Warren Mills, J., Curtis, A., Pine, J. C., Kennedy, B., Jones, F., Ramani, R., & Bausch, D. (2008). The clearinghouse concept: a model for geospatial data centralization and dissemination in a disaster. **Disasters**, 32(3), 467-479. [ISSN: 0361-3666] The version of record is published by Wiley and can be accessed at http://onlinelibrary.wiley.com/doi/10.1111/j.1467-7717.2008.01050.x/pdf.

The Clearinghouse Concept: A Model for Geospatial Data Centralization and Dissemination in a Disaster

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Abstract: The disaster clearinghouse concept originates with the earthquake community as an effort to coordinate research and data collection activities. Though prior earthquake clearinghouses are small in comparison to what was needed in response to Hurricane Katrina, these seminal structures are germane to the establishment of our current model. On 3 September 2005, five days after Katrina wrought cataclysmic destruction along the Gulf Coast, FEMA and Louisiana State University personnel met to establish the LSU GIS Clearinghouse Cooperative (LGCC), a resource for centralization and dissemination of geospatial information related to Hurricane Katrina. Since its inception, the LGCC has developed into a working model for organization, dissemination, archiving and research regarding geospatial information in a disaster. This article outlines the formation of the LGCC, issues of data organization, and methods of data dissemination and archiving with an eye towards implementing the clearinghouse model as a standard resource for addressing geospatial data needs in disaster research and management.

Introduction

> *Over the past year, the dispersal of consistent, comprehensive, geospatial data across jurisdictions to support rapid response in antiterrorism and crisis management events has emerged as a critical responsibility of the geospatial community within the United States* (Tait, 2003, p. 81).

In the immediate aftermath of Hurricane Katrina and then Hurricane Rita, such issues of geospatial data became of key importance to those involved in response and recovery in these events. To address the needs of response and recovery activities, personnel from the Federal Emergency Management Agency (FEMA) and Louisiana State University (LSU) collaboratively developed the LSU Geographic Information Systems GIS Clearinghouse Cooperative (LGCC),2 a disaster-based clearinghouse. The LGCC accumulates, organizes, disseminates and archives geospatial data and other relevant information, such as research articles and government reports, for use in the recovery effort in Louisiana. Though integral to filling geospatial data needs in response and recovery for the hurricanes that devastated the Louisiana coast in 2005, this resource in particular and the clearinghouse model in general is more broadly capable of providing information that can be translated across a variety of emergency management applications, especially for preparedness and mitigation in future events. For example, in the response phase the clearinghouse can be accessed to obtain pre-event data such as road networks and runway locations that can assist in directing resources into the impacted area; while in the recovery phase damage assessment data that have been captured and stored in the clearinghouse can be used in a number of studies, including validation of various models of loss estimation, or as a factor in determining a spatial sampling scheme for interviewing families on their resiliency. Capturing and preserving such a data set can also be useful in identifying repetitive loss properties or as baseline information for charting the recovery process, as damage may be a factor in a study on rates of return. Damage assessment data are but one example of information that may help to guide mitigation policy and thus reduce future losses. It is important that such perishable data be preserved and made accessible for purposes such as these.

A precursor to the current LGCC model was originally developed by the earthquake research community and most recently applied in the aftermath of the 1994 Northridge earthquake, and then more formally developed in response to the 2001 Nisqually earthquake (CSSC, 2001). Due to the scale differential between these earthquakes and the regional destruction along the Gulf Coast, these seminal beginnings were small in comparison to what was needed for the response to Hurricane Katrina. However, their structure is germane to the establishment of our current model. FEMA and several LSU faculty and staff had built prior relationships based on implementation of other FEMA programmes, including the HAZUS loss estimation model, Flood Map Modernization, and work on the Hurricane Pam scenario. On 31 August 2005, a FEMA–LSU conference call helped lay the groundwork for the LGCC, including establishment of FEMA-Store, a file server with 20 terabytes dedicated to disasterrelated geospatial information.

FEMA personnel arrived on site by 3 September, five days after Katrina made landfall along the Gulf Coast. FEMA-Store then developed into the more comprehensive LSU GIS Clearinghouse Cooperative (LGCC), for centralization and dissemination of geospatial information related to Hurricane Katrina (and then Rita), and in which FEMA-Store was renamed GIS-Store. Since its inception, the LGCC has developed into a working model for organization, dissemination, archiving, and research regarding geospatial information in a disaster event. This article outlines the formation of the LGCC, issues of data organization, and methods of data dissemination and archiving. Furthermore, based on the utility of such a resource, we propose that the clearinghouse model should be included as a central component of disaster management.

History of the clearinghouse concept

The ‘clearinghouse’ concept is not new. Many groups have clearinghouses for various forms of information dissemination, for example, the National Diabetes Information Clearinghouse (2007), the National Work Zone Information Clearinghouse (1998), the New York State GIS Clearinghouse (2007), and the Georgia GIS Clearinghouse (2007),3 to name just a few. In addition, ‘Many governments have developed digital clearinghouses and warehouses of geospatial data as part of efforts to sponsor and build spatial data infrastructures’ (Goodchild, 2003, p. 99). However, in terms of a specific focus on clearinghouses that deal with information related to disasters, the concept has not been widely employed and is an under-utilized method for efficient data organization and dissemination in disaster events. Indeed, no normative model exists for these functions in a disaster. Data organization and dissemination occurred in an ad hoc fashion in response to Katrina and in an organized way for Rita, but only as a result of the experience of responding to Katrina. Though national and state standards and prescriptions exist for precisely this type of circumstance, not all jurisdictions are equally prepared or have the capability or will to prepare according to government specifications. The clearinghouse is an attempt to answer this lack of organization.

A clearinghouse is ‘a central agency for collection, classification, and distribution, especially of information’ (Merriam Webster, 2006). Given this definition, the clearinghouse concept is a natural model for dealing with issues of geospatial data accumulation, organization, and dissemination in disaster events. However, before Hurricane Katrina, its use was infrequent and relatively modest in scope, in addition to being unofficial (it is not mandated as part of an established emergency management plan). This is not a criticism, as the events associated with past natural disasters were themselves smaller in scope than the regional issues currently being dealt with along the Gulf Coast. This comparison, however, highlights an essential component of a clearinghouse model: that it must be scalable to deal with any event of any geographic determination. As the scope of a disaster is never fully known before the event, scalability is essential to deal with a range of possibilities, from a hazardous materials release in a rural area to a hurricane impacting a major metropolitan area. In fact, the LGCC model was designed to facilitate scalability and adaptability to local, state, and federal data needs.

The United States Geological Survey (USGS) has developed a plan to coordinate post-earthquake investigations and several state emergency management and geoscience agencies (California, Nevada, Utah and Washington). The Western States Seismic Policy Council (WSSPC) and the Earthquake Engineering Research Institute (EERI) have also developed earthquake clearinghouse plans (USGS, 2003). The earthquake research community has formed clearinghouse efforts to coordinate research and data collection activities for significant earthquakes since the 1971 San Fernando earthquake. However, the short-lived clearinghouse in the aftermath of the 1994 Northridge earthquake was the first documented implementation of a clearinghouse that supported emergency management activities and was the first to incorporate Geographic Information Systems (GIS) (SCEC, 2000). In addition, the Nisqually Earthquake Information Clearinghouse4 was initiated through collaboration between FEMA and the University of Washington to support emergency management and data collection in the 2001 Nisqually earthquake. The Nisqually clearinghouse continues to serve its purpose via the Internet as it preserves and disseminates information from this event. In fact, the structure of the Nisqually clearinghouse was the basis for the LSU GIS Clearinghouse Cooperative (Figures 1a and 1b).

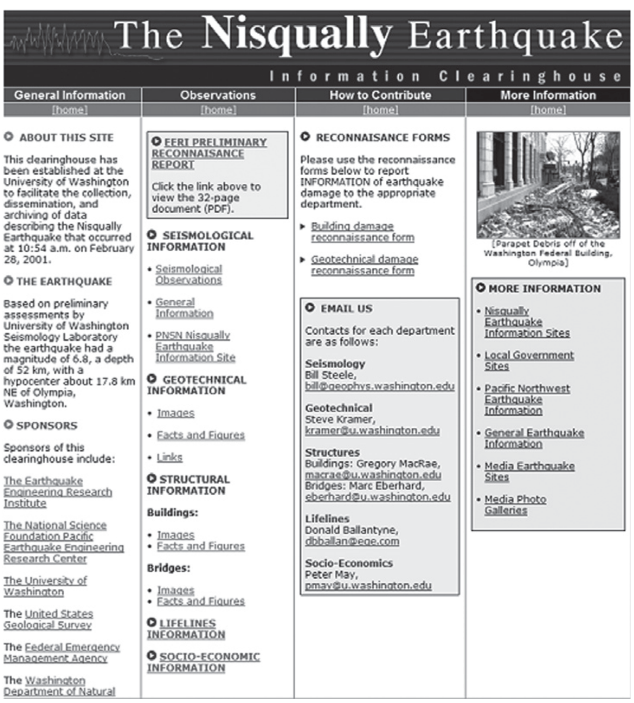


Figure 1a Website for the Nisqually Earthquake Information Clearinghouse
Source: www.ce.washington.edu/~nisqually/index.html.

Figure 1b Website for the Hurricane Katrina and Rita Clearinghouse Cooperative
Source: www.katrina.lsu.edu/.

The Nisqually clearinghouse set several precedents, as outlined in the California Seismic Safety Commission's (CSSC) 2001 review of the Nisqually event. The use of the Internet for data exchange, the financial investment by FEMA and another agency for approximately US$60,000 (US$50,000 of this amount from FEMA), and the maintenance of operations beyond five months, all contributed to this clearinghouse being the most formalized at that time (CSSC, 2001). According to the report, the Northridge Earthquake Clearinghouse was operational for only 14 days (CSSC, 2001), whereas the LSU GIS Clearinghouse Cooperative was fully functional for approximately one and a half years and there is no foreseeable end to its online accessibility; its data and products are expected to be permanently preserved. The LGCC received some formal FEMA funding, but also benefited from donated services. A number of vendors donated aerial imagery, software, hardware and personnel. Large expensive data sets that were purchased by FEMA and other agencies, including satellite and additional aerial imagery acquisitions, were also provided to the LGCC for dissemination and permanent preservation. Clearinghouses are in a far better position than government agencies to make effective use of these donated services in the aftermath of a disaster, for while emergency management professionals require these data for immediate use in achieving situation awareness for decision support, researchers can mine the datasets for applications in the months and years beyond their immediate use. In addition, many agencies are not structured to disseminate their geospatial data in the midst of a disaster and requests to do so distract personnel from their focus on response and recovery. The clearinghouse concept is structured to be flexible to assist researchers and government by filling such functions.

In addition to serving the needs of response and recovery, both the Nisqually and LGCC sites provide a historical record for application in a variety of future disaster situations. For example, the United States does not commonly experience evacuation of a major metropolitan area, yet Katrina offered a rare glimpse into what evacuee dispersal and impact on host communities might resemble for other cities. Therefore, the spatial movement of evacuees captured by FEMA and stored in the LGCC is a resource for the study of this issue in preparation for future events. For more local interests, this information could be used to alter evacuation routes or re-allocate more efficiently government services to host communities in Louisiana or throughout the Gulf Coast region. Again, this is but one example.

Inception of the LSU GIS Clearinghouse Cooperative

From experiences providing GIS support in the State Emergency Operations Center (EOC) during Katrina, our LSU team quickly became aware of the need for a centralized source of geospatial data. During our time as responders in the EOC, access and centralization of GIS data were daily hindrances to efficiency. In one instance, personnel from the Division of Administration (DOA) requested a map of state-owned land in order to start evaluating potential temporary housing sites. This dataset was held by another office in DOA, yet the requesting party did not know where to go for this dataset. Fortunately, through an established relationship between LSU and the Office of State Lands, a personal phone call was made requesting delivery of the data. Later that afternoon the data was delivered to the EOC on compact disc. Had relevant geospatial data been centralized in advance of the disaster, this map would have taken a few minutes to produce; instead the process took half a day.

FEMA was also aware of this need. We therefore initiated what was called FEMAStore. The FEMA-Store server was housed at LSU's CADGIS Research Laboratory, while Cisco Systems Virtual Private Network (VPN) client software provided remote access to this resource for users in the EOC and in other off-campus locations (Curtis et al., 2006a; Curtis et al., 2006b). The FEMA-Store provided a workspace for projects and a seamless method of data sharing as well as centralized warehousing of data from multi-agency sources wherein they could both deposit and withdraw these data.

> *Initially, interagency data sharing was an essential component of FEMA-Store for providing the most complete data for the most informed maps and information for decision support. When the Federal Emergency Management Agency (FEMA) mitigation team arrived, however, it also became a resource for their mitigation efforts, which were also facilitated through the CADGIS Lab at LSU* (Curtis et al., 2006a).

This example demonstrates the transferability of a clearinghouse application from one aspect of emergency management to another—that is, from response to recovery to mitigation to preparedness, as this resource is being utilized in all four aspects. For example, map layers of storm surge inundation limits and general flood extent were initially used in the response phase to determine the condition of transportation routes and some hazardous material storage locations, yet these same data are now being used as a tool for preparedness and mitigation education. Models of storm surge from Katrina and Rita have been geographically shifted to show impact on other areas of the Louisiana coast in order to give local residents a picture of what they could have faced and what they may experience in the future. This graphic representation allows residents to visualize their risk and make plans accordingly.

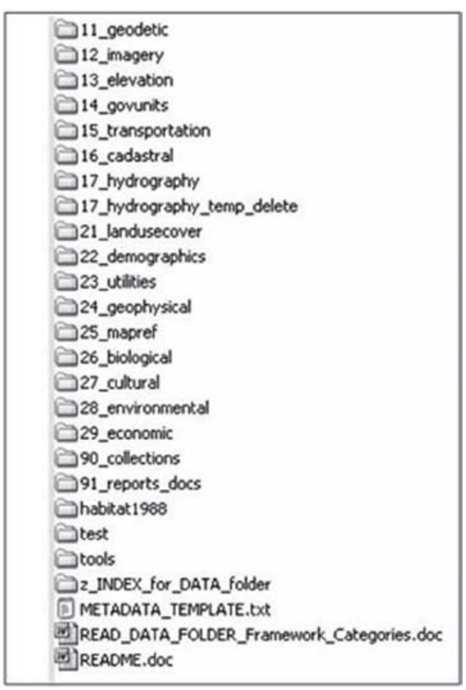
Issues of data organization

During disaster response, many data sets are shared, and done so with great speed. Metadata is not always included and because many people use this resource, storage of the datasets represents organized chaos more than meaningful structural organization. For example, during the response to Katrina, shapefiles (GIS map layers such as transportation routes and political boundaries) were stored on FEMA-Store in folders. The file names ranged from the name of the depositor to the name of the depositing agency, the name of the theme of the data enclosed in the folder, the purpose of the data, to whom the data should be transferred, and any number of other ways in which folders are intuitively named. Intuition in file naming conventions is essential in the hectic and stressful work of response with GIS. However, because data were being rapidly uploaded from the spectrum of government agencies, and from a variety of individuals within these agencies, naming of files and folders did not follow a pre-determined convention. At the end of the response, organizing these files could not occur without a number of phone calls and e-mails to track down ownership in order to create associated 'readme' files with metadata, and these investigations did not always uncover the minimal desired metadata.

When the waters had receded and the response was transitioning to recovery, barring discussion of the Hurricane Rita response for which FEMA-Store was also utilized, time was available to take a step back and reflect on the data warehoused on FEMA-Store and to investigate the most effective transitional organization structure for this information. *Data*, *incoming data*, *incoming Rita data*, *incoming Wilma data, projects,* and *products* were the initial folder classification names to make the data userfriendly while in transition to final organizational structure. Eventually, these data were moved into three major divisions within GIS-Store: the *data* folder, the *incoming data* folder, and the *projects* folder. The concept behind this structure was that the *incoming data* folder would allow for the seamless deposit and dissemination of data among agencies. However, users of data from *incoming data* understand that they are using data 'as is'. Once the GIS-Store managers have reviewed the contents, they are published in the *data* folder. The *projects* folder allows for a private area for individual users to keep protected data.

After investigating the data contained in GIS-Store, the National Spatial Data Infrastructure (NSDI) organization method was selected (Figure 2).

Figure 2 NSDI based organization of the data folder in GIS-Store
Source: GIS-Store, provided by the LSU GIS Clearinghouse Cooperative.



The NSDI Framework Layers are an intuitive option for the *data* folder because the layers were established by the Federal Geographic Data Committee (FGDC) for use by federal agencies (FGDC, 2007). Since the LGCC serviced FEMA and other federal agencies, it made sense to use categories already known by and mandated to these agencies. However, the Louisiana GIS Council (LAGIC) found that the NSDI layers did not cover geospatial data used at the state and local levels. Therefore, the framework layers were extended (through the direct and indirect efforts of LAGIC) to form what is termed the Louisiana Spatial Data Framework layers (LSDF). The LSDF layers are a superset of the NSDI layers.

The organization of the *incoming data* directory by agency was done to provide a mechanism to determine origination of the data. In the hectic days following Katrina's landfall, data appeared in the *incoming data* directory in a haphazard manner that made accessing it time consuming, though nonetheless necessary. At that point, there was not enough time to dictate a structure, as the focus was on supporting search and rescue teams. Eventually, it became difficult to track from where data originated. Once the pace slowed, as we transitioned from response to recovery, the incoming data were organized into agency folders. This organization allowed the GIS-Store administrators the ability to determine from which agency data were placed onto GIS-Store. It also allowed agencies the flexibility to organize the data into their preferred sub-folder organization without intervention by the GIS-Store administrators. Moreover, any agency can read any other agency's data, but cannot modify it.

For more sensitive data or data that needed processing before being made available, a *projects* folder was provided. Only the owner of a project folder and the GISStore administrators can read and write data within a folder in this section.

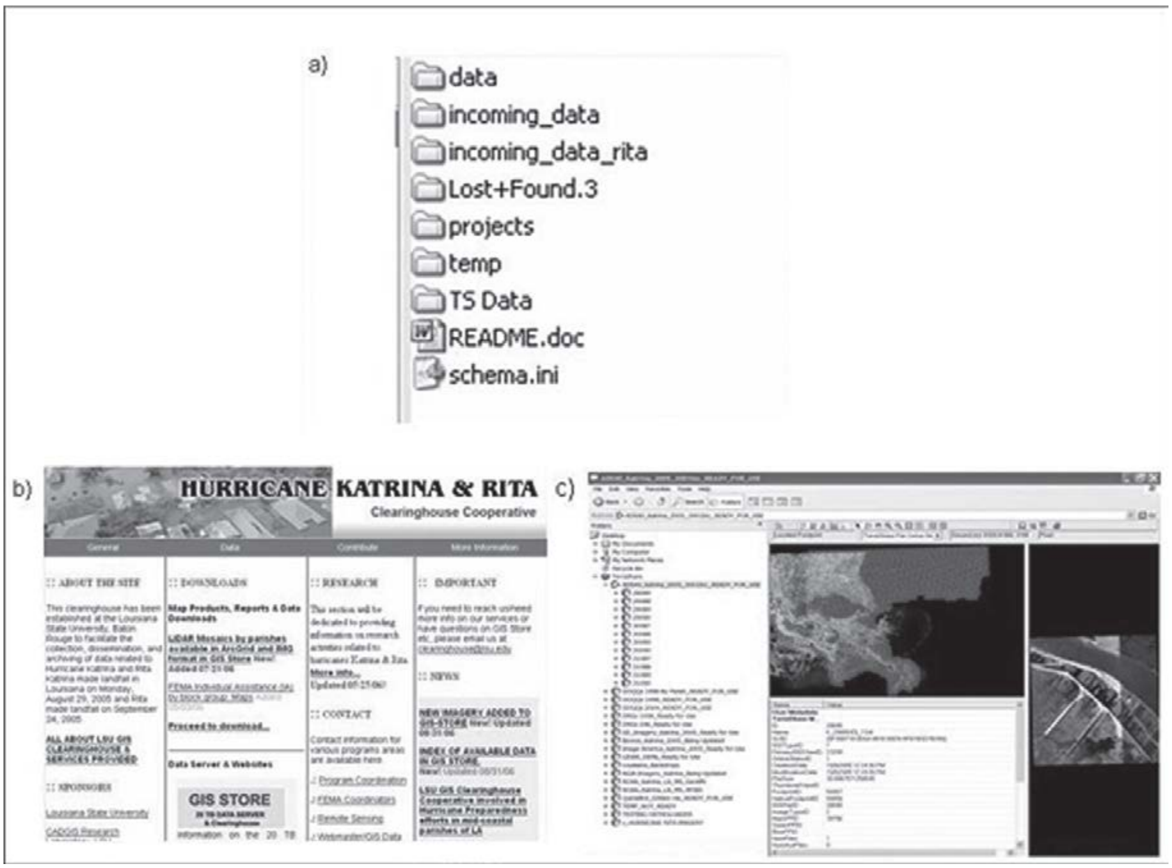
Data dissemination

A central function of the LGCC is to disseminate geospatial information that relates to Hurricanes Katrina and Rita. Dissemination is critical for enabling government agencies, non-profit organizations, and researchers to have access to publicly available FEMA data. Although this agency creates a wealth of event-based data—such as distribution of Individual Assistance (IA) recipients, damage assessments, and high water marks that indicate extent and depth of flooding—FEMA is structured for internal support and not for efficient distribution of geospatial data to outside groups. Filling this need is a primary role of the clearinghouse, in addition to centralizing and disseminating other related information. It is important to note use of the word 'information' rather than just 'data' as information includes data, but is more comprehensive. For example, through our e-mail address clearinghouse@lsu.edu, government and related personnel can request assistance in finding and accessing geospatial data. In order to fulfil these requests, we may need to point someone to a report or, sometimes, send someone to another contact for data that requires special clearance. The LGCC is more than just a data warehouse; it is a geospatial information resource. Therefore, it is important that a clearinghouse has representatives present at all relevant discussions held by producers of event-related geospatial data, and that it has a finger on the pulse of the various activities yielding these data throughout the phases of emergency management. This includes having a liaison officer who is knowledgeable of FEMA programmes. In a post-disaster environment, the data available to an agency are often not as important as the chain of contacts related to those data.

Methods of dissemination used by the LSU GIS Clearinghouse Cooperative

Due to the variety of geospatial data needed in all phases of emergency management, the LGCC developed several methods of dissemination depending on the type of data and restrictions placed on the data. The three components of dissemination are a) GIS-Store, b) Web: Clearinghouse, Atlas and Rasterserver websites, and c) Terrashare (Figure 3).

Figure 3 Methods of data dissemination via LGCC: a) GIS-Store, b) Web, and c) Terrashare



Source: a) GIS-Store; b) http://www.katrina.lsu.edu/; c) Terrashare.

The GIS-Store is a 20 terabyte data server installed as a common storage area for easy access of geospatial data needed by federal, state and local agencies involved in hurricane related efforts. Access to this server is restricted and requires an approved login and password provided by LSU. Apart from acting as a valuable data-file server for imagery, vectors, and data collections and reports, the GIS-Store is also used as a facility to provide workspace for users who are in need of large storage capacities.

Since GIS-Store is a file-based resource, it makes sense to provide a simple, intuitive navigation mechanism. The mechanism in which most users are familiar is Windows Explorer. Through the use of Virtual Private Network (VPN) software and user IDs that are able to access the LSU network through the VPN, LSU Information Technology Services (ITS) provides off-campus users access to GIS-Store as though it were another disk drive on their computer. The GIS-Store administrators are able to regulate the type of access these accounts have to GIS-Store. The use of VPN software has eliminated the need for the use of less secure FTP methods and time consuming web downloads.

However, VPN use was not problem-free. There were concerns of various agencies' IT departments with the loading of the VPN software on to agency machines, as the speed and quality of network connections has the potential to create instability. In addition, there were some problems with the GIS-Store hardware, though these problems were attended to by the support assistance of Panasas Inc., the company that donated the data storage system for GIS-Store.

Though information on the website is publicly available, GIS-Store represents a warehouse of data that is restricted to use by government officials and those officially associated with the recovery effort, such as contractors, public advocacy groups, and university-based researchers. GIS-Store is a resource that facilitates data sharing and accessibility for agencies and associated personnel. However, it also serves as an archive of much of the geospatial data used in the response and recovery. Furthermore, due to the extensive collection of base map information, GIS-Store is a resource for any future disaster event in coastal Louisiana, whether natural or human-made.

> *The vision for spatial data integration is to support antiterrorist and crisis management events by establishing a national spatial data network . . . To realize this vision, cooperative relationships in every major metropolitan area between all governmental, academic, and commercial organizations responsible for maintaining the jurisdiction's spatial data will be required* (Tait, 2003, p. 83).

The LGCC is one such resource, based on the broader clearinghouse concept, which can be implemented to realize this vision in any disaster event.

Since the GIS-Store is a secure server with restricted access to only a limited number of approved users, there is a need for a system to distribute data to the public through other easily accessible means. In this respect, LGCC implemented various web applications developed and maintained by the CADGIS Research Laboratory. The primary website was the Hurricane Katrina and Rita Clearinghouse Cooperative website (http://katrina.lsu.edu), which acts as the public forum for all LGCC efforts. Apart from having the latest information and updates on the clearinghouse, the website also hosts several useful map products in 'pdf ' and 'jpeg' formats, vector data as shapefiles, Google Earth formats, publications and reports. The legacy backbone of this public website, and GIS-Store itself, is the LSU Atlas website (http://atlas.lsu.edu). Atlas is an interactive site that provides a variety of Louisiana spatial datasets including aerial photographs (DOQQs), elevation data (LIDAR), topographic maps, and standard vector layers. In addition, Rasterserver is primarily an image extractor website that helps users obtain imagery for the area that they specify. This resource, developed by Intergraph Corporation, was established after Hurricane Katrina for extracting post-event imagery.

Terrashare is an enterprise imagery database management system that allows researchers and students in the LSU campus to access and view high resolution imagery in a highly efficient and relatively seamless manner without the need for GIS software or the time-consuming process of loading and splicing large files. It is a tool that allows images and image footprints to be displayed within Windows Explorer. Terrashare can also be integrated into a GIS programme such as GeoMedia or ArcGIS to facilitate the display of imagery along with other GIS layers. The file arrangement is logical so that the end user will be able to access the imagery irrespective of any file relocation that may happen during re-organization efforts. This tool is currently restricted to users on LSU campus and machines on the LSU domain. The software was provided free of charge by the Intergraph Corporation.

A significant concern for a clearinghouse, however, is that the data provided are based on what is collectively shared; in other words, everyone benefits in direct proportion to what everyone contributes. A disaster event-related clearinghouse may be initiated with certain base data sets, such as elevation, levees and navigable waterways, but these are soon not enough. The resource is reliant on users depositing data to increase its utility to the response and recovery, such as adding post-event elevation, damaged and structurally sound levees, and debris locations in navigable waterways. Initially, this was not a problem for the LGCC: when organizations realized the scale of the disaster almost everyone freely gave data to help the cause. However, after the cooperative impulses that characterized the initial disaster response efforts faded, and as practices returned to the *status quo*, data sharing was limited and constrained by the same proprietary concerns that had encumbered collaborative efforts prior to the storms. Data that had been freely shared resumed its proprietary nature and thus access was restricted; contractors and agencies stopped depositing data; ownership was questioned and disputed. The Privacy Act, which impacts data collected by the federal government, was often cited as a barrier to data-sharing, which then led to initiatives to file for Freedom of Information Act (FOIA) requests so that organizations could access the data they needed.

Archiving

A repeated failure of disaster management—at least in terms of geospatial data—is the lack of concern with doing more than merely capturing the required data for immediate use. Great value may come from holding disaster data for review and study after the event has passed. For example, understanding locations of civil unrest, particularly the armed attacks on first responders and law enforcement in New Orleans, may provide greater understanding of where this activity might recur during a subsequent event in New Orleans. It also might serve as an educational resource for identifying likely locations for similar events in other urban areas.

Through archiving disaster-based data, a clearinghouse may become a tool for learning lessons from one event in order to have more efficient management in subsequent events. Institutional memory and the need for knowledge transfer from one event to the next is an essential component of preparedness, mitigation, response and recovery. Long-term preservation and access to perishable event data are critical. After all, how can we improve our performance if we do not remember and then apply what we have learned from past events? Archiving geospatial data is one method of preservation for future application.

> *One of the best resources we have for preparing for the next major event is the lessons and data accumulated from this catastrophic experience. If we do not preserve this data and use it for research purposes, then we have wasted time and energy and done a great disservice to those who will be affected by the next major hurricane. For these reasons, these data are being archived and made accessible to the research community at FEMA for mitigation and long-term recovery and to the LSU researchers who provided support and want to explore the data to improve our knowledge for the next time* (Curtis et al., 2006a).

The archival component of a clearinghouse may well be its most useful, especially given the widespread access to this resource via the Internet. As in the case of the Nisqually Earthquake Information Clearinghouse, the hurricanes can still be studied and information about them gleaned from this site, which creates the potential to improve what we know and how we manage the next event. Given that Hurricanes Katrina and Rita will be studied for generations to come and given the breadth of multi-source information generated on these events, synthesizing this material into one location is a challenge, but one that a clearinghouse is well-suited to overcome. Personnel involved in homeland security and emergency management will benefit from not trying to re-invent the wheel each time, and not making mistakes where the solutions to problems are already known. The centralization and archival functions of the clearinghouse concept make it potentially fruitful in these avenues of progress.

However, given the clearinghouse's potential contribution to enabling more effective emergency management, the question arises whether its benefits are worth its costs. The LGCC can be functional on US$150,000 per annum. This price covers storage and maintenance of data and the technical and professional responsibilities of faculty, staff and graduate students. However, given our personal experiences of living through Katrina and Rita and managing this one aspect of geospatial decision support, a more sobering and perhaps more meaningful question is what are the costs of *not* having readily accessible geospatial data in response? What is it worth to reduce preventable death, prolonged discomfort, escalation of trauma, uncertainty of impact to critical infrastructure or environmentally hazardous sites—in essence, greater potential damage to life, property and the environment? What is it worth to reduce the scale of disaster? This response may sound grandiose, yet the point is quite grounded and basic: the better the information and the more quickly it flows, the more aware and better prepared are emergency management professionals to deal with disaster successfully. This goal is the essence of the 'clearinghouse' concept.

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