Geographic Information System for the Nashville Fire Department

Leading Community Risk Reduction

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Abstract

The problem was that the Nashville Fire Department had not identified a geographic information system that it could use to enhance its delivery of services.

The purpose of this applied research project was to identify a geographic information system that could be used by the Nashville Fire Department for processing of information.

Using descriptive research, the researcher answered these three questions:

1) What agencies or organizations in Nashville currently use geographic information systems?
2) What geographic information systems are being used by other fire departments and for what purpose?
3) How can the Nashville Fire Department use geographic information systems for processing future information?

The procedures used in this applied research project included a review of literature, interviews, and an external survey that was used to help determine what other departments were currently using geographic information systems.

Results showed most departments/agencies in Nashville are currently using geographic information systems to plan and manage problems; the external survey revealed that most career fire departments surveyed are using geographic information systems to some degree.

Recommendations include working with local department agencies in order to benefit from their databases, using existing resources from the United States Fire Administration and Internet along with visiting a city currently using geographic information systems.

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Introduction

In the 21st century, the American Fire Service is facing new threats and risks, which may mean it will be dealing with different types of emergencies. The different types of emergencies in the future may or may not be considerably larger or worse, but they are likely to be more complex and require more preparation, mitigation, response and recovery efforts. On September 11, 2001, the New York City fire department responded with all of the data they had, but the up-to-date information they did not have may have cost them more lives and property. Even the best fire department can be intimidated when it is time to access and analyze the volumes of data collected to handle the different emergencies to which we respond. It is not enough to just possess large volumes of data; the data should be able to be used to protect lives and property before and during any type of emergency. A geographic information system (GIS) can be the key to decision making and proper planning for the different types of emergencies the fire service will face in the future.

According to Jack Dangermond, president of Environmental Systems Research Institute (ESRI),

> GIS works effectively in all four phases of the disaster management cycle: preparation, mitigation, response, and recovery. Whether analyzing consequences; projecting and predicting; disseminating information; allocating personnel, equipment, and resources; getting from A to B; or picking up the pieces in ways that help rather than hinder stricken families, businesses, and regions, GIS is the tool of choice. (Amdahl, 2001, Preface)

GIS has an obvious relevance, not only for storage and display of data, but also because of the ability to bring together those data sets for integration.

According to the Federal Emergency Management Agency (FEMA) Mapping and Analysis Center,

> GIS is a very useful tool for many aspects of emergency management, including: emergency response, planning, exercises, mitigation, homeland security and national preparedness. Due to its ability to manage and display data, GIS has robust modeling capabilities, allowing it to adjust data and scenarios for prediction, planning and estimation. (FEMA Online, 2003)

It appears that GIS fulfills the core mission of the American Fire Service by helping people and saving lives through proper planning, response to and prevention of different types of emergency situations.

The problem is that the Nashville Fire Department (NFD) has not identified a GIS that it could use to enhance its delivery of services as part of its effort to mitigate hazards and resources and protect lives and property from different types of emergencies. Given the right tools, such as GIS, the NFD could get a better grasp of the "big picture," and begin to meet the emergency services needs of the community by understanding where damage and rescue requirements are most critical.

In the past, the NFD has collected large amounts of data and stored it in file cabinets at the station, headquarters, fire prevention office and a number of other facilities throughout the department. Since most of the information gathered over the years are still in those file cabinets and are considered "out of sight out of mind," that

information is considered by most in the department to be irrelevant. All the information gathered is not stored in file cabinets. Some individuals keep information they collect to themselves, never telling anyone. When those key personnel leave, they often take that specific knowledge with them. This loss of information can be serious because firefighters usually don't get a second chance when making critical decisions. These decisions often include, but are not limited to, response routes, hydrant location, building construction and hazardous material location. Sometimes when it comes to accessing information, nobody can quite put his or her hands on the information needed in helping to make the appropriate decision. In "GIS for Fire Planning and Response" the writer states, "GIS is ideal for fire planning. Fire hydrant locations, response area requirements, hazardous material locations, commercial building locations, fire history, station location needs, and other key requirements can be analyzed and visually displayed in GIS" (ERSI Online, 2003). Modern technology has made great strides, which, in theory at least, have been for the betterment and safety of the American Fire Service.

The purpose of this applied research project will be to identify a geographic information system that could be used by the NFD for processing of information. Descriptive research will be used to answer the following research questions:

1) What agencies or organizations in Nashville currently use geographic information systems?
2) What geographic information systems are being used by other fire departments and for what purpose?
3) How can the Nashville Fire Department use geographic information systems for processing future information?

Background and Significance

The NFD serves a city of approximately 570,000 people in a 533 square mile area. There are approximately 1,265 personnel in the NFD. The Nashville Fire/Emergency Medical Services (EMS) Bureau is the largest bureau in the Department with approximately 900 personnel separated into three major divisions: Fire/EMS, Urban Search and Rescue (USAR)/Technical Rescue, and Special Hazards/Water Rescue.

The NFD ranks with big business in number of employees, size of budget, magnitude of capital investment, and complexity of problems they face. When the NFD is managing different emergencies daily, they need to have current and accurate information to help make decisions that will save lives and resources. To make better informed decisions in the future, the NFD should focus on how GIS could benefit the department with the processing of information.

In the past, the NFD has spent thousands of hours collecting information just to store it in file cabinets. In "A Picture is Worth a Thousand Words: Part 1" Coleman (2003) states, "Regardless whether your system is complex or simple, information sitting in a file cabinet is invisible and irrelevant to many of the policy discussions that go on about what a fire department does" (p. 64). Coleman also states, "Anything that you have got stuck in your file cabinet can be made active in a GIS environment" (p. 64). From response to on-scene decision making, firefighters have relied upon their knowledge for any type of emergency. Even the communications center has used hard-copy files to dispatch the closest company to the best of its knowledge. Basically we have been using handy maps for emergency response, leaving pre-planning information back at the

station, locating hydrants from past experience and using knowledge gained from previous incidents to protect the community.

Within the last two months, the NFD has assigned two fire service personnel to investigate the use of GIS and how it can increase the departments effectiveness. In the video “GIS Technology” the narrator states, “…GIS technology can increase the effectiveness of our organizations by the management of enormous amounts of information. GIS technology can allow fire service leadership to request, plan and utilize resources to mitigate emergencies” (Fire & Emergency Training Network, 2002, motion picture). So far the personnel assigned have worked with the planning department to map out hydrant locations for each station’s district. This hydrant map took the place of a computer print out for each station’s response area and provided a clear photographic representation of existing hydrants. At this point the use of GIS is in it’s infancy state in the NFD.

In the future, the NFD could benefit by the use of GIS data to improve services and increase the equity and quality of decision making and planning before, during, and after any type of emergency. In “A Picture is Worth a Thousand Words: Part 2,” according to Coleman (2003) “[The fire service] ought to be the resident experts on what the ‘picture’ of fire protection really looks like” (p. 27). Coleman further states that we should “take all of that boring, dry and dusty data out of [our] file cabinet and turn it into a portrait of [our] community that even the general population could view it with a sense of awe” (p. 28). The preparation by the NFD to respond to different types of emergencies depends on a number of factors including adequate planning, available equipment and appropriate organization of emergency services.

This applied research project is related to the National Fire Academy's Leading Community Risk Reduction course in Unit Two on Assessing Community Risk. The objective of Unit Two is to identify and quantify risk to lives, property and community vitality in a model city. This research project also supports the United States Fire Administration's goal "to promote within communities a comprehensive, multi-hazard risk reduction plan led by the fire service organization" (NFA, 2002, p. II-2) by identifying how GIS could be used by the NFD for processing of information. Utilizing GIS, the NFD could present the city with a clear picture of the nature and extent of the emergency services problem. According to Ismail, in "Geographic Information Systems,"

> One of the major benefits of any GIS is that it enables users to visualize information and as the visualization of information is one of the most powerful learning and understanding methods available, a GIS becomes one of the most potent methods of analyzing, understanding, and presenting data. (Tripod Online, 2003)

GIS provides answers by visually displaying information into living maps that can make complex information easier to understand during any type of emergency situation.

Literature Review

Although computerized technology such as GIS has only been around for 30 years or so, it has been described in several ways. These descriptions show the many uses and importance of GIS in both the public and private sector.

GIS technology can be used to find solutions for planning and management problems. In research conducted by Cavarra, Favall, Giamini, Meriggi, and Paresch (2000) they state:

> Geographical Information Systems (GIS) are computer-based systems used to store and manipulate geographic information. They are designed to support the capture, management, manipulation, analysis, modeling and display of spatially referenced data for the solution of complex planning and management problems. (p. 361)

GIS combines different layers of information about a location to give the user a better understanding of how to plan and manage problems.

Solution to problems was also stated by Goodchild, Longley, Majuire, and Rhiad (2001). In "Geographic Information Systems and Science," they state, "Information Systems help us to manage what we know, by making it easy to organize and store, access and retrieve, manipulate and synthesize, and apply to the solution of problems" (p. 6). GIS not only keeps up with the circumstances of an incident, but also where incidents have occurred. This allows for quick solutions to problems.

GIS has the ability to combine general information with specific information to come up with possible solutions. Clarke (2002) in "Getting Started with Geographical Information Systems" states:

> We use the information mapped in the GIS for doing exactly what an information system should do: to solve problems, do queries, come up with the answer, or try out a possible solution . . . . This means that GIS is

> a generic problem-solving tool; it is not something built just to do that project or get this week's assignment done. (p. 5)

Thus being able to solve multiple problems is a key reason for using GIS.

The United States Fire Administration (USFA) "GIS Tutorial" (2003) states, "A Geographic Information System (GIS) is a computer-based system used to capture, store, retrieve, manipulate, analyze, and display spatial information and its associated attributes. It combines spatial and tabular information to produce maps and to perform spatial analyzes." Producing maps provides a way to display all the different layers of information at one time.

It is the local government's ultimate responsibility for making the right decisions concerning the long-term health, safety, and welfare of the community. In "Beyond Maps: GIS and Decision Making in Local Governments" O'Looney (1997) states, "Because at least 70 to 80 percent of the average local government's work involves land or geographically related issues or tasks, cities and counties are investing heavily in information systems" (p. 1). O'Looney (1997) also states that "GIS technology increases the ability of local governments not only to improve efficiency, but also to look at the long-term effects of their action" (p. 4). The fire service plays a major role in each government's operational efficiency for the long-term health, safety, and welfare of the community.

In local governments, GIS is usually located in planning as an individual department operation. The use of GIS in specific local planning tasks is highlighted in "GIS in Planning Departments: Preliminary Results from a Survey

of Local Planning Authorities in Wales" conducted by Gill, Higgs, and Nevitt (1999). In their research they state:

> The types of benefits offered by GIS include improved information processing, better data access and data integration, increased speed of data retrieval, improved presentational capabilities, increased staff productivity and accommodation savings, as well as benefits to the general public in terms of improved services. (p. 3)

Local governments have the opportunity to maximize the use of GIS to benefit the community.

American Forests conducted a survey of 200 cities and counties during 1996-97 to establish a nationwide baseline of local government conditions and use of GIS. According to Beattie, Kollin, Lyday, and Warnecke (1998) in "Geographic Information Technology in Cities and Counties: A Nationwide Assessment," the survey "indicates that 87 percent of cities with populations greater than 25,000 and counties with populations greater than 50,000 have acquired GIS software" (p. 22). This study shows that many cities are now adopting this technology to improve their services, manage resources and make better decisions.

In 1992, the Federal Emergency Management Agency (FEMA) began working on a nationally applicable GIS-based tool for communities called HAZUS ("Hazards U. S.") with the National Institute of Building Sciences. FEMA uses GIS in disaster response to make critical decisions before a disaster occurs in an area. "In the early, crucial stages of a disaster or emergency and throughout the disaster process managers use GIS products because they provide

important information … quickly and in easy-to-understand formats" (FEMA Online, 2003). In order to mitigate hazards and protect lives and property from natural disasters, FEMA also states it "aims to provide individuals, businesses, and communities with information and tools to work proactively to mitigate hazards and prevent losses resulting from disasters" (FEMA Online, 2003). In 2002, FEMA also produced a video entitled *"HAZUS: What Could Happen?"* to show how communities are using "HAZUS" in planning for disasters. This video provides communities a way to begin their own risk assessment plan.

GIS has been utilized to save time by making accurate assessment and guiding the search and rescue teams on-site during several disasters. Some of these disasters include Hurricane George, Hurricane Fran and the Oklahoma City Bombing. In "Managing Disasters by GIS" Carothers (1999) states, "As GIS has become easier to use, faster to implement, and less expensive, its lining of maps to multiple data bases provides rescue workers and planners with a quick way to visualize disaster situations, prioritize needs, and respond quickly" (p. 36). When the fire service is managing the impact of a disaster, they need current and accurate information to make decisions.

Dymon (1999) in "Effectiveness of Geographic Information Systems (GIS) Applications in Flood Management during and after Hurricane Fran" states, "Geographic Information Systems (GIS) are powerful tools for eliminating guesswork when it comes to decision making processes during and after a disaster" (Colorado University Online, 2003). GIS leads to better decision making because of better information. This information can also be used to determine the extent of damage and where to deploy needed resources.

Ismail (2001) states in “Geographic Information Systems” that there are four primary uses for a GIS. These include:

- Strictly as a presentation tool, a GIS shows the spatial pattern of information.
- It allows you to query the data bases, and organize and show the data geographically, and manipulate and analyze it.
- A GIS cannot only query a data base, but because of its analysis capabilities, a GIS can aid your planning and decision making process like no other tool.
- It can be used by businesses and government entities that deliver almost anything to determine the minimum path and best route to get from point A to anywhere else. (Tripod Online, 2003)

Even local businesses are starting to use GIS software to analyze business trends and make key decisions about location and design of operations. One of these is Domino’s Pizza Incorporation. With over 900,000 pizzas to prepare and deliver nationwide on its biggest day of the year, Super Bowl Sunday, Domino’s uses GIS “to map in advance the best delivery route to each customer’s address . . . . Select store locations based on driving distance, buying trends and other factors; to distribute inventory efficiently; and to identify businesses opportunities” (Hammond, 1999, p.1).

Several fire departments and agencies have used GIS to collect data, deploy emergency personnel and equipment, route vehicles and assess overall damage during different emergencies. Using GIS effectively has become of interest to the fire service.

In 1990 Wilson, North Carolina, Fire/Rescue Services was recruited to implement the use of geographic information systems to find what it could do for the fire service. According to Chief Oliver (2002), “The department looked to GIS data for quick, visible, up-to-date information on pre-incident surveys, hazmat facilities, dangerous buildings, problem hot spots, repeat calls, arsons, false alarms, water supplies, prevention activities and inspection schedules” (p.36).

John Mays’ (1991) research looked at using GIS to focus upon prevention objectives for Overland Park, Kansas, by enhancing the department’s inspection program. His research states the following could be monitored and an overall plan developed:

1) Number of targeted occupancies within a given district.
2) Number of incident call history to said targets.
3) Dates assigned for regular inspection.
4) Number of re-inspection.
5) Calendar system for routing future inspections. (p. 4)

Using GIS to identify high-risk areas allows the fire service to develop staffing, education and enforcement plans for proper prevention.

Research was conducted for Fire Management in Hong Kong by Lai and Lam (1998). In “Use of the Geographic Information Systems Approach in Optimizing Fire Management,” they state:

> A GIS provides a way to access and integrate massive amounts of location-based information from different sources in one unified setting…. The spatial component integrates all aspects into one setting to facilitate

> fire incident analysis, inspection mapping, emergency dispatching, vehicle routing, and hydrant and hazardous materials mapping. (p.28)

The Winston-Salem Fire Department feels like it has accomplished the ultimate level of service and safety concerning fire response utilizing the GIS component. In July of 1998, Conley and Lesser stated:

> The Computer Aided Dispatch information passed to the GIS routing application is used to determine the shortest route to the emergency site, to identify the fire hydrant locations along with pertinent capacities, and to highlight the existence and characteristics of any hazardous materials. Building floor plans that include sprinkler locations, access points, and emergency exits are available as electronic images and may be retrieved. (Winston-Salem Online, 2003)

GIS has become important in the planning for and response to different types of emergencies. GIS has increased the firefighters knowledge of how we handle different types of emergencies.

Kara and Verter (2001) researched truck shipments of hazardous materials between Quebec and Ontario, Canada in "A GIS-Based Framework for Hazardous Materials Transport Risk Assessment" and state, "One of the powerful features of the GIS environment is the ability to calculate the area of the exposure zone…" (p.1113). GIS can help reduce the risk of an incident becoming uncontrollable by identifying the status of an emergency by location and the areas most affected.

Procedures

The desired outcome of this research was to identify a geographic information system that could be used by the NFD for processing of information. Descriptive research was used to guide the applied research project to help understand the answers for the three research questions. The research questions deal with the current use of geographic information systems in Nashville government, other fire departments, and how GIS could benefit the NFD in the future.

Research began in August 2003 with a literature search at the National Emergency Training Center's Learning Resource Center. Literature reviews continued through December 2003 by the interlibrary loan process and the public library in Nashville. During this time, personal communication and online research was conducted. Previous Executive Fire Officer applied research papers, books, CD-ROM (compact disk-read-only memory), and articles in professional fire service journals were reviewed.

The researcher decided to survey the busiest career fire departments that responded to more than 70,000 total calls in 2002. Matthews and Rochie (2003) identified the busiest career fire departments in *Firehouse Magazine* "National Run Survey- Part 1". A cover letter (Appendix A) and survey (Appendix B) were prepared for each individual department identified by Matthews and Rochie. There were 30 career fire departments in the United States (Appendix D) identified in the survey. Based on total calls for 2002, these 30 were chosen to answer the survey.

The researcher then used the "National Fire Department Census Database" (USFA Online, 2003) to obtain addresses for each department. Twenty-eight departments

were registered in the census database. Addresses for the other two were located by conducting an online search.

A survey (Appendix B) was developed for the busiest career fire departments in the United States that serve the majority of Americans. The survey asked respondents, based on their knowledge of GIS, to identify how GIS was being used in their community. Question 1 on the survey asked if they were familiar with GIS, and if not the respondent was asked to stop. If the respondents were familiar, questions 2 and 3 asked what other departments in the community currently use GIS and does their fire department use it. Respondents were asked in question 4 what type of GIS software the department currently uses and in question 5 what function it was used for. Complete survey results are represented in Appendix C. By identifying how the busiest career fire departments are using GIS, the possibility of using GIS for processing future information in the NFD should increase.

After obtaining the addresses for all 30 fire departments, an envelope containing a cover letter, survey, and self-addressed stamped envelope was prepared. Each self-addressed stamped envelope was numbered 1 thru 30 on the back. This represented how the departments ranked in the National Run Survey. The completed surveys were collected over a three-week period. Those departments who were not identified by their numbered return envelope were mailed another envelope containing the same cover letter, survey, and self-addressed stamped envelope. This entire process took six weeks to complete. This gave adequate time for the researcher to receive mail back from each individual department.

Assumptions and Limitations

As with any survey, the GIS knowledge and experience of the respondent is crucial in interpreting the questions and formulating the response. An assumption was made that each fire department respondent asked to fill out the survey had some previous knowledge of GIS. If not, they found the appropriate information.

One problem encountered was the lack of information on which fire departments were currently using GIS. Literature review of previous Executive Fire Officer applied research papers was very limited and dated. Without this information, it was difficult to know which fire departments were currently using GIS.

Another problem seemed to be with the cooperation of local Nashville departments, mainly the planning department. The planning department is considered as the lead agency for the use of GIS in Nashville, but did not provide much help in direction with identifying what other departments were using GIS.

Definition of Terms

ArcView. ArcView provides data visualization, query, analysis, and integration capabilities along with the ability to create and edit geographic data.

Disaster. An emergency becomes a disaster when it exceeds the capability of local resources to manage. Disasters often result in great damage, loss, or destruction.

Environmental Systems Research Institute. Environmental Systems Research Institute integrates information into a common spatial language.

MapInfo. MapInfo provides location-based information, understanding, and expertise to business and governments around the world.

Spatial Information. Spatial information is related to the space around us, in which we live and function.

Tabular Information. Tabular information is data organized in a table format.

Terrorism. Terrorism is the unlawful use of force or violence against persons or property to intimidate or coerce a government, the civilian population, or any segment thereof in furtherance of political or social objectives.

Risk Assessment. Risk Assessment is a process used to identify the communities fire protection and other emergency service needs.

Results

What agencies or organizations in Nashville currently use geographic information systems?

An external survey (Appendix B) was used to help identify what other city departments were currently using GIS. Twenty-eight respondents (93%) completed the external survey. The complete survey results for the external survey appear in Appendix C. Question 1 asked, "Are you familiar with geographic information systems (GIS)?" Twenty-five respondents (89%) answered *yes*. Question 2 asked, "What other departments in your community currently use GIS?" The Police, Public Works and Emergency Management category was chosen by 22 respondents (88%) each as the department currently using GIS the most. The Health and Electric Department category was chosen least by eight respondents (32%). A breakdown of all responses to question two are shown in Table I:

Table I

Departments	*n* =	(%)
Planning	20	80
Police	22	88
Health	8	32
Codes	11	44
Public Works	22	88
Assessor of Property	14	56
Water Services	19	76
Electric Department	8	32
Emergency Management	22	88
Other	3	12

Note. N=25 and the three responses for the category "Other" include convention bureau, council and election board.

To identify the agencies and organizations in Nashville currently using GIS, interviews were conducted with the director of GIS services at the local level. Interviews were also conducted with the director of the Emergency Communications Center and with Information Technology Services at the local level. Also, the Internet provided some information about other departments in Nashville.

In the Emergency Communications Center, GIS is used in computer-aided dispatch (CAD) to rapidly locate and visually display incident locations. Advanced vehicle location is also in use so dispatch managers can track the location of police cars

on a GIS map at the dispatch center in “real time” (R. Brown, personal communication, November 10, 2003).

The Information Technology Services Director stated all Nashville departments are currently using an enterprise GIS for compatibility. This allows each department to manage their own information and cross-check information with other departments (R. McKinney, personal communication, November 7, 2003).

According to the “Metropolitan Government of Nashville and Davidson County Planning Department” website:

> Several Metro departments use GIS in a wide variety of applications. They range from mapping property and zoning boundaries at the Planning Commission to analyzing crime events at the Police Department. Departments currently using GIS in some form are Planning, Public Works, Water Services, Codes, Health, Emergency Management, Police, Assessor of Property and the Board of Education. Nashville Electric Service also uses GIS and works closely with Metro to ensure that all data can work together. (Nashville Online, 2003)

Currently there are 65 departments in Nashville using GIS in some way according to the GIS Manager. The police department, for example, uses GIS to visualize where certain types of crimes are occurring, providing officers from different precincts a clear picture of the issues affecting their neighborhoods. The health department taps into the data when issuing permits for new septic tanks or to generate soil maps. And the school district looks to GIS when evaluating the impact of student population growth on school boundaries (J. Higgs, personal communication, November 4, 2003).

What geographic information systems are being used by other fire departments and for what purpose?

The literature review provided information on how several fire departments were currently using different types of GIS software to plan, manage and make decisions. Information on GIS software use was also provided by the external survey.

ArcView was supplied by ESRI to Wilson, North Carolina in 1990 to find out what it could do for the fire service. It is also used in Hong Kong by Fire Management to protect the community and the environment by becoming more effective in planning and resource management. Winston-Salem, North Carolina utilizes ArcView to improve decision-making during an emergency. ArcView has also been used to construct risk assessment models for truck shipments of hazardous materials between Quebec and Ontario, Canada to minimize transport distance, population exposure, expected number of people to be evacuated and to the probability of an accident.

John May's research focused on the use of MapInfo Corporation, as a mapping application for looking at the community's fire risks in Overland Park, Kansas. Although Overland Park was the only department not using ESRI in the literature review, the external survey results were similar with most departments using ESRI.

The survey was used to help identify what type of GIS other fire departments used. Question 3 "Does your department currently use GIS?" Twenty-three respondents (92%) answered *yes*. When asked "What type of GIS software does your department currently use?" in question 4, the ESRI category, which produces ArcView, was chosen by nineteen respondents (83%).

How can the Nashville Fire Department use geographic information systems for processing future information?

It appears that most career fire departments surveyed are using GIS for various reasons. Question 5 on the survey asked "Does your department currently use GIS for?" Eighteen respondents (78%) chose the fire incident analysis category. A breakdown of all responses to question five are shown in Table II:

Table II

GIS Use	*n* =	(%)
Hydrant Location	15	65
Inspection Mapping	11	48
Hazardous Materials Location	16	69
Vehicle Routing	13	57
Dispatching	16	69
Fire Incident Analysis	18	78
Other	8	36

Note. N= 23 and responses for "Other" category are represented in Appendix E.

According to the Director of Nashville Fire Department, Stephen Halford, there are many helpful uses of GIS. These include the following: the posting of medical units at high-call volume areas, aerial mapping for better on-scene management of building fires, water main size overlays for water supply issues, sewer line system overlays to anticipate hazardous materials movement and emergency vehicle routing (Personal communication, December 9, 2003).

The person newly assigned to coordinate GIS for the NFD also sees many advantages for using GIS. GIS will be used to determine all future fire station locations. Maps for fire inspectors will be produced to identify priorities in their territory and track their progression (R. Musgrave, personal communication, December 6, 2003).

Discussion

If the fire service is not already using GIS, the chances are that it will use computerized technology in some form in the coming years. With greater importance being placed on up-to-date data visualization, it seems GIS will prove to be that technology. According to "Why Use GIS,"

> Pattern recognition is something human beings excel at. There is a vast difference between seeing data in a table of rows and columns and seeing it presented in form of a map. The difference is not simply aesthetic, it is conceptual-it turns out that the way you see your data has a profound effect on the connections you make and the conclusions you draw from it. (GIS Online, 2003)

GIS is like painting a picture to tell a story with the ability to display numbers and facts. Most fire departments appear to be using GIS for the ability to visualize information and respond more efficiently and effectively to save time, resources and lives.

Today more individuals and governments use GIS to answer the fundamental question, "where?" To answer this question, the use of GIS is rapidly growing in government. State profiles were prepared for *The National States Geographic Information Council* about the status of GIS and related technologies in all 50 states

during 1999-2000. According to the report, Tennessee was one of the first states to officially direct a statewide approach to geographic information and related technology in 1982. Soon after, the planning department in Nashville began using GIS to map out property and zoning boundaries. Since then GIS has been applied to most Nashville departments/agencies.

Most governmental departments/agencies seem to rely on ESRI. It was first used by the Puerto Rico planning board in 1969. In "GIS Market Nears $1 Billion" market research firm Daratech reported, "State and local government purchases account for 20% of GIS revenue, followed by telecommunications companies and utilities. ESRI and Integraph together account for half of GIS revenue" (Ferris, 2002, p. 12). Ninety-two percent of the respondents chose the ESRI category in question 4 on the survey. ESRI has been put to the test in Nashville over the last ten years after being struck by two disasters. The worst ice storm in 50 years and a severe tornado with over 200 mph winds that went through the middle of downtown. Using ESRI the Nashville Electric Service was able to quickly identify those areas with severe damage.

To save lives and minimize property damage, the NFD relies on quality and quantity of available information for emergency response. "GIS Solutions for the Fire Service," reveals that:

> GIS allows public safety personnel to effectively plan for emergency response, determine mitigation priorities, analyze historical events, and predict future events. GIS should be considered a tool for the fire service to analyze, mitigate and model fire-related issues. In an effort to provide a

> higher level of service to the community and for the safety of personnel, computerized technology such as GIS should be considered. (ESRI, 2001)

An advantage of GIS for the NFD would be the ability to display critical information to increase the quality of service, efficiency of response and personal safety.

GIS is also used to plan for the future. Chief Oliver (2002) in "Atlas, arrayed" states, "A strategic GIS view of the community can help define station locations, realign response districts and identify target hazards such as flood plains, as well as locate water supply and high calls-for-service areas" (p.34). Chief Oliver (2002) in the Fire and Emergency Training Network video "GIS Technology" also states that GIS is "taking information and putting it at the fingertips of the company officer." Oliver also points out "you can find out where your weaknesses are and adjust your department accordingly" (Fire & Emergency Training Network, 2002, motion picture). This information allows company officers to make better decisions early on during emergencies.

This researcher believes that technology such as GIS has raised the fire services' expectations of coping with the risks faced from different emergencies. The external survey revealed that many departments are using GIS for various reasons. GIS allows the fire service the opportunity to think about the "why" and "what if" before and during decision making. It appears that the NFD has started slow by producing hydrant maps, but the future seems wide open with possibilities.

GIS has opened a vast new potential for the fire service in the way firefighters communicate, analyze information, and make decisions. It appears whatever the firefighters current responsibility is in the fire service -- planning, mitigation, response, or

recovery-- the chances are that he or she will come across and probably use a GIS in some way in the future. The use of GIS in the fire service seems to be limited only by the imagination of the user. It is up to the fire service to make things happen in the future, and GIS provides the way.

Recommendations

The problem was that the NFD had not identified a GIS that it can use to enhance its delivery of services. The purpose of this applied research project was to identify a GIS that could be used by the NFD for processing of information.

Based on this study, the NFD should utilize GIS to help fulfill its moral responsibility to protect lives and minimize property damage.

The literature review presented in the study has shown that GIS can optimize various aspects of the fire department to prepare, mitigate, respond and recover from different types of emergencies in the future.

Therefore, based on the literature review, external survey, and the analysis of this applied research project, the following recommendations should be considered for the use of GIS in the NFD. This plan is for enhancing the delivery of services in the NFD by using GIS to process future information.

Realizing GIS is a system that is designed to store, retrieve, manipulate, and display geographic information; the NFD should do the following:

1. To save time and money, eliminate redundancy and ensure accuracy, the NFD should work with the local department agencies to benefit from their current GIS databases.

2. To build a GIS, the NFD should look into accessing existing resources such as the “GIS Tutorial” published by the United States Fire Administration. This tutorial teaches the fundamental concepts of GIS technology by demonstrating several techniques for displaying and querying information. It also provides free up-to-date Internet resource links for specific information, such as the U.S. National Grid and U.S. Geological Survey.
3. To get a better understanding of how GIS can be used by the fire department, the NFD should learn from other departments, sending two fire department employees to other departments to get hands-on practical experience.
4. To allow for the NFD to move forward, a plan should be developed by the fall of 2004 to be implemented in the spring of 2005. This plan should allow the NFD to keep track of the enormous amount of information processed every day before, during and after any emergency. Implementation of this plan should ensure that the NFD can keep up with the growing demands for preparation, mitigation, response, and recovery for any future emergencies that occur. This will ensure that Nashville stays protected.

Over the last 30 years, GIS has evolved from a “nice to have” into a “need to have.” From its original use as a planning and mapping tool, GIS is now used to provide a simplified view of the real world around us. Maybe the price and cost are high for implementing GIS, but no information may end up costing the NFD more during different types of emergencies. If the NFD does not have the critical information needed to make “informed decisions,” both lives and property could suffer. GIS can improve the accuracy and speed to different types of emergencies for the NFD in the areas of

preparation, mitigation, response, and recovery. As GIS continues to advance and become a component of the fire service, who knows what applications the future will bring in helping deal with different emergencies when they occur? Even though GIS seems to have a short history, it appears that the future is very bright.

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Appendix A
Survey Cover Letter

To Whom It May Concern:

My name is Travis Ford and I am a District Chief with the Nashville Fire Department in Nashville, Tennessee. I am currently in the Executive Fire Officer Program at the National Fire Academy. I'm required to complete a two-week course and an applied research project. I'm doing a research paper on how geographic information systems (GIS) could benefit the Nashville Fire Department.

The attached survey is for my research paper and should take no longer than five minutes to complete. Would you take a few minutes to answer the survey and mail it back in the self-addressed stamped envelope?

If you would like a copy of the paper or survey, please enclose a business card and I will forward a copy of my research paper or survey results to you.

Thank you for your time and participation in this research.

Travis Ford
500 2nd Ave. North
Nashville, TN 37201
615-862-5422

Appendix B
Geographic Information System (GIS) External Survey

Based on your knowledge of geographic information systems (GIS) in your community please answer the following questions:

1. Are you familiar with geographic information systems (GIS)?

   Yes___ No____ Not Sure_____

   (Only proceed if you answered yes)

2. What other departments in your community currently use GIS?

   Planning _____ Assessor of Property _____

   Police _____ Water Services _____

   Health _____ Electric Department _____

   Codes _____ Emergency Management _____

   Public Works _____ Other _____

3. Does your department currently use GIS?

   Yes___ No____ Not Sure_____

4. What type of GIS software does your fire department currently use?

   ESRI _____ Intergraph _____ Other _____

5. Does your department currently use GIS for?

   Hydrant Location _____ Vehicle Routing _____

   Inspection Mapping _____ Dispatching _____

   Hazardous Materials Location _____ Fire Incident Analysis _____

   Other (Specify) _____

Appendix C
Geographic Information System (GIS) External Survey Results

Based on your knowledge of geographic information systems (GIS) in your community please answer the following questions:

1. Are you familiar with geographic information systems (GIS)?

   Yes **25** No **2** Not Sure **1**

   (Only proceed if you answered yes)

2. What other departments in your community currently use GIS?

   Planning **20**
   Police **22**
   Health **8**
   Codes **11**
   Public Works **22**
   Assessor of Property **16**
   Water Services **19**
   Electric Department **8**
   Emergency Management **22**
   Other **3**

3. Does your department currently use GIS?

   Yes **23** No **2** Not Sure **0**

4. What type of GIS software does your fire department currently use?

   ESRI **19** Intergraph **2** Other **2**

5. Does your department currently use GIS for?

   Hydrant Location **15**
   Inspection Mapping **11**
   Hazardous Materials Location **16**
   Vehicle Routing **13**
   Dispatching **16**
   Fire Incident Analysis **18**

   Other (Specify) **8 (Appendix E)**

Appendix D
Fire Departments Surveyed

1. City of New York Fire Department
   http://nyc.gov/html/mail/html/
   mailfdny.html

2. Chicago Fire Department
   10 West 35th St.
   Chicago, IL 60616

3. Philadelphia Fire Department
   240 Spring St. Fire Admin. Bldg.
   Philadelphia, PA 19123-2991

4. Los Angeles City Fire Department
   200 N. Main St. Suite 1020
   Los Angeles, CA 90012-4110

5. Dallas Fire Department
   1500 Marilla St.
   Dallas, TX 75201

6. Dallas Fire Department
   1500 Marilla St.
   Dallas, TX 75201

7. Los Angeles County Fire Dept.
   1320 N. Eastern Ave.
   Los Angeles, CA 90063

8. Houston Fire Department
   1205 Dart St.
   Houston, TX 77007

9. Washington DC Fire Department
   1932 Vermont Ave. N.W. Suite 102
   Washington, DC 20001

10. Baltimore City Fire Department
    414 N. Calvert St.
    Baltimore, MD 21202

11. Columbus Fire Department
    3675 Parsons Ave.
    Columbus, OH 43207

12. Phoenix Fire Department
    150 S. 12th St.
    Phoenix, AZ 85034

13. Prince Georges County Fire Dept.
    9201 Basil Ct.
    Largo, MD 20774

14. San Antonio Fire Department
    115 Auditorium Circle
    San Antonio, TX 78205

15. Jacksonville Fire Department
    515 N. Julia St.
    Jacksonville, FL 32202

16. Memphis Division of Fire Services
    65 S. Front St.
    Memphis, TN 38103

17. San Francisco Fire Department
    698 Second St.
    San Francisco, CA 94107-2015

18. St. Louis Fire Department
    1421 N. Jefferson St.
    St. Louis, MO 63106

19. Clark County Nevada Fire Dept.
    575 E. Flamingo Rd.
    Las Vegas, NV 89119

20. City of San Diego Fire Dept.
    1010 2nd Ave. Suit 400
    San Diego, CA 92101-4970

21. Jackson Fire Department
555 Southwest St.
PO Box 17
Jackson, MS

22. Fairfax County Fire-Rescue Div.
4100 Chain Bridge Rd.
Fairfax, VA 22030

23. Cincinnati Fire Division
430 Central Ave.
Cincinnati, OH 45140

24. Orange County Fire Rescue Dept.
6590 Amory Ct.
Winter Park, FL 32793-5879

25. Boston Fire Department
115 South Hampton St.
Boston, MA 02118

26. Miami Dept. of Fire- Rescue
444 S.W. 2nd Ave.
Miami, FL 33130

27. Nashville Fire Department
500 2nd Ave. North
Nashville, TN 37201

28. Charlotte Fire Department
228 E. Ninth St.
Charlotte, NC 28202

29. Seattle Fire Department
301 Second Ave. South
Seattle, WA 98104

30. Baltimore County Fire Department
700 E. Joppa Rd.
Towson, MD 21286-5500

Appendix E
Results from Question 5 on the External Survey

"Does your department currently use GIS for?"

Responses in the "Other" category are listed below. Eight respondents, in question 5, specified more than one example. They responded that GIS is used by their fire department for the following:

GIS is used by other fire departments for:

- Evacuation Areas
- Homeland Security
- Flood Area Determination and Notification
- Wild-land Urban Interface
- Plume Modeling for Hazardous Materials Incidents
- Tactical Information Surveys
- Pre-fire Planning
- Administrative
- Performance Measure Evaluation
- Resources Allocation
- On-scene Emergency Management
- Station Location Determination
- Firebox Determination
- Testing Automatic Vehicle Location Systems