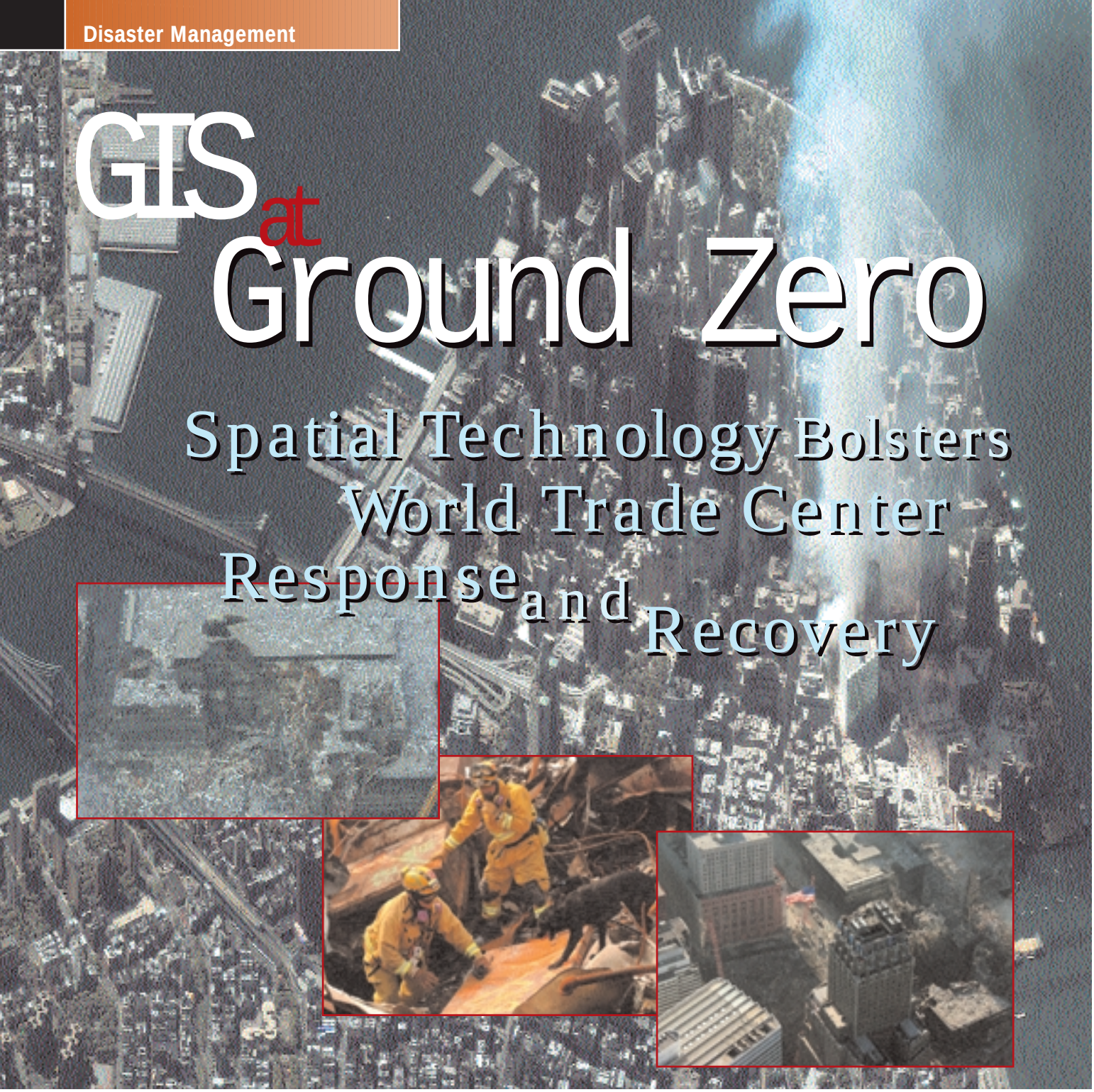
GIS at Ground Zero

Spatial Technology Bolsters World Trade Center Response and Recovery



By **Bruce Cahan** and **Matt Ball**. Cahan is president of Urban Logic, a New York nonprofit organization, and director of the Financing Solutions Team for the Geospatial Information Implementation Initiative sponsored by the Federal Office of Management and Budget and the Federal Geographic Data Committee (*http://www.fgdc.gov/I-Team*); e-mail: *bcahan@urbanlogic.org*. Ball is the editor of *GEOWorld* magazine and show manager of the GEOTec Event; e-mail: *mball@aip.com*.

Since the World Trade Center atrocities on Sept. 11, news reports have described at length the heroic efforts of fire, police and many other professionals responding to New York's urban trauma. New York City Mayor Rudolph Giuliani and his fire and police commissioners demonstrated tremendous compassion for the victims' families and high-level disaster management skills. The mayor publicly complimented the efforts of the city's municipal workers and alluded to the logistics and technologies involved in coordinating federal, state, local and other agencies; accepting private assistance; and rebuilding the comfort zone for the city's resilient citizens. Perhaps the public's confidence in emergency response and urban intelligence efforts to avert future tragedies might improve by knowing the role that technologies—particularly GIS and related spatial technologies—played in bringing order to the chaos. Moreover, New York's experiences may assist government and industry planning

A one-meter resolution satellite image of Manhattan was collected on Sept. 12, 2001, by Space Imaging's IKONOS satellite. (spaceimaging.com)
Close-up aerial photographs (left), taken Sept. 21, show detail of the destruction. (New York Mayor's Office of Emergency Management)
On the same day, California Task Force-8's Mike Scott and his dog, Billy, search through the rubble for victims (middle).(Andrea Booher/FEMA News Photo)
Flying high over Ground Zero on Oct. 12, the American flag blows in the wind from one of the site's many cranes (right). (Photo by Mike Rieger/FEMA News Photo)

that relies on spatial technologies for homeland security, critical infrastructure assurance and other public health and safety challenges.

Geography as the Common Denominator

Cities are built in layers, from the bedrock and soils upon which their foundations lie to the subways, streets, buildings and other infrastructure that evolve over time. The response effort for the World Trade Center attacks involved hundreds of federal, state, local and private groups with separate knowledge, jurisdiction and interest in these layers. No one group alone had all the data needed to do the job or to coordinate with others performing essential tasks. Geography provided the common denominator for all response and recovery efforts.

Fortunately, relief workers had a highly detailed base map, NYCMAP, which was developed by city technology leaders during the last five years at a cost of $5 million. The seamless digital orthophotographic layer was compiled from more than 7,500 aerial photographs. The vector layer was photogrammetrically captured from the same aerial photographs and enhanced to include the city's streets, properties, building footprints, transportation networks, rivers and waterways. The vector and orthophoto data were developed to meet national map accuracy standards for one inch:100 feet, which specify an absolute positional accuracy of +/- two feet horizontally and +/- one foot vertically.

Getting Up and Running

The importance of the base map to the response and recovery effort was immediately apparent to Alan Leidner, director of Citywide GIS at the New York City Department of Information Technology and Telecommunications (DOITT). He was on the way to his office just blocks from the World Trade Center when the attack occurred. The debris from the attack destroyed the city's Emergency Management Center at 7 World Trade Center, forcing the city to find an alternate Command Center to spearhead its disaster response efforts. After spending hours searching for the alternate site, Leidner went home and waited for the phone to ring. At 5 p.m. the call came, and he reported to the Command Center organized by the Mayor's Office of Emergency Management (OEM) at the Police Academy at 20th St. Here he was greeted with the urgent request, "We need a map of the (Ground Zero) site."

The most easily accessible copy of NYCMAP was at Hunter College, which was contracted by the city to help ensure the base map's accuracy. Other copies were destroyed at 7 World Trade Center; inaccessible in the City Planning Office and DOITT buildings, which were blocks from the World Trade Center; or locked up in buildings closed for the day. The staff at Hunter College immediately started making maps and brought these to the Command Center late that night.

On the morning of Sept. 12, Hunter College brought three computers containing the NYCMAP to the temporary Command Center. The city's Parks Department, centered uptown, also was spared by the disaster, and in a few hours staff members loaded a complete GIS network into a truck and delivered it to Leidner at the Command Center. Just one day after the attack, the mapping operation was under way.

According to Leidner, "We started out calling ourselves the Emergency Mapping Operation, but very soon, within just a few days, we realized that we were the clearinghouse for all data. So we renamed ourselves the Emergency Mapping and Data Center (EMDC)."

On Sept. 14, the whole Command Center was transferred west to Pier 92 at 52nd St. and the Hudson River. EMDC's equipment and hardware were assembled from many agencies and offices without delay. A generous donation was made by Compaq (20 workstations and servers) and Hewlett-Packard (six high-speed plotters). ESRI and other companies donated GIS software. The people to staff the new center included the city's own experts in computer mapping and analysis, along with many from various city departments, including Information Technology, Parks, Finance, City Planning, Transit Authority, Transportation, Buildings, Police and Fire. A call for volunteers went out to the members of GISMO, the local GIS user's group, and more than 100 people responded. Workers also included staff driven or flown in from companies such as Compaq, ESRI, PlanGraphics, MITRE, Hewlett-Packard, IBM, Urban Data Solutions, Urban Logic and URS Consultants, to name a few. In addition, neighboring state (New Jersey) and county (Westchester) GIS coordinators with robust geospatial operations sent their best GIS programmers. Within days, a 24-hour mapping and data integration center emerged that served 300 people whose agencies at the OEM Command Center on Pier 92 supported and coordinated several thousand workers associated with the disaster recovery and rescue effort.

By Sept. 15, there were three primary GIS operations in Manhattan: the New York City EMDC on Pier 92, the Federal Emergency Management Agency (FEMA) Disaster Field Office (DFO) on Pier 90 and the Urban Search and Rescue (USAR) operation at the Jacob Javits Convention Center. Collaborations immediately started to follow the needs of the emergency response: save lives, safeguard rescue workers and buildings, and rebuild public confidence. Data started streaming in and were tied to the city's base map. 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 theory of how valuable a common base map and coordinate system could be in dense urban settings was now accepted as fact—essential infrastructure relied on by the city's mayor and senior management.

Tasking Spatial Technologies

In the early days of the response effort, there was a huge desire to understand exactly what area was affected and what it looked like. Toward that end, several spatial technologies were applied, including remotely sensed imagery, Global Positioning System (GPS) technology and GIS.

"Beyond the courage and expertise of your first responders, getting accurate data and integrating and modeling that data is absolutely the lifeblood of dealing successfully with an emergency," says Leidner.

Imagery

The New York Fire Department's Phoenix Photography and Imagery Group, led by Captain Justin Werner, began taking aerial photographs on the first day—even when it meant holding cameras while hanging out of police helicopters. Bruce Oswald, the state's GIS coordinator in the Office for Technology, handled EMDC's request for digital orthophotography. Initial flights, using traditional methods, didn't provide the quick turnaround that was required. Oswald contracted with Earth Data Technologies, which agreed to perform the work at cost and was able to process the data within 12 hours of receiving them. The original request was expanded to include light detection and ranging (LIDAR) imagery, which allowed emergency managers to see through the smoke, and thermal imagery for mapping hot spots that represented thousands of gallons of fuel oil and jet fuel buried amid the Ground Zero rubble. The thermal imagery helped to keep workers away from dangerous parts of the site, as fires continued to flare

Urban Data Solutions Inc.

A Ground Zero visualization shows building status data using Urban Data Solutions' 3-D database of Manhattan.

when debris removal let air into the pile.

The orthophotography was processed in Albany, N.Y., and posted to an FTP site that was provided by the EROS Data Center in Sioux Falls, S.D. Because of the lack of bandwidth in some areas of the city, state police drove the data down twice a day, delivering them on CD-ROM to the fire department, the EMDC and FEMA.

GPS

At Ground Zero, workers on the pile required accurate locations of features, items found and dangers. A variety of tools were used, including laser rangefinders, GPS equipment from Trimble and ruggedized handheld computers with GPS capability from LinksPoint.

LinksPoint created an application that allowed the firefighters to identify and bar code items found on the pile along with time, date and GPS location. Prior to this solution, it took three to five minutes to catalog each item found on paper, and workers tried to guess where they were in the grid system. Moreover, they needed to take the paperwork to someone who would enter it into a database. The handheld application allowed workers to catalog each item in about 30 seconds, and accuracy was greatly increased. Ground Zero is a crime scene, so police and the medical examiners office use details on all items collected and mapped.

GIS

Mapping Ground Zero. The role of FEMA and the USAR teams was to provide accurate maps and measurement of the rubble pile that is Ground Zero. The team collaborated with EMDC and worked directly with the Fire Department and rescue crews to relay changing conditions on the pile back to the Command Center.

The World Trade Center site went down five basement layers, containing subway, water, gas and utility lines. Fires raged above and below ground, with temperatures reaching 1,000 degrees Fahrenheit. Voids and valleys existed in the debris pile, and workers were concerned about the mass shifting. There also was concern that the waterproof outer walls or "bath tub" of the basement layers might be compromised, allowing Hudson River water to flood the site. In addition, coordinated movement of search and rescue teams needed to be mapped and monitored so efficient and timely searches took place.

Structural engineers were busy assessing these factors and relaying the data back to the mapping operation. Infrastructure data were assembled, sometimes in the form of nonregistered digital computer-aided design drawings. The data were integrated with the building plans to provide a 3-D view underground; before and after views of the site helped determine existing conditions.

Mapping the vicinity. The attack affected a huge area, and most of Lower Manhattan was closed in the days immediately following Sept. 11. EMDC focused on the area south of Canal St., mapping building damage detail as well as outage detail regarding electrical, water, gas, steam and telephone services. The team also assessed vehicle and pedestrian access to the area, including subway and river crossings. All of this detail became static maps that were posted to the World Wide Web for the public, employers and employees to see daily changes and recovery progress. Utility outages, mass transit re-routing information and street closures were constantly changing, and such details were extremely important to those who were displaced by the tragedy.

By week two, EMDC had developed an interactive mapping application by adapting the city's Emergency Management Online Locator System. The application allowed people to enter the address of a building in which they were interested, find out what zone the building was in and determine whether or not they could travel to it and work in it. Originally built to support public information needs in a hurricane or flood scenario, EMOLS showed EMDC's "why not" attitude toward rapid adaptability and ingenuity.

Coordinating Maps as Media

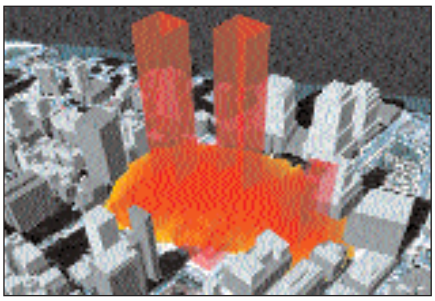
Data came into the EMDC and were modeled and related to the mayor, the fire commissioner and others on the mayor's management team in their attempts to shrink the "Red Zone," the most hazardous area around the Trade Center that was cordoned off from public access. The entire picture of city mass transit, Wall Street businesses and related regional data could be assembled to stage rescue operations, route emergency vehicles and assets, remove debris and coordinate the presentation of current conditions for the rescue crews to use to help safeguard their operations. EMDC gave the mayor maps he used to explain the changing conditions at Ground Zero, reducing the curiosity of onlookers and keeping larger crowds from the area at times when rescue/recovery teams and demolition vehicles required as much room to work as possible. He also used the maps to explain to congressional delegations, business leaders and industry representatives the shear enormity of the damage and its impact on the city as well as the extent to which aid from outside the city would be needed to recover.

Evolving Work Processes

Dozens of specific work processes emerged and became more effective as the days went on. Interoperability concerns (i.e., wanting to use one dataset in a proprietary format) were addressed in many ways. For example, many EMDC staff members found or wrote conversion and importing programs for key data. To maintain accuracy, changes to the map layers required approvals through the mayor's Office of Emergency Management by multiple government and private groups that ordinarily wouldn't communicate in real time. Each day brought new types of data acquisition, users and uses.

Far from being the grist of esoteric national or industry discussions, standards for data quality and access became time critical:

• How recent are the data? (timeliness issues)



JB Akin and David Gadsden, DESC Inc., Edmond, Okla.

Using GUIDO for ArcView 8.1, a model was developed to show the potential energy of collapsing towers. The energy of an individual tower was estimated to equal approximately 270,000 pounds of TNT.

• Where did the data come from? (authenticity and pedigree issues)

• Are the data reliable enough to disseminate to the media, so New Yorkers trying to return to work or their homes will know how to get there and what to expect when they arrive? (metadata, data content and disclaimer issues)

• Which data did which GIS programmer use when to produce which version of what type of map for which users? (clearinghouse, data catalog, archiving and services issues)

• How do we make sure that certain preliminary information stays confidential within the emergency response community and isn't generally released? (data access, data lifecycle/ripening and security issues)

The normal technical issues (i.e., how to integrate data gathered at different scales for single purposes) assumed new importance, as increasing streams of data flowed into EMDC (as the spatial data integrator for OEM's Command Center) from throughout the city. City managers of the EMDC operation met nightly with volunteers and contractors to review ways to improve the next day's processes for updating information, make changes to the digital information, disseminate the changes and service "rush" projects for the mayor and key agencies.

"The one compelling thing about this work was that the maps we were creating were absolutely critical for making informed decisions on the ground," notes Sean Ahearn, professor of geography at Hunter College. "When you're making a map, and you realize the gravity of the situation and the fact that lives are endangered at that site, it changes your perspective on the importance of creating those products."

Quantifying the Effort

Numbers confirm how much was contributed to the rescue and response in the crucial first week. More than 750 map requests were satisfied (each requestor would ask for several kinds of maps). Daily more than 325 maps and other graphics were distributed in paper and CD-ROM form—50 percent went to city agency users, 20 percent to state users, 20 percent to federal users, 3 percent to sister states and counties, 6 percent to corporations and 1 percent to nonprofit aid workers.

Hundreds of copies of the maps were made by the requesting agencies and disseminated through the media. In the weeks after the attacks, the output increased and the percentages distributed to various groups (like utilities, insurance companies, the media and others) changed. More than 50 percent of the first week's maps were nonstandard—"customized" using data or data layers of unique interest to the requestor and his or her function or logistical interest in managing the response. Within the first month, there were 50 standard production maps that were each modified at least every other day. Within the first two months, EMDC responded to more than 2,000 requests and plotted about 10,000 maps.

The people, technology, work processes and shared data resources aligned at EMDC were known to exist and, under the city's leadership with federal and state governments, were brought together through heroic effort. Other regions might not be so "fortunate." In this emergency, EMDC's role as data integrator (and technology and staff assembler) evolved into an effective and unspoken "mutual aid pact" for all involved. Other communities would likely benefit from having such pacts in place before disaster strikes.

Without EMDC and the city's base map, many of the emergency services, relief agencies, media and private companies would have had to generate their own views of Lower Manhattan to remediate the effects of the terrorist attack and its aftermath. EMDC let these groups communicate, collaborate and leverage disparate assets and specialists in real time with a maximum of efficiency and effectiveness. The whole world has watched New York City recover from Sept. 11, and spatial technologies played a critical role.

Extended Coverage Online

The various perspectives and lessons learned from an event of this magnitude could never be summarized in one article. The breadth of input for this piece provides a much more complete picture. *GEOWorld*'s editorial staff has compiled these additional details on the magazine's World Wide Web site at *http://www.GEOPlace.com*. Click on GIS at "Ground Zero" under GEOResources to view the content below. *GEOWorld* welcomes additional content from anyone wishing to share his or her thoughts or experiences. Send content to John Hughes, *GEOPlace*.com editor in chief, at *jhughes@aip.com*.

Documents

Key Activities, Products and Lessons Learned from New York City's Emergency Mapping and Data Center, Jim Hall, project manager, PlanGraphics.

Deep Infrastructure, Wendy Dorf, New York City Department of Environmental Protection; K. Adams Manion, URS Consulting; and Marina Havan-Orumieh, PlanGraphics.

Real-Time Interoperability for Environmental Information, Stefan Falke, American Association for the Advancement of Science (AAAS), Science and Technology Policy Fellow at the Environmental Protection Agency (EPA).

The Role of I-Teams, Bruce Cahan, president, Urban Logic, a New York nonprofit organization, and director of the Financing Solutions Team of the OMB Geospatial Information Implementation Initiative.

GIS Position Descriptions and Data Structure, Dave Kehrlein, California Office of Emergency Services.

Lessons Learned, *GEOWorld*.

New York City's GIS Utility.

Interviews

Sean Ahearn, professor, Hunter College Geography Department, and director, Center for Analysis and Research of Spatial Information (CARSI).

Daniel Dubno, CBS News technology producer and chair of the Radio and Television News Directors Association, Remote Sensing Task Force.

Jack Eichenbaum, city assessor, New York City Department of Finance, and coordinator for the GIS and Mapping Organization (GISMO).

Russ Johnson, Public Safety Industry manager, ESRI.

Dave Kehrlein, California Office of Emergency Services, Urban Search and Rescue.

Alan Leidner, director of Citywide GIS at the New York City Department of Information Technology and Telecommunications.

Bruce Oswald, state GIS coordinator, New York State Office for Technology.

Strite Potter, president and founder, LinksPoint.

Chris Schielein, ESRI.

First-Person Accounts

Jim Hall, project manager, PlanGraphics.

Ron Langhelm, GIS coordinator, FEMA Region X.