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Geospatial Information: The Future of Situational Awareness During Complex Catastrophes

by

Colonel Kevin Julius Quarles
United States Army

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Complex catastrophes are capable of causing significant casualties and extensive infrastructure damage. In extreme cases, they can trigger cascading effects that could threaten national security. Over the last decade there have been significant improvements in disaster response planning and emergency communications. However, there is a gap in the communications capability between the personnel coordinating disaster response operations and the victims who need assistance. The public needs an alternative method of communications to request help when phone service is unavailable. If left unsolved, during complex catastrophes this gap could lead to preventable casualties and unnecessary damage. Many government, private and volunteer organizations already use geospatial information during disasters to build situational awareness. Our disaster preparedness plans and policies need to incorporate the public's use of social media with embedded geospatial information as a tool to build situational awareness and provide the public with an alternate method of emergency communications.

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by

Colonel Kevin Julius Quarles
United States Army

Dr. Allen S. Miller
Center for Strategic Leadership and Development
Project Adviser

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U.S. Army War College
CARLISLE BARRACKS, PENNSYLVANIA 17013

Abstract

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Complex catastrophes are capable of causing significant casualties and extensive infrastructure damage. In extreme cases, they can trigger cascading effects that could threaten national security. Over the last decade there have been significant improvements in disaster response planning and emergency communications. However, there is a gap in the communications capability between the personnel coordinating disaster response operations and the victims who need assistance. The public needs an alternative method of communications to request help when phone service is unavailable. If left unsolved, during complex catastrophes this gap could lead to preventable casualties and unnecessary damage. Many government, private and volunteer organizations already use geospatial information during disasters to build situational awareness. Our disaster preparedness plans and policies need to incorporate the public's use of social media with embedded geospatial information as a tool to build situational awareness and provide the public with an alternate method of emergency communications.

Geospatial Information: The Future of Situational Awareness During Complex Catastrophes

> Survivable, resilient, enduring, and effective communications, both domestic and international, are essential to enable the executive branch to communicate within itself and with: the legislative and judicial branches; State, local, territorial, and tribal governments; private sector entities; and the public, allies, and other nations. Such communications must be possible under all circumstances to ensure national security, effectively manage emergencies, and improve national resilience.
>
> —Barack Obama[1]

Disaster response technology and concepts used by officials during catastrophes have evolved significantly over the last decade, but there remains areas for further improvement. One of these areas is how disaster response officials gain and maintain situational awareness in order to provide effective and efficient disaster response. This paper examines the current and potential use of geospatial information to build and maintain situational awareness during a complex catastrophe and provides recommendations for actions to protect the Nation during these types of events.

Saving lives, treating the wounded, and mitigating further damage are time sensitive critical activities. In order to accomplish those activities, government organizations at all levels, private industry and volunteers have to gain and maintain situational awareness so they can coordinate disaster response activities. At the fundamental level, establishing situational awareness means analyzing voice, data, and visual information to make decisions. These inputs form the core information that support the decision making process across several domains (land, air, sea, space, and cyber), depending on the crisis. There are three key factors that impact establishing situational awareness during a complex catastrophe: (1) the physical infrastructure that supports disaster response communications; (2) communications protocols and

operating standards; and (3) the stakeholders. The author has intentionally prioritized the general public, putting it at the top of the list of stakeholders because improving public safety is the central purpose of this thesis.

The paper is organized into six chapters. The first chapter includes the definition of a complex catastrophe; potential threats to national security when a catastrophe triggers cascading effects and difficulties in establishing situational awareness during relief operations. The second chapter includes a review of the key Presidential Directives, federal laws, and Department of Homeland Security (DHS) plans and policies that establish the need for disaster response situational awareness. Chapter three includes an analysis of complex catastrophe case studies and computer simulations. These examples are compared against the National Emergency Communications Plan to restore commercial and emergency communications and form the basis for recommendations contained at the end of the thesis. The fourth chapter examines the use of geospatial information to create crisis maps during the 2010 earthquake in Haiti. The fourth chapter also includes the growth of not-for-profit crisis mapping organizations and how the use of their information by relief agencies improved overall situational awareness. The fifth chapter summarizes the DHS development of Geospatial Concept of Operations (GeoCONOPS) to integrate federal agencies during disaster response. It also includes the Department of Defense (DOD) requirement to conduct Defense Support to Civil Authorities and the United States Northern Command's use of the Situational Awareness Geospatial Enterprise, (SAGE). The final chapter includes a brief summary, recommendations to incorporate the use of

geospatial information into the National Response Framework, followed by a brief conclusion.

Chapter One

Introduction to Complex Catastrophes with Cascading Effects

Complex catastrophes are difficult to predict, occur relatively infrequently, but have the potential for devastating consequences. One recent example of a complex catastrophe with cascading effects occurred on March 11, 2011. At 2:46 p.m. local time, a magnitude 9.0 deep-sea earthquake struck the eastern coast of Honshu, Japan's largest island. The earthquake and subsequent tsunami caused a complex catastrophe with cascading effects for Japan. In all, 15,700 people were killed, thousands more were injured and some were swept out to sea and never recovered. The disaster caused significant infrastructure failures; 332,395 buildings, 2,126 roads, 56 bridges and 26 railways were destroyed or damaged.[2] The combined effects of the earthquake and tsunami created a series of cascading failures that overwhelmed the workers at two of Japan's nuclear power plants. The core reactor at the Fukushima Daiichi nuclear power plant suffered a complete meltdown and required the mass evacuation of 170,000 people from a 20km radius around the plant. Another 30,000 people were evacuated from a 10km radius around the Fukushima Daini power plant, the second nuclear facility damaged during the disaster.[3] The next section will examine the definition of a complex catastrophe and the implications to U.S. national security.

Definition of a Complex Catastrophe

The Department of Homeland Security and the Department of Defense use slightly different definitions to describe a "complex catastrophe". The Department of Homeland Security National Response Framework uses the term "complex incident".

The origins of this term come from the Post-Katrina Emergency Management Reform Act of 2006. The Reform Act defines a complex incident as,

> any natural or manmade incident, including an act of terrorism, that results in extraordinary levels of casualties or damage, mass evacuations, or disruption severely affecting the population, infrastructure, environment, economy, national morale, or government functions in an area and may include an incident with a sustained national impact over a prolonged period of time, that may rapidly exceed resources available to State and local government and private-sector authorities in the impacted area, or may significantly interrupt governmental operations and emergency services to such an extent that national security could be threatened.[4]

In February of 2013, the Deputy Secretary of Defense for Policy authorized the term "Complex Catastrophe" for use by the DOD.[5] The primary difference between the definitions is the DHS version includes the requirement to coordinate a rapid federal response. This is because the DHS is the lead federal agency during natural disasters.[6] The DOD version omits this language because they are a supporting agency to DHS and the Federal Emergency Management Agency (FEMA), the subordinate organization that coordinates disaster response. The DOD definition is found in Joint Publication 3-28, *Defense Support to Civil Authority*. Joint Publication 3-28 defines a complex catastrophe as,

> any natural or man-made incident, including cyberspace attack, power grid failure, and terrorism, which results in cascading failures of multiple, interdependent, critical, life-sustaining infrastructure sectors and causes extraordinary levels of mass casualties, damage or disruption severely affecting the population, environment, economy, public health, national morale, response efforts, and/or government functions.[7]

As highlighted during the nuclear power plant example, one of the secondary effects of complex catastrophes is the potential for chain reaction failures of other systems. The term 'cascading effects' is used to describe this scenario, and depending

on the severity, the entire United States could be affected. The next section will provide a few examples of how cascading effects can impact the entire country.

Cascading Effects can Threaten National Security

A complex catastrophe can trigger cascading effects, such as the earthquake and tsunami that led to the Fukushima Daiichi nuclear power plant disaster. In extreme cases, cascading effects can threaten national security. Examples include long-term disruption to the global financial markets; widespread agricultural failures and distribution to food supplies; severe damage to the defense industrial base that threatens production and maintenance of major weapons systems; damage to energy infrastructure that causes widespread prolonged blackouts; and regional damage to transportation networks that causes severe supply chain disruptions. These examples are considered Critical Infrastructure and Key Resource (CIKR) sectors and the protection of these resources is vitally important to "the American way of life."[8]

A regional supply chain disruption is one example of how a complex catastrophe could affect the Nation. If it occurs in a multi-state area, the secondary and tertiary effects have the potential to damage the national economy. For example, the average car contains 14,000 parts. These parts are made by vendors from around the globe and delivered to factories as assemblies in order to maximize production. Examples include engines, transmissions, dash boards, wheels, brakes, wiring harnesses, etc. Delays in the delivery of the raw materials used to make the parts, or the assemblies impacts the company's bottom line. When manufacturers are surprised by disasters and unable to replace supplies, repair damaged facilities, or overcome shipping delays, there are business consequences that can have lasting effects.[9] At the 2013 World Economic Forum, a group of leading experts met to discuss building resilience in supply chains.

Using research provided by the Accenture Corporation, the group concluded that supply chains are not designed to function efficiently during low probability but highly disruptive events. After examining 62 case studies of businesses that experienced supply chain disruptions, the average company lost 7% of its shareholder value. The study also concluded that shareholder loss was directly tied to the length and severity of the disruption and share prices were slow to recover.[10] Following a catastrophe with cascading effects, it could take years to rebuild all the damaged infrastructure. The U.S. could suffer strategic supply shortages due to transportation disruptions and limited availability of scarce resources. In this scenario the U.S. economy will be damaged, the severity will be proportional to the number of affected industries and the length of the supply chain disruption. A more detailed review of past catastrophes is contained in chapter three in order to establish a benchmark for U.S. disaster preparation.

Difficulties in Gaining Situational Awareness

Gaining situational awareness following a major disaster is always challenging. There are tens of thousands of local, state, federal, tribal, and territorial departments who perform emergency support functions across the Nation. These departments and agencies operate in different domains: land, air, space, sea, and cyberspace. And in many cases, these departments require unique elements of information to create a common operating picture. There are also hundreds of Private Volunteer Organizations (PVO), and Non-Governmental Organizations (NGO) who provide disaster response capabilities and they use different methods of communication. Collectively, this federation of uniformed personnel, private business owners, volunteers, government organizations and individuals make up the stakeholders who conduct disaster response. The information and the organizations requiring it are dispersed and diverse, and this

creates interoperability challenges. Therefore, gaining and maintaining situational awareness remains difficult. The next chapter is a review the executive orders, laws, plans and policies that guide and direct the stakeholder's activities.

Chapter Two

Presidential Directives

There are several key Presidential Directives that identify responsibility for establishing systems and processes for the stakeholders to protect the homeland during complex catastrophes. On 28 February 2003, President George W. Bush signed Homeland Security Presidential Directive-5 (HSPD-5), *Management of Domestic Incidents.* HSPD-5 assigned the Secretary of Homeland Security as the Principal Federal Officer for coordinating disaster response and directed the establishment of a National Incident Management System (NIMS) to protect the homeland against terrorist threats, disasters and other emergencies.[11] In December of 2003, President Bush issued Homeland Security Presidential Directive-7 (HSPD-7), *Critical Infrastructure Identification, Prioritization and Protection.* HSPD-7 established the requirement to identify and prioritize the Nation's Critical Infrastructure and Key Resources (CIKR) and to protect it from terrorist attacks.[12] HSPD-7 was superseded and is discussed later in this chapter.

Originally established in December of 2003, Homeland Security Presidential Directive-8 (HSPD-8), *National Preparedness,* established preparedness goals, standards and listed specific threats to national security. In March of 2011, President Obama updated the original document and signed Presidential Policy Directive-8 (PPD-8). PPD-8 which emphasizes the whole of government approach to disaster response and adds several new and significant threats to national security; acts of terrorism;

cyber-attacks; pandemics; and catastrophic natural disasters. Under PPD-8, each of the supporting agencies and departments is required to identify the core capabilities they must possess to protect the Nation from those threats. PPD-8 also establishes the requirement for the Secretary for Homeland Security to report to the President on the federal agencies' progress in accomplishing the National Response Goals.[13] Goal 5.4 specifically addresses the need for rapid recovery from a catastrophic event:

> Catastrophic events produce changes in habitability, the environment, the economy, and even in geography that often can preclude a rapid return to the way things were. Our national ability to stabilize the affected area is key to saving and sustaining lives, enabling the delivery of an effective response, and building the foundation for recovery. Coordination and unity of effort between individuals, businesses, nonprofit organizations, and local, tribal, territorial, state, and federal governments is vital to recovery efforts. Individuals, businesses, nonprofit organizations, local, tribal, state, and federal governments all have responsibilities in disaster recovery, underscoring the need to improve coordination and unity of effort.[14]

In order to accomplish this goal, President Obama signed Presidential Policy Directive-21 (PPD-21) on February 12, 2013. PPD-21 supersedes HSPD-7 and places additional importance on the need for critical infrastructure security and resilience. This directive identifies sixteen areas of strategic interest that are considered CIKR. PPD-21 also assigns responsibility to several federal agencies and departments to ensure the CIKR is protected from damage or attack.[15] These Presidential Directives provide the authority and responsibility for the DHS to plan, coordinate, and execute disaster preparation and response operations. The next section examines the President's authority to conduct Federal disaster response. It also covers the National Response Framework (NRF), the National Incident Management System (NIMS), and the policies that regulate the national emergency management communications architecture.

Federal Law and Policies that Require Situational Awareness

The Robert T. Stafford Disaster Relief and Emergency Assistance Act of 1988 defines the President's authority when responding to a state's request for disaster relief. The process starts after the Governor declares a state of emergency and makes a formal request to the President for federal disaster assistance. Once the President makes an emergency disaster declaration, FEMA is responsible for coordinating the disaster response activities of the whole community.[16] It is important to note that a Governor may request Federal assistance before a disaster occurs, as in the case of an approaching hurricane. This allows for additional preparation and evacuation to avoid unnecessary loss of life and property damage. However, storm severity and damage is still extremely hard to predict, even with advanced warning.

In July of 2006, Congress enacted new legislation in the aftermath of Hurricane Katrina to correct gaps in statutory authority, inadequate organizational structure, and planning and communications shortcomings. The Post Katrina Emergency Management Reform Act established new authorities for the DHS and FEMA. Specifically, the new law directed the reorganization of FEMA, clarified FEMAs principle mission and core functions, and revised federal emergency management policies.[17] As mentioned previously, there are still significant challenges associated with disaster response communications and additional reforms are needed. Since the Post Katrina Emergency Management Reform Act, FEMA, new plans and policies were created to improve disaster response. This included new legislation designed to strengthen the national emergency communications architecture and assign responsibility for policy development and restoration in the event of a communications failure.

On 6 January 2005, the DHS published the National Response Plan (NRP). This document called for the establishment of new organizational structure and protocols to improve interagency coordination during federal disaster response.[18] The NRP introduced several key concepts that are still in use today, including the “all hazards” approach to preparing for disaster response. This approach calls for the integration of individuals, private businesses, emergency management agencies and organizations that are critical to establishing and maintaining core response capabilities.[19]

To facilitate planning by federal agencies and accelerate employment of their resources, FEMA developed Pre-Scripted Mission Assignments (PMAs).[20] Many of the departments and agencies maintain quick reaction capability to execute pre-scripted missions. A separate document called the National Response Framework-Complex Incident Annex (NRF-CIA), directs the establishment of pre-identified, rapidly deployable federal agency emergency response teams. These teams immediately augment the local and state response forces.[21] The National Response Framework-Complex Incident Supplement (NRF-CIS), provides the operational details of how FEMA executes this plan in cooperation with the affect State.[22]

The NRP also directed the establishment of a permanent operations center to coordinate the activities of the whole community. The National Operations Center (NOC) is manned 24/7 and fuses intelligence, law enforcement, disaster information and reports from private industry to establish a common operating picture for DHS. The NOC has five separate subordinate headquarters to coordinate disaster response and protection of CIKR: National Response Coordination Center, National Infrastructure Coordination Center, Interagency Watch, Information and Analysis Component and

Operational Planning Element.[23] In order to synchronize activities and planning efforts between federal response agencies and the industries that own and maintain non-governmental CIKR, the NOC collaborates on the Homeland Security Information Network (HSIN). HSIN is a secure, web-based application that provides 24/7 situational awareness of terrorist threats and emergencies to all subscribers. HSIN provides all source reporting from multiple local, state, and federal agencies; supports instant messaging and real time chat; and provides a forum to share geospatial data.[24]

The National Response Framework (NRF) replaced the National Response Plan of January 2008. The latest version of the NRF was published in May of 2013. The NRF expanded the interagency approach to disaster response and calls for "whole community" approach to accomplishing the National Response Goals identified in PPD-8.[25] The NRF also clarified primary and supporting responsibility for core emergency response capabilities and acknowledges the need for disaster response officials to gain and maintain situational awareness. The NRF defines this requirement under Capability Number Eleven, Operational Communications. The objective of this capability is to, "ensure the capacity for timely communications in support of security, situational awareness, and operations by any and all means available between affected communities in the impact area and all response forces."[26]

There are two critical tasks that support this objective. The first is to, "ensure the capacity to communicate with both the emergency response community and the affected populations and establish interoperable voice and data communications between local, state, tribal, territorial, and Federal first responders." The second is to, "reestablish sufficient communications infrastructure within the affected areas to support

ongoing life-sustaining activities, provide basic human needs, and transition to recovery."[27] The language in Capability Number Eleven is significant because it establishes the requirement for Federal first responders to have interoperable communications with other agencies, departments, and the general public in the affected area. Capability Number Eleven provides the connection between the Presidential Directives and Homeland Security Presidential Directives at the national level, with the actual integration of the general public and the whole community at the scene of the disaster.

The second significant development in planning was the creation of a core set of principles and protocols that standardized incident management across the country. HSPD-5 required the establishment of the National Incident Management System (NIMS).[28] NIMS provides a universal standard for incident command and control and promotes interoperability between emergency response departments, highlights the need for mutual support agreements, and defines the roles of NGOs and public officials in incident management.[29] The Incident Command System (ICS) established in NIMS promotes collaborative information sharing and, in the event of multiple emergency locations, collaborative decision making. NIMS identifies the need for standardized response functions within the incident command system; operations, planning, logistics, and finance. It also includes special staff functions that support public information, safety, and the need for liaison officers. NIMS also provides guidance on incident command and succession of command.[30] The next section focuses on the authority of the President to authorize federal resources to conduct disaster response.

On July 6 2012, President Obama signed Presidential Executive Order 13618, *Assignment of National Security and Emergency Preparedness Communications Functions*, which identifies the need to integrate the communications of domestic and international agencies in order to respond to emergencies and build disaster resilience.[31] In response to this order, DHS designated the Office of Emergency Communications (OEC), as the primary agency to ensure the interoperability of emergency communications at all levels of government and facilitate restoration of those systems in the event of disruption.[32] The OEC developed the National Emergency Communications Plan (NECP), to support this goal. Chapter three includes a detailed description of the NECP and a case study comparison to determine what recommendations are needed to improve complex catastrophe situational awareness.

Chapter Three

Complex Catastrophe Case Studies

The National Infrastructure Simulations and Analysis Center (NISAC), a subordinate element of the Office for Infrastructure Protection within the Department of Homeland Security, provides computer based modeling analysis of the Nation's CIKR in order to assess, "infrastructure risk, vulnerability, interdependencies, and event consequences."[33] The DHS and FEMA use NISAC threat stream analysis to shape policy, develop national level response plans, and provide products to HSIN subscribers. NISAC analysis includes dealing with the effects of a pandemic influenza outbreak, disruptions to the global financial markets and payment systems, the loss of power grids and high-voltage transformer failure, chemical supply chain disruption, Atlantic and Gulf Coast hurricane analysis, and earthquake modeling.[34] One of the most significant threat models NISAC has produced is the New Madrid Seismic Zone

earthquake scenario. This scenario highlights the potential challenges disaster response officials could have with gaining situational awareness and being able to communicate with disaster victims.

In October of 2009, the Mid-America Earthquake Center published a report on the potential damage caused by another catastrophic earthquake in the New Madrid Seismic Zone.[35] The New Madrid Seismic Zone consists of three separate fault lines that connect the cities of St Louis and Memphis. The fault lines include the bordering states of Tennessee, Kentucky, Illinois, Missouri and Arkansas and extend into Alabama and Mississippi in the south and Indiana in the north.[36] The Mid-America Earthquake Center report indicated that the fault lines are connected and each is capable of producing a magnitude 7.7 earthquake over the length of the entire fault line. This scenario would cause a complex catastrophe with the most extensive damage occurring in Tennessee, Missouri, and Arkansas.

Using a peer review to confirm the computer modeling, the Mid-America Earthquake Center estimates that the rupture of all three fault lines would cause “86,000 injuries and fatalities; damage 715,000 buildings and 3,500 bridges; cause 425,000 breaks and leaks to both local and interstate pipelines; leave 2.6 million homes without power; damage 130 hospitals; and displace 7.2 million people across the eight-state region.”[37] The report also indicated that the response to this catastrophe would require 42,000 search and rescue personnel with initial damage estimated at $300 billion with long term damage at $600 billion or more.[38] If an earthquake strikes the New Madrid Seismic Zone as predicted, it could create a complex catastrophe and pose a threat to national security due to the severity of cascading effects. The New Madrid Scenario

highlights the potential challenges with first responders communicating with each other and the public. The next section will examine how the use of social media helped connect first responders to victims during a natural disaster.

Hurricane Sandy and the Use of Social Media

In October of 2012, the entire eastern seaboard of the United States was affected by Hurricane Sandy before the storm made landfall along the New York-New Jersey shore. In the states of New York and New Jersey, the storm killed 43 people, injured over 10,000 and caused $68 billion in damages across 24 states.[39] The loss of life, injuries and damage to homes and property was horrific, but Hurricane Sandy was not a complex catastrophe. While the storm caused temporary disruptions to transportation, energy, communications and financial systems, it did not impact national security. The use of social media by governmental and volunteer organizations during Hurricane Sandy helped coordinate response efforts and provided an alternate system of communication between first responders and victims.[40]

The New York Office of Emergency Management (OEM) is responsible for disaster response plans for the city of New York. In accordance with the OEM Coastal Storm Plan, the Mayor of New York City took every precaution. The Mayor issued evacuation orders, closed the ports, and staged emergency response teams and logistics ahead of the storm. Similar preparation was conducted in New Jersey and both Governors issued disaster declarations before the storm's arrival to start the Stafford Act process. The New York City OEM sent warning messages via text messages, twitter feed, mobile and landline phone calls, and email to more than 165,000 residents who signed up to receive storm updates.[41] The Mayor also used the city's '311' public service announcement system. The 311 system is web based and includes government

information and non-emergency services information to raise public awareness. It also functions as a two-way means of communications by encouraging residents to report problems using a variety of communications options.[42] During Hurricane Sandy, affected residents used the 311 system to report damage and request assistance. At the highest peak of usage, the call volume reached 274,000 calls in a single day.[43] The American Red Cross headquarters in Washington, D.C. used their operations center to capture over two million social media posts from the disaster area. The information that the Red Cross collected was filtered and categorized into a few thousand pieces of information that were used for situational updates and forwarded to disaster response agencies to help prioritize relief efforts.[44]

Following the storm, Deputy Mayors Linda I. Gibbs and Caswell F. Holloway presented an after action report Mayor Michael Bloomberg. The report identified six categories for improvement and included the collective recommendations of twenty-five city agencies. Despite the success of the 311 system, the first category identified for improvement was communication.[45] The primary theme of the communications comments called for, “better integration of the City’s data across platforms and agencies to increase situational awareness and allow more targeted, efficient response and recovery operations.”[46] Other recommendations included making participation in the Federal Communications Commission’s Disaster Reporting Information System mandatory. Currently telecommunications providers are not required to share the status of their efforts to restore voice, data, and internet services with emergency response personnel. The report also called for requiring the use of uninterrupted power supplies

for cell phone towers. Most cell towers are connected to a commercial electrical grid and even if the tower is not damaged, the loss of power disrupts service.[47]

Review of Current Plans

The Department of Homeland Security has made tremendous progress in improving disaster voice and data communications for first responders. The Middle Class Tax Relief and Job Creation Act enacted into law in February of 2012 called for the creation of the First Responder Network Authority. This agency within the National Technology Information Administration will report to a board that is chaired by the Secretary of Homeland Security. The purpose of the First Responder Network Authority, or FirstNet, is the establishment of a national public safety broadband network to support data communications.[48] FirstNet is one of several significant improvements in disaster response communications and interoperability between departments and agencies.

Communications and Infrastructure Improvements

In conjunction with the Middle Class Tax Relief and Job Creation Act, Congress purchased 10 MHz of additional bandwidth in the 700 MHz frequency range for exclusive use by first responders. This purchase of additional bandwidth doubled the voice communications capacity for local, state, and federal disaster agencies.[49] The next significant advancement of voice communications occurred with the implementation of Phase II of Project 25 (P25). This project was originally started in 1989 and its purpose is to create interoperable digital voice communications regardless of equipment vendor.[50] P25 allows encrypted voice communications between fire, police, emergency medical services, etc.

There are also additional plans to significantly upgrade commercial communications infrastructure. On the 14th of June, 2013, President Obama signed an Executive Order directing the acceleration of broadband infrastructure across America. The purpose of this Executive Order is to rapidly expand public access to the internet in order to stimulate business, create jobs and improve public safety. The number and locations of new broadband towers is currently being examined by the Broadband Development of Federal Property Working Group. The goal of this group is to provide ninety-nine percent of America the opportunity to connect to the internet.[51] The proliferation of broadband towers will also facilitate first responders being able to access the FirstNet. Once complete, these changes will vastly improve incident command voice and data communications.

The National Emergency Communications Plan

In addition to the equipment and technical upgrades, DHS has established improved protocols. The Office of Emergency Communications (OEC) is the agency whose primary responsibility is to develop the plan to restore response level emergency communications. The Office of Emergency Communications defines response-level communications as, "the capacity of individuals with primary operational leadership to manage resources and make timely decisions during an incident."[52] In order to accomplish this task, the OEC developed the National Emergency Communications Plan (NECP). The NECP applies the whole community approach to restoring emergency communications. The vision of the NECP is to ensure emergency response personnel have continuous, interoperable, and reliable communications across all emergency response disciplines.[53] The NECP also includes recommendations for new investments in technology and capability to accomplish this vision. In addition, the Office

of Emergency Communications publishes a radio frequency guide to help teams establish and restore emergency communications. The OEC has distributed more than 45,000 copies of the National Interoperability Field Operations Guide (NIFOG) to enhance public safety.[54]

The National Emergency Communications Plan uses a phased approach to accomplishing response level communications. The plan calls for local departments to establish their own communications contingency plans and purchase the required equipment for primary and alternate means of communication. The national goal for 2013 was for seventy-five percent of all first responders to restore emergency communications within three hours following a significant event.[55] The goal was met on schedule and the next milestone calls for ninety percent of first responders to restore communications within the same time standard. This process is incentivized through the Homeland Security Grant Program to off-set the cost of upgrades that would otherwise be unaffordable. In addition to emergency communications, the grant program supports a wide range of initiatives that promote disaster preparedness. Since 2008 the grant program has contributed over $6.5 billion.[56]

In accordance with the National Emergency Communications Plan, commercial service providers such as Sprint, Verizon, Vonage, Direct TV, etc., are responsible for restoring their service with no planned federal assistance. During a complex catastrophe resulting in extensive damage to buildings, roads, bridges, and power grids, relying on the commercial service to re-establish temporary service in a timely manner represents a significant risk to the general public. The decision by FEMA not to include the restoration of commercial communications infrastructure in the federal response

plan is complicated by the legal and monetary challenges associated with using government assets to restore commercial communications.

These factors complicate assessing FEMAs current communications disaster response plans. It is clear that the restoration of the commercial infrastructure is a critical element of public safety and ultimately tied to the information requirements disaster response officials need to build and maintain situational awareness. There have been tremendous advances in the last decade in disaster response planning and emergency communications infrastructure development. These improvements will help build communications resilience and national preparedness. However, there is a gap in capability between the personnel conducting disaster response operations and the victims who require their assistance. The current level of planning compared to the complex catastrophe case studies highlights the need for multiple and reliable methods of communication so that the public can call for help.

This point is emphasized in Executive Order 13618, “private sector entities; the public, allies, and other nation’s communications must be possible under all circumstances to ensure national security, effectively manage emergencies, and improve national resilience.”[57] Developing contingency plans that effectively close the gap between restoration of emergency communications and the commercial infrastructure remains a fundamental challenge. The increased capacity of the physical infrastructure and system redundancy makes the probability of a total loss of communications less likely. The more pertinent question is, what is the best way to rapidly gain situational awareness on degraded infrastructure in order to focus response

efforts? The next chapter examines the use of social media and geospatial disaster mapping as a possible solution to that question.

Chapter Four

The Haiti Earthquake and the Evolution of Geospatial Disaster Mapping

On 12 January 2010, the Haitian people experienced a complex catastrophe. A magnitude 7.0 earthquake struck near the capital city of Port-au-Prince and immediately overwhelmed the Haitian governments' ability to conduct disaster relief. The United States Geological Service estimates the earthquake killed at least 100,000 people with some Haitian reports indicating the number could have been as high as 316,000 killed and 194,000 injured. The earthquake displaced 1.3 million people, destroyed 97,000 homes and damaged 188,000 more.[58] Haitian President Preval survived the quake, the government institutions did not. The Presidential Palace collapsed, the Ministry of Finance, Public Justice and Public Works were all severely damaged or destroyed. Among the dead were members of Parliament, and the President was unable to communicate with members of his Cabinet. The United Nations Secretary General, Ban Ki-moon estimated that one-third of Haiti's population was affected by the quake.[59]

Prior to the earthquake, the United Nations had already established a mission in Haiti under Chapter VII operations to create stability, promote human rights and support governance. Following the earthquake, the United Nations Stabilization Mission in Haiti (MINUSTAH) coordinated the disaster response of the international community. The response included disaster aid from 102 countries and monetary relief from the United Nations, the European Union, the World Bank and many other financial institutions.[60] Motivated by the desire to help locate missing friends, one group of volunteers decided to help by communicating with victims through social media and sharing their needs

with rescue personnel. The volunteers were able to identify the victims by manipulating the geospatial information contained in the social media posts and plotting the coordinates on a map.

This group of volunteers, led by Dr. Patrick Meier, used the internet to mobilize over 1,200 volunteers from 49 countries in a matter of a few days.[61] In order to provide twenty-four hour support to the earthquake victims, Dr. Meier divided the volunteers into several teams. One group of volunteers was responsible for monitoring cell phone Short Message Service (SMS) texts, blogs, Twitter feeds, and Facebook posts. Those messages were transferred to other volunteers who translated the posts from Creole to English. Another group of volunteers sorted the messages by urgency and category. Once the messages were prioritized, another group used the geo-location tag on the text messages to create a crisis map. In all, over ten-thousand messages were recorded and updated in real time. The map included the location of trapped victims, where relief supplies were needed, hospital information and shelter locations.[62] The web-based software platform the volunteers used to create the map is called Ushahidi, the Swahili word for “testimony” or “witness”.[63] Dr. Meier’s group eventually became known as “Mission 4636”. This name stuck to the group because 4636 was the toll free SMS number which victims used to text requests for help.[64]

The members of Mission 4636 learned valuable lessons from the Haiti earthquake on how to organize and design future crisis mapping volunteer groups. The volunteers had no dedicated office space, organizational structure, no workflow protocols, and their efforts were initially unknown to the relief agencies. Dr. Meier organized the core group of volunteers from friends and classmates and used the

basement of the Fletcher School at Tufts University to launch Mission 4636.[65] In spite of these challenges and the fact that their crisis map was not widely used by disaster response officials, the group received praise for their heroic efforts. FEMA Director Craig Fugate posted on Twitter that the crisis map was the most comprehensive and up to date map available for relief operations.[66] Before coming ashore to conduct relief operations, members of the 22d Marine Expeditionary Unit reached out to Mission 4636 to become familiar with their Ushahidi crisis map. After viewing the content and understanding its full potential, the 22d MEU used the Mission 4636 crisis map as their common operating picture and credited the volunteers with saving several lives.[67]

The members of Mission 4636 were not the only group of volunteers who used crowdsourcing techniques to help build situational awareness. Hundreds of other volunteers used satellite imagery and a software platform called “Open Street Maps” to build a post-disaster map to aid relief efforts.[68] The city of Port-au-Prince had never been accurately mapped and what maps did exist were in short supply. Following the earthquake rescue workers struggled trying to navigate to victims. The volunteers that leveraged the Open Street Maps software were able to assist relief workers by providing the best routes and identifying damaged infrastructure.[69] As with Dr. Meier’s group, the Open Street Maps team conducted critically important work, but it was not utilized to its full potential.

The volunteers who used the Ushahidi platform during Mission 4636 were determined to correct these deficiencies and created a not-for-profit company called “The Standby Task Force”. This group corrected the organizational and procedural shortcomings noted during Mission 4636. The Standby Task Force consists of over

1000 highly skilled volunteers from 70 countries who are experts in geospatial crisis mapping. Since the conclusion of Mission 4636, the Standby Task Force has supported humanitarian assistance and disaster relief operations in Pakistan, the Philippines, South America, and three countries in Africa.[70]

The Growth of Crisis Mapping Organizations

The earthquake in Haiti inspired several advances in geospatial technology and crowd sourcing techniques to improve relief operations. During the March 2011 Japanese earthquake, Mr. Hal Seki used Ushahidi and Open Street Maps to launch a crisis map called Sinsai.info. Mr. Seki's platform launched within four hours of the earthquake and during relief operations collected 9,000 reports and 1.2 million page views from 151 different countries.[71] The group of volunteers that formed Ushahidi.com took responsibility for improving the software platform. They improved how information from users is collected and displayed on an interactive map. These changes improved the product by making it easier to use and more intuitive. Ushahidi.com also released a new frontend of the original software called "Crowdmap". This platform uses the same core geospatial technology and can be launched in two minutes. Once launched, the updated version immediately starts collecting and analyzing information. This leap in technology has the potential to help disaster relief officials overcome latency challenges by gaining and maintaining situational awareness. Another positive feature about Ushahidi.com is there are no licensing fees and all the products are available on the internet for free.[72]

Since his first deployment of crisis mapping volunteers in Haiti, Dr. Meier has become an expert in the field. The International Network of Crisis Mappers, co-founded by Dr. Meier, is purportedly the world's largest disaster mapping organization.[73] In

addition to building new capability and capacity, Dr. Meier used his experiences to build a vast network of partners in the disaster relief and technology communities. This organization is partnered with hundreds of institutions and universities, 50 United Nations agencies and has over 6,000 members who participate globally. The team at Crisis Mappers produces, “applications, participatory maps & crowd-sourced event data, aerial & satellite imagery, geospatial platforms, advanced visualization, live simulation, and computational & statistical models to power effective early warning for rapid response to complex humanitarian emergencies.”[74]

There are other examples of private volunteers and major corporations participating in disaster response operations, all of whom bring unique capabilities to help victims and build situational awareness. The Digital Humanitarian Network supports disaster decision making by combining infrastructure data and social media posts in real-time and displaying the product on an interactive map.[75] Google provides mass notification alerts to warn people of potential threats and hazards. They also employ disaster response teams that build crisis maps to help victims reconnect with missing relatives.[76] Over the last few years Google has supported dozens of international and domestic relief operations. Google response teams were used during the 2012 wildfire season, Hurricane Sandy, the F5 tornado in Moore, Oklahoma, and the Boston Marathon Bombing.[77] The public and private sector have made significant contributions to disaster response operations using geospatial information. However, their efforts are not integrated into the NRF. The next chapter summarizes the military’s role in disaster relief operations and how the DHS and DOD use geospatial information to develop situational awareness.

Chapter Five

DHS Use of Geospatial Information

Beginning in 2009, the DHS created a domestic common operating picture that leverages geospatial information across multiple domains and includes dozens of Federal agencies. This system of systems is called Geospatial Concept of Operations (GeoCONOPS). The purpose of GeoCONOPS is, "to identify and align the geospatial resources that are required to support the NRF, ESFs, and supporting federal mission partners all in coordination with PPD-8."[78] GeoCONOPS is a web-based application that connects all federal-level National Response Framework stakeholders who utilize geospatial information to support situational awareness.[79] The list of developing partners and current users of GeoCONOPS includes: the Departments of Homeland Security, Interior, State, Defense, Justice, Commerce, Agriculture, Energy, Transportation, Health and Human Services, Housing and Urban Development, Veteran's Affairs, the Environmental Protection Agency, and the Federal Aviation Administration. There are also dozens of subordinate offices and directorates of the primary agencies who utilize GeoCONOPS.[80]

In order to collaborate with the non-governmental and private stakeholders who use geospatial information, DHS established the Open Geospatial Consortium. The Geospatial Consortium includes over 400 research organizations, non-profit companies and commercial members.[81] This group helps develop geospatial products that support search and rescue operations, CIKR damage assessments, and improved incident management situational awareness.[82] GeoCONOPS is updated annually and currently being considered for inclusion in PPD-8. GeoCONOPS version 5.0 was released in June of 2013 and its use and functionality has dramatically improved national

preparedness. The utility of GeoCONOPS easily facilitates situational awareness during homeland security and homeland defense operations.

DODs Use of Geospatial Information

The DOD has two homeland missions; Homeland Defense, the primary mission, and Defense Support to Civil Authorities (DSCA). The Stafford Act, in conjunction with Department of Defense Directive (DODD) 3025.18, *Defense Support to Civil Authority* provides the Secretary of Defense the legal authority to support disaster response operations once the President makes a Federal disaster declaration.[83] As identified in PPD-8, DSCA complements the National Response Framework "all hazards" approach by leveraging the full resources and unique capabilities of the DOD. Potential DOD missions include disaster response, support for special events, and law enforcement support.

In order to accomplish those missions, the Secretary of Defense can employ a full range of DOD resources and personnel. The personnel categories include Active Component, Reserve Component, and National Guard members serving under Title 10 orders, contractors, and Department of Defense Civilians. Employment of federal assets is done in coordination with the governor(s) requesting federal assistance and through the direct liaison of a Federal Coordinating Officer.[84]

Inside the U.S., the Homeland Defense and Defense Support to Civil Authority missions are the responsibility of the United States Northern Command (USNORTHCOM) Combatant Commander.[85] For the Pacific area of responsibility, the same responsibilities are assigned to the United States Pacific Command (USPACOM) Combatant Commander.[86] The two missions have their own separate planning documents, Contingency Plan (CONPLAN) 3400 and 3500 respectively. One of the

current shortfalls with these plans is neither Combatant Commander has assigned forces to source the FEMA PMAs. In the event of a complex catastrophe, this would delay the employment of DOD resources, including communication personnel and equipment. And while the DOD maintains immense communication capacity, it is not well suited to provide commercial internet for the general public.

There are additional challenges with integrating and coordinating DOD functions that support CONPLAN 3500 with interagency partners. There are several initiatives underway to improve DOD planning, responsiveness, and interoperability between the DOD and the supported disaster response agencies. In July of 2012, the Secretary of Defense published new guidelines to the Service Secretaries to improve the military's response to complex catastrophes. The new guidelines include providing the USNORTHCOM Combatant Commander increased access to the Reserve Component forces of each of the Services, updating and sharing all DOD complex catastrophe response plans with state, regional and federal agencies, and sharing all DOD situational awareness systems with other stakeholders.[87] The Commanders of USNORTHCOM and USPACOM have taken several significant steps in accomplishing these requirements.

Situational Awareness Geospatial Enterprise (SAGE)

Inside the USNORTHCOM Command Center, the current operations team uses multiple situational awareness systems to provide real-time information in the air, space, cyber, maritime, intelligence, and land domains. One of the tools employed by the land domain team is called Situational Awareness Geospatial Enterprise (SAGE). The SAGE platform uses Google Earth for the base map and allows users to upload and view geospatial reports.[88] SAGE integrates information from the DHS, HSIN, the National

Oceanic and Atmospheric Association, and the United States Geological Service.[89] SAGE users can customize the Google earth map by selecting categories of information that support their situational awareness requirements. This feature allows users to custom build map products for their particular requirements and agencies. Options include displaying the current status of hundreds of critical infrastructure sites across the U.S. from all sixteen CIKR categories. Users can also display severe weather forecasts and storm tracks, current and projected flooding information, seismographic information, in-progress disaster response and the agencies who are supporting those operations. In all there are several hundred choices for the user to select from and SAGE allows for both classified and unclassified collaboration.[90]

Chapter Six

Summary

Over the last ten years there have been tremendous improvements in the communications infrastructure plans and policies that support the 78,000 disaster response stakeholders. The advances in wireless broadband and dedicated communications frequencies for first responders will dramatically improve response capability and build communications resilience. However, there is still a vulnerability with public communications that these initiatives have not yet addressed. The public needs redundant methods of communication to request assistance during catastrophes. The use of geospatial information has the potential to mitigate this vulnerability and provide the best situational awareness to disaster response personnel. In order to accomplish this, the policy language in the *National Security and Emergency Preparedness Communications* Directive should include crisis mapping during disaster preparation and response. FEMA also needs to educate the public on using alternate

means of communications to request help and contribute information to build and maintain situational awareness.

Recommendations

The following recommendations are offered for further study and possible action by DHS to improve situational awareness during complex catastrophes.

(1) The Department of Homeland Security, as well as the Federal Coordinating Officers and NORTHCOM should consider how to better integrate the public and crisis mapping into national preparedness and include the solution in the National Response Framework, SAGE and DSCA operations. Capturing social media reporting by the public and incorporating it into geospatial products has proven to facilitate situational awareness and save lives. If the public were properly trained on how to contribute information to these systems, disaster response officials could use crisis maps as a means of two-way communications. Crisis maps can help inform the public where to obtain emergency shelter, receive medical assistance, food and water, avoid hazards, establish traffic patterns, and post mass notifications. By allowing the public to view selected information on a crisis map for their personal situational awareness, the tool could reach its full potential and be mutually supporting to all stakeholders. As an interim solution, the author further recommends the NOC and FEMA coordinate with selected crisis mapping agencies now to ensure their products are available on the HSIN.

(2) At the national level, the federal government has a responsibility to ensure citizens can call for help. If the telecommunications companies are unable to restore service, the government must develop contingencies to mitigate the unnecessary loss of life and damage to property. This recommendation is not intended to replace the

Nation's 911 system, the National Emergency Broadcast System, or any other emergency communications system. The purpose of this recommendation is to add additional methods of communication given the likelihood of damage during a complex catastrophe. Possible solutions include new laws and regulations requiring cellphone and broadband towers to have uninterrupted power supplies to mitigate the risk of power grid failures. Data and voice systems used for maintaining situational awareness must be backed up in a cloud in case the primary servers are unavailable.

Finally, more resiliency is needed in the communications architecture and the policies that regulate the commercial carriers. The commercial carriers must be compelled to notify first responders when and where communications disruptions occur. Emergency managers should use this information to confirm where coverage has been disrupted and if the public is at risk, immediately launch an Ushahidi application over the affected area to start building situational awareness.

There are challenges and potential risks with using crowd sourced information. False reporting, over-reporting, timeliness and insufficient reporting are all issues that have occurred and will continue to occur in the future. Following the Haiti earthquake, the United States Institute of Peace (USIP), commissioned a special report to capture the lessons learned from crowd sourcing efforts during relief operations. The report highlighted this problem and recommended two solutions. The first included building networks of trusted reporters.[91] This is contingent on those reporters being informed and trained on where to send social media posts. The second recommendation addresses the false reporting problem. This requires the use of free software by crisis mappers that flags reports that appear to contain inaccurate information. Ushahidi.com has built a

program called “Swift River” that allows uses to screen reports based on phone numbers and email addresses to determine the accuracy of information.[92] Ushahidi.com also has a call back feature that allows users to follow up with victims to verify reports or request additional information. The USIP report also recommended integrating crisis mapping agencies with disaster relief organizations to share capabilities and requirements.

Conclusion

Complex catastrophes have the potential to cause cascading effects and in extreme cases, threaten national security. The United States and its territories face several scenarios that could cause such an event. In order to facilitate timely and effective disaster response and protect the Nation from the long term effects of a complex catastrophe, response officials must have tools that facilitate situational awareness. Disaster response concepts and technology used by officials during catastrophes has evolved significantly over the last decade, but there are still areas that need further improvement. Government organizations at all levels, private industry, volunteers and especially the general public must have resilient communications. The use of social media by the public as an alternate means to call for help has proven to save lives. Capturing the geospatial information embedded in the social media messages to build crisis maps has also been proved to be an effective method of gaining situational awareness. Now is the time to incorporate these techniques into disaster preparation and response plans to help protect the Nation from the threat of a complex catastrophe with cascading effects.

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