chapter twenty-two

Coordination and control in emergency response

John M. Flach, Debra Steele-Johnson, Valerie L. Shalin, and Glenn C. Hamilton

Contents

22.1 Introduction

On the afternoon of Sunday, September 14, 2008, the remnants from the Gulf Coast's Hurricane Ike moved through Ohio. Although not as devastating as a tornado, hurricane force winds caused substantial storm damage and extensive loss of power. The high winds cut electrical service to more than half of the local power company's one-half million regional customers. The company's website initially indicated that service restoration would be a "multiday effort." However, full restoration was not reported until 2 weeks after the initial storm, on September 29, 2008. The result was that significant stress was placed on the regional medical emergency response resources. For example, 1100 new patients reported to local emergency departments in the first week of the power outage, and

some ambulances were diverted from the nearest emergency rooms due to overflowing capacity.

In this chapter, we share lessons learned from extensive interviews with a wide range of participants in this emergency event. We summarize our observations in the context of theoretical work on the dynamics of "complex adaptive organizations." Our goals are to explicate theories of complex adaptive organizations by grounding them in the concrete events associated with this particular emergency situation. We also provide some practical suggestions that might be useful in preparing for future emergency situations. Section 22.2 will introduce the construct of a complex adaptive organization and will illustrate how this construct applies to the regional emergency response organization. This will be followed by a section that considers the implications for coordination and control using Handy's (1992) recommendations for "federalism" as a general approach for managing complex adaptive organizations.

AU: Please provide section number.

22.2 Complex adaptive organizations

22.2.1 Adaptive organizations

What is a complex adaptive organization? Let us begin by considering the term adaptive, which reflects a specific kind of control system. A simple control system (e.g., a servomechanism) adjusts its behavior based on error feedback as a function of fixed parameters (e.g., gains) that are optimized for a particular situation. An adaptive control system, however, is a system that is capable of adjusting its parameters to meet differential demands of changing situations. For example, a nonadaptive autopilot will have a fixed set of control parameters. These parameters will typically be optimized for some situations (e.g., altitudes), but these parameters will result in suboptimal performance or even instability in other situations (e.g., at other altitudes). In contrast, an adaptive autopilot is designed to adjust its parameters when situations change to achieve more satisfactory performance in a wider range of circumstances. Adaptive control will be necessary for systems that operate over a range of situations where no single control solution will yield stable performance. Although an adaptive control system may not achieve optimal performance in any particular situation, these systems will typically be more robust or resilient in their ability to achieve satisfactory performance over a wide range of situations.

Thus, an adaptive organization is an organization that is able to adapt its behaviors (tactics or processes) to yield satisfactory performance over a wide range of changing situations. For these organizations, rigid adherence to fixed procedures will not yield consistently satisfying outcomes due to the changing demands of situations. To achieve consistently satisfying outcomes in changing situations, it is necessary that these organizations

adapt their processes to cope with the changing demands. For military organizations, the need for adaptation is reflected in observations such as "no plan survives contact with the enemy" and warnings against "fighting the last war." In the management literature, a term closely associated with the construct of adaptive organization is the construct "learning organization" (e.g., Senge, 1990). Adaptation and learning are essentially synonymous, reflecting the need for change to better fit the demands of changing circumstances.

Like military organizations, emergency organizations must be prepared to adapt to novel situations since no two emergency events will be exactly the same. The 2008 windstorm was a unique situation for the Ohio region. Tornados, which are more common to this region, are typically localized in both location and time. In contrast, this windstorm event impacted a large region, and the significant stresses on the emergency response system emerged gradually over time as a result of the cumulative effects of extensive power outages. Because of its uniqueness, it took significant time for many responders to fully appreciate the full scope of the emergency. Shortly after the precipitating event, interviewees varied widely in terms of threat recognition and in perceptions of both short- and long-term threats resulting from the windstorm.

Virtually all interviewees acknowledged the wind devastation on Sunday. Standby medical personnel attending an outdoor community event claimed early initial concern. One interviewee was off duty on Sunday but came into the office because of the storm. However, a few others reported a proactive response. For example, most did not contact their emergency command centers or their employers. Although one interviewee acknowledged returning home from a trip to a "war zone," he did not contact his superiors. Another hospital interviewee reported that he noted the debris and wind but was not concerned and was not on call. A fire department interviewee also noted the wind and damage as he drove back into town from a weekend trip, but it was late and he went home. He initiated emergency procedures on Monday morning and began to assess the extent of the damage and loss of power. By Monday morning, some hospital administrators were concerned and went in early and/or contacted other hospitals to make plans for a surge in demand.

The insidious aspect of the windstorm, however, was not the initial physical damage of the wind but the cumulative effects of the resulting extended power outages. Few interviewees from the urban areas of the county claimed immediate recognition of the potential long-term threat to their communities. In contrast, one interviewee from a rural area did claim to recognize that the damage was likely to have long-term impacts due to prior experience with other weather events. This interviewee appreciated that for a low-priority rural community, the lack of power (electricity) would likely last weeks rather than days. However, the same interviewee reported

that it was difficult to convince younger, less-experienced colleagues of the potential long-term consequences.

Since every emergency situation is unique in some way, there will be demands that cannot be anticipated in terms of planning or training exercises. Thus, it will be necessary for the organization to make adjustments in real time (i.e., to adapt) to achieve satisfactory performance.

22.2.2 Complex situations

In considering complex adaptive organizations, the term complex can reflect either properties of situation dynamics (e.g., degrees of uncertainty) or properties of the organization (e.g., the number of components or degrees of freedom) or both. The complexities of the situation dynamics associated with regional emergencies are easy to imagine. The county primarily impacted by the windstorm covered approximately 462 square miles and had a population over 500,000 in more than 200,000 households. Forty-three percent of the land was urban, supporting residential, commercial, and industrial usage. The county was home to eight hospitals, providing approximately 2500 beds.

The following list of initial consequences of the storm gives a sense of the scope of the problem:

Debris: the windstorm knocked down trees, obstructing public streets and private driveways. Unsafe debris removal practices sometimes resulted in accidents and injuries.

Downed power lines: the windstorm knocked down power lines, most of which were initially dead.

Refrigeration: the absence of electricity disabled home refrigerators, in some cases impacting the storage of temperature-sensitive medications and, more broadly, food storage. This, in turn, increased the risk of food-borne illnesses and caused economic hardship for low socioeconomic status citizens who lost food supplies. More than 19,000 people applied for replacement food stamps.

Gasoline: the absence of electricity prohibited the operation of gasoline pumps, resulting in gasoline shortages for first responders as well as the general public.

Traffic lights: the absence of electricity disabled traffic lights, resulting in both an increase in traffic accidents and the need for portable stop signs.

Water supply: both of the city water supplies initially relied on emergency generators as a source of power.

Communications: the absence of electricity eliminated digital/wireless home telephones and traditional and cable television. Further, wind damage to cell towers, high demand for signals for calls, and

reliance on car batteries for recharging phone batteries limited cell phone usage.

Electricity-dependent home and outpatient care: the absence of electricity affected many people who depended on electricity to live independently of the hospital healthcare facilities. This included people dependent on oxygen, dialysis patients, bariatric patients, and those dependent on electric wheelchairs for mobility. For example, the absence of electricity prohibited the use of in-home oxygen concentrators and delivery systems along with the electricity-based breathing treatments that some residents require. Otherwise stable and independent, oxygen-dependent residents had to seek alternative sources for oxygen and breathing treatments. Those unable to find alternative sources faced the potential of deteriorating health that in some cases required emergency medical treatment.

In the case of the windstorm, the complexity was not simply a function of the many dimensions, but it was magnified by the cumulative interactions within and across these factors over time. As noted in the previous section, this complexity created a degree of ambiguity that made it difficult for many of the people involved to recognize the full extent of the emergency situation as it developed.

AU: Please specify section number.

AU: Please note that Sections 22.2 and 22.2.3 both have the same title. Please provide different section titles to avoid ambiguity.

22.2.3 Complex adaptive organizations

The other facet of complexity has to do with the structure of the organization itself. Emergency response organizations are not monolithic organizations with clearly defined roles and hierarchical command structures. Rather, emergency response organizations are an example of what systems theorists call a federation of systems. Sage and Cuppan (2001) identify a federation of systems as a special case of a complex adaptive system within the more general class of "system of systems." A system of systems is a collection of component systems, each with independent organizational structure and function that collaborate to achieve some common function. The component systems are often geographically distributed, and typically the collaborations evolve over time. The goals and collaborative behaviors are emergent properties of this evolution. In other terms, a system of systems is a multiteam system (MTS). Mathieu, Marks, and Zaccaro (2001) define an MTS as follows: "Two or more teams that interface directly and interdependently in response to environmental contingencies toward the accomplishment of collective goals. MTS boundaries are defined by virtue of the fact that all teams within the system, while pursuing different proximal goals, share at least one common distal goal, and in doing so exhibit input, process and outcome interdependence with at least one other team in the system" (p. 290).

Sage and Cuppan (2001) define the particular case of a federation of systems as a system of systems with "little central power or authority for 'command and control'" (p. 327), that is, a federation of systems is based on a rather loose coalition that emerges due to a common interest in achieving functions that require cooperation. Although the combination of teams within the federation of systems creates increased possibilities for meeting complex situation demands, it also adds to the complexity of the system control problem. Although each component system is a resource for meeting the variety of needs of a situation, each is also a source of uncertainty. In other words, for stable solutions to emerge the individual components must adapt to not only their local situation dynamics but also the changing behaviors of other components (that are also simultaneously adapting to their own local situation dynamics).

The federation of systems responding to the 2008 windstorm included multiple political and public service organizations including local (cities and towns and their associated police and fire units) and more global units (countywide organizations), multiple medical organizations (state and regional organizations, eight hospitals, an emergency operations center (EOC), an acute care center (ACC), and numerous distributed clinics and medical offices), the regional utility company, and civilian organizations (churches, neighborhood associations, and citizen band radio operators). Note that due to nesting and overlapping across these various teams, some individuals were members of multiple teams.

Consistent with the construct of a federation of systems, most of the component teams had primary functions other than regional emergency response, that is, they were not specifically organized for responding to regional emergencies. An exception to this was the EOC. The EOC was physically located in the major population center near the east side of the county. It had the dual mission of performing as both a planning (including training) agency and a response organization. During emergencies, the EOC is intended to perform a logistics function, coordinating resources in response to local requests and coordinating communications and resource requests with the state.

22.3 Coordination and control

Sage and Cuppan (2001) suggested five dimensions of federalism (attributed to Handy [1992]) that we will consider in relation to the challenge of coordination and control in federations of systems in general and for emergency operations in particular. These five dimensions are subsidiarity, interdependence, standardization, dual citizenship, and separation of powers. We will consider each in turn.

22.3.1 Subsidiarity

Under subsidiarity, power or authority resides with the lowest possible point within an organization. In other words, the component system elements have maximal flexibility and authority to respond to local contingencies. The flexibility for the components to adaptively respond to local situational demands without waiting for instructions from a higher authority is an attribute that allows federations of systems to adapt to complex dynamic situations more effectively than hierarchical, centrally controlled organizations.

In military systems, the need for subsidiarity is reflected in the construct of "command intent." This suggests that commanders should leave sufficient discretion to junior-level officers so that the system can adapt to changing contingencies that could not be anticipated in a fixed formal plan. Commanders should specify a general intent, but they should trust local subordinates to work out the details of implementing that intent based on local contingencies. Shattuck (2000) describes the tension that military commanders experience between centralization and flexibility: "The senior commander must make an inherent tradeoff which impacts the subordinate commander's ability to adapt to battlefield conditions. The battlefield is a highly complex, uncertain environment where a commander matches wits with his opponent while coping with such variables as terrain, weather, morale, fatigue and equipment. Providing subordinate commanders a large degree of flexibility is critical to success" (p. 68).

Thus, a value of federalism is that the component teams can function somewhat autonomously in dealing with contingencies that could not be anticipated in any a priori plan and where there is insufficient time to wait for directions from a centralized authority due to unavoidable communication delays. The subsidiarity property has two complementary implications. Centralized authority must avoid overconstraining their subordinates who are dealing with the chaotic demands at the front lines, as suggested by the construct of command intent. Additionally, subordinates must be willing to take the initiative to act in the absence of specific directives from above.

In emergency operations, the distributed and evolutionary nature of the organization that is composed of subteams, typically with a great deal of autonomy, helps to ensure that these teams are not hampered by a strict centralized authority. For example, the EOC typically functions as a logistics center, distributing resources where they are needed, rather than as a command center, that is, it is designed to be a liaison between local and state agencies. The EOC's role is to keep everyone on the same page, so to speak, and to direct resources to where they are needed most. This is more of a support and logistics function than a command function.

In our interviews after the windstorm, we observed large variabilities among the component units about whether they took local initiative. For example, some organizations (e.g., fire departments) took the initiative to canvas their local communities to identify where there were power outages, whereas other communities waited for the central utility company to tell them where the power outages were. Note that the communities that took the local initiative generally felt that they fared better than those that waited for direction from higher authorities. Similarly, as discussed earlier, some emergency personnel took initiative to report to their units, whereas others waited to be called.

22.3.2 Interdependence

Interdependence is a property of any organization. Thompson (1967) described three types of interdependence within organizations: "pooled," "sequential," and "reciprocal."

Pooled interdependence refers to situations in which each of the components within an organization operates with a high degree of autonomy, but the products must be combined to satisfy the shared goals. Sequential interdependence refers to situations in which there are precedence relations among the components in the organization such that processes of one component depend on the satisfactory completion of processes by another component. In this case, not only do shared functional goals require cooperation but also is cooperation required to achieve local subgoals. Finally, reciprocal interactions refer to situations in which the processes and functions of particular components must adapt based on how other components behave. In this case, there are not only functional dependencies but also process dependencies such that the processes within a component may need to change depending on the actions of other components.

Perhaps the distinct aspect of federations of systems in general and emergency operations in particular is the balance across these three types of dependencies. All three types of interdependence were evident in the windstorm event. Most of the component systems had specific independent functions (i.e., search and rescue, civil order, transport, medical treatment, logistics, etc.) that were necessary for satisfaction of the overall goals, but often these could be accomplished with a relatively high degree of autonomy. On the other hand, there were also obvious precedence constraints. For example, emergency departments depended on local resources to transport individuals and the EOC depended on information from hospitals to assess the regional needs. There were also obvious reciprocal relations, such as the utility company being able to work more efficiently in those communities that took the initiative to determine where power was out.

Ambulances having to reroute patients when their normal emergency departments became overpopulated is another example of reciprocal relations.

22.3.3 Uniform and standardized way of doing business

Sage and Cuppan (2001) suggest that due to the interdependencies of federations of systems, coordinated control is not possible without "agreement on basic rules of conduct, common traditions of communicating, and common units of measurement of progress and quality" (p. 330). Thompson (1967) differentiates three types of coordination (i.e., ways of doing business) that tend to be associated with the different types of interdependence: "standardization" (pooled), "planning" (sequential), and "mutual adjustment" (reciprocal).

Standardization reflects a minimal requirement for coordination. Namely, there must at least be some common language for communication so that the outputs from one component can be interpreted and combined by other components. In the windstorm event, the need for standardization was highlighted in association with the needs for oxygen. An important factor driving the emergency situation was the surprisingly large number of people who relied on in-home oxygen systems requiring electricity. Thus, significant demands were placed on emergency departments at local hospitals, as they became "oxygen bars."

As oxygen supplies became depleted, confusion arose because of ambiguities about terminology. For example, when a request for oxygen came in, did the requestor want large or small canisters with regulators? Did they want concentrators for personal or multipatient use? Perhaps the request referred to tanks of compressed gas or cryogenic liquid gas, which itself required special vaporizers to support inhalation. In some cases, those placing the request for oxygen did not understand the various types of oxygen delivery equipment and the specific resources this equipment required. Some emergency personnel needing oxygen suggested contacting welders, but this source of oxygen does not meet Food and Drug Administration standards. More typically, numerous oxygen-related confusions resulted from the fact that several key people who normally facilitated such requests were out of town. Interviewees reported confusions regarding the location of oxygen stores. In one case, both state resources and hospital association resources were stored in the same warehouses, but inventory-labeling problems and ambiguous requests made it unclear to managers whose oxygen resources were being requested, where those resources were located, and whether the requestor had the owner's authority to access these supplies. Persistent, though somewhat extended, communication eventually resolved this problem. However, more clearly established standards for labeling the oxygen supplies could have led to more efficient coordination.

Planning is typically needed when there are precedence dependencies among components. In this context, we are using the term plans to refer to a priori programs established prior to an emergency event to identify processes for coordinating activities. These typically provide a scheme or schedule for the appropriate sequence and timing of activities. The importance of a priori planning was illustrated by uncertainties regarding the EOC. The EOC was open and operating by 4:30 PM. on Sunday, the initial day of the windstorm event, as it should have been. However, there was widespread confusion about whether it was open and what its role was. For example, some saw it as a central node in the communication network for tracking resources. Thus, all requests and other information should have been routed through the EOC. Others saw the EOC as a resource of last resort. So, they did their best to access and monitor resources locally and only involved the EOC when all other sources failed.

Similar confusions were found with respect to the ACC, a state-level asset managed by the department of emergency medicine at a local university. The ACC was a lower level medical care facility designed by the state to be set up in a "building of opportunity." It required a physical building since it did not have an independent housing arrangement. The ACC was designed to provide four clinical care functions: intravenous hydration, antibiotics, pain management, and respiratory therapy. The ACC would not be used for trauma surgery but would be set up to handle less acute hospital care such as caring for oxygen-dependent patients. Several issues were highlighted in relation to the ACC, including understanding the asset, activation, and conflicts of interest.

Some interviewees, for example, hospital personnel and county EOC personnel, had a limited understanding of the capabilities of the ACC. Some did not realize that the ACC would have to be staffed by local medical personnel, that it required a physical location (i.e., a building in which the ACC could be set up), and that daylight and lead time would be required for deployment. Further, given the expense of deploying the ACC, some interviewees raised the possibility of the partial deployment of the ACC, namely, deploying only those components of the ACC needed to address the current event.

A specific protocol was required to activate the ACC, including a formal request to the state department of health. However, affected personnel, such as hospital administrators, were unclear on the protocol for activating the ACC. Further, there was uncertainty regarding who in the county had the authority to make the decision. Finally, interviewees reported that there were mixed and contradictory reports regarding whether the ACC had been activated and whether the ACC was needed.

AU: Please provide reference citation and page number for this direct quotation.

Whereas at least one hospital advocated activation, another hospital-based interviewee commented that "we weren't out of supplies … didn't need any of the stuff that they had." The association of area hospitals

recommended against deployment. The EOC combined this recommendation with input from one of the local fire departments to decline pursuing activation. A question arose regarding whether the hospital association was the appropriate authority for making this decision or whether another group, such as the public health department or the Red Cross, would provide a more objective hand in deciding whether to activate the ACC.

These issues associated with both the EOC and the ACC reflect the kind of issues that should be addressed through planning and training prior to an emergency event. The lack of understanding of the appropriate protocols or standards added unnecessarily to the confusion and undermined effective coordination during the windstorm event.

Whereas planning involves a priori programs prior to an emergency, complex work typically also involves ad hoc planning or replanning. This leads to the third type of coordination in Thompson's model: mutual adjustment refers to the ability of components within an organization to adapt their processes and functions based on the activities of other components. This requires extensive communications for each component to know what the other components are doing. Thus, effective communications have been hypothesized as a key element that differentiates effective team performance (Entin and Serfaty, 1999; Serfaty, Entin, and Deckert, 1994). Entin and Entin (2001) have operationalized this in terms of the ratio of "push" to "pull" information. Pull refers to information that is elicited through requests. Push refers to unsolicited information that is made available or "pushed" to other components in the organization prior to any requests. Entin and Entin (2001) hypothesized that teams with high push-to-pull ratios anticipate the information needs of other components and push information to these components, making them more able to manage complexity.

SurgeNet was a critical communication resource among hospitals during the windstorm. It was an online database that could be used and accessed by the local hospitals. It was available and was regularly used by hospital and emergency personnel to manage patient distribution across hospitals. Emergency personnel used information from SurgeNet to determine which emergency departments were full and which could still accommodate patients. When an emergency department was full, it posted that information on SurgeNet so that emergency personnel could "reroute" patients to an emergency department in a different hospital.

According to news reports, area emergency departments treated record numbers of patients, and many were operating beyond their capacities at some points during the emergency period. The emergency departments were all on "reroutes" to other hospitals, and one interviewee reported that his hospital implemented its normal diversion plan due to the crowded emergency department.

SurgeNet was effective in communicating this information to emergency personnel. However, SurgeNet might have been expanded to push additional information about hospital resources other than beds in emergency departments. More process-oriented measures, including the availability of diagnostic and treatment devices (e.g., computer axial tomography scans and ventilators) as well as projected demand, may have been useful for allowing more effective mutual adjustments. For example, some hospitals were unable to provide cooling for diagnostic equipment due to the electrical outage, so this resource was not temporarily available.

Pushing information about resources should help the systems to anticipate future conditions. Knowledge of a future surge in resource requirements provides a valuable time cushion when the necessary mutual adjustments require time. Such an anticipation requires a richer model of the influences on resource demand, and technology can be an effective integrating mechanism. For example, if the surge in emergency department demands due to oxygen boarders, dialysis patients, and others in the community whose health depended on power could have been anticipated and documented on a tool such as SurgeNet, time would have been gained to coordinate a more efficient response to the surge.

An important implication of the advances in information technologies (e.g., SurgeNet or the Internet) is that they make it much easier to push information to others in the network. However, one factor that made adapting to the windstorm more difficult was the breakdown in the normal communication technologies resulting from the power outages. Several interviewees discovered belatedly that their home phones or cell phones were not usable due to lack of electricity or dead batteries. Assuming that supervisors would call with requests, emergency personnel at home may not have realized that their digital phones were not working.

Reliance on phones proved challenging for other reasons. Phone contact lists often failed to include cell phone numbers that were critical for administrators not at their desks. Indeed, some interviewees reported attempting to contact someone to ask whether the EOC had been activated, but the phone contact lists included only office telephone numbers and not cell phone numbers. Cell phone charging was limited to automobiles, requiring appropriate technology and sometimes separating the users, including emergency response personnel, from incoming calls during the charging process. In addition to breakdowns in phone communication systems, access to computers that also depended on electricity was compromised. One of the factors contributing to the uncertainty about the status of the EOC was the fact that they used e-mail to announce their opening.

AU: Please specify what "they" refers to here.

For many of the teams identified as high-reliability systems (e.g., aircraft flight deck crews) there is an intact communication network (e.g., a voice loop). In these systems, the initiative to proactively push information

may be important for team effectiveness. However, in the windstorm event, where there were significant compromises to the communication network, the key word seemed to be initiative rather than push. In other words, given the compromises to the communication infrastructure it was necessary that all the components take initiative to both push and pull the information that they needed. For example, it was clear that system response was hampered as some people passively waited for information to be pushed to them. However, failed equipment and lack of correct phone numbers prevented the dissemination of this information.

22.3.4 Dual citizenship

In federations of systems, individuals have at least dual citizenship, that is, they are both members of a component organization and members of the federation. In fact, in the windstorm event many people were affiliated with multiple component systems. For example, an individual representing a hospital may also be a member of the regional association of hospitals and may also participate on state-level bodies. Sage and Cuppan (2001) suggest that for federations of systems to work successfully, citizenship in the federations needs to be emphasized. When goal conflicts inevitably arise, the common goals of a federation need to take priority over the goals of individual component organizations.

A particular source of conflict between component and federation goals involved the activation of the ACC. Our interviews highlighted very real conflicts of interest for area hospitals in relation to the ACC. For example, if the ACC was activated, area hospitals might have lost revenue. On the other hand, area hospitals incurred increased costs, for example, from oxygen boarders. In addition, the cost of activating the ACC, as well as the cost burden related to activating the ACC, was unclear to participants, as was a clear means of reimbursement and restocking. Finally, several other issues arose that were related to relative costs, including how much the state would be charged for oxygen boarders and whether the ACC could accept health insurance.

Further, some interviewees substantiated hospital concerns regarding a potentially lower standard of care provided by the ACC, that is, the ACC is designed to perform only four functions rather than all of the functions of a hospital. This raised concerns in area hospitals regarding possible claims of physician or hospital malpractice resulting from referrals of patients to the ACC and questions on how and under what conditions such referrals would be made. Finally, some of the concerns regarding activating the ACC were related to the "can do" culture of hospital and medical personnel and long-range competition among hospitals. Healthcare providers felt that a request for help with their own mission might be interpreted as a weakness that they were reluctant to admit.

22.3.5 Separation of powers

Sage and Cuppan (2001) suggest that the functions of management, monitoring, and governance of federations of systems be "viewed as separate functions to be accomplished by separate bodies" (p. 330), as various functions have different time and value constraints. For example, issues associated with the standards for implementing the EOC and the ACC were governance issues that should have been addressed through long-term planning and training. However, the bodies that coordinate this long-range coordination are typically not the best vehicle for the process of real-time command and control during an emergency event. The fact that the EOC served a leadership role for planning and training may have been one source of confusion about its function during the actual windstorm event.

There was also separation of power issues associated with the ACC. The ACC generally was a state resource that was monitored by the local hospital association through a local medical school. However, in the context of the emergency situation, there has been a suggestion that the real-time management decisions about initiation and operation of this resource should be decoupled from the hospitals and should be made by a public health agency that has no revenue-based conflicts of interest and that can consider the larger emergency system, including the Red Cross operations.

With respect to the larger emergency context, many of the problems during the windstorm seemed to emerge as a function of a gap between the mission of the Red Cross to feed and clothe the healthy and the mission of hospitals to treat the sick and injured. The definition of good health is context dependent, and disasters change the context. Individuals who seem healthy with the assistance of technology, in this case electricity-based oxygen concentrators, are unhealthy in its absence. Weather or problems with the water supply could also differentially affect the same populations.

Issues arose when one of the Red Cross sites made it difficult to accommodate patients who were dependent on oxygen or other services that required access to electrical outlets. Thus, there was a need for a resource to meet the middle ground of people who were at the edges of health and required assistance for health support, including those with physical disabilities. The ACC, if it had been activated, may have been a resource for meeting this need. The disconnect between the hospital mission and the Red Cross mission suggests an opportunity to learn and adapt from the windstorm. This should be considered at the governance level in terms of potential implications for considering alternative management schemes and implementing these schemes in terms of planning and training. This, in turn, has obvious implications for changing the way in which the ACC resource might be managed in the future. It also has implications for the choice of sites for Red Cross–managed treatment centers (i.e., access to electricity and accessibility need to be considered).

22.4 Summary and conclusion

In the case of the 2008 windstorm, there is no evidence that any lives were lost due to failures of the emergency response systems. However, there is evidence to suggest that the system came dangerously close to its capacity limits. Some have wondered whether the region was saved from more catastrophic consequences because the windstorm was followed by unusually mild weather conditions. Further, there are lessons to be learned that might improve coordination in future emergencies. For example, the oxygen problem suggests the need to establish a clear taxonomy for identifying the different types of oxygen needs. It was also clear that there is a need for better standardization (through planning and training) with respect to the implementation and operation of the EOC and the ACC. Another important lesson is the need for people to better compensate for breakdowns in the normal communication infrastructures. Thus, they need to be more proactive in both pushing information from other components and pulling information from other components. Finally, there seems to be a clear gap between the mission of hospital emergency departments and the mission of the Red Cross treatment centers with respect to those at the edge of health who are dependent on electricity-based technology. This gap was an important factor in the excessive demand that was placed on emergency departments at local hospitals.

The construct of a federation of systems or a team of teams is relatively new in the organization literature. We doubt that the emergence of this construct reflects the emergence of a novel form of organization. In fact, we suspect that such an organization has always been true for regional emergencies (and probably also for military adventures). However, the increased attention on this type of organization may reflect the gradual extinction of more monolithic and hierarchical organizations that find it increasingly difficult to survive in a world where the pace of change is high and where there are increasing opportunities and demands for collaborations among globally distributed component teams. Thus, rather than being an anomaly, the federation of systems that has probably always been typical for emergency operations is increasingly becoming the standard for successful organizations (Galbraith, 1995).

A benefit of this evolution for emergency systems is that increasing attention is being paid to the problem of controlling these teams of teams. Therefore, we have used Sage and Cuppan's (2001) prescriptions for federalism as a framework for evaluating performance during the 2008 windstorm with the hope that this will provide insights toward potential improvements. Other literature that provides potential prescriptions for evaluating the effectiveness of emergency systems include research on "high-reliability organizations" (Weick, Sutclife, and Obstfeld, 1999) and the management literature on "learning organizations" (Senge, 1990).

In all of this literature, the focus is on the ability of organizations to adapt to meet the demands of complex, dynamically changing situations.

We see larger overlaps in the prescriptions from the literature. Thus, these are not competing or conflicting views, but rather they seem to be converging insights about fundamental issues related to the stability of complex organizations operating in complex environments. To a large extent, this insight might be summarized in terms of Ashby's (1956) "law of requisite variety" (Flach, in press). In essence, this law states that a controller must be at least as complex as the problem that is being controlled. In other words, it takes complexity to destroy complexity. The federalism described by Sage and Cuppan (2001) seems to be a particularly effective way for an organization to increase its complexity (i.e., degrees of freedom or flexibility) so that it can adaptively respond to solve complex problems like regional disasters. Thus, we have used that construct to organize some of our observations from the 2008 windstorm.

References

Ashby, R. (1956). *An introduction to cybernetics*. London: Chapman & Hall.

Entin, E. E., & Entin, E. B. (2001). Measures for evaluation of team processes and performance in experiments and exercises. Paper presented at the Proceedings of the 6th International Command and Control Research and Technology Symposium, Annapolis, MD.

Entin, E. E., & Serfaty, D. (1999). Adaptive team coordination. *Human Factors*, 41(2), 312–325.

Flach, J. M. (in press). Complexity: Learning to muddle through. Cognition, Technology & Work.

Galbraith, J. R. (1995). *Designing organizations: An executive briefing on strategy, structure, and process*. San Francisco, CA: Jossey-Bass.

Handy, C. (1992). Balancing corporate power: A new federalist paper. *Harvard Business Review*, 70(6).

Mathieu, J. E., Marks, M. A., & Zaccaro, S. J. (2001). Multi-team systems. In N. Anderson, D. Ones, H. K. Sinangil & C. Viswesvaran (Eds.), *International handbook of work and organizational psychology* (pp. 289–313). London: Sage.

Sage, A. P., & Cuppan, C. D. (2001). On the systems engineering and management of systems of systems and federations of systems. In *Information, knowledge systems management 2* (pp.245–325). IOS Press.

Senge, P. M. (1990). *The fifth discipline: The art and practice of the learning organization*. London: Random House.

Serfaty, D. S., Entin, E. E., & Deckert, J. C. (1994). Implicit coordination in command teams. In A. H. Levis & I. S. Levis (Eds.), *Science of command and control: Part III coping with change* (AIP Information Systems) (pp. 87–94).

Shattuck, L. (2000). Communicating intent and imparting presence. *Military Review*, 66–72.

Thompson, J. (1967). *Organizations in action*. New York: McGraw-Hill.

Weick, K.E., Sutclife, K.M., & Obstfeld, D. (1999). Organizing for high reliability: Processes of collective mindfulness. In R.S. Sutton & B.M. Shaw (Eds.), *Research in organizational behavior*, Volume 1, (pp. 81–123). Stanford, CA: Jai Press.

AU: Please update volume and page numbers if possible.

AU: Please provide publisher location and editor names for the reference Sage and Cuppan (2001).

AU: Please provide volume number for the reference Shattuck (2000).

AU: Please provide page range for the reference Handy (1992).

AU: Please provide publisher location and details for the reference Serfaty et al. (1994).