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FINAL REPORT TO THE NATURAL HAZARDS RESEARCH AND APPLICATIONS INFORMATION CENTER, MARCH 1993

MAP USE DURING AND AFTER HURRICANE ANDREW

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In South Florida, at 5 a.m. on the Monday morning of August 24, 1992, the 164 to 200+ mph gusts of Andrew, a Class 4 hurricane (Bair, Elliott and Ruff, 1992) and the first named storm of the 1992 hurricane season, cut a 20 mile wide swath of destruction from the southeast to the northwest across southern Florida. The National Weather Service had been tracking and reporting the progress of Hurricane Andrew for about a week, and the National Hurricane Center predicted the expected time and place of landfall with remarkable accuracy. However, forecasters failed to anticipate the storm's severe intensity and its rapid speed over land. Prior to the landfall, a mass evacuation, especially of those living in areas of potential storm surge, was ordered by officials throughout South Florida. The eye of the storm moved directly over Homestead, FL and the Everglades National Park. Most communities in the path were severely damaged.

Hurricane Andrew took a relatively low toll of lives but caused immensely high property costs. Although rumors regarding migrant workers who might have perished could not be substantiated, the number of those who died as a direct result of the storm was around thirty persons. Damage was spread over an area of more than 500 square miles, and the magnitude of the disaster was initially difficult to assess. An estimated 100,000 homes were either destroyed or damaged by wind and flying debris. There were no communication systems in the affected area. The entire infrastructure originally existing in the storm's path ceased to function. Victims were without shelter and power and experienced critical shortages of water, food and health supplies. A federal disaster was declared almost immediately, but it was state, county and local organizations that had to respond to the initial, overwhelming devastation. School openings were postponed until September 14 to allow time for evacuees to move out of the schools used as emergency shelters and for school roof and structural repairs to be completed. Storm debris hauled to landfills is estimated to have been equivalent to the volume generated in 15 normal years of landfill operations. Elections were postponed and held September 8. Rough early estimates of the total damages from Hurricane Andrew in Florida and Louisiana is $20 billion. However, the figure may eventually reach $30 billion. Hurricane Andrew is being considered the most costly natural disaster in U.S. history.

FEDERAL DISASTER RESPONSE POLICIES

Hurricane Andrew proved that some of the basic assumptions and policies upon which federal disaster response is planned are unrealistic. It is assumed that affected jurisdictions will be

capable of estimation of damages and that federal agencies will provide assistance and resources only upon request. Neither Dade County nor the state of Florida was able to provide the needed detailed assessment of damages. A Federal Disaster Field Office (DFO) was established in the former Eastern Airlines terminal at Miami International Airport on the Thursday of the week of the disaster. This DFO served as the hub for most immediate disaster response activities. Federal, state and local agencies and organizations coordinated their activities out of this headquarters. The Red Cross and other volunteer agencies mobilized and brought their trained people to the disaster area, but they were not able to provide immediate shelter and food needed for nearly a quarter of a million people. A week after Andrew struck, tent cities were being set up for the victims. Sixteen days into the disaster, 97,000 households were still without water and power, and there was still no communication system. Evacuees who were trying to return to their neighborhoods found landmarks and street signs destroyed to the extent that they had great difficulty locating their devastated or non-existent homes and found no neighborhoods as such at all. Eventually, 28,060 military personnel had to be deployed in the disaster zone to support the Joint Task Force Andrew humanitarian relief operations.

ARRIVAL IN MIAMI

My research assistant, Nancy Winter, and I arrived in Miami on Sunday, September 7. We had difficulty finding our hotel which was supposed to be located near the airport. After more than an hour of searching and driving, we realized that the reason we could not find the place was because the hotel's sign was missing; it had been blown off the building. This was a small lesson for us in what emergency workers had to deal with when going into the disaster area where there were not only missing building signs, but no street signs.

OUR RESEARCH FOCUS

Two questions were the focus of our research. 1) How were maps used by emergency personnel and by the public during and after Hurricane Andrew? and 2) What kinds of maps were needed during and after the disaster? Interviews were conducted with emergency personnel in the Andrew Disaster Field Office and with hurricane victims in the communities of Goulds, Perrine and Homestead. Results from this research include findings not only from our interviews but also from our attendance at a meeting of key officials of the Federal Emergency Management Agency (FEMA) Emergency Support Function of Planning and Information to which we were invited.

INTERVIEWS WITH THE VICTIMS

The media, but especially television, provided the only maps the interviewees considered during this disaster. Victims interviewed did not employ any maps with which to evacuate. Most of them owned no maps to use, nor did they even think about using maps. Those who evacuated went to local institutions for shelter or drove to the homes of relatives. Despite the many warnings to

evacuate broadcast by the National Weather Service, we found a surprising 50% of the people we interviewed in the severely devastated areas did not evacuate during the storm. Instead, victims prayed, or secured the walls of their homes. This percentage is even lower than a New York Times/CBS Poll taken in Dade County, Florida on September 12-14 in which 77% of those interviewed said they did not evacuate during Hurricane Andrew (*The New York Times, September 20, 1992*). Our interviews revealed that the majority of people found that they had to leave after the storm because of lack of electricity and severe damage to their houses. The pattern of whether or not persons evacuated depended upon ownership of property. We found that nearly 90% of the homeowners we interviewed did not evacuate while in contrast those who rented tended to evacuate. All our interviewees declared that they received plenty of warning before they made evacuation decisions. The majority received warning information from television; others received phone calls from neighbors and friends. All respondents watched the progress of the hurricane on television and kept up with weather bulletins issued by the National Weather Service.

Interviews with emergency personnel, who were also victims, and who live in South Florida and who experienced Hurricane Andrew revealed that it was a very fast moving hurricane with an exceptionally nasty center and surprisingly reduced winds on the back side of the eye. A number agreed that "the whole thing was over in 45 minutes" with the winds dropping to 70-80 miles after the eye passed and the waves of rain afterwards abating rapidly and gone by noon that day. This was unlike other historical Florida hurricanes such as Donna which took a slow, meandering 12 hours to cross overhead. The extreme devastation to structures from Hurricane Andrew was attributed to exceptionally high winds at the eye. They were calculated to have been in excess of 200 mph in some specific and restricted areas.

MAPS AVAILABLE TO EMERGENCY MANAGERS AND PERSONNEL

We began research at the Disaster Field Office in Miami. When we arrived, map resources were scarce, and this lack of maps caused problems. Emergency workers complained about the overall lack of available spatial data. Those not familiar with the area were practically lost without effective maps to use. In one incident a group was assigned to a particular task within the disaster area, but they drove around all day never locating the site. The only map available to them was a Florida State Road Map. With most of the highway and exit signs blown away, these maps were of limited use, especially because of their lack of detailed information about cities and towns.

Most federal and state agencies had some kind of crude crisis map on their office walls. Many of these maps had been brought by individuals who were "map-oriented" or were Rand McNally maps supplied at the DFO by Dade County. Pins and colored identifiers were used to show the various resource centers that a particular agency or organization was responsible for. These were maps that stayed stationary in the office and were used during decision making.

Maps Provided by Dade County

Dade County not only provided all the maps at its disposal, but ordered more. One 20 year veteran Dade County official, Assistant Director of the Department of Business and Economic Development (DBED) who lived in the impacted area, acted immediately after Andrew struck to order all available *State of Florida* maps from Rand McNally. The company had nearly 5,000 copies in stock and immediately available. These maps were distributed to various agencies and organizations at the DFO for them to gain spatial knowledge of the overall disaster area. Most agencies and organizations used these maps as basemaps upon which they added their own data, making them invaluable crisis maps. Emergency personnel commenting on the Rand McNally handouts maps admitted they were not ideal because they did not show enough detail, but they pointed out that there were no other maps on hand. Emergency workers supplying aid in the field were also given the Rand McNally maps even though they were limited in their effectiveness because they did not show enough landmarks nor information for emergency managers unfamiliar with the area yet dealing with a lack of street signs.

Dade County's Office of Computer Services and Information Systems (OCSIS) powered down their computers before the storm to help prevent power surges which would affect the computer system. The computers are located on the second floor above flood level. On the third is a Geographic Information System (GIS) which served an important function in the early response stage of Hurricane Andrew. The initial damage assessment map titled *Hurricane Andrew Severe Areas South Dade County, Florida*, and dated Sept. 2, 1993, was made through the application of this GIS and became an indispensable crisis map. Produced by Metro-Dade, the information on this map was collected by the local police then added into the county-wide GIS. This map was updated as soon as more damage information became available. It was hand colored on the basis of the aggregation of police reports. It was the first real damage report developed with any systematized reliability. Although in essence subjective, the information came from a usually reliable source, the police. Since they couldn't get into all areas because of the blowdown (and such impenetrable areas became severity boundaries) and because the police helicopters had been in a hanger that collapsed at Tamiami Airport so no police helicopters could be used, the police had to make some assumptions in reporting the hurricane damages. Initially, this crisis map showed the location of Distribution Centers, DMAT Field Units, Red Cross Service Centers, FEMA Disaster Application Centers, Hurricane Shelters, Water Distribution Sites, Tent Areas, Burn Sites, Kitchens, and Trash Sites. The same Dade County DBED official who had ordered the Rand McNally maps took the initial version of this damage assessment map to a local printer to have 3,000 copies made. They were distributed widely to agencies and organizations and were found on most of the office walls in the DFO.

Two other very useful Dade County GIS map products produced in the wake of Hurricane Andrew and in great demand after the disaster included a map of all public buildings in south Dade County existing before the storm and a detailed road network map. Dade County also provided maps already existing in their files including a series of population maps showing ethnic distributions. These maps proved to be very useful to emergency managers since the disaster area had a wide range of culturally diverse neighborhoods. Dade County landuse maps were also

available upon request.

Map and Photo Sources: County-State Coordination

The Assistant Director of the DBED also tapped state sources for aerial imagery of the disaster area. At the state level, nine tapes of the Florida coast had been shot on August 24, 1992, by the South Florida Water Management District. The six helicopters of this Water Management District had flown along the coast to film beach erosion, but they had also turned their cameras inland. They knew from these photos that the total Hurricane damage was worse than they had originally thought. The state had some SPOT satellite images to work with and had a Department of Defense trained photo interpreter on their staff. The County DBED official was invited to go to the state capital to investigate the state's imagery, but he was too busy at the DFO to take the time off. A representative from the Governor's Liaison Office visited the DFO a couple of days after the storm. He was making efforts to coordinate the state GIS because he was preparing a paper for Congress on the use of GIS on the state level. He made available to the county DBED official a damage assessment map produced by the state, but the county had to pay $55 to have it sent by express mail. The County DBED official explained: "They're dealing with different problems than we are. Dade County is only 1/67th of their problem. They have a long-term orientation; they know a disaster can happen in any one of the other of Florida's 67 counties."

Photo Source: County-Federal Coordination

The Assistant Director of the DBED also made arrangements to secure a set of aerial photographs from the federal government. After the storm, he talked to the Dade County Tax Assessor and ascertained that the tax department's primary need was post-storm photos and maps in order to establish damage assessments and to come up with estimates of the financial impacts. The DBED official called the Pentagon and talked to people in the photo division about the possibility of receiving some aerials of southern Florida. Two days later he received two sets of photos from a company called Continental. However, there was a mixup, he received two of the same sets while two copies of another set went to the Corps of Engineers. They discovered what had happened two days later and exchanged sets. These photos came at three different scales: 1"=800'; 1"=400' and 1"=200". In all, the DBED official tried for three days to get photos from the federal government. He learned three things: 1) some photo work had been done; 2) intelligence people had done some work to interpret these photos; and 3) it would take days or weeks to get permission for him to access the data and materials at an unclassified level from intelligence agencies.

Even though the Dade County DBED official finally had both the South Florida Water Management District images and a set of aerial photos obtained by Army Corp of Engineers' overflights after the hurricane, these two sets of photographs could not be used by the County for comparative purposes because no photo interpreters were available to make the assessments at that point.

TECHNOLOGY AND HUMAN RESPONSE

One of our major findings is the role Geographic Information Systems (GIS) played in producing maps for coordination of Hurricane Andrew response and recovery efforts, a historic first. Two weeks into the disaster, on Friday before our research team's arrival, Digital Matrix Service, Inc. (DMS), a private firm located in Miami, volunteered to set up and staff, without cost for one month, their GIS called InFoCad for use in the office dedicated to the Federal Emergency Management Agency's (FEMA) Planning and Information Support Function. This private firm realized immediately after Andrew struck that their digital database, which had been prepared for a client and included every street from Palm Beach to the Keys, would be an invaluable resource for FEMA. The firm (DMS) negotiated with the Washington office of FEMA and within 24 hours the Director of FEMA's Information and Planning had accepted the offer and arranged to have the Army Special Forces transport two workstations, an X-terminal and a pen plotter into the Andrew Disaster Field Office.

In-House Mapping Capability Solves a Communication Gap

A critical communications problem was the first of many problems solved by the in-house mapping capability of DMS. Many victims still stranded by the storm had no communication with the outside world. The White House Task Force had arranged to have the Goodyear Blimp stationed over the worst hit neighborhoods to furnish messages to victims. These were flashed on the blimp in both Spanish and English. The problem was how to find the location of the victims. Literally as soon as the DMS computers were plugged in at the DFO, an emergency worker requested a map showing the coordinates of all of the neighborhoods in Homestead and Florida City. The captain of the blimp used this coordinate map and his on-board global positioning system equipment to find the location of the requested neighborhoods and flashed information about aid, shelters, field kitchens and hospitals were conveyed to those in need.

The success of DMS in completing this first custom-made map was the start of a stream of ongoing requests for specially prepared crisis maps needed by emergency managers in the DFO. The DMS personnel expanded their mapping capability rapidly as the demand for mapping on site increased.

Daily Update of the Database

Digital Matrix Service, Inc. updated its database daily as requests for new maps grew. Decision making by emergency managers was enhanced by the availability of maps showing the distribution of a wide variety of services. Maps showing the distribution of these listed items served important functions:

Army Kitchens
Red Cross Service Centers
Burn Sites
FEMA Disaster Application Centers
Health Centers
HRS Services
Hurricane Shelters
Medical Facilities
Tent Shelters
Trash-Transfer Stations
Unemployment Centers
Portable Toilets

Map Types Used by Emergency Workers

Between September 6 and October 27, Digital Matrix Service, Inc. kept a daily log of the maps requested. There were 633 requests for maps. Ninety-nine percent of the map requests were of TYPE I data or point data, showing the site locations of a specific data set (see Table 1).

Table 1

TYPE I DATA

. Disaster Application Centers (DAC)
. American Red Cross Kitchens
. American Red Cross Warehouses
. American Red Cross Headquarters
. Metro Dade Burn Sites
. Unemployment Claims Offices
. American Red Cross Hurricane Shelters
. Disasters Medical Assistance Teams
. IRS Service Centers
. Trailer Parks
. Portable Toilets
. HRS Service Centers
. American Red Cross Service Centers
. Metro Dade Trash Sites
. US Army Tent Shelters
. US Army Kitchens
. Community Health Centers
. MERS/MATTS
. Emergency Reception Centers

Table 2

TYPE II DATA

. Building and Zoning Damage
. Contractor Zones
. Dunn and Brad Street Census Data
. FIRM Data
. FPL Siren Buffers
. Polling Locations
. Surge Contours
. Zip Code Zones
. Mortalities
. Damage Assessments
. Evacuation Zones
. FPL Siren Locations
. Hotel Locations
. Voting Precincts
. Surge Polygons
. Hazardous Mitigation

Another 38% requested in addition to TYPE I data, TYPE II data or aerial data to be added to the categories on the map (see Table II). More complex and time consuming from a production perspective were maps that required Type III data; these maps required scanning, rectifying and manipulation. However, 11% of the requests were for TYPE III data (Table 3).

Table 3

TYPE III DATA

. Scanned and rectified aerial photography provided by the Army Corp of Engineers
. Scanned and rectified USGS Topographic Quads

GIS as an Analytical Tool

After several days of operation, the value of the Geographic Information System was realized by many emergency workers, and requests for analytical maps grew steadily. In one case, GIS operators were asked to identify polling places for a rescheduled Primary Election which had been postponed because of Andrew. The established database being employed by DMS facilitated queries and analysis of the entire land area affected by the storm. Identification of polling sites was not an easy task considering that by law these places had to be a certain distance away from any military activity. With over 28,000 military personnel in the area, this became a challenge. GIS was successfully employed, and with the first few challenges grew a need for more analytical maps. In the end, 63% of the total number of maps produced by DMS required GIS applications such as zooming into a land area for a specific need or GIS being applied as an analytical tool.

Planning and Information Meeting: What is a GIS?

The head of the FEMA Planning and Information Emergency Support Function, Jack Bryan, had developed an intellectual conviction and a vision that GIS applications can play a critical role in information processing during disaster response and recovery. To further enhance information flow and to educate those providing the 12 Emergency Support Functions in the Disaster Field Office about the immediate efficacy of GIS applications, he invited the key response agencies to a meeting on September 9. The purpose of the meeting was to seek cooperation and understanding about the need to coordinate all available existing resources for management of the integration of various databases into the GIS being applied daily at the DFO. During the meeting it became clear that the majority of key personal had little understanding about what a GIS is or what it can do. One of the outcomes of the meeting was that GIS became in the case of Hurricane Andrew a key teaching device and a spur to communication between different agencies.

The Problem of Shared Authority Over Data and Resources

At the September 9 meeting, official representatives from the major response agencies were asked to provide lists of their available data sources that were in digital form. It became obvious that the Joint Task Force could provide much of the immediately needed data. The longest discussion in the meeting centered on the issue of the need for a central authority to preside and provide priorities for the sharing of and integration of data. While the Joint Task Force members were willing to provide support and interpreted data, they were reluctant to share any raw data in digital form with private agencies. Local and state agencies, on the other hand, shared their digital data sources, and many private companies, intent on relieving the suffering of the hurricane victims, shared their resources.

SUMMARY AND CONCLUSIONS

The lack of available maps during the response stage of any disaster can delay support for victims and needed management responses. An historic and lucky circumstance occurred after Hurricane Andrew. Through the involvement of private resources, the need for GIS support in mapping for disaster response was highlighted. The work of Digital Matrix Service, Inc. clearly demonstrated that by having a GIS-backed mapping capability available, the demand for crisis mapping grew rapidly. The issue of the costs of supplying communities or counties in disaster prone areas with hardware to provide GIS crisis mapping support in an emergency can be put in perspective by this report. The *Wall Street Journal* reported that "the price of a unit of processing power on a chip has fallen by half roughly every 18 month ever since the late 1960's invention of the microprocessors, which combine on one piece of silicon groups of circuits that can be programmed." Funding for the collection of emergency data on a GIS to aid emergency managers during a disaster and the hardware to apply GIS technology to crisis mapping during a disaster should be on top of every planning list.

Evaluation of GIS's and Digital Data

Clearly, Geographic Information Systems in their current format pose problems. Still difficult to operate unless run by technocrats, GISs need to be made more accessible and easier to operate so they can be applied by any intelligent non-specialist. GISs also need to be able to integrate different structured data-sources. There is a need to inventory existing GISs in order to identify what GIS is most appropriate to be used in an emergency situation when managers are under stress and time constraints. Maybe a new system easier to operate needs to be designed. The system has to be self-contained. It should be able to run with the use of generators or batteries, but still the system needs to be able to handle large datasets.

Another problem is the collection of data. An inventory of available digital data sources should be conducted, and the resulting list should be compiled and published. There is a need for standardizing sets. Finally, there is a problem of coordination of existing data sources between

agencies. This might be eased by the establishment of a GIS library service that would provide GIS data information and answer questions at all times. This service would be aware of any digital data files on the federal and state and local level by regions.

Guidelines should be written after the evaluation of digital datasets, and their usefulness for emergency managing should be evaluated. How often does the data need to be updated? Is the scale appropriate? How much detail is needed? These are some of the questions that need to be addressed.

Crisis mapping after Hurricane Andrew illustrated that timely research on perfecting a geographic information system for providing mapping during a disaster should be a high priority item in emergency management today.

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