Chapter Three

DESIGNING ADAPTIVE SYSTEMS FOR DISASTER MITIGATION AND RESPONSE: THE ROLE OF STRUCTURE

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Introduction

The concept of resilience, defined here as the "capacity for collective action in the face of unexpected extreme events that shatter infrastructure and disrupt normal operating conditions," is characterized by experienced researchers as involving the mental processes of sensemaking (Weick, 1995), improvisation (Mendonça, Beroggi and Wallace, 2001), innovation (Demchak, Chapter 4, this book), and problem solving (Comfort, 1994). Each of these processes involves the exercise of mental skills that depend upon keen observation and access to real-time information in changing conditions. Together, they represent the wider interpretation of resilience that is discussed earlier in Chapters One and Two.

This chapter argues that a further process, cognition, is central to increasing resilience in the capacity of communities to manage recurring risk and to respond to, and recover from, disaster. Interpreting cognition in terms of its contribution to resilience, the main theme of this book, requires re-conceptualizing the relationship between perception and action and determining when in the sequence of an organization's performance resilient behavior occurs and what factors contribute to its emergence in practice.

Cognition in the context of disaster is defined as the capacity to recognize the degree of emerging risk to which a community is exposed and to act on that information. When risk is not recognized by those who are legally responsible for protecting communities and no action – or inadequate action – is taken, the situation can rapidly escalate into a threatening, imminent disaster. Retrospective analysis of the response to an actual disaster can provide insight into the role of cognition among responders to disaster operations

With a clear focus on the role of cognition, we reframe the concept of intergovernmental crisis management as a complex, adaptive system. That is, the system adjusts and adapts its performance to fit the demands of an ever-changing physical, engineered, and social environment. The terms of cognition, communication, coordination, and control are redefined in ways that fit the reality of practice more accurately in extreme events (Comfort, 2007). In this process, a framework emerges for analysis. This conceptual framework is used to assess the performance of the intergovernmental system that evolved in response to the 2005 Hurricane Katrina and ensuing flood in New Orleans. The goal of this analysis is to determine more specifically the structure and processes within organizations and among jurisdictions that build resilience to extreme events.

An effective intergovernmental crisis management system is a dynamic inter-organizational system characterized by a cumulative sequence of decisions that leads to a coherent response system. This sequence includes four subsets of decisions that define an evolving strategy of action: 1) detection of risk; 2) recognition and interpretation of risk for the immediate context; 3) communication of risk to multiple organizations in a wider region; and 4) self organization and mobilization of a collective, community response system to reduce risk and respond to danger.

Each sub-set of decisions involves the search and exchange of information across organizations and jurisdictions that underscore the shared responsibility of decision makers in mobilizing a coherent response to the extreme event. With each decision, the responsible managers may choose to reduce, share, or ignore the risk. The cumulative record of decisions taken across organizations and jurisdictions represents the collective capacity of a region to manage the risks to which it is exposed. This capacity is documented by its reduction in loss and adjustment in allocation of resources and attention to create an effective balance between immediate demands and long-term goals. Resilience in practice means maintaining this balance between short-term needs and long-term goals of safety and security for the community.

The tension between structure and process in organizing collective action represents a classic problem in organizational design and performance. This tension is especially critical in disaster environments, where the goal is to maintain continuity of operations in communities shattered by destructive events. Organizations and institutions provide structure, order, and predictability in stable communities. The difficulty occurs when the established order no longer fits the requirements for managing risk to the community. The challenge lies in maintaining a sufficient balance between structure, or clear rules for conducting the operations needed to protect a community, versus process, the urgent demands of the environment that may require novel approaches and flexible adaptation to support action.

In this chapter, we first consider a set of propositions that contribute to resilience in disaster response. We examine these propositions in reference to the actual performance of the disaster response system following Hurricane Katrina, using the situation reports that were recorded by the Louisiana Office of Homeland Security and Emergency Preparedness. We analyze the performance of the response system in terms of the rate of response to requests for assistance, and review the conditions under which the system operated. Next, we identify a set of bottlenecks, or decision points in the process where action stalled in response operations following Katrina. Finally, we review the requirements for improving organizational learning in intergovernmental disaster response systems.

Risk Assessment and Response in a Disaster Management

Resilience differs from standard conceptions of emergency management. Emergency management has largely focused on local events. More difficult and less frequent, but far more devastating, are large, multi-jurisdictional regional events. Hurricane Katrina, for example, crossed the jurisdictional boundaries of multiple municipalities and counties in nine states, three federal regions, and international borders of Caribbean island nations, Mexico, and Canada.[1] Managing disasters on such a scale exceeded the capacity of the Federal Response Plan and the National Incident Management Plan, the plan and procedures governing disaster operations that were in effect when Katrina struck on August 29, 2005.

The challenge to researchers and disaster managers lies in determining how to recognize the emerging threat in sufficient time to take informed action to reduce the risk and to mobilize an effective response. This capacity to assess the indicators of risk and comprehend the threat before it becomes full-blown danger distinguishes resilience from standard emergency management, which is primarily reactive. For example, fire trucks respond only after the fire has already started.

Disaster management systems require the rapid mobilization of a dynamic inter-organizational system that moves from individual to organizational to system levels of action, analysis, and aggregation of information. These different scales of action require different types of information and different means of communication to create a "common knowledge base" to

[1] R. Knabb, J. Rhome, and D. Brown. "Tropical Cyclone Report, Hurricane Katrina, August 23-30, 2005." National Hurricane Center, 20 December 2005.

support collective action against threats at each jurisdiction, and successively for the response system. It is at these transition points of escalating requirements for action that human cognitive, communicative, and coordinating skills frequently fail. Six propositions developed from prior research in disaster response and recovery (Comfort et al., 2006a; 2006b) present a conceptual framework for building resilience in communities exposed to recurring risk. The basic argument is that human capacity to act collectively and constructively in risky, uncertain environments can be significantly enhanced through appropriate uses of information technology.

Detection of Risk

Detection of risk involves a complex process of assessing both vulnerability and capacity of a region exposed to threat. In detection of risk, scientific data are transmitted through a network of scientists that review and validate the data and then forward their assessment to decision makers. For example, the National Hurricane Center first identified a tropical depression forming off the Bahamas as a potential risk to the Gulf Coast on August 23, 2005. Meteorologists at multiple weather stations on the Gulf Coast tracked the intensifying storm to monitor its direction and intensity before transmitting their collective assessment to policy makers, emergency managers, and the public. Engineers in the urban center of New Orleans checked the status of the built infrastructure; hospitals in the region at risk reviewed procedures for managing patient care. Yet, the cumulative assessment of risk across sectors and jurisdictions was not integrated to provide a detailed assessment of threat to the region from the imminent storm.

The process of risk detection is vulnerable to the fragilities of human organization and performance. Responsible decision makers may be watching separate conditions for indicators of vulnerable performance, but miss the interaction among these conditions that may intensify the potentially destructive impact for the whole community. The design of appropriate networks of sensing technologies to assess performance in a core set of interacting conditions and operational systems critical to the community could augment the early detection and validation of risk. These data, reported as thresholds of risk across a set of critical conditions, such as status of the levees in New Orleans, number of households without means of transportation, status of evacuation planning, and contingency plans for power generation, would provide a more integrated and timely assessment of risk to human decision makers responsible for risk reduction.

> **Proposition 1**: Human capacity to detect risk increases with the timeliness, accuracy, and validity of data transmitted in reference to a core set of thresholds of risk to conditions critical for continuity of community operations.

Recognition and Interpretation of Risk

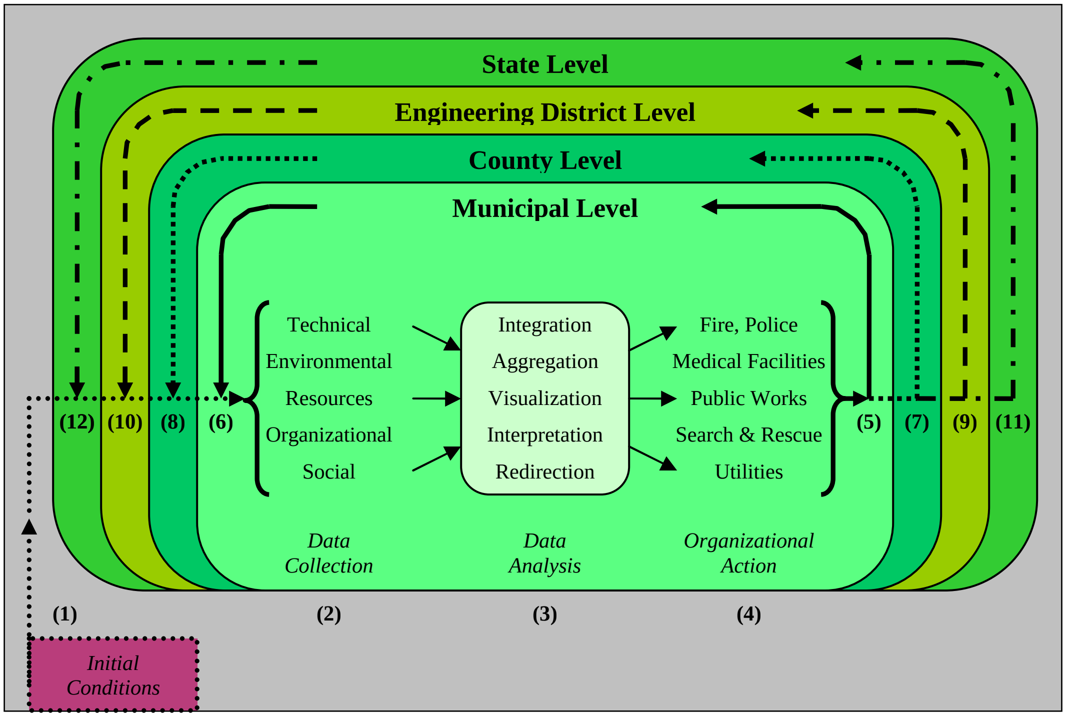
Prior research has found that an individual's capacity for problem solving drops under increasing complexity (LaPorte, 1975) and stress (Miller, 1967; Simon, 1981). This drop in capacity is the result of the increased number of risk factors, the degree of unfamiliarity with new information, and the degree of uncertainty that characterizes extreme events. In these contexts, appropriate uses of information technology offer a means of extending human problem solving capacity in uncertain conditions. A key question for investigation is the extent to which a socio-technical information infrastructure, designed to detect and transmit risk information quickly and accurately, can facilitate the rapid recognition of risk within a community and lead to more informed, timely action.

> **Proposition 2**: Human capacity to recognize risk conditions can be increased by focusing risk data through notifications or selected views that are directly relevant to the responsibilities of each major decision maker in the system, thus reducing the overload of less relevant information and time required for information processing and facilitating the rapid absorption of threatening information by individual decision makers.

Communication of Risk

The prevailing method of communicating risk in disaster environments relies largely on command and control processes executed through a carefully defined hierarchical order. For example, the National Response Plan (FEMA, 2004) and the National Incident Management System (FEMA, 2005), adopted by the Federal Emergency Management Agency and the Department of Homeland Security as the authoritative policies governing emergency operations at the time of Hurricane Katrina, follow a serial format for communicating risk and requests for assistance from lower to upper jurisdictional levels. An analysis of communication patterns among emergency response agencies in the hours and days leading up to, and following, Hurricane Katrina as the storm made landfall on August 29, 2005 illustrates the breakdown of this design in practice (Comfort, 2005; 2006). Building the awareness of risk to support collective action is a cumulative process. If the first two steps of risk detection and communication have not been carried out successfully, the effort to engage organizations from a wider arena into the emergency response system is likely to flounder or fail.

Figure 3.1: Bowtie Architecture for the Iterative Flow of Information within a Disaster Management System



Our model for achieving this task of communicating critical information to focused audiences is the "bowtie" architecture for decision support (Csete and Doyle 2004; Comfort 2005). As shown in Figure 1, this design identifies key sources of data that "fan in" simultaneously to a central processing unit (or "knot") where the data are integrated, analyzed, and interpreted from the perspective and performance of the whole system. The new information is then "fanned out" to the relevant actors or operating units that use the information to make adjustments in their specific operations informed by the global perspective. This design fits well with an Emergency Operations Center, where status reports from multiple agencies are transmitted to the service chiefs who review the data from the perspective of the whole community. The set of service chiefs collectively integrate, analyze, and interpret the data to adjust performance reciprocally among multiple organizations based on timely, valid information. This process represents self organization (Axelrod and Cohen, 1999) in emergency response, guided by the shared goal of protecting lives, property, and maintaining continuity of operations for the whole community (Comfort 1994).

This theoretical framework acknowledges the importance of both design and self organizing action in guiding coordinated action in a complex, dynamic environment. It can be modeled as a set of networks that facilitate the exchange of incoming and outgoing information through a series of analytical activities that support systemic decision making. The information flow is multi-way, but decision support gains efficiency through integrated analysis and coordinated action toward a clearly articulated goal for the whole system. The system operates by identifying the key sources of information, the key processes of analysis and interpretation of incoming data, and the key routes of transmission for updated status reports on critical thresholds of risk. It maintains self organizing functions in that personnel, with informed knowledge, adjust their own actions to achieve the best performance for the whole system. Design, self organization, and feedback are central to effective performance of distinct organizational units within the global response system.

> **Proposition 3**: The capacity of a set of organizational managers, each with specific responsibilities and operating at different locations, to coordinate their actions can be increased by the simultaneous transmission of relevant risk information to each manager, creating a "common operating picture" of risk to the region for all managers.

Self Organization and Mobilization

The collective capacity of a community to take informed, coherent action in the face of danger is a measure of that community's resilience. This capacity depends upon the cumulative set of cognitive, communicative, and adaptive processes outlined above. If any one of the preceding steps fails, the capacity of the community for collective action is weakened. If all of the preceding steps are performed effectively, the capacity for collective action is strengthened. Further, instances of negative feedback can have the reverse effect of weakening the whole system's performance in response to danger.

Disaster management involves multiple governmental, nonprofit, and private entities with different structures and organizational models. The interest of each organization in gathering information and disaster management data derives directly from its own mission. In current disaster management systems, these organizations are vulnerable to information overload caused by the transmission of large amounts of irrelevant information. As the number and variety of sensors, or monitoring instruments, continue to grow, so does the volume of data generated by these socio-technical sources of information. The capacity for multiple managers at different levels of responsibility to view the relevant information for their specific arenas of action simultaneously enhances their ability to adapt and adjust their performance to the emerging threat more quickly, efficiently, and effectively. Setting the thresholds of risk for participating agencies exposed to threats of different degrees of severity and limited by different levels of resources, requires the judgment of experienced emergency managers as well as timely, valid information. The model of an executive dashboard, or visual display of real-time information using bowtie architecture, offers a mechanism for building a 'common operating picture' among responsible actors in a complex disaster management system for a community at risk.

> **Proposition 4**: The collective capacity of a community to act in coherent ways to reduce risk can be increased through information search, exchange, focused views, and feedback processes to create an interorganizational learning system that adapts its behavior to fit available resources to changing conditions of risk more appropriately.

Vulnerability to Systemic Failure

In each of the four decision processes identified above, human capacity for informed action is enhanced by access to appropriately designed and functioning information technology. The interaction between organizational performance in coordinating action and the availability and access to a functioning information infrastructure has a fundamental effect upon a community's capacity to manage the risk to which it is exposed. Without access to such a technical information infrastructure, the organizational capacity to mobilize collective action in a region will likely fail. The collapse of the emergency response system in New Orleans after the city lost its communications aptly illustrates this argument (Comfort, 2006).

> **Proposition 5**: Without a well-defined, functioning information infrastructure supported by appropriate technology, the collective response of a community exposed to serious threat will fail.

Designing a Resilient Disaster Management Network

A disaster response system functions largely as a network of organizations that are focused on a common goal: risk reduction and continuity of operations for the community exposed to threat. The capacity of organizations to recognize risk may be affected by the structure of the network. If an organization performs a bridging function between two unrelated organizations (Burt, 1992) in the network, it will gain more influence in the operation of the whole system. If an organization is isolated from other units in the system, it will likely lose influence in the operation of the whole system. The performance of the whole system depends upon the collective capacity of its members to recognize risk, and the degree of collaboration they are able to achieve in adjusting their actions reciprocally to one another in order to manage their risk effectively.

Proposition 6: The performance of the entire disaster management system depends on the iterative functions of scanning the environment for risk, detecting it accurately, verifying the degree of risk, analyzing the information from the perspective of the whole system, and transmitting the results in timely manner to the multiple actors to serve as a basis for coordinated action.

These six propositions, taken together, constitute a conceptual framework regarding the evolution of capacity for collective action in communities exposed to recurring risk. The test of the framework is whether it provides insight into the strengths and weaknesses of practice.

Disaster Response in Practice

Could actual disaster operations be analyzed to determine if the decision processes that characterized them correspond to, or vary from, the model of decision making represented in propositions outlined above? The situation reports recorded by the Louisiana Office of Homeland Security and Emergency Preparedness (LOHSEP) offer an unusual source of empirical data against which to test a theoretical model of an evolving disaster management system. Since the performance of this intergovernmental system following Hurricane Katrina has been evaluated and discussed extensively in other studies (U.S. Congress, 2005; Farber et al., 2007; Brookings Institution, 2005; Comfort, 2005; 2006), the descriptive context of this disaster will not be repeated here. Rather, the focus of this analysis will be to assess the actual stages of an evolving disaster system, documented by actions recorded in the Situation Reports (sitreps) maintained by LOHSEP. The sitreps were recorded under the tense, urgent conditions of a major disaster and are subject to human error. Yet, this set of reports is likely the most complete record of the disaster operations conducted by the State of Louisiana. This dataset documents the types of state level transactions undertaken in disaster operations, with interactions and exchanges reported among municipality, parish, and federal levels of response operations.

The analysis that follows is based on the situation reports that were prepared and maintained by LOHSEP for 23 days, August 27 – September 19, 2005 during the two days preceding and twenty-one days following landfall of Hurricane Katrina on August 29, 2005.[2] The situation reports represent the official record of disaster operations undertaken at the state level in Louisiana in reference to Hurricane Katrina. The reports identified the organizations within the state of Louisiana that initiated requests for assistance (initiating organizations), date, and time of each request. The reports also identified the type of assistance requested (transactions) and the organizations to whom the request was assigned for action (assigned organizations). Finally, the reports identified the status of the request in the response process, specifying the date and time that any change was made.

Each of the six propositions presented above will be examined in reference to the situation reports to assess the record of actual performance against the theoretical model. A critical condition for effective performance in disaster management is the emergence of a 'common operating picture' among the organizations participating in response operations. This condition is facilitated by the simultaneous transmission of relevant risk information among the set of participating organizations. Examining the situation reports recorded by LOHSEP, the record shows the status of interactions among organizations with key responsibilities in disaster operations in the period immediately before, and after, the storm.

Detection of Risk

In the evolving conditions prior to Hurricane Katrina's landfall on August 29, 2005, the National Weather Service (NWS) detected a tropical storm off the Bahamas on August 23, 2005, and tracked the storm as it moved across Florida and into the Gulf of Mexico over the next five

[2] There were no situation reports available for August 31, 2005, the second day after the storm.

days, intensifying to a Category 5 hurricane (Johnson, 2006). The NWS predicted landfall in Louisiana and Mississippi on August 29, 2005 as a Category 4 hurricane. The scientific evidence documenting the storm and its increasing severity was reported to the news media by the NWS on a daily basis, (*Times Picayune*, August 24-29, 2005). Scientific institutions had detected the storm and made this information publicly available. Yet, other thresholds of risk were not detected or reported as the hurricane was approaching landfall. These risks included the weakened status of the levees in New Orleans (Seed et al, 2005) and the evacuation needs for a large number of low income residents of New Orleans who had no means of transportation (GAO, 2006; Brookings, 2006). While the status of these conditions was known by different agencies, such as the Louisiana State University Hurricane Center (van Heerden et al., 2005), there was no integration of data from multiple sources that would have identified a broader threshold of risk for the Gulf Coast region, and particularly the City of New Orleans. This lack of integration of risk data from different sources inhibited the emergence of a "common operating picture" for the public agencies responsible for emergency management agencies. Without a common understanding among agencies of the severity of the hurricane and its potential impact on communities directly in its projected path, the scientific information did not trigger coordinated action critical to resilient response at federal, state, and local levels. Inaction at this point in the evolving event affected all subsequent decisions in the process.

Recognition and Interpretation of Risk

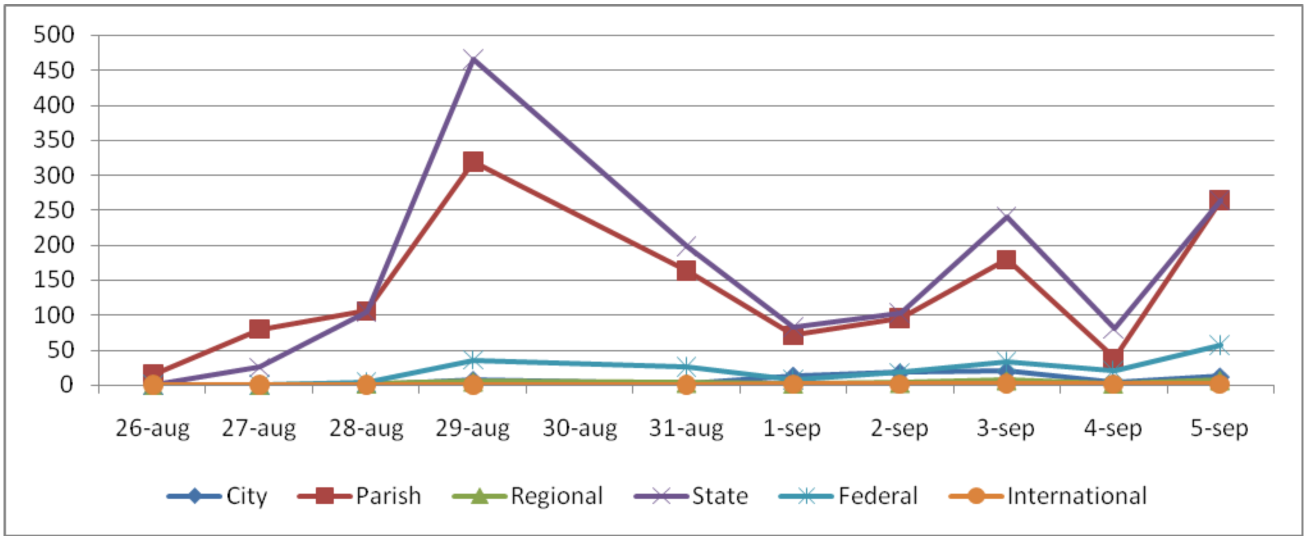
Analysis of the situation reports confirms that the public agencies responsible for disaster preparedness at local, state, and federal levels of authority did not adequately recognize the threat to the vulnerable infrastructure and population of New Orleans, and consequently did not interpret the risk in time to mobilize action. Table 1 reports the number of requests for assistance that were registered in the LOHSEP situation reports by jurisdiction and date. Only 15 requests for assistance from parishes were registered on August 27, 2005, two days before landfall. That number increased to 80 requests on August 28, 2005, with 25 requests from state agencies. Only on August 30, 2005, the day after Katrina made landfall, was there a significant increase in the number of requests for assistance initiated by parish, state, and regional jurisdictions, with a modest number, 36 requests initiated by agencies at the federal level. Figure 2 shows the graphic distribution of the number of requests by date and jurisdictional level.

Table 3.1
Number of Requests for Assistance Registered in
LOHSEP Situation Reports by Date and Level of Jurisdiction

	City		Parish		Regional		State		Federal		International		Total	
	N	%	N	%	N	%	N	%	N	%	N	%	N	%
26-Aug	0	0.0	15	1.13	0	0.0	0	0.0	0	0.0	0	0.0	15	0.47
27-Aug	0	0.0	80	6.01	0	0.0	25	1.6	0	0.0	0	0.0	105	3.27
28-Aug	0	0.0	106	7.96	2	6.5	105	6.7	4	2.0	0	0.0	217	6.75
29-Aug	7	9.3	319	23.97	5	16.1	466	29.8	36	17.6	0	0.0	833	25.92
31-Aug	2	2.7	163	12.25	3	9.7	198	12.7	26	12.7	0	0.0	392	12.20
1-Sep	13	17.3	71	5.33	2	6.5	83	5.3	8	3.9	1	16.7	178	5.54
2-Sep	18	24.0	96	7.21	3	9.7	103	6.6	18	8.8	1	16.7	239	7.44
3-Sep	20	26.7	179	13.45	7	22.6	240	15.3	34	16.6	2	33.3	482	15.00
4-Sep	3	4.0	38	2.85	2	6.5	80	5.1	21	10.2	1	16.7	145	4.51
5-Sep	12	16.0	264	19.83	7	22.6	264	16.9	58	28.3	1	16.7	606	18.86
Total	**75**	**100**	**1331**	**100**	**31**	**100**	**1564**	**100**	**205**	**100**	**6**	**100**	**3212**	**100**

Source: Situation Reports, Louisiana Office of Homeland Security and Emergency Preparedness, August 27 – September 6, 2005

Figure 3.2
Number of Requests for Assistance Registered in
LOHSEP Situation Reports by Date and Level of Jurisdiction



Source: Situation Reports, Louisiana Office of Homeland Security and Emergency Preparedness, August 27 – September 6, 2005. Situation Reports were not available for August 31, 2005.

The data in Table 3.1, corroborated graphically in Figure 3.2, show that little more than 10% of the actions taken in response to Hurricane Katrina were taken prior to landfall on August 29, 2005. These findings demonstrate the widespread lack of recognition of the severity of the risk and consequent inaction by responsible agencies in the face of impending danger. Failure at the initial point of detecting risk was compounded by failure in interpreting the gravity of that risk for the region, especially for the vulnerable City of New Orleans.

The LOHSEP situation reports document the pattern of requests for assistance that came to the State Emergency Operations Center, the sequence used in processing the requests, and the actions taken in response. Table 3.2 reports the total number of requests for assistance that were submitted to LOHSEP by the fourteen major types of response functions for the period, August 27 to September 6, 2005. The top row of the table shows the number of requests for each type of response function. The lower rows show the status of the requests as they entered the system and the subsequent actions taken. The status categories represent the phases of the dispatch process. NR means that a request was received at the LOHSEP EOC, but no response was given. 'Action required' means that a request was received, and registered for action. 'Pending' means that the request was assigned to a responsible agency for action. 'Cancelled' means that the request was aborted and no action was taken. 'On-going' means that the request was received, and that the urgent situation reported as requiring assistance is continuing. 'En route' means that a unit has been dispatched to a specific location to provide assistance. 'On scene' means that the unit has arrived at the scene and that assistance is being given. 'Released' means that the unit has completed its task and has returned to service. The total number of requests minus the number classified as no response equals the number of active requests. On scene + en route + released equals the number of completed actions that constructively contributed to disaster operations.

Table 3.2
Frequency Distribution of Requests for Assistance
by Mission Status reported to Emergency Operation Center, State of Louisiana

	Search & Rescue		Damage Assessment		Supplies		Transportation		Evacuation		Shelter		Security		Emergency Response		Medical		Utility		Heavy Equipment		Light Equipment		Personnel		Communication & Coordination		Row Totals	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
No Response	27	14.8	3	37.5	166	25.0	40	21.5	8	57.1	45	19.0	104	20.6	21	25.0	63	35.4	58	25.7	130	28.3	16	19.8	28	20.9	20	26.7	729	24.0
Action Required	95	52.2	7	87.5	414	62.3	99	53.2	12	85.7	115	48.5	207	41.0	45	53.6	141	79.2	115	50.9	245	53.4	36	44.4	71	53.0	38	50.7	1640	54.1
Operation Pending	98	53.8	2	25.0	248	37.3	65	34.9	3	21.4	83	35.0	248	49.1	36	42.9	26	14.6	100	44.2	157	34.2	38	46.9	47	35.1	24	32.0	1175	38.7
Cancelled	15	8.2	1	12.5	37	5.6	26	14.0	1	7.1	28	11.8	36	7.1	4	4.8	21	11.8	35	15.5	60	13.1	5	6.2	27	20.1	4	5.3	300	9.9
On-Going	0	0.0	0	0.0	0	0.0	2	1.1	0	0.0	0	0.0	9	1.8	0	0.0	0	0.0	0	0.0	7	1.5	0	0.0	0	0.0	1	1.3	19	0.6
En Route	5	2.7	0	0.0	9	1.4	5	2.7	0	0.0	12	5.1	27	5.3	5	6.0	1	0.6	28	12.4	9	2.0	2	2.5	4	3.0	0	0.0	107	3.5
On Scene	0	0.0	0	0.0	0	0.0	7	3.8	0	0.0	36	15.2	51	10.1	2	2.4	3	1.7	1	0.4	24	5.2	7	8.6	0	0.0	10	13.3	141	4.6
Released	0	0.0	0	0.0	3	0.5	1	0.5	0	0.0	0	0.0	2	0.4	0	0.0	1	0.6	8	3.5	1	0.2	0	0.0	1	0.7	1	1.3	18	0.6
Total Transactions	182	6.0	8	0.3	665	21.9	186	6.1	14	0.5	237	7.8	505	16.6	84	2.8	178	5.9	226	7.4	459	15.1	81	2.7	134	4.4	75	2.5	3034	100

Source: *Situation Reports*, Louisiana Office of Homeland Security and Emergency Preparedness, August 27 – September 6, 2005.

By this classification, four categories of requests for assistance represent the largest share of the total number of reported transactions. These categories include requests for supplies, shelter, security, and equipment. Surprisingly, the category that received the least requests was evacuation, indicating that those residents who could leave did, and those who could not were likely more in need of supplies, shelter, security, and equipment. The sobering finding in this table is the high number of actions that remained pending across all categories of response functions, 38.7%, and the low number of actions, again across all categories, that were successfully completed, 0.6%, during the eleven-day period for which status reports were recorded. These data document again the heavy burden of demands placed on the state agency in the first days after the storm, and its inability to meet them in a timely manner. This situation indicates a lack of dynamic exchange among jurisdictional levels. Given a lack of recognition of risk prior to the storm at all jurisdictional levels, the interorganizational system of disaster response outlined in policy and procedures was not effectively mobilized in the first eleven days after landfall.

Communication of Risk

Communicating the risk that has been detected and recognized as a threat to the community is the next set of decisions that are essential to resilient response. The legal framework of the National Response Plan (FEMA, 2004) and the National Incident Management System (NIMS) (FEMA, 2005) outlines a formal process for communicating risk among the jurisdictions. This framework specifies that when municipal jurisdictions are overwhelmed in extreme events, they request assistance from the next level of jurisdiction, parish or county. If the parish/county is overwhelmed, it requests assistance from the next level of jurisdiction, the state.

In turn, when the state is overwhelmed, it requests assistance from the federal level. The design of NIMS is to facilitate a smoothly functioning transition of assistance and authority across jurisdictions to activate a truly national response system of support and assistance to extreme events. Under this legal framework, the situation reports submitted to LOHSEP can be interpreted as requests for assistance from parishes and in the case of New Orleans, a parish/city. Consequently, one measure of resilience in the communication of risk to wider arenas of response and resources is the timeliness of response to these requests.

Table 3.3 presents the data regarding the change in status categories as requests for assistance were processed by LOHSEP. The data show the number of hours that requests were held in each action status category before moving to the next, and. provide a profile of the pace of disaster operations and the amount of delay involved in meeting requests for action. The profile shows the slow evolution of the Katrina response system over the period of eleven days for which status data were reported.

Again, the data document the sizeable delay in assigning the requests to an agency for action – the change from 'action required' to 'pending' – for even the most urgent requests. For example, the delay for search and rescue (Mean = 48.2 hours), was more than two days, and emergency response (Mean = 33.7 hours), was more than a day. For less immediate requests, such as utilities, the time delay was 3.6 days, and for supplies, the time delay was even longer, an average of 7.2 days. Clearly, the EOC at LOHSEP was overwhelmed. The categories with the largest number of requests – Security, Search & Rescue, and Supplies – had significant delays, indicating disconnected linkages in the interdependent disaster response network.

Two types of requests for assistance made to LOHSEP revealed a higher rate of completion than the others, security and utilities. Given the primary need for both types of assistance in the badly damaged environment left by Hurricane Katrina, this finding documents the priorities set by the response agencies. While the requests detailed in the Situation Reports were initially intended for Louisiana state agencies, the cumulative delay in response indicates

Table 3.3
Change in Status of Requests for Assistance, Louisiana Office of Homeland Security and Emergency Preparedness

	Search & Rescue	Damage Assessment	Supplies	Trans-portation	Evacuation	Shelter	Security	Emergency Response	Medical	Utility	Heavy Equipment	Light Equipment	Personnel	Communication & Coordination	Row Totals
Number of Requests, Required to Pending	**26**	**1**	**30**	**6**	**1**	**9**	**30**	**3**	**2**	**20**	**6**	**4**	**5**	**N/A**	**143**
Total number of hours in Status	1254.0	107	5208.0	112.0	4	290.0	981.0	101.0	52.0	1740.0	128.0	156.0	256.0	N/A	
Mean Number of Hours in Status	48.2	107	173.6	22.4	4.00	32.2	32.7	33.7	26.0	87.0	21.3	39.0	51.2	N/A	
Median Number of Hours in Status	12.0	107	192.0	15.5	4.00	27.0	37.0	32.0	26.0	93.0	17.0	42.5	39.0	N/A	
Std. Deviation	122.8	N/A	48.6	15.1	N/A	32.9	14.1	20.6	5.7	33.2	14.6	29.5	53.1	N/A	
Range	627.0	N/A	179.0	38.0	N/A	105.0	72.0	41.0	8.0	124.0	35.0	67.0	130.0	N/A	
Minimum	0.0	N/A	67.0	6.0	N/A	2.0	0.0	14.0	22.0	20.0	4.0	2.0	14.0	N/A	
Maximum	627.0	N/A	246.0	44.0	N/A	107.0	72.0	55.0	30.0	144.0	39.0	69.0	144.0	N/A	
Number of Requests, Required to (Pending) to Cancelled	**7**	**1**	**12**	**8**	**1**	**10**	**19**	**2**	**12**	**15**	**28**	**2**	**11**	**2**	**130**
Total number of hours in Status	79.0	50	568.0	344.0	108	468.5	494.0	89.0	721.5	1004.0	2141.5	130.0	365.5	41.0	
Mean Number of Hours in Status	11.3	50	47.3	43.0	108.0	46.9	26.0	45.0	60.1	66.9	76.5	65.0	33.2	20.5	
Median Number of Hours in Status	4.0	50	39.5	21.0	108.0	40.8	26.0	44.5	8.5	46.0	61.0	65.0	29.0	20.5	
Std. Deviation	16.9	N/A	29.3	51.4	N/A	40.3	25.5	60.1	82.2	51.8	57.5	83.4	19.7	16.3	
Range	41.0	N/A	111.0	136.0	N/A	138.0	94.0	85.0	188.5	148.0	188.0	118.0	71.0	23.0	
Minimum	0.0	N/A	3.0	4.0	N/A	6.0	0.0	2.0	4.0	2.0	2.0	6.0	6.0	9.0	
Maximum	41.0	N/A	114.0	140.0	N/A	144.0	94.0	87.0	192.5	150.0	190.0	124.0	77.0	32.0	
Number of Requests, Required to Completed (Enroute+On Scene+Released)	**2**	**N/A**	**6**	**3**	**N/A**	**11**	**35**	**2**	**1**	**28**	**6**	**1**	**N/A**	**1**	**96**
Total number of hours in Status	2.00	N/A	112.0	8	N/A	370.0	762.0	56	37	1810.0	193.0	2.0	N/A	14.0	
Mean Number of Hours in Status	1.00	N/A	37.3	2.70	N/A	33.6	21.8	28.0	N/A	64.6	32.2	2.0	N/A	14.0	
Median Number of Hours in Status	N/A	N/A	25.0	2.00	N/A	19.0	19.0	28.0	N/A	39.0	24.5	2.0	N/A	14.0	
Std. Deviation	N/A	N/A	39.0	3.05	N/A	38.8	24.6	12.7	N/A	47.5	34.5	N/A	N/A	N/A	

Source: Situation Reports, Louisiana Office of Homeland Security and Emergency Preparedness, August 27 – September 6, 2005 the inability of the state to meet these requests without federal assistance. This finding further indicates a low capacity of the state's emergency preparedness system to absorb threatening information and communicate it effectively among its members.

Comparing the response time among the fourteen response function categories, we calculated an analysis of variance (ANOVA) to determine whether there is any significant difference among the means of categories. The results of the ANOVA show a significant difference in mean time spent in moving from 'Action Required' to 'Released', or completed action among categories of transactions (p=0.000). A Post Hoc test (Games-Howell, because of its heterogeneity) indicates that the mean time for response to requests classified as 'utilities' differs significantly from that for the categories of 'security', 'transportation', 'emergency response.' Response to requests for assistance regarding 'utilities' was especially slow in comparison to other categories. These findings indicate the points of decision in the response process where additional staffing and personnel would increase the resilience of the response system. The means plot shows the ANOVA results graphically in Appendix 1.

Self organization and Mobilization of Collective Action

The fourth proposition in the model for a resilient community refers to its capacity to engage in self organizing action and to mobilize collective action in the response system to reduce risk. Importantly, the data document the rate of change for the whole system, as well as identify the status categories and types of transactions for which the delay in response was the greatest. The high ratio of requests that remained 'pending' and 'cancelled' in categories of 'Search and Rescue' and 'Evacuation' documents the difficulty in mobilizing support for these critical functions in disaster operations.

The role of LOHSEP, under the Louisiana Emergency Plan, was to provide back-up support to the local municipalities and parishes. The low rate of completion for these tasks indicates a serious lack of coordination among the federal, state, parish, and municipal agencies engaged in disaster operations. In contrast, although the length of time spent in meeting requests for assistance regarding utilities was substantially more that the other types of transactions, the ratio of task completion (16.7%) for this category was relatively high.

The findings presented in Table 3.4 corroborate the substantial delay reported in Table 3.3 (above) in moving requests for assistance from one phase of the response process to the next in the overall disaster operations system for the State of Louisiana. Table 3.4 also documents significant differences in demand among the fourteen categories of response transactions. The data presented in both Tables 3 and 4 indicate apparent bottlenecks in moving information and action through the network of the organizations that participated in disaster operations at the state level. The overall performance of the response system revealed substantial delays in managing operations at the state level among state agencies, between state agencies and parishes, and between state and federal agencies. These findings suggest points at which well-designed changes in the process of managing requests for assistance could improve the resiliency of the intergovernmental response system.

Vulnerability to Systemic Failure

If the four decision phases identified in a disaster management system – 1) detection of risk; 2) recognition and interpretation of risk as a basis for action, 3) communication of risk to wider arenas of response and resources, and 4) self organization and mobilization of action to reduce risk – are not carried out effectively, the system is vulnerable to failure. Data from the

Table 3.4
Types of Ratio for Changes in Status,
Requests for Assistance in Disaster Operations, Louisiana Office of Homeland Security and Emergency Preparedness

		Search & Rescue	Damage Assessment	Supplies	Transportation	Evacuation	Shelter	Security	Emergency Response	Medical	Utility	Heavy Equipment	Light Equipment	Personnel	Communication & Coordination	Total
No Response Ratio	Number of 'No Response'	27	3	166	40	8	45	104	21	63	58	130	16	28	20	729
	Number of Total Requests	182	8	665	186	14	237	505	84	178	226	459	81	134	75	3034
	Ratio of NR to Requests	14.84	37.50	24.96	21.51	57.14	18.99	20.59	25.00	35.39	25.66	28.32	19.75	20.90	26.67	24.03
Holding Ratio	Number of 'Action Required to Pending'	26	1	30	6	1	9	30	3	2	20	6	4	5	N/A	143
	Number of Total Requests - No Response	155	5	499	146	6	192	401	63	115	168	329	65	106	55	2305
	Ratio of Action Required to Pending	16.77	20.00	6.01	4.11	16.67	4.69	7.48	4.76	1.74	11.90	1.82	6.15	4.72	N/A	6.20
Cancellation Ratio	Number of 'Action Required to Cancelled'	7	1	12	8	1	10	19	2	12	15	28	2	11	2	130
	Number of Total Requests - No Response	155	5	499	146	6	192	401	63	115	168	329	65	106	55	2305
	Ratio of Action Required to Cancelled	4.52	20.00	2.40	5.48	16.67	5.21	4.74	3.17	10.43	8.93	8.51	3.08	10.38	3.64	5.64
Completion Ratio	Number of 'Action Required to Enroute, On Scene, and Released'	2	N/A	6	3	N/A	11	35	2	1	28	6	1	N/A	1	96
	Number of Total Requests - No Response	155	5	499	146	6	192	401	63	115	168	329	65	106	55	2305
	Ratio of Action Required to Enroute, On Scene, and Released	1.29	N/A	1.20	2.05	N/A	5.73	8.73	3.17	0.87	16.67	1.82	1.54	N/A	1.82	4.16

Legend: **No Response Ratio** = Number of 'No Response' / Number of Total Requests by Transaction Category; **Holding Ratio** = Number of 'Action Required to Pending' / (Number of Total Requests by Transaction Category - Number of No Response); **Cancellation Ratio** = Number of 'Action Required or Pending to Cancelled'/ (Number of Total Requests by Transaction Category – Number of No Response); **Completion Ratio** = Number of 'Action Required to Enroute, On-scene, and Released' / (Number of Total Requests by Transaction Category – Number of No Response.

Source: *Situation Reports*, Louisiana Office of Homeland Security and Emergency Preparedness, August 27 – September 6, 200

LOHSEP situation reports indicate serious weaknesses at each decision phase, revealing vulnerability to failure not only for the communities exposed to risk, but for the entire nation in catastrophic events. The analyses documented that there was no systematic, reliable information system that could provide decision support to LOHSEP. Without that infrastructure, the communications processes, and therefore the potential for managing collective action in response to this event, largely failed.

Redesigning a More Resilient System

The analysis of the Louisiana situation reports document the overloaded response system at the state level for Hurricane Katrina, but the larger question is how can these findings be used to inform the redesign of a dynamic intergovernmental system that can adapt quickly to reduce risk from extreme events. The results from the preceding analyses lead to further research questions: 1) Where are the bottlenecks in the network? 2) Why is there delay in the transmission of critical information among the participating agencies? 3) Why is there a difference in rate of response among the types of transactions?

Examining the record of time spent in each phase of the response process, two types of bottlenecks appear to occur in the system. The first is defined as a jamming point in the process of mobilizing response operations, and the second is jamming the interaction of one organization with another organizations in the system. One possible explanation for the delay in response activities may be the existence of bottleneck organizations in the system. If participating organizations cannot scan, validate, and process the appropriate information and resources in an efficient and effective way, they create a domino effect of escalating delay in task completion for all other organizations that are dependent upon that first step. In this section, we will examine which organizations created bottlenecks in the response process, limiting performance of the whole network.

What is a Bottleneck Organization?

A bottleneck is a critical point that can cause delay in the interdependent process of emergency response, hindering the operations of the whole system. In seeking to improve the resiliency of the response system, it is essential to identify points in the evolving process where delay by one organization may trigger a cascade of delay throughout the set of organizations participating in response operations. The source of the delay could be either technical or organizational, and it is often both. But if these "bottlenecks" can be identified in an actual response system, the response process can be redesigned to operate more efficiently in future disaster operations.

The situation reports from LOHSEP provide four data points that can be used to track a request for assistance through the response process: 1) initiating organization, 2) transaction, 3) assigned organization, and 4) status of interaction. To identify the bottlenecks, we focused on the assigned organizations because they receive requests from the initiating organizations and are responsible for taking the next stage of action. If they accept and act on the request, they also distribute incoming information and resources to other organizations in the system.

To identify the bottlenecks in 'process,' we counted the total number of hours that a request for assistance spent in one phase before it was shifted to the next phase in the response process. As shown in Table 3.5, the total number of hours for the entire system to shift from action required' to 'pending' is 10,389 hours with the mean of 72.7 hours and standard deviation of 30 hours. Although there are no data for the status change from ‘On-scene’ to ‘Released’, the recorded time delay was very severe in shifts from ‘Action Required to Pending’ ‘and ‘Pending to Cancellation.’ After LOHSEP received the initial and unverified requests from initiating organizations, agency staff needed to verify the incoming request and assign it to a response agency. This procedure was established to validate the request, and ensure that scarce resources

Table 3.5
Summary, Total Time Delay in Hours Reported for Each Change of Status

	Number of Transactions	Total Time Elapsed (Hours)	Mean	Median	Standard Deviation	Maximum	Minimum	Range
Action Required to Pending	143	10389	72.7	32.0	30.0	150.0	0.0	150.0
Pending to Enroute	23	938	40.8	39.0	47.0	150.0	0.0	150.0
Enroute to Onscene	21	353	16.8	19.0	7.6	43.0	8.0	35.0
Onscene to Released	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Action Required (Pending) to Released	13	893	68.7	44.0	54.3	150.0	2.0	148.0
Action Required to Cancellation	88	5031	57.2	39.0	51.2	192.5	0.0	192.5
Pending to Cancellation	42	1569	37.4	15.5	46.4	162.0	0.0	162.0

Source: *Situation Reports*, Louisiana Office of Homeland Security and Emergency Preparedness, August 27 – September 6, 2005.

were allocated appropriately. During this period of verification, the request was classified as ‘pending.’ In an event of the scope and scale of Hurricane Katrina, the workload of LOHSEP staff in processing the incoming requests for assistance quickly increased to the point that the requests were stalled in the pending phase. Quick and effective decision making was severely limited. In this time-dependent process, the time lag decreased dramatically in the subsequent status shifts. Apparently, once the request was assigned to an action agency, and further accepted by that agency, the delivery of services was relatively efficient. This level of performance may reflect the considerably lower number of tasks that were assigned for action out of the total number of requests.

Managing disaster response operations is a very complex, interdependent process. Ironically, the very structure of the process designed to ensure efficient management of resources in disaster operations likely contributed to the substantial delays in mobilizing action and the ineffectiveness of the overall performance of the disaster response system following Hurricane Katrina. The role and location of an organization in the disaster response system can affect substantially the performance of other participating organizations in the system. Clearly, a new model for increasing effectiveness in mobilizing disaster operations is needed, one that acknowledges the capacity of the organizational system to anticipate, adapt, and reallocate its resources according to the demands from its operational context.

To identify the organizations that created bottlenecks, we counted the accumulated time period in hours for each responding organization to estimate the length of time it took for these organizations to shift to the next stage in response operations. For example, if it took 35 hours for FEMA to shift from ‘action required’ to ‘pending’; and 10 hours to shift from ‘pending’ to ‘on scene’, and again took 12 hours from ‘on scene’ to ‘released’, then the total accumulated number of hours in this case is 57 hours and the mean is 19 hours. One possible criticism for this approach is that if any one organization has a lot of interactions with other organizations, then the accumulated time would increase accordingly. By dividing the accumulated number of hours over the response process by the number of interactions, we calculated the mean time of the delay between an initial report of 'action required' and the shift to the next stage of action. The results are reported in the following Table 3.6.

Table 3.6
Total Time Lag for Each Responding Organization

Name of Organization	Accumulated Total Delay, When Responding (Hours)	Number of Transactions	Mean (Hours)
Department of Health and Hospitals, Louisiana	730.5	5	146.1
American Red Cross: Louisiana Southeast Chapter	144	1	144.0
Department of Transportation and Development, Louisiana	152	2	76.0
Army Corps of Engineers	4571	64	71.4
Louisiana Emergency Operations Center	283	4	70.8
Federal Emergency Management Agency, United States	1477	25	59.1
Department of Agriculture and Forestry, Louisiana	955	18	53.1
Department of Wildlife and Fisheries, Louisiana	791.5	20	39.6
Parish of East Baton Rouge	39	1	39.0
Civil Air Patrol - Louisiana Wing	76	2	38.0
Emergency Management Assistance Compact	37	1	37.0
Louisiana State Police	145.4	4	36.4
Homeland Security Division of LOHSEP	64	2	32.0
Louisiana Office of Homeland Security and Emergency Preparedness	862	27	31.9
Louisiana Army National Guard	312.5	10	31.3
Louisiana National Guard	2915.5	105	27.8
Louisiana Air National Guard	183	10	18.3

Source: Situation Reports, Louisiana Office of Homeland Security and Emergency Preparedness, August 27 – September 6, 2005

None of the organizations reported rapid mean response records, but compared to the others, Louisiana National Guard, Louisiana Office of Homeland Security and Emergency Preparedness, and Louisiana State Police were more efficient in playing their roles. These findings document the lower time lag for the organizations responsible for security at the state level in comparison to the other categories. Other organizations that received a significant number of requests, such as the US Army Corps of Engineers, and FEMA, were much slower in their response.

The next question is what causes the bottlenecks for these organizations. Is it related to managerial problems in each organization? Or is it from the location of these organizations in the emergency response process? Or is it both? With current data, it is difficult to determine whether managerial failure really existed. But it is possible to check the structure of the disaster response network by using network analysis to determine what might affect the delay of the responding organizations. Network measures of degree centrality, betweeness centrality, density, and distance were calculated to see whether there exists any significant correlation between these measures and mean time lag.

The organizations listed in Table 3.6 represent the set of organizations identified in the Situation Reports as the primary actors in disaster response system that emerged following Hurricane Katrina. Each organization interacted with other organizations in the performance of the fourteen categories of response actions. These fourteen categories represent subnets of actions taken within the entire disaster response system. Table 3.6 presents a summary of the accumulated time, total number of requests for assistance, and mean response time for each organization.

Network analysis measures confirmed a high degree of fragmentation among the organizations participating in response operations. The set of 181 organizations that were identified as interacting in the first eleven days reported a total degree centralization of .193, low for a coherent response system. Out of 181 organizations, 54, or 29.8%, were isolates, or organizations that were unconnected with others. Network analysis offers several further measures of this disaster response system, but these findings will be presented in a subsequent paper.

Further evidence of bottlenecks is given by a regression analysis of the hours of delay time in interactions initiated between jurisdictions. Table 7 presents findings that report regression coefficients for mean hours of delay for jurisdictions initiating interactions with other jurisdictions against the dependent variable, duration of time spent in mission phase. The first column indicates the number of cases for each pair of interacting organizations. The second column reports the regression coefficient and the third column reports the significance level, with $p < .05$ considered statistically significant.

Interestingly, the findings document that the response operations were largely performed at the parish and state levels of jurisdiction. The largest category of interactions, 125, or 32.9%, initiated by parish organizations to the state, had a significant delay time, $p < .03$. The next largest category of interactions, state organizations interacting with other state organizations, 120, or 31.6%, also showed a delay time, but it was not significant. All categories including federal interactions, except city to federal, reported statistically significant delay times. These findings document the slow response of jurisdictional agencies generally, but the particularly slow federal response to any jurisdictional level except city. The city to federal relationship must be viewed cautiously, as there were only four cases reported in the Situation Reports

Table 3.7
Regression Coefficients for Mean Hours of Delay
Against Duration of Time Spent in Mission Phase by Jurisdictional Relationship

Jurisdictional Relationship*	Number of Cases	Coefficient**	Significance Score
City organization interacting with State organization	4	17.70	0.52
City organization interacting with Federal organization	3	14.03	0.08
Parish organization interacting with either Parish or Regional organization	2	65.20	0.09
Parish organization interacting with State organization	125	12.66	0.03
Parish organization interacting with Federal organization	44	44.97	0.00
State organization interacting with State organization	120	8.22	0.11
State organization interacting with either Federal or Regional organization	43	34.36	0.00
Federal organization interacting with State organization***	23	26.30	0.00
Federal organization interacting with Federal organization	3	74.86	0.01
International organization interacting with State organization	1	12.70	0.00

Dependent Variable: duration
N = 380
$R^2 = 0.1226$
* These 10 relationships are the only relations observed with an identifiable mission duration.
** All coefficient scores reported here are in reference to the score on Federal to State Durations, since that case was used as the reference case.
*** The case of Federal organizations interacting with State organizations was taken as the reference case, since it had the lowest mean duration time. Values listed here are formally presented as the constant in the regression analysis results.

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Intergovernmental Disaster Response as a Learning Process

The analysis of the situation reports of actual disaster operations conducted through LOHSEP document the degree to which the intergovernmental system was overwhelmed in the Katrina disaster. The data show that four of the six propositions (pages 63-69) listed above as essential for a resilient intergovernmental response system were not present in the response system that evolved in Louisiana after Hurricane Katrina. Regarding Proposition 1, the situation reports documented delays in the data transmission that reduced the capacity of state managers to comprehend the full extent of losses to the communities affected by the hurricane and flood.

In reference to Proposition 2, the extensive delays in moving requests for assistance through the different steps in the process of allocating response personnel and resources provided clear evidence of overload for the system. Regarding Proposition 3, the evidence showed that managers at different locations – parish, other state agencies, federal agencies – did not have a common understanding of risk to the region. Concerning Proposition 4, the sitrep data revealed little capacity for participating organizations to act collectively and coherently. There was little evidence of information exchange or feedback among the organizations participating in the response system.

Propositions 5 and 6 indicate how an intergovernmental response system could be strengthened by investing in information infrastructure that would facilitate communication and feedback within and between parishes, within and between state agencies, among state agencies and parishes, and between state and federal agencies. Extending a well-designed information infrastructure across intergovernmental boundaries, including federal agencies, was presumably the intent of NIMS, but this goal was not realized in the response operations following Katrina. Without a well-functioning information infrastructure, communication and coordination fail, and the response system is compromised. As data from disaster operations in Katrina demonstrated, the system was essentially a scattered set of organizations that performed in an erratic manner under severely compromised operating conditions.

The initial lack of region-wide recognition of the threat posed by the advancing storm in the days prior to landfall on August 29, 2005 inhibited the emergence of a common consensus on strategies to minimize risk among the many jurisdictions and organizations operating in the region. The technical failure of the communications system in the days immediately after landfall left the state organizations without direct contact with the parishes and municipalities most at risk. Without that ‘common operating picture” clearly communicated to the relevant actors, the delays among this large set of interdependent set of actors increased, and the emergency response system outlined on paper cascaded into failed actions.

The challenge, of course, is to use findings from this analysis to assess more accurately the points of possible intervention that could have reversed the downward spiral of failure in the intergovernmental response system. Clearly identified, these points could serve as the basis for redesigning an effective intergovernmental crisis management system. Returning to the propositions specified in the theoretical model, a major investment of time, effort, and talent in building an analytical knowledge base for the region at risk is a primary first step toward increasing the capacity of the region to manage the recurring risk of hurricanes and water-related hazards in the vulnerable Gulf Coast Region. Disaster plans that are bounded by jurisdictional constraints limit the vision needed to recognize the risk of catastrophic events that threaten wide geographic areas or span decades in their return rates.

Second, the human capacity for managers and organizations to learn new strategies, try new approaches, and evaluate rigorously failed policies offers the strongest potential for constructive change in the region. Yet, this is a learning process, and it needs to be structured for timely, valid information exchange and nurtured to elicit candid feedback to achieve significant results. Third, information technology, carefully designed to function in extreme events and deployed with consistent standards for operation, offers a substantial technical advantage in coping with complex, interdependent, large-scale catastrophic events. But this strategy requires a consistent commitment of time and effort to maintain a current knowledge base and to train personnel to use the technology appropriately. The alternative, not to take advantage of appropriately designed information technology to facilitate management of both risk and related technologies at a regional level, is starkly clear in the sobering losses in lives and billions of dollars in damage following Hurricane Katrina.

Third, clear evidence of bottlenecks in the response process is revealed in the status data reported in the Situation Reports maintained by the Louisiana Office of Homeland Security and Emergency Preparedness. Based on these findings, the highest priority in redesigning an effective system for disaster mitigation and response is reducing the impact of such obstacles to managing the efficient flow of information within and among participating agencies. This task requires a sociotechnical approach, given the volume of requests in a major disaster, and the need for response organizations to build surge capacity before an extreme event occurs.

Acknowledgments

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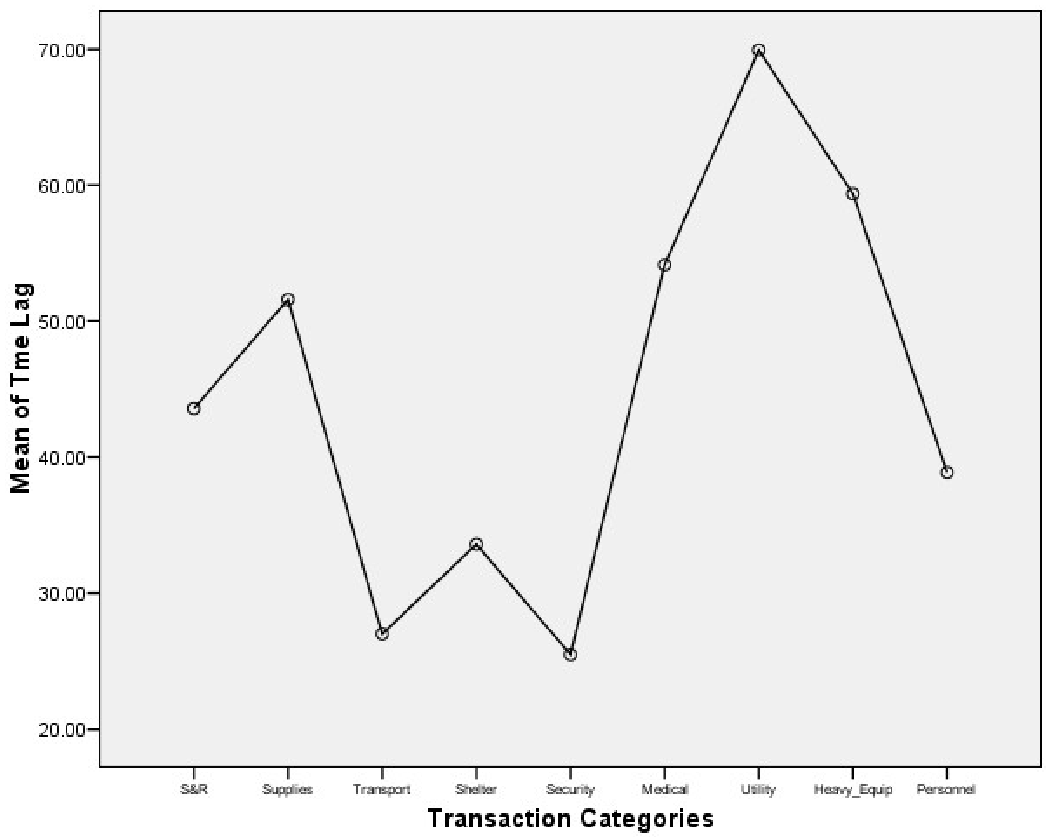
Appendix 3.1

Means Plot of ANOVA

The results of the analysis of variance (ANOVA) show a significant difference in means among the nine categories of response functions by transactions; F (8,394) = 7.181 P-value=0.000 (a=0.05). Because equal variances are not assumed, this analysis used the Games-Howell Post-Hoc test to check which category is different from other categories in mean difference. According to this Post-Hoc test, the category of Utility has a longer mean time lag compared to the other categories, and Security has a significantly shorter mean in response time. (The mean difference is significant at the .05 level). The transaction categories of 'Damage Assessment', 'Evacuation', 'Communication & Coordination', 'Emergency Response', 'Light Equipment', 'Others' have not been included in this ANOVA because of the small number of cases in these categories.



Appendix 3.2
Network Measures for Disaster Management Categories

	Search & Rescue	Security	Transportation	Emergency Response	Utility	Supplies	Personnel	Equipment	Medical	Communication	Shelter	Evacuation	Aggregate Network
Row count	35	88	80	35	49	102	37	76	44	31	55	11	217
Column count	35	88	80	35	49	102	37	76	44	31	55	11	217
Edge count	58	169	151	55	78	194	49	144	70	33	83	6	625
Density	0.049	0.022	0.024	0.046	0.033	0.019	0.037	0.025	0.037	0.036	0.028	0.055	0.013
Isolate count	3	6	6	0	3	4	2	3	4	4	3	3	15
Component count	4	8	8	2	4	6	4	7	6	8	5	5	16
Characteristic path length	1.851	2.023	2.93	1.538	2.13	2.189	2.079	2.481	1.963	1.775	1.448	1	2.611
Krackhardt Connectedness	0.834	0.826	0.809	0.889	0.880	0.886	0.794	0.777	0.744	0.458	0.826	0.236	0.866
Degree Centralization	0.245	0.301	0.203	0.123	0.335	0.314	0.225	0.221	0.266	0.194	0.250	0.117	0.521
Betweenness Centralization	0.047	0.037	0.081	0.015	0.087	0.040	0.079	0.062	0.054	0.032	0.020	0.000	0.045
Closeness Centralization	0.013	0.001	0.004	0.018	0.004	0.001	0.011	0.003	0.009	0.010	0.004	0.035	0.001
Fragmentation	0.166	0.174	0.191	0.111	0.120	0.115	0.206	0.223	0.256	0.542	0.174	0.764	0.461

Source: *Situation Reports*, Louisiana Office of Homeland Security and Emergency Preparedness, August 27 – September 6, 2005.

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