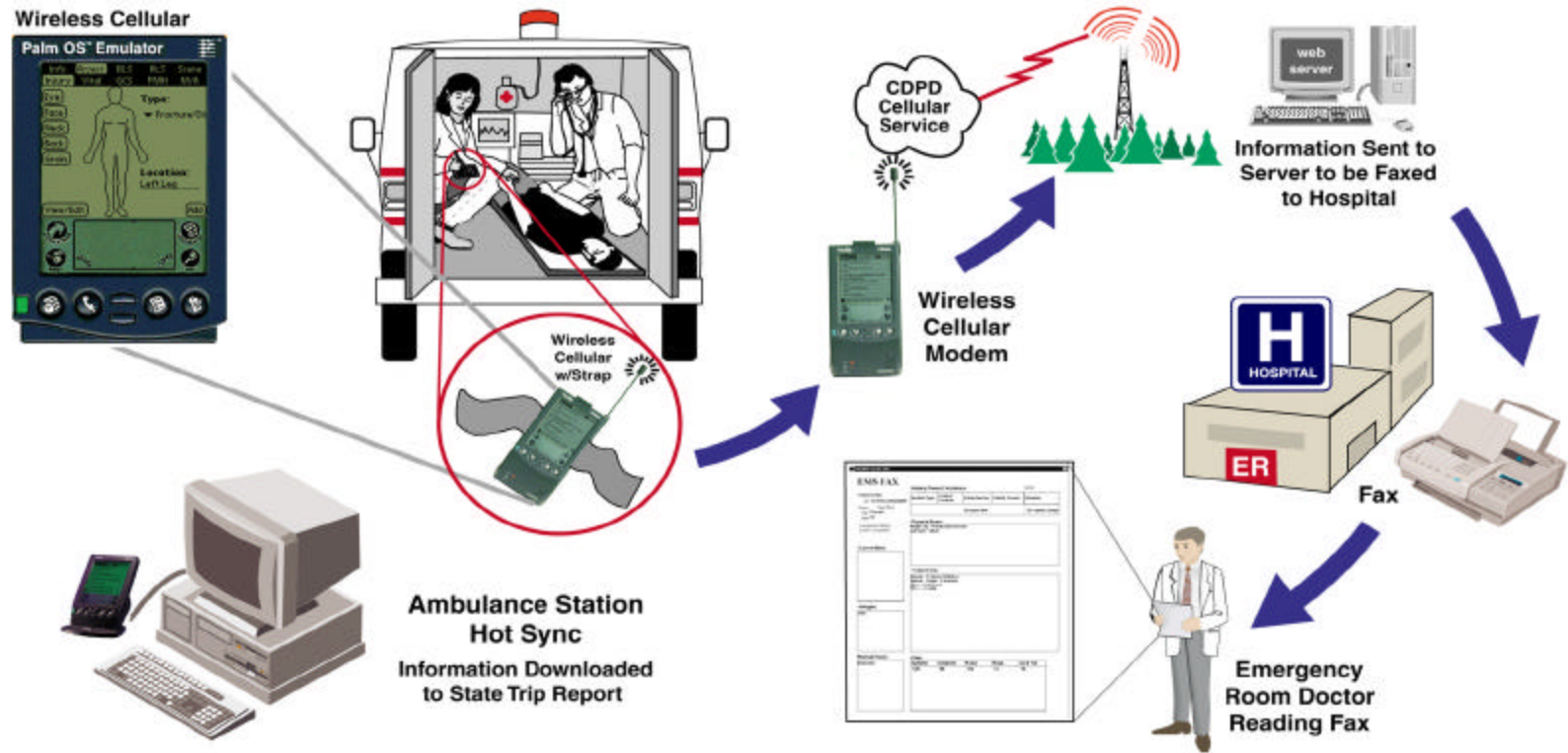


Figure 1 – System Diagram

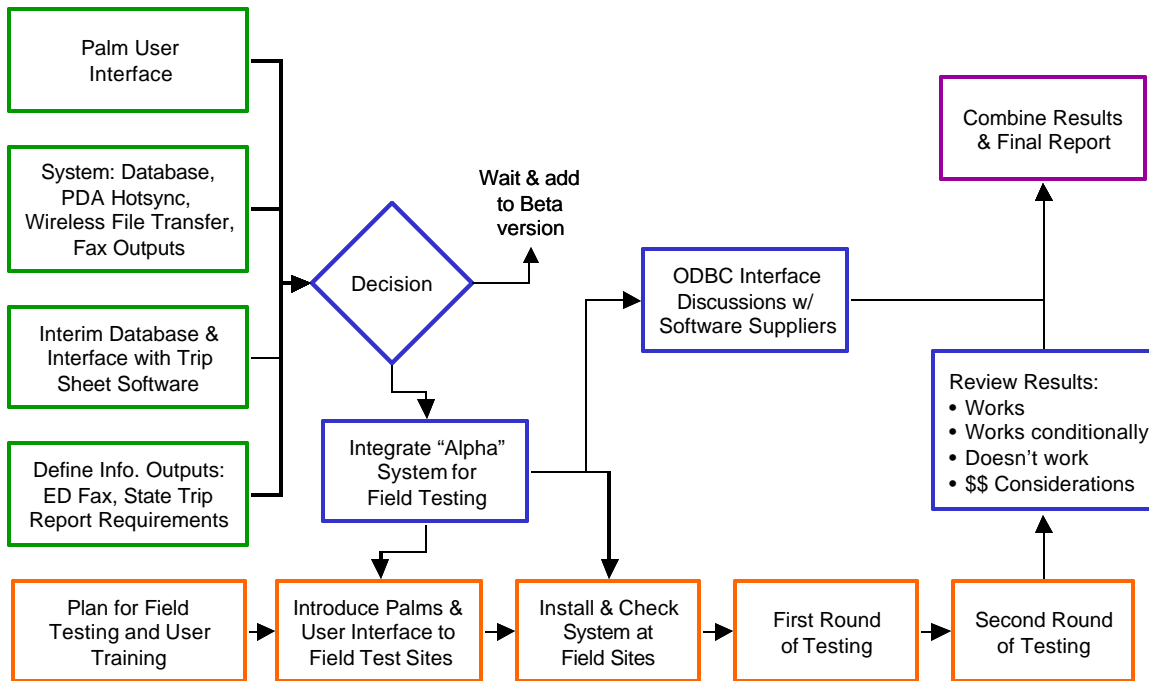


Figure 2 – Concept and Field Tests Overview

DISCUSSION

Task 1 - Determination of user requirements.

EMS providers, ED physicians, and the Pennsylvania Department of Health (PA DOH) all provided input regarding the data and information to be collected by the system. While their requirements were similar overall, each group had a unique viewpoint in terms of the order and priority of the data fields to be collected. For example, EMS providers need to collect data for the Pennsylvania pre-hospital trip report and for internal data requirements. Physicians want data on the sequence of events and treatments as they transpired in the field. And the PA DOH seeks to increase the accuracy and timeliness of data submission from the field for the pre-hospital trip report. A consensus was reached on the data requirements and a common, collective data set was selected for field tests.

Task 2 - Integration of hardware and software into an operational system for field tests.

Once the data set was determined, the next step involved integrating the software applications with the selected hardware. First the data collected by the handheld units had to be formatted to meet the needs of each user group. An application was developed to serve as an interface between the handheld database and both the approved state trip reporting software application and the wireless transmission functions. The application was integrated and tested in-house with the EMStat desktop trip sheet reporting software, provided by Med-Media, Inc, to enable the data collected on the handheld to be uploaded into the required reports. The in-house testing focused on the viability of collecting data on the handheld, wirelessly transmitting the data, hotsyncing with a desktop PC, and uploading the data into EMStat.

Initially, the data that was transmitted wirelessly was collected using off-the-shelf server software, which ultimately proved unstable for this application. We developed new server software to use

in the field testing which has proven to be more stable, reliable, and cost-effective solution in field tests. We anticipate that as the wireless market becomes better defined, more software options will be available and standards for wireless communications will evolve.

Task 3 - *Conducted field tests in service areas within Seven Mountains and Susquehanna Regional Councils.*

The system developed was to be tested in two geographic areas—the Seven Mountains region, served by the Alpha Community Ambulance Service, Inc., and the Susquehanna region, served by Danville Ambulance, Inc. The system first was installed at Alpha, which is located in State College, Pennsylvania. Alpha has been actively involved in the evolution of this system, both in an advisory and a participant role. Following system setup, Alpha personnel participated in testing to determine the functionality, accuracy, and stability of the system. Following the initial tests, training was provided for Alpha users in early February 2000, in two four-hour evening sessions. The training consisted of general handheld usage, specific application training, and use in simulated emergencies. The users were trained on how to download the information on the handheld into the pre-hospital trip report software (EMStat) on the desktop PC. The wireless transmission was not introduced in the initial training because the necessary software changes and testing were not complete. After training, the users used the handhelds in the station to become more familiar with the software and hardware and then began to use them in the field. A number of unforeseen system bugs—related to the uniqueness of the pre-hospital trip software—were identified and corrected. See Test Plan, Appendix A.

Task 4 - *Assessment of field tests in Seven Mountains and Susquehanna Regional Councils.*

Early assessments of the field tests were based on observations and interviews. Users expressed enthusiasm for the application. The more technically inclined users have incorporated the handhelds into their daily routines. These users better understand the technology and how it can be used to increase their efficiency in reporting. Some users have taken the initiative to create their own solutions. For example, some users take complementary notes in a memo pad application on the handheld; these notes can be cut and pasted into the pre-hospital trip report narrative. The learning curve for less technically inclined users was considerably longer. These users generally showed more reticence in relying on such technology and less confidence in their ability to use it. All users—whether technically oriented or not—must understand and know when and how these tools can be used to make their jobs more effective and easier.

The field tests demonstrated the feasibility of the overall concept and supported the use of the technology for gathering information in the field. Some issues that were identified and are being addressed include:

- The adverse effects that some weather conditions have on screen appearance/readability suggest the need for protective covering or enhanced video capabilities
- The questionable durability of the handheld units indicates the need for protective casing
- The need for hands-free use by EMS personnel suggests the need for thigh straps or other attachment devices

These issues may not affect the functionality of the system, but they must be addressed to ensure user efficiency and user acceptance of the system.

RECOMMENDED FUTURE STUDY PLAN

Future studies are required to measure the improvements possible by implementing and using this handheld wireless technology in the field. The following approach is recommended for future field operational trials.

Measure System Benefits

1. Develop a plan for collecting field data during the operational trials. Determine the optimal information needed to evaluate the technology's benefit to users and administrators.
2. Integrate the handheld devices with the cellular communications available in the Seven Mountains and Susquehanna EMS Regions, where the field operational trials will be conducted. Install the system that was used to demonstrate the concept in the Wireless Handheld Devices Assisting Emergency Medical Field Personnel [DOH Contract ME99110, 1999].
3. Conduct field operational trials involving EMS providers from Seven Mountains and Susquehanna EMS Regions. Work with Centre Community Hospital in State College and Geisinger Medical Center in Danville to evaluate the wireless transmission of information to the Emergency Department.
4. Evaluate the system findings from field operational trials to determine usefulness, benefits, and areas for improvement.
5. Analyze the data collected and determine the expected (or potential) cost benefits of such a system.

Investigate Security of Wireless Communications

1. Investigate the possibility of using data encryption for wireless communications between the handheld units and the emergency department.
2. Survey existing encryption techniques.
3. Test encryption techniques to determine the security of transmitted data.

Develop Printing Options

Currently, the data collected on the handhelds must be downloaded to an Access database and used to populate reporting software. No other means exist for immediately viewing the data. This effort is directed at enabling the user to print newly-collected data upon arrival at the hospital. Such capability will be useful in situations where a wireless connection (for faxing) is unavailable or when time constrains prohibit the transmission of a fax.

1. Determine the format of the collected data that will be required to support printing capabilities.
2. Design and develop a desktop application to transform the hot-synced data from the handheld device into a report that can be printed on site.
3. Analyze the feasibility and usefulness of such an option in the ED.

Investigate the Possibility of "Pushing" Data to the Handheld Devices

1. Determine the procedures that 911 operations use to communicate information about emergency and non-emergency calls to EMS personnel.
2. Develop a strategy to capture the emergency and non-emergency call information electronically.

3. Investigate the design of an application to push the electronic information from 911 Operations into the handheld devices. Such information would include standard data—such as name and address—which require considerable time and effort to enter on a handheld in the field.

The results of these recommended field operational trials will be useful for planning the implementation of such a system for actual use. Exploring these varying options will enable ARL to identify the final system capabilities that will produce optimal patient outcomes and maximize medical personnel availability.

Appendix A – Testing Plan

Critical Uniform Reporting for Emergency Services (CURES) Field Testing Plan

PROGRAM GOALS:

1. Improve patient outcomes through expedient and efficient collection and exchange of emergency patient information between pre-hospital care personnel and physicians at the receiving facility (i.e., hospital).
2. Improve handling of necessary and required emergency response information to increase the accuracy, timeliness, and efficiency of administrative reporting.

PROGRAM OBJECTIVES:

Develop and implement a mobile data system that collects relevant pre-hospital emergency service information at the point of service and performs two subsequent functions:

- Forwards patient-critical information to the receiving facility prior to or upon arrival at the emergency department (ED)
- Uploads trip report data into formats suitable to meet the mandatory state trip reporting requirements

CURRENT STATUS:

With the support of Geisinger Health Systems, The Pennsylvania State University Applied Research Laboratory (ARL) developed a mobile data system prototype that includes a handheld electronic device programmed to allow EMS personnel to enter information using a touch screen. The system was developed with input from ED physicians and Emergency Medical Service (EMS) field personnel and administrators; however, the system has not been fully tested in an actual operational setting. To move from concept to implementation, two steps are planned—field tests (DOH II) and field operational trials (DOH III).

In field testing, EMS personnel will use the handheld system, assessing the software and providing feedback regarding features needed to maximize the use and utility of the system. The system will then be updated based on the feedback, and a revised version will be made available for field operational trials, which will place the system into actual operation in the two service areas (i.e., Susquehanna and Seven Mountains regions). Benefits realized by using the new system will be identified and measured.

FIELD TEST OBJECTIVES:

Determine what features of the mobile data system are needed to support the adoption and use of the system by EMS field personnel. Areas to assess include:

- The utility of the handheld device: form factors, touch screen, battery life, durability, etc.
- The layout and format of the graphical user interface (software application)
- Compatibility of system in a real-world field environment
- The communication system (wireless modem) interface and functionality
- The layout and format of the electronic fax bulletin to be transmitted to the ED
- The integration and functionality with desktop trip reporting software

FIELD TESTING APPROACH:

- Select two service areas and obtain a commitment of (non-monetary) support from EMS providers and EM Physicians
- Work with EMS service administrators to identify six EMS professionals (from each service) to participate in the field testing

QUALITATIVE MEASURES:

- Assess the type and form of information that is most useful for all end uses, including the ED attending physician’s immediate needs
- Assess the type and form of information that EMS personnel can practically record and provide

FUTURE QUANTATIVE MEASURES:

- Measure patient arrival time at ED, fax transmission arrival time at ED, and number or percentage of transmission failures/delays.
- Compare differences in times and transmission errors between Months 2 and 3. (See Schedule below.)
- Assess time savings realized by automating the administrative reporting required for the state trip report

KEY PERSONNEL:

Testing Coordinator:	Janet Jonson/Penn State ARL	814/863-4458	jlj6@psu.edu
Danville Service Area:	Scott Danowsky/PSGHS	570/271-8794	sdanowsky@psghs.edu
Centre County Service Area:	Chris Pedersen /Alpha Amb.	814/237-8163	cpederse@alpha.rba.com