Learning about Interoperability for Emergency Response: Geographic Information Technologies and the World Trade Center Crisis

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Abstract

Geographic information technologies (GIT) have the potential to integrate information among multiple organizations. In fact, some of the most impressive advantages of using geo-spatial data are derived from the power of bringing together geographic data covering territories that may well be administered by different organizations and from layering geographic data with other social and demographic data sets. However, building the GIT infrastructure necessary for interoperability and integration has been very challenging. Technical capabilities are available, but organizational, institutional and political factors are seen as powerful barriers. Using structuration theory, this paper argues that the World Trade Center crisis was a catalyst for a change in the conceptualization of GIT for emergency response and, consequently, much was learned about interoperability and inter-organizational geographic information systems.

1. Introduction

Of the various waves of technology development that have diffused widely over the last three decades, among the most exciting have been tools that use or generate geo-spatial data, that is, data providing location information in which a common spatial coordinate system is the primary means of reference. Unlike the Internet, electronic mail, group decision support systems and other related technologies whose direct impact has been to complement or improve methods of communication, geo-spatial technologies are more specifically tools for analysis and decision making. The term "geographic information systems" (GIS) has historically been used to encompass the hardware, software, geographic data, personnel, and assortment of functionalities that taken together comprise or enable processes for making decisions. More recently, it has become clear that GIS together with global positioning systems (GPS), aerial photography, remote sensing techniques, and other spatially related tools for decision making comprise a larger array of complementary tools that can be grouped together under the more comprehensive rubric of "geographic information technologies" (GIT). Businesses, nonprofit organizations, and particularly government organizations at a variety of levels have glimpsed the relevance of GIT for improving organizational processes; however, most have yet to fully comprehend or realize the benefits thought to be associated with geo-spatially based analysis and problem solving.

Advocates of geographic information have long claimed significant advantages in bringing a spatially oriented perspective to bear on organizational decision making. In the areas of economic planning and development; water, agricultural, energy, cultural, land, and mineral resources; environmental management; forestry; geology; public health; land-use planning; public safety; social services; transportation; waste management; utilities; and wildlife conservation and management, GITs are thought to provide strategic spatially enabled decision making capabilities [28].

However, over the years, these capabilities have proven more difficult to realize than might have been supposed. For one thing, spatial data, the fundamental building block of a spatially enabled perspective, can be expensive to acquire and use [29]. For another thing, as Sommers [27] suggests, the characteristics of geographic information technologies "differentiate it from other technologies and necessitate specialized organizational management approaches" (p. 157). Geo-spatial data is of a particular kind, with multiple uses and multiple relationships to other organizational data and technologies, with resulting challenges for implementation and use.

Finally, some of the most impressive advantages of using geo-spatial data are derived from the power of bringing together geographic data covering territories that may well be administered by different organizations and from layering geographic data with other social and demographic data sets. However, among the most difficult hurdles to overcome has been creating interoperable systems, both technical and organizational, that are capable of sharing data. Organizations frequently do not know about existing data sets and when they do, there are additional problems with ownership, pricing, lack of metadata about data characteristics, and lack of incentives, tools, and guidelines for sharing data [3]. While managers with organizational responsibility for the development and use of GITs, particularly within government organizations, have understood this for some time, it has been difficult to create the kinds of collaborative arrangements required to share geo-spatial information and to work together to construct the organizational and technical infrastructure required for interoperability.

Although these problems with achieving the full potential of GIT have existed for years, general awareness of the importance of GIT and an appreciation of its attendant challenges changed dramatically as a result of the World Trade Center (WTC) attacks that took place on September 11, 2001, and across the period of first response and subsequent recovery efforts.

In this paper, we argue that, due primarily to the experience and success of GIT professionals working together with first responders and other decision makers to mobilize an effective emergency response, government decision makers' fundamental conceptualizations about the value and role of GIT were transformed. In the immediate aftermath of the WTC attack, GITs presented options allowing responders to construct innovative technological tools that enabled complementary emergency responses not otherwise possible. In this short-lived but intense milieu of technological adaptation and innovation, GITs came to be looked upon in ways that more fully appreciated the capabilities and advantages of a geo-spatial perspective. The result has been that the role of geographic information and associated technologies in an emergency response situation is now understood as going well beyond the simple production of maps, to encompass operational and technological interoperability for organizing and supporting emergency responders and for contributing to homeland security.

We bring a structurationist theoretical perspective to bear in arguing that during the WTC crisis, GITs were "enacted" in a variety of novel ways by interorganizational systems of social actors thrust together by the demands of the crisis. The WTC crisis presented a novel "time-space edge," initiating a period of radical change that required technical interoperability and intensive collaboration among actors from the GIS community, emergency responders, government officials, and politicians during the immediate response and aftermath. One lasting consequence of this period is that government leaders have come to see that GIT infrastructure plays an important role at the center of disaster management and national security. The crisis was thus a catalyst for change in the use of GIT as a technology-in-practice and, reciprocally, in the social structures in which GIT is expected to be deployed in the future. We begin our discussion by building a structurationist theoretical foundation for the data analysis to follow.

2. Social structures and information technology

Scholars rarely argue anymore that technologies are directly responsible for social change. Instead, several theoretical traditions now propose alternative ways to understand the relationships between information technologies and the social systems in which they are deployed. These more holistic approaches have been called the "ensemble view" of technology [22] because they suggest that information technologies are comprised not only of physical artifacts but also of the social relations around those artifacts. Technology is only one component of more complex socio-technical systems [16; 24]. Social components of such systems may include factors such as: organizational commitment, training, and policies [15] that affect how a new technology is managed in an organizational context; roles that various stakeholders play in designing, developing, and implementing a technology; the inter-organizational systems and alliances of inventors, research and development organizations, corporations, and governments that arise in order to develop new technologies [17]; and the role of user groups in determining how technologies come to be systems embedded in complex institutional and cultural contexts [9; 10; 13; 14; 15].

In one further variant of the ensemble approach, scholars have also suggested that technology and social structure are mutually implicated in reciprocal processes of influence and evolution [18; 22]. A variety of positions with similar arguments are assembled under the label of "structuration" theories because they all propose, following the structuration theory of Anthony Giddens [12], that technologies have the potential to change social structures while simultaneously suggesting that social structures shape how we think about, design, and use technologies. When both processes are considered simultaneously, reciprocal relationships between technology and the social world are foregrounded, rather than unidirectional causal relationships.

Two examples of the structuration perspective are the structurational model of technology [20; 23] and adaptive structuration theory [6; 25]. Using different but related theoretical constructions, these theories argue that there is a dynamic interaction between social structures and information technologies. In recent years, the importance of the user's enactment in understanding the bi-directional relationship has been established [10; 21]. Thus, it is of considerable importance to focus on understanding how users enact technologies in ways that are idiosyncratic or that diverge from the uses sanctioned in organizational contexts.

2.1. Adaptive structuration theory

Adaptive Structuration Theory (AST) is one of the most fully developed theoretical perspectives for understanding how new technologies come to reproduce social structures or to generate structural change in organizations. DeSanctis and Poole [6] describe how structuration processes play out in the process of technology use in organizations to reproduce existing social structures or change them by virtue of the kinds of structures that are incorporated into technology during the design process.

According to Giddens [12], structure consists of rules and resources that actors draw upon to produce social behavior. For DeSanctis and Poole [6], social structures are physically incorporated in new technologies in two complementary ways. First, technologies embody rules and resources embedded in the form of particular material capabilities, functionalities, and features that comprise a variety of behavioral options to be used in constructing social action.

When users collectively and routinely draw upon and apply particular features of a system or when they reference the way the technology "should" work in order to construct a shared perspective on a task, they are engaged in the "appropriation" of a technology. More specifically, in appropriating technological features, users reproduce the rule or resource instantiated by that feature, which is then brought into social action and reproduced as structure in the social world. DeSanctis and Poole [6] make it clear that appropriation can take place in many different ways and note that appropriation may be "unfaithful" or inconsistent with the spirit and design of the structural features. When unfaithful appropriations take place, users apply structural features in ways that are "out of line" with the spirit of the technology.

2.2. Enactment of technologies-in-practice

Orlikowski [21] critiques aspects of AST by returning to Giddens' [12] original formulation of structure, which has a "virtual" rather than material existence and is brought into being only through social action. She reminds us that "while a technology may be seen to embody particular symbol and material properties, it does not embody structures because those are only instantiated in practice" [21, p. 406] systematically repeated over time. Her point is that users "enact" technology in their collective and repeated use of it, bringing technology and its potential structures into being through practices. Orlikowski [21] uses the term "technologies-in-practice" (p. 407) to refer to the enacted structures of technology or the sets of rules and resources that are reconstituted through users' selective engagement with particular technological features. As it exists for the user, technology-in-practice is a "repeatedly experienced, personally ordered and edited version of the technological artifact, being experienced differently by different individuals and differently by the same individuals depending on the time or circumstances" (p. 408).

Olikowski [21] also acknowledges that technologies are inscribed with particular properties and capabilities defining what it is in principle possible to do with the technology. However, users will make their own selections among these possibilities. They may be influenced in their selections by the "images, descriptions, rhetorics, ideologies, and demonstrations" (p. 409) of the technology provided by individuals who play a number of intermediary roles in selling, reporting on, training, championing, and mentoring others in the technology. But, ultimately, users do many things with technology in its current state, some unanticipated by designers, and they often "add to or modify the technological properties on hand (e.g., installing new software, peripherals, or adding data, etc.), thus actively shaping or crafting the artifact to fit their particular requirements or interests" (p. 409).

In the process of enactment, users bring a number of factors to bear on their engagement with a technology including their knowledge of the structural properties of the social systems they inhabit. In drawing on these structural properties, users' experiences are shaped by material aspects of the technology, that is, its "*facilities,*" but they are also shaped by *norms* for appropriate behavior within an organization and with respect to a technology and by *interpretive schemes* drawn from the institutional context through which structure is instantiated. As users draw upon facilities, norms, and interpretive schemes, they enact a set of rules and resources that reconstitute the structural properties of the social system from which these three elements were originally drawn. Thus, an important part of analyzing a technology-in-practice is to understand how structural properties of the social system, through the modalities of facilities, norms, and interpretive schemes, shape users' tendencies to enact technology in particular ways, giving rise to the possibility of structural reconstitution.

2.3. Structural and technological change

Despite this tendency toward stability, as Orlikowski and DeSanctis and Poole both note, the possibility of change is inherent in technologies-in-practice because technologies are never completely stabilized. Users may change their awareness, knowledge, power, motivations, circumstances, and, as previously noted, the material features of the technology itself. Any of these factors may change how or what structural properties of the social systems are drawn upon or what norms or interpretive schemes users select in their use of a technology.

A further implication is drawn by Orlikowski [21] who observes that the same technological artifact may be enacted in multiple ways, depending on how users draw on structural properties of the larger social systems comprising their work environment. At times, technological artifacts may be enacted in ways that essentially reconstitute existing structure and ways of doing things, which she terms *inertia*. But individuals may also practice enactment as *application*, when they use a new technology to enhance existing ways of doing things, which both reinforces existing structure and improves work processes. Finally, users may enact technology in ways that change both existing social structure and their ways of doing work. The enactment of change takes place when users *improvise* on a technology-in-practice, experimenting, adapting, or customizing aspects of the technological artifact, perhaps by adding new data or building new components. In Orlikowski's [21] case studies, change took place under conditions in which users were very knowledgeable and quite motivated to use a technological artifact in their work environment and were able to draw upon structural features that included a strong team focus, a cooperative culture, and a commitment to learning (p. 423).

In these structurational accounts, technology change in organizations, when it occurs, is cast as a series of modifications, adaptations, and improvisations on artifacts that already exist and that take place incrementally across time as users explore possibilities. Although this characterization is appropriate for routine technology use, Giddens, who also focused on large-scale social transformation, proposed several conditions under which change can happen more profoundly. In fact, for Giddens all social life is episodic, but he was particularly interested in comparing large scale episodes or "sequences of change having a specifiable opening, trend of events and outcomes" [12, p. 374]. Social change is never determined; instead it is subject to the "conjunctions of circumstances and events that may differ in nature according to variations of context, where context (as always) involves the reflexive monitoring by agents involved in the conditions in which they 'make history' [12, p. 245]. Such novel conjunctions may arise in the context of "time-space edges," which are at the nexus of contact between different structural types of society. "These are edges of potential or actual social transformation, the often unstable intersections between different modes of social organisation" [11, p.23] and they are produced in conditions of "warfare, invasion, or threats of attack of various kinds [2, p. 275], which bring different forms of social organization together and that harbor the potential for significant change. While most change associated with technology use no doubt takes place incrementally in organizations, the WTC attacks of September 11, 2001 created a profoundly novel time-space edge, which brought decision makers and technologies together with exigencies demanding response. One of the long range consequences of this upheaval was a profound change in both the use of GIT and the structures in which they were used.

3. Method

This paper presents one set of findings from a broader exploratory study conducted through a partnership between the Center for Technology in Government at the University at Albany, State University of New York, and Urban Logic, Inc., a New York City (NYC) nonprofit organization closely involved in the WTC response. The research was supported in part by a grant from the National Science

Foundation Digital Government Research Program.[1] The goal of the research was to understand the roles of information and technology in response to the attack on the WTC as well as the influence of the response on the subsequent work of both government agencies and private organizations.

3.1. Respondents and questions

Between August 2002 and July 2003, 29 interviews, were conducted. Participants included seven NYC officials, five New York State officials, five federal government officials, five nonprofit agency representatives, and seven private sector executives. These interviews were semi-structured, open ended, from one to two hours in length. Interviews focused on information-related responses to the attack, with special attention to data needs and resources during the response period; the use of information technology in the response; interorganizational relationships during the response period; the effect of pre-existing resources, plans, or programs on the ability to respond; and the effect of rules and laws on the ability to respond. The GIT-related data were drawn from the larger questions on information and technology during analysis.

3.2. Coding and data analysis

Interview data was managed and organized using Atlas-ti, a leading software package for qualitative analysis [26]. A set of coding categories related to GIT and related functionalities (e.g., NYC base map; LIDAR, discussed below; building identification numbers, etc.), and material aspects of GIT (e.g., data compatibility and sharing; visualization, analysis, and interpretation) was developed and used. We also coded the data for key elements of the structurational framework (e.g., existing GIT resources; adapted GIT resources; and improvised GIT resources; organizational change; and lasting effects of the crisis).

4. Data analysis and findings

Analysis of the broader context of the response indicates that information and technology played critically important roles in the aftermath of the WTC attacks [4; 5]. Effective use of a variety of information technologies helped government agencies and their partners better cope with and respond to multiple crises and ongoing recovery demands. At the same time, the severity of the situation was exacerbated by extensive damage to critical communications equipment and computing infrastructure as well as the absence, loss, or inaccessibility of needed information. The immediate response and subsequent recovery challenged every aspect of public service. However, of the many kinds of data and technology put to use, GIT emerged as a particularly versatile analytical and inter-organizational resource that enabled effective responses to numerous critical exigencies.

4.1. Re-conceptualizing the Role of GIT

It became apparent relatively early in our analysis of the interviews that GIT had played a special role in the response to the WTC attack and, due to its demonstrated effectiveness, attitudes about GIT were in the process of changing. These attitude changes have been reflected in public acknowledgments of the value of GIS and the future role it should play in emergency management and homeland security, as well as its potential for use in other types of public sector decision making. Such acknowledgments were viewed as confirmation of what many GIT staffers involved in the response and recovery already understood. In the words of one member of the WTC crisis mapping team:

> "What we see in a most unfortunate situation is the culmination of our entire career. We knew a long time ago that development of this kind of technology would ultimately change the way operations were done on any level of government. And unfortunately we put it to test in this emergency situation and it's really come through in flying colors for people doing all kinds of missions and operations. And on that level, it really feels wonderful and we're hoping that it'll now become institutionalized and be actually the standard for all operations that are coming along in the city of New York…"

This sentiment was echoed by an interviewee at the federal level whose GIT responsibilities had changed literally overnight from domestic concerns to emergency response and national security concerns. Within one year of September 11, 2001, this respondent was appointed to lead a federal interagency collaboration charged with developing interoperable systems for accessing geographic data.

[1] Turning to Digital Government in a Crisis: Coordinating Government, Business & Nonprofit Services in Response to the World Trade Center Attacks of September 11, 2001, NSF Digital Government, Exploratory Research, Grant # EIA 0221927.

> "I would say that the World Trade Center incident, September 11, had a lot to do with being a catalyst for the recognition of a significant contribution that geo-spatial makes to emergency response, O.K.? And that combined with this Office of National Preparedness that basically had national preparedness as its mission, you know, saying "Yeah, we've gotta get the geo-spatial component into national preparedness". Now, would I be sitting here in an interagency geo-spatial preparedness team had September 11 not happened? I for sure would not be sitting here because I would still be focusing primarily on (prior domestic issues)."

Beyond the first few months of recovery, the views of those directly involved in responding were reflected in the judgments of many who sought to "learn the lessons" of the WTC crisis. Indeed, some of the most frequently mentioned learned lessons centered on the role and importance of GIT in both emergency management and homeland security. In perhaps its most public validation, on September 9, 2002 New York Governor George Pataki signed a proclamation recognizing September 25, 2002 as Geographic Information Systems Day.

We sought to understand how this new found recognition was won and how specific understandings about GIT came to be changed in the course of response to WTC. The remainder of our data analysis focuses on understanding how various geo-spatial technologies were used in first response and later recovery and what impact they had on the status of GIT as an information technology. Our analysis is organized around two extended and specific instances of GIT use that illustrate the kinds of technology enactments that took place under conditions of crisis: In these case studies, we see how the use of GIT *facilities,* together with a variety of organizational and occupational *norms* and *interpretative schemes,* enabled the enactment of new technology *applications* and *improvisations*.

4.2. Case 1: NYCMAP -- The New York City Base Map as a core data set

Geographic information systems were not new to New York City when the WTC towers were attacked on September11, 2001. For the preceding five years, municipal government agencies had collaborated to develop a base map of the city compiled from more than 7,500 aerial photographs at a cost of $5 million. NYCMAP (pronounced "nice map") was designed to function as a framework displaying fundamental geographic features, such as streets, buildings, tunnels, towers, piers, subways, parks, beaches, water bodies, and more. On this framework many additional layers of information might be subsequently superimposed, such as water mains, sewers, underground utilities, tax lots and property records. The map had been constructed under the auspices of the New York City Department of Information Technology and Telecommunications (DOITT), but was an extension of previous efforts by key personnel in the City's Environmental Protection Agency [7]. The City contracted with researchers at Hunter College's Center for the Analysis and Research of Spatial Information (CARSI) for quality control of the map data. On February 15, 2001, when the New York Times first wrote about it, NYCMAP was scheduled to be available to the public by early fall 2001 on the city's official Web site [7].

With the loss of the City's Emergency Operations Center (EOC), destroyed by debris from the Towers, the City had lost access to its own copies of the base map. As the City mobilized to create a new temporary command center, they drew on pre-existing personal and professional relationships for mapping resources and staff. Initially, the Director of CARSI was contacted to provide the City with the only immediately accessible copy of the base map. Access to NYCMAP, plus a complete GIS network provided by the City's Parks Department, which had not been affected by the attack, enabled NYC's mapping operation to begin on September 12.

A few days later, the mapping organization moved to Pier 92, where it was staffed 24 hours a day by volunteers, many of whom were affiliated with GISMO (GIS and Mapping Organization), a pre-existing user group of GIS professionals in NYC comprised principally of staff who worked for public, private, and nonprofit organizations. This ad hoc mapping unit supported 300 NYC government and nonprofit staffers whose agencies were working in support of the search and rescue and subsequent recovery efforts. Originally conceptualized as simply a mapping center, the unit quickly evolved into the Emergency Mapping and Data Center (EMDC), as it became clear that new applications under construction were helping responders cope with problems that were hitherto unimagined and life-threatening.

There were actually three mapping operations providing maps to the response teams. In addition to the EMDC unit on Pier 92, there was a mapping unit staffed by members of the Federal Emergency Management Agency (FEMA) Disaster Field Office on Pier 90 and the Urban Search and Rescue (USAR) operation at the Jacob Javits Convention Center. However, EMDC was unique as a mapping operation for a number of reasons. First, EMDC was an interagency and multi-organizational unit, comprised of volunteer staffers from government and business organizations, working cooperatively to provide resources needed for recovery. In this respect, the EMDC functioned as one form of manifest time-space edge in that, in this location, personnel from a variety of organizations physically assembled, collaborated on-site, and combined their expertise and resources in efforts to respond to the immediate requirements of the crisis.

Second, EMDC appears to have functioned as the site in which considerable mapping innovations were produced, principally because of its work integrating new data sets with the base map. Over time, members of rescue and recovery teams came to EMDC to get their questions answered. As Manion, Dorf, and Havan-Orumieh [19] put it, "As fires raged at Ground Zero, more comprehensive data sets were needed to help direct rescue and recovery efforts. What was feeding these fires? Where should efforts be focused to contain and eventually extinguish these fires? How could search crews be better directed to more promising recovery areas? Digital images of subsurface floor plans were registered to the NYCMAP and integrated with other data sources to provide search, rescue and recovery grids by FDNY (Fire Department of New York), Urban Search and Rescue, and structural integrity by NDDC engineering consultants."

The process of generating useful mapping tools was initially quite challenging for the newborn EMDC. However, it was facilitated by applying a standard occupational norm in IT development – i.e., talk to the user – thus stimulating subsequent exchanges of perspectives between staff technically proficient in GIT technology, but not in first response, and first responders who lacked knowledge about the capabilities of GIT. One of the GIT principals in the EMDC described it in this way:

> "…we never envisioned ourselves as almost in a first responder capacity. And then we hadn't thought about, well, what does a first responder need going on to a site? So our consciousnesses just weren't there. …. you know, it's an axiom of IT … that you have to talk to the user. OK, so we followed that and said, OK, let's talk to the users. And as we talked to the users, I mean, you know, we can do this, what do you need? They said well, we need this, we need this…ohhhh…we need that. OK, we'll produce that and then it became very interactive. Once we had established the links, especially through OEM and the fire departments and the people responding and we were saying, what do you need, what do you need? And they kept on telling us, and then we started to put our heads into their heads, and then the imaginative process began, and ohhhh and then we began to be able to anticipate what they might need and started to make decisions based on our new level of consciousness. And that iterative back and forth started really early. . . . And then the interaction led to, oh, logically, they need this so we have to produce this. But then wouldn't they need something more. And I know some technology that maybe could deliver another dimension of this kind of data and this kind of mapping and imagery. And pretty soon we were really cooking."

In the course of this intense activity, this process appeared to become reciprocal as first responders began to understand what GIT could accomplish. Thus, participants' understandings of geographic information, in Orlikowski's [21] terms their *interpretive schemas*, were modified. EMDC staff came to understand and even anticipate what first responders needed, while first responders came to understand what they might ask EMDC to contribute.

Soon the EMDC functioned not only to reproduce existing maps, but also to acquire information from a variety of sources that could then be tied to the foundational base map, producing novel mapping products. As Cahan and Ball [1] note, the base map was the technical facility essential to these data integration efforts: "Without the base map, no common framework would have existed to so quickly tie together the essential information used to coordinate the city's response." The existence of the physical base map provided what Leidner (2002) called the "foundation layer" or "'velcro layers,' where all the data sticks" and was critical to subsequent efforts to layer additional data, creating more sophisticated applications. The base map thus provided a fundamental set of technical facilities from which further innovative and useful mapping products might be fashioned. In Orlikowski's [21] terms, prior to September 11, the base map functioned as a technology-in-practice whose enactment might be characterized as *application* "where people choose to use the new technology to augment or refine their existing ways of doing things…" (p. 422).

However, following September 11, the base map became the site of significant improvisation; on the foundation of the base map new data were located and superimposed in order to respond to the exigencies of the situation:

> "Early on we thought, well, we're the mapping guys…whatever data you have, we'll create a nice

picture that'll help you. And then we were being asked to do way in excess of just producing a map. We were asked to integrate data, to represent it on a map, to analyze it, to do a lot more kinds of things to develop applications and to solve problems that we never imagined. So we became the emergency mapping and data center… We sort of dubbed ourselves as the deliverer of that data and particularly integrated data from all these different silos generating the data, not only the past data, our map, the agency databases, but the data generated by an emergency that needs things to be integrated with data from the past. And all that stuff became products."

Unfortunately, the data needed was not necessarily "in-hand". Instead, it was "located on desktops across the city. The GIS team had to go to where the data was, collect it -- often on disk – and import it into the GIS laptops and desktops" [8].

It is a testimonial to the strength and trust of pre-existing relationships that data was shared even though it was proprietary in some instances. These applications were possible in part because the EMDC was staffed by members of GISMO, who knew each other through prior organizational contacts, who shared expertise through an informal extra-organizational mechanism, and who already subscribed to occupational (if not organizational) norms of data sharing, and in part because the crisis itself produced an intensely collaborative milieu. In such an environment, new norms were generated making it permissible to share data sets, trusting that appropriate agreements about their use could be spelled out subsequently.

It is additionally important to note that the data in the developing database were dynamic, representing a set of physical conditions that were initially being combed by search-and-rescue squads, and then later being disassembled in the process of recovery. The database and the maps to which it gave rise were constantly being updated to conform to new conditions, so much so that conditions called for a method for controlling "versions" of data in the database that were verified and posted by administrators in the EMDC (Schielein, 2002). The base map thus proved to be a crucial technology-in-practice as one piece of the GIT ensemble; it was enacted in multiple and useful ways producing improvisations in the creation of 2,600 maps requested just to the EMDC at Pier 92 to respond to both life and death needs as well as the need to get life back to normal for thousands of NYC residents driven from their homes in the vicinity of the WTC.

4.3. Case 2: EMOLS -- A special case of technology improvisation

One of the most compelling illustrations of how NYC's base map was appropriated for an improvisation on technology lies in the story of EMOLS (Emergency Management Online Locator System), an interactive Web-based mapping application[2] originally designed for the City's Office of Emergency Management's (OEM) for the purpose of providing New York metropolitan area residents with reliable and current information about ongoing and potential emergencies, conceived initially for hurricanes and heat waves. Citizens could enter street addresses into the system to obtain information about the status of their particular neighborhoods: for example, to find out whether they were in the hurricane zone, the location of appropriate emergency shelters, the status of evacuation alerts, available routes out of the City, and other relevant instructions. Thus, in DeSanctis and Poole's [6] terminology, the spirit of this application lies in its intent to provide a means for direct communication and information exchange between OEM and citizens in conditions of disaster preparedness and response.

An adaptation made feasible because of the existence of NYCMAP, EMOLS was completed and uploaded to the NYC OEM Web site about six weeks prior to September 11, 2001. This fact is of crucial importance because EMOLS availability was essential in making possible almost immediate communication among government officials, first responders, the media, and hundreds of thousands of NYC residents and others directly affected by the WTC crisis. Designed initially to convey relatively simple weather-related information about geographic zones, EMOLS' purpose was amplified during this crisis because of its apparent potential for almost instantaneous communication. In an adaptation of EMOLS that had not been originally foreseen, maps that conveyed the status of a variety of utility and municipal services available in sectors of the disaster zone came later to comprise multiple alternative layers in an interactive mapping application that provided the most current information about geographic zones of access during the crisis.

During the first three or four days of the crisis, as conditions changed frequently and significantly, crisis managers needed to draw and redraw dangerous "zones" inaccessible to residents around WTC. After data about buildings with collateral damage, air pollution, and other pertinent indicators would arrive at OEM, decision makers would review the

[2] see http://www.nyc.gov/html/oem/html/emols/emols.html

information and discuss boundaries for the zones, which would then be immediately transferred to Web-accessible maps. Changes were frequent, but because the application was on the Web it was possible to keep citizens aware of up-to-date information, emphasizing both the flexibility of EMOLS as a tool and the ubiquity of the Web for communication. However, it was NYCMAP and its core data set that initially made EMOLS feasible at all, and then made it possible to improvise and develop the new mapping products as circumstances evolved.

5. Conclusion

The story of NYCMAP and its improvisations is born out of the development of a time-space edge called the Emergency Data and Mapping Center, which physically assembled a group of GIS staffers from a variety of organizations, each with expertise and access to resources that, under normal circumstances, would be separated by organizational boundaries. Further, in perhaps a second time-space edge, GIT staff in the EMDC were proximate to traditional units of emergency first responders – police, firefighters, medical teams, etc., who were also housed on Pier 92 and who needed help in coping with the immediate demands of the crisis. The proximity of tool makers to each other and to tool users under conditions of life and death stimulated the development of new understandings about what was possible and desirable to do with existing geographic information and GIT software, the dissolution of prior organizational impediments, and the production of norms that made such inter-organizational improvisation possible.

What have we learned from these case studies of the structuration of geographic information technologies in the World Trade Center crisis? Perhaps the first contribution lies in an extension of structuration theory to the case of geographic information technologies. Although by now a well-accepted theory of technology change, structuration theory and its variants have traditionally been applied to communication technologies, such as Lotus Notes and group decision support systems. There is thus some usefulness in applying structuration theory to a somewhat different form of technology and inquiring about the possibility of reciprocal relationships between social structure and technology, which are expected to be apparent.

Prior to September 11, 2001, GIT was constrained in its usefulness by existing social and organizational structures. Clearly, the technology offered the promise of advantages to be gained by merging diverse data sets, by combining geographic information across legal and cultural jurisdictional boundaries, and by creating systems that were interoperable across a variety of computing environments. However, existing norms preventing data sharing, organizational boundaries that marked data sets as “owned,” and interpretive schemes that limited the ability of decision makers to “see” the advantages of interoperable systems severely inhibited the range of allowable action. However, in the throes of actual crisis, as life and death hung in the balance, such social structural impediments lost their usual force and fell by the wayside. In so doing, material features of GIT; enabling capabilities that have been available for a long time, were drawn upon by GIT staffers. In the course of this repeated activity with NYCMAP, it became clear that GIT presented significant advantages for managing emergency response and by extension in this particular case, for homeland security. Most important for the discussion herein; it was clear that the integration of data through interoperable systems is central to the role of GITs in providing access to critical, yet disparate information necessary for effective delivery of government services; in particular, in crisis response.

It is interesting to note that in the wake of the WTC crisis, new structures have been created to facilitate action designed to overcome traditional barriers to maximizing the advantages of GIT. Some efforts, such as the Federal Geographic Data Initiative, have acquired new life. One also sees the development of new inter-agency collaborative efforts to support the integration of data through data sharing agreements across local, state, and federal government entities. As would be expected from a structuration perspective, in such efforts, one finds that attributes of the technology are shaping social structures.

In Orlikowski’s [21] study of change outcomes within three different organizations using Lotus Notes, we see three different outcomes that seem to be based on differential but evolutionary organizational conditions faced by the individuals within. In the WTC case study, we get a clear view of what happens when individuals from many organizations are thrust together under the most demanding circumstances, and are perhaps not surprised to see an overwhelming incidence of technology improvisation.

Thus, just as there is some usefulness to extending the application of structuration theory to a new instance of technology such as GIT, this analysis also makes an interesting extension to structuration theories applied to technology. By reclaiming the idea of somewhat large scale and rapid social transformation we have demonstrated how technology change can be implicated in the development of more large-scale social transformation.

6. References

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