

MCEER RESEARCH TASK STATEMENT

Thrust Area: Networking

Budget:

Yr 9 Assigned

Project Number: 9.5.2

Task Title: Integrated Databases and Software for Evaluating Satellite Imagery

Investigator: Ronald T. Eguchi/ImageCat, Inc.

Institution:

**indicates task leader*

Statement of Project Goals: *(Conceptually describe what the work is intended to accomplish, in 100 words or less. Do not provide detailed description here.)*

This task explores the feasibility of creating an on-line map catalog of aerial and satellite images from recent disasters. This will provide a template for serving imagery, GIS data, GPS data, digital photos and digital video in real time for future events. As part of this task, we will approach various satellite companies and agencies to discuss possible Memorandum of Understandings (MOU) with MCEER. This supplemental task is associated with our main task on *Use of Remote Sensing for Emergency Response and Recovery*.

Problem Description and Research Approach of Proposed Work for Year 9: *(Detailed description of research to be conducted and methodology to be used.)*

From Main Project Description:

It is increasingly recognized that remote sensing technologies have a critical role to play in disaster mitigation, response and recovery. Preliminary studies in Russia and the U.S. suggest that prior to an earthquake, satellite and airborne imagery is a source of critical infrastructure data for developing building and lifeline inventories. Researchers in the US, Japan and Europe have demonstrated how, after an event, satellite imagery provides a ‘quick-look’ regional overview of urban damage. Building damage has been identified on moderate-resolution optical (Landsat and SPOT) and SAR (ERS) imagery for Marmara, Turkey and most recently, high-resolution coverage (QuickBird and IKONOS) of Boumerdes, Algeria and Bam, Iran. Moving forward, it is anticipated that remotely-sensed data will increasingly support preparedness activities, streamline post-earthquake reconnaissance, facilitate more effective decision-making, and ultimately, reduce losses and save lives by improving the overall response.

In general terms, this research task is working towards the use of advanced technologies in real-time reconnaissance and decision support systems. Research is investigating the application of these technologies during: (a) the immediate response period (initial days following a large earthquake); (b) the early recovery period (several weeks following the earthquake); and (c) as a key component of longer-range mitigation and preparedness programs. The study approach seeks to identify ways in which decisions made during these disaster phases, together with the timeframe within which they are made, can be improved through integrating remote sensing technology.

Specific to Networking Task:

In the past, disseminating the results of advanced technology research has been problematic due

to difficulties in transferring and viewing very large data files. To address these concerns, we have developed and are implementing the VIEWS (Visualizing the Impacts of Earthquakes With Satellites) system which currently serves data collected in the field along with satellite imagery and maps. The next phase of this networking task will be the integration of real-time GPS and streaming video into an online system using wireless connections. The final product will have the core capabilities of the VIEWS tool and the widespread deployment of an online system with the additional functionality of viewing real-time video feeds as this information is collected in the field. Each video stream will be virtually linked with GPS readings, allowing them to serve as dynamic hyperlinks on the online GIS map. The system will have the capability of tracking the locations of multiple investigators. To view the disaster scene from a given location, observers with access to the website will simply click on the point corresponding to the GPS location, and the video feed would begin streaming.

Significant tasks include:

1. Assess various hardware, software, wireless protocols, and internet infrastructure for system compatibility,
2. Develop a real-time data transfer system for GPS and video,
3. Develop client-side software or protocol to link video stream IP to GPS feed,
4. Develop server-side software to receive and display real-time video and GPS feeds, and
5. Develop a module on the server to achieve real-time data, as well as link GPS to video feeds

This framework will be developed and housed by MCEER through its newly created Remote Sensing Institute. Earlier this year, MCEER received a donation from Silicon Graphics for a high-performance server. We will work with MCEER to explore the use of this processor for hosting datasets created from our remote sensing research and to share this information with a broad range of groups, including government agencies, industry and other research organizations.

Assessment of State-of-the-Art: *(Describe other relevant work being conducted within and outside of MCEER, and how this project is different.)*

The proposed system builds on several technologies including several systems developed at MCEER. This includes rapid IMS development for disasters implemented at Cornell University, the VIEWS system, as well as the widespread use of web-cams on the internet. To our knowledge, integrating these technologies in a mobile environment has not been done before.

Progress to date:

(If applicable, a short description of achievements in previous years. Clearly distinguish progress achieved in the past year, i.e., accomplishments from April 1, 2004, to March 31, 2005.)

To date, research has focused on building and verifying tools to effectively collect data in the field and effectively distribute this data with GIS and very large images. We have also programmed an internet mapping system that integrates raster and vector data. Satellite or aerial photos are massively compressed, and served rapidly. Individual map features can be

hyperlinked to images or other data. The map application has standard point and click pan and zoom capabilities. The system architecture, database design, and the user interface are developed. This system, known as VRS (Virtual Reconnaissance System) serves as an "Event Template" that can be immediately customized for any location in the world. The data collection program, known as the VIEWS reconnaissance system has evolved from a prototype to a deployable program with several major improvements, including: the ability to add additional GIS data interactively, a single interface for the collection and review of data, loading previous GPS sessions, a revamped graphical user interface, and savable user workspaces.

Along with the 2003 Bam Iran earthquake deployment of last year, the VIEWS system was deployed in the Parkfield and Niigata, Japan earthquakes of 2004. Establishing value as a multi-hazard tool, VIEWS was also deployed following Hurricane Charley and Hurricane Ivan in 2004 and to inventory Tsunami damage following the Indian Ocean Earthquake. Also, the EERI IT subcommittee has expressed significant interest in using VIEWS routinely for earthquake reconnaissance.

It is expected that the VIEWS system will have significant value in emergency response beyond data collection for research. Outreach for the VIEWS system was very effective during 2004, with several presentations and articles in trade or mainstream publications. These include the DigitalGlobe press release "ImageCat Investigates Tsunami Damage Using DigitalGlobe Satellite Imagery" covered by: CBS MarketWatch, Colorado Springs Business Journal, DallasNews.com, KRON 4, KVVU-TV, Lycos, PR Newswire, RockyMountainNews.com, Ventura County Star - CA News, WGCL-TV, Yahoo, and the DigitalGlobe homepage. Additionally, there have been several articles in the GIS trade publications frequently read by the emergency response community, including: Earth Imaging Journal, GeoPlace, GeoWorld, and GeoSolutions.

Role of Proposed Task in Support of Strategic Plan: *(Describe how the effort will make a unique, useable contribution to the MCEER strategic plan.)*

From Main Project Description:

The development of advanced technologies that quantify post-earthquake damage in near real-time is a critical step towards improving existing response and recovery procedures. Quantifying building inventory in an accurate and up-to-date manner will improve the reliability of existing loss estimation tools. As an element of MCEER's Thrust Area 3, these technologies will enhance community resilience, by: (1) helping emergency officials quantify the extent and severity of disaster impacted areas, in near real-time; and (2) contributing to decision support systems that prioritize response activities based on need, opportunity and available resources; and (3) supporting preparedness activities to identify vulnerable areas and devise mitigation strategies.

Specific to Networking Task:

The tools that are being developed under this task (VIEWS, VRS) are reaching a wide audience that includes first responders, the media and other scientists and engineers. In addition, the future marketing of these tools under the MCEER Remote Sensing Institute will help to sustain research in the remote sensing area well beyond Year 10.

Task Integration: *(Describe how the work performed interfaces with other tasks and researchers funded by MCEER.)*

From Main Project Description:

This task focuses on the development and use of advanced technologies for emergency response, recovery and mitigation. New tools and more comprehensive databases of the urban environment are required to reduce the losses from, and improve response to major disasters. Thrust Area 3 will result in better tools for emergency planners, officials, reconnaissance teams and recovery workers. This research also feeds into other decision-support tools being developed within Thrust Area 3. For example, providing community-based data (in the form of building and infrastructure databases) and immediate post-disaster impact information for the Recovery Tool that is being developed by Stephanie Chang at the University of British Columbia will be a high priority in Year 9.

As a result of this research, it is anticipated that planners will have access to better information on exposed assets, more reliable methodologies to project future earthquake losses, and real-time decision support systems that will identify post-earthquake damage within a matter of hours.

In addition, ImageCat has been collaborating closely with other members of the remote sensing group, including UCI (Shinozuka), UCLA (Houshmand) and EarthData. For Year 9, we expect these collaborations to continue and be augmented by efforts from George Washington University (Williamson).

Specific to Networking Task:

This task will build on work being completed by the present investigator in Thrust Area 3. In particular, VIEWS and VRS will enable the rapid dissemination of damage detection and assessment derived from remote sensing products. Additionally, the data collected from these systems will enable the further development and calibration of change detection algorithms.

Possible Technical Challenges:

Simultaneously collecting, serving, linking, and achieving GPS and video presents several challenges. These include overcoming several file access and permission problems, initially establishing which video stream corresponds to which GPS unit, maintaining a link with the video stream if the IP is modified by an additional wireless router, and archiving the GPS and video in a manner in which they are subsequently linked, while simultaneously serving the data.

Anticipated Outcomes and deliverables:
(Also indicate those of particular benefit to IAB members and other end users.)

Real-time video and GPS data visualized in an online GIS system with satellite imagery, served seamlessly with the MCEER Webpage.

Potential end-users beyond academic community: *(IAB members and others.)*

Loss estimation modelers, government agencies, insurance companies, reinsurance companies, emergency responders and managers, and industry.

Educational outcomes and deliverables, and intended audience:

Special seminars and/or classes on the use of advanced technologies for real-time crisis management. Training seminars for using VIEWS and other products are possible through MCEER's Remote Sensing Institute.

Project Schedule and Expected Milestones for the Project: *(Milestones and estimated time of achievement; e.g., Fall, Spring, Summer.)*

1. Assess various hardware, software, wireless protocols, and internet infrastructure for system compatibility (Fall 2005)
2. Develop a real-time data transfer system for GPS and video (Fall 2005)
3. Develop client-side software or protocol to link video stream IP to GPS feed (Winter 2005)
4. Develop server-side software to receive and display real-time video and GPS feeds (Spring 2005)
5. Develop a module on the server to achieve real-time data, as well as link GPS to video feeds (summer 2005)

Team Members: *(If known, provide names of team members associated with project including project leader, other faculty and their departments, undergraduate students, graduate students, postdoctoral students, industrial participants.)*

- Ronald T. Eguchi
- Charles K. Huyck
- Beverley J. Adams
- Michael Z. Mio
- Paul R. Amyx

Possible Direction of Work in Subsequent Years:

Security and the scalability of wavelet compression and streaming video will be addressed. We will continue to address the collecting, processing and display of remotely-sensed images on MCEER's website and work with satellite companies or data providers to display satellite images on future disasters within days of the event.

Multi-Hazard Statement:

To date, the VIEWS system has been used to collect damage information for hurricanes and tsunamis. Because the system logs any type of damage, adjusting the data collection for multi-hazard events is quite simple. Additionally, much of the system design stems from research conducted after the events of September 11th, as documented in the MCEER special report series: *Emergency Response in the Wake of the World Trade Center Attack: The Remote Sensing Perspective*. Specifically, we found that if remote sensing data are collected and made available, it will be used and referenced continually. For the data to be used most effectively, access to the data should be widespread, simple to use, and integrated with GIS and real time data. These findings provided a foundation for VIEWS. Because VIEWS has already been tested for a variety of natural hazards and was developed with several considerations from manmade hazards, it is considered primarily as a multi-hazard tool

The milestones above will apply in our extension to multi-hazard applications. We will begin testing and validating these tools by using the data already collected from several non-earthquake disasters. These include the hurricanes in 2004 and the recent Indian Ocean tsunami.