State of Louisiana
GIS Support for Emergency Operations
Before, During, and After the Hurricanes of 2005

Executive Summary

Louisiana lies at the mouth of the Mississippi River, on the northwestern shore of the Gulf of Mexico. Because of the natural history of Louisiana and the development of the Mississippi River delta, much of the state is comprised of low-lying, coastal wetlands extending far out into the Gulf. This makes Louisiana and its people highly vulnerable to hurricane damage. The city of New Orleans, located 100 miles by river from the mouth of the Mississippi, is mostly below sea level. Across the state, nearly a million households are in areas no more than 20 feet above sea level. Fortunately, until 2005, Louisiana has been largely spared from major hurricanes striking its largest city. Pre-Katrina estimates of the possible loss of life from a catastrophic storm were in the tens of thousands.

In preparation for such a disaster, the Louisiana Department of Transportation and Development (LADOTD) chose to implement advanced information technologies, such as geographic information systems (GIS), to be able to better inform the public, enable officials to make smarter decisions, and facilitate first-responders efforts to effectively locate and rescue storm victims. The GIS technology implemented serves both the department as well as other state, federal, and local government agencies in support of emergency management operations. The system was constructed from an enterprise perspective. In this manner, GIS tools were available to the professional staff, engineers, planners, and managers to do their work.

The need for the enhanced technology became apparent following Hurricane Ivan, in 2004, when Louisiana officials recognized the difficulty of quickly evacuating over one million residents from metro New Orleans. Subsequently, LADOTD and Louisiana State Police worked together, using GIS technology to analyze the problem and then develop a comprehensive Louisiana Emergency Evacuation Plan. Over a million copies of this plan and maps were prepared and distributed to the public. Consequently, as Hurricane Katrina approached, 1.3 million people were safely evacuated without incident.

The GIS system also proved valuable in enabling LADOTD staff to track the storm and provide timely updates to government officials, including state and local emergency managers. Text advisories along with graphical maps were sent by email to key personnel. In addition, interactive, GIS server-based maps were kept current and available on the Internet. These included weather conditions, river levels, road conditions, and the location of emergency evacuation routes, *etc*.

After Katrina passed, LADOTD provided FEMA with essential data and GIS capabilities while they set up disaster relief operations at the Baton Rouge Joint Field Office (JFO). Additionally, LADOTD produced the initial search and rescue grids for New Orleans and made it available on its website for general dissemination. Over the following weeks, thousands of maps were produced for FEMA, the National Guard, and first-responders arriving from across the nation.

Since hurricanes Katrina and Rita, GIS technology has supported many recovery activities such as debris removal, damage assessment, and bridge safety inspection, as well as planning for restoration. For examples of the application of this technology, go to: http://dotdgis.dotd.louisiana.gov/website/GIS-T2006.ppt.

The Business Case

The business problem. The Louisiana Department of Transportation and Development is responsible for developing, maintaining, and operating the transportation network (air, road, and water) of the state. During emergencies these facilities are vitally important to support the safe evacuation of residents, before the event, as well as the movement of support personnel into key positions to assess and repair damage. Under normal operating conditions, these functions are supported by a number of information systems. During emergencies, information transfer inside and outside of the department becomes critical as decision makers are called into action and need to elicit action on the part of the general public. These essential systems can only be tested with repeated drills that mimic real-life conditions.

Background. Essentially all of the assets and activities of a state department of transportation are spatial in nature. Indeed, this is true for every government agency. Traditional information technology has ignored the spatial nature of data, yet often compartmentalized it in reports and summaries that group the information into "geographical" units (cities, counties, states, *etc*.). With the advent of geographic information systems (GIS), these characteristics of the data can be exploited and add value to it in many different ways. GIS can perform spatial analysis and produce graphical output that provides new, clearer ways of communicating information. For these and other reasons, LADOTD embarked on an enterprise GIS implementation in 2001.

Preparing with drills. As natural disasters, hurricanes are large spatial events and require the handling of a large volume of data. GIS technology is well suited to address these issues. At LADOTD, GIS has been essential in preparing the annual hurricane drill. Using Internet technologies, GIS has produced mock storms with maps, wind rings, and damage assessments that have made the drill more realistic. During the approach of the mock storm, IT GIS staff collect information from simulated National Hurricane Center advisories. These are transformed into graphical maps and disseminated to emergency managers inside and outside of the department. These drills included participants from other state agencies, local emergency management officials, the US Coast Guard, seaports, and airports across the state. The focus of these drills was to test and improve communications to participants of the status of the transportation system and how to implement contraflow (the evacuation of New Orleans using all roads outbound, in both directions). The "Hurricane Lola" drill (2005) can be viewed at the LADOTD website: http://dotdgis2.dotd.louisiana.gov/website/lola_all.

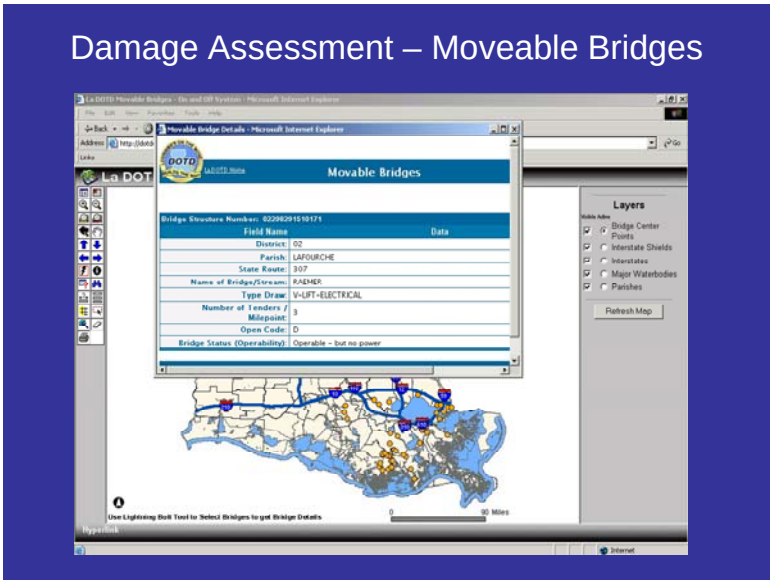
Responding to storms. The first test of these systems was in 2002, when Hurricanes Isadore and Lili hit, within a week of each other. Pre-storm information delivery went well, but it became clear that there was a need for disseminating road closure information. During the storm, the IT GIS staff created an interactive, map-based "Road Closure" website, from text descriptions on the Louisiana State Police website. In addition, a second interactive, map-based website was created that gives users direct access to real-time USGS river gauge data. This provided emergency operations officials with "live" data on flooding.

From 2002 to 2005, Louisiana had several "near-miss" hurricanes that served as further "tests" of LADOTD's information delivery systems for emergencies. During that time, real-time weather data, in a GIS format, was added as a new interactive, map-based website. One of these new layers was "Road Speed Impact" for all of the state-maintained highways. This produces a map with colored lines (green, yellow, orange, and red) representing the reduction in speed due to wind and rain, making it possible to assess the entire system status, at a glance.

Improving the Operation of Government

The most obvious improvement in emergency response during the hurricanes of 2005 was the quick and effective evacuation of New Orleans. Approximately 1.3 million persons were safely and without incident, moved to shelters. This is in sharp contrast to earlier attempts to implement contraflow, where evacuees were subjected to 10-12 hour traffic jams, just to get to Baton Rouge, 90 miles away. The GIS analysis and preparation of maps and evacuation guides for the public made a difference in the effectiveness of these operations.

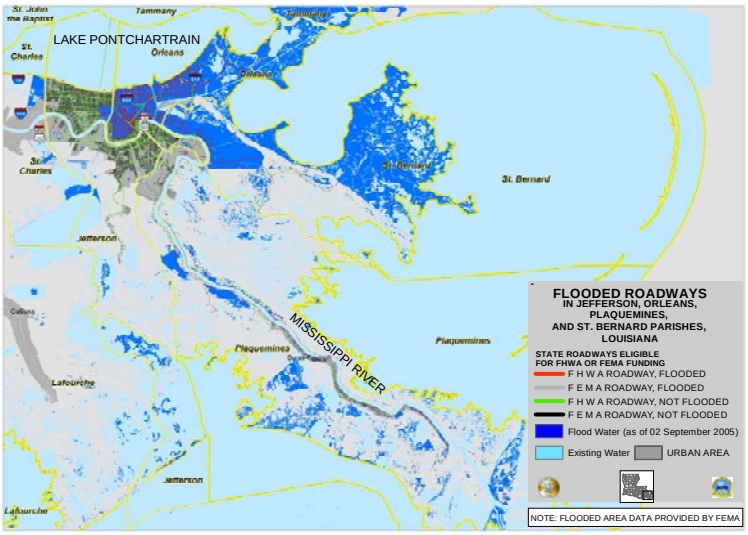
During Hurricane Katrina, hundreds of "moveable" bridges (draw, swing, pontoon, *etc*.) were affected. Each structure had to be inspected and certified for safe operation. The IT GIS team created a new interactive, map-based website displaying the highway system and all of these bridges. The map was hyperlinked directly into the bridge database and was able to display data in a user-friendly format on the status of the bridge. As inspectors completed their work, this site provided information to LADOTD, as well as the public on the availability of these essential facilities.



Immediately after the storm, it was impossible to get first-hand information on road conditions in the field. Using LADOTD's "HydroWatch" website, river stages and water elevations were available for many locations along bridges. This interactive, map-based website was instrumental in determining whether roads along the coast were passable or under water, without endangering the lives of personnel to travel out into the field.

After hurricane Katrina passed and search and rescue operations began, LADOTD created an "Operational Grid" over the New Orleans area. This was a simple set of rows and columns of polygons that were used to uniquely identify areas in the city. This was 3ssential for first-responders who came from across the country and were not familiar with the local area. An interactive, map-based website was created to quickly disseminate this to other agencies as well as the general public.

As 911 calls arrived, the locations were geocoded to find a longitude and latitude which was compared to the grid to guide search and rescue teams. In addition, TeleAtlas, a DOTD vendor, donated 200 TomTom personal navigation devices for first-responders. These are hand-held GPS (Global Positioning System) devices that operate with touch-screen technology and provide a voice response system that guides the user to a specified destination. This was essential technology, because most of the first-responders were from out of state, street signs were down, and landmarks were often destroyed. These units were used by helicopter pilots, as well as boats that were navigating among the flooded streets of New Orleans.



2 SEPTEMBER 2005 SOUTH LOUISIANA FLOODED ROADWAYS

LADOTD teamed with another contractor, 3001, Inc., who provided technical support and analysis to assist the IT GIS staff with other flood-related work. As the levees broke and began to flood New Orleans, it was necessary to determine what roads were flooded and estimate the volume of water that needed to be removed from the metropolitan area. This was done using data from the LADOTD's GIS Data Warehouse. Digital Elevation Models (DEM) of the land surface were used to create a seamless, three-dimensional representation of the flooded areas.

From this, road intersections were analyzed for surface elevation and transferred to maps that could be used by teams responding to the flood. These vehicles could traverse areas that were four feet, or less, deep but needed to avoid deeper water. In addition, these data were used to estimate the volume of water in the flood. Knowing the land surface elevation and the water level elevation, the flood volume was derived. With this and the operating capacity of the functioning pump stations, it was possible to estimate the amount of time it would take to dewater the flooded city.

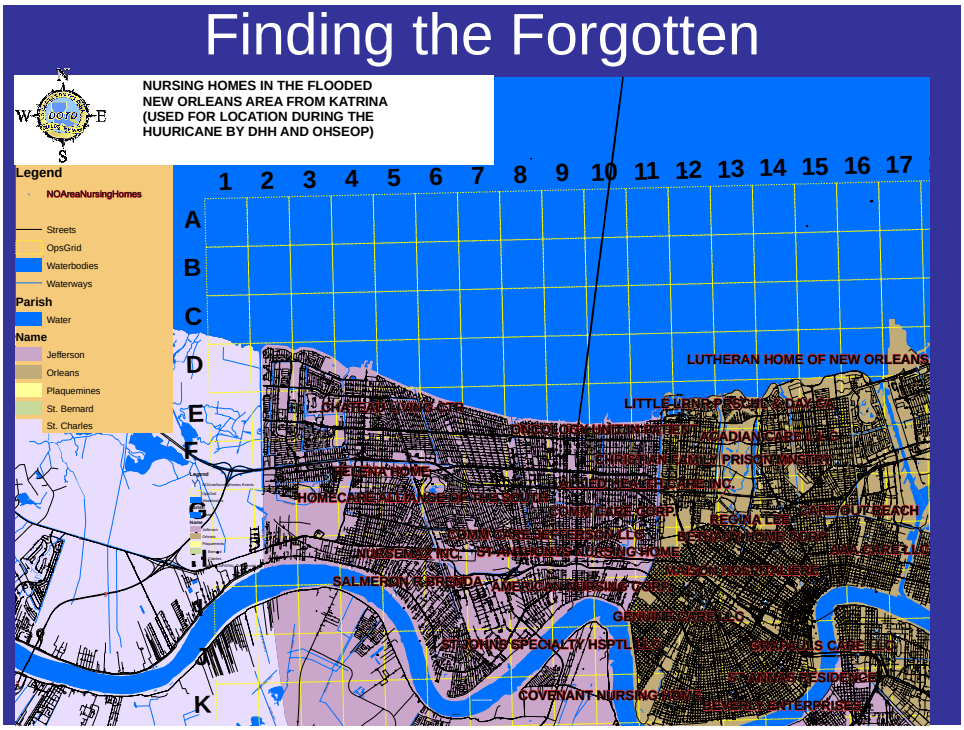
The recovery effort has also been aided with GIS technology. Using spatial analysis techniques, the mileage of flooded roads was relatively easily estimated without dangerous, costly, and time consuming field measurements. Debris were estimated using GIS, as well as locating and managing debris collection points along the state highway system. These activities continue today, and will do so for several years.

Benefits

The benefits in an enterprise implementation of GIS technology lie in placing the power of the software in the hands of trained professionals. Because it is implemented as an IT solution, it is available across the entire department and can be supported by a relatively small staff. In the case of LADOTD, the IT GIS staff consisted of one GIS Manager, two GIS Technical Specialists and an IT Technical Support Specialist. This has been adequate to support the implementation of enterprise GIS, expand and maintain services and data. These include one Intranet web service, two Internet web services, and a DB2 database that houses the GS Data Warehouse. With this configuration GIS users not only have access to the GIS data, but also to legacy, mainframe databases that are also stored in DB2.

The ArcIMS web services are an efficient way to serve data to internal and external users. All of the LADOTD ArcIMS websites are accessible by thin-client web browsers, as well as thick-client ArcGIS software. Thus with one hardware and software implementation, data and information can be provided to novice, browser-based users and advanced GIS users, inside and outside of the department.

When it was realized that nursing homes may have “fallen through the cracks’ in the evacuation of New Orleans, the Louisiana Department of Health and Hospitals (DHH) had no way to locate and track them down. LADOTD prepared maps, using the “operational grid,” local streets, and information from an Experian database showing where all the nursing homes were located. These went to DHH who passed them to helicopter pilots and other search and rescue units.



The LADOTD GIS operation was so effective that FEMA approached the department for access to data, hardware, and plotting capabilities. During the two-weeks it took FEMA to setup and staff their "Geospatial Intelligence Unit" (GIU), they were in constant contact with LADOTD, working side by side, to develop their own resources.

To view the websites developed at LADOTD go to:
http://dotdgis.dotd.louisiana.gov

For a presentation and examples of many maps produced for the hurricane response, see:
http://dotdgis.dotd.louisiana.gov/website/GIS-T2006.ppt

Realized Return on Investment

As an enterprise GIS implementation, it is difficult to quantify an ROI. This is because the investment benefits are shared by essentially every function within the department. There are annual maintenance costs that are not directly offset by revenues. There is no way to capture the cost savings resulting from making an engineer or other professional more efficient or effective.

GIS technology contributed to a better evacuation of New Orleans and it contributed to saving people's lives and property. But these are all "opportunity" costs. The fact is LADOTD's GIS technology played a large role in planning and executing the largest mass evacuation of a modern metropolitan city and continues to play a major role in recovering from the largest geospatial disaster in American history.