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LOMA PRIETA, CALIFORNIA EARTHQUAKE, 1989 SPURS DEVELOPMENT OF A GIS BASED EMERGENCY RESPONSE SYSTEM

ABSTRACT: In the aftermath of the 1989 Loma Prieta,California Earthquake, the U.S. Army Corps of Engineers (CE) was designated by the Federal Emergency Management Agency (FEMA) as a central agency for implementing cleanup and restoration operations. Given the wide extent of the damage from Oakland in the north, to Santa Cruz and Watsonville in the South, it was assessed that CE's resources for tracking such extensive operations were highly deficient. Substantial concern that this 7.1 temblor was not the "big quake" spurred urgency to improve this situation. This paper describes the operation and benefits of a PC / GIS-based Emergency Response Management System (ERMS) developed using the lessons learned from the current disaster to be better prepared next time. Key features include:

- Large file management system
- Supporting graphic database
- Supporting nongraphic database
- Library of "intelligent" symbols
- Simple user interface
- Polygon overlay capability

INTRODUCTION

In the aftermath of the 1989 Loma Prieta, California Earthquake, the U.S. Army Corps of Engineers (CE) was designated by the Federal Emergency Management Agency (FEMA) as a central agency to help with administering federally funded cleanup and restoration operations. The work required repeated inspections of many damage sites, contracting for widely-varied repairs and appropriate control of rapid Federal spending. The major technical problem facing the CE was the lack of an effective computer system to handle the data generated by the emergency response effort. Given the wide extent of the damage from San Francisco and Oakland in the

north, to Santa Cruz and Watsonville in the south, it was assessed that CE's information management resources for tracking such extensive operations were deficient.

Prior to the earthquake, the CE's Sausalito Office had already prepared plans for implementing a Geographic Information System (GIS) to automate maps and database of their jurisdiction to address emergency response issues. These plans were based on the use of desktop computers because there was concern that in the event of a catastrophic disaster, a mainframe resident system could be rendered useless. On the other hand, if even one set of software disks and a single battery powered PC survived, an emergency response system could be mobilized regardless of the severity of the situation.

On Tuesday morning after the 7.1 earthquake, based on this earlier planning, the Corps ordered 25 USGS 1:100,000 scale quadrangle maps in AutoCAD (DWG) format for the entire area affected by the quake from one of several private sector suppliers of public domain data, American Digital Cartography (ADC) of Appleton, WI.

Brad Sharp of Autodesk, Inc., and Kristen Routh of Facility Mapping Systems Inc.(FMS) volunteered time \to help CE put this automated map data to use. Lou Goldklang and Gary Adams of Autodesk arranged to have 12 Compaq computers in one of the Autodesk training rooms dedicated to the development of a prototype Emergency Response Management System (ERMS). Dennis Klein, of FMS developed a set of GIS specifications for the ERMS based on modifications standard FMS/AC templates. Key aspects of the ERMS specification included:

- A project-wide map management system for establishing and operating a continuous automated land base using ADC map quads.

- Data collection tasks for assembling manual maps containing detailed infrastructure data regarding hard hit areas.

- A library of "intelligent" symbols representing each category of disaster incidence tracked by FEMA's Disaster Survey Reports (DSR).

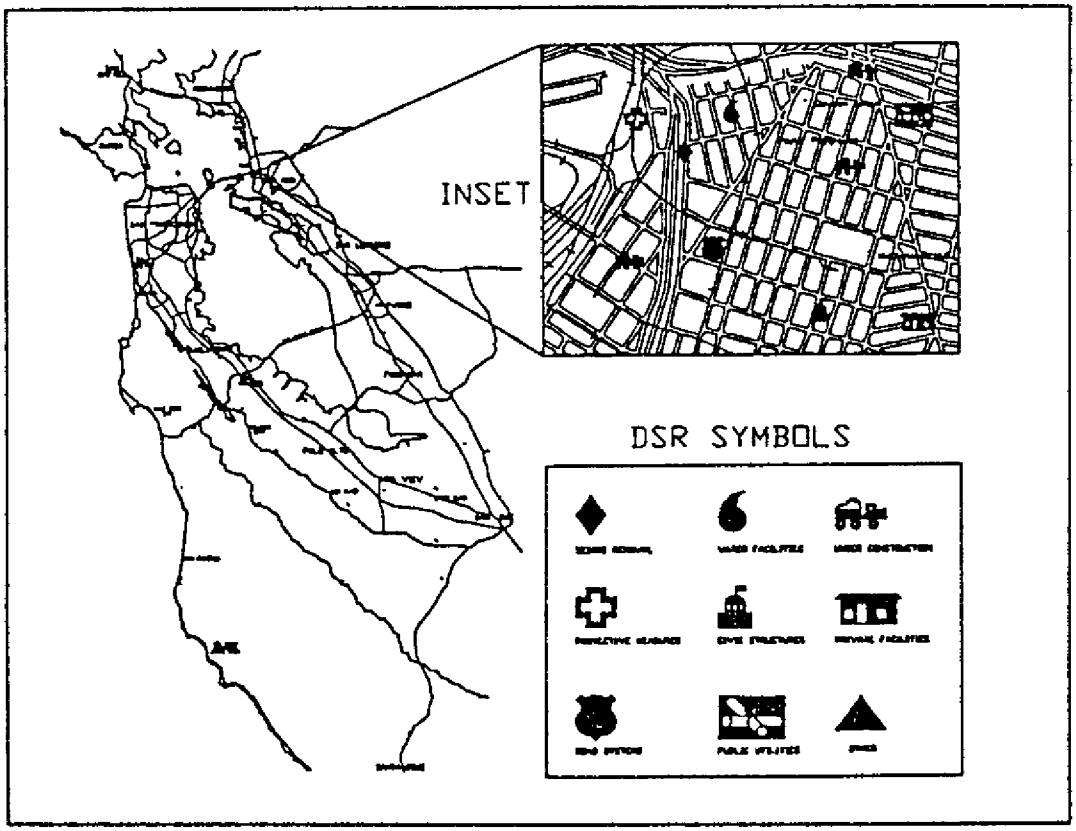
- User interface to support the posting, editing, spatial referencing, and analysis of the current status of emergency response operations and corrective measures.

- A supporting nongraphic database (DBM) suitable for managing DSR status information associated with each DSR map symbol.

- Screen menus and MACROS for interfacing the graphic and nongraphic databases to enable users to optimize the allocation of disaster response resources.

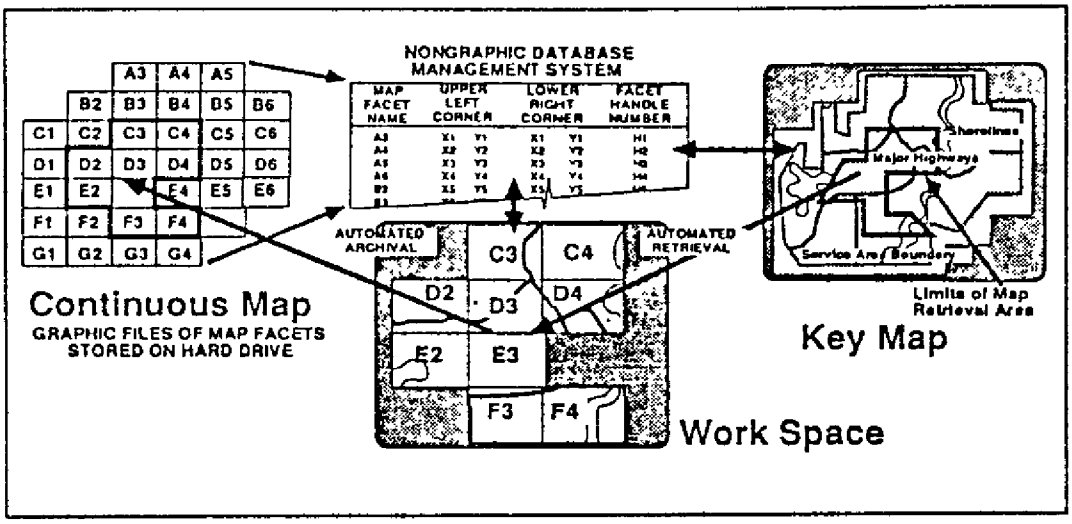
- Guidelines for establishing a spatial database of the San Francisco Bay to assist with dredging operations to reopen the damaged shipping channels.

FIGURE 1
CONCEPTUAL REPRESENTATION OF
EMERGENCY RESPONSE MANAGEMENT SYSTEM (ERMS)



With the assistance of Jeffrey Pike and other Autodesk training center volunteers, work was soon completed to organize this massive set of map files into a manageable automated land base. Will Crichton, of FMS, used FMS/AC's Large File Management System to quickly build a key map of the entire region (see FIGURE 1) made up of elements from each of the over 25 USGS 1:100,000 quadrangle maps (see FIGURE 2). In a matter of hours, a GIS map grid based on this key map was established and the massive USGS files were broken up into hundreds of small map facets to expedite graphic data retrieval and archival. In this manner, a continuous map of the entire region, approximately 55 megabytes, can be stored on a file server, but only a few hundred Kb of map data is typically active at any one time.

FIGURE 2
SCHEMATIC REPRESENTATION OF ERMS
PROJECT-WIDE MAP MANAGEMENT SYSTEM



It was requested by the Corps that the USGS data be updated with TIGER File map information in order to have a name on each street and the ability to automatically locate an individual street address. In response to a special request by CE to the US Census Bureau, 189 pre-release TIGER 1: 100,000 Files (3 1° Areas) were supplied to ADC. Within a single day, ADC was able to translate the TIGER File data into AutoCAD readable format using technology well underway for the upcoming FMS/ TIGER template, a joint FMS and ADC product. Using the MAP management system, it was a simple matter to partition these large TIGER map files into a practical continuous map for the entire effective region.

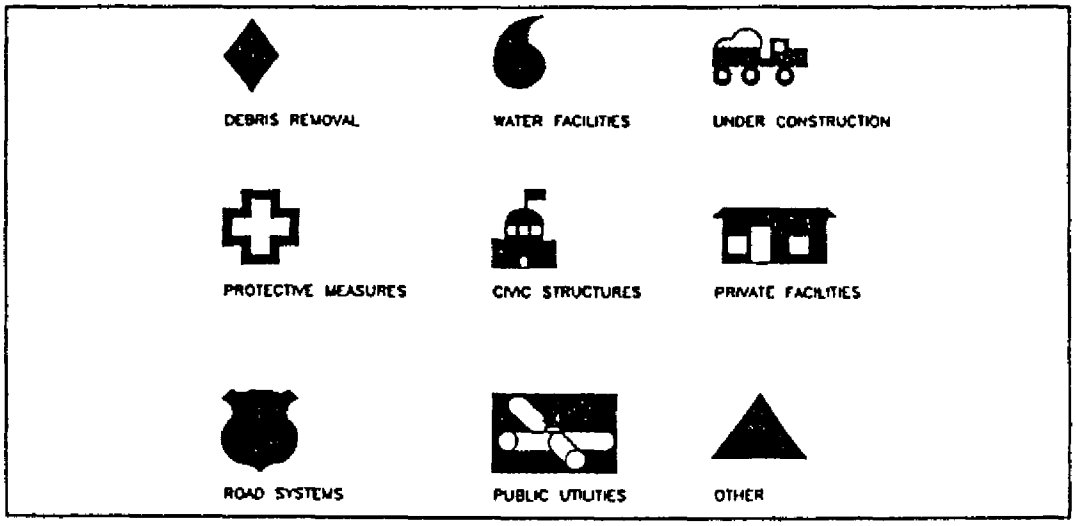
At the same time that the mapping project was underway, FMS personnel, under CE direction assisted in collecting manual maps regarding infrastructure information. Detailed maps of the Marina District were made available from officials of the City of San Francisco. The Cypress Freeway area maps were made available from officials of the City of Oakland who had to retrieve the originals from a building condemned by the earthquake. Maps of other critical damaged infrastructure areas were made available including Santa Cruz, Watsonville, and Los Gatos.

DESCRIPTION OF MODEL

At the time the continuous mapping system for the entire project area was being finished, work was completed on the a preliminary user interface for the ERMS. As seen in FIGURE 1, the ERMS developed to date consists of a symbol library tied to the nine different Disaster Survey Report Categories of the FEMA information management system. Supported by MACROS and Screen Menus complete with ICON driven menu squares (see FIGURE 2), the ERMS supports the ability to:

- Zoom on the keymap to a desired location by entering a city code and street address.
- Retrieve the pertinent land base data including any previously placed DSR symbols.
- Add new DSR symbols and/or edit the status of existing DSR symbols
- Access/edit the pertinent record in the DBM by touching the DSR symbol.
- Retrieve all records in the DBM within a polygon window of interest to review status, conduct subsequent Boolean searches.
- Post the pertinent DBM data onto the automated map as graphic text annotation.
- Highlight all symbols the meet the conditions of a search query.
- Archive all changes to the retrieved map data by updating map facets in the continuous project map.

FIGURE 3
CLOSE UP VIEW OF THE DSR'S ICON MENU SCREEN
PORTION OF THE ERMS USER INTERFACE



In addition to the development of the ERMS, under the direction of CE, FMS completed a prototype for a dredging management model for that portion of San Francisco Bay most damaged by the earthquake. Using the spatial analysis capabilities of the FMS utility, Automated Polygon Processing, an intelligent layer was constructed of the various factors affecting marine navigation in the San Francisco Bay. These layers included depth of the water, depth of the bay mud sediment, limits of the established shipping lanes, and areas containing utility cables. Due to the earthquake, portions of the shipping lanes had collapsed and needed to be dredged in order to reopen. All of the map bay data is analyzed to form a comprehensive spatial database model complete with supporting database allowing users to perform queries and highlight those areas of the map that share common sets of conditions. This model is used to best allocate cleanup operations and track the daily/weekly progress of dredging activities.

Another aspect of ERMS is the ability of the underlying Desktop GIS software system to perform an important capability in times of an emergency: network tracing on a utility network. At full implementation, the CE intends to have maps which contain connected intelligent utility models for streets, natural gas, electric power and water supply, for areas most subject to severe earthquake damage. With these intelligent models in place it will be possible to simulate valve and switch position resetting in order to better respond to emergency situations. For example, before sending in rescue crews, it will be possible to test the results resetting certain gas valves to see for sure if the gas lines will be turned off, which switches need to be thrown in order to serve electric power from a different direction, where exactly is the power outage and what switches can be thrown to serve power to a damaged area from a different direction, and which streets are operable.

CONCLUSION

Due to the power of the PC environment and supporting software technology, The Army Corps of Engineers is now better prepared to implement emergency disaster plans. Key agencies will be able to locate valves to turn off gas lines in fire areas, analyze transportation alternatives and manage relief personnel, equipment, and materials more efficiently. The Loma Prieta, California Earthquake of 1989 brought together a wealth of knowledge, expert software, and dedicated personnel in a time of crisis. These new solutions can benefit all in times to come.