ITS and Transportation Safety: EMS System Data Integration to Improve Traffic Crash Emergency Response and Treatment – Phases IV and V

Final Report

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CTS 12-27

Technical Report Documentation Page

1. Report No.	2.	3. Recipients Accession No.
CTS 12-27		

4. Title and Subtitle	5. Report Date
ITS and Transportation Safety: EMS System Data Integration to Improve Traffic Crash Emergency Response and Treatment – Phases IV and V	September 2012
	6.

7. Author(s)	8. Performing Organization Report No.
Benjamin Schooley, Thomas A. Horan, Yousef Abed, and Abdullah Murad	

9. Performing Organization Name and Address		10. Project/Task/Work Unit No.
Humphrey School of Public Affairs University of Minnesota 301 19th Ave S Minneapolis, MN 55455	School of Information Systems and Technology Claremont Graduate University 130 E. 9th Street Claremont, CA 91711	CTS Project #2011067 and 2012046
		11. Contract (C) or Grant (G) No.

12. Sponsoring Organization Name and Address	13. Type of Report and Period Covered
Intelligent Transportation Systems Institute Center for Transportation Studies University of Minnesota 200 Transportation and Safety Building 511 Washington Ave. SE Minneapolis, Minnesota 55455	Final Report
	14. Sponsoring Agency Code

15. Supplementary Notes

http://www.its.umn.edu/Publications/ResearchReports/

16. Abstract (Limit: 250 words)

Researchers developed a software system called “CrashHelp” to improve the information exchange from emergency medical services (EMS) practitioners to emergency room/trauma center providers. The system combines mobile smartphone, multimedia, Web server, and location-based technologies for paramedics to send key information to hospital providers in a more data-rich manner than is currently available. This study outlines the development of a second version of CrashHelp and summarizes the results of an initial pilot testing in the Boise, Idaho, region. In addition, the study contains an analysis of the data system standards for EMS and intelligent transportation systems to understand how they should be applied to the CrashHelp system. Finally, the study investigates the potential sustainability of the CrashHelp system in several respects, including deployment in regions with little prior infrastructure, as well as in more urban and developed areas. This included investigating business models and deployment models for delivering CrashHelp as a product or service in the future.

17. Document Analysis/Descriptors	18. Availability Statement
Emergency medical services, EMS, Handheld computers, Collisions, Injuries, Trauma, Hospital emergency rooms, Information technology, First responders, Real time data processing, TechPlan, Electronic health record, Intelligent transportation systems, Intelligent transportation systems, CrashHelp	No restrictions. Document available from: National Technical Information Services, Alexandria, Virginia 22312

19. Security Class (this report)	20. Security Class (this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	29	

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September 2012

Published by:

Intelligent Transportation Systems Institute
Center for Transportation Studies
University of Minnesota
200 Transportation and Safety Building
511 Washington Ave. S.E.
Minneapolis, Minnesota 55455

Acknowledgments

The authors wish to acknowledge those who made this research possible. The study was funded by the Intelligent Transportation Systems (ITS) Institute, a program of the University of Minnesota's Center for Transportation Studies (CTS). Financial support was provided by the United States Department of Transportation's Research and Innovative Technologies Administration (RITA).

We appreciate the hard work of several key team members on this project who have participated at various stages of research, analysis, software development, and report writing including graduate students Joe Roberts, Crispaul Obana, and Kelsey Figge.

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Executive Summary

Over the past several years, the research team has investigated the role that information technology (IT) plays in enhancing emergency medical services (EMS) across the continuum of patient care. One critical informational and technological gap identified in prior research is the need for improved information exchange from EMS "pre-hospital" practitioners to "hospital" emergency room/trauma center providers. To address this gap, the team developed a software system called "CrashHelp". The system combines mobile smartphone, multimedia, Web server, and location-based technologies for paramedics to send key information to hospital providers in a more data-rich manner than is currently available.

This report outlines the development of a second version of CrashHelp, and summarizes the results of an initial pilot testing of the system in the Boise, Idaho, region. In addition, the report contains an analysis of the data system standards for EMS and Intelligent Transportation Systems (ITS) to understand how they should be applied to the CrashHelp system. Finally, the report investigated the potential sustainability of the CrashHelp system taking into account several contexts, including considerations for developing regions with little prior infrastructure, as well as in more urban and developed areas. This included investigating business and deployment models for delivering CrashHelp as a product or service in the future. The overall main goal of this project was to advance the CrashHelp system from a prototype to a limited production application available for use by practitioners in real-world EMS systems.

The CrashHelp team developed CrashHelp version 2.0, building upon the existing CrashHelp version 1.0, to enhance its usability and scalability for the purpose of deployment. Moreover, in this new version, considerable steps were taken to mitigate information privacy and security risks associated with the use of health information and mobile computing. A three-month pilot test of CrashHelp version 2.0 was then conducted in the Boise, Idaho, region. Results from the pilot test included both positive findings as well as issues and challenges that need to be addressed in the future. Findings indicated potential value to expanding and refining the CrashHelp system and continuing to test the application in rural locations for improving EMS communications and practices and patient outcomes for those involved in rural and severe crashes.

To improve the performance of CrashHelp, the research team analyzed data system standards for EMS and ITS to understand how they should be applied to the CrashHelp system. An important aspect of this analysis was to define the set standards and methods needed for integrating (or sharing) CrashHelp data with other data systems for traffic safety, emergency medical care, trauma data analysis – and for oversight at local, regional, and state levels. In this regard, CrashHelp version 2.0 was built upon certain identified industry standards at the database, middleware (server), mobile device, and data element levels. It is expected that the next version of CrashHelp will include a standardized API built upon standards that will enable other authorized data systems (e.g., EMS patient care records, hospital electronic health records (EHRs), and others) to pull information from CrashHelp.

With respect to the broader implementation and use in the EMS/ITS marketplace, feedback from practitioners indicated CrashHelp could have the most significant impact on patient care for incidents that present long transport times and more severe medical conditions. As such, rural

and remote regions where transport distances and times are greater are important contexts for focusing the future study of CrashHelp. In this regard, further pilot testing of CrashHelp will be undertaken in rural Idaho and Minnesota. Further, several potential options for commercializing the CrashHelp system have been identified. These include licensing CrashHelp software to EMS software firms that provide electronic patient care records and firms that provide telemedicine products to hospitals, or offering CrashHelp as a subscription-based service. The next phase of CrashHelp testing will provide a deeper understanding about the potential for these software-licensing approaches.

Chapter 1. Background and Purpose

Past research has established a need to investigate how information can be utilized across the array of organizations and data systems that function across the emergency response continuum of care, including crash notification, 911 dispatch, EMS response, admission into trauma wards, rehabilitation, and the eventual status of health outcomes. Managers, analysts, and policy makers need access to such aggregated data for more accurate, timely and comprehensive decision-making.

Over the past several years, the CrashHelp research team has investigated the role that information technology (IT) plays in enhancing emergency medical services (EMS) across the continuum of patient care. One critical informational and technological gap that has been identified through prior research is the need for improved information exchange from EMS "pre-hospital" practitioners to "hospital" emergency room/trauma center providers. To address this gap, researchers developed a software system called CrashHelp and recently conducted an initial pilot test in the Boise, Idaho, region. The CrashHelp system is aimed at assisting with the collection of basic pre-hospital patient information and visualizing key information points to emergency room and trauma center providers. The system combines mobile smartphone, multimedia (pictures, digital audio), Web server, and location-based technologies for paramedics to send key information to hospital providers in a more data-rich manner than is currently available.

The goal of this project is to advance the CrashHelp system from a prototype to a limited production application available for use by practitioners in real-world EMS systems.

The research objectives for this project include:

- Examine advanced functionality, yet simple to use features, to apply to the CrashHelp prototype that will enable improved decision making by emergency practitioners.
- Develop and apply functional and required security and privacy features to the CrashHelp prototype.
- Expand the CrashHelp prototype to include aggregate level clinical and operational performance metrics that would provide valuable decision level information for planners and practitioners.
- Investigate EMS and Intelligent Transportation Systems (ITS) data and integration standards for possible inclusion in the CrashHelp prototype.
- Explore reported and practitioner perceived medical outcomes that could result from using CrashHelp in a real-world clinical setting.
- Analyze sustainability of the CrashHelp system for broader implementation and use in the EMS/ITS marketplace.

Chapter 2. Task 1a: CrashHelp Version 2.0 Development

The CrashHelp team built upon the existing CrashHelp version 1.0 to enhance its usability and scalability for the purpose of deployment. Researchers engaged "on the ground" practitioners, including medical professionals from the Emergency Department (ED), to streamline the efficient and effective use of the mobile handheld device and visual display of the emergency department interface. The CrashHelp team drew from interviews with EMS stakeholders in Minnesota and Idaho over the past three phases of CrashHelp analysis and development to construct version 2.0 of the application. This Phase IV work implemented the final set of requirements, presented the CrashHelp prototype to end-users in three iterations, and refined the prototype into a deployable application. One important component was to build out needed functionality for use in a multi-user setting including essential security and privacy dimensions of the system. The CrashHelp software version 2.0 is described in a paper accepted for presentation at the annual America's Conference on Information Systems (see Reference 1). The paper describes the three main components of the CrashHelp system: 1) the smartphone application for paramedics, 1) the Web application for emergency departments, and 3) the enterprise application server that facilitates information management and exchange between the smartphone and the Web interface. Figure 1 below is a generalized representation of components used by the two major CrashHelp stakeholders: ambulance paramedics and emergency department practitioners.

Figure 1. CrashHelp Overview

The CrashHelp system version 2.0 functional architecture is described below. This is described in terms of: 1) data storage, 2) enterprise applications on the CrashHelp server, 3) mobile applications (mobile apps), 4) Web applications for the emergency department, 5) integrated security applications and features, 6) data exchange standards, and 7) systems integration and interoperability across mobile and Web applications. These are described further in Table 1 below.

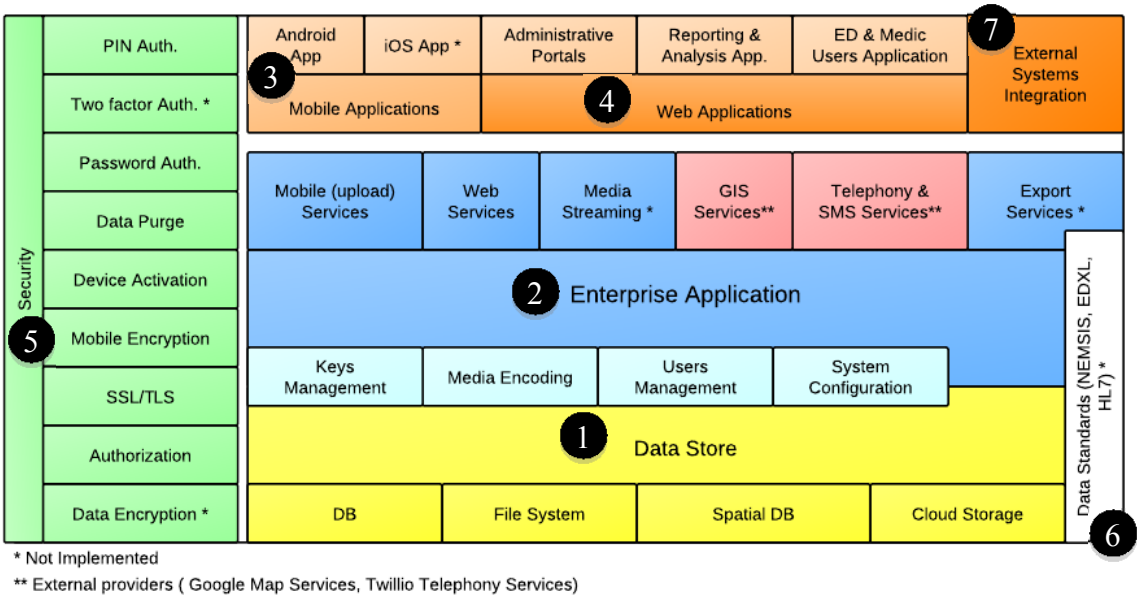

Figure 2. CrashHelp Version 2.0 Architecture

Table 1. CrashHelp Version 2.0 Component Descriptions

1	**Data Store**	The CrashHelp system uses a variety of data storage capabilities to store all system data including patient and incident data, associated multimedia files, user information, and system configuration. These data storage resources include: **Database:** A relational database is used to store incident information (e.g. timestamps, patient data, location information). **File System:** A secure system file folder on the server is used to store encrypted multimedia files (e.g. digital images, audio and video files). **Cloud Storage:** A secure Amazon S3 cloud storage resource is used to backup stored multimedia files and provide data redundancy.
2	**Enterprise Applications**	The CrashHelp enterprise application is a middleware software system that facilitates secure connectivity and integration between several system components. The applications include: **Mobile Services:** A secure set of RESTful Application Programming Interface (API) services are implemented to allow mobile devices to communicate and exchange data with the enterprise application. **Web Services:** A secure set of RESTful API services are implemented to allow emergency department users to communicate and retrieve data from the enterprise application via Web browser. **GIS Services:** A Google Maps API is utilized to provide geo-spatial (i.e., GIS) functionality and electronic mapping tools. **Telephone & SMS Services:** A secure telephony API provided by Twillio.com is used to facilitate phone calls and SMS functionality between users.
3	**Mobile Application**	The CrashHelp system provides two mobile apps that allow users to interact with the system: **Android Application (Medic App):** A mobile app running on an Android Smartphone device enables paramedics to collect incident information, capture multimedia files, and transmit the information to the corresponding hospital ED. **iPad Application: (ED App):** A mobile application running on Apple iPad provides ED staff with access to previously sent CrashHelp records. The application also provides notification functionality and chat-like functionality between the ED and paramedics in the field.
4	**Web Application**	The CrashHelp system provides three main Web applications that allow users to interact with the system: **Administrative Portal:** A secure Web application that allows administrators at hospitals, ambulance companies, and government agencies to manage their users, devices, and access credentials (logins) to the CrashHelp system. **Reporting and Analytics Portal:** A secure Web application that allows managers and administrators to generate reports and perform GIS analysis. **ED and Medic Web Application:** A secure Web application that allows ED and paramedic users to browse and retrieve previously recorded CrashHelp records. The application also provides notification functionality and chat-like functionality between ED personnel and paramedics in the field.
5	**Security**	CrashHelp implements many security modules that are utilized across various components of the system. Additional details about the security risks and features are described in Table 2 in the next section of this report: **Software Availability and Distribution:** The CrashHelp Hand Held Application is not publicly available in any mobile app market. This shall prevent unauthorized users from downloading the application or communicating with the CrashHelp system. **Device Activation:** All mobile devices go through an activation process after installing the

		CrashHelp application. Only an administrator can initiate the activation process by using the Administrator Portal. **Device Access:** The Smartphone screen locks at time-out (duration can be configured), and unlocks with a unique PIN/pattern (optional). **PIN Authentication:** A unique user PIN number, device serial number, and device phone number are sent to the server over a secure Web session to authenticate the user with the server. **Mobile Encryption and Data Purge:** Once paramedics create an incident record in the mobile app, all data is encrypted to the device and deleted after sending the data. In the case of a "send" failure, the encrypted incident records are purged after 24 hours. **Password Authentication:** User name and password are required to access any service. **SSL/TLS**: All data communication and transmission between mobile devices and the server are communicated over an encrypted channel using industry standard protocols, including secure socket layer / transport layer security (SSL/TLS).
6	**Data Standards**	The following Data Standard and Data Exchange Standards will be considered to allow external system interation. Additional information about the data and system standards applied to CrashHelp can be found in section "Task 3" and Table 3. • National EMS Information System (NEMSIS): The NHTSA Version 2.2.1 definition of EMS Dataset and Demographic Dataset will be implemented in the database. Also, the NHTSA Version 2.2.1 XML standard will be used to provide a data export function • Emergency Data Exchange Language (EDXL): The EDXL suite comprises a number of individual standards but only EDXL-DE (Distribution Element) and EDXL-TEP (Tracking of Emergency Patients) will be targeted, as the others are not applicable. • HL7: HL7 Continuity of Care Document (CCD) required data elements will be collected and implemented in XML format for export.
7	**External System Integration**	**Export Services**: A secure RESTful API will be provided to allow external systems to integrate with CrashHelp via commonly used data standards.

Chapter 3. Task 1b: CrashHelp Security and Privacy Framework

The CrashHelp team took considerable steps to mitigate information privacy and security risks associated with the use of health information and mobile computing. The following is a multi-layer security and privacy framework implemented by the CrashHelp team. The framework is described below in terms of:

A) the handheld mobile app,
B) the middleware and Web-application server, and
C) the Web interface for emergency departments.

A. CrashHelp Hand Held Application.

System Users: EMT's, Paramedics in the field

Software: CrashHelp v.2.0

Software Availability: The CrashHelp Hand Held Application is not publicly available in any cloud-based mobile app marketplace. This shall prevent unauthorized users from downloading the application or communicating with the CrashHelp system. A system administrator sends a download link containing the CrashHelp software and activation code to an authorized device and user to install the application (see "Device Activation" below).

Device Activation: All mobile devices run through an activation process after installation of the CrashHelp application. Only a system administrator and representative of the relevant organization (i.e., hospital, ambulance provider) can initiate the activation process by using the Web-based Administrator Portal. The activation process starts by entering the device name and phone number in the Administrator Portal. An SMS message with an activation code and a link to download the application is sent to the device. The activation code must be entered into the mobile CrashHelp Application to activate the device after downloading and installing the application. In addition, the activation process facilitates registering the device serial number and phone number.

Device Access: The device screen locks out at time-out (duration can be configured). The screen unlocks using a unique PIN/pattern (optional as per the security policies of each end-user organization).

Application Access: A unique PIN number must be entered that is associated with each mobile user. The PIN is determined by the system administrator.

Data Security: Once a paramedic creates an incident record in the mobile app, the following security measures are applied:

- Incident records are saved in hidden files on the device.
- Incident records (including multimedia files) are automatically and periodically encrypted.
- Incident records are purged (deleted) from the mobile device after data has been sent to the server, or after 24 hours in case of a sending failure (duration can be configured).

Secure Session: Before any data is sent, a secure session is established with the server.

User Authentication: A unique user PIN number, the device serial number, and device phone number are sent to the server using the secure session to authenticate the mobile user.

Data Transmission: All data communication and transmission with the server are communicated over an encrypted channel using SSL/TLS.

Device Management: The Web-based CrashHelp Portal provides a device management functionality that allows hospital and ambulance agency administrators to:

- Distribute (send) the CrashHelp software application download link to select devices.
- Add (activate) new devices to a specific paramedic provider.
- Add new users (Paramedics) to a specific paramedic provider.
- Associate/Dissociate devices to a specific medic unit within an ambulance provider.
- Enable/Disable devices.

B. CrashHelp Middleware and Web Application Server

Users: CrashHelp Administrators
Software: Configuration built using Sun Microsystems/Oracle GlassFish Enterprise Application Server
General: CrashHelp leverages the Oracle enterprise class application server that integrates database, application, and Web server functionality together thus reducing security risks associated with working across these functions.
Secure Session: The CrashHelp server maintains a security certificate, identifies and authenticates users, and maintains secure sessions (SSL).
Access Rights and Roles Management: Access rights and roles for all users are configured and managed using the CrashHelp administration system. These roles and rights are applied to specific user logins, enforcing rules about: who has the authority to access, when users can access, and what data and functions can be accessed.
Storage and Device Encryption: Data can be encrypted to the system database and to a physical hard drive.

C. CrashHelp Web Interface

Users: Emergency Department / Trauma Practitioners
Software: Web Browser (IE 6.0, Firefox 1.5, Chrome, Safari)
Secure Session: Standard Web browsers facilitate SSL transmission with the CrashHelp server. A secure session is established and the user is authenticated with the server prior to accessing and visualizing CrashHelp information.

The following Table 2 summarizes the information risks, associated mitigation processes that the CrashHelp team has enforced for the CrashHelp 2.0 system at the application layer, and the justification for enforcing the controls.

Table 2. Security and Privacy Risks, Mitigation, and Reasoning

Risk/Control	Process	Justification(s)
Mobile App Distribution	The CrashHelp Hand Held Application is not publicly available in any mobile app market. All mobile devices go through an activation process after installing CrashHelp application.	This shall prevent unauthorized users from downloading the application or communicating with the CrashHelp system.
Verifying Users	Only designated administrators from each organization can add/suspend/activate users by using the Administrator Portal. Administrators cannot overlook passwords, but they can reset them.	The practice of storing hashed passwords shall protect users' passwords, especially for those users whom like to use one password for multiple accounts.
Verifying Mobile Devices	Only an administrator can initiate the activation process by using the Administrator Portal. The activation process starts by entering the device name and phone number in the Administrator Portal. An SMS message with an activation code and a link to download the application will be sent to the device. This activation code needs to be entered into the CrashHelp Application to activate the device after downloading and installing the application. In addition, the activation process allows the system to register the device serial and phone number.	This shall guarantee only authorized devices may communicate with the CrashHelp server.
Data Access: Role-based	Each type of user (medics/hospital staff/government staff) is assigned a role. Based on his/her role, a user may access a different type of data element and functionality for his/her organization.	This shall restrict system access to authorized users only.
Data Access: Content-Based	Within the same user type, a user may access a very specific type of data. E.g., even though all medics are assigned one role (i.e., "medics"), an individual medic can only view the incidents he/she sent and cannot view incident information sent by another medic.	This shall restrict access of certain content to authorized users only.
App In Use: PIN	Prior to sending an incident, a unique PIN number is required. Then, user PIN number, device serial number, and phone number are sent to the server using the secure session to authenticate the user.	This shall authenticate users and keep track of who sent what information.

App In Use: Encryption	Incident records (including multimedia files) are saved in hidden files on the device and encrypted periodically. Also, all data communication and transmission with the server are communicated over an encrypted channel using SSL/TLS.	In case of lost or stolen phones, the data is protected with encryption. The data is also secure during transit (i.e., in between the device and the server).
App In Use: Deletion	Incident records are purged (deleted) from the mobile device after data has been sent to server. In the case of a "send" failure, the encrypted incident records are purged after 24 hours.	This shall prevent data misuse by users themselves or any other unauthorized users.
Data at Rest	Data can be encrypted in the database on the system server. It can also be encrypted on the server hard drive.	This shall prevent data from being accessed on the server or hard drive by unauthorized users.
Physical and Network Security	The CrashHelp server resides in a high security data center that meets FISMA moderate level security standards, passes SAS70 Type II audits, ISO 27001 certification, PCI DSS level 1 compliance, FIPS 140-2 compliance, and HIPAA compliance.	The facility in which the server, software application and all data are located shall adhere to industry standard security and privacy controls to secure personal health information.

Chapter 4. Task 2: CrashHelp System Prototype and Field Test

The CrashHelp system was developed, refined, and launched as version 2.0. A three-month pilot test was then conducted in the Boise, Idaho, region with participation by the following organizations: Ada County Paramedics, Canyon County Paramedics, St. Alphonsus Boise, St. Alphonsus Nampa, St. Alphonsus Eagle, St. Luke's Boise, St. Luke's Meridian, and West Valley Medical Center. Twenty ambulances across two agencies were each provided a mobile smartphone for the duration of the pilot through sponsorship by the Idaho EMS Bueau. The final report for the Boise, Idaho, CrashHelp Pilot Test (see Reference 2) offers a detailed discussion and evaluation of findings. A brief summary is provided below.

Results from the pilot test included both positive findings as well as issues and challenges that need to be addressed in the future. In terms of system use, over 800 CrashHelp records, 400 pictures, and 400 voice recorded descriptions by EMS personnel were transmitted during the three-month pilot test demonstrating use and value of integrating multimedia information into the pre-hospital to hospital communication process (see Tables 3 and 4). Approximately 46% of all paramedics used CrashHelp at least once, with more than 15% of paramedics using the system at least 10 times. Though paramedics were not required to use the system at any time, the consistency and frequency of use provided a solid experience base to draw from to increase the validity of research evaluation findings. There is a significant need to continue the testing and evaluation of CrashHelp to determine long-term value of the technology across medical providers and transportation stakeholders in a transitional setting into more rural areas of Idaho. Summary level findings from the pilot evaluation are provided below.

Table 3. Total Numbers for Pilot Program

# of inci-dents	# of attached images	# of attached video files	# of attached audio files	Text messages sent/received
801	• 437	• 25	• 446	• 126

From an operational perspective, the CrashHelp technical system functioned as planned. Table 4 below summarizes the CrashHelp features used and high-level technical findings.

Table 4. Summary of Technical Findings

Heuristic/Metric	Finding
Types of incidents CrashHelp was used for	• All types (~25% trauma)
• Technical performance during pilot (transmission speed, bandwidth, data completion rates, etc.)	• Excellent (99% uptime)
• Technical Errors	• Infrequent (~2-3%)
• Features most used	• Camera, audio, texting, notifications
• Features less used	• Electronic Map, Video

A. Summary Findings:

Interviews and focus group discussions were held with participant organizations including 18 medics, 20 charge nurses, 5 ED administrators, and 2 physicians. Responses were aggregated and are summarized into key points below. Participants discussed the following benefits to using CrashHelp:

- Viewing well-taken and effective pictures caused a heightened situational awareness about patient needs and enabled emergency practitioner decision-making.
- The mobile app was perceived as "user friendly", requiring little training prior to use.
- The mobile app was not perceived to interfere with pre-hospital patient care any more than current radio and phone communication activities.
- CrashHelp augmented pre-hospital to hospital EMS communication practices, facilitating multi-tasking in a fast paced EMS environment.
- Paramedics wanted to use CrashHelp more as nurses adopted and appreciated the information they sent.
- Nurses wanted to use CrashHelp more as paramedics adopted and used the mobile app to send incident records.
- CrashHelp enabled multi-tasking; something valued and viewed by many nurses as "fitting" with ED processes.
- CrashHelp may have provided the most value for EMS incidents exhibiting higher severity levels and longer transport times, and provided the least value for incidents exhibiting short transport times.
- CrashHelp enabled patient monitoring for injuries and/or health status progression.

The following technical improvements were discussed as important to future versions of the CrashHelp system:

- Need to address the demand for integration with existing EMS and hospital information systems (e.g., Computer-Aided Dispatch, electronic Patient Care Records, electronic Medical Records/Health Records (electronic patient charts), and telemedicine applications).
- Need to improve the mechanism for automatically notifying ED nurses about a new CrashHelp record – including automated landline phone calls.
- Need to develop a mobile app for the ED to utilize on smartphones, iPads, or Tablets.
- Need to develop capability to enable hospital to hospital referrals in the case a patient needs to be transferred to a higher level of care (i.e., Trauma level 2 to Trauma level 1) or more appropriate care (i.e., stroke center).

The following challenges need to be addressed in future implementations:

- Wireless network coverage and immature technology challenges – the 3G network was not always fast enough and was not always available everywhere.
- There is a need for EMS picture-taking protocols – a set of picture taking standards could significantly improve the quality of pictures sent to the ED.
- Lack of consistent and professional training – future implementations should provide more comprehensive fact-to-face training for EMS practitioners.
- Accommodating workflow variation across different hospitals – each hospital has unique communication processes for incoming EMS patients. These need to be better accounted for.
- Keeping up with the demand for new features in a fast moving mobile marketplace. Consumers of smartphone apps are expecting very high quality and high performing applications due to major advancements in the marketplace. Expectations need to be kept in check especially in terms of balancing security risks.
- Balancing data provider (paramedic) versus data consumer (ED) expectations. Paramedics are data providers while the ED is the primary data consumer. Expectations differ across groups and must be accounted for.

Future CrashHelp studies should address each of the above challenges as well as the following future directions:

- Researchers should engage physicians in the use and evaluation of CrashHelp more directly. This group of individuals is difficult to reach yet important for determining the value of the system.
- Future research should include a pilot test that incorporates rural and remote regions in order to test the hypothesis that CrashHelp provides more value for incidents that exhibit longer transport times.

Summary implications of the CrashHelp pilot test include:

- CrashHelp is a novel smartphone innovation focused specifically on improving communications between EMS and ED. It is the first of its kind, aiming to test new mobile functionality in a real-world test bed.
- The pilot test demonstrates potential widespread value of using smartphone technology and multimedia information for augmenting EMS communications in a manner that 1) fits with EMS practices, and 2) enables more informed EMS patient decisions.
- The pilot study bridges a research and demonstration gap between mobile technology software development and emergency health care.
- The pilot study demonstrates research and development opportunities related to mobile computing, wireless technologies, Web technologies, and EMS.

B. Pilot Evaluation: Summary Conclusion

The CrashHelp field test and pilot provided a unique opportunity to test the use of smartphones to communicate patient information between paramedics and emergency department practitioners. The pilot test was exploratory by design, aimed at understanding which features would be used and valued most by EMS practitioners. Findings indicate potential value to expanding and refining the CrashHelp system and continuing to test the application in rural locations for improving EMS communications and practices and patient outcomes for those involved in rural and severe crashes.

Chapter 5. Task 3: Technical Standards and Multi-System Integration Analysis

The CrashHelp team analyzed data system standards for EMS and ITS to understand how they should be applied to the CrashHelp system. An important aspect of this analysis was to define the set standards and methods needed for integrating (or sharing) CrashHelp data with other data systems for traffic safety, emergency medical care, trauma data analysis – and for oversight at local, regional, and state levels.

CrashHelp version 2.0 is built upon the following industry standards at the database, middleware (server), mobile device, and data element levels. It is expected that the next version of CrashHelp will include a standardized API built upon the following standards that will enable other authorized data systems (e.g., EMS patient care records, hospital electronic health records (EHRs), and others) to pull information from CrashHelp.

Table 5 below describes the technology standards used in the development of the CrashHelp. The major components of the system include the 1) database, 2) middleware, 3) mobile devices, and 4) data standards. This table shows each component's subcomponent/function, standard and technology, implementation, and notes/description as needed.

Table 5. CrashHelp Technology Standards for Data Exchange and Integration

Component	Subcomponent/ Function	Standard and Technology	Implementation	Notes/Description
Database	Database Management System (DBMS)	Rational Database	Microsoft SQL Database Server in Amazon EC2 Windows instance	
	Database Query	SQL	Transact-SQL	
	Database Connection	Java Database Connectivity (JDBC) - Java Persistence API	Microsoft JDBC Driver for SQL Server v4	Local connection
Middle-ware	Virtual Server	Operating System	Microsoft Windows Server 2008	
	Application Server	Java Platform, Enterprise Edition (Java EE)	Glassfish V2.0	Open source
	Primary Application	Web Application	Java EE Web Application	
	Application Authentication	Web Login		
	Service- Data Types	JSON - XML/1.1	Java Architecture for XML Binding (JAXB)	RFC 4627 application/json. - W3C http://www.w3.org/TR/2008/REC-xml-20081126/
	Services Architectural Style	Representational state transfer services (RESTful services) over HTTPS/1.1	Java API for RESTful Web Services (JAX-RS)	HTTP/1.1 - W3C http://www.w3.org/Protocols/
	Services Authentication	RFC 2616 (Hypertext Transfer Protocol – HTTP/1.1) and RFC 2617 (HTTP Authentication: Basic and Digest Access Authentication).	Java Authentication and Authorization Service (JAAS)	RFC 2617 - http://www.ietf.org/rfc/rfc2617.txt

	Data Cryptography	Public-Key Cryptography Standards (PKCS) RSA 128-bit - Shared-Key Advanced Encryption Standard (AES)	Java Cryptography Architecture (JCA)	
	Multimedia Encoding: Audio	MP3	JAVE Encoder	ISO/IEC 13818-3
	Multimedia Encoding: Video	Flash Video (Flv) format	JAVE Encoder	
	SMS Notification	SMS Gateway provider	Twillio.com	JSM 1.1
	Phone Call Notification	Telephony Service Provider	Twillio.com	
Mobile Devices	Hardware Platform	Verizon Motorola Droid X	Android Operating System	
	Development Platform	Android SDK 2.1	Java Programming language	
	Server Communication	See Services Architectural Style & Services Authentication above		
	Data Cryptography	See Data Cryptography above		
	Files: Images	JPEG compression	ISO/IEC FDIS 10918-5 - http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=54989	
	Files: Audios and Video	3rd Generation Partnership Project (3GPP) format	3GPP Specification http://www.3gpp.org/specifications	
	Database	Transactional database engine	SQLite	
	Layouts	XML 1.0 Specification	Android XML vocabulary	
	Network communications	Commercial 3G data network		

Data Standards	Data Exchange – EMS Incident Records	National EMS Information System (NEMSIS)	1-The NHTSA Version 2.2.1 definition of EMS Dataset and Demographic Dataset will be implemented in the database 2-The NHTSA Version 2.2.1 XML standard will be used to provide a data export function	http://www.nemsis.org/v2/index.html
	Data Exchange – Emergency Management	Emergency Data Exchange Language (EDXL)	The EDXL suite comprises a number of individual standards but only EDXL-DE (Distribution Element) and EDXL-TEP (Tracking of Emergency Patients) will be targeted as the other are not applicable.	http://www.fema.gov/about/programs/dismanagement/standards/language.shtm
	Data Exchange – Hospitals / Electronic Health Records	HL7	HL7 Continuity of Care Document (CCD) required data elements will be collected and implemented in XML format for export	http://wiki.hl7.org/index.php?title=Continuity_of_Care_Document_(CCD)
	Data Exchange – Trauma Registries	National Trauma Data Standard (NTDS)	NTDS 1.0 provides an XML data definition and standard for hospital, state, and national data exchange of trauma registries.	

Chapter 6. Task 4: Sustainability Analysis

For this task, the CrashHelp research team investigated the potential sustainability of the CrashHelp system taking into account several contexts including considerations for developing regions with little prior infrastructure, as well as in more urban and developed areas. This task also included investigating business models and deployment models for delivering CrashHelp as a product or service in the future. Findings are discussed below.

A. Context Considerations

As discussed in detail in the Boise, Idaho, pilot test evaluation report, practitioners felt that CrashHelp may have the most significant impact on patient care for incidents that present long transport times and more severe medical conditions. As such, rural and remote regions where transport distances and times are greater are important contexts for focusing the future study of CrashHelp. In this regard, the CrashHelp team has secured funding from the Idaho Department of Transportation (IDT) to conduct a six-month rural pilot test of CrashHelp. This will include hospitals in the populated Boise region as in the first pilot test, as well as extending the test to a rural ambulance provider and emergency department servicing regions that are located further from the city. The interest from IDT as evidenced by their funding support, and enthusiasm from Idaho stakeholders, attests to the potential long-term sustainability of the CrashHelp system.

Furthermore, the Minnesota Department of Transportation (Mn/DOT) has also expressed interest in supporting a six-month pilot test of CrashHelp in their state. Their support is supplemented by Minnesota Department of Health (MDH) support through their Rural Flex Grant program. A "go-live" date for beginning the field test has been set in June for Cuyuna Regional Medical Center and its 3 ambulances to test CrashHelp. The Mn/DOT support will allow for CrashHelp testing to extend across the Central Trauma Regional Area Council (CENTRAC) – which includes primarily rural and remote areas of the state.

B. Commercialization Options

The CrashHelp team investigated several potential options for commercializing the CrashHelp system. These are described below:

- **Software Licensing:** An existing EMS software company may find interest in licensing the CrashHelp technology and including it as a product offering to existing customers. The CrashHelp team explored this option through its existing associations with EMS software companies over the past four years. The most probable types of software companies include those that provide:
- **Electronic Patient Care Records (ePCR):** Several organizations provide software for ambulance incident reporting. These electronic reports are long and extensive and are typically not completed until well after a patient arrives to an ED. CrashHelp offers the ability to notify an ED much quicker, but does not take the place of a completed ePCR. One recent conversation with the CEO of ImageTrend, a Minnesota based EMS software company, found CrashHelp to be an innovative approach and wanted to be kept abreast

of research findings to think through potential sales approaches for penetrating the EMS software marketplace.

- **Telemedicine Applications:** A wide range of companies offer telemedicine solutions to hospitals. The most successful of these solutions (in terms of viable business models) typically provide video and voice conferencing solutions for remote clinics to communicate with medical specialists at larger hospitals and private practices. One such company, whom has their software solutions implemented in several Boise, Idaho, hospitals, voiced interest in expanding their product line to include CrashHelp.

The next phase of CrashHelp testing will provide a deeper understanding about the potential for these software licensing approaches.

- **Software as a Service:** The CrashHelp system has, from the beginning, been constructed as a service-oriented approach to solving an information exchange gap. We continue to believe that the system best fits with a subscription based pricing model, where EMS agencies and hospitals pay a subscription fee for communicating CrashHelp records. Because the system crosses organizational boundaries, that is, the software is not used by a single organization but rather is used to share information across multiple organizations (ambulance companies, hospitals, government agencies), a group of cooperating organizations in a region would pay into a pool to support an intermediary organization that would provide CrashHelp as a service. While this approach can be justified on a conceptual level, this model will be explored further in terms of its feasibility at a practical level during the next phase of testing.

C. Near Future Sustainability: Extended CrashHelp Testing

These commercialization options will be made more viable with additional testing of CrashHelp. To that end, two additional testing environments have been successfully pursued. They are as follows:

- **Idaho Phase II:** Objectives of the project are to field test the CrashHelp mobile application in Idaho to test the use and value of transmitting multimedia information from pre-hospital EMS personnel to motor vehicle crash (MVC) stakeholders, including hospitals of receiving crash victims and for highway operations. To date interest has been expressed by paramedics and hospital personnel to continue the initial CrashHelp pilot in Boise, Idaho, and to explore expanding into a rural region of Idaho where the majority of fatalities occur. Project tasks moving forward include continuing CrashHelp field test operations for an additional 6 months. This will also involve include a preliminary plan for field test operations in at least one rural region of Idaho.
- **Minnesota CrashHelp:** This project will be a pilot test of the CrashHelp technology in rural Minnesota. Similar to the Idaho test, it will include implementation and operation of CrashHelp for 6 months, collection and evaluation of quantitative and qualitative data and documentation and presentation of the results. The project team will also work with Towards Zero Deaths (TZD) Minnesota to arrange presentations at regional workshops, and other opportunities to increase awareness of this opportunity to improve Emergency Medical Services as part of the TZD program.

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