

GEOGRAPHIC INFORMATION SYSTEM TECHNOLOGY
FOR THE DANVILLE FIRE DEPARTMENT

Executive Analysis of Fire Service Operations in Emergency Management

David R. Eagle
Danville Fire Department
Danville, Virginia

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CERTIFICATION STATEMENT

I hereby certify that this paper constitutes my own product, that where the language of others is set forth, quotation marks so indicate, and that appropriate credit is given where I have used the language, ideas, expressions, or writings of another.

Signed: _____

Abstract

Danville utilizes Geographic Information Systems (GIS) to improve its municipal services. The problem was that the Danville Fire Department (DFD) was not familiar with GIS.

The purpose of this research was to understand GIS, identify beneficial applications, and determine needed resources.

Descriptive research was used to answer three questions:

1. What is GIS?
2. What resources would be required to implement GIS in the DFD?
3. How is GIS used by other fire departments and what applications would be beneficial?

Procedures for this research included a literature review, interview, and survey of other fire departments.

Results showed a wide array of applications that improve resource management which in turn provides better services, all of which will save lives. Recommendations include implementing GIS into the DFD using existing municipal resources.

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Introduction

Having information and data readily available is often necessary to make the quick critical decisions necessary to handle an emergency efficiently and safely. Geographic Information Systems (GIS) is technology that allows the retrieval of critical information quickly and easily.

In a time when the fire service is asked to do more with less, technology helps to deliver more bang for the buck. Improving efficiency, by saving time and man power is often a necessity. The fire service has emerged to address all types of hazard mitigation, as it has taken on increasing roles in disaster response. Emergency response of all types is growing more complex and the sharing of information between agencies is often imperative. The events of September 11th and Hurricane Katrina brought forth the critical need for sharing wide ranges of critical information. Today, there is Presidential mandate for interoperability between agencies of all levels of government.

In the three decades since the development of GIS technology, thousands of state and local governments, and numerous other organizations have benefited from integrating GIS software into their daily operations. GIS is a valuable tool to help organizations move forward efficiently while responding to issues of accountability and performance measurement. With a solid footing, GIS has a positive ripple effective and can build on itself, benefits will spill over from department to department. GIS is a vital tool for its capacity to supply critical information instantly. (Thomas, 2004, p. XIV)

Technology in the fire services is in no way a substitute for the real men and women who put themselves in harms way each and every day. It is however, available to improve efficiency,

preparedness and safety. From self contained breathing apparatus to thermal imaging, the fire service continues to look for ways to improve safety and efficiency. GIS is one form of technology that fire departments are becoming more and more familiar with.

Many government agencies have recognized the important role that GIS can play in dealing with emergencies. The Federal Emergency Management Agency (FEMA) on their website for mapping and analysis, states that GIS is a very useful tool for many aspects of emergency management, including: emergency response, planning, exercises, mitigation, homeland security and national preparedness. In addition to its ability to manage and display data, GIS has robust modeling capabilities, allowing its users to adjust data and scenarios for prediction, planning and estimation (FEMA Online, 2006).

The City of Danville is one governmental agency that utilizes GIS technology to improve its municipal services. The problem is that even though GIS is available, the Danville Fire Department (DFD) is not familiar with GIS, what applications would best be utilized, or what resources would be required to implementing this technology.

This is a problem because we as a fire department are not as informed or efficient as we could be. We have information available to us but we do not know how to access it nor do we have the means for accessing this information quickly which could mean the difference of life and death. The DFD is missing out on the ripple effect that other city governmental departments are seeing with improved efficiency.

The purpose of this research is to gain a better understanding of GIS and to identify what resources are required by the DFD to utilize GIS technology and to investigate what applications of GIS may best be integrated to improve the delivery of emergency services to the community.

Descriptive research methods will be used to answer the following questions.

1. What is GIS?
2. What resources would be required to implement GIS in the DFD?
3. How is GIS used by other fire departments and what applications would be beneficial?

BACKGROUND AND SIGNIFICANCE

The Danville Fire Department is a career department that was established over a hundred years ago. The DFD operates out of seven stations and covers a geographic location of 47 square miles. At the time of this research, the population of Danville is 48,411 which represents a nearly 12% drop in population over the past fifteen years. There has also been a more than 15% drop in private industry jobs over this period. Danville currently has a 9% unemployment rate which is more than twice the state average (Weldon Cooper Center, 2004).

The local economy has been based largely on tobacco and textile manufacturing which has dwindled significantly in recent years causing local revenue expectations to decline. In an effort to redefine itself as a community and to look for new ways to expand the workforce, Danville is looking toward technology. Nationally, and to an increasing extent the global economy is rapidly moving toward being “knowledge-based” with decreasing reliance on manufacturing and agriculture. The products of a knowledge-based economy are primarily intellectual and are dependant on technology.

In an attempt to be competitive in this global economy, Danville and its surrounding county has partnered with Virginia Tech and has utilized tobacco indemnification monies to

develop an advanced network of electronic communication infrastructure which includes, electronic communications and highly capable internet services with broadband, wireless, optical fiber and multimedia service access points. This infrastructure serves to give potential businesses an attractive advantage and allows Danville to be a player in this emerging economy.

To assist in the promotion of the City of Danville and the advances that are available, the City has developed and utilized GIS as a tool for mapping and sharing information. The city has utilized GIS for several years now and more city departments have found value in utilizing this technology. The problem is that even though GIS is available, the DFD does not know what applications of GIS would best be utilized by the department or what resources are required to use GIS.

This is a problem because when dealing with emergencies and making the quick decisions that are necessary to mitigate the consequences of emergencies, information is critical. The DFD has information available to them but it is not known how to access it with available resources, how to share this information, or how to retrieve this information quickly under the stressful circumstances of an emergency.

As a department, the DFD collects valuable information about hydrants and their available water supply and places this information on hydrant cards that are stored in the fire stations and taken out into the field when the department does hydrant maintenance. Information about buildings and their features are also collected through a pre-incident survey program where this information is stored in notebooks that may or may not be on the truck. Maps are frequently used by firefighters to learn the streets of their response territory, the location of hydrants, and the quickest path of travel. Currently the maps used are out of date and new maps have to be ordered through another city department. Information regarding hazardous materials

is collected and stored in a file cabinet. Certain haz-mat characteristics of buildings may be noted on the pre-incident survey form. Countless hours are spent updating critical information that is stored in multiple locations and many times inaccessible during the times when it is needed.

Valuable information is often available but is centrally not stored using a method that makes it simple to find or easy to share among those who need the information to make quick and critical decisions during an emergency. As emergency response continues to grow more complex and the amount of information continues to compound, public safety individuals can not remain static. Technologies such as GIS must be explored to keep up with the changing environment around us.

People have used maps to present, share and analyze information for thousands of years. Geographic information systems are merely the latest extension of this ancient tradition. GIS is a computer-based system for the capture, storage, retrieval, manipulation, analysis and display of information (Mumm, 2000, p. 8).

I guess as the old saying goes, “A picture is worth a thousand words”. Chief Ronny Coleman agrees with this vary statement, as he discusses the value of displaying information in the form of a picture as opposed to presenting it as text. “Anything you have stored away in a file cabinet can be displayed spatially in a GIS environment” (Coleman, 2003, p. 62).

This research project is related to two of the United States Fire Administration’s operational objectives. GIS can be a valuable tool for reducing the loss of life of firefighters from fire and from other factors by creating a database of vital information that can be accessed quickly helping firefighters to plan and be better prepared and able to make critical decisions. The use of GIS technology by the DFD will also help to promote within the community a comprehensive, multi-hazard risk-reduction plan as it will allow the City of Danville to identify

targets, share information between agencies and appropriately plan and develop risk reduction strategies.

This applied research project is relevant to the National Fire Academy course, *Executive Analysis of Fire Service Operations in Emergency Management*, as GIS is a valuable tool which can be utilized by senior fire officers for planning, analysis and effective resources management during large-scale incidents involving multi-agency response.

The research of this project will investigate what a GIS is and look into the value of using this technology. It will utilize descriptive research methods to illustrate what GIS is comprised of and how its applications are beneficial to the fire service. It will also investigate how other fire departments around the country are utilizing GIS to improve there service delivery and what resources are needed for the DFD to utilize GIS. The goal of this project is to serve as a planning and management tool to determine if GIS is something that can be used by the DFD to improve safety, inter-agency communications, and lead to a better prepared department which in-turn will benefit the community by providing better more efficient services and more importantly the potential for lives saved.

LITERATURE REVIEW

The purpose of this review of literature was to gain a better understanding of what GIS is, what applications of GIS are available, and what resources are needed to implement this technology.

In order to understand how GIS can best be utilized by the DFD we must first understand what GIS is and how it works.

The Federal Emergency Management Association's (FEMA), *Geographic Information System Tutorial*, defines GIS as a computer-based system that combines spatial or mapping data that can be assigned to real world coordinates with tabular data to capture, store, retrieve, manipulate, analyze and display information (FEMA, 2003).

David Davis in his book *GIS for Everyone*, states that GIS is kind of a supermap, where computer software links geographic information (where things are) with descriptive information (what things are like). Unlike a paper map that can be one dimensional, GIS mapping can have many layers of information underneath its surface (Davis 1999, p2). Geographic Information Systems provides a systematic way to collect and manage location-based information that combines geographic data (man-made and natural features on the earth's surface) with other types of information (names, classifications, addresses, and much more) to generate visual maps and reports. This information can be crucial to local government (O'looney, 2000 p. 5).

Through visualization, a GIS system can be used to produce not only maps, but drawings, animations, and other cartographic (map-linked) products. These new images allow public safety personnel to support their responsibilities for enhanced decision making and analysis in ways that were literally never before available (Weaver, 2001 p. 35).

The GIS tutorial CD created by FEMA has an episode of *American Heat* titled "GIS Technology in the Fire Service." On this broadcast, program manager Gary Grant says that the management of information is a tax on resources. GIS technology promises to revolutionize the management of information that is needed to make more informed decisions. It will allow fire personnel to better utilize resources and provide better services, all of which will save lives (FEMA, 2003).

Geographic Information Systems is technology which allows the user through computer software to organize critical information and assign it to a geographic location, a specific address on a map that makes retrieval quick and easy. It has the potential to drastically improve information management and it allows the user to visualize what is going on so that better informed discussions can be made. With GIS an unlimited amount of layers of information can be added to store, manipulate, and for the analysis of critical data that may be needed to save lives.

When evaluating how GIS can be utilized, it is also important to investigate what resources are needed to implement this technology.

Geographic Information System Tutorial is a reference CD that is designed to teach the fundamental concepts of GIS. It shows how it can be used with NFIRS data, provides some hands-on uses and reviews the basic components that are needed.

This reference CD discusses how four elements are essential components of a GIS setup: Hardware, Software, Data and People.

The first of these elements is **hardware** which includes multiple pieces such as computers from low end desktops and laptops to high end servers. It also includes data storage which includes hard disks, compact disks, network storage and other storing devices. Other hardware needed is a method for data input which converts existing information into a format that can be used by GIS. This includes paper maps, aerial photos, physical addresses; coordinated data collected using global positioning systems (GPS), satellite images and other digitalized geographic data. Another component that is needed to maximize the use of GIS is hardware utilized for data output. This is generally achieved by various types of printers and plotters. When selecting hardware, a GIS user should consider the amount of data to store and plan the

memory available accordingly. Another important concern is the speed of retrieving the information and an upgrade in processor speed may be warranted. For displaying the information a user may want a high quality video card and a good color printer.

The second element discussed on the GIS tutorial is **GIS software**. Most software packages share basic features such as thematic mapping, labeling, geocoding and many other applications. The selection of software should be based on individual needs and it should be understood that price varies with functionality. There are many software packages available such as ESRI (Arcview, arc/info) Mapinfo, Caliper (maptitude), Integraph (Geomedia), Tactician among others.

The third element is the backbone of any GIS and is the **data**. In many cases data already exists in other community, state, federal and academic GIS departments. It can be put in locally or can be obtained from any number of public and private sources. Utilizing existing data can greatly reduce the costs of data.

The **people** using GIS are the last critical element. The people are the ones who utilize the hardware, and software and manipulate the data for analysis and various applications. So training of these people is important so that information can easily be retrieved and utilized (FEMA, 2003).

Global Positioning Systems is a hardware component that is changing the way we know where we are, where were going, and where we've been. GPS is composed of twenty-seven NAVSTAR satellites orbiting 12,000 miles above the earth; five monitoring stations; and individual receivers on earth that receive radio signal broadcasts from at least three of these satellites simultaneously pinpointing an exact location of latitude and longitudinal coordinates on the ground (Terry, 2000 p. 3).

The role pinpoint accuracy of positioning plays in both natural and man-made disasters may seem inconsequential at first glance, but the truth is that GPS and GIS are becoming more and more important – Not just in the wake of disaster when, for instance, relief efforts might call for quickly generated maps of flooded areas, for helicopters to navigate through thick smoke, or for the exact location of people buried alive – but in the planning and preparatory phases of emergency management as well (p 85).

Another hardware component of GIS that is changing the way that we locate emergency vehicles is automatic vehicle location (AVL). Companies such as OnStar and Lo-Jack are popular business applications of using AVL with GPS to track personal vehicles. The fact is that business and government are using AVL for fleet management of commercial vehicles, delivery trucks, and eighteen-wheelers. The market shows however that the sharpest increase in using AVL with GIS is the public safety sector, where the exact location of ambulances, fire trucks, and police cruisers can mean the difference between life and death (p. 77).

GPS/AVL brings the focus of modern technology upon public safety organizations at a time when critics are demanding more productivity with fewer resources. This technology using GIS provides for progressive, very accurate and inexpensive resource management that can improve response times, automates documentation and maximizes asset management (Thorp, 1995, p. 47).

A GIS is made up of computer hardware that is often already available. Coupled with a specific software package, information and data received from almost unlimited sources is allowed to interface with specific coordinates on a map that become easy to retrieve, analysis and manipulate to improve planning, preparedness, and the services that are capable of being delivered.

Chief Don Oliver of the Wilson Fire and Rescue was recruited over a decade ago to implement GIS into the fire service and report on how it could benefit a fire department. Oliver states that his department utilized GIS for quick, visible and accurate information on pre-incident surveys, hazmat facilities, and identification of dangerous buildings, problem hot spots, repeat calls, arsons, false alarms, water supply data, inspection schedules and prevention activities (Oliver, 2002, p36).

Chief Oliver's implementation of GIS paid off a few years later when Hurricane Isabel hit the east coast of North Carolina. City staff used the GIS for pre-incident analysis of flood-prone areas to prepare street closures, position resources, track feeder lines that loose power, and to monitor incidents as they unfolded. GIS mapping provided staff in the emergency operations center a visual map of what was happening. He stated that they were also able to track power outages and were able to identify critical-care patients and respond appropriately if they lost power (Thomas, 2004, P 22).

Jefferson Parish, Louisiana, may well be one to the nation's most flood-prone areas. In the last two decades, the parish has experienced hundreds of millions of dollars in flood damage. To mitigate this problem, the parish has constructed an extensive network of drainage canals and levees, along with 37 pump stations that discharge flood waters over levees and into the numerous lakes and rivers. To further lessen flooding potential the parish has integrated GIS as part of an aggressive plan to anticipate problems and to improve response to trouble that may arise. This new capability will assist in optimizing management efforts by providing greater decision making possibilities before, during, and after severe storms. By linking accurate, up to date facilities information and spatial relationships using GIS, Jefferson Parish expects to more

efficiently manage its utilities. At the same time they anticipate improving everything from long-term planning, to prioritizing capital improvements, to emergency response, and day-to-day maintenance and repair activities (Frazier, 1995, p. 89).

Winston Salem, NC won an international award for its pioneering efforts with a project called Integrated Network Fire Operations (INFO). Now, finding out where the fire is and getting there quickly has never been easier. The big three-ring binders with pages falling out and stuffed full of information which may mean the difference between life and death has been replaced with touch-screen computer terminals on the trucks. The City has built a street centerline file utilizing Global Positioning Systems (GPS) technology to provide the basic routing framework. GIS software utilizes the centerline network and alarm location to define an optimal route at the moment (taking into account temporal factors such as traffic jams, accidents, roadwork), the location of hydrants, important landmarks, as well as building diagrams, floor plans, pre-fire survey information and important hazardous materials data along with any other special needs. Each fire truck is connected via a shock-proof laptop mobile data terminal with Automatic Vehicle Locator (AVL). As an emergency call comes in through the call center the call taker and a CAD computer routs the call through a fiber distribution data interface network to each fire station through a PC and a T1 internet link. Each fire truck is connected through a modem using a radio repeater connecting to a laptop and mobile data terminal. This provides the data quickly to make a determination on the best route to reduce the emergency response time, as well as any important factors that need to of concern during the emergency and should be focused on (Amdahl, 2001, p. 39-44).

In Geographic Information Systems: Selected applications in Government, chapter five is devoted to fire departments. This compilation by the Westchester department of Information

Technology investigates several fire departments across the country. A common theme is that GIS is an excellent tool to improve its response and pre-planning capabilities. It is used to assist in the coordination and management of programs, as well as for traditional mapping applications. GIS allows you to organize information, plan for emergencies, access maps and data. Danger zones, critical infrastructure and community risk factors can be mapped to improve community preparedness and improve response (Albert, 2000, p. 15-16).

Following the bombing of the Alfred P. Murrah Federal Building in April 1995, rescuers were able to use GIS to carefully organize search and rescue operations. Emergency responders used building plans to identify what they were finding and also to target areas of possible rescue for trapped victims. It is estimated that this allowed for greater success, faster response and a possible savings to the City of between \$6 and \$15.6 million (Ferris, 2004, p.18-19).

China Camp State Park in northern California is a magnet for hikers, mountain bikers, campers and other outdoor enthusiasts. Each year, the San Rafael Fire Department would respond to dozens of hard to find emergency calls, some taking an hour or more to locate. With the use of GIS, extremely accurate maps were created that speeded up response times dramatically (Holland, 1998 p. 42).

Wildland fire managers and planners are rapidly discovering how GIS technology can help them. Areas such as fuel management, wildland prevention and detection, pre-suppression activities, dispatching, suppression activities, and wilderness fire management all incorporate the use of GIS. When dealing with the complex and escalating issues of wildland-urban zones, multiagency cooperation, and environmental concerns, a GIS provides an efficient tool that can integrate and analyze large geographic data bases and produce information useful for fire planning and real-time decision-making (Salazar, 1995, p.12-15).

The use of a GIS does not generate a model per se, but it provides a spatial framework for fire risk evaluation which makes it possible to study the geographical distribution of fire risk. It also allows for the detection of those areas where fuel management should be done, where watch towers should be built or to help in the design of adequate fire-breaks. This method is cost effective and allows a whole territory to be covered, with good spatial resolution. Digital information can be used for forecasting, training and many different purposes (Salas, 1994, p.13).

Jack Dangermond, the president of the Environmental Systems Research Institute (ESRI) who is the leader in the GIS movement states that it is hard to imagine a more striking or beneficial use of GIS than in matters of public safety. GIS works effectively in all four phases of disaster management: preparation, mitigation, response, and recovery. Whether analyzing consequences; projecting and predicting; disseminating information; allocating personnel, equipment, and resources; getting from point A to point B; or picking up the pieces, GIS is the tool of choice (Amdahl, 2001, preface).

Fire Departments are successfully using GIS for many applications that may also be useful for improving the service delivery provided by the DFD. As the DFD is responsible for responding to a wide range of emergencies that continue to grow in their complexity it is imperative to explore new technology and take advantage of new opportunities for improving data and resource management.

PROCEDURES

The purpose of this review of literature was to gain a better understanding of what GIS is, what resources are needed to implement GIS in the DFD, and what applications of GIS are available

that other fire departments use that may improve the DFD. It will be utilized to determine what direction the DFD needs to follow in order to develop a plan for implementing GIS technology into the DFD. The procedures used to gather information to answer the above mentioned research questions included a literature review, personal interview, and a survey instrument.

In order to fully understand the first question: what is GIS, the researcher used the resources of the National Fire Academy's Learning Resource Center to identify relevant books, journals, and articles. References were also obtained through the interlibrary loan program, the City of Danville Department of Information Technology and through a comprehensive internet search. These findings are presented in the Literature Review section of this project.

To answer the second question and gain a better understanding of Danville's GIS capabilities, the resources that are currently available, and what would be required of the DFD to implement GIS, a personal interview was conducted with Inez Pollock. Pollock is the GIS coordinator for the City of Danville and works out of the Department of Information Technology (IT). The interview took place in the City Planning Conference room on October 19, 2006 and was set up in advance by telephone. Pollock was the obvious choice for gaining information concerning the capabilities of Danville's GIS and the resources that are available because she is a Certified Professional GIS coordinator, she has intricate knowledge of Danville's GIS and because she is the coordinator and liaison for implementing GIS in Danville City Departments that select to utilize this technology.

The questions were pretty basic and included: 1. what is GIS? 2. What resources are currently available in Danville? 3. What resources does the fire department need to implement this technology?

To answer the third question a review of literature took a detailed look at how GIS is being used and what application of GIS were beneficial by examining relevant books, magazine and journal articles and information retrieved online. Finally, a survey instrument was developed and used to gather data on the use of GIS technology by other departments and the applications that they found to be beneficial.

The survey instrument asked the respondents nine questions concerning GIS, if and how it was used, what types of software they utilized, if mobile devices or AVL was used, if it is beneficial to the department and how the system is supported.

The survey (Appendix A) was distributed on November 18, 2006 by email with a cover letter (appendix B) to sixty career fire departments consisting of different size paid departments from across the country. The departments were selected from contact rosters obtained from the National Fire Academy and from departments chosen from the web site of top 150 fire departments as presented by fireprep.com. This list was chosen to ensure a balanced cross section of the country and determine many different applications of GIS being used in the fire service. The survey was due back to the surveyor by December 7, 2006. Of the sixty surveys that were distributed, eight did not reach the intended recipient because of changed or incorrect contact information and twenty-three departments responded to the survey which represents a forty-four percent rate of return. A list of the fire departments that responded to the survey can be seen in appendix C.

Assumptions and Limitations:

During the development of the survey instrument an assumption was made that applications of GIS used by other fire departments would be relevant and useful to the DFD. For example, in the western part of our country, wildland fires is a big problem and it appears that GIS is a very

useful tool that is often used for prevention, mitigation strategies and resource tracking during these kinds of fires. Located in the southern part of Virginia the DFD is not prone to wildland fires and therefore we would not utilize GIS in the same way as those fire departments that are subject to wildland fires. Another example is that GIS is often used in costal areas during hurricane events. Although we have felt the effect of some eastern hurricanes, the consequences are generally much different for our jurisdiction than for those located along the coast and therefore the use of GIS maybe considerably different.

It can be assumed that when developing applications of GIS that may be beneficial to a locality that individual circumstances and specific needs should be taken into account when developing applications. What is useful to one department may not always be appropriate or useful in other areas of the country.

It is also assumed that the person filling out the survey had enough knowledge of GIS to interpret each of the questions and formulate a response or get the survey into the right hands; however, this may not have been the case.

Limitations experienced with the survey were that only 44 percent of those surveyed completed and returned the survey. This rate of return limits the findings from other departments and may affect the legitimacy of the results.

RESULTS

The results of this applied research project have been compiled from an extensive review of literature, a comprehensive interview and a compilation of survey information. This research found the following results:

Research Question #1-What is GIS?

Numerous and varied definitions of GIS were found each describing how geographic information systems is computer programming that integrates an unlimited amount of information stored in layers with specific geographic coordinates on a map that can easily be retrieved.

The Federal Emergency Management Association's, Geographic Information System Tutorial, defines GIS as a computer-based system that combines spatial or mapping data that can be assigned to real world coordinates with tabular data to capture, store, retrieve, manipulate, analyze and display information (FEMA, 2003).

David Davis in his book GIS for Everyone, states that GIS is kind of a supermap, where computer software links geographic information (where things are) with descriptive information (what things are like). Unlike a paper map that can be one dimensional, GIS mapping can have many layers of information underneath its surface (Davis, 1999, p2). Geographic Information Systems provides a systematic way to collect and manage location-based information that combines geographic data (man-made and natural features on the earth's surface) with other types of information (names, classifications, addresses, and much more) to generate visual maps and reports. This information can be crucial to local government (O'looney, 2000 p. 5).

Research Question # 2-What resources would be required to implement GIS in the DFD?

When asked what is GIS? Inez Pollock, GIS coordinator for the City of Danville stated: Geographic Information Systems or GIS, is technology that allows the user to interface information with a geographic address on a map.

Basically, a GIS combines hardware, software, people, methods and data to capture geographically referenced information on the earth's surface. A GIS combines layers of information about a location. Roughly 80% of all objects have a geographic reference and can be mapped. For instance: street lights, stop signs, buildings and fire hydrants all have a specific coordinates or address and can be mapped geographically.

A GIS uses the information associated with each feature and allows a computer to analyze, map and display the information in a fast, effective, and visual manner. By utilizing the data associated with each feature, we are able to make concise, informed decisions quickly which can save time, money, and in the fire department's case even lives.

What resources are currently available in Danville?

GIS is made up of four basic resources: Hardware, Software, Data, and People. Almost every department in the City is using GIS in some capacity and finding value in what it has to offer. Many of these resources are already in place and the data layers that are available continue to grow every day.

Hardware for instance is made up of computers, data storage on disks and our City network server, our fiber network, and devices such as a GPS receiver. We already have these things available. For instance, the Water Department has a layer showing water mains throughout the City and already displays the locations of hydrants that may be beneficial to the fire department. This information was put in by plotting the location coordinates using another hardware device, a GPS receiver.

Software for GIS is also something that we already have as a municipality. We use ESRI software. ESRI is the Environmental Systems Research Institute, Inc. which is the largest builder of GIS software. With our ESRI software, we use ArcView GIS, which is a desktop software package that is an easy to use interface that allows the user to load spatial and tabular data that can be easily retrieved, displayed, manipulated and analyzed. I kind of think of ESRI as the “Microsoft” of GIS and ArcView as the “Windows”.

The data component of GIS is probably the most expensive component and we have been collecting this data for several years now. Different city departments are compiling data that is put into layers that can be shared by other city departments. For instance, we have mapped out all of our street center lines, gas lines, water lines, and other utility infrastructure. We have fire stations and all the structures in Danville already mapped out with addresses. We have recently added a layer of vacant structures that might be of interest to the fire department. We have enterprise zones and other elements that are used by Economic Development. The fire department would have to determine what applications you would want to use and we can make that layer of information available to you. The number of layers that can be added is almost unlimited. If you think of something that would be beneficial, we can convert it to a version that can be added as a layer. We also have a layer of aerial photographs. Currently we are using pictures from 2005. However, in the spring of 2007, we plan to have another flyover to update our aerial photos of the city.

Other information of all types is stored in a tabular format utilizing excel or access software that is then stored in layers on a map using the ArcView software.

Danville Public Works and Utilities are already using GPS receivers, AVL and GIS mapping to track resources. GPS allows for tracking and mapping at pinpoint accuracy and coupled with AVL a department can track and display resources in real time. For instance, Rick (Rick Drazenavich, Public Works Director) can track the garbage trucks. He can see exactly where they are and go back to a specific time frame and track where they went and the time that they were there. He was having a lot of calls from customers who stated that they were skipped on the garbage route. Now he can track these resources. Our police department has recently put laptops in some of the police cars. The Police use the "Panasonic Toughbook" because of its durability in the field and they use radio technology to important information directly to the police car. The only problem with this is that you have to be in a "hot spot" to use this. Hot spots are areas that have a good radio signal. We have pretty good coverage around the city but you can loose your signal easily when you get out of radio range. In a couple of years we will move to mobile wireless technology but we haven't got there yet.

When it comes to the people component of GIS, that is referring to us the users of GIS. IT offers in house training to teach the basics of using GIS and how to use the ArcView software.

What resources does the fire department need to implement this technology?

Basically, we could get you set up to start using the available layers of GIS now. The fire department has many of the resources already available for instance we will be able to use the computers that are already there in the fire stations. Once requested, I can put in an IT ticket to added GISmo web to the computers in the stations and then we can set up some form of training for the fire personnel that will be using GIS. GISmo is an intranet version of GIS that is available to all City departments. The data is stored on the city mainframe and it is transferred to computers throughout our departments by a fiber network that is already in place. A GISmo software program would have to be loaded onto the computers at the fire stations and then it could be retrieved by firefighters.

As you determine what layers you would find beneficial, we can customize layers to fit your needs and can budget for additional resources for instance you may want to add computers to the fire truck in the future. Then the information would be available in the field. Once the wireless technology is available the information will be there quickly as they respond to an emergency. Right now, it is available if they are in one of the “hot spots” (Pollock, personal interview, October 12, 2006).

Research Question #3-How is GIS used by other fire departments and what applications would benefit the DFD?

There are many different applications of GIS that can be used by the fire service. The literature review identified how several fire departments use GIS for storing and managing critical information for planning and preparation of emergencies of all types and for mitigation, response and recovery purposes. GIS is an excellent tool to improve response and pre-planning capabilities as it allows you to organize information, plan for emergencies, access maps, identify danger zones, critical infrastructure and specific community risk factors which can be used to improve community preparedness and emergency response. A common theme identified GIS as a tool for the mapping of response areas, damage assessment, critical infrastructure, hydrants, identifying critical areas, special needs, and for identifying specific hazards. It is used to assist in the coordination and management of programs, as well as for traditional mapping applications. Many fire departments around the country are utilizing GIS technology as a method for improving their service delivery and are seeing good results.

Chief Don Oliver from Wilson Fire and Rescue has developed many positive applications as he was recruited by the United States Fire Administration to implement GIS into the fire service and report on how it could benefit a fire department. ESRI supplied ArcView software to allow Wilson, NC to pilot GIS for emergency responders. Oliver states that his department found GIS to be an invaluable tool utilized for gathering quick, visible and accurate information on pre-incident surveys, hazmat facilities, and identification of dangerous buildings, problem hot spots, repeat calls, arsons, false alarms, water supply data, inspection schedules and prevention activities.

Jefferson Parish, Louisiana utilized GIS to mitigate the problems associated with flooding that was a common occurrence. GIS was also used for the long-term planning elements to budget for necessary infrastructure to prevent future floods and lessen the impact on the community.

Winston-Salem, NC utilized GIS software (ArcView) that utilizes a street centerline network that was recorded using GPS to define an optimal route at the moment of alarm (taking into account temporal factors such as traffic jams, accidents, roadwork), the location of hydrants, important landmarks, as well as building diagrams, floor plans, pre-fire survey information and important hazardous materials data along with any other special needs.

GIS allows multiple agencies to share information quickly and in an organized way during complex emergencies. GIS has been utilized during both natural and man-made disasters as a tool to manage resources, organize search and rescue operations and make critical decisions.

The use of a survey helped to identify how other fire departments were using GIS.

Of the sixty surveys that were distributed, eight did not reach the intended recipient because of changed or incorrect contact information and twenty-three departments responded to the survey which represents a forty-four percent return rate.

Survey Instrument Results Tabulated

TABLE 1

Reply	#1 Yes	#1 No	#2 Yes	#2 No	#4 Yes	#4 No	#5 Yes	#5 No	#7 Yes	#7 No	#8 Yes	#8 No	#9 Yes	#9 No
1	1		1		1			1	1		1		1	
2	1		1			1		1	1			1	1	
3		1											1	
4	1		1		1		1		1		1		1	
5	1		1		1		1		1		1		1	
6	1		1			1		1	1			1	1	
7	1		1			1	1		1		1		1	
8		1												1
9	1			1		1		1	1			1	1	
10	1			un		1		1	1			1	1	
11		1											1	
12		1												1
13	1		1		1			1	1			1	1	
14	1		1		1			1	1			1	1	
15	1		1		1		1		1		1		1	
16	1		1		1		1		1			1	1	
17	1		1		1		1		1			1	1	
18		1												1
19	1		1		1			1	1			1	1	
20	1		1		1				1		1		1	
21	1		1			1	1	1	1			1	1	
22		1											1	
23	1		1			1		1	1			1	1	
Total														
23	17	6	15		10	7	7	10	17		6	11	20	3

Un = unsure

Geographic Information Survey Results

1. Does your fire department utilize GIS? **17 responded yes and 6 responded no**
2. Do you use ESRI software? If not what do you use? **15 of 17 that use GIS utilized ESRI software, one was unsure, and one did not report the type of software used.**
3. What other types of companion software do you utilize? **Six departments reported using companion software and three were unsure. The companion software listed were: All ESRI products, InInterAct CAD, ProQA,EMD, Oblique Imagery, DECCAN products: CAD analyst/ADAM, BARB (www.deccanintl.com), ArcGIS, ArcView, Zone 7.5-cad for**

drawing preplans, Pictometry, All ESRI/GIS products, Deccan International's Fire ADAM, CAD analysis, and BARB (Box Area Runcard Builder).

4. Does your department use any mobile GIS devices? **10 Yes and 7 No.**

Panasonic Toughbooks, OMG routers, 700 MHz voice & data, datacards, mobile wireless, mobile data terminal use for AVL/AVRR – has GIS mapping background with preplan links, mobile data computers, mobile wireless, hot spots, Verizon EVDO PCMCIA cards

5. Do you use AVL? **7 Yes and 10 No**

Mobile network, RDLAP but switching to cellular within months, MDC, gps attached to mobile computers, radio, Verizon EVDO PCMCIA cards.

6. How are you using GIS?

TABLE 2

Application	Response	Application	Response
Hydrant locations	15	Response Mapping	10
Haz-mat identification	10	Vehicle Routing	7
Inspection Mapping	5	Dispatching	12
Fire Incident Analysis	8	Unsafe/vacant building sites	1
On-scene Management	3	Pre-incident Surveys	4
Resource Allocation	8	Smoke Alarm installation tracking	1

Please specify any other uses that you have found beneficial? **ISO analysis- hydrant/station locations, Identify fire/EMS boundaries, identify structures, static water supplies, Haz-mat mapping, call location, utility location, 3D building views through oblique imagery, station location analysis, apparatus deployment modeling, variety of reporting applications, elevation maps and flood prediction modeling, operational planning, aerial photographs, hazard identification.**

7. Do you find GIS and its applications to be beneficial? **17 or 100% of those surveyed that are using GIS found it to be beneficial.**

8. Does your department have someone designated solely for GIS/IT support?

Response: 6 Yes and 7 No: Of the six yes responses only 3 had someone in-house provide support. The seven no responses as well as other 3 yes responses identified that they had support in another municipal department.

9. Does your local government utilize GIS? **20 of the 23 responses identified yes that there local government utilized GIS with 3 no responses.**

DISSCUSSION

In the fire service, the access to quick, accurate information can mean the difference between life and death. Coupled with the nations increasing demand on interagency cooperation and data sharing, the use of GIS technology is a proven method of achieving these means. As the fire service continues to change and the types of emergency response grow more complex, it appears that many fire departments around the country have taken advantage of and are finding value in utilizing GIS technology.

Before conducting this research, this writer was unaware of the vastness of GIS or exactly what GIS was and how its applications could be utilized in the fire service.

GIS is kind of a supermap, where computer software links geographic information or where things are, with descriptive information that tells what things are like. Unlike a paper map that can be one dimensional, GIS mapping can have many layers of information underneath its surface that can help people make better decisions (Davis, p.2). Inez Pollock, GIS coordinator for the City of Danville, added that GIS allows the user to interface information with a geographic address on a map that allows the user to make concise, informed decisions quickly

which can save time, money, and in the fire department's case even lives. She also stated that there are many layers of information already available in Danville.

All the fire departments that responded to the survey instrument that used GIS, found it to be a beneficial tool. A common theme for all departments was that it maximizes information management and allows the user to retrieve information quickly and in a visual way that allows them to respond more efficiently and effectively to save time, resources and provide better emergency service. In essence, it allows the user to paint a detailed picture to visualize data, and make better informed decisions.

Every department researched in the literature review section of this paper as well as those departments surveyed reported that GIS was a beneficial tool for information management yet this researcher was surprised that such a small percentage of those surveyed tracked pre-incident survey information. Chief Don Oliver of Wilson Fire and Rescue states that his department found GIS to be an invaluable tool utilized for gathering quick, visible and accurate information on pre-incident surveys, hazmat facilities, and identification of dangerous buildings, problem hot spots, repeat calls, arsons, false alarms, water supply data, inspection schedules and prevention activities (Oliver, 2002, p36). A majority of the fire departments surveyed tracked the locations of hazardous materials, mapped hydrant locations and response areas but very few tracked pre-incident surveys and only one department stated that they mapped vacant or unsafe buildings. Since pre-incident surveys are often used in the fire service to gain important data about a building with a specific location or address, it only makes sense that a GIS would be a more efficient method of storing and retrieving this critical information. In Winston Salem, NC, the big three-ring binders with pages falling out and stuffed full of information which may mean the

difference between life and death has been replaced with touch-screen computer terminals on the trucks (Amdahl, 2001, p. 40).

GIS is a valuable tool to help organizations move forward efficiently while responding to issues of accountability and performance measurement. With a solid footing, GIS has a positive ripple effect and can build on itself, benefits will spill over from department to department. GIS is a vital tool for its capacity to supply critical information instantly (Thomas, 2004, p. XIV). In the field of emergency services, accountability is essential and it appears that many fire departments that utilize GIS are using it not only to store critical information that can be obtained quickly but also to track and maintain accountability of on scene resources.

The fire department in Winston-Salem, NC also utilized GIS software (ArcView) that utilizes a street centerline network that was recorded using GPS to define an optimal route at the moment of alarm (taking into account temporal factors such as traffic jams, accidents, roadwork) (Amdahl, 2001, p. 38). Many of the departments surveyed also reported in the Results section of this paper that they utilize GIS for dispatching and vehicle routing. As GIS deals with mapping and can analyze data to determine an optimal route based on what is going on at the time this appears also to be a beneficial use of GIS that can save time and possibly lives.

This researcher also discovered that many of the resources needed to utilize GIS are already available. Software for GIS is also something that we already have as a municipality. We use ESRI software. ESRI is the Environmental Systems Research Institute, Inc. which is the largest builder of GIS software. With our ESRI software, we use ArcView GIS, which is a desktop software package that is an easy to use interface that allows the user to load spatial and tabular data that can be easily retrieved, displayed, manipulated and analyzed (Pollock, personal

interview, October 12, 2006). Although, ESRI is certainly not the only GIS software company available, it was learned that they are by far the largest and are used by the majority of the fire departments in the country. It was also found that ArcView is the most popular program used to display and utilize stored data. Computers are another resource needed to begin utilizing GIS that should be available to most fire departments today. It only makes sense that almost every fire department that is utilizing GIS has data and software available since their Municipality is also finding beneficial uses of this technology and the sharing of data makes it more cost effective.

This researcher has learned that GIS is certainly something that would be beneficial to the DFD and although challenged financially, the use of GIS can be achieved by utilizing existing resources and shared data. Existing data that is stored by the DFD can also be converted to a tabular format that can be stored in a GIS with the help of Danville's IT department, making it much easier to retrieve, share, analyze and visualize data to provide better emergency services to the citizens of Danville. The use of GIS is changing the way the fire service plans, mitigates, responds, and recovers from emergencies of all types and complexities. It has become important for departments of all sizes and in all regions of the country to adapt and change with the times, realizing that new technologies have become an essential part of the fire service and customizing applications of GIS is one method for meeting these changing needs.

RECOMMENDATIONS

The City of Danville utilizes Geographic Information Systems (GIS) to improve its municipal services. The problem is that even though GIS is available, the Danville Fire

Department is not familiar with GIS, what applications would best be utilized, or what resources would be required to implementing this technology. The purpose of this applied research was to gain a better understanding of what GIS is and to identify what applications would be beneficial to the DFD, and to determine the needed resources.

Based on the research compiled for this applied research project it has been determined that the DFD should be utilizing GIS to improve its information management capabilities and to track specific resources. It is believed that specific application of GIS can be beneficial in allowing the DFD to not only better prepare and respond to emergencies but to allow the department to better mitigate and recover from emergencies as well. GIS also provides a stable platform for information sharing and allows for better communication with different departments and agencies. After all, “a picture is worth a thousand words.”

This study found that many of the pieces and resources for utilizing GIS are already in place. The DFD merely needs to tap the existing resources that are available. This shall include using existing hardware, software, data, and people. Taking advantage of already existing resources will save tremendously on time and money. Based on the results of this study the following recommendations are encouraged:

- Need to tap existing GIS resources. Request IT department to add GISmo web intranet service to the existing computers in the seven fire stations. This will allow members of the DFD to begin using existing data layers that the City of Danville has to offer.
- Establish a GIS user group with-in the fire department to meet with the Danville IT department’s GIS coordinator. This user group should consist of several

employees who have an interest in GIS and can begin piloting the use of GIS applications in the department.

- Develop training for the fire department on the use of the ArcView programming, so fire personnel can gain a better understanding of the current applications of Danville's GIS database and how to use it.
- User group should customize existing data layers in an easy to use format to be used by the fire department and discuss and develop new applications and data layers that will improve the DFD service delivery.
- The DFD GIS user group should develop a plan for wide scale implementation of GIS into the department. The user group should review the department's current data bases to determine what can be added as a GIS application. For instance: Inez Pollock stated that since hydrant locations are already mapped and available, hydrant maintenance data can be stored using GIS. The user group should explore how current fire hydrant maintenance records can be converted to a tabular format using a program like excel or access so that it can be attached to the GIS. In the same regard, the user group should explore how our current pre-incident survey database can be attached to the correct address in the GIS. The user group should not only look at what information can be stored using the GIS but also how it can be easily used to stream line data entry and retrieval.
- Identify and apply for a grant to purchase "Panasonic Toughbook computers" that can be mounted to the fire trucks so that data can be compiled in the field and so that critical information can be quickly retrieved and accessible during an emergency. This type of mobile computer was recommended by the Danville IT

Department because they are familiar with its capabilities since other Danville departments are utilizing them and because they will be providing the support.

- Develop a method of evaluating GIS applications and their usefulness and ease of use to the department to identify areas of improvement.
- Explore the possibility of integrating GPS receivers or AVL's to fire apparatus to allow the department to utilize GIS for tracking resources, providing routing directions, and to visualize locations to make better decisions.
- Future plans should include integrating GIS and the National Fire Incident Reporting System to better be able to visualize, reveal patterns, and analyze data relationships and plan for future events. This will help to track fire problem areas, re-evaluate staffing, apparatus, and district boundaries to improve response times and resource allocation.

The possibilities of using GIS are very great and are limited only by one's imagination. It is recommended that the DFD start utilizing GIS to be more efficient and to allow critical and accurate information to be retrieved quickly. By utilizing existing resources the cost will be minimal. By piloting a GIS program many of the applications can be developed by those with an interest in this technology and applications can be prepared in an easy to use format, supported by existing staff and then implemented department wide. As funding is available or secured from alternative sources, additional applications can be explored.

Future researchers may want to identify departments who utilized GIS for large scale operations and better determine what applications were most beneficial and what applications should be readdressed or discontinued.

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APPENDIX A

Geographic Information System (GIS) Survey

The following questions are related to GIS. The person completing this survey needs to be familiar with how GIS is being utilized in their department. Please ask for assistance if another person would be better suited to participate in this survey.

1. Does your fire department utilize GIS? Yes No

If you answered no, please proceed to question 9 and complete the survey.

2. Does your department use ESRI software? Yes No

If not what type of GIS operating software do you use?

3. What other types of companion software do you utilize?

4. Does your department use any mobile GIS devices? Yes No

If yes please describe what kind of mobile devices are utilized. (mobile wireless, hot spot wireless, other)

5. Do you use AVL (auto vehicle locators)? Yes No

If so, what method are you using? (i.e. radio, cellular tower, mobile network, etc.)

6. How are you using GIS? (Please check all that apply)

- | | |
|---|--|
| <input type="checkbox"/> Hydrant Locations | <input type="checkbox"/> Response Mapping |
| <input type="checkbox"/> Haz-Mat Identification | <input type="checkbox"/> Vehicle Routing |
| <input type="checkbox"/> Inspection Mapping | <input type="checkbox"/> Dispatching |
| <input type="checkbox"/> Fire Incident Analysis | <input type="checkbox"/> Unsafe/ Vacant Building Locations |
| <input type="checkbox"/> On-Scene Management | <input type="checkbox"/> Pre-Incident Surveys |
| <input type="checkbox"/> Resource Allocation | <input type="checkbox"/> Smoke Alarm Installation Tracking |
| <input type="checkbox"/> Strategic Planning | <input type="checkbox"/> Damage Assessment |

Please specify any other uses that you have found beneficial and/or any details of your existing use of GIS that would be helpful.

7. Do you find GIS and its applications to be beneficial to your department?

Yes No Not Sure

Please describe why:

8. Does your department have someone designated solely for GIS/IT support?

Yes In-house Other municipal dept. Other
No

9. Does your local government utilize GIS? Yes No Not Sure

Optional:

Person/position completing survey:

Fire Department:

Phone and/or email address:

Comments:

Thank you for your participation

Please return this survey by email by selecting **FILE** and then on **SEND TO** and then select **MAIL RECIPIENT (as attachment)** and return to me by the email address below. You may also fax, or mail the survey to

**David Eagle, Fire Marshal
Danville Fire Department
297 Bridge Street
Danville, VA 24541
eagleldr@ci.danville.va.us
Phone: (434) 799-5226
Fax: (434) 797-8943**

APPENDIX B

Dear fellow fire professional,

My name is David Eagle and I am the Fire Marshal for the Danville Fire Department in Virginia. I am currently enrolled in the National Fire Academy's Executive Fire Officer Program where I am gaining research into the applications of Geographic Information System technology. The enclosed survey will be used as part of the research portion of this program and more importantly will be used to gain valuable information to develop a plan for using applications of GIS that will benefit my community.

I would appreciate your assistance by completing the survey even if you do not currently utilize GIS in your department and returning it no later than the 5th of December. Upon completion of the survey, you may return it by clicking on **file** and then on **send to** and select **mail recipient (as attachment)** and return it to me at **eagleldr@ci.danville.va.us**

<<GISsurvey.rtf>>

Thank You for your participation,

David Eagle
Fire Marshal
Danville Fire Department

APPENDIX C

FIRE DEPARTMENTS RESPONDING TO SURVEY

Central Jackson County	Jackson County, MS	bchlapek@cjcfd.org
Charlotte Fire Department	Charlotte, NC	rāju@ci.charlotte.nc.us
Denver Fire Department	Denver, CO	davidrichards@ci.denver.co.us
Grand Rapids Fire Dept.	Grand Rapids, MI	gszotko@ci.grand-rapids.mi.us
Green Bay Fire Department	Green Bay, WI	donph@ci.green-bay.wi.us
Hamilton Township Fire District #9	Hamilton Township, NJ	mdaski@aol.com
Henrico County Division of Fire	Henrico County, VA	ncaputo@co.henrico.va.us
Hutchinson Fire Dept.	Hutchinson, KS	jeffd@hutchgov.com
Jackson Fire Department	Jackson, MS	rpbush@hotmail.com
Larkspur Fire Department	Larkspur, CA	sshurtz@larkspurfire.net
Moses Lake Fire Department	Moses Lake, WA	cmoberg@ci.moseslake.wa.us
Norfolk Fire-Rescue	Norfolk, VA	Bruce.evans@norfolk.gov
North Las Vegas Fire	North Las Vegas, NV	gorgons@cityofnorthlasvegas.com
Pinehurst Fire Department	Pinehurst, NC	ffrtiz@villageofpinehurst.org
Prince William County Fire Department	Prince William Co., VA	skersse@pwcgov.org
Rialto Fire Department	Rialto, CA	fbekker@confire.gov
Rockingham County Fire	Rockingham County, VA	rsymons@rockinghamcountyva.gov
Springfield Fire Department	Springfield, MA	jrendergast@springfieldcityhall.com
Winston-Salem Fire Department	Winston-Salem, NC	stevewi@cityofwsfire.org
Upper Merion Fire & Rescue	Upper Merion, PA	jwaters@umtownship.org
Victoria Fire Department	Victoria, TX	ssherman@victoriatx.org
Washington DC Fire Dept.	Washington, DC	Michael.willis@dc.gov
York County Fire & EMS	York County, VA	disnerj@yorkcounty.gov