Toward the Next Generation of Emergency Operations Systems

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ABSTRACT

For more than half a century the Emergency Operations Center (EOC) has been a key component of emergency management (EM), homeland security and business continuity practice. Changes in the technical, threat, economic and social environments are placing new pressures on the concept of the EOC in the public, private and community sectors. Investigation of the desirable attributes of a "Next Generation EOC" has led to alternative EOC roles and configurations. This paper describes emerging pressures on, and trends in, emergency and business contingency management systems, and describes a research program to explore solutions to both new and persistent design challenges.

Keywords

Emergency operations center, mobile command, incident command, common operating picture

INTRODUCTION

Today's typical EOC operates on largely the same principles as military control centers from the Second World War and Civil Defense command shelters during the Cold War era.

> "An emergency operations center is the protected site location where management decisions are made and coordinated responses are orchestrated related to an emergency incident…the purpose of an EOC is to provide a Commander and his immediate staff a secure centralized location, with adequate communications for command and control during a disaster or emergency." (DoD, 2008)

While that definition is excerpted from a U.S. military document it would not sound foreign or inapplicable to most civilian emergency managers in the U.S. and many other countries[1]. It incorporates four general assumptions about the nature of an EOC:

- **Physical Collocation**: The EOC is a single site where decision makers gather to share information and coordinate activities using shared communications facilities;
- **Protection through Isolation**: The EOC is designed to provide protection for its staff from a potentially hostile environment;
- **Hierarchical Authority**: The purpose of the EOC is to consume information and produce decisions that are binding on resources and actors at other locations ("command and control"); and,
- **Intermittent Use**: The EOC is a special-purpose facility that is used during exceptional events (e.g., "a disaster or emergency".)

An EOC is, of course, more than just a physical facility with a technical infrastructure. An EOC also has protocols, human interfaces and human resource requirements and an organizational structure (DHS, 2008). In

[1] Civil-government EOCs in the U.S. tend to restrict their command-and-control role to issues of resource management and external coordination, while delegating operational control to on-scene incident command post (ICP) personnel. (DHS 2008)

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effect, an EOC is an alternate system of governmental, corporate or organizational governance that is invoked under extraordinary circumstances.

PRESSURES ON THE TRADITIONAL MODEL

A variety of external forces are acting to make the creation and sustenance of the "traditional" EOC challenging and those pressures are increasing, particularly in the rapidly evolving economic, organizational and social environments.

For many operators the most immediate challenge is the economic difficulty of obtaining and maintaining suitable physical space. EOC workspace must meet special criteria for location, construction, infrastructure and furnishings (Serina, 2009). Many EOC managers are under constant pressure to share their facilities with other, more frequent activities that can reduce the readiness of the space and create reluctance to activate the EOC.

This economic pressure, particularly in times of economic retrenchment, is only exacerbated by the need for not only primary but also alternate EOCs, on the rationale that any fixed facility, even if hardened, can become unusable under some conceivable circumstance. This is one of the drivers toward the growing popularity of mobile EOCs and command vehicles.

A further complication arises from uncertainty about the nature and scope of threats the EOC may be used to manage.[2] This variability can make it difficult to produce persuasive forecasts of actual space or other operational requirements.

Related to economic pressures, but also as a result of technological change and shifting social norms, is the tendency to flatten hierarchical organizations and grant greater autonomy to nominally subordinate departments and organizations. As a result there is a growing tendency to supplement, if not replace, a single all-unifying EOC with a federation of departmental, regional or otherwise specialized operations centers and command posts. [3]

At the same time mobile technologies, smartphones and ubiquitous communications are enabling greater participation by untrained or partially trained citizenry, sometimes in unexpected ways. Such widely diffused technologies may add pressure on government and corporate emergency managers to "come out of the bunker" and engage with the public in ways to which the traditional EOC is not conducive.

Finally, as noted earlier, the activation of an EOC is inherently an expensive and disruptive act. Relocating decision makers and implementing the alternate governance procedures of the EOC necessarily impinges on existing routines, practices and authorities. Although this has always been a challenge to EOC managers, the acceleration of technological threats and communications makes the resulting inertia ever more problematic.

RESULTING TRENDS

Some general trends in EOC practice can be understood as responses to the ongoing challenges:

- **From Central toward Distributed**: As noted above, EOC functions in many jurisdictions and enterprises are increasingly "democratized" along departmental, geographic or other lines, while at the same time on-scene Incident Command Posts (ICPs) are becoming more capable and sophisticated. As a result, higher-level EOCs often struggle to keep up with "subordinate" center activities (Smith and Simpson, 2005).
- **From Static toward Mobile**: Mobile command facilities are not only a cost-effective way of providing an alternate to a fixed EOC, they also can deployed at incidents that would not traditionally require such sophisticated capabilities. Having a marked mobile command vehicle on scene creates a clear visible presence for the public to see at the site and in the media. A variety of mobile command vehicles have

[2] For example, winter flooding in California's Central Valley typically comes with days of advance warning, whereas earthquakes occur without notice. Hazardous materials incidents must be handled in minutes or hours, while other emergencies may persist for days or weeks. And some emergencies are localized (e.g., air crashes, gas line explosions) while others, such as earthquakes, tsunami and hurricane, threaten a wide area and may involve a complex web of jurisdictions and non-governmental actors.

[3] To some extent this is simply an internalization of the complexity of the private sector and civil government, where inter-organizational relationships only rarely can be reduced to a simple hierarchy.

evolved ranging from relatively simple incident commanders' vehicles to full-blown complexes of multiple tractor-trailer units (Smith and Simpson, 2005).

- **From Reactive toward Proactive**: The threat of terrorism, in particular, has led many government agencies to place increased emphasis on prediction and prevention[4]. Increasingly, other agencies are also being driven to advance action by an increasing ability to predict certain hazards such as heat waves, large storms, power shortages or even civil disturbances. Likewise in the private sector, as high-efficiency practices and just-in-time inventories make enterprises ever more sensitive to fluctuations in their supply-chains, energy or human resources, continual monitoring and advance action are becoming increasingly important to the bottom-line
- **From Intermittent toward Continual**: The rapid onset of many hazards, the growing costs of delayed response and the risks and costs encountered during transitions from normal to emergency modes of operation align to incent a shift toward "always on" systems that scale up or down as required but never entirely deactivate.
- **From Command & Control toward Cooperation & Coordination**: One common trigger for activation of a government EOC is a need to coordinate multiple agencies that do not have a clear command relationship with one another.[5] Likewise, commercial enterprises often rely on webs of material and service providers. In addition, social media are forging new partnerships between formal organizations and emergent communities of interest that have no persistent internal lines of authority.

CHALLENGES FOR CONTINUITY AND CONTINGENCY MANAGEMENT

The traditional strategy of the traditional EOC can be summarized as: "Put the right people together in a room and let them work things out." The essential elements of this strategy are: 1) proper selection of the group of people; and, 2) physical collocation to enable collaboration. Both assumptions are subject to the pressures and trends previously noted. As a result, certain broad challenges face the designers of next-generation Continuity and Contingency Management (CCM) systems.

One challenge is the sharing of knowledge and priorities among a variable set of actors in a flexible and distributed process. Security and auditability rules frequently require that participation in EOC/CCM processes be limited or at least well documented. When these rules cannot be enforced physically at a single location tools are needed for the discovery and authentication of identities and roles, as well as mechanisms for ensuring reciprocity in access-control policies at multiple physical or virtual locations. Thereafter, effective tools are needed for the effective expression of information, opinions, priorities and options across a distributed network of participants.

Equally challenging is the conversion of shared knowledge and priorities into actionable decisions in the absence of strict hierarchical authority. Current EOCs commonly delegate the detailed work of developing intelligence, plans and records to relatively small "breakout groups" in separate rooms. Within those groups a variety of negotiation and consensus-building processes occur. Those interpersonal processes can be the first victims of physically distributed operations. Little of the extensive research into methods for collaborative decision making in distributed environments across organizational boundaries has been applied to EOC practices.

A third challenge is the need for rapid response and smooth transitions between day-to-day and exigent operations. There may appear to be a conflict between the two elements of this challenge, but that can be resolved by understanding both as a need to avoid the delays, confusions and conflicts that arise from "shock loads" on systems that cannot adjust their scale and tempo sufficiently without wrenching dislocation. Thus this challenge can be reframed as a requirement for economically viable day-to-day systems that can adapt seamlessly to extraordinary and unforeseen situations.

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[4] This is particularly common among law enforcement and security agencies, many of which now operate watch, warning or fusion centers on a 24-hour basis.

[5] For instance a wildland fire impinging on an urbanized area in the United States may involve separate police, fire and emergency medical agencies, but also public works, social services and even schools, plus contractors and other non-governmental actors such as the Red Cross, the Salvation Army, and faith- and community-based groups that do not fall under direct governmental "command and control."

IMPORTANCE OF DEMONSTRATION, SIMULATION AND EXERCISE

Emergency management and business continuity—which we call continuity and contingency management (CCM)—deal with the effects of relatively low-frequency events on relatively complex systems. In addition to creating an economic challenge (since such occurrences tend to be of low probability in any conventional accounting period) this also means that these fields can be resistant to simple analytic approaches. Attempts at such analysis may find themselves either "data starved" or confounded by uncontrolled variables (or both.) And yet the complexity of emergencies is itself one of their defining characteristics.

Practitioners in these fields supplement their necessarily limited experience of actual emergencies through simulated exercises of various degrees of formality. While the design and conduct of such exercises have their own challenges (themselves worthy of study and new solutions) such practical studies are an essential counterpart to theoretical analysis. Action Research, Contextual Design, Agile Development and Participatory Design are among paradigms that attempt to bring developers into much closer contact with practitioners in real or simulated situations and to do rapid evolutionary cycles of development, deployment and evaluation.

Not only do demonstrations, simulations and exercises permit concepts to be tested against real-world complexities, but they also provide a mechanism for introducing practitioners to new approaches and tools that they might put into further application, having evaluated them in a low-risk simulated environment.

> "Especially in light of the significant non-technical factors affecting adoption of IT for disaster management, it is critical to establish mechanisms that ensure that researchers are exposed to real problems and that practitioners are exposed to new technology opportunities. Because most practitioners are distributed across local agencies, forging such ties is likely to be harder in disaster management than in sectors like defense, but it is no less important." (Rao, 2007)

Facilities and resources for controlled learning through experimentation and exercise are essential to bridging the gap between research and practice and help bring technical advances and best practices into widespread application.

THE NEXT-GENERATION EOC RESEARCH PROGRAM

As one approach to the challenges and trends of EOC design, and in partnership with the NASA Ames Research Center, the California Emergency Management Agency and a consortium of local jurisdictions and agencies, the Disaster Management Initiative[6] has launched a "Next Generation EOC" project at Carnegie Mellon University's Silicon Valley campus (CMSV). Its facilities include:

- **CCM Lab / EOC Simulator**: In addition to indoor classroom and laboratory spaces the Disaster Management Initiative operates a dual-trailer mobile workspace that can simulate a variety of mobile and space-constrained operations functions.
- **Incident Command Site (the "Smart Bubble")**: The area surrounding the CCM trailers is served by a wireless "Smart Bubble" to support research and exercises of convergent multi-vehicle incident command posts, an increasingly common phenomenon in both urban and wildland operations. The first planned use of this facility will be during an interoperability "plugfest" exercise among multiple mobile EOC and ICP vehicles in association with the California Emergency Management Agency and the California Fire Chiefs Association in May, 2011.
- **Distributed EOC Networks**: Via the Santa Clara Emergency Wireless Network the State of California's emergency satellite network and commercial wireless Internet providers, the CCM Lab maintains dedicated always-on network links to a number of nearby static city, county, regional and state EOCs, thus extending its Smart Bubble services to geographically dispersed sites.

In addition, the CCM Lab can interoperate with the co-located collapsed-structure training facility operated by the NASA Ames Research Center's Disaster Assistance and Rescue Team[7].

Among a wide range of CMSV research activities and topics a number are contributing to CCM system design, including:

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[6] http://dmi.sv.cmu.edu

[7] http://dart.arc.nasa.gov

- **Collaborative Tools for Distributed CCM**
  - Geocam: Geo-oriented imaging for situation assessment and documentation
  - Tactical File System for mobile and distributed data sharing
  - Delay Tolerant Networking for messaging and data harvesting in disrupted environments
  - Hyperwall: Shared visual display surfaces as a tool of collaboration
  - Common Operational Picture / Integrated data visualization
  - Attention management and mitigation of information overload
- **Sensemaking and Engagement in Social Media**
  - Semantic Geotagging and Filtering
  - Social media tracking, analysis and curation
  - Crowdsourced emergency mapping
- **Standards Development and Dissemination**
  - Emergency Digital Exchange Language (EDXL) applications
  - Open Geospatial Interoperability Standards
  - Information and software repository
- **Wireless Data Services and Mobility Platforms**
  - Personal locators and safety monitors
  - Smart Spaces / "Internet of Things"
  - First Responder Mobile Aide

THE DISASTER MANAGEMENT INITIATIVE AT CARNEGIE MELLON UNIVERSITY, SILICON VALLEY

The Disaster Management Initiative brings together public organizations, non-profits, private corporations, technologists and citizens to jointly develop better technical solutions for disaster management, using principles of Action Research, Contextual Design and Participatory Design as enablers for close collaboration between these different sectors in rapid refinement cycles of research, develop, prototype, pilot, evaluate.

The Disaster Management Initiative was specifically created to address challenges and opportunities identified by the disaster management community. Challenges include: motivation of citizen preparedness; availability of open and interoperable technologies and standards to improve communication, coordination and collaboration; and clear policies encouraging smooth multi-jurisdictional collaboration. At the same time, dramatic advances in smart wireless device technology and the power this puts into the hands of citizens drives a rethinking of the relationship between emergency response organizations and the people they are designed to protect.

ACKNOWLEDGMENTS

The contributions and insights of Valerie Lucus-Davis, Lisa Cockerill, Steve Davis, Murray Turoff, Bob Fields, Robert Dolci, the late John Laye and numerous other friends and affiliates of the Disaster Management Initiative were invaluable in the development of this paper and are gratefully acknowledged.

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