Redding Responder Phase I Final Report

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3. EXECUTIVE SUMMARY

The Redding Responder Study was initiated as a component of the Redding Incident Management Enhancement (RIME) Program. The goals of the RIME program are to leverage technology and communications deployments for emergency communication providers in the RIME region by evaluating agency requirements, providing migration paths and improving incident management. The RIME region consists of 19 counties in northern California, which cover nearly 30% of the State's area, approximately 25% of the State's State Highway Lane Miles, and less than 4% of the State's population. RIME organizations include Caltrans District 2, Caltrans Division of Research and Innovation, Norcal EMS, California Department of Forestry and Fire Protection, and other local and state agencies.

The Redding Responder Study was sponsored by the Caltrans' Division of Research and Innovation. The Western Transportation Institute at Montana State University was contracted to conduct research and development comprising the study. Research and development was conducted to address the needs of Caltrans District 2, based in Redding. While targeted specifically at the needs of Caltrans District 2, consideration was given to prospective needs of other RIME agencies and other Caltrans districts, including those in urban areas. Research and development was conducted over a two-and-one-half year time period.

The premise behind the Redding Responder Study is that the collection and transmission of digital photographs and other incident information will enhance incident management and help to clear incidents more quickly. Secondary benefits include those associated with the development and implementation of a systematic methodology for collecting and documenting incidents for future analysis and training. The principal challenges include overcoming limited communication capability in the RIME region and achieving a desired ease of use necessary to make such a system usable in the field. While off-the-shelf hardware and software products exist to solve related problems, such products do not adequately address these principal challenges without further integration and development.

Specific situations in which the product of this study would be used include rockslides, landslides, mudslides, earthquakes, severe weather, and other events in which roadways would be damaged or obstructed. Such events are common in District 2, particularly during the wet months of fall, winter and spring. Use for traffic accidents and during wild land fires would also be likely.

A Project Process Model was developed to incorporate aspects of the Systems Engineering approach, as exemplified by the "Vee" Model and the Spiral Model for Development, which is commonly used to minimize risk in the development of complex systems. The resulting process model is consistent with the Caltrans' Stages of Research Deployment. Specifically, a sequence of prototypes was developed to refine the project concept, elicit requirements and feedback throughout the project, and evaluate technologies and techniques for use. With each "iteration," Caltrans was presented with the next version of the product, and feedback was elicited to determine necessary modifications and additional requirements. Feedback was documented and incorporated into subsequent development. Three early iterations were conducted for the purpose of concept refinement prior to development. A fourth iteration was conducted to develop and evaluate a laboratory prototype to demonstrate the concept, test hardware and software, and elicit feedback. A fifth iteration was conducted to develop and evaluate a controlled field demonstration prototype, a fully functional system that could be used in a limited capacity in the field.

The concept of the prospective system resulting from concept refinement was:

> A system integrating hardware, software and communications shall be developed to give responders the ability to download and use pertinent and available electronic data including maps and aerial photographs as well as weather conditions. The system will also allow for the collection and transmission of at-scene information that is difficult to convey via voice communications. Photos can be taken at the scene, associated with data such as time and GPS location, and organized to provide a more complete picture of the scene. Photos can be enhanced with hand-drawn diagrams outlining the situation and plans in much the same way a football coach might outline a formation or play on a chalkboard. Forms can be included and tailored to a situation or by responsibility, facilitating more accurate and timely recording of information as well as future evaluation and analysis.

The associated objectives were to:

- Create and provide the information elements, framework and pilot deployment of an information collection system centered on the information needs of District 2 field units and Redding TMC for transportation management and incident response/clearance, and of relevance to other emergency response organizations. The incident information collection system will include capabilities for collection of incident images, facilities for annotating images and maps to describe incident scope and severity, incident GPS location, as well as form-based information as deemed appropriate by District 2.
- Create and provide the information elements, framework, and pilot deployment of an incident support information system based on the needs of District 2 field units and Redding TMC, and of relevance to other emergency response organizations. The incident support information system will include capabilities for downloading maps and aerial photos, weather conditions, and other support materials related to the incident and its location.
- Provide the necessary hardware and communications infrastructure for the exchange of at-scene information collected via the information collection system and the distribution of incident support information to responders as described for the incident support system. The communications system will provide the means to exchange information between District 2 field personnel at the scene and Redding TMC, and will be capable of incorporating other emergency response organizations. In Responder vehicles this will consist of a mobile data terminal (ruggedized Tablet PC), a satellite or satellite/cellular combo phone; Internet data connectivity kit including cabling and software and providing GPS hardware with computer connectivity, and a digital camera with computer connectivity. The incident information collection system and the incident support information system software will reside on and interface with this equipment to facilitate the collection of information and transmission of data to and from the incident scene.

This concept and three associated objectives would be addressed by a single integrated system.

The resulting controlled field demonstration prototype consists of integrated hardware and software to satisfy these objectives as a "proof of concept." Hardware components include a rugged Tablet PC, a weather-proof digital camera, a GPS, a cellular modem, and a satellite modem/phone. The Tablet PC is mobile within and outside a vehicle, and communicates with the GPS and modems via an 802.11 wireless connection. The camera is a standard digital camera. The GPS, cellular modem, and satellite modem/phone are integrated within a single case encapsulating cables, power, antennas and other devices necessary for interconnection and wireless access.

Software components include a custom-developed Responder application and associated drivers for the various hardware devices. The Responder application is location-aware, determining location from the GPS and using that location to automatically pre-populate incident information and to pinpoint the incident on a street map, an aerial photo and a USGS topographic map. Digital photos can be uploaded from the camera and added to the Incident Organizer, the organizational structure within the Responder application used for collecting and saving incident information. Photos and maps can be annotated using the Tablet PC pen, and free-form sketches can be drawn to depict further incident information. Weather information specific to the Responder location can be downloaded and displayed by executing a single command. The Responder location is used to automate the process of requesting and retrieving weather information, freeing the end user from manually navigating to it. Similarly, incident information is automatically organized and optimized for storage into a Microsoft Word document, which is automatically transmitted as an email attachment to the TMC upon request. The application determines whether to use cellular or satellite for transmission, dependent on signal strength and availability.

There were several key areas of focus for research on this project. First and foremost, it was desirable to elicit and understand District 2's needs and to accommodate those needs in a system that was easy to use. In other words, research was conducted to make the system both useful and usable. The second research focus area involved determining ways to maximize the use of resources, particularly limited bandwidth and storage capacity. It was necessary to determine what information could be stored locally on the Tablet PC and what information could be downloaded on the fly. It was also necessary to determine how to most effectively upload information from the Responder system to the TMC. The third focus area involved determining the limitations of communication systems and how to optimize their use in light of these limitations. In particular, it was desirable to determine the impact of terrain on satellite communications and the necessary signal strength requirements for effectively using cellular data communications.

Through the iterative, spiral process, requirements and feedback were elicited throughout the study, and feedback was used to form and test the system user interface. Emphasis was given to ease of use, and the resulting system has been judged as easy to use through a number of demonstrates as well as hands-on testing.

Resources were maximized to deliver mapping and weather information to the application in an efficient and timely manner. It was determined that maps had to be stored locally on the Tablet PC rather than downloaded. Map "tiles" were selected and stored to only cover roadways, rather than all areas in northern California, reducing the amount of storage space required for maps. Weather information was aggregated and compressed for download where possible to minimize download time. Web services were used as data sources to eliminate the download of unnecessary information such as images and links that are common in web pages. Weather information was downloaded using location information gathered from the GPS and mapping utilities, freeing the user from memorizing URLs and navigating through subsequent links to drill down to specific weather information.

Satellite and cellular communication was studied in general and particularly in the RIME region, as well as in remote areas of Montana. Over 1200 miles of California state and federal roadways were systematically driven in the RIME region, to collect signal strength measurements and evaluate performance. Extensive site studies were conducted in which signal strength readings were collected and data transmission tests were carried out. It was discovered that cellular performs well with strong signal strength readings, but does not perform well even with apparently moderate signal strength readings. Thus, cellular signal strength readings must be strong in order for cellular to be used by the system. Satellite performance degrades with greater obstruction of the sky. Extensive data was collected and a model was developed to simulate satellite signal strength and coverage dependent on site "horizon profiles," which model the obstruction of the sky at a site due to terrain. Through analysis of collected data and through extensive simulation using the model, it was determined that dropped connections are sure to occur with significant obstruction of the sky, particularly obstructions above 30 degree angles of elevation. But, "re-dials" can be used to reestablish connections and send moderate sized data with a reasonable chance of success. Software can be made to automate this process, alleviating the end user of related monitoring, decision making and manual reestablishment of connections.

The controlled field demonstration prototype was successful in demonstrating a "proof-of-concept" that such a system could be developed and made usable and useful by Caltrans responders in the RIME region. Subsequent research and development is necessary to harden the system and make it field-ready for production use. Caltrans is proceeding with a second phase of the Responder study, within which the system will be developed and tested further, with the goal of preparation for production use. Phase 2 is scheduled to begin in the December 2005 – January 2006 timeframe, and will be conducted over two-and-one-half years.