# ITS and Transportation Safety: EMS System Data Integration to Improve Traffic Crash Emergency Response and Treatment – Phase II Report

**Final Report**

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This research project examines the linkages between ITS systems and the SHSP, focusing on three elements. The first element relates to the role of ITS in producing timely data on safety dimensions, including its visual representation in geographic information systems and related platforms. The second element examines the use of ITS with emergency medical services (EMS) and the data that can be used from EMS systems for safety planning purposes. The third element includes an analysis of innovative and new practices for capturing, sharing, and visualizing safety information required by emergency healthcare providers for enhanced levels of decision making and planning.

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## Table of Contents

Chapter 1. Introduction ..... 1
Chapter 2. Background and Study Focus ..... 3
Chapter 3. Methodology ..... 5
Chapter 4. Comparative Analysis across States ..... 7
Chapter 5. Comparative Case Analysis: Minnesota and Alabama ..... 9
Chapter 6. Regional Comparative Case Analysis: Rochester and Salt Lake City ..... 11
Chapter 7. Design Requirements of an Integrated Trauma Information System (CrashHelp). 15
CrashHelp Prototype Requirements ..... 15
Chapter 8. CrashHelp Prototype Design ..... 19
CrashHelp Architecture ..... 19
CrashHelp Data Flow Overview ..... 20
The Mobile, Handheld Application ..... 21
CrashHelp Emergency Department and System Oversight Application ..... 22
Stakeholder Evaluations of CrashHelp ..... 26
CrashHelp Deployment Analysis ..... 30
Chapter 9. Conclusion ..... 33
References ..... 35
Appendix A. The Need for Decision Support for EMS
Appendix B. EMS and Trauma Information Systems Comparison across States

## List of Figures

Figure 1. Overview of EMS Data Systems Today ..... 8
Figure 2. Model for Sharing EMS Information ..... 13
Figure 3. CrashHelp System Interfaces ..... 19
Figure 4. CrashHelp System Architecture ..... 20
Figure 5. Data Flow Diagram ..... 21
Figure 6. Mobile Application Screen Shots ..... 22
Figure 7. CrashHelp ED Application ..... 23
Figure 8. Incident Status Page ..... 23
Figure 9. Crashes – Map View Page ..... 24
Figure 10. Crash Profile Page with Microsoft Virtual Earth and Google Map View of Incident Location ..... 25
Figure 11. Data Layers Page ..... 26
Figure 12. CrashHelp Deployment Architecture ..... 31
Figure 13. CrashHelp Deployment Architecture ..... 32

## List of Tables

Table 1. Case Comparison in Alabama and Minnesota ..... 9
Table 2. Case Comparison in Rochester and Salt Lake City ..... 11

## Executive Summary

This paper stems from the second phase of research examining the extent to which emergency medical services (EMS) systems, a key component of Strategic Highway Safety Plans (SHSPs), can provide safety-related data for transportation safety assessment and planning purposes. These systems include integration of automatic crash notification (ACN), 911 dispatch, EMS, trauma, and health provider-level information. A literature review and expert interviews were completed during the first phase of this project and these highlighted the need for an integrated trauma information network system.

Following a comparative analysis of integrated trauma information systems across several states, initial prototype design and development of an integrated trauma information system solution, and an investigation of subsequent implementation steps, the "CrashHelp" prototype, was developed to inform, educate, and support decision making in communicating patient health issues related to road transportation safety and performance including emergency response to roadway crashes. The prototype integrates a range of data regarding motor vehicle crashes, emergency responses to those crashes, and related patient-care information in the pre-hospital and hospital settings. This paper describes iterative development of this application including stakeholder feedback from emergency response practitioners and emergency room physicians on the application and its practical usefulness. Finally, this report explores deployment options for use in Minnesota and beyond.

CrashHelp's two primary interfaces utilized by end users include, 1) a hand-held device for paramedics to collect information at a crash site, and 2) a Web-based application to visualize integrated information at the emergency department (ED). The hand-held device utilizes an Android application that enables emergency médical technitians to collect data for a crash incident and patient, take a picture of the scene, record audio notes, and capture video for the incident. Both the traveling public and state departments of transportation are expected to be beneficiaries of such a system.

From stakeholder evaluations CrashHelp emerged as a potential solution for enhancing the timeliness of information exchange, improving practitioner decision support, and for aiding policy and oversight of emergency response to traffic crashes. The current prototype, though in its beginning stages, currently requires additional enhancements and then will be taken back to end users to evaluate and provide feedback based on their real-world, practical experience delivering emergency medical care. Important ongoing goals for the CrashHelp system are to help inform practitioners of timely and pertinent crash information, to enhance patient care to victims, and to provide valuable end-to-end information for making policy decisions and enhancing EMS care from a systemic level.

# Chapter 1. Introduction

The SAFETEA-LU legislation mandates Strategic Highway Safety Plans (SHSPs) that are collaborative, comprehensive and based on accurate and timely safety data. While Intelligent Transportation Systems (ITS) have long promised the opportunity to realize these objectives, traditionally there has been little emphasis on examining the extent to which Emergency Medical Services (EMS) systems can provide safety-related data for transportation safety assessment and planning purposes. Furthermore, there has been little emphasis on how information tools should be designed to benefit a wide range of EMS users and stakeholders. This paper addresses these issues, presenting findings through Task 5 activities from project Phase II work.

A literature review and expert interviews were completed during the first phase of this project and these highlighted the need for an integrated trauma information network system. A case study analysis was included in this first phase of research conducted at the Mayo Clinic in Rochester, Minnesota as well as findings from focus groups conducted with decision makers at Minnesota state level agencies including the departments of transportation, public safety, public health, and emergency medical services. These interviews revealed that EMS is viewed as a key component of SHSP, but that there had not been a detailed analysis on how integration of automatic crash notification (ACN), 911 dispatch, EMS, trauma, and health provider-level health information systems can be utilized to enhance traffic safety.

The second phase of research included a comparative analysis of integrated trauma information systems across several states, initial prototype design and development of an integrated trauma information system solution, and an investigation of subsequent implementation steps. An interim report for this phase of work detailed a comparative analysis of systems implemented in other states (Task I) as well as early development of a high-level “CrashHelp” architecture and prototype of key system features (Task 2). This paper describes iterative development of the “CrashHelp” prototype application including stakeholder feedback from emergency response practitioners and emergency room physicians on the application and its practical usefulness (Task 3). Finally, this report explores deployment options for use in Minnesota and beyond (Task 4).

## Chapter 2. Background and Study Focus

The passage of SAFETEA-LU ushered in a new era of transportation planning, one that includes requirements to conduct safety planning as well as mobility and capital planning. The legislation mandates Strategic Highway Safety Plans (SHSPs) that are collaborative, comprehensive and based on accurate and timely safety data (USDOT, 2006). It requires states to advance their capabilities for traffic records data collection, analysis, and integration with other sources of safety data from other agencies and organizations (e.g. state traffic record systems, input from police such as citations, input from emergency service providers, etc.). States are encouraged to improve the timeliness, accuracy, completeness, uniformity, integration, and accessibility of the safety data needed to identify priorities for federal, state, regional and local highway and traffic safety programs. A significant challenge exists for transportation planners to understand where a range of pertinent information exists, to identify strategies for sharing such data across multiple local and state agencies, and to identify new and alternative ways to extract and display applicable information to decision makers (Shepherd, Baird, Abkowitz, & Wegmann, 2006). Moreover, while these systems have their day-to-day use in managing the surface transportation systems, increasingly there is interest in ensuring that such information systems are scalable during times of emergency, such as during natural or man-made disasters (e.g., earthquakes).

Correspondingly, while ITS has long promised safety benefits, there has not been an emphasis on examining the extent to which ITS are capable of providing safety-related data for assessment and planning purposes. This research project examines the linkages between ITS systems and the SHSP, focusing on three elements. The first element relates to the role of ITS in producing timely data on safety dimensions, including its visual representation in geographic information systems and related platforms. The second element examines the use of ITS with emergency medical services (EMS) and the data that can be used from EMS systems for safety planning purposes. The third element includes an analysis of innovative and new practices for capturing, sharing, and visualizing safety information required by emergency healthcare providers for enhanced levels of decision making and planning.

This study may have practical implications on patient care of automobile crash patients. Information technology is generally viewed as a key “enabler” of coordination and decision making. Health information technology (HIT) has been found to help improve the quality of patient hand-offs, lead to decreased errors of omission, and reduce risk of patient injury during the transition of care (Erich, 2007; Van Eaton, et al., 2005). In terms of patient outcomes, it has been reported recently that patients who suffer traumatic injuries have a 25% better chance of survival if taken to the appropriate trauma center according to the severity of their injuries (Landro, 2007). Inasmuch as technology can facilitate decision making in this regard, patients may be affected. More specific to this study, there is an identified need for improving the timeliness and accuracy of information exchange for trauma patients between emergency responders and a receiving hospital, which has been identified as an important element for improving the timeliness and quality of care provided in emergency medicine (Benner et al., 2007; Schooley and Horan, 2007; Institute of Medicine, 2006; Schooley and Horan, 2007; Adams et.al., 2004). Thus a key focus of this research is to address a need for development of innovations that may impact the driving public and the emergency care providers that treat individuals injured from the driving public (Coughlin, 2005) (see Appendix A for additional background literature).

# Chapter 3. Methodology

This research grew out of findings from the Phase I literature review, SHSP analysis on use of emergency response data, case study analysis in Rochester, Minnesota, and focus group discussions on emergency medical information integration with Minnesota state level officials from DOT, DPS, DPH, and EMSRB. These efforts resulted in the development of an initial high-level conceptual model for an integrated trauma information system.

After an initial scan of systems in several states, the focus of this phase of research was on building an actual prototype. Prototype development is an iterative process derived from Action-Design Research methodology which has emerged as a transdiscplinary approach to studying socio-technical systems in a manner that gives attention to both analysis and design aspects of the research endeavor (Hevnor, 2004). As such, it is dedicated to the development of knowledge useful to both research and practice (Baskerville and Wood-Harper, 1998). The goal of this action-design research is to afford policy and EMS practitioner decision makers the information not previously accessible in aggregate while producing a technological artifact aimed to extend scientific knowledge about how multi-organizational systems use such information (Baskerville and Meyers, 2004). Specifically, our action-design research approach features multiple methods, including systematic case study analysis of qualitative interviews and focus groups, quantitative secondary data obtained from a prior phase of research, the development of tools to understand and potentially affect the problem, and qualitative stakeholder assessment of the value and feasibility of implementing such tools to enhance multi-organizational emergency response. In doing this we have aimed to create both a data-driven understanding and a tool that helps improve safety and EMS planning, while at the same time contributing to the body of knowledge underlying emergency health systems research and evaluation (Schooley et al., 2009). Application of research findings are aimed at improving the manner in which emergency health practitioners analyze, characterize, and assess a patient and related performance.

In terms of prototype design, internet-based information system development is well suited to Agile Development methodologies where close collaboration between developers and domain experts facilitates the frequent delivery of new and/or enhanced functionality. In this manner, incremental units of functionality may be made available to users instantly rather than being bundled with other functionalities subject to an arbitrary release schedule. As opposed to desktop applications that may have release cycles of several months or even years, it is not unusual for Internet-based information systems to be updated several times a day (Jazayeri, 2007). Agile methods – short, iterative development cycles - have been utilized during the development of the CrashHelp system. As such, a prototype model was developed by the project team to integrate and visualize a range of crash and EMS response data aimed at enhanced safety and emergency health decision support. Feedback was obtained from a wide range of potential user types, stakeholders, and researchers to inform the usability, success factors, and value proposition of the model. Deployment options and policy considerations were also examined, and this report presents each of these foci.

## Chapter 4. Comparative Analysis across States

A first step of this project was to conduct a high-level comparison across several states including: Idaho, Alabama, Washington, Virginia, and Utah. These states were selected due to their advanced IT systems and policy initiatives that have been underway in recent years pertaining to crash analysis, EMS, and/or trauma data systems. The states were analyzed along 3 dimensions: policies that enable and/or restrict information sharing across EMS, Trauma, Public Health, Public Safety, and Transportation (Safety) departments; organizational structures that facilitate or prohibit information sharing; and information technology infrastructure developments that integrate EMS, trauma, and car crash data. A summary table was reported in the project interim report and is provided in Appendix B. This was developed by assessing information accessible through each state website including state rules, regulations, laws, data system documentation, organizational charts, agency histories, strategic plans, and other operational information about collaborations with other agencies and organizations. Key findings include:

**Technology:** All states evaluated have recently implemented or are in the process of implementing statewide EMS and trauma data systems that link to one another. Due to the relative novelty of these systems, actual linkage and full implementation of these systems will take several years. As such, there exists a unique opportunity for researchers to start developing methods and tools for utilizing the linked data that exists within these systems.

**Policy:** All states evaluated have policies that promote collaborations and/or partnerships with other agencies toward the common goal of reducing trauma and the negative health effects of trauma. Most states have explicitly stated policies, rules, and/or statutes that call for the development of statewide EMS and trauma data systems for the purpose of conducting research, evaluating and improving the design and planning of EMS and trauma systems. One interesting state in particular is Idaho due to its recent legislation related to sharing EMS and trauma data for research purposes.

**Organizational:** All states evaluated have EMS and trauma responsibilities that fall within the state Department of Public Health. Several states have developed collaborations and partnerships with agencies interested in reducing trauma and its effects. Utah, Idaho, and Virginia publish information on their websites that directly references the Strategic Highway Safety Plan (SHSP) and collaborations with state DOTs, Public Safety departments, and other transportation safety organizations.

Also derived from this analysis was an overview of the types of advanced technologies and innovations used across EMS service components from the time of a crash through notification, response, patient treatment and outcomes. Figure 1 provides an illustration of the types and range of IT systems that could potentially provide information to an integrated model for decision making. Most of these systems to date are disparate and separate; each designed to carry out a specific purpose. Efforts to integrate information across these various entities are a relatively new undertaking.

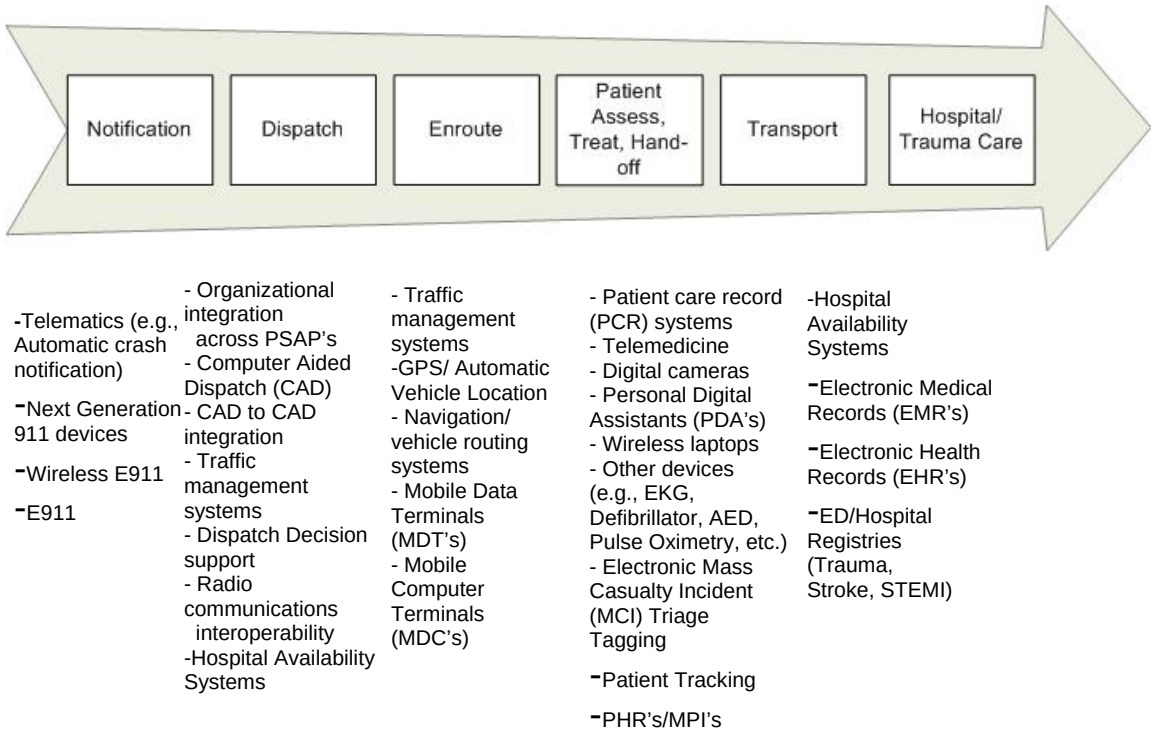


**Figure 1. Overview of EMS Data Systems Today**

This review of state systems verified the importance and priority of linking traditionally disparate databases for EMS and trauma and the emergent need to link with transportation safety professionals and data systems. We have also verified that these linked systems are relatively new and still under development. Currently, a need exists to understand how to visualize this linked data in a format that can be used by a wide range of practitioners.

This assessment was also used to choose comparative case study locations for further understanding of how information and data systems are currently being used in the field. For this analysis, Utah and Alabama were selected due to their long history of building and integrating information systems in the EMS domain. These states are discussed further below.

## Chapter 5. Comparative Case Analysis: Minnesota and Alabama

Two states noted for their innovation in information integration are Alabama and Utah The tables below provide a state and local level comparison of EMS information systems used in Alabama, Minnesota, and Utah. The analysis is organized according to significant functional aspects of EMS and trauma information sharing including: incident notification, patient-care data collection and reporting, interagency information sharing, information handoff to the emergency department, trauma registry record creation, and guiding information policies.

**Table 1. Case Comparison in Alabama and Minnesota**

| Categories | Alabama | Minnesota |
|---|---|---|
| Incident Notification | Alabama has approximately 84 Emergency Communications Districts (ECDs), most of which are at the County level, but several also at the municipal level. All regions are e911 and Wireless Phase II compliant, except for 4 rural counties. Computer Aided Dispatch (CAD) systems are used in many regions to capture incident data, which is then forwarded on and integrated into ePCR systems used by local EMS responders.<br>A system to collect ACN/AACN data and integrate it into the trauma system exists in Alabama's central Birmingham Regional EMS System (BREMSS). It is not utilized statewide. | There are 115 PSAPs in Minnesota, statewide 911 converage provided by 87 county systems. Enhanced 911 is provided statewide. Minnesota was an early leader in providing Wireless 911 coverage across the state.<br>Computer Aided Dispatch (CAD) systems are used in many regions to capture incident data, which is then forwarded on and integrated into ePCR systems used by local EMS responders.<br>A system to collect ACN/AACN data and integrate it into Mayo Clinic PSAPs in Southeastern Minnesota was developed as part of the Mayday Plus test project. The system is still functional on a limited basis, but has not expanded statewide. |
| Patient Care Record – EMS Data collection | Alabama has a centralized Electronic Patient Care Reporting (ePCR) Software system that is National EMS Information System (NEMSIS) Gold Compliant. The software, designed by GRAYCO Systems, has been customized for Alabama's EMS Community for ease of use, maximum compatibility, and to conform to Alabama's NEMSIS Dataset. EMS providers can elect to use a web based ePCR system provided by the state, or they can use a NEMSIS compliant third-party software application.<br>A Third Party Integration Module is available to any Providers for Third-Party NEMSIS Compliant software vendors to share their data with the state system. If integration is not possible, a | Minnesota has implemented a Web-based, statewide data system called MNSTAR (Minnesota Statewide Ambulance Reporting), which went online on April 1, 2003. It gives Minnesota's 256 local EMS agencies the flexibility to either collect their own data and then upload NEMSIS XML data to the state system via a web based interface, or to enter their EMS runs via a web browser using an online run form. |

| Categories | Alabama | Minnesota |
|---|---|---|
| | stand-alone submission tool is supplied and can upload any NEMSIS Compliant XML File to the state. | |
| Interagency Information Sharing | Alabama encourages sharing of EMS data with other agencies. The Alabama Incident Management System (AIMS) allows and encourages ongoing, real-time communication between health facilities (Hospitals, Nursing homes, Community health centers, medical needs shelters, and EMS providers) and State Emergency Operations Centers (EOCs). The trauma system involves the trauma center working together with 9-1-1, EMTs, ambulances, helicopters, and other health care resources in a coordinated and preplanned way. | In October 2006 Minnesota received an award from the NEMSIS Technical Assistance Center for being the first state to regularly submit EMS data to the new national database.<br>The EMS data can be shared with other agency data systems including the Crash Outcomes Data<br>Evaluation System (CODES) at the Department of Public Safety and the<br>Traumatic Brain and Spinal Cord Injury Registry at the Department of Health. |
| Information Handoff to the ED | Information handoff generally occurs via verbal exchange between EMS attendants and ED staff. A paper form PCR is also completed and handed to the ED. | Information handoff generally occurs via verbal exchange between EMS attendants and ED staff. A paper form PCR is also completed and handed to the ED. |
| Guiding Policy | The Alabama Legislature passed the Statewide Trauma System Bill that will facilitate the development of a state-of-the-art trauma system for the State of Alabama. A NEMSIS data set has been defined and EMS providers are required to submit an ambulance run report for every run. | The State Trauma Advisory Council was established by legislation to advise, consult with and make recommendations to the Commissioner of the Minnesota Department of Health regarding the development, maintenance and improvement of the statewide trauma system. NEMSIS data set has been defined and EMS providers are required to submit an ambulance run report for every run. |
| Trauma registry information collection | Alabama administers a consolidated trauma registry called the Alabama Trauma Registry (ATR).<br>The Alabama Department of Public Health (ADPH), Office of EMS and Trauma utilizes data to identify specific educational, policy, and improvement needs for the EMS providers. | Minnesota has its own comprehensive statewide trauma system. It is a voluntary, inclusive network of currently trained and equipped trauma care providers throughout the state ensuring that optimal trauma care is available and accessible everywhere.<br>The Minnesota trauma registry, MnTrauma, is a Web-based, encrypted data collection tool used by designated trauma hospitals to submit trauma data to MDH. |

## Chapter 6. Regional Comparative Case Analysis: Rochester and Salt Lake City

The table below provides a region level comparison of EMS information systems used in Rochester, Minn., and Salt Lake City, Utah. The analysis is organized according to functional aspects of EMS and trauma information sharing similar to the above state level analysis.

**Table 2. Case Comparison in Rochester and Salt Lake City**

| Categories | Salt Lake City, UT | Rochester, MN |
|---|---|---|
| Incident Notification | The Salt Lake Valley Emergency Communications Center (VECC) is a consolidated 911 call center that answers police, fire, and medical emergency calls for a large proportion of Salt Lake City and County. A sophisticated computer aided dispatch (CAD) software system is used to answer calls and dispatch resources.<br>DOT sponsored a CAD to traffic management system (TMS) integration project to better coordinate DOT and emergency response efforts. | Mayo Medical Transport has its own consolidated communications center that receives medical 911 phone calls from law enforcement PSAPs in the region. Mayo uses the Zoll Data systems RescueNet computer aided dispatch (CAD) software, which sends 911 data to the Mayo Medical Transport ePCR system (also a RescueNet product).<br>A system to collect ACN/AACN data and integrate it into Mayo Clinic PSAPs in Southeastern Minnesota was developed as part of the Mayday Plus test project. The system is still functional on a limited basis. |
| Patient Care Record – EMS Data collection | Salt Lake EMS providers can opt to use any number of NEMSIS compliant ePCR systems or to use the Utah state operated Prehospital OnLine Active Reporting Information System (POLARIS), which is a web based system open for any provider to utilize. In either case, ePCR data must be entered or uploaded to POLARIS for every EMS incident.<br>POLARIS is also used to conduct analysis for quality assurance and quality improvement. | The Zoll Data Systems RescueNet PCR software is used by all ambulance personnel. A comprehensive run report is collected and data can be sent to the state via NEMSIS format. The report is generally completed after an incident has completed.<br>A data warehouse is used to integrate PCR records from other ambulance providers outside the Mayo system. |
| Interagency Information Sharing | The Utah State EMS Bureau encourages use of the POLARIS system by any number of agencies that might benefit, including for health information | The Mayo Clinic owns several organizations across the EMS response including the Mayo Clinic Emergency Communications Center, Mayo |

| Categories | Salt Lake City, UT | Rochester, MN |
|---|---|---|
| | exchange, motor vehicle crash analysis, and others. | Medical Transport (air and ground ambulance services), as well as emergency departments and trauma centers in the region. This enables information exchange across functional domains. Relationships have also been created with the Minnesota Department of Transportation, Minnesota State Patrol, and many other EMS providers to further enhance coordination and information sharing. |
| Information Handoff to ED/Trauma | Information handoff generally occurs via verbal exchange between EMS attendants and ED staff. A paper form PCR is also completed and handed to the ED. | Information handoff generally occurs via verbal exchange between EMS attendants and ED staff. A paper form PCR is also completed and handed to the ED. |
| Guiding Policy | Salt Lake City benefits from progressive state level policies aimed at information sharing, integration, and the use of technology to enhance services. | Mayo Clinic operates much of the end-to-end provision of EMS services in the region. Mayo's practices are based on innovative practices and high levels of quality care to patients. They provide training and outreach to other EMS providers and are actively engaged in all aspects of EMS policy in the region |
| Trauma registry information collection | Salt Lake trauma centers maintain their own trauma registries that send data to the | The Mayo Clinic operates its own trauma registry software that sends data to the state trauma system. |

Taken together, the case studies allowed for development of a general information sharing model for states and regions. Characteristics of the model are shown below. These include:

- Integrated information across the end-to-end spectrum of EMS services, from the time of a crash through patient outcomes.
- Multiple user types from the various organizations that would provide or consume information. These include: 911 dispatch, EMS, health care, researchers, and administrators.

- A stack of functional web enabled capabilities including data analytics, security and privacy, data upload and integration, data exports, and real-time data exchange with other authorized data systems.
- Flexibility to interface with the system using a common web based interface, using standards based vendor provided software systems, or legacy systems.
- One-way or two-way communication, depending on the type of user and data that is being exchanged. For example, CAD systems are providers of data while EMTs could both consume existing patient information as well as provide a new patient record for a new incident.

A significant information sharing gap identified in the case studies is the sharing of pre-hospital information to emergency departments in real-time, or near real time. Typically, EDs do not receive electronic information in a timely manner, creating a possible scenario where patient and crash information could be lost, forgotten, misread, misunderstood, or not communicated at all. The next section of this report discusses the design and development of a data system aimed at addressing this information sharing gap.

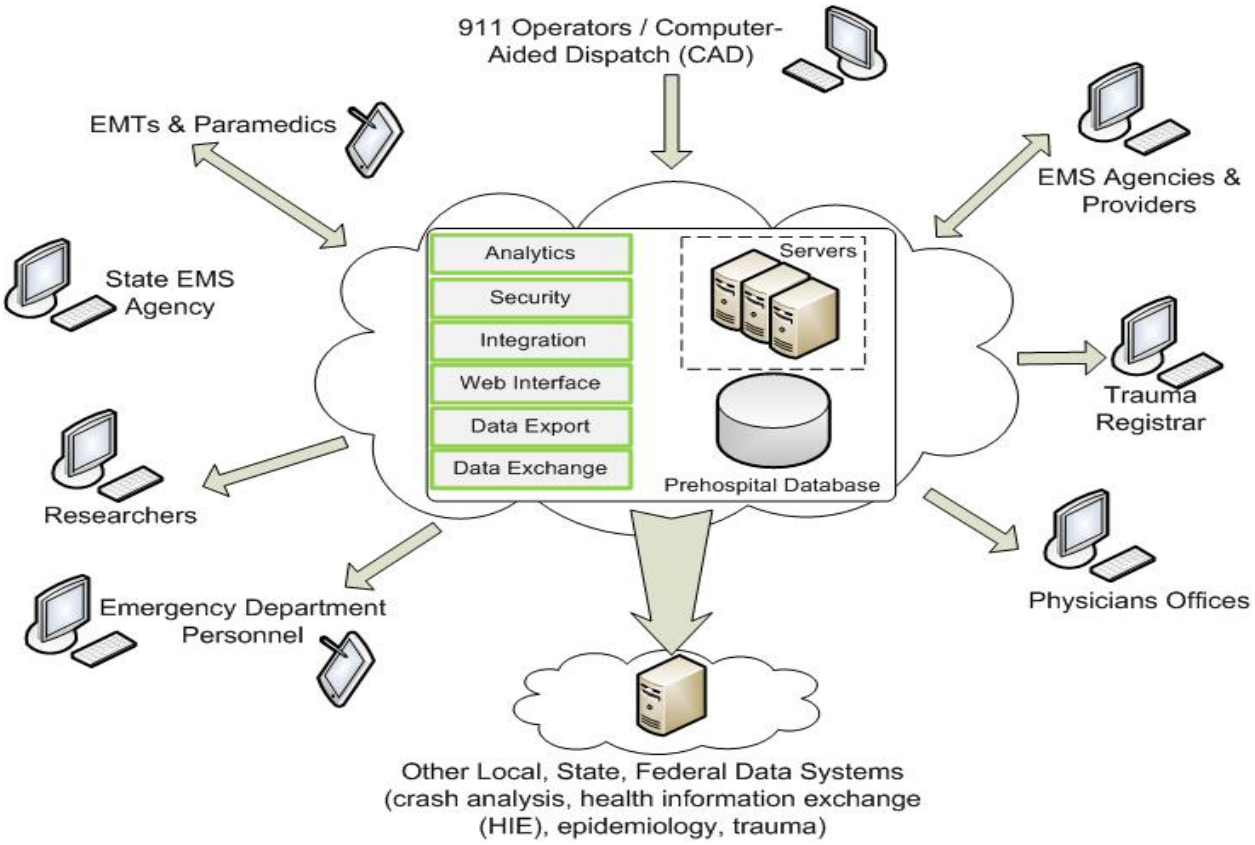


**Figure 2. Model for Sharing EMS Information**

# Chapter 7. Design Requirements of an Integrated Trauma Information System (CrashHelp)

The CrashHelp prototype is a software application for time-critical, end-to-end, emergency medical services (EMS) and healthcare delivery. The prototype was designed to integrate information about EMS responses and hospital treatment of motor vehicle crash (MVC) patients within the Mayo Clinic trauma jurisdiction. It was designed through interviews and focus group discussions with end users in an iterative fashion. Data collected from the Mayo Clinic from prior research was used to create an initial data and system model inclusive of 127 automobile crash incidents that resulted in EMS response and ambulance delivery to a Mayo Clinic trauma center.

From the outset, the goal of CrashHelp was to enhance decision making, help reduce emergency response times, and improve the quality of healthcare. The system was designed to 1) provide health care practitioners with near real-time resource and patient-care decision making, and 2) support retrospective analysis of system performance for oversight and quality improvement initiatives. Unified patient information and performance reporting across emergency response and trauma care, derived from the operational level findings in prior research, (Schooley et al., January 6-9, 2009) were applied to this prototype.

### *CrashHelp Prototype Requirements*

Through a series of iterative design and development sessions, the following themes were identified as key to communicating EMS and Trauma issues related to emergency response:

- Visual Display – It is critical to portray EMS responses in a manner that is both comprehendible to a wide range of users and that simultaneously brings together a range of related disparate data.
- Human – It is important to humanize the EMS response. Past research indicated that EMS personnel want to know what happened to the patients they treated. CrashHelp offers personnel a holistic view of the emergency response for a particular patient.
- Integrated Analysis – A wide range of users need a situational and/or performance profile of EMS responses at both individual and aggregate levels, allowing for development of local and regional system-wide improvements with policy leaders, health, and safety professionals.

For the prototype design, a number of data classes were assessed and considered across pre-hospital and hospital (trauma center) care settings. These data types represent the range of data that may be useful to a wide range of user types. The actual data to be used depends on the ability to access the data from the organizations that own it. These include:

- Pre-hospital event times (time stamps) for: receipt time of the 911 phone call; time of ambulance dispatch; time of ambulance arrival on-scene; time of ambulance departure to the hospital; and time of ambulance arrival at the hospital.
- Resources deployed and type of transport: Basic Life Support; Advanced Life Support; Ground Transport; and Air Transport.

- Pre-hospital impression, assessment, and procedures including: the initial complaint reported by caller/patient as well as the EMT primary and secondary impression of the trauma patient.
- Images and video of a trauma incident scene and/or patient.
- Digital audio description of an incident as recorded by an EMT or paramedic.
- Crash information including: Incident type (motor vehicle accident), use of extrication by emergency crews, and Automatic Crash Notification information.
- Basic demographic data on the patient, including age, gender, and ethnicity.
- Location information including: location of the incident and location of the receiving hospital.
- Trauma Center (registry) data including: Facility name; facility type; date and time of arrival; discharge date; basic demographic data; alive- or deceased: on - arrival status; injury severity score (ISS); length of stay at hospital (LOS); hospital disposition; and discharge diagnosis.
- Fire station and hospital data including: name; address; longitude; and latitude.

Functions were identified and analyzed in an iterative agile development manner using pre-factoring and model-driven refactoring (Rosenberg et al., 2005). Findings were also used to elicit the meanings, needs, issues, and benefits of an open, standardized, integrated, yet secure and private information sharing environment. Iterative design and development with EMS practitioners, together with prior research findings, resulted in the following functional requirements.

- Handheld mobile device – Utilize handheld, mobile technologies to capture digital voice, video, images, and GPS data for display and easy access in the ED.
- Map – Visually display spatial data about an incident for situational awareness and decision support, along with key clinical indicators (age, response time).
- EMS Incident Profile – Visually display pre-defined queries of EMS events, including EMS responder and patient information.
- EMS Response Details – Enable drill-down (query/filter) through various data sets to extract specific information needed by end users about a specific EMS incident.
- Near real-time incident and patient status – Provide indicators and dashboard gauges that allow visualization of EMS location, performance and patient status across a range of defined EMS incidents.

End-user design features were identified to embed within the software application. These included:

1. End-to-end operational process considerations to provide emergency medical care as seen through the eyes and experience of a patient. The focus here is on patient information that can be viewed in the system from the start to finish of an EMS incident.
2. A multi-organizational view of the system and use by practitioners. A common operating picture (COP) is important for many organizations and user types. Thus the system design must take into account the information needs of many, making it usable to all.
3. Dynamic information sharing considerations by a range of user types including dispatch, EMS, ED, trauma, and public health oversight organizations. Deciding what information will

be received, how it will be received, and where it will come from will define much of the system design and use capabilities.

4. Visualization of a range of data, images, video, and audio from a range of devices (e.g., mobile phones, computer aided dispatch software). Usability is a quality of utmost importance. Information must be visualized in a way that optimizes consumption for a fast-paced environment.

Also the following architecture, integration, and technical requirements were defined:

- Web-based – The CrashHelp system will be built upon Web-based design principles to allow for flexibility in the use of information and accessibility for a wide range of users.
- Middleware – Middleware technology provides a means for integrating and routing information securely and privately between devices and interfaces. It allows for flexibility in creating a range of configurable information services, enables configurable interface visualizations, and facilitates interaction with other services and applications. While the current system design includes a handheld device configured for a phone running the Google Android operating system, middleware allows for any compatible device to securely interoperate (e.g., iPhone).
- Open Development Platforms – As much as possible, software will be built using open (i.e., open source) and standardized technologies to increase accessibility of the system to the widest range of users while at the same time lowering development costs. The mobile application for EMTs described herein is developed on the open-source Google Android operating system with the Java programming language.
- Security – Identification, authorization, and authentication of users, secure data transfer, encryption and decryption are required for transmitting and saving data within HIPAA rules.
- Data standardization: Data standardization is required for integrating data into a larger information network. The NEMSIS standards as well as others (e.g., NTDS, HL7) provide frameworks for standardizing CrashHelp data.

## Chapter 8. CrashHelp Prototype Design

Drawing from the requirements above, the CrashHelp system was developed utilizing a range of current and emerging concepts and technologies including Web 2.0, geographic information system (GIS) Mashups, web services, dashboards, and multi-media mobile applications. Figure 3 illustrates CrashHelp's two primary interfaces utilized by end users, 1) a hand-held device for paramedics to collect information at a crash site, and 2) a Web-based application to visualize integrated information at the emergency department (ED). A set of server-side applications and databases are used to integrate, aggregate, and "mash-up" information for viewing in the Web-based application.

**Figure 3. CrashHelp System Interfaces**

### *CrashHelp Architecture*

The handheld application for use by EMTs and paramedics was developed on the Google Android operating system. The application for use in the ED for physicians, nurses, and administrators can be accessed using any device running a standard web browser. The Android application enables EMTs to collect data for a crash incident and patient, take a picture of the scene, record audio notes, and capture video for the incident. Basic patient data, location and EMT contact information are also collected. These data are then sent to the CrashHelp database. The ED application displays incident and patient information collected from the Android application, as well as from other potential data sources such as computer-aided dispatch, trauma center, and patient-care record systems. CrashHelp displays the patient and incident information on a map. Detailed incident information can be drilled-down on from the initial screen. Location information is also aggregated from Google and Microsoft web services to provide mapping, street level, and "bird's eye views" of an incident location. The CrashHelp system architecture is illustrated in Figure 4 below.

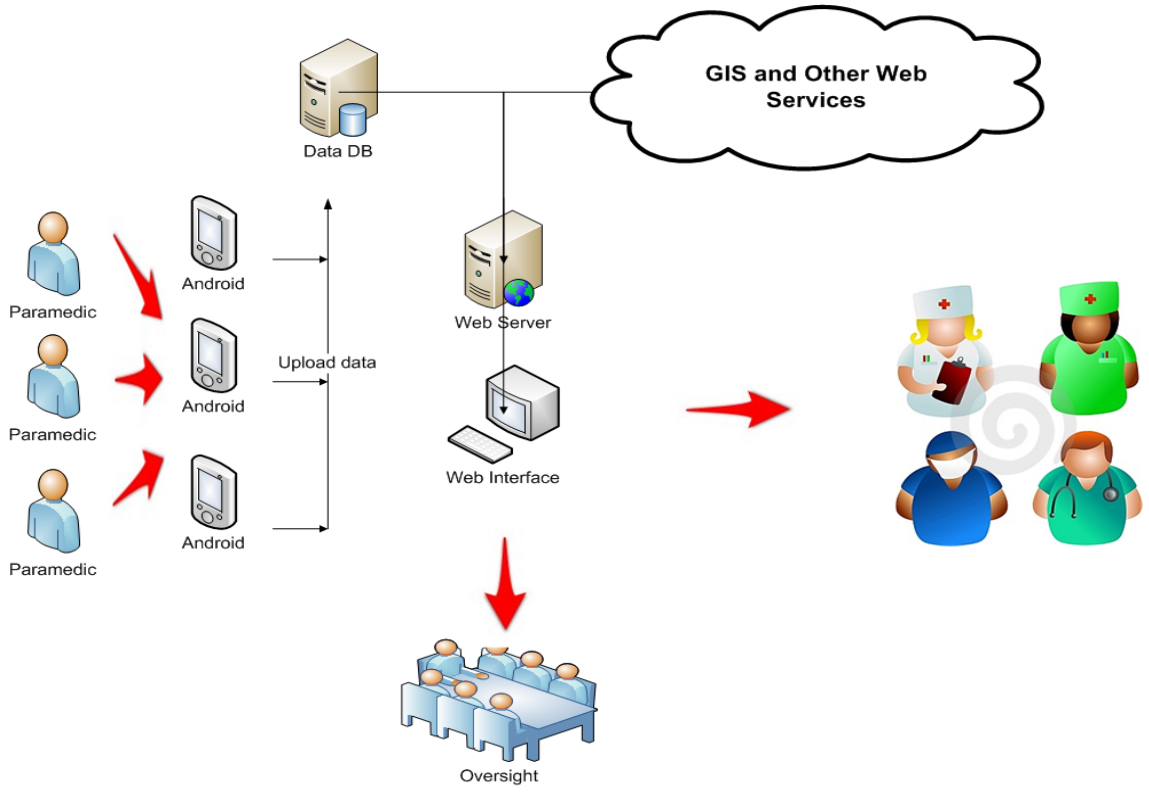


**Figure 4. CrashHelp System Architecture**

***CrashHelp Data Flow Overview***

Figure 5 displays an overview of the intended use of the CrashHelp system and how data flows across users, from the 911 call center, to paramedics at a crash site, to care providers in the ED. The CrashHelp System initiates when the 911 call center receives a call and collects incident information. Following receipt of the call, emergency medical service providers (paramedics, EMTs) are dispatched and sent the information collected from the 911 call center. The information is also saved in the 911 computer aided dispatch database. When the EMT reaches the incident location, he/she uses a cell phone application to 1) takes a picture of the scene, 2) records audio notes, and 3) captures video for the incident, 4) collects basic patient information and sends it to the CrashHelp database. After arriving at the trauma center where the patient is admitted, a nurse in the emergency department reviews patient and incident information provided by the EMT. The patient record is also saved in the CrashHelp database and the incident information, including the patient-care record, is displayed on the CrashHelp system map.

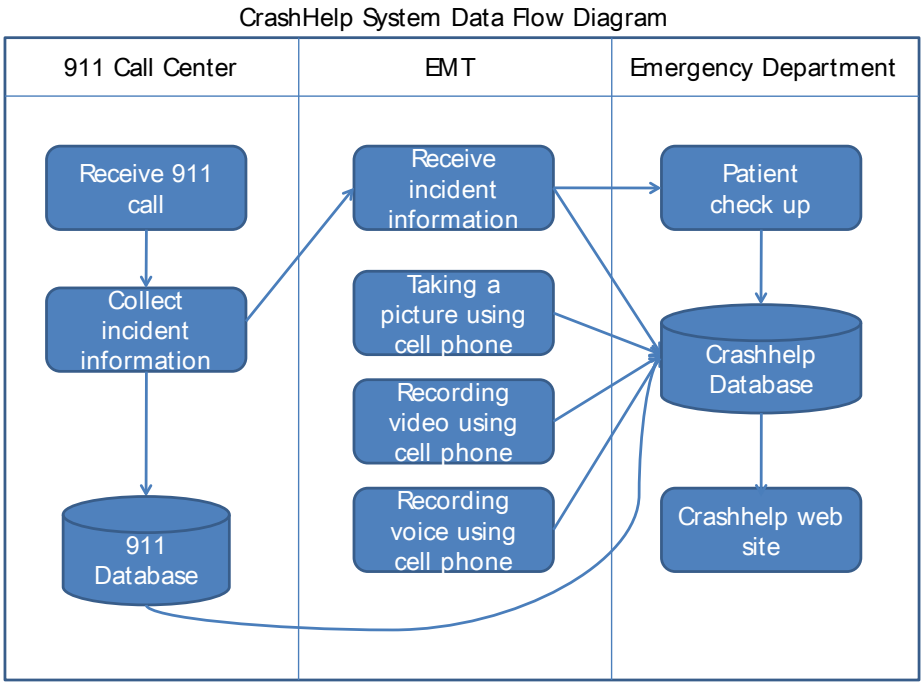


**Figure 5. Data Flow Diagram**

***The Mobile, Handheld Application***

A handheld mobile application was developed for paramedics and Emergency Medical Technicians (EMTs) to use at a crash site. It was developed using the Java programming language for use on the Google Android operating system. The first user screen allows creation of a new incident (Figure 6(a) below). Simple navigation then allows the user to take pictures, video, or digital audio (Figure 6 (b,c,d)), record basic patient information (i.e., name, age, gender) (Figure 6 (e), and send the data along with GPS coordinates, name of the medical attendant, and phone number of the device (Figure 6(f)) to the system server.

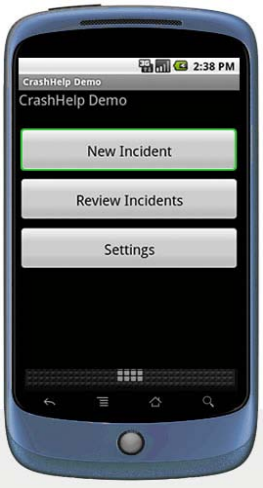


**Figure 6(a)**

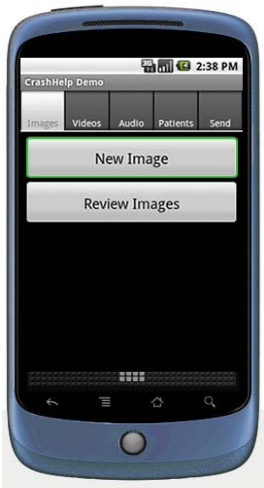


**Figure 6(b)**

**Figure 6(c)**

**Figure 6(d)**

**Figure 6(e)**

**Figure 6(f)**

**Figure 6. Mobile Application Screen Shots**

### *CrashHelp Emergency Department and System Oversight Application*

Once incident information has been sent to the CrashHelp server, it can be accessed in the emergency department via a standard web browser. The prototype (Figure 7) displays two frames within a web browser. The left frame displays views of incident status, data layers, GIS tools, and resources. The right frame displays the incident map view. These views enable a range of user types to receive end-to-end EMS response and trauma care information.

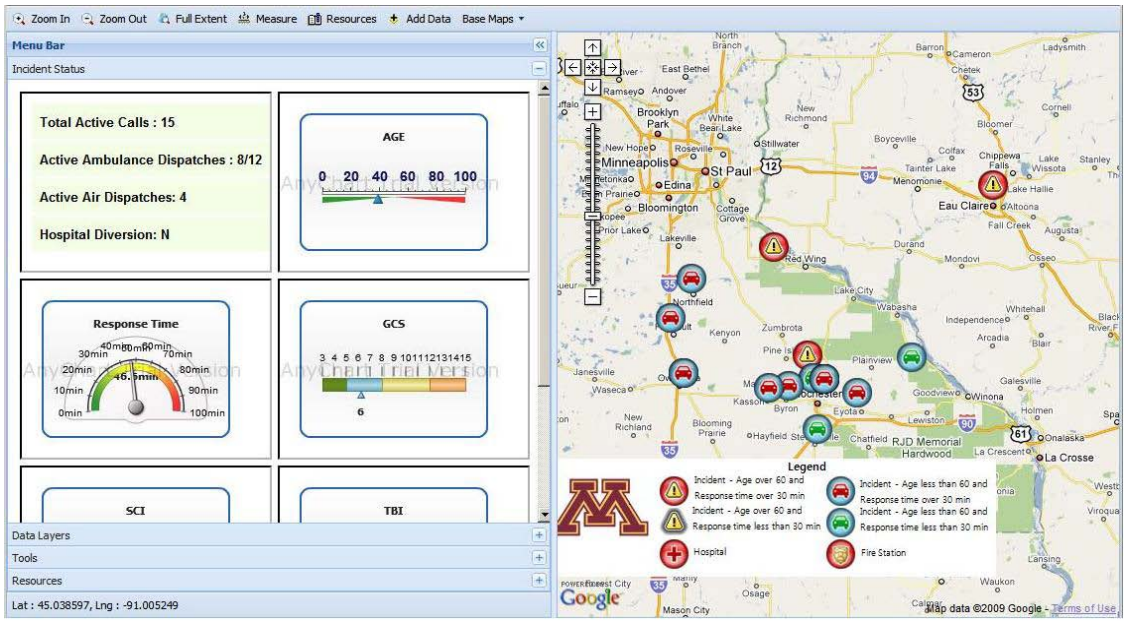


**Figure 7. CrashHelp ED Application**

**Incident Status**. The "Incident Status" page (Figure 8) displays current (near real-time) aggregate incident information using graphical gauges. Users are able to view information such as the average age of incident participants, the average response time of EMS personnel, the average injury scores as assessed by health practitioners such as the Glasgow coma score (GCS), spinal cord injury score (SCI), and traumatic brain injury (TBI) score of injured participants.

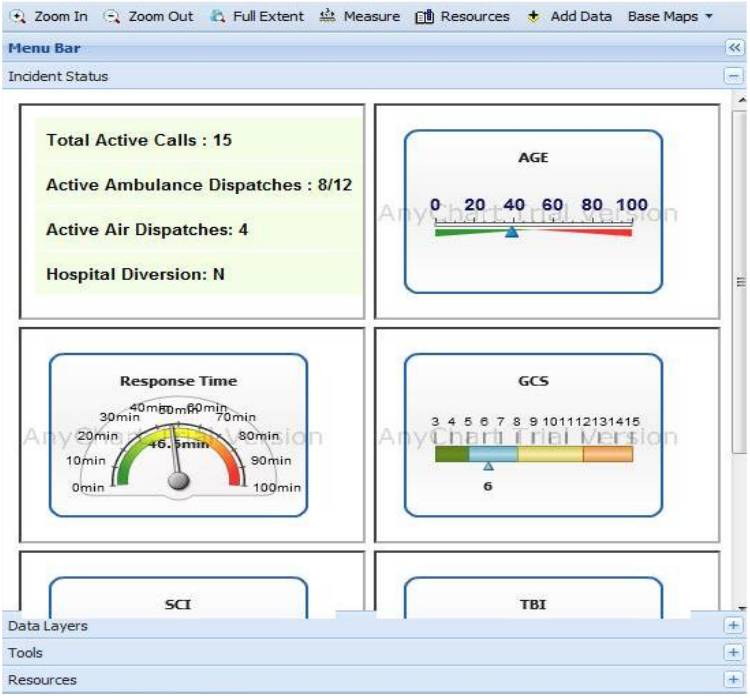


**Figure 8. Incident Status Page**

The current version of the CrashHelp prototype does not collect “live data”, but the intent is to implement this capability in a future version of CrashHelp.

**Crashes - Map View**. The “Crashes – Map View” page (Figure 9) displays the locations of current incidents and related resources (e.g., hospitals) in the Rochester, Minnesota region. A user may select an icon to view more detailed information about each resource. A user can select different base map configurations, Google or Microsoft.

When the user selects an incident icon, the system allows for a “drill down” to display detailed incident information including photos taken on-site, streaming video, a Microsoft Virtual Earth map, and a Google Street View (Figure 10).

Similarly, when a Fire Station or Hospital symbol is selected, detailed information about that resource, such as name and the street address, are displayed.

The indicators discovered in the statistical analysis phase of this research were implemented into the GIS interface. Four separate icons for incidents indicate various combinations of age and response time. For example, one icon indicates that an incident has exceeded 30 minutes from the time of emergency notification. Another icon indicates that a crash patient is over age 60. Another icon indicates combined age and response time factors. In sum, the various icons represent “alerts” to practitioners based on clinical indicators for probable or likely injury.

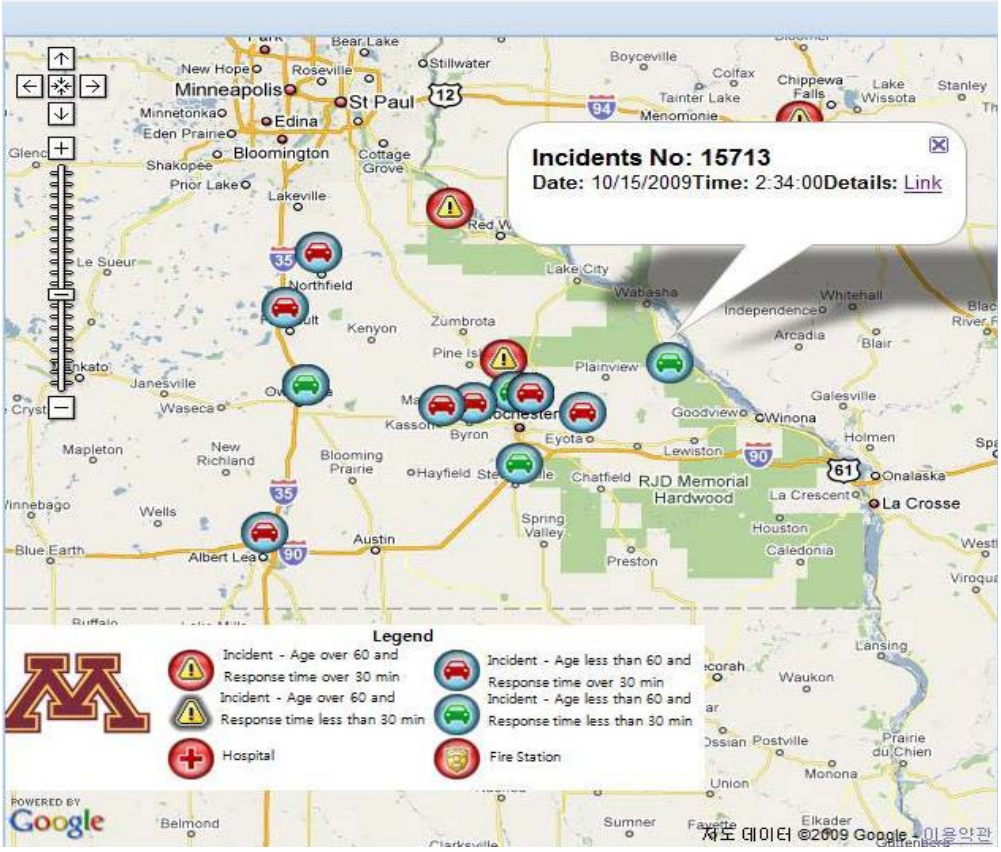


**Figure 9. Crashes – Map View Page**

**Crash Profile Page**. Another feature of CrashHelp is a detailed view of an incident. A drill down on an incident from the GIS interface results in a display of detailed incident information on the Crash Profile page (Figure 10). Incident information is divided into several categories. The "Patient & Medical" section includes the patient profile information collected and reported by EMS responders. The "Incident Status" section includes response time data from 911 dispatchers (e.g., arrive on scene, depart to hospital, etc.). Incident location information is displayed on the Microsoft Virtual Earth map and the Google Street View. Gauges provide indicators for Injury Severity, total response time for that patient. Additionally photo images, audio, and video, taken at the incident scene with the mobile phone application, are included on this page.

**Figure 10. Crash Profile Page with Microsoft Virtual Earth and Google Map View of Incident Location**

**Data Layers**. The "Data Layers" page (Figure 11) provides detailed resource information such as incidents, fire stations and hospitals, cell phone service areas, locations of traffic cameras, fatal crash hot-spot statistics, and current weather information.

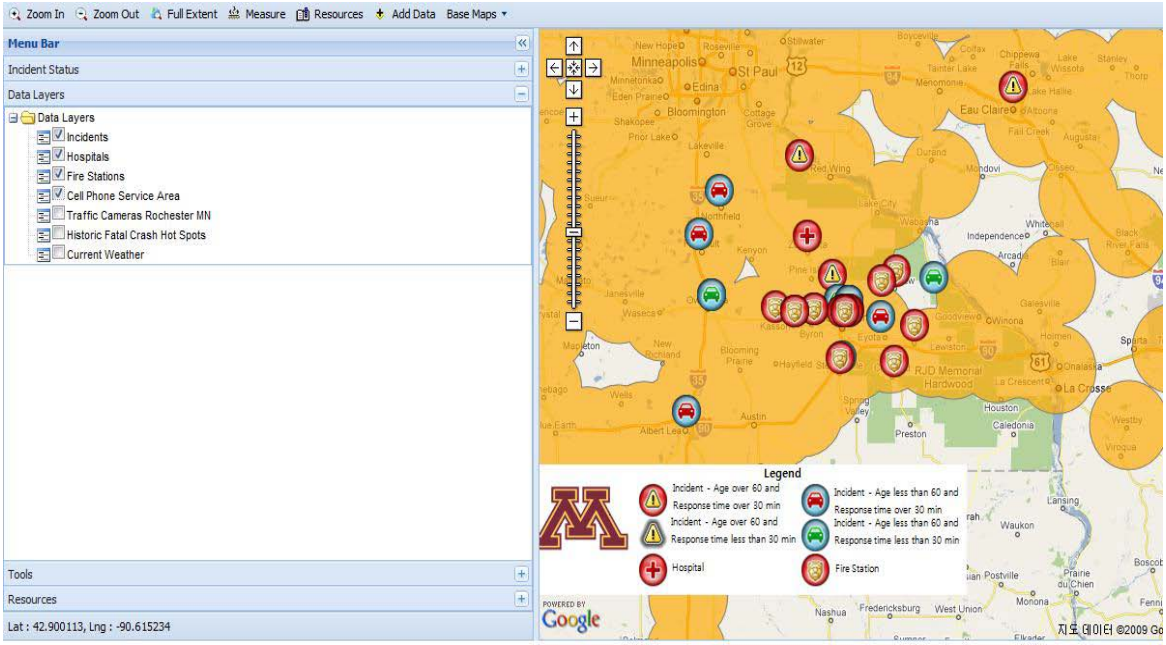


**Figure 11. Data Layers Page**

When a user selects a view of incidents, hospitals, fire stations or traffic cameras, the CrashHelp system displays a resource icon on the map. When a user selects a view of cell phone service areas, fatal crash hot spots, or current weather, the CrashHelp system displays colored area boundaries.

***Stakeholder Evaluations of CrashHelp***

The CrashHelp prototype was presented to several groups of emergency practitioners and researchers for feedback. Groups included: the Intermountain Injury Control Research Center, the Department of Informatics, and the Center for Excellence in Public Health Informatics, School of Medicine, University of Utah; the Utah Department of Health, EMS Bureau; the EMS Safety Foundation (National organization of EMS practitioners); and Mayo Clinic practitioners.

Participants were asked questions in regards to the utility and value of the CrashHelp system, needed improvements, perceived challenges, and the potential deployment options for such an application. Several themes emerged. These are categorized and discussed below.

CrashHelp emerged as a potential solution for enhancing the timeliness of information exchange, improving practitioner decision support, and for aiding policy and oversight of emergency response to traffic crashes. Participants confirmed several beneficial aspects of the CrashHelp system. These include:

- ***Timely Information Hand-off.*** Information technology must facilitate information hand-off *at* or *before* the patient hand-off to the ED. Participants believed that CrashHelp could potentially allow for much more timely information to the ED. Responses included: “We have to find a way to get it [information] to the ED on time. There has to be some way to resolve this.” (ED Physician)

- ***Focus on Patient Care.*** Information technology must interfere in the least possible way with care processes and practices. Participants expressed that the CrashHelp interface represents an improvement in this regard. Responses included: "I don't have time to enter all that [PCR] information. If I have a choice between stopping profuse bleeding and messing around with a laptop, the choice is pretty obvious." (Paramedic)

- ***Value to ED Decision Makers.*** Information technology must provide value added context to decision makers at the ED/Trauma Center. While responses from participants varied significantly in terms of the value CrashHelp could provide to practitioners, most believed that at least some of the information would be valuable to the ED. Responses included: "I think the basic information, the context of what happened on scene helps out the most." (Director, Trauma)

- ***Value to Administrators and Operational Decision Makers.*** Information technology must provide value to policy and oversight professionals for post incident evaluation. Participants discussed how the aggregation of multimedia information could be used for education, training, case reviews, and other post incident situations. Responses included: "Adding GIS and pictures would really help with education, case reviews, medical reviews, QI. It would be nice." (EMS Medical Director)

Practitioners validated that the current prototype has made significant strides in each of the above four areas and suggested improvements to further enhance the system. Participants discussed the features of CrashHelp that they believed provided the most significant benefit. Themes from participant responses are provided below.

- ***GIS visualization.*** The GIS graphical display combined with performance indicators and dashboard gauges were viewed as potentially valuable for providing timely situational awareness about the emergency and trauma system service demands, for providing potentially important information for making emergency care decisions for individual patients, and for Quality Assurance / Quality Improvement activities during post incident reviews. Additionally, the GIS interface was viewed as a user-friendly platform for accessing needed information. Some participants suggested the GIS mapping functionality could be expanded to the handheld device for use by paramedics and EMTs. Others felt that a wide range of other mapping layers could be added to provide additional post incident analysis capabilities to practitioners responsible for system policy and oversight. Examples include aggregate crash data maps, traffic congestion, road construction, and location information on other available resources at the time of a crash.

- ***Multimedia Information.*** The ability to capture and display pictures, video, and voice recordings along with time and location information was viewed as potentially the most significant feature of the prototype. These features were viewed as valuable for enabling ambulance teams to "get back out on the street faster" and for affording trauma teams the information needed to help determine when to assemble a trauma team (or not) prior to patient arrival. While still pictures could be the most valuable in some circumstances (e.g., snapshot of a wound), the video could provide more value in others (e.g., illustrating depth perspective into the impact made on a vehicle from a crash). Finally, the digital recording was equated with the "verbal snapshot" that paramedics typically

provide in the ED in today's EMS environment; with the added flexibility of recording the snapshot for anytime listening.

- ***Minimal Data Entry.*** Participant discussions also revealed the value of minimizing the amount of manual data capture required in the field. Too much data entry can be a significant barrier to use in a time-critical situation. Simply capturing age, gender, patient name, and incident number were thought to be "good enough." This data together with location, image, voice, video, and automated emergency response time stamps were believed to be highly useful.

- ***Integration of Multiple Data Sources and Feeds.*** While participants discussed the need for the handheld device to be geared towards minimal data entry, the CrashHelp GIS visualization was viewed as valuable for enabling the integration of many disparate data points. Inasmuch as data could be captured from a wide range of devices and data systems, CrashHelp could provide a wider range of value to a wider audience of users. The challenge here is to obtain agreements from the wide range of organizations who own the disparate data.

Participants believed the features above could provide the following beneficial results:

- ***Improved Patient information handoff for improved continuity of care.*** Exchanging patient information (including images, video, and audio) across pre-hospital (EMTs / paramedics) and hospital emergency department domains for near real-time use could potentially have significant impact on patient safety and care.
- ***EMS training and education.*** The visual display of incident, location, and targeted data could provide a valuable platform for training EMS professionals on best practices and protocols.
- ***Clinical Quality Improvement.*** The system could provide a visual basis for discussing the "good" and "bad" cases and scenarios to improve care protocols and processes.
- ***Feedback Mechanism to Practitioners for improved personnel satisfaction.*** A common need described by paramedics, 911 operators, and firefighters is the desire to see what happened to a patient he/she served. The tool could allow for a quick query of an incident and related patient outcome information in a post-incident environment.
- ***Visualization for improved decision making.*** The prototype could provide a common operating picture (COP) for larger scale decision making, such as trauma center diversion and re-routing in the case of mass casualty incident (MCI) situations.

Finally, several participants discussed the potential value of the CrashHelp system to specific types of users. These users included:

- ***Physicians.*** Much of the perceived value of CrashHelp to physicians in the ED depends largely on how much the visualization of information could be configured to their needs. A common sentiment is that "physicians want to see what physicians want to see", meaning that every physician has his/her own perception as to what information he/she wants.

- ***Paramedics/EMTs.*** Many participants saw the application as it currently stands as providing little value to paramedics. Paramedics in the field are data "providers" and not "consumers" of the application, and therefore have little to gain. Another point of view however, is that paramedics will see value in using the application inasmuch as it provides value to physicians and patients. In other words, paramedics are motivated enough knowing the application helps improve patient outcomes. Several participants discussed potential enhancements that could provide higher value to paramedics, such as providing a map-based common operating picture (COP) to the handheld device in the field (e.g., hospital availability, fire engine location en-route, law enforcement location en-route), and providing on-demand training, policy, and procedure content to the device in the field.

- ***Administrators.*** Several individuals discussed how the application could benefit a wide range of analysts, quality improvement specialists, administrators, and others who may use the system for post-incident and post-crash analysis. Most believed CrashHelp could make a significant impact in this regard. However, the impact would be highly dependent on how well the near real time information would be collected, how much information would be collected, and the quality of the information collected. A large library of videos could provide a potentially valuable array of evidence for improving safety and patient care.

While participants discussed many potential benefits (discussed above), they also mentioned several needed improvement areas. These are discussed below:

- ***Customization of views*.** In the case of the emergency department, users may desire to configure the application so as to customize what they can and can't see on the screen. Each user has his/her own preference in terms of the types and amount of information that he/she perceives as valuable. Creating information "components" that can be turned on or off could allow for a more preferred user experience.

- ***Customization of incident and patient types.*** The current CrashHelp system delineates between young and elderly crash patients. Participants discussed the need to look at pediatric situations differently than adult situations as well.

- ***Backend Organizing Logic*.** In order to enable customization and configuration of the interface, there is a need for a "backend" ontology, or comprehensive method for organizing logical components of the system, multimedia content, language, and cognitive decision-making criteria. This will also aid in post incident analysis, for data mining multimedia information.

- ***Include ACN data*.** Automated capture of crash data along with video, images and voice may provide the most benefit to users. Combining information collected by the handheld device with automatic crash notification (ACN) data could help provide a much deeper understanding about the incident. The video and pictures, only providing a 2 dimensional perspective, could be more valuable with data describing the severity of impact to a vehicle and the probability of injury.

- ***Legal Implications.*** Participants discussed the need to consider legal implications of exchanging crash data and the need for a clear set of security policies and requirements for using a handheld device in the field. For example, policies need to be implemented in case devices are lost or stolen, or to prevent users from uploading crash pictures to personal websites.

- ***Data Standardization***. Participants noted the importance of adhering to data standards that have been defined for healthcare and EMS (e.g., NEMSIS, NTDS, HL7).

Finally, participants believed an important next step would be to further develop and pilot test the application and evaluate its ability to enable timely and quality information handoff across pre-hospital and hospital settings. It is further expected that these findings will lead to new protocols and applications for enhancing emergency medical response by aligning emergency health services with potential technology solutions.

***CrashHelp Deployment Analysis***

Researchers explored several deployment scenarios for the CrashHelp system. These scenarios take into consideration findings from the comparative case studies in Minnesota, Alabama, and Utah; iterative design and development with Mayo Clinic practitioners; and feedback received from practitioners through interviews and focus groups. The deployment analysis focused on potential models to implement CrashHelp that leverage emerging technologies and existing and emerging EMS data system architectures and organizational relationships. A summary of findings are discussed below.

*CrashHelp implemented as a component of an existing EMS or hospital software vendor solution.* Many individual EMS agencies, providers, and hospitals already own expensive software systems and devices. While these organizations may desire the added functionality of CrashHelp, they may not want, as one practitioner stated, "…yet another device or software system to log in to." In the case of cities, smaller regions, or groups of collaborating providers, CrashHelp may be most suitable as an add-on component to existing vendor software systems.

*CrashHelp "plugs in" to a state/regional information exchange.* As discussed in the Alabama, Minnesota, and Utah case studies, many states are developing statewide data systems to aggregate and share EMS and health data. One potential scenario would be for the CrashHelp system to interoperate with a statewide information exchange. Handheld devices could provide data to the exchange. Information components, or pre-defined sets of information, could be provisioned as "web services" to be consumed by any number of user types across the state.

*CrashHelp is configured as several smaller, interoperable information services that can be consumed in parts or as a whole.* Some organizations or regions may want to use only the functionality of the handheld device, while others may want to use both the device and the GIS application. One deployment scenario would be to allow CrashHelp to be used in part, or as a whole, depending on the needs of an organization or set of organizations.

*CrashHelp is a standalone system that an EMS agency could "subscribe to" as a software service over the Internet.* This option could be optimal for small EMS agencies and providers who do not currently own or operate expensive EMS software systems. While the handheld

devices themselves would need to be purchased, the Web-based interface allows any existing Internet enabled device to connect, keeping deployment and management costs at a minimum.

In order to accommodate various deployment scenarios, the CrashHelp system architecture has been revised. The next phase of research will implement the revised changes. Figure 12 below illustrates an architecture with a flexible software middleware (App Server) solution that can facilitate the deployment options described above. The architecture enables any type of device to be used by EMTs and paramedics so long as it adheres to data standards and defined web services. The current CrashHelp system uses Google Android mobile phones. However, any device could be used, including iPhone, Palm, Microsoft or other common handheld phone running a CrashHelp mobile application. The architecture enables any type of device to be used by emergency department personnel, so long as it has a standards web browser. The architecture can leverage existing web services, such as mapping services provided by Microsoft and Google, and is flexible enough to provide two-way data exchange between the handheld device. Finally, the middleware allows for customizable web services to be written, so that practitioners at the ED could pull only the data they want, and leave behind any information that they believe is not useful.

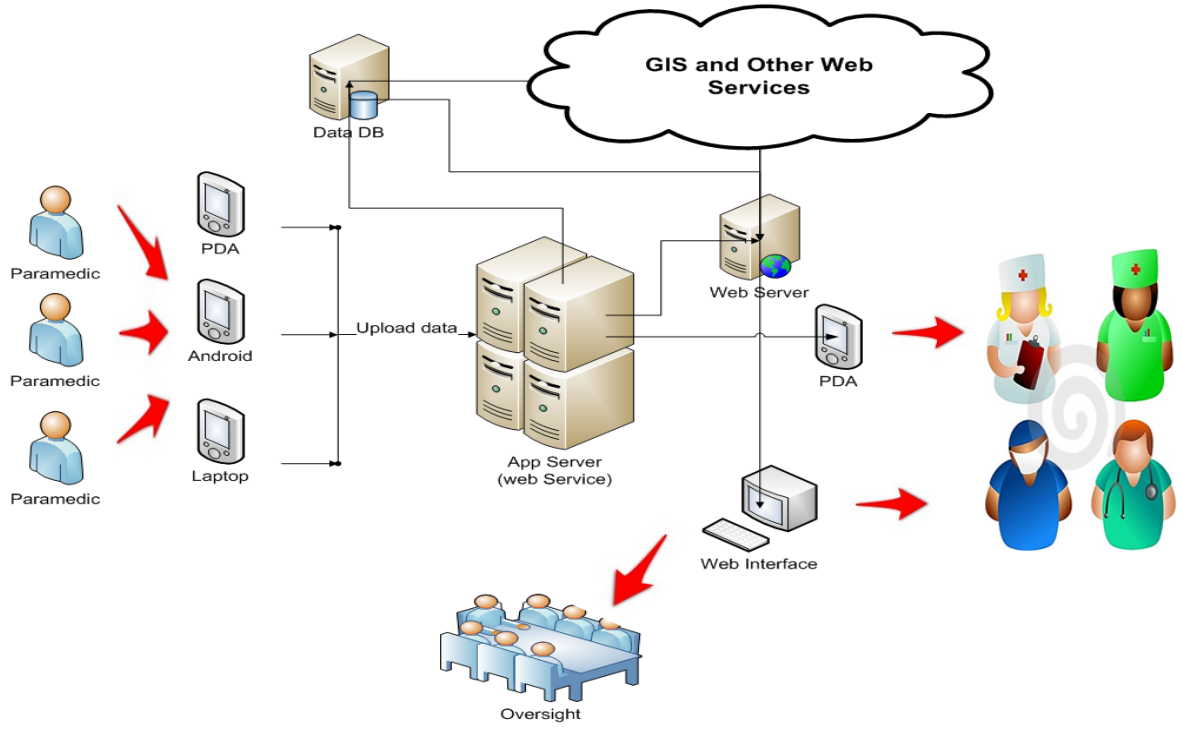


**Figure 12. CrashHelp Deployment Architecture**

The case study analysis described earlier in this report provided a means to derive a generalized architecture for sharing crash and patient data across participating EMS organizations. Looking to this model, the CrashHelp system could be deployed as an integral part. In Figure 13 below, CrashHelp could be deployed on existing handheld devices used by EMTs and paramedics or on new devices purchased by an agency. Deployed as a web service, the CrashHelp middleware

could allow integration with existing ePCR systems owned and operated by EMS providers, or integrate directly with a State operated web based ePCR system (as in the case with each of the three states EMS systems analyzed). This would ensure that data collection efforts are not duplicated, while benefiting from the added functionality of the handheld device. This would also allow the ED practitioners to customize a view of incident information based on any and all information collected by 911 and EMS personnel, not just the data collected using the handheld device. This would also allow the flexibility required for CrashHelp to function in a wide range of deployments at the local and state level.

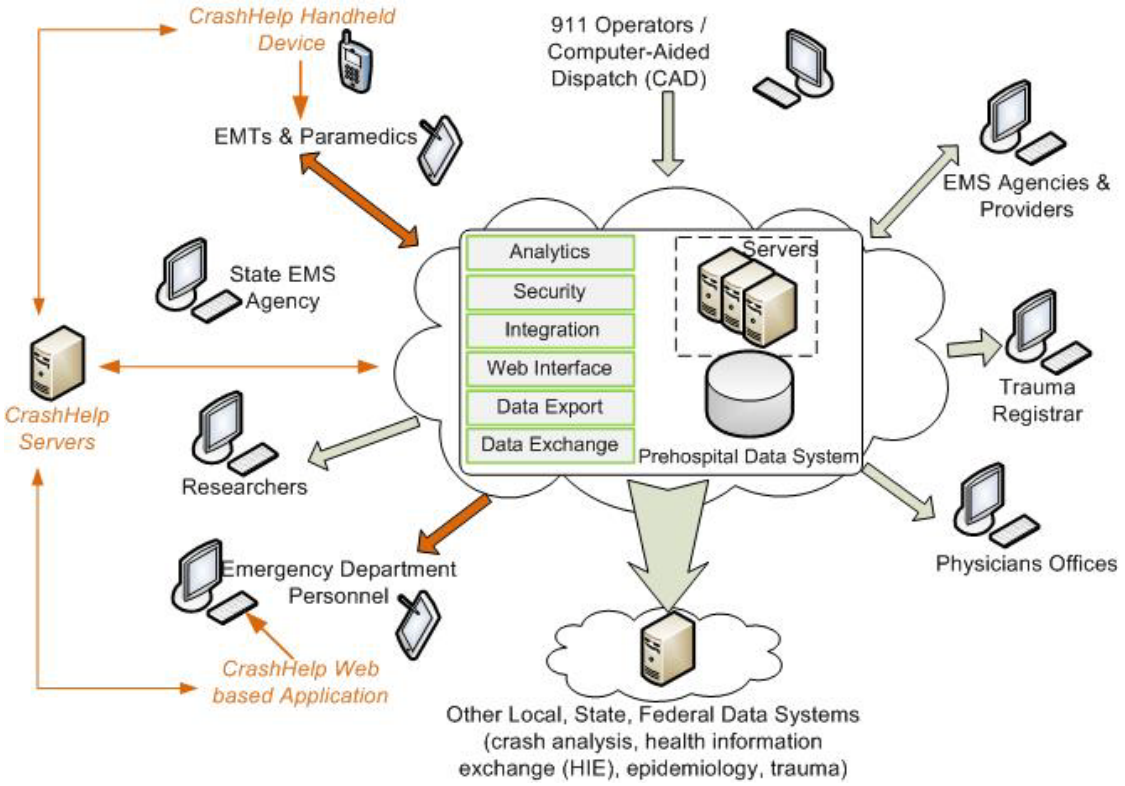


**Figure 13. CrashHelp Deployment Architecture**

# Chapter 9. Conclusion

Communicating patient health issues related to road transportation safety and performance about emergency response to roadway crashes is a challenging task. In this study, the design and development of a prototype system to inform, educate, and support decision making as related to these issues was discussed. This prototype integrates a range of data regarding motor vehicle crashes, emergency responses to those crashes, and related patient-care information in the pre-hospital and hospital settings. They contain a map to visually display spatial data and a drill-down capability that allows end users to query/filter these data sets to extract information related to specific incidents and generate performance views from that information.

The Web is rapidly moving toward a platform for mass collaboration and performance visualization in content production and consumption where fresh content on a variety of topics, people, and places is being created and made available through secure Web-based mediums. The CrashHelp system, though in its beginning stages, currently requires additional enhancements and then will be taken back to end users to evaluate and provide feedback based on their real-world, practical experience delivering emergency medical care.

Specifically, the need to include additional emergency response data and additional fields related to patient care and outcomes, and to refine the interface to allow for greater accessibility to information are among the immediate next steps for expansion of the database. As stated by the World Health Organization (WHO), the level of road traffic injury is unacceptable and largely avoidable. Yet, as traffic crashes continue to occur, EMS and trauma care represent important services for reducing the disability and death consequence of these crashes. Important ongoing goals for the CrashHelp system are to help inform practitioners of timely and pertinent crash information to enhance patient care to victims and to provide valuable end-to-end information for making policy decisions and enhancing EMS care from a systemic level.

Both the traveling public and state departments of transportation are expected to be beneficiaries of such a system. In terms of the former, the aim is to develop a visual way to display safety data so that routes and conditions (in terms of safety) can be as readily understood as traffic congestion maps are currently used. In terms of the latter, the aim is to provide state departments of transportation with a framework that can be utilized to achieve near-real-time performance monitoring and related safety planning. The benefits of this research also assist state departments of transportation in creating a SHSP that meets the data intensive requirements of SAFETEA-LU with the ultimate goal of reducing the number of highway fatalities and serious injuries on all public roads. The study also investigated related uses by emergency planners in terms of data systems use during times of emergency.

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# Appendix A. The Need for Decision Support for EMS

Emergency Medical Services (EMS) is designed to care for and transport sick or injured patients to the hospital (IOM, 2006). In the United States, there are over 16 million patients transported by EMS to Emergency Departments (EDs) every year (Burt et al., 2006). The service lies at the intersection of health care, public health, transportation and public safety, interacting with and carrying out the roles and responsibilities of each (IOM, 2006). For each emergency incident, multiple organizations including 9-1-1 call centers, first responders (e.g., Fire Departments), ambulance transport providers, and hospitals engage in a time-sensitive, process oriented service that is highly information dependent. However, the collection, aggregation, and reporting of patient and incident information for EMS has long been a challenge largely due to the dynamic, fast paced, high stress, emergency care delivery context (Institute of Medicine, 2006).

Discontinuous patient care, which occurs when one clinician relinquishes care to another, is a significant challenge that is further magnified in fast-paced and short-stay environments such as the ambulance or ED (Wiler et al., 2010; Benner et al., 2007; Schooley and Horan, 2007; Carver and Turoff, 2007). In emergency medical settings, written and verbal information is often forgotten, misplaced, omitted, or unreadable (Adams et al., 2004; Erich, 2007; Orthner, 2005). Many emergency care providers are unable to identify a standard operating procedure for the information hand-off period (Bomba and Prakash, 2005). It has been suggested that the lack of conformity and structure during critical information traffic is a significant cause for redundant or omitted information, most of which is either verbal or handwritten (Agency for Healthcare Research and Quality, 2007); and this can lead to medical errors (Chisholm et al., 2000).

In general, health information technology (HIT) has been found to help improve the quality of patient hand-offs, lead to decreased errors of omission, and reduce risk of patient injury during the transition of care (Erich, 2007; Van Eaton, et al., 2005). This has been found in emergency settings for better meeting patient needs (Taylor, 2004; Watcharasriroj and Tang, 2004; Van Eaton, et al., 2007). One tool that has been used in EMS to help facilitate accurate and timely information hand-off is the electronic Patient Care Record (ePCR) (Spaite, 1990; Meislin et al., 1999). E-PCR systems have been designed to: aggregate data across 9-1-1 call centers, first responders, and transport organizations; capture over 400+ standardized data elements (Dawson, 2006); record health care procedures, patient assessments, medications, protocols, patient history, demographics, and situational context information. E-PCR's have been very important for record keeping, research, and clinical quality improvement initiatives. These systems are also increasingly used to share EMS data with other agencies and their respective data systems.

While there is increasing use of ePCR systems across the US (Williams, 2008), challenges to collecting and sharing pre-hospital information remain. It remains unclear to what extent ITS design features have been established to guide technology enabled care processes in EMS, and to improve traffic safety.

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## Appendix B. EMS and Trauma Information Systems Comparison across States

| | Technology | Policy | Organizational |
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| **Utah** | AIS is the prehospital data system used by the Bureau since 1985. It is being superseded by POLARIS (Prehospital OnLine Active Reporting Information System). It supports EMS agencies' efforts to comply with the State data reporting requirements. A statewide trauma registry has been implemented. Data dictionary defined. Linkage with NTDS established. Data validation and reporting capable. Publicly accessible reporting interface available. This system connects with NTDS. Utah State submits trauma data to NTDB by 33% or more. http://www.utahtrauma.org/index.html<br><br>http://health.utah.gov/ems/ | EMS agencies and hospitals must comply with the data reporting requirement in Utah Administrative Rule R426-7 that includes NEMSIS reporting of PCRs within 30 days of the end of each calendar quarter. Minimum data set defined. ED's must report the patient's emergency department disposition; and the patient's hospital disposition to the reporting agency. EDs must also submit outcome data to POLARIS as per timeline noted above. | Utah Department of Health, Bureau of EMS responsible for statewide EMS communication systems. The statewide Trauma system lies within the EMS Bureau. Collaboration with the Intermountain Injury Control Research Center (U. Utah). SHSP – efforts must be made to coordinate EMS into transportation safety. Collaborators: UDOT, FHWA, U. Highway Patrol, U. Dept of Health. |
| **Alabama** | Alabama has a statewide electronic Patient Care Reporting (ePCR) software that is compliant with NEMSIS. The ATS patient routing is done by a single high-tech communication center that monitors the resources of every trauma center and coordinates patient transport to the appropriate ready trauma center. ATR is a system that supports the collection, storage and subsequent analysis of trauma-related data on a statewide level. | The Alabama Legislature passed the Statewide Trauma System bill which will facilitate the development of a state-of-the-art trauma system for the State of Alabama (currently under development). Statewide Trauma Advisory Council creates a statewide trauma registry, provides for regional trauma advisory councils, and would provide funding through the State Board of Health. | Alabama Department of Public Health (ADPH), the Office of EMS and Trauma in Alabama's EMS advisory committee members include representation from American Academy of Pediatrics, American College of Emergency Physicians, Alabama Highway Safety Administration, Alabama Hospital Association, State EMS and Trauma, Emergency Nurse, and EMTs. The trauma system |

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| | Alabama State submits trauma data to NTDB by 67% or more. The Alabama Incident Management System (AIMS) aids in monitoring hospitals, nursing homes, and ambulance resources during times of disasters.<br><br>http://www.adph.org/atr/ | | involves trauma center working together with 9-1-1, EMTs, ambulances, helicopters, and other health care resources in a coordinated and preplanned way. http://www.adph.org/ems/ |
| **Idaho** | The Idaho Trauma Registry (ITR) currently has over 33% reporting across the state. It links with NTDB. A data dictionary has been defined. Required data fields defined. A statewide EMS data system is also under development. NEMSIS reporting is also approximately 33%. The State is reporting to NEMSIS. Required data elements have been defined. http://www.healthandwelfare.idaho.gov/site/3344/default.aspx | October 2005, the EMS Bureau contracted for the development and implementation of a statewide trauma registry in compliance with Idaho Code §57-2003. The purpose of the registry is to collect data needed to analyze the incidence, severity, causes, costs and outcomes of trauma in Idaho in order to improve emergency medical systems and to prevent serious injuries. The legislation increases the Emergency Medical Services fee portion of the motor vehicle registration fees by thirty cents and dedicates that amount to the operation of the Idaho Trauma Registry. The statute encourages information sharing for research and evaluation purposes. | Idaho Department of Health and Welfare, Bureau of EMS responsible for statewide EMS communication systems. The statewide trauma system lies within the EMS Bureau. Collaborations include: IDOT, FHWA, Public Safety, Dept of Health. |
| **Virginia** | The statewide EMS Registry (EMSR), provided by ImageTrend, Inc. is compatible with the Virginia Statewide Trauma Registry and NEMSIS, and is able to | §32.1-111.3 of the Code of Virginia requires the development of a comprehensive, coordinated, statewide emergency medical | Virginia Department of Health, Office of EMS. Division of Trauma/Critical Care. Pre-hospital Patient Care Reporting (PPCR) |

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| | expand to include surveillance capabilities and data linkages with hospital bed diversion and patient tracking systems. The EMSR will link emergency medical services (EMS), law enforcement, fire and hospital databases to enhance regional communication and collaboration. Includes a Web-based data collection and reporting tool. EMS Registry allows EMS agencies the ability to review their own data, conduct quality monitoring and performance improvement. Virginia Statewide Trauma Registry (VSTR) is an automated system to collect mandated retrospective data on patients with injuries resulting in hospitalization, transfer or death. ALL licensed hospitals which render emergency medical services must participate in the trauma registry. | services plan by the Virginia Office of EMS (OEMS). The Office of EMS strategic plan calls for creating partnerships, creating tools and resources, developing infrastructure, assuring quality and evaluation. http://www.vdh.state.va.us/OEMS/EMSPlan/StrategicAndOperationalPlan.pdf | Program. Virginia State formed Virginia Surface Transportation Safety Executive Committee in reaction to public health concern. This commitment has been renewed through the signing of Virginia's Transportation Safety Charter to create, implement, and evaluate the Commonwealth's Strategic Highway Safety Plan. This committee's role is to ensure consistent communication and cooperation among all safety stakeholders into an integrated action plan. Virginia Regional Emergency Medical Services Councils, integral parts of Virginia's comprehensive EMS system, serve to assess, identify, coordinate, plan and implement efficient and effective regional EMS delivery systems. |
| **Wash-ington** | The Washington Trauma Registry (WTR) collects detailed demographic and clinical data on major trauma patients from pre-hospital agencies and trauma-designated acute care and rehabilitation services. WTR has 34% to 66% submission for NTDB. The Washington EMS Information System (WEMSIS) goal is to promote evidence-based decision making and EMS quality improvement. The | The Washington Emergency Medical Services and Trauma Act of 1990 declared includes: Clear lines of authority and responsibility; Designation of services; Trauma Care services; Verification of Pre-hospital Trauma services; Field triage criteria development; Regional planning and implementation; Cost containment considerations; | Department of Health, Office of EMS & Trauma. The Washington State Department of Health (WSDH) has a governor-appointed, thirty members Steering Committee on EMS and Trauma Systems that consists of representatives from surgeons and physicians, hospitals, prehospital providers, firefighters, local health departments, consumers and other |

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| | WEMSIS, an ImageTrend EMS Bridge suite, is a statewide comprehensive pre-hospital emergency data collection, analysis and reporting system. The integration of the trauma system with the existing EMS system is currently being implemented. http://www.doh.wa.gov/hsqa/default.htm | Integration of trauma/injury prevention; trauma registry development; Establishment of regional quality assurance/ improvement programs; Integration of trauma rehabilitation services; and, Evaluation of system effectiveness. The Act encourages the development of EMS and trauma software tools and partnerships for trauma prevention and control. | affected groups. Office of Emergency Medical and Trauma Prevention (EMTP) consists of four sections: Education, Training and Regional Support, Licensing and Certification, Prevention, Policy and Planning, and Trauma Designation, Registry and Quality Assurance. There are eight EMS and trauma care regions with Washington State. This represents local and regional interests, and establishes the development of the trauma system as a grass roots effort. They are supported through contracts with the state EMTP office, and are charged with developing regional plans and regional patient procedures. |