SETLabs Briefings
VOL 6 NO 2
2008

Lull after the Storm: Disaster Management for Utilities

By Jafrullah Mohammed

Geographic Information System plays a pivotal role in effective Disaster Management for the utilities

Disasters, both natural and man-induced, like hurricanes, winter storm, fire, flood hazardous material incident and terror-strikes take their toll on utilities every year. Among the 62 weather-related disasters that United States sustained between 1980 and 2004, Hurricane Katrina (August 2005) was the costliest and one of the deadliest hurricanes the country had ever seen. The storm is estimated to have been responsible for $81.2 billion (U.S. dollars) in damage, making it the costliest natural disaster in U.S. history [1].

With such repeated anticipated abuses on the utility industry, the companies bear a moral responsibility to protect employees, comply with various regulations, minimize loss of services and possible damage to equipment, reduce exposure to civil or criminal liability and restore the services at the earliest. Providing more accurate restoration estimates is the primary customer satisfaction issue in the utility industry.

Good disaster management requires information that is accurate, current, timely, and quickly analyzed. Much of the information used for disaster management has a spatial dimension that is reflected in questions as: Where are critical facilities located? What is the best route? What is the area of impact? How will the size of the impacted area change over time? What is the size of affected service area? How many people are in the affected service area? What resources are located close by?

GIS-enabled robust information infrastructure is a must to answer these questions, to help in effective and timely decision making in protecting the assets and people. The capability to analyze spatial information (provided by GIS) helps in all phases of the emergency response management such as: identifying the equipment that may be impacted by the disaster; identifying the related/connected equipment that needs to be turned off to minimize further loss; tracking the closest truck/crew to the affected area; finding the fastest/safest route to reach the location; locating the equipment on location and depicting the restoration progress as thematic maps at regular time intervals for efficient tracking through management dashboard.

This article discusses a GIS based Application Framework that is required for a utility to effectively manage a disaster when it is struck by major disaster.

DISASTER MANAGEMENT

Disasters are characterized by the scope of an emergency. An emergency becomes a disaster when it exceeds the capability of the local resources to manage it and a disaster often results in great damage, loss, or destruction [2].

Disasters can be effectively managed with the help of a Geographical Information System based application framework

Emergency management activities can be grouped into the following four phases that are related by time and function to all types of emergencies and disasters. These phases are also co-related to each other as they move from one to the other and do not exist in isolation.

Prepare: In this phase, the process begins with a full and detailed review of all existing emergency plans and business continuity plans (BCP) to maintain critical operations in the event of disruption from new classes of threat. During the phase, utilities develop action plans for an anticipated disaster. Common preparedness measures include proper maintenance and training of emergency response services; development and exercise of emergency customer warning; inventory; and maintenance of supplies and equipment.

Respond: During disaster events, customers look to the utility for information and the status of restoration activities. Strategic Customer Response will ensure that activities during the event and the aftermath are managed in such a way that the impact is minimized and that customers are kept informed. These response activities should be central to the plan as customers are the utility's reason for existence.

Recover: Post disaster, the priority turns to recovery from its effects and building resilience into the business by ensuring that plans, procedures and resources are in place. This would minimize or eliminate the effects of future events and business operations can go on with minimal disruption. The leanings from the events are then gathered and used to update and finetune the plans and procedures.

Mitigate: Mitigation efforts attempt to prevent hazards from developing into disasters or to reduce the effects of disasters when they occur. The mitigation phase differs from the other phases because it focuses on long-term measures for reducing or eliminating risk. The implementation of mitigation strategies can be considered as a part of the recovery process, if applied post-disaster. However, even if applied as part of the recovery efforts, actions that reduce or eliminate risk over time are still considered mitigation efforts. Mitigation is the most cost-efficient method for reducing the impact of hazards.

Geo-spatial and information technology plays an important role in enabling disaster management with the capabilities mentioned above. Every utility needs to improve decision making during emergencies, so that it can restore service as quickly as possible while minimizing risk to repair crews and the general public.

Disaster Management System should be so designed that GIS is ably integrated in it. Only then, can multiple decision alternatives can be had of

DISASTER MANAGEMENT IN THE CONTEXT OF UTILITIES

Unfortunately, in the recent past the disasters caused from storms have become more intense and/or frequent. Utilities, particularly electric distribution systems, are more prone to storms than any other types of disasters. Hence storm disaster management has become a challenge for the utilities. This paper particularly focuses on disaster management for disasters caused specifically by storms, in the following sections. The Disaster Management System (DMgS) needs to be designed to operate in conjunction with existing operation systems of a utility that include Outage Management Systems (OMS), Geographic Information system (GIS), Asset Management and Work Management Systems (WMS), as utilities have already adopted automated geospatial and information technology to assist in the daily management of operations.

A DMgS needs to handle when a utility is struck by an event. It should be designed to provide a common operational view of the disaster to all the parties that include utilities' higher management, field restoration crews, Emergency Operations Centers (EOC)/Emergency Command Centers (ECC), government, local authorities, customers, neighboring utilities and emergency responders etc. The design should consider programming intelligence to analyze costs and benefits of a variety of "what if" scenarios to effectively acquire and deploy resources to address the operational objectives.

The design should include the capability to integrate with GIS to be able to suggest a variety of decision alternatives, through analysis and present various scenarios from spatial perspective. It should also have the capability to store all activities for a replay so that utilities can re-visit the "scene" to enable storm personnel to learn and practice under a multitude of scenarios and conditions. This would dramatically minimize the potential for costly mistakes during actual incidents.

The affected utility has the need to act fast and with utmost efficiency to inform customers and restore power as quickly as possible. But the very magnitude of the destruction would have taxed the utility's physical resources beyond its limits. The intelligence component of the DMgS should enable managers to take quick decisions. It should also support control room operators and field service crews who can aid significantly in split-second decision-making. The demand for information about the extent of damage and what-is–to-be-done-about-it comes in simultaneously from every direction and from different sources. Total restoration planning should have the ability to provide groups of customers with the most accurate range of times they are planned to be restored and is often based on priority with the most urgent being attended to first. This could range from security and public safety to critical infrastructure such as hospitals, crucial public utilities to extended care facilities, to the largest single group per specific repair and until the last customer is re-energized.

The DMgS should have properly defined basic business rules to support mutual aid management, where help from neighboring utilities and contractors is identified. The system should have integrated workflows with the external/neighboring utilities or a resource co-coordinator, so that the utility can start immediately, releasing accurate data to the outside and begin making informed decisions about external help-requirements based on cost and desired restoration times.

The DMgS also needs to be designed to take care of the entire restoration process. Within hours, the entire nature and size of the event can change as dozens of field crews, repair vehicles, outside contractors, equipment suppliers along with police/medical/emergency assistance and on-site support services start arriving at the location. The DMgS needs to provide extensive procedural and logistical support needed to successfully integrate the foreign crews and equipment including accommodation, boarding and transport. As resources are put in place, the system should automatically assign tasks and schedule them in accordance with defined restoration goals and priorities. Incoming field crews should be able to log directly into the system with their mobile data devices through the web browser. They should be immediately brought up to speed with real-time status reports and identification of duties including on-board equipment needs, special skills requirements, job locations and priorities.

Regardless of the size of a storm, communications management is of extreme importance and an equally demanding task for an operator. Being a part of DMgS, the system needs to track all activities and generate proper reports for internal and external agencies including, amongst others, utility management, police, medical emergency, media, customers, stakeholders, and government departments.

Another important aspect that DMgS needs to have is the support for EOC/ECC. They are established to connect with local emergency services, law enforcement and other key municipal, provincial, state, and/or federal agencies that can log directly into the EOC/ECC liaison area and access updated requests made by the utility. This includes auto-scheduling to assist the relative agencies in deployment of their own specific resources. Reciprocally, it should allow the EOC/ECC to notify the utility of security and public safety concerns such as roadblocks, collapsed buildings, toxic buildups, fire and flood potential etc. All of these can be plotted to map displays for a "bird's eye view" of the service territory. As sectors become secured, the information is relayed to the EOC/ECC so that operators can track progress right on their computer screens. DMgS needs to manage all

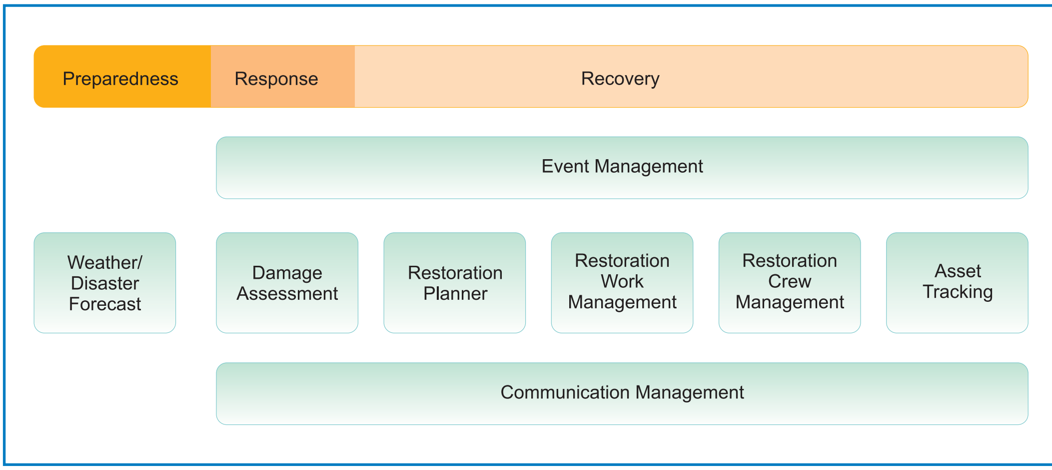

Figure 1: *An Application Framework for Disaster Management* **Source:** *Infosys Research*

logistics amongst the huge volumes of data being generated daily during a restoration project and should have operations log facility to track and record all major communications between the EOC/ECC and the utility for future reference.

DMgS needs to manage the restoration process and utilize the internet so that users from upper management to the repair crew, from virtually any location, can truly maximize time and efforts to get their lights back on. DMgS also needs to present/share a big picture of restoration progress (probably using a map) to all the stakeholders. Being informed and better equipped for the worst, provides the foundation for more competent, effective and quicker restoration efforts in the future.

APPLICATION FRAMEWORK FOR A DMgS

DMgS framework needs to encompass the best of all functionalities to address preparedness, response and recovery to any outage situation whatever may be the cause. Post disaster, the data in a user's existing OMS must be further extrapolated to derive intelligence, for a better prediction of when a customer would have her service restored.

The subsequent section describes a framework of applications required to be part of disaster management infrastructure for forecasting weather/disasters, assessing damage, tracking damage, prioritizing work orders, organizing logistics, people managing and systems for a safe and efficient recovery [Fig. 1]. Even though the approach discussed here mainly focuses on disasters created by storms, the infrastructure requirements are more or less similar for other disasters as well.

Listed below are some of the important applications of a Disaster Management System and their functionalities.

Weather/Disaster Forecast: *This application will have forecasting engine to predict the weather changes, storm paths based on the current location and its storm properties.*

Good weather/disaster forecast application is part of Disaster Management System. The intelligence engine need not be an integral part of the DMgS but it can be with other disparate systems managed by external agencies with a common agreed framework (such as Service Oriented Architecture) to share information. For example, weather intelligence can be provided by a third party agency which specializes in this aspect and shares the information online. However, the real-time weather systems data is a must and it is a very useful tool in implementing storm preparations. GIS plays an important role by plotting the weather/storm data on the map. For example when storm occurs, its predicted path can be plotted on the map and based on the extent of its diameter predicted, affected area can be shown on the map. That helps the utilities to alert the "critical care customers" and helps in placing crews on-call and/or holds crews at the Area Work Centers to ensure timely response to events. Reaching out to customers before, during or after a power outage can go a long way towards strengthening customer satisfaction. It is possible to reduce costs through automated calling and messaging technologies. This application can be integrated with simple mail transport protocol (SMTP) servers and Short Messaging Services (SMS) servers for sending automated alerts. Alternatively, utilities can outsource these calls to third-party call centers or through vendors that offer a sophisticated dialer that can deliver the utility's message to the customer.

Event Management: *Application to create and track individual disaster/emergency events.*

This application supports creation of events in the DMgS facilitating the tracking of all activities related to an event till its closure. There may be several events like storms, occurring at the same time across the service areas. It is essential to track all the activities related to these events individually, as it helps to replay these events subsequently in the system, as valuable learning can be fed back into the system as disaster intelligence. GIS helps in delineating the affected areas, affected network segments, marking the location of temporary work bases on the map, delineating the critical infrastructure and linking with corresponding events. Restoration schedules, restoration crews, work orders related to the restorations and actual expenditure are linked to the event in the system and tracked till the closure of the same. Delineation of affected areas on map using GIS over a long time helps significantly in carrying out vulnerability analysis. Vulnerability analysis can be calculated in many ways, including the estimated value of damages to the utility equipment and number of people left without power for number of days. These can be presented as maps of areas affected by a given hazard. This information again helps utilities in the area of disaster preparedness. The audit history of all events-related changes is maintained in the event manager. The event manager should also be designed to handle the non-event related outages (outages not caused due to an event) at the time of an event, as the entire service area might not have been affected by an event.

Loyalty of customers can be earned by reaching out to them at all times during the disaster period

Damage Assessment: *A damage assessment application to delineate and identify the affected network areas and affected customers.*

More severe storms cause greater equipment damage that takes longer to repair. The duration of the outage can also be affected by the utility's storm planning and mobilization efforts. Equipment inventories and available restoration personnel can have a direct impact on the duration of a power outage, following a major storm. This application helps emergency managers in assessing the extent and amount of damage. The goal is to devise a restoration plan and determine whether it is necessary to bring trouble-crews and crews from neighboring utilities on contract. One of the most accurate means of evaluating storm damage is to document and analyze customer outage calls. Existing OMS needs to be tweaked to handle large-sized outage tickets in addition to its task of handling routine outages. This helps in scaling the existing outage workflows to handle large sized emergency events without devising new work flows to handle mass outages. The OMS needs to generate trouble tickets in bulk in conjunction with the event manager application, to match the affected network due to the storm. For example, if a trouble ticket is raised on a network element, bulk trouble tickets need to be raised on connected downstream network elements/connections, in order to be able to track restoration at individual level. A user can define affected area from other sources of information and add affected network circuits to the affected area. The function should also support data coming from field assessment surveys and patrols through the field devices. GIS based field applications help carrying out planned and quick damage assessment surveys effectively. This function draws information from various sources and tries to derive the extent of damage to the network.

GIS comes in handy, while depicting the affected/outage area on the map and plays an important role in damage assessment and restoration planning. After the initial damage assessment, the focus would be on restoring service to critical infrastructure such as schools, water treatment plants, critical pumping stations, and hospitals [3].

GIS helps extensively in disaster management by playing a vital role in damage assessment and restoration planning, among other things

Restoration Planner: *A decision support system to help decision makers in planning the restoration activities based on built-in-intelligence from the historical data.*

With better planning, utilities can respond quickly when customers need them the most. This is a decision support system that helps the managers in deriving "estimated time to restore," based on the historical data and predictive intelligence (empirical models) built in the system over time.

This is one of the most complex applications as it has to derive the expected restoration times considering the priorities, constraints and trade-offs. Predicting restoration times at customer level is a very difficult and unreliable process and customers tend to be very frustrated when they find themselves without power at the predicted restoration time. Hence this needs to be done at city, county or region level. Since these expected restoration times are communicated to the customers, this application attains utmost importance as it has to predict the expected restoration times that are 'near to reality.' GIS helps in linking these "expected times to restore" (ETRs) which are derived for electric circuits (feeders) to geographical (city, county etc.) boundaries and service area boundaries. The Restoration Planning module aggregates OMS data as well as damage survey data, crew availability and crew movement to estimate restoration rates and durations. GIS helps in accurate planning by providing travel distances, alternate routes and shortest routes that can be linked with travel times for individual crews.

Restoration Work Management: *This application will have an extended functionality of existing work management system to take care of workflow related to the restoration related work execution.*

Work management during the storms is a daunting task considering the emergency and size of the restoration work. This application takes care of work order creation for issue to external contractors' internal business units, gangs and/or individual resources and tracks expenditure at an asset level with the help of GIS-based asset management system for restoration related work. This function needs to be tightly coupled with asset management system and restoration crew management application. The emergency response team uses this information to prioritize outage management and assign crews. Dispatchers rely on this to transmit work orders to trucks in the field. Coordinating the manpower and materials for recovery is a logistical challenge. At the peak of restoration activities, the storm recovery team swells to a huge team in size. Bringing in these many resources, presents the challenge of getting crews to and from work sites in unfamiliar areas and managing work assignments to ensure a safe restoration. GIS allows dividing service territory into manageable work areas and providing map sets for the crews. In addition, GIS can provide custom maps to meet special requests. Often field crews are assigned to work on a certain feeder until all customers on that feeder are restored. A customized map, displaying just that feeder to show where the feeder ran and the location and types of devices, proves invaluable.

GIS plays an important role in restoration progress tracking. Dynamic thematic maps generated depicting status of the outage

Restoration workflows if properly devised in advance can help the restoration team to track resource allocation and expenditure made at asset levels tickets on the geographical boundaries and service boundaries presented on the internet greatly helps top management in understanding the overall picture of restoration progress.

Restoration Crew Management: *An application to handle restoration crews with ability to take care of foreign crews from neighboring utilities.*

As the restoration process starts, a large number of restoration crews along with repair vehicles, outside contractors, equipment suppliers along with police/medical/ emergency assistance get into action. This application takes care of work assignments, crew dispatching and tracking including support for arrangement of lodging, boarding and transport. The application also integrates the foreign crews from the neighboring utilities into its support processes.

Communication Management: *A Communication Management Application to manage all the disaster related communication -- internal as well as external.*

During the restoration effort, customers need to be fed information on the progress and current work locations. This application tracks all activities and generates proper reports for internal and external agencies including amongst others, utility management, police, emergency, medical emergency, media, customers, stakeholders, and government departments.

This application publishes the restoration data on the web for general public. By linking with the restoration work management application, outage status information can be passed to a GIS application to create a map for website showing the magnitude and general location of outages across the service territory. The web map is automatically updated periodically, as service is restored or new outages occur, displaying most recent information on the webpage. This can be an important public resource that helps a utility to meet the challenges presented by storms. Website visitors can see how many customers are still without power and the general locations of the remaining outages. Utility can also show the number of resources/crews that are physically working in that area and a forecast of the recovery work path can also be provided.

Integration with the current day technologies like e-mail and SMS is essential to deliver timely information to all the stakeholders. Expected restoration time estimates are fed back into the CIS so that customer representatives or the voice response unit (VRU) can inform callers when their power will be restored.

Asset Tracking: *An asset tracking module to track assets effectively at the time of emergencies with latest technologies like Global Positioning System (GPS) and Radio Frequency Identification (RFID).*

GIS updated web maps can help the utility plan for the number of resources required for restoration and as also forecast the time required to restore services fully

Utilities involve disasters that have challenging asset-tracking needs. Radio frequency identification technology can help utilities and rescue workers to deploy equipments more effectively during a crisis, and locate equipment for retrieval once services are restored. GIS provides capabilities to show where trouble spots are located on the map. The utility can equip its trouble trucks with GPS receivers and mobile data terminals so that their movements can be tracked and displayed in real time.

CONCLUSION

Disasters are crucial moments for utilities. At the wake of a disaster, utilities have a moral responsibility to protect employees, comply with various regulations, minimize loss of services and possible damage to equipment and reduce exposure to civil or criminal liability and restore services at the earliest. Restoration is always a complex challenge. A significant aspect of the challenge is cost control, involving materials, crew deployment, restoration strategy, and support staff. This calls for the need to have a comprehensive systems and application infrastructure that meets the complex requirements of a DMgS. With labor accounting for a major percentage of outage costs, minimizing trouble-crew downtime by several minutes can add up to millions of dollars in savings throughout the course of a multi-storm season.

REFERENCES

1. Billion Dollar Disasters: A Chronology of U.S. Events by LiveScience Staff. Available on http://www.livescience.com
2. Russ Johnson, GIS Technology for Disasters and Emergency Management, An ESRI White Paper, May 2000
3. Jafrullah Mohammed, Emergency Response Infrastructure for Utilities, Mapworld Forum Conference, January 2007.

Author Profile

JAFRULLAH MOHAMMED
Jafrullah Mohammed is a Senior Project Manager working for the GIS practice within Energy, Utilities and Services of Infosys. He has several years of experience in developing custom GIS applications and implementing Enterprise GIS systems in India and overseas. He can be contacted at Jafrullah_Mohammed@infosys.com.

For information on obtaining additional copies, reprinting or translating articles, and all other correspondence, please contact:

Telephone : 91-80-41173871

Email: SetlabsBriefings@infosys.com