

COMMUNICATION, COHERENCE, AND COLLECTIVE ACTION: The Impact of Hurricane Katrina on Communications Infrastructure

LOUISE K. COMFORT
THOMAS W. HAASE
University of Pittsburgh

Communications infrastructure is critical to managing the complex, dynamic operations that evolve in disaster environments. The impact of Hurricane Katrina destroyed the communications infrastructure within the New Orleans metropolitan region, leaving emergency response personnel and the public with little capacity to exchange information vital for coordinating response actions. The loss of communications proved especially damaging, given the size of the geographic region and the number of people affected. The authors used content analysis of news reports to identify the network of organizations that emerged in response to Hurricane Katrina, and network analysis to examine patterns of interaction among the organizations. The patterns reveal significant asymmetry in information among organizations at different levels of authority and responsibility in the disaster response system, a condition that contributed to the collapse of coordination in disaster operations. Conversely, well-designed communications and information infrastructure can contribute significantly to the resilience of communities exposed to recurring risk.

Keywords: *communications processes; interoperability; disaster response system; network analysis; information asymmetry*

Communications in Disaster Mitigation and Response

The centrality of communications to effective mitigation and response in natural disasters has long been recognized by practicing emergency managers and experienced hazards researchers (California Office of Emergency Services, 1994; Comfort, 1999; Mileti, 1999; Waugh, 2000). Yet the fragility of communications infrastructure in practice determines the level of interorganizational performance in actual disaster operations. Nowhere was this premise more evident than in the halting intergovernmental response to Hurricane Katrina, beginning on August 23, 2005, when Katrina was first identified as a tropical storm forming in the Caribbean to its final disintegration over Quebec and New Brunswick, Canada, on August 31, 2005. The course of the storm during those 8 days crossed the jurisdictional boundaries of at least nine states,¹ three federal regions, and international borders within the Caribbean and with Mexico and Canada. The scope of the sociotechnical communications infrastructure needed to support interorganizational coordination across this large, complex

Louise K. Comfort is a professor of public and international affairs at the University of Pittsburgh. She teaches in the fields of policy analysis, information policy, policy design and implementation, and organizational theory. Her primary research areas are decision making under conditions of uncertainty, complex systems, and disaster management.

Thomas W. Haase, JD, is enrolled in the doctoral program at the University of Pittsburgh Graduate School of Public and International Affairs. His research interests include national security, public policy and the evolution of networks in environments of uncertainty.

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nine states, three federal regions, and international borders within the Caribbean and with Mexico and Canada. The scope of the sociotechnical communications infrastructure needed to support interorganizational coordination across this large, complex region exceeded the capacity of the existing patchwork of communications infrastructure largely managed by private companies that supported the public agencies engaged in this response.”

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Hurricane Katrina affected an extraordinarily large geographic area with a wide range of communities and infrastructures exposed to risk. In the critical hours before and after Katrina made landfall slightly east of New Orleans, Louisiana, on August 29, 2005, at 6:10 a.m., access to timely, valid communications to assess and report the rapidly changing conditions in these communities was essential for coordinated action among the jurisdictions and organizations legally responsible for protecting life and property. With 1.5 million people at risk in the Gulf Coast region, there was no more important function for emergency managers than communications. The task of mobilizing a coherent, coordinated warning and response system for this catastrophic storm was massively complex.

The communications infrastructure needed to support intergovernmental decision making to enable communities to respond effectively to such a wide-ranging, rapidly moving, destructive storm was not in place. Consequently, when communications failed totally for the City of New Orleans under the brunt of hurricane winds and subsequent flooding, managers of emergency service organizations, businesses, and nonprofit organizations such as schools, hospitals, and nursing homes lost their capacity to coordinate action in collective response to the spreading danger. Without timely updates and clear reports on the status of operations at different locations, the enormity of the problem was beyond the comprehension of the personnel on duty at city, state, and federal levels of responsibility. Personnel had no means by which to integrate reports from multiple locations to create a region-wide profile of the event or to assess accurately the escalating destruction, let alone mobilize coordinated action against the rapidly growing threat.

In the absence of timely, valid communications, organizations cannot function effectively under the urgent stress of disaster. Individuals are left to make their best guesses about risk and safety; rumors spread wildly; and available skills and resources are overlooked as personnel search hurriedly for workable strategies of action. The collapse of interorganizational response to Hurricane Katrina was regrettably apparent when the existing communications infrastructure failed. This fact was acknowledged by Louisiana Governor Kathleen Babineaux Blanco when she stated that “the big problem [in managing disaster response] was that the communications network was down. The day after the storm, cell phones, blackberries, and landlines were useless at the moment when coordination among many branches of government was critical,” (Maggi, 2005) **CORRECT?** The challenge to practicing managers and researchers in the aftermath of this devastating event is to acknowledge communications as a primary requirement for collective action and to build a communications infrastructure that enables personnel at different levels of responsibility and authority to adapt their actions reciprocally in accordance with rapidly changing conditions. Building capacity for collective action for broad regions exposed to threat, such as the Gulf Coast in Hurricane Katrina, requires technical investment and social organization

Initial Conditions for Communications Processes in Disaster Environments

Without explicit design, communications processes in environments exposed to significant disaster risk encounter serious constraints. First, there is the continuing uncertainty of risk, what constitutes the threat, if or when it will occur, and its probable impact on different components of the community. Second, known information regarding communities at risk may vary in accuracy, extent of coverage, and validity. Third, the hazard may threaten diverse populations and types of infrastructure that function interdependently within a large region, creating complex conditions for continuity of operations. Fourth, the economic costs of disaster are likely to vary for groups of the population that have different margins of reserve. Determining what levels of risk, if any, are “acceptable” for which groups may diminish credibility for public organizations. Finally, in a large and varied region with many jurisdictions

and multiple organizations that have legal responsibilities in disaster conditions, it is essential to create a common-knowledge base regarding exposure to risk for the region. Different organizations may not know or understand the level of risk to which their community is exposed, or what resources may be available under common threat. Explicit knowledge regarding exposure to danger and appropriate behavior under threat that would facilitate collective action may not be widely shared.

Under these conditions, emergency managers act with only the knowledge available to them. To improve performance, it is necessary to increase the range, frequency, and access to information sources, as well as feedback from the different constituencies exposed to different levels of threat. This exchange of information is critical as it allows a continuous process of updating the changing status of a community under stress. Communications need to be operational not only among the component actors of the affected region but also among potential donors and supportive participants in the emerging response system. The response system extends a widening circle of support, feedback, and correction of error that needs to be focused on specific problems, yet simultaneously provide an overall status of the community.

This dynamic process of information exchange allows reciprocal adaptation among participants as they learn the limitations and strengths of their fellow actors in the set of shared tasks. Under the urgent stress of disaster, this process of communication cannot be left to chance; it is necessarily a product of design. The concept of *informed collective action* functions consistently only when supported by a well-designed information system that facilitates information search and exchange among responsible organizations under dynamic conditions.

Communications Infrastructure in Disaster Response

The need for interoperability of communications systems in disaster response is a well-known problem. It has long been identified as a primary requirement for increasing performance among first-response agencies (Comfort, 2005). Given the costly breakdown in communications between the New York City Police and Fire Departments in response to the terror attacks of September 11, 2001, interoperability is now included as a priority in the National Incident Management System (Federal Emergency Management Agency [FEMA], 2004). Yet implementation of interoperability in communications systems among organizations with emergency responsibilities has lagged in practice, and it was regrettably absent among the range of local, state, and federal organizations responding to the threat of Hurricane Katrina.

The persistent difficulty in designing and implementing communications infrastructure to support timely exchange of information among multiple jurisdictions and organizations in rapidly escalating disaster operations is caused by technical and organizational constraints. Technically, there is a scarcity of bandwidth for radio communications, and concern for the security of critical information that may be accessed over airwaves by unauthorized persons. Organizationally, there is reluctance among first-response organizations to share scarce bandwidth with personnel outside their immediate range of operations. This reluctance intensifies across jurisdictional boundaries, when local organizations need to communicate secure information with state or federal organizations. In the aftermath of Hurricane Katrina, this situation was compounded by the extraordinary destruction wrought by the disaster to the physical communications infrastructure.

In New Orleans, for example, ordinary telephone service was cut by the hurricane-force winds and rising water. Electrical transmission lines were down, and no electronic communications were functioning. Cellular phone base stations were flooded, rendering cell phones inoperable. Satellite phones were nonfunctional during and immediately after the storm. In the first 3 days following Katrina's landfall, there was essentially no reliable means of communication among the range of local, state, and federal organizations seeking to coordinate their actions from different jurisdictional levels of authority. Valiant efforts were made to establish communications; however, the units were either too large, such as the FEMA mobile

communications trailer that could not be moved over damaged roadways into the flooded city of New Orleans, or too dependent on specific operating conditions, such as satellite phones, to function under the severe devastation created by the disaster. The New Orleans Police Department confirmed, in their review of disaster operations, that they “did not have any real communication system within the city” (Maggi, 2005 **CORRECT?**).

Only on September 4, 2005, when federal troops arrived under the authority of the Department of Defense, were effective communications units established in the disaster-affected region. Prior to that time, organizations were seriously limited by their inability to communicate vital information. Emergency responders sent messages by boat, by courier, or by whatever means were available to exchange information. Coast Guard helicopters had to land to communicate with rescue personnel on scene. A large proportion of the interorganizational collapse was due to the lack of a “common operating picture” that could only be developed with effective, timely communications. Such communications require that a sociotechnical infrastructure be established and workable prior to a hazardous event, with alternate routing and back-up plans to support innovative strategies contingent on the specific conditions of the disaster.

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Discrepancies Between Disaster Plans and Actual Practice

The sobering contrast between carefully written and rehearsed disaster operations plans and actual performance of multiorganizational response systems under the stress of a catastrophic event such as Hurricane Katrina compels review of human cognitive capacity and the technical and organizational means of supporting this action. Hurricane Katrina provided the first major test of the newly established Department of Homeland Security (DHS) and the revised National Response Plan and National Incident Management System (FEMA, 2004) that were intended to make the nation safer and more secure. DHS, hastily assembled following the terrorist attacks of September 11, 2001, had kept its focus on terrorism. Consequently, the personnel selected for leadership positions in the new department had little experience in natural disasters, and less scientific knowledge of the conditions that contribute to the formation and escalation of natural disasters. FEMA, which had been an independent agency with cabinet status during the 1990s, was folded into the larger DHS, along with 21 other federal agencies. Many experienced disaster managers, noting the shift in the agency’s priorities, left the agency, reluctant to participate in the dismantling of a program of disaster mitigation, or reduction of risk before disaster occurs, that they had built.

In this climate of organizational redefinition and change, the capacity of FEMA as an organization that served as the coordinator of resources and response to communities at risk was seriously eroded through reduction in funding for mitigation, management, and training for natural disasters. Although DHS formally adopted an all-hazards approach to planning for disaster response, the capacity to implement those plans in a smoothly functioning, intergovernmental response system to serve a large, diverse, and risk-prone nation was not developed.

At least five major discrepancies between policy and practice were apparent in the intergovernmental response system that evolved following Hurricane Katrina. None of these discrepancies is new. All have been acknowledged and documented many times before (Comfort, 1999; Comfort, Hauskrecht, & Lin, 2005; Holland, 1995; Mileti, 1999). These five discrepancies include:

- the gap between human cognitive capacity to comprehend the complex interactions among the physical environment of cities, their built infrastructure, and human interaction and the level of risk that can be generated by these interacting systems
- the gap between the construction of effective infrastructure systems that integrate life-line systems of electrical power, communications, transportation, gas, water and sewage distribution, and the investment and resources needed to maintain these technical systems under a steady erosion of physical wear and human action the gap between organizational

design and the investment in resources and training to enable personnel to carry out the intended functions of their organizations that have responsibility for risk reduction and response the gap between public perception of risk and the capacity to take actions to reduce risk at multiple levels—household, workplace, community, governmental authorities the gap between the diversity of actors and varied components in an emergency response system and the capacity to integrate the skills and knowledge of these different actors into a coherent, effective emergency response system.

In the language of complexity theorists, Hurricane Katrina was a “symmetry-shattering event” (Prigogine & Stengers, 1984); that is, some events are so powerful that they shatter the existing conceptions of social and political organization and create an opportunity for rearranging the components of society in a new way. Recognition that Katrina precipitated known vulnerabilities in the geography, infrastructure, and capacity of the Gulf Coast cities that, unattended, led to extraordinary losses in lives and property² compels a reexamination of the conditions that led to this outcome. Such an inquiry is even more critical to a nation such as the United States that commands the technical capacity, organizational skills, and resources to reduce disaster risk. The consequences of this storm have been so massive, the costs so high, the flaws in public preparedness and management of risk so blatant that none can claim that change is not needed. The difficult task is determining what that change should be, and how it can address the known gaps in the reduction of disaster risk.

Addressing the gap in cognitive capacity of policy makers and practitioners to comprehend the destructive power of natural phenomena is the first step toward constructive action. To do so, it is useful to document the kinds of actions that policy makers and emergency response agencies took in reference to Katrina, and when and under what conditions coordination failed. Looking for a daily record of actions undertaken to cope with this event, we conducted a content analysis of news reported in the *Times Picayune*, the major New Orleans newspaper that continued publication throughout the disaster, albeit from Baton Rouge. Through the content analysis, we identified all organizations that participated in the response operations to Hurricane Katrina and the interactions among them. This set of organizations made up a response system of organizations seeking to protect lives, protect property, and maintain continuity of operations within the affected area. We used these data to characterize the response network and to analyze the relationships among them, using the software program, UCINET. This analysis will inform the discussion of the other four gaps observed in disaster response management and serve as a guide to redrawing strategies for protecting urban environments.

Characteristics of the Katrina Response System

The size and diversity of the organizations involved in response operations for Hurricane Katrina are significant. Table 1 shows the composition of the response system that evolved over a period of 24 days—3 days before the hurricane made landfall east of New Orleans, and 21 days following.

Table 1 documents this large response organization, 535 organizations in total, with the largest number, 305, or 57%, identified as public organizations. It is interesting to note, the breakdown by jurisdiction shows the largest number of public organizations, 146, or 47.9%, were from the subregional, parish, and municipal levels, in contrast to 69 organizations, or 22.6%, from the national level. State organizations, 78, made up 25.6% of the public organizations. The dominance of local organizations in the public sector contrasted with the majority of national organizations, 75, or 52.4%, in the private sector. The nonprofit sector made up the smallest group of organizations, with a majority, 44, or 52.3%, identified as local organizations. It is also noteworthy that a small but significant number of international organizations, 20, or 3.7% of the total number of 535 organizations, participated in the response system. The special interest groups identified were political parties that did not fit easily into any one of the other three categories. Given the size and diversity of this set of response

Table 1: Frequency Distribution of Organizational Response System by Sector and Distribution, Hurricane Katrina, August 26–September 19, 2005

	<i>Public</i>		<i>Nonprofit</i>		<i>Private</i>		<i>Special Interest</i>		<i>Total N of All Organizations</i>	
	N	%	N	%	N	%	N	%	N	%
International	11	2.1	3	.6	6	1.1	0	.0	20	3.7
Federal	69	12.9	23	4.3	75	14.0	1	.2	168	31.4
Regional	1	.2	7	1.3	25	4.7	0	.0	33	6.2
State	78	14.6	7	1.3	4	.7	2	.4	91	17.0
Subregional	11	2.1	12	2.2	10	1.9	0	.0	33	6.2
Parish and/or county	69	12.9	3	.6	1	.2	0	.0	73	13.6
City	66	12.3	29	5.4	22	4.1	0	.0	117	21.9
Totals	305	57.0	84	15.7	143	26.7	3	.6	535	100.0

SOURCE: *Times Picayune*, 2005.**Table 2: Frequency Distribution of Organizations Interacting in Response Operations by Sector and Jurisdiction, Hurricane Katrina, August 26 – September 19, 2005**

	<i>Public</i>		<i>Nonprofit</i>		<i>Private</i>		<i>Special Interest^a</i>		<i>Total N of All Organizations</i>	
	N	%	N	%	N	%	N	%	N	%
International	2	.6	0	.0	4	1.3	0	.0	6	1.9
Federal	47	14.8	12	3.8	33	10.4	1	.3	93	29.2
Regional	0	.0	4	1.3	14	4.4	0	.0	18	5.7
State	46	14.5	2	.6	2	.6	0	.0	50	15.7
Subregional	7	2.2	7	2.2	8	2.5	0	.0	22	6.9
Parish and/or county	49	15.4	3	.9	1	.3	0	.0	53	16.7
City	50	15.7	15	4.7	11	3.5	0	.0	76	23.9
Totals	201	63.2	43	13.5	73	23.0	1	.3	318	100.0

SOURCE: *Times Picayune*, 2005.

a. Special Interest is identified as the Democratic Party.

organizations, the demand on communications infrastructure for coordinating response was extraordinarily high.

Table 2 presents the number of organizations that interacted during response operations to provide search-and-rescue services, medical care, shelter, welfare, and other assistance to the population of the devastated region. This profile of organizations that interacted with one another in the conduct of response operations documents the problem of communications, and the difficulty in achieving effective coordination. The total number of organizations interacting with others drops by more than 200, from 535 to 318. Of this smaller set of interacting organizations, almost two thirds, 201, or 63.2%, were public organizations, whereas private organizations, 73, or 23%, made up the next largest group. Again, the striking contrast between these two sectors is that the majority of public organizations participating in response, 106, or 52.7%, were local—sub-regional, parish, and city—whereas the majority of private organizations, 47, or 64.4%, were national and regional. Nonprofit organizations made up the smallest group of interacting organizations, with local organizations constituting the largest segment, 25, or 58.7%. The set of organizations can be considered a network of organizations engaged in response operations.

To examine the interactions among the organizations in more detail, we conducted an analysis of this response system using the UCINET software for network analysis (Borgatti, Everett, & Freeman, 2002). To make this large network of 318 organizations more manageable for network analysis, we grouped several subsets of organizations into larger categories.

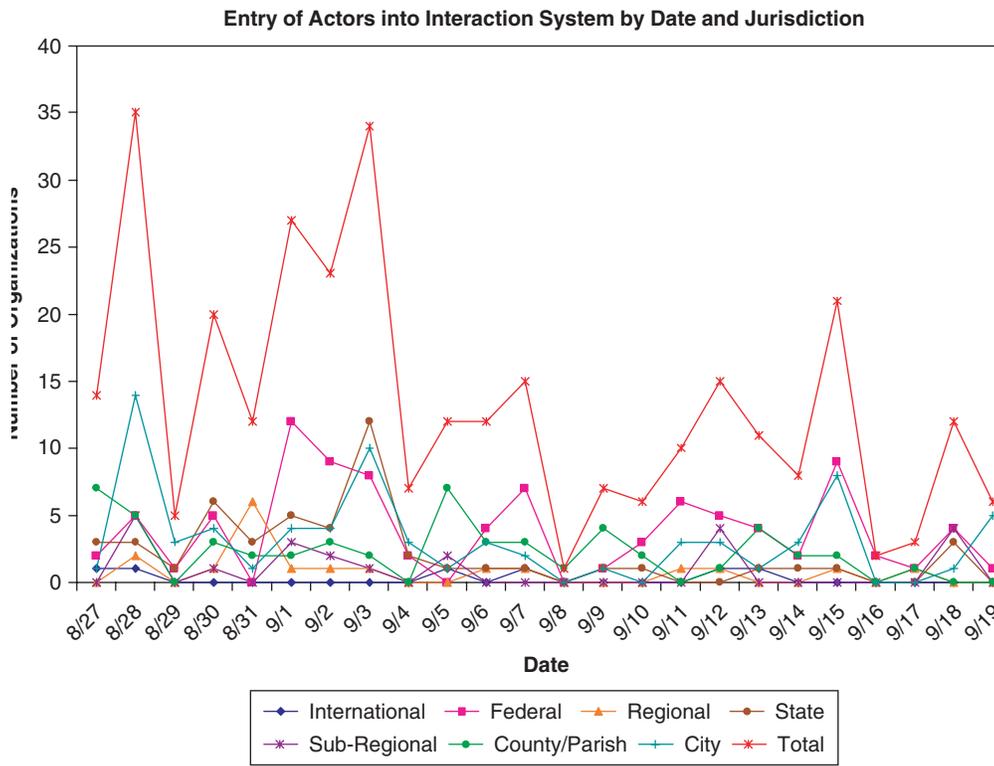


Figure 1: Entry of Actors into Interaction System by Date and Jurisdiction
 SOURCE: *Times Picayune* (2005).

For example, all K-12 schools in the affected area were grouped into the category *Local Schools*. All hospitals were grouped into the category *Local Hospitals*. All airlines flying into Louis Armstrong International Airport were grouped into the category *Airlines*. All National Guard units were grouped into the category *Guard*. This effort reduced the total number of organizations to 251, which maintained the basic characteristics of the network.

More telling in terms of the performance of the response system as a whole is the time at which organizations from different sectors and jurisdictions entered into the disaster response system. Figure 1 depicts the frequency of reported interactions among organizations engaged in disaster response activities for the 24-day period of the study by jurisdiction, as cited in the *Times Picayune* (2005). These data indicate the time of entry into the disaster response system. Figure 1 documents the early and intense interactions by the City organizations on Days 1 and 2 before landfall, and the later entry of federal organizations into the response system on September 1, 2005, 4 days after the storm and the breaching of the levees.

Figure 2 shows the date of entry of organizations engaged with others into the disaster response system by sector. These graphs support the assertions of local emergency managers that they were operating largely alone in the days preceding the hurricane’s landfall, despite requests for state and federal assistance, and similarly in the 2 days following landfall and the flooding. Significant federal assistance arrived only on September 1, four days after the hurricane made landfall and the levees breached

Figure 3 shows the overall network of interaction among both jurisdictions and sectors among the 251 organizations interacting in response to the disaster. The graph shows a clustering of six to seven subnetworks in the central section of the larger network, with a wide arc of organizations that is tenuously linked to the central group by only eight other organizations. These eight linking organizations represent “cut points” within the network that, if

Table 3: Degree Centrality

	<i>Degree</i>	<i>NrmDegree</i>	<i>Share</i>
Mean	2.422	.969	.004
Standard Deviation	3.825	1.530	.006
Sum	608.000	243.200	1.000
Variance	14.634	2.342	.000
SSQ	5146.000	823.360	.014
MCSSQ	3673.235	587.718	.010
Euc Norm	71.736	28.694	.118
Minimum	1.000	.400	.002
Maximum	42.000	16.800	.069
Network Centralization = 15.96%			
Heterogeneity = 1.39%			
Normalized = 1.00%			

NOTE: NrmDegree = normed degree.

Table 4: Closeness Centrality

	<i>Farness</i>	<i>nCloseness</i>
Mean	26864.047	1.301
Standard Deviation	19760.900	.504
Sum	6742876.000	326.587
Variance	390493184.000	.254
SSQ	279154720768.000	488.647
MCSSQ	98013790208.000	63.711
Euc Norm	528350.938	22.105
Minimum	15493.000	0.400
Maximum	62500.000	1.614

NOTE: SSQ = sum of squares; MCSSQ = mean-centered sum of squares; Euc Norm = Euclidean norm.

broken, would disconnect the arc of organizations from the larger network. Indeed, the cut points also vary in importance. Four such organizations, Operations Life-Line Depot, U.S. Marines, American Red Cross, and U.S. Customs, maintain critical links to four other organizations, local media, City of Slidell, Houston Astrodome, and Catholic Charities USA. Breaking any one of these connections would disrupt the network. Clearly, organizations reached out to assist one another but did so more frequently within jurisdictions, instead of crossing jurisdictional levels as intended in the National Response Plan. These patterns document the asymmetry of information processes that was noted by managers at every jurisdictional level in the review of disaster operations in the weeks immediately after the event.

An analysis of network centrality identifies those actors that are the most important in shaping the performance of the network, as they have the most ties with other actors (Wasserman & Faust, 1994, pp. 169-178). Three types of centrality reveal interesting characteristics about this network: degree centrality, closeness centrality, and betweenness centrality. An analysis of degree centrality shows that eight of the 251 organizations participating in the Katrina response network had the highest degree centrality; that is, these organizations were most frequently engaged in interactions with other actors in the network. These eight organizations included: FEMA, National Guard, president of the United States, governor of Louisiana, New Orleans Police Department, local hospitals, government of Jefferson Parish, and mayor, New Orleans. The descriptive statistics for an analysis of degree centrality are presented in Table 3. The summary measure of centralization for the network is 15.96%, which indicates a loosely

Table 5: Betweenness Centrality

	<i>Betweenness</i>	<i>nBetweenness</i>
Mean	205.430	.660
Standard Deviation	739.320	2.375
Sum	51563.000	165.664
Variance	546594.438	5.642
SSQ	147787808.000	1525.527
MCSSQ	137195200.000	1416.186
Euc Norm	12156.801	39.058
Minimum	.000	.000
Maximum	8065.853	25.914
Network Centralization Index = 25.36%		

NOTE: SSQ = sum of squares; MCSSQ = mean-centered sum of squares; Euc Norm = Euclidean norm.

coupled network. Table 4 presents the measures for closeness centrality. *Closeness centrality* indicates how close an actor is to all other actors in the network (Wasserman & Faust, 1994, p. 183). This measure is useful in terms of estimating the flow of information through a network, assuming that if the actors are close to one another, the exchange of information occurs more quickly. Consequently, actors with the shortest paths to other actors (number of links needed to reach other actors) are likely to be more influential in the network. The summary statistics for closeness centrality show a very high mean for the measure of "farness," or distance among actors; that is, the findings show significant distance among the actors in the network, a condition that hinders rapid communication. The graph is unconnected, and no measure of centralization was calculated. The lack of connectedness shown by this analysis for the Katrina response network confirms the difficulty in achieving coordination in disaster operations.

A third measure of centrality for the network is betweenness centrality. *Betweenness* is a measure of the extent to which an actor lies in the direct path of communication exchange between two other actors (Wasserman & Faust, 1994, pp. 188-189). Table 5 presents the findings from this measure of centrality.

The mean of betweenness for the network is 205.4; that is the mean number of possible paths for information to flow from one actor in the network to all others, while the maximum is 8,065.8. This is a substantial range and shows wide variation in the capacity of actors in the network to exchange information in a timely manner. The network centralization index is 25.36%, which is higher than the measure of degree centrality. This measure likely reflects the relatively high number of subnetworks, or clusters within the larger network of participating organizations.

The network diagram shown in Figure 3 reveals a pattern of subsets of organizations engaged in response operations. These subsets appear to be effective means of accomplishing shared tasks, given the scope and severity of the disaster; however, they also confirm a lack of coherence for the larger network. Using UCINET, 35 cliques were identified within the larger network, as shown in Table 6.

The composition of the cliques reveals an interesting pattern of interaction among the participating organizations. *Cliques* are subsets of organizations, often no more than three or four, that develop recurring patterns of interaction in the conduct of disaster operations. They are important in understanding the constraints on the network. They are usually developed in an effort to facilitate action under stress; however, they may also inhibit the full exchange of information and resources with other organizations in the network by excluding others from the exchange.

Of the 35 cliques identified, the largest number, 11, or 31.4%, represented interactions among federal and local agencies. The next largest subset of cliques included 5, or 14.3%,

Table 6 Cliques Identified within the Disaster Response Network: Hurricane Katrina, August 27 – September 19, 2005

1	Office of the President of the United States; Federal Emergency Management Agency; Congress; Department of Defense	16	Department of Health and Human Services, United States; Centers of Disease Control and Prevention; Local Hospitals, Medical Care
2	Office of the President of the United States; Federal Emergency Management Agency; Department of Homeland Security, United States	17	Office of the President of the United States; United States Army; Department of Natural Resources
3	Office of the President of the United States; Federal Emergency Management Agency; Governor of Louisiana; Mayor of New Orleans	18	Office of the President of the United States; United States Secret Service; Governor of Louisiana; Mayor of New Orleans
4	Office of the President of the United States; Federal Emergency Management Agency; Jefferson Parish Correctional Center	19	Louisiana Office of Homeland Security and Emergency Preparedness; Louisiana Emergency Operations Center; St. Tammany Parish Emergency Operations Center
5	Federal Emergency Management Agency; Army Corps of Engineers; St. Tammany Parish Emergency Operations Center	20	Department of Public Safety and Corrections, Louisiana; Orleans Parish Prison; New Orleans Police Department
6	Federal Emergency Management Agency; Army Corps of Engineers; Jefferson Parish Correctional Center	21	Department of Homeland Security, United States; Department of Health and Hospitals, Louisiana; St. Gabriel Morgue
7	Federal Emergency Management Agency; Army Corps of Engineers; New Orleans Sewerage & Water Board	22	Louisiana State University Department of Psychiatry; Mayor of New Orleans; New Orleans Police Department
8	Federal Emergency Management Agency; Army Corps of Engineers; The Shaw Group, Inc	23	Governor of Louisiana; Department of the Treasury, Louisiana; United States Senate
9	Federal Emergency Management Agency; Local Hospitals, Medical Care; St. Tammany Parish Emergency Operations Center	24	Jefferson Parish; Operation Life-Line Depot; Local Schools, K-12
10	Federal Emergency Management Agency; Local Hospitals, Medical Care; St. Charles Parish	25	Jefferson Parish; National Guard; Local Schools, K-12
11	Federal Emergency Management Agency; Local Hospitals, Medical Care; Terrebonne Parish	26	Department of Homeland Security, United States; Jefferson Parish; National Broadcasting Corporation
12	Federal Emergency Management Agency; Local Hospitals, Medical Care; Jefferson Parish Correctional Center	27	St. John Parish; Slidell Police Department; Local Schools, K-12
13	Federal Emergency Management Agency; Local Hospitals, Medical Care; City of New Orleans	28	County of St. Louis, Missouri; Regional Assistance Center; Salvation Army
14	Federal Emergency Management Agency; St. Tammany Parish; Louisiana Office of Homeland Security and Emergency Preparedness	29	SuperDome; National Guard; Local Schools, K-12
15	Federal Emergency Management Agency; Governor of Louisiana; Local Hospitals	30	Mayor of New Orleans; New Orleans Police Department; New Orleans Hornets
		31	New Orleans Police Department; New Orleans Fire Department; Wal-Mart
		32	St. Tammany Parish; Entergy Corp.; National Guard
		33	Governor of Louisiana; Fertility Institute of New Orleans; Louisiana Legislature
		34	St. Tammany Parish; National Guard; Local Schools, K-12
		35	Office of the President of the United States; Governor of Louisiana; United States Senate

organizations involved interactions at the state and local level. Only 4 cliques, or 11.4%, involved the interactions among federal, state, and local agencies that was the intent of the National Incident Management System adopted by the DHS (2004). An equal number, 4 cliques, or 11.4%, engaged in interactions among local agencies. Only 2 cliques represented interactions among federal and state agencies, a finding that confirms the gap between plans

and practice. Three cliques involved only federal agencies, and the remaining cliques represented singular types of interaction. The number of cliques in this large network also indicates the difficulty of enabling collective action across the network.

Discussion

Five observations are significant from this analysis. First, the findings reveal a striking pattern of asymmetry in the communication processes among the organizations participating in response operations. Despite the explicit intent to build collaborative relationships across jurisdictional levels in disaster response, as stated in the National Response Plan and the National Incident Management System (FEMA, 2004), the network of actors identified for the Katrina response system showed only modest levels of interaction across all four jurisdictional levels. The news reports document a higher degree of action at the local level, with federal agencies providing assistance directly to local agencies without coordinating their actions through state agencies. This pattern of performance makes it extremely difficult to develop the “common operating picture” of needs and resources that is so essential to effective emergency management across all jurisdictional levels.

Second, the severity of disruption in the communications infrastructure seriously hampered the responsible organizations’ capacity to anticipate the level of destruction and illustrated the need to build technical support for organizational action in disaster response. The catastrophic failure in organizational response to the needs of the communities of the Gulf Coast reflects vividly the sociotechnical nature of disaster response. The technical infrastructure is critical to support the organizational infrastructure, and the performance of either one must be assessed in relation to the performance of the other.

Third, the information infrastructure needed to support organizational performance in a rapidly changing environment must be established prior to the disaster. The information needs for managing a disaster over a large regional scale escalate proportionally to the number of communities and the size of the communities exposed to risk. Creating a regional knowledge base to areas exposed to the same risk, such as hurricanes for the five states that ring the Gulf Coast, is central to achieving coordination when hazards strike. It is a long-term effort that requires a continuing commitment to update and upgrade the capacity of practicing managers to function in their specific areas of responsibility, while simultaneously adjusting their performance to the constraints and resources available in neighboring jurisdictions. Without current knowledge of risks and resources, actual performance under stress of disaster is almost certain to fail.

Fourth, the interdependence between social and technical systems in managing disaster risk is such that the two sets of systems are best conceived as functioning as an integrated sociotechnical system. The technical system is designed to support the organizational system by monitoring hazards, maintaining records of actions taken, and anticipating future problems. The organizational system, in turn, is needed to maintain the technical system and overcome the vulnerabilities, bias, and human error that creep into the management of disaster events. The integration of the two types into a genuine sociotechnical system offers a powerful mechanism for reducing disaster risk.

Finally, given the complexity and cost of managing catastrophic disasters, it is critical to strengthen the capacity for self-organization at every level of management and operations. One can envision communication processes occurring more effectively along a diagonal that crosses jurisdictional and sectoral lines than in a standard hierarchical format. The disaster response network identified from news reports shows the potential for this kind of self-organizing system. A well-designed communications and information infrastructure would contribute substantially to achieving that goal. Enabling communities to manage their own risk more efficiently and effectively needs to be established as a primary goal of disaster risk reduction.

APPENDIX

LEGEND TO ORGANIZATIONS NOTED IN FIGURE 3

<i>Acronym</i>	<i>Organization</i>	<i>Acronym</i>	<i>Organization</i>
Abc	American Broadcasting Corporation	chref	Chalmette Refining LLC
Abcur	Ascension Baptist Church	cjean	City of Jean Lafitte
Abp	Associated Branch Pilots	ckenn	City of Kenner
Afaca	Air Force Academy	cleco	Cleco Corp
Airln	Airlines	cmk	Clarence M. Kelly & Associates
Alcen	Westwego Alario Center	cno	City of New Orleans
Amscc	Arthur Monday Senior Citizens Center	coast	United States Coast Guard
Anof	America's New Orleans Fund, Inc.	cong	United States Congress
Appd	Assumption Parish Police Department	cousa	Conference USA
Ardno	Archdiocese of New Orleans	cslide	Government of Slidell
Armrk	Aramark	cust	United States Customs Agency
Army	United States Army	cwestw	City of Westwego
Armycp	Army Corps of Engineers	dala	Department of Administration, Louisiana
Astro	Houston Astrodome	dbry	Dewberry Technologies
Atf	Bureau of Alcohol, Tobacco, Firearms and Explosives	dcc	Dixon Correctional Center
Bass	Bass Enterprises	dea	Drug Enforcement Agency, United States
Bech	Bechtel National, Inc.	dela	Department of Education, Louisiana
Boh	Boh Bros. Construction Co.	depla	Department of Emergency Preparedness, Louisiana
Brdpw	Baton Rouge Department of Public Works	deqla	Department of Environmental Quality, Louisiana
Brma	Baton Rouge Metropolitan Airport	deus	Department of Education, United States
Brpd	Baton Rouge Police Department	dhla	Department of Health and Hospitals, Louisiana
Brtc	Baton Rouge Technology Center	dhhs	Department of Health and Human Services, United States
Carn	Carnival Corporation	dhs	Department of Homeland Security, United States
Catlc	Catholic Life Center	dibr	Diocese of Baton Rouge
Cba	Columbia Broadcasting Service	dmjm	DMJM Harris-AECOM
Ccusa	Catholic Charities USA	dnrla	Department of Natural Resources, Louisiana
Cdc	Centers of Disease Control and Prevention	dod	Department of Defense, United States
Cgret	City of Gretna	dojla	Department of Justice, Louisiana
ch2m	CH2M Hill	dojus	Department of Justice, United States
Chara	City of Harahan	dpsc	Department of Public Safety and Corrections, Louisiana
Chase	Chase Bank	dpsc	Drug Enforcement Agency, United States
Dpty	Democratic Party	gmiss	Governor of Mississippi
Dtdla	Department of Transportation and Development, Louisiana	gnoec	Greater New Orleans Expressway Commission
Dtla	Department of the Treasury, Louisiana	gop	Orleans Parish
Dtus	Department of Transportation, United States	gpd	Gretna Police Department
Dwfla	Department of Wildlife and Fisheries, Louisiana	gpp	Plaquemines Parish
Ebrfd	East Baton Rouge Parish Fire Department	grd	National Guard
Ejmse	E.J. Morris Senior Center	gsa	Government of Saudi Arabia
Enmcc	Ernest N. Morial Convention Center	gsbp	St. Bernard Parish
Entgy	Entergy Corp.	gscp	St. Charles Parish
Equip	Equipfax	gsg	City of St. Gabriel
Exper	Experian	gsjp	St. John Parish
Exxon	Exxon Mobil Corp	gslcm	County of St. Louis, Missouri
Fcc	Federal Communications Commission	gstp	St. Tammany Parish
Fdaus	Food and Drug Administration, United States	gtep	Terrebonne Parish
Fedda	Federal Drug Administration		

(Continued)

APPENDIX (Continued)

Fema	Federal Emergency Management Agency	gtex	State of Texas
Fina	Fertility Institute of New Orleans	hnb	Hibernia National Bank
Flour	Fluor Corp	hnbh	Hibernia National Bank Operation Center Houston
Foley	Foley & Judell	hnbs	Hibernia National Bank Operation Center Shreveport
Gao	General Accountability Office		
Gark	State of Arkansas	hnoc	Historic New Orleans Collection
Ge	General Electric	hnoca	Harrah's New Orleans Casino
Gebrp	East Baton Rouge Parish	hpd	Harahan Police Department
Ggi	City of Grand Isle	hwfs	Herb Wallace Fire Station
Ghari	County of Harris, Texas	ibm	International Business Machines
Gjp	Jefferson Parish	icp	Illinois Conservation Police
Gla	Governor of Louisiana	jandj	J&J Maintenance, Inc.
Glafop	Lafourche Parish	jlei	Joint Legislative Committee on Insurance
Glafp	Lafayette Parish		
Dpty	Democratic Party	jpcc	Jefferson Parish Correctional Center
Dtdla	Department of Transportation and Development, Louisiana	jpccs	Jefferson Parish Clerk of Courts
		jpdc	Jefferson Parish District Court
Jps	Jefferson Parish Sheriff's Office	jpem	Jefferson Parish Emergency Management
Kbrs	Kellogg Brown & Root Services		
Kenyn	Kenyon International Emergency Services	jpm	Jefferson Parish Morgue
		mtf	Metairie Transit Facility
Kfc	Kentucky Fried Chicken	munts	Munters
Kpd	Kenner Police Department	muph	Murphy Oil Corp
Kuc	Kentucky Utility Crew	naacp	National Association of the Advancement of Colored People
Laasc	Louisiana Arts and Science Center		
Laia	Louis Armstrong International Airport	nasa	National Aeronautical and Space Administration
Laleg	Louisiana Legislature	navy	United States Navy
Lasc	Louisiana Supreme Court	nbc	National Broadcasting Corporation
Lchsp	Local Hospitals, Medical Care	nbla	National Bond Lawyers Association
Lcmcd	Local Media	nemec	National Center for Missing and Exploited Children
Lcmno	Legal Council for the Mayor of New Orleans	ndms	National Disaster Medical System
Lcsch	Local Schools, K-12	nfl	National Football League
Leoc	Louisiana Emergency Operations Center	nhc	National Hurricane Center
		nocao	New Orleans City Attorney Office
Lspol	Louisiana State Police	nofd	New Orleans Fire Department
Lsu	Louisiana State University	nofid	New Orleans Finance Department
Lsubs	Louisiana State University Board of Supervisors	noh	New Orleans Hornets
		noma	New Orleans Museum of Art
Lsudp	Louisiana State University Department of Psychiatry	noms	New Orleans Mission
		nopd	New Orleans Police Department
Lsuji	Louisiana State University School of Journalism	noswb	New Orleans Sewerage & Water Board
		nsml	North Shore Square Mall
Lsum	Louisiana State University, Manship School for Mass Communications	ofpb	Office of Former President Bush
		ofpc	Office of Former President Clinton
Maf	Michoud Assembly Facility	OI	Operation Life-Line Depot
Mar	United States Marines	opc	Orleans Parish Coroner
Marsal	Alvarez & Marsal	opcd	Orleans Parish Communications District
Matl	Mayor of Atlanta	opcde	
Meoc	Mississippi Emergency Operations Center	opp	Orleans Parish Civil District Court
		paosli	Orleans Parish Prison
Mlv	Mayor of Las Vegas	phs	Public Affairs Office, Slidell
Mmefs	Marrero Marrero-Estelle Fire Station	picay	United States Public Health Service <i>Times-Picayune</i>
Mno	Mayor of New Orleans	srita	St. Rita's Nursing Home
Motor	Motorola, Inc	ssa	Social Security Administration
Msl	Mayor of Slidell	ssc	Stennis Space Center
Potus	Office of the President of the United States	sthba	St. Tammany Parish Home Builders Association
Ppsrf	Plaquemines Parish Sheriff Office		

(Continued)

APPENDIX (Continued)

PscLa	Public Service Commission, Louisiana	stpc stpeo	St. Tammany Parish Council St. Tammany Parish Emergency Operations Center
Ptgal	Port of Galveston		
Ptno	Port of New Orleans	stpep	St. Tammany Parish Office of Emergency Preparedness
Push	Rainbow/PUSH		
Rac	Regional Assistance Center	stpsa	St. Tammany Parish Sheriff's Office
Rc	American Red Cross	sts	New Orleans Saints
Rgcon	Register of Conveyances	svelib	St. Ville Elementary Library
Rgmort	Recorder of Mortgages	svps	St. Vincent de Paul Society
Rshot	Royal Sonesta Hotel	swm	Southwinds Motel
Rta	Regional Transit Authority	ths	The Humane Society
Sa	Sports Authority	tiaf	Tiger Athletic Foundation
Salamy	Salvation Army	tjc	TJC Engineering, Inc
Sbem	St. Bernard Emergency Management	toyct tunon	Houston's Toyota Center TransUnion
Sbfd	St. Bernard Parish Fire Department	unmem	University of Memphis
Sbps	St. Bernard Parish Sheriff Office	unsms	University of Southern Mississippi
Sbv	Southern Baptist Volunteers	untul	Tulane University
Scctx	Shelter in Corpus Christi Texas	urban	Urban League
Sdc	Superdome Commission	usrep	United States House of Representatives
Sdphd	St. Bernard Port, Harbor and Terminal District	ussen	United States Senate
Sgm	St. Gabriel Morgue	usss	United States Secret Service
Sgt	Southgate Towers	vp	Office of the Vice President of the United States
Shaw	The Shaw Group, Inc		
Shell	Gulf Royal Dutch Shell, PLC	walmt	Wal-Mart (Tchoupitoulas Street)
Shfb	Second Harvest Food Bank	water	Coast Waterworks, Inc
Silpd	Slidell Police Department	wndx	Winn-Dixie's Riverside Market Place
Sm	ServiceMaster		
Smu	Southern Methodist University	wpd	Westwego Police Department
Spdme	SuperDome	wunon	Western Union
Spwir	Sprint Wireless	yates	W.G. Yates & Sons Construction Co.

Notes

¹ The National Hurricane Center reported the course of the storm as passing through Florida, Louisiana, Mississippi, Alabama, Tennessee, Georgia and moving through the eastern Great Lakes region of Illinois, Michigan, and Ohio before finally breaking up over the province of Quebec, Canada (Knabb, Rhome, & Brown, 2005).

² These losses have been cited elsewhere; however, it is important to cite the figures again to note the scale of this disaster. The losses include more than 1,300 dead, more than 1.5 million people displaced from their homes, more than 60,000 homes destroyed, an estimated U.S. \$300 billion to repair the infrastructure, rebuild homes, provide social assistance to those displaced from their homes, jobs, and communities (*The New York Times*, 2005).

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