Project ENSAYO: A Virtual Emergency Operations Center for Disaster Management Research, Training and Discovery

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Abstract

Disaster management, before, during, and after the event, is dynamic, complex, and ill-defined, and the events themselves are rare and diverse due to the many characteristics that define them. Prior decisions may be thoroughly documented via after action reports, but these may not cover every issue as frequently unique and unanticipated events arise during each emergency. The nature of the decisions, where they are made, who makes them, the data and information resources required to make and monitor them, and the location of available knowledge to drive them may sometimes be unknown, unavailable, or both. This paper describes the research activities of Project Ensayo, which seeks to support and enable multiple research projects investigating processes, functions and structures present at Emergency Operations Centers, including situational awareness, knowledge management, inferences from dynamic data, disaster management and mechanisms of command, control, communication and coordination.

1. Introduction

"Hurricane Katrina was an extraordinary act of nature that spawned a human tragedy. It was the most destructive natural disaster in American history, laying waste to 90,000 square miles of land, an area the size of the United Kingdom. In Mississippi, the storm surge obliterated coastal communities and left thousands destitute. New Orleans was overwhelmed with flooding. All told, more that 1500 people died. Along the Gulf Coast, tens of thousands suffered without basic essentials for almost a week.

But the suffering that continued in days and weeks after the storm passed did not happen in a vacuum, instead, it continued longer that it should have because of – and was in some cases exacerbated by – the failure of the government at all levels to plan, prepare for and respond aggressively to the storm. These failures were not just conspicuous; they were passive. Among the many factors that contributed to these failures, the Committee found that there were four overarching ones: 1) long-term warning went unheeded and government officials neglected their duties to prepare for forewarned catastrophe; 2) government officials took insufficient actions or made poor decisions in the days immediately before and after landfall; 3) systems on which officials relied on to support their response efforts failed; and 4) government officials at all levels failed to provide effective leadership. These individual failures, moreover, occurred against a backdrop of failure, over time, to develop the capacity for a coordinated, national response to a truly catastrophic event, whether caused by nature or man-made." [1]

A critical part of natural disasters involve dynamic decision-making before, during and after the events [2, 3]. The Stafford Act establishes the federal programs and processes used by the federal government for

granting both emergency and major disaster aid to individuals, profit and non-profit organizations, local governments and states. Depending on the type of disaster, emergency or major disaster, the President will engage the federal government in emergency response activities (e.g., debris removal, temporary housing, distribution of food and medicine). Restoration efforts following emergencies are estimated to require less than US $5M, while major disasters are estimated to require more than this amount. In December of 2005, the US Department of Homeland Security (DHS) issued the National Response Plan (NRP) as a comprehensive framework for the management of emergencies of national significance within the National Incident Management System (NIMS), and Incident Command System (ICS) as the incident management organization (command, operations, planning, logistics, and finance/administration). A careful investigation of the government response to Hurricane Katrina, one of the major natural disasters in the history of the United States, reveals widespread dissatisfaction with the results following the government's overwhelmed capabilities to respond [4].

In fact the lessons learned from Katrina were very similar to those identified with Hurricane Andrew, which occurred ten years prior (showing that there hasn't been much advancement in this area) and include: "(1) clearly defining and communicating leadership roles, responsibilities, and lines of authority for catastrophic response in advance of such events, (2) clarifying the procedures for activating the National Response Plan and applying them to emerging catastrophic disasters, (3) conducting strong advance planning and robust training and exercise programs, and (4) strengthening response and recovery capabilities for a catastrophic disaster" [4]. Local emergency response protocols are defined by the NRP and the ICS. The number of organizations involved in emergency response ranges depending on the magnitude of the disaster. For example, it's estimated that around sixty organizations at the federal level alone, were involved in the recovery efforts following hurricane Katrina. Furthermore, voluntary organizations, for example the International Federation of Red Cross as well as local voluntary organizations, may follow a different set of protocols [2, 3].

Disaster management, the focus of Project Ensayo, is becoming an increasingly important topic of research as evidenced by recent events such as hurricanes Katrina and Rita, and the 2004 Indian Ocean tsunami, as well as by other disasters such as earthquakes, forest fires, floods and severe winter storms, and from civil disturbances (campus shootings, WTO protests), infrastructure failures (power failures, aircraft disasters, industrial accidents) and terrorism events. Disaster management, before, during, and after the event, is dynamic, complex, and ill-defined. Decision-making is often distributed, ad hoc, and made by individuals and institutions that do not normally interact, whose routines may not be sufficiently defined, relevant, or even known, and may lack substantial "institutional" memory as the institution itself is both emergent and ephemeral.

2. Miami-Dade EOC

The state of Florida, considered one of the most effective in disaster management, has designated the State Emergency Response Team (SERT) with the mission to "Ensure that Florida is prepared to respond to emergencies, recover from them, and mitigate against their impacts". The SERT has identified eighteen hazards that pose an emergency threat to Florida, which are: 1) wildfires, 2) thunderstorms, 3) tornadoes, 4) lightning, 5) flood, 6) terrorism, 7) drought, 8) heat waves, 9) hurricanes, 10) cold, 11) animals, 12) nuclear, 13) hazardous materials, 14) cyber attacks and information warfare, 15) space weather, 16) aircraft, 17) bombs, and 18) earthquake. The division is organized into four bureaus: compliance planning and support, policy and planning, preparedness and response, and recovery and mitigation. The Bureau of Preparedness and Response is responsible for developing and maintaining the State's ability to effectively respond to a wide variety of threats and has two sections preparedness and response. The Response Section coordinates emergency response at the state level, and provides the necessary technical assistance to county governments. The Miami-Dade County Office of Emergency Management (OEM) is the lead agency in an emergency event. The Emergency Operations Center (EOC) is the site for all of the emergency management operations.

In order to respond to a hurricane emergency, the EOC is organized under the ICS with Operations, Planning, Logistics, and Finance and Administration. Figure 1 depicts the floor plan organization for the operation of the EOC. Furthermore, Operations depends on a large array of organizations that are organized into three branches: the Public Safety Functional Group Branch, the Human Services Functional Group Branch, and the Infrastructure Functional Group Branch [5]:

i. Public Safety Group Branch. The Public Safety Functional Group Branch includes, but is not limited to, the following organizations: National Park Service, Florida Fish and Wildlife Conservation Commission,

US Coast Guard, the Department of Environmental Resources Management (DERM), Miami-Dade Fire Rescue Dept., Florida National Guard, Animal Services, Miami-Dade Corrections Dept., Florida Dept. of Law Enforcement, Florida Highway Patrol, and Miami-Dade Police Dept. The Public Safety Manager Branch Director coordinates the activities of the public safety functional group, with the assistance of the Public Safety Assistant.

ii. Human Services Group Branch. The Human Services Functional Group Branch consists of, but is not limited to, the following organizations: Dept. of Human Services, Team Metro, Salvation Army, Greater Miami Convention and Visitors Bureau, American Red Cross, Miami-Dade County Public Schools, Miami-Dade Voluntary Organizations Active in Disaster (VOAD), Dept. of Mental Health, Miami-Dade Housing Agency, Florida Dept. of Children and Families, Miami-Dade County Health Dept., Florida Agency for Health Care Administrators (AHCA), and the Miami-Dade Fire Rescue Emergency Management Services. The Human Services Manager Branch Director coordinates the activities of the Human Services Functional Group Branch, with the assistance of the Human Services Assistant and the Special Needs Coordinator.

iii. Infrastructure Group Branch. The Infrastructure Functional Group Branch consists of, but is not limited to, the Miami-Dade Solid Waste Dept, Miami-Dade Water and Sewer, South Florida Water Management District, Miami-Dade Transit-Regular Services, Miami-Dade Transit Evacuation, Miami-Dade Public Schools, Miami-Dade Public Works, Florida Dept. of Transportation, Miami-Dade Parks Dept., Agriculture Extension, City Gas Comcast, Miami-Dade Enterprise Technology Services Dept. (ETSD), BellSouth, and Florida Power & Light, the airports, and the Port of Miami. The Infrastructure Manager Branch Director coordinates the activities of the Infrastructure Manager Branch with the assistance of the Infrastructure Assistant. The Operations Section Manager coordinates the activities of the three functional groups branches, with the assistance of the EOC Support Manager, the Operations Section Assistant, and the Planning Situation Assessment Assistant.

A number of additional organizations are represented in the periphery of the EOC: Florida Division of Emergency Management (DEM), neighboring county's emergency management liaisons (including Monroe County, Broward County, Florida City, Martin County, and Collier County), and the Divisional EOCs (Miami Beach, North Miami, North Miami Beach, Homestead, Coral Gables, Hialeah, and the city of Miami). In addition, representatives from Homestead Air Force Reserve Base and FEMA are also included. Many other agencies are called upon following a disaster event.

During such events, critical decisions must be made that involve cross-organizational and cross-agency coordination, and sharing of data, information and knowledge. As these events and their contexts are infrequent and varied, the nature of the decisions, where they are made, who makes them, the data and information resources required to make and monitor them, and the location of available knowledge to drive them may sometimes be unknown, unavailable, or both. At the Miami-Dade EOC decisions are thoroughly documented via after action reports that cover a period of twelve hours before, during, and after the hurricane. But even though the Miami-Dade EOC is disciplined about recording the necessary documentation to prevent loosing their corporate memory, these after action reports may not cover every issue that needs to be dealt with during an emergency, as frequently unique and unanticipated events arise during each emergency. Furthermore, people may leave the organization, due to attrition or retirement, and some of the informal rules that serve as the "glue" that affords the very ability to function may be lost.

Finally, coupled with these events are also the unlikely, but not inconsequential, coincidental disasters, which have been essentially unexplored. There are associated and substantial risks associated with coincidental events of terrorist opportunity, for example, where airborne bio-terrorism agents could be released during a hurricane. This would result in data being available, but essentially masked, within the structure and dynamics of unfolding events, resulting in few if any decisions made regarding the masked attack. One mechanism to explicate, educate, and replicate these rules, both formal and informal, is through a computational discovery infrastructure for disaster management. That environment is called Ensayo.

3. Project Ensayo

Project Ensayo is a large, multidisciplinary effort that is focused on building a computational discovery infrastructure to examine the decision-making and organizational complexities that arise from unique, complex, and significant events associated with the management of disasters, such as recovering from a hurricane in South Florida. Project Ensayo will support and enable multiple research projects investigating processes, functions and structures present at EOCs, including situational awareness, knowledge management, inferences from dynamic data, and mechanisms of command, control, communication and

coordination. The project team includes researchers from multiple universities: Florida International University (FIU), Emory University, University of Notre Dame (ND), and University of Puerto Rico-Mayaguez (UPR-M); academic departments (computer science, management information systems, electrical engineering), research disciplines (knowledge management, sensor networks, software development, cognitive science, computational discovery, human and social dynamics), and key external partners (Miami-Dade EOC, City of Miami, IBM, Florida Power & Light, and Public Health). The proposed Virtual EOC (vEOC) will support and enable multiple current and future research projects that would not be possible without the Ensayo vEOC.

The researchers are designing and developing, and will deploy and operate a virtual EOC that will enable and support research on dynamic decision-making, decision support and knowledge management in the context of predefined organizational structures to coordinate cross-institutional management of disasters. The research infrastructure that will be designed and implemented in Project Ensayo will model of the infrastructure Miami-Dade EOC. The project goal is to connect Ensayo to every key decision-making office in the Miami area that is responsible for decisions under the scenarios addressed, within the EOC context.

A review of the literature in emergency response systems reveals that the disciplines of operations research and management science had a significant impact during the 1970s, which led to the implementation of substantially new policies and practices in policing and firefighting [6, 7]. On the other hand, recent disaster events, both in the US and

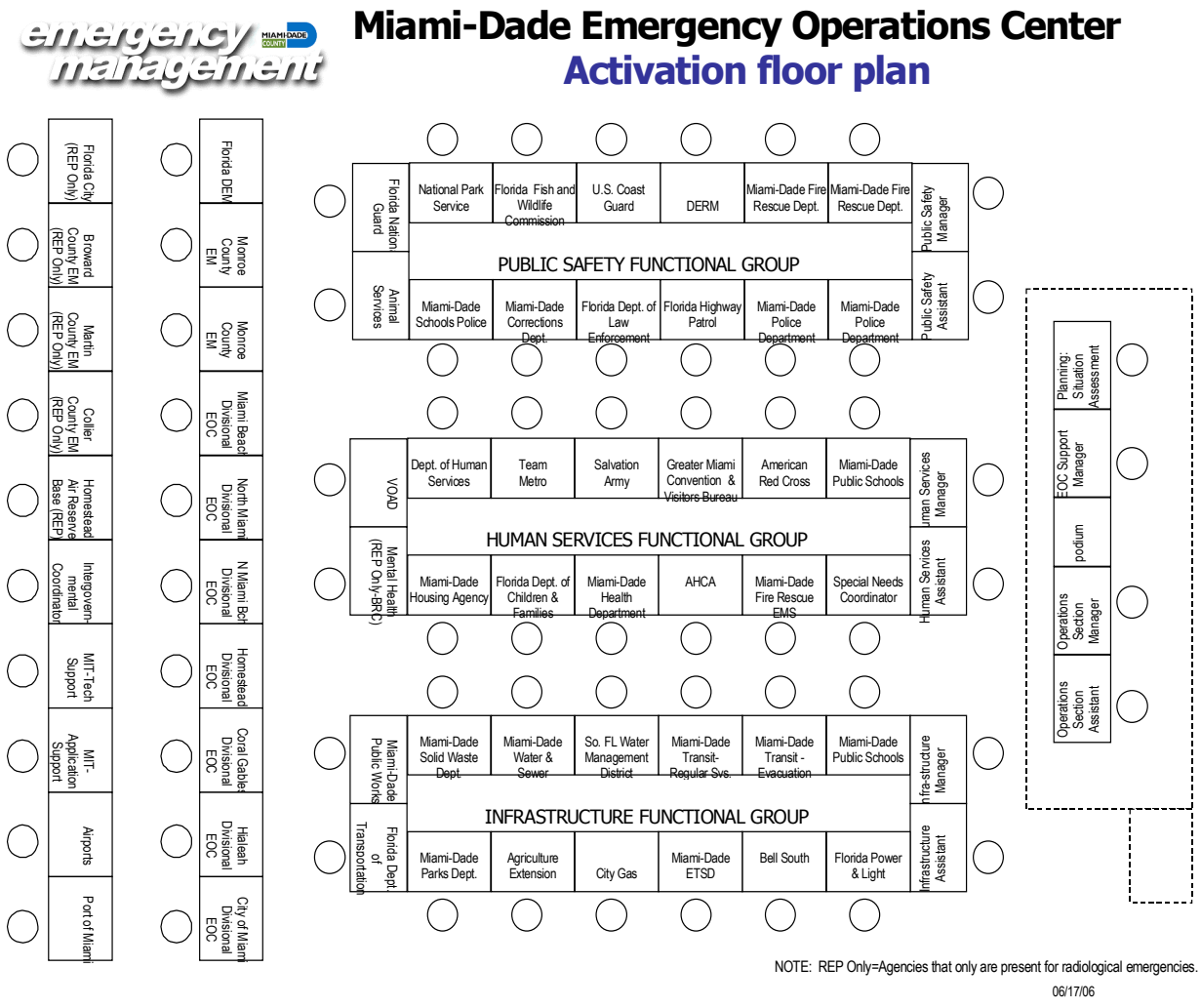

Figure 1. Miami-Dade Emergency Operations Center Floor Plan

around the World, have attracted our interest in this area as we witness that "some of these once-successful models have faded from use … while we observe the relative scarcity of papers on emergency services in recent years and ask whether the new attention on homeland security and emergency preparedness may presage renewed interest and activity in model development and application in these area" [8]. In addition, innovative computational discovery techniques make possible new research approaches those were perhaps technologically or economically infeasible during the height of the emergency modeling of the 1970s [8]. Finally, computational discovery techniques also enable the study of 9/11-type events, which are non-routine type emergencies that offer no practical ways to be validated.

In summary project Ensayo, the vEOC, will serve the following research objectives:

i. A research-enabling environment and infrastructure - to enable the research of knowledge management and collaboration issues in complex environments, such as those arising when managing disasters.

ii. A test-bed for policies, processes, best practices and disaster management technologies - aimed at improving both the effectiveness and efficiency in the management of disasters.

iii. An education and training facility for students, managers, and EOC staff across the world - by providing a pedagogical infrastructure for students on-site (same place) or off-site (different place), collaborating with other physical entities (real actors) or artificial agents (virtual actors).

The development of the vEOC is in itself an innovative research project, which requires the development of a collaboration platform to support Same-place or Different-place collaboration of EOC participants. At the same time the vEOC requires the development of Virtual actors (artificial agents) capable of collaborating with Real actors (physical agents) in a variety of scenarios. This project will enable the research team to set up and test the infrastructure for inter-university and inter-organizational collaboration, including both private and public organizations, and to enable the research and training that will support degree programs that the faculty and graduate students, many of them representing minority groups, will benefit from. The first task in developing this research is to model the business processes at the EOC, which is discussed in the next section.

4. Modeling of the EOC business processes

As we venture in the disaster management research arena, we understand that a meaningful model of the EOC cannot be developed without intimate knowledge of the organization, its operation, and it's objectives [8]. A methodology must be developed to accurately capture how decisions are made in the EOC, that is, how to codify the events that ensue when managing a disaster. As part of this research, a protocol will be developed to objectively collect and annotate observations that represent how the disaster is actually managed. This protocol may include talk-aloud, articulating decisions in terms of the domain, video and audio recording. The process mapping effort will include coding at the organizational level, taking into considerations 1) how the organization members interact (who talks to whom), 2) organizational communication network analysis, including identifying patterns and hubs, and 3) examples of miscommunications (that is, when decisions are made outside the EOC network). For this purpose, our team has already started to collaborate at the EOC during its periods of activation. For example, the project lead and two PhD students participated at the EOC during its activation before, during, and after Tropical Storm Ernesto last August. This particular event enabled the researcher team to better understand the operation dynamics at the EOC, the role that technology currently plays in supporting this environment, and the potential areas for research in this area. The first step in the development of the Ensayo Virtual EOC is to understand the decision and communication processes that the existing EOC infrastructure supports.

In order to begin mapping the business processes of the EOC we selected one of the standard operation procedures (SOPs) that define the work of the Infrastructure Group following a disaster. The following figure was developed using the Rational Rose Development Tool in order to map the interactions of the actors that collaborate in the Infrastructure Group. Figure 2 is the top level that defines the top-level business process model for the Energy standard operating procedure, which is one of the responsibilities of the Infrastructure Group. Each of the major processes depicted in the middle of Figure 2, can be furthermore be detailed by zooming into each of the entailed sub-processes.

5. Conclusions

Project Ensayo is being developed in conjunction with the Miami-Dade Emergency Operations Center. Such emergency centers are "organizations" but suffer from the lack of normal conditions that permit organizational learning in the traditional sense. The

participants are fluid and carry little organizational knowledge, the events are rare and diverse, the complexity of interactions within and between organizations is high and time-sensitive, and the pressures and risks are enormous. We envision that Ensayo will contribute to research and education to better allow, and even to assist, such centers in their time of need.

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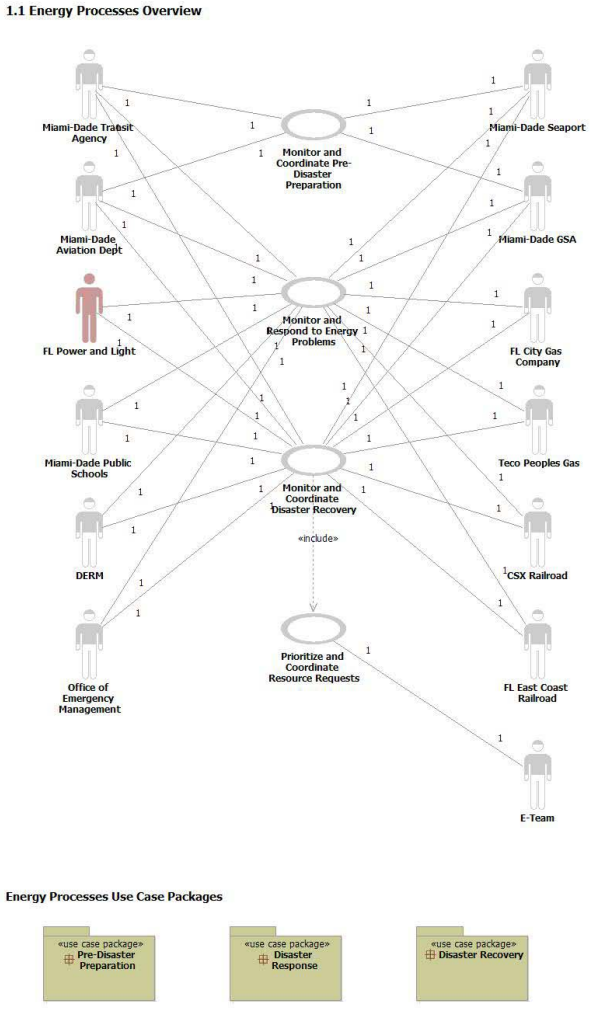

Figure 2. Top Level Business Process Model for the Energy SOP of the Infrastructure Group

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