CHAPTER *: CHALLENGES AND OPPORTUNITIES

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ABSTRACT

The acronym GIS can be decoded in three distinct ways: GISystems, GIScience, and GIStudies. This framework is used to provide an overarching synthesis, and to ask whether the chapters of the book provide a complete picture of geospatial issues and applications to homeland security. Three characteristics distinguish homeland security applications from other domains: the need for speed, the difficult environments in which technology must operate; and the impossibility of anticipating many relevant kinds of events in either space or time. One of the strongest factors impeding the effective use of geospatial technologies is lack of collaboration between institutions and between the cultures of emergency response and GIS. The final section identifies four themes that are largely missing from the book, but nevertheless represent opportunities and challenges for the future.

Keywords: geocollaboration, geographic dynamics, sensor networks, volunteered geographic information

*.1 INTRODUCTION

Secure borders, freedom from fear, effective law enforcement, and well-laid plans for emergencies are just a selection of the many themes that are encompassed by the notion of homeland security, and that emerge in the chapters of this book. As the chapters have clearly shown, all of these themes have geospatial dimensions, and can be addressed by the kinds of tools that we now lump under the heading of geospatial technologies and that range from the lowly paper map to the most advanced gadgets and simulation models, within the broader compass of abstract concepts that Bednarz and Bednarz (this volume) term spatial thinking. In this final chapter I will risk an attempt to bring the great diversity of what has gone before to some kind of concluding synthesis, and to offer some ideas about future directions, for both research and practice.

The computer application known as GIS began to emerge in the 1960s, but not until the 1980s was there a consensus on its definition and domain, and a substantial commercial software industry. While the acronym originally stood for geographic information system, I suggested in the early 1990s (Goodchild, 1992) that it could also be decoded as geographic information science, and could stand for the many fundamental ideas that lie behind the software, or belong to the body of scientific knowledge that the software implements. This body of knowledge is extensive, encompassing not only the more traditional fields of cartography and surveying, but also more recent interest in photogrammetry, remote sensing, spatial databases, spatial cognition, and spatial statistics. Later (see, for example, Longley et al., 2005) the decoding geographic information studies came to be associated with research on the societal context and social impacts of the technology. Today other terms such as geomatics have become popular in some countries and communities, but this three-part structure still provides a useful framework.

On this basis the chapters of this book might align as follows. In the first category of applications of GISystems one could place the work of Ashby, Chainey, and Longley (this volume) on geodemographics and policing; Brody and Zahran (this volume) on floods and wetlands; Huang et al. (this volume) on pest management; Mesev et al. (this volume) on demographic segregation; Pan et al. (this volume) on the economic impacts of disasters; Shroder (this volume) on Afghanistan; Ward (this volume) on medical geography; Wunneburger, Olivares, and Maghelal (this volume) on sex offenders; and Zhan and Chen (this volume) on evacuation. All in their various ways demonstrate the power of geospatial data and tools in tackling specific problems within the broad rubric of homeland security; and together they account for almost half the book.

The second category of GIScience would emphasize the principles underlying geospatial technologies, research on their development, and fundamental questions raised by their use. In this category one might place the chapter by Thurasingham et al. (this volume) on securing the geospatial web; Castle and Longley (this volume) on software for the analysis and simulation of pedestrian movement; Filippi (this volume) on the technology of remote sensing; and Monmonier (this volume) on the acquisition of detailed elevation data. Finally, the third category of GIStudies could include the Bednarz and Bednarz (this volume) chapter on spatial thinking and its importance to homeland security; the Crampton (this volume) chapter on the politics of fear and its implications for geospatial perspectives; Hannah (this volume) on Foucault and the future of the German census; McIntyre (this volume) on the importance of education in GIS; and the framework of uses and users presented by Seitz (this volume).

While this categorization is by no means perfect, it does allow one to ask two important questions: how well do the chapters of this book cover the ground in each of the three areas, compared with the literature and the work of others; and what gaps exist that might present challenges or opportunities for the future? In the first category of GISystems it is easy to think of application areas important to homeland security that are not addressed in the chapters of this book. For example, GISystems might be used to study the resilience of conventional infrastructure networks (road, rail, pipelines, etc.), and the beginnings of such a literature can be found in the work of Grubesic and Murray (2006), Church and Scaparra (2007), and others. GISystems are crucial in the study of risk from hazards such as earthquakes, severe storms, and wildfire, and in risk mitigation. In the second category, several reports (e.g., NRC, 2003, 2007) have drawn attention to the need for research on the adaptation of geospatial technology to the extreme conditions of emergency management, when smoke, darkness, and noise may make conventional tools useless. Finally, there are challenges and opportunities in the area of GIStudies, dealing for example with the economics of GIS and returns on investment (GITA, 2007), with the conflict between surveillance and the right to locational privacy, and with the need to build a secure, resilient national spatial data infrastructure (Thurasingham et al., this volume). In this last area, it would be good to know the views of the U.S. Department of Homeland Security, and to learn more about its specific activities and how it organizes its own commitments to GIS.

In the following sections I expand on these ideas, and point to specific challenges and opportunities. The perspective is essentially personal, reflecting my own experience and interests, and ideas that seem particularly current within the broad framework of GIS.

*.2 WHAT IS SPECIAL ABOUT HOMELAND SECURITY?

In 2005–6 I had the pleasure of chairing a committee of the National Research Council charged to address the role of geospatial data and tools in emergency management. The report (NRC, 2007) first concludes that GIS is essential in all four phases of emergency management—preparedness, response, recovery, and mitigation—and moreover that the case for GIS is extremely powerful and compelling. It identifies three ways in which emergency management is distinct from other applications of GIS.

First, while traditional applications of GIS have often proceeded at a fairly leisurely pace, and it is not uncommon for GIS projects to last several years from initial conception through problem formulation, data collection, analysis, and final publication, applications in emergency management almost always stress the need for speed. The term golden hour is often used by responders to denote the first sixty minutes following the event, when there are the greatest opportunities for saving lives. In the case of the bombing of the Murrah Federal Building in downtown Oklahoma City in 1995, for example, the explosion which occurred at 9.02am local time on April 19 caused an immediate need for all relevant geospatial data, including evacuation routes, locations of hospitals, and building plans. Yet in this and many other recent disasters it has taken hours and in some cases days to assemble the trained personnel, hardware, software, data, and network communications of an operational geospatial capability. Paradoxically, people all over the world were able to access geospatial data about New Orleans in the immediate aftermath of Hurricane Katrina through services such as Google Earth—but those on the ground in the impacted area had to wait days for the necessary power and Internet connectivity.

The report has several recommendations designed to get the geospatial operation up and running faster. Central to these is the need for overhead imagery, whether from satellite, unmanned aircraft, or helicopter. In some recent events it has been people with cameras in helicopters that have provided the first usable images of damage, and the basis for planning organized response. In many cases the lack of prior arrangements for acquisition of imagery from commercial sources has been a major impediment to progress, as has the lack of arrangements for distributing such imagery to those who need it most.

Second, emergency responders often work in difficult environments that are in sharp contrast to the highly functional office environments of desk-top GIS. The New York firemen climbing the stairwells of the World Trade Center on Sept 11 2001 were working in environments that were often dark, full of smoke and dust, and noisy, and were often unable to communicate with their peers. This was no place for laptops, or even PDAs. In the evidence presented to the committee, it was often clear that the most useful geospatial product in such situations is a paper map, and indeed that there was often a strong

negative reaction on the part of emergency responders to sophisticated electronics. As a result, the report calls for research on how to adapt geospatial data to the particular environments in which responders must work, and for efforts to improve the training of first responders in the use of geospatial technologies.

The third important characteristic of emergencies is their unpredictability, and particularly the impossibility of predicting either when—the precise timing of the event—or where—the area impacted by the event, in other words its spatial footprint. Within the impacted area of Hurricane Katrina were two states and numerous cities and counties. Literally hundreds of agencies from federal to local had some degree of responsibility for the impacted area, and numerous non-governmental organizations were also involved, from the Red Cross to universities and the volunteer GIS Corps. The need to coordinate and communicate created perhaps the greatest impediment to the effective use of geospatial technologies, and problems of an institutional nature quickly came to dominate the aftermath. Thus there is a strong argument for giving institutional issues, within the broader realm of GIStudies, the highest priority in future research.

* 3 CAN CULTURES COMMUNICATE?

The chapters of this book have been written largely by professionals steeped in the culture of geospatial technologies. While they may not all be advocates, and the list of authors certainly includes several skeptics, there is nevertheless a distinct tendency evident in the chapters to treat the geospatial aspects of a problem as primary. Professionals committed to GIS have often been accused of over-selling, but a more subtle issue is of major concern here, and it is the cultural divide that separates specialists in emergency management, and more broadly in homeland security, from specialists in geospatial technologies. The NRC report concludes that the two groups learn remarkably little about the other's domain in formal education, since courses in geospatial technologies often give little attention to emergency management, and courses in emergency management often make little mention of GIS.

But the divide is deeper than that, for as Bednarz and Bednarz (this volume) argue, thinking spatially is different. People who think spatially likely begin with a map, and with the perception that the Earth's surface is a continuum. Cities and states are not lists and tables, but places distributed over a landscape that varies at all levels of detail, from the coarsest to the finest. Spatial thinking places great emphasis on context, the importance of surroundings in understanding events and patterns of behavior. Spatial thinkers know about and trust Tobler's First Law of Geography, the statement that nearby things tend to be more similar than distant things. Spatial thinking may be the subject of their research, as it is for Bednarz and Bednarz (this volume); or the framework within which they develop tools; or no more than a conceptual underpinning to their use of tools. But invariably they will give primary importance to geographic space in whatever they do.

By contrast, emergency responders see the event, its victims, and their alternative courses of action as primary. If geospatial technologies are used, it is because they, like many other kinds of tools, are found to be useful—but they have no deeper level of commitment to any one class of tool. They will likely agree that geospatial technologies are important, but unlikely to see them as in any way unique or more important than any other technology, or as a basis for organizing their workflow. In this context, the title and contents of this book appear somewhat odd. Why select these particular aspects of the subject, and what benefits result from assembling chapters on this theme rather than on any other cross-cutting theme? GIS professionals know the answer, but it is not necessarily shared by other kinds of professionals. After all, while GIS is important in all aspects of homeland security, and in many activities of the U.S. Department of Homeland Security, it is not to date reflected at a high level in the organizational structure of that agency (though its Geospatial Management Office plays an important role), or in the topics of the various research centers it has funded to date. GIS is everywhere in the agency, but at the same time it is in danger of being nowhere.

*.4 EMERGING THEMES

Despite the broad coverage of topics in GISystems, GIScience, and GIStudies, there are several important areas of geospatial research that deserve mention, and that may provide challenges and opportunities for the community. In this section I review four of these. Again, I think it is important to emphasize that this is essentially a personal list, and that by describing it I hope to stimulate further discussion on areas that I have omitted.

*.4.1 Dynamics

The roots of GIS lie in the map, a paper document that once printed is difficult to update. Maps are expensive to produce, and thus tend to be directed at the most popular applications, and to emphasize features that change the least. We make maps of topography, roads, cities, soils, and vegetation, but not of the instantaneous positions of vehicles, or of flows or transactions. This is a powerful legacy for GIS, and the technology remains largely concerned with the static aspects of the Earth’s surface, and difficult to adapt to its more temporal aspects.

This situation is changing, however, and the dynamics of the Earth’s surface are coming more and more to dominate GIS development. While there is little mention of this work in the chapters of the book, significant efforts have been made in recent years to develop specialized GIS software for dynamic simulation (e.g., PCRaster, http://pcraster.geo.uu.nl), for the analysis of travel behavior, and more generally for the representation and analysis of the entire range of geographic dynamics (Goodchild, 2007).

In the area of homeland security, work on dynamics is helping to produce real-time simulations of evacuation (Cova and Johnson, 2002); models of the spread of atmospheric plumes and flood surges; and a host of techniques for analyzing intelligence

and making inferences about potentially dangerous events. The chapter by Castle and Longley (this volume) presents a very useful analysis of the state of this art in modeling the behavior of pedestrians, while Zhan and Chen (this volume) show how it can be applied to the analysis of evacuation.

*.4.2 Geo-collaboration

Another research thread focuses on the use of the Internet and geospatial tools to foster and facilitate collaboration between the various actors in matters of homeland security. Nowhere is this more valuable than in emergency management, when effective communication between all of the various responders and decision-makers can often make the difference between success and failure. Responders arriving on the scene often have only partial knowledge of the event, and lack the kinds of local awareness and skills needed to be effective. Better communication is needed not only between responders and their managers, but also peer-to-peer between responders, and peer-to-peer between managers and their agencies. Work at Pennsylvania State University (http://www.geovista.psu.edu/work/projects/geocollaboration.jsp) is exploring this notion of geo-collaboration, and prototyping the kinds of tools needed to make it operational and effective.

*.4.3 Sensor networks

A sensor network can be defined a distributed network of devices that know their positions and that sense various aspects of their environments and report them to a central server. They might consist of video cameras or microphones in the case of surveillance, or temperature sensors in advance of a wildfire front (http://www.rfidjournal.com/magazine/article/1724), or sensors distributed in the world's oceans to provide early detection of tsunamis. Many existing networks meet this definition, including the weather stations that provide minute-by-minute monitoring of the Earth's atmosphere. Sensors may be carried on people or vehicles; in the former case one thinks of the atmospheric pollution sensors carried by children involved in research on asthma, while the latter case includes participants in research on travel behavior that have allowed their vehicles to be tracked. Clearly many applications of sensor networks are of importance to homeland security.

As sensors become cheaper, smaller, and more versatile the associated problems of computation, compilation, and distribution of their signals is emerging as a major topic for geospatial research within the domain of GIScience. Several researchers have addressed the social impacts and implications of sensor networks within GIStudies, and there is increasing interest in such issues as privacy (Curry, 1998).

*.4.4 Volunteered geographic information

Finally, and related in many ways to sensor networks, is the topic of volunteered geographic information (VGI), a form of user-generated content that is attracting very significant attention in the geospatial research community. VGI is exemplified by a

growing collection of Web sites, including Wikimapia (http://www.wikimapia.org), OpenStreetMap (http://www.openstreetmap.org), and Flickr (http://www.flickr.com), all of which allow their users to enter data regarding places on the Earth's surface, in the form of descriptions, actual street maps, and photographs respectively. Blogs and Wikis that use geo-tags to allow contributors to reference information to points on the Earth's surface are other forms of VGI. Efforts such as these are engaging thousands of comparatively unqualified amateurs in what amounts to an increasingly significant mechanism for creation of geographic information. Research is clearly needed on the social aspects of the phenomenon (What makes people do this, and are they accurate?), the technical aspects (Can techniques be devised to mine this information?), and the conceptual aspects (What do people need to know to be more effective?).

While VGI is normally associated with the creation of conventional geographic information through unconventional means, it also can play a very significant role in homeland security. One can imagine a future in which citizens within the footprint of a disaster are able to contribute what they know and can see around them to central repositories using such devices as mobile phones; and in which the resulting information is made almost instantly available to responders. Useful intelligence, in both a commercial and a military sense, can often be gleaned from the content contributed by citizens to blogs or contained in email. This is a very different world from the traditional one, in which virtually all geographic information was compiled and distributed by central government agencies, and it is growing very rapidly.

*.5 CONCLUSION

Reading through the chapters of this book, one is struck again and again by the importance of geospatial technologies, and by the need for a concerted effort to make them more available, and to educate people in their effective use. In the hands of a user who thinks spatially, geospatial technologies are amazingly powerful extensions of the senses, revealing things that would be impossible to obtain in any other way. Geospatial technologies replace the tedium, inaccuracies, and lack of replicability of more traditional approaches with a workflow that is readily shared and understood. Much remains to be done to enhance their specific applicability to issues of homeland security, but the chapters of this book demonstrate the vast range of opportunities that exist.

At the same time one would be foolish not to recognize the problems that can result from their misuse. Results from computers can easily appear more accurate than they really are, because of the ample precision of the machine. Users may be overconfident in the results of simulations, conveniently ignoring the uncertainties that are inherent in any model of the world. The logical precision of a GIS may be at odds with the much more casual and ambiguous way in which humans interact with the planet, giving different names to the same place, making maps that sometimes reveal as much about the agendas of their makers as they do about the real world they are intended to represent. Geospatial technologies are not readily adapted to representing the different views and perceptions

people have of their surroundings, or the ways some cultures manage and conceptualize space.

In the final analysis, however, it is impossible to avoid the fact that geospatial technologies have an enormous amount to offer homeland security, and that their greater and more effective use, along the lines presented in this book, cannot but help to make the world a safer and more secure place.

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