GIS for Fire Deployment Analysis

Introduction

This paper will describe how GIS can be used for fire deployment analysis. I will attempt to outline how a department can acquire the capability to utilize GIS for deployment and the basic steps to get started. The basic hardware and software and GIS data options will be identified along with sources for GIS data. Various intermediate and advanced options for the use of GIS for deployment analysis will be presented and expanded deployments of GIS for response and recovery will be reviewed.

Requirements

In the recent past, GIS software was expensive, GIS data was limited and the hardware performance and operating system software made it very difficult and very expensive to implement. Today, the software has become more affordable, the computers have become more powerful and less expensive and GIS data has become more available. The basic requirements for a desktop GIS are as follows:

Hardware

Pentium Processor
256 Megabytes of RAM
10 to 20 Gigabytes of Storage

Software

Desktop GIS such as ArcView with the Network Analyst extension in order to perform analysis on road networks.

GIS spatial data (minimum)

Local Streets with road classifications
Fire Station locations

Other desirable GIS data

Jurisdictional boundaries
Fire districts
Fire Hydrants
Zoning
Parcels

Other data

Data table with historic incident response history (from 3 monts to 1 years worth or records).

GIS Operator

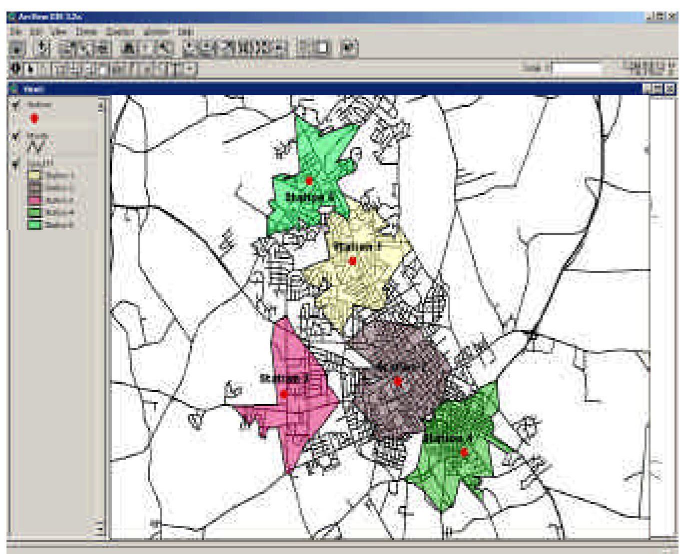
A person(s) who can operate a desk top GIS. Typically 16 to 32 hours worth of training required to begin basic GIS work.

GIS data can be obtained from commercial sources for most communities at very affordable prices. Many times the jurisdiction will have a GIS department where this data (possibly with other data) is available. The fire station layer can be created by "gecoding" station locations onto the GIS display by entering each stations address.

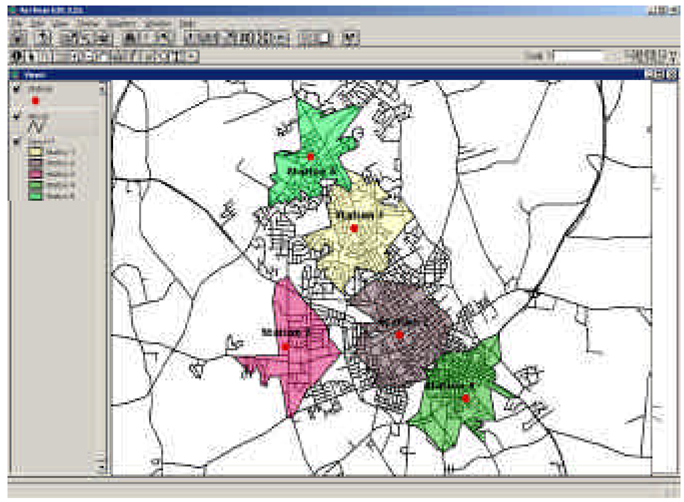
Getting Started

Once the minimum data layers have been acquired, basic response analysis can be analyzed. Each road type from the classification of roads should be assigned miles per hour base upon the realistic speed apparatus can travel on each road type. Most street data sets will have 4 to 6 general road types. The miles per hour can be assigned and GIS will populate the miles per hour for each of the road types within the table. Individual modifications can be made to road segments where required.

GIS will calculate travel times and distances based on the user's inputs. For example, the user can enter the minutes of travel time he or she wants displayed. If the user wants to see total response time from the of call received, (process call, turn out time, etc.) that time can be deducted from the drive time. For example, if it averages 1 and ½ minutes before the apparatus moves onto the street, the drive time should be calculated for 2 and ½ minutes for a total 4 minute response.



The next step will consist of getting a table with historical incident information from the departments records system. Standard tables can be exported as a DBF file and imported directly into ArcView. The incidents can be geocoded on the map by matching the address in the records table with the address on the street data layer. The user can then begin to geocode incidents by incident type by time of day or other desired variable. GIS will put a point on the map for every fire that meets the users criteria. The actual response time in the data table can then be compared with the projected response time shown in ArcView.



The basic functions of modeling response times, geocoding actual historical responses. Comparing actual response times to modeled response times, etc. can be done using GIS without great difficulty. Once these basic capabilities are established, more capability can be added. Determination of run orders (where does each stations apparatus arrive as the 2nd unit, third unit, etc. More data can be added to do other analysis (hydrants, hazardous materials, vacant buildings, demand zones, buildings, floor plans, natural hazards, pipelines, etc.)

GIS deployment for the Attacks on New York and the Pentagon

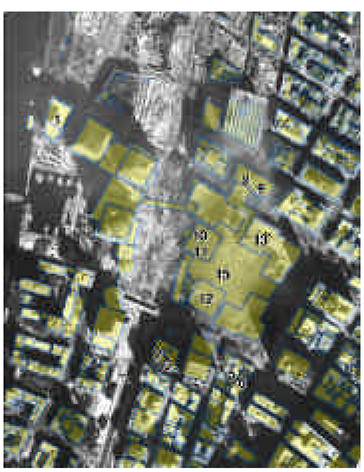
During the events following the terrorist attacks of September 11, GIS was deployed for search and rescue and recovery. The magnitude of the world trade center attack and the difficulty of managing this incident is difficult to describe. GIS technology helped to reduce some of the confusion chaos and helped emergency management personnel make critical decisions.
Among the damage of 9/11, the state-of-the-art Office of Emergency Management operated from was the 3rd building to collapse. The operation was temporarily relocated to Pier 92 on the Hudson River.

The newly created OEM became the central hub for emergency operations to strategize and deploy resources. Among the dozens of emergency response, fire, medical, and law enforcement agencies operating within the OEM, a mapping center was created and equipped with 20 GIS workstations and five map making plotters. New York City had long been a leading government user of GIS, producing rich geographic databases and maps and digital imagery of its critical infrastructure for years; this would prove vital in the ensuing response. With GIS capabilities quickly up and running at the new EOC, combined with pre-existing GIS databases, the technology was the foundation for many activities.

The result was a database enterprise for storing, managing, and editing spatial and related tabular information. This allowed for disparate information pools created independently by private and public utilities, fire, public works, water, sewer, police, and others to be integrated and stored in one location. This centralized, integrated environment provided dynamic mapping capabilities that in turn spurred optimized emergency field operations.

Maps of all types were created including:

- transportation and public access
- major river crossings
- subway service
- telephone usage
- pedestrian and vehicular traffic restrictions
- power grids
- operational areas
- damage assessments
- fire, emergency services, and police emergency response assets
- staging areas
- water outages
- personnel services such as food stations and hydration stations
- three dimensional building maps



Search And Rescue

The entire World Trade Center site was a hazard, especially as Search and Rescue Personnel moved through the debris and removed it, looking for survivors and collecting information.

Search and rescue facilities were located at the JAVITS Convention Center, where Urban Search and Rescue (USAR) teams were housed and logistically supported. Incident Support Teams provided administrative and planning assistance. It was the incident support teams that brought GIS capabilities to these operations.

ESRI provided a support team to work onsite at the OEM mapping center 24 hours, seven days a week. The mapping services team literally produced thousands of maps.

Many other private companies provided assistance with computers, software, technicians, network expertise and other services. GIS maps were used during daily briefings and for mapping incident action plans. USAR teams used the maps with search grids. USAR teams were given works assignments based on search grids identified within GIS. After a grid was thoroughly examined, crane operators carefully removed a layer of debris, which was the loaded into trucks and taken to an examination area. The debris was spread out so more precise inspections could take place. The debris was marked and recorded so that anything found could be mapped and linked to its grid cell location at the World Trade Center.

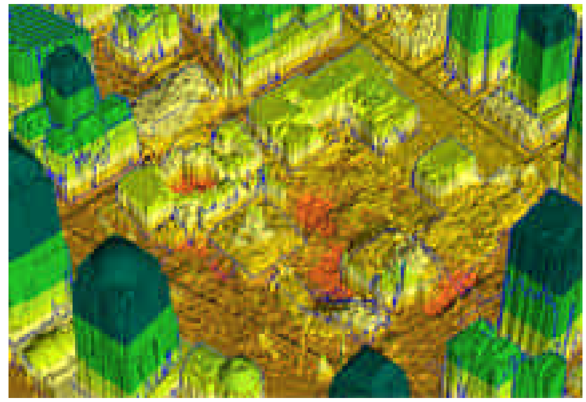
As floors were examined and surveyed, voids, or open pockets among debris wreckage, were mapped using GIS. Color coded maps of building levels revealed the status of the search operations for the floor, for example, whether sections have been searched and cleared, whether collapsed, flooded, or exposed to a hazard such as fire or potentially toxic pollutants.

Aerial photos were overlaid with square grids and mapped to continuously provide a time-stamp monitor for operations. Maps could then be examined to evaluate operations progress.

In addition, detailed, ground-level photos where hot-linked linked to the GIS database map so that users could select a building or grid cell on the base map and quickly access them.

Asset and infrastructure maps generated prior to the attacks allowed users to more quickly locate items after the attack by providing a reference point; whereas rubble and debris was disorientating for USAR teams. Maps of floor plans and other assets allowed workers to find items, such as downed electric lines, gas mains that need to be examined for leaks; or other critical infrastructure assets.

Emergency response professionals also used light intensity detection and ranging (LIDAR) images to create three-dimensional maps illustrating smoldering hotspots, voids, and pile movement. LIDAR images were produced daily to understand how the debris was shifting, fire progression and other information.

Emergency Decision Support

Emergency decision support was facilitated using GIS. Locating downed power, telephone, and water service, utility infrastructure generators, bridges that support heavy load removal, fuel tank locations, building ownership information, and much more were mapped and managed using GIS; users could quickly view infrastructure damage to determine where repairs were needed, what services were and weren't working, and much more. Deploying emergency personnel, routing crews, identifying larger open areas in lower Manhattan for equipment staging (cranes, etc) and assigning areas of work were made easier with digital maps.

In addition, getting information to the public was facilitated using maps. News maps enhanced stories by visualizing information related to recovery efforts, giving readers a view of the events as they transpired. Officials from the mayor's office requested maps to keep the mayors staff apprised of issues and progress in search and recovery.

As time elapsed and more information were collected and stored in GIS, advanced modeling features helped staff model the collapse of buildings and how the debris and pressure were distributed over the areas infrastructure.


GIS at the Pentagon

Similar activity occurred at the Pentagon. Computer Aided Design (CAD) files of the Pentagon's blueprints from the on-site contractor were transformed to GIS formant and were printed out in the form of poster-size floor plan maps.

GIS was used to visually depict the extent of Pentagon damage. A map was created using a numeric value system between one and four assigned to each structural column affected by the explosion and fire; then, using sophisticated GIS analysis, a model was created depicting the likely trajectory that took place as the plane impacted the Pentagon.

Rescue efforts and victim locations were mapped. CAD maps were layered over aerial photographs to model impact damage and fire at the Pentagon. After interviewing survivors, the last known locations of those still missing were plotted on a map as well, allowing for search and rescue crews to more precisely explore areas where people were last seen.

GIS for Homeland Security: What Can be done?

While the events of already mentioned show examples for how GIS can be used in rescue and recovery efforts, a more profound role for GIS can be its use for surveillance, preparation, planning, mitigation and response for Homeland Security.

Surveillance and detection of potential terrorist activity is critical for preventing terrorist acts. Terrorism and criminal activity requires funding, people, materials and logistics. The connections between these involve patterns in time and space. GIS techniques can be used to correlate apparently disconnected events, to see the big picture emerge from huge volumes of data. The key is the fusion of data from disparate sources into a common spatial framework. As a growing range of sensors are deployed to gather information concerning suspicious activities, GIS can be used to integrate their information into a meaningful common picture.

Assessing and analyzing the locations and vulnerabilities of water supplies, distribution pipelines, roads, bridges, public transportation, populations, schools, hazardous material locations, public assemblies, national monuments, and other assets can be performed efficiently using GIS.

When vulnerabilities are identified, GIS can assist in the identification of mitigation strategies and can model various alternatives This may include setbacks around buildings, closing certain access points, fencing exposed areas, relocating hazardous materials, etc.

GIS supports other critical homeland security planning requirements. Some of these include:

Identification of evacuation routes

The locations and capacities of evacuation shelters,

Potential locations of staging areas

The locations and capacities of geographic areas for incident management facilities. Analyzing the locations of public safety response assets (fire, ems, police, etc.) and their ability to respond quickly to potential complex emergencies

GIS played a key role in the search and rescue and recovery efforts at the World Trade Center and the Pentagon. The chaos and confusion of complex emergencies require can be more effectively managed when responders and workers have a clear picture of what needs to be done, where it needs to done and critical priorities. In complex emergency events, many people from different agencies must respond and take coordinated action. These required coordinated actions are usually communicated through the medium of a map. Today, GIS not only provides maps, but provides great amounts of additional information about each feature on the map when needed. However, powerful as it is for response and recovery, it's greatest capability is for preparation; preventing events before they occur, reducing the consequences when and if they occur and providing responders the information they need to make accurate decisions when life safety is in the balance.