GEOGRAPHIC INFORMATION SYSTEM: PLANNING FOR ITS IMPLEMENTATION INTO A MUNICIPAL FIRE DEPARTMENT

Executive Analysis of Fire Service Operations in Emergency Management

By: Mark P. Young
Casper Fire Department
Casper, Wyoming

An applied research project submitted to the National Fire Academy as part of the Executive Fire Officer Program

April 2004
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

The problem for the Casper Fire Department was that while a modern Geographic Information System (GIS) existed and was applied within the City of Casper, the fire department and its personnel had limited knowledge and exposure to GIS and its capabilities. This resulted in a work environment where GIS had been grossly misunderstood and underutilized. Having found GIS to be a valuable tool in limited application city wide, the City Manager had strongly advocated the use of GIS throughout the entire city organization.

The purpose of this research was to identify uses of GIS in the fire service and to also choose an effective planning model that would be used in implementing a department specific Geographic Information System specifically for the Casper Fire Department.

Descriptive research was used to answer three research questions:

1. What is a Geographic Information System?
2. How are Geographic Information Systems (GIS) being utilized by other fire departments and what value has it added?
3. How can the Casper Fire Department best implement and effectively utilize GIS?

The procedures used in this applied research project were comprised of a literature review and a survey. All applicable literature was analyzed to assist in the definition, purpose, usage, benefits and planning of a Geographic Information System (GIS). A specific survey instrument was used to discover information on how widespread the use of GIS was in the fire service. The survey also revealed information on how GIS was being applied by various fire departments and what benefits were gained by its usage.

Results of the literature review and survey suggested that GIS was being used by many different fire departments across North America and that those fire departments have found its
application to be very beneficial in day to day planning and operational issues. This research also discovered several different planning methodologies to implement GIS into an organization. Research also suggested the use of one specific planning model due to its all inclusive planning and implementation principles.

A recommendation was made to adopt a nine-stage planning and implementation model that will be used to plan for and implement GIS into the Casper Fire Department. All remaining research data will be used by the Casper Fire Department in selecting appropriate GIS uses.
### TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Certification Statement</td>
<td>2</td>
</tr>
<tr>
<td>Abstract</td>
<td>3</td>
</tr>
<tr>
<td>Table of Contents</td>
<td>5</td>
</tr>
<tr>
<td>Introduction</td>
<td>6</td>
</tr>
<tr>
<td>Background and Significance</td>
<td>8</td>
</tr>
<tr>
<td>Literature Review</td>
<td>12</td>
</tr>
<tr>
<td>Procedures</td>
<td>24</td>
</tr>
<tr>
<td>Results</td>
<td>28</td>
</tr>
<tr>
<td>Discussion</td>
<td>43</td>
</tr>
<tr>
<td>Recommendations</td>
<td>48</td>
</tr>
<tr>
<td>References</td>
<td>51</td>
</tr>
<tr>
<td>Appendix A</td>
<td></td>
</tr>
<tr>
<td>Survey Cover Letter</td>
<td>52</td>
</tr>
<tr>
<td>Appendix B</td>
<td></td>
</tr>
<tr>
<td>Survey Instrument</td>
<td>53</td>
</tr>
<tr>
<td>Appendix C</td>
<td></td>
</tr>
<tr>
<td>Survey Instrument Results</td>
<td>55</td>
</tr>
<tr>
<td>Appendix D</td>
<td></td>
</tr>
<tr>
<td>Evolution of GIS Chart</td>
<td>61</td>
</tr>
<tr>
<td>Appendix E</td>
<td></td>
</tr>
<tr>
<td>GIS Planning Model Recommendation</td>
<td>62</td>
</tr>
</tbody>
</table>
INTRODUCTION

Today’s modern fire service is being exposed to many new technologies that claim to provide the ultimate in effective and efficient service delivery. These technologies run the gamut from new hand tools, SCBA’s, personal protective equipment, thermal imaging cameras, chemical detection devices and computer aided dispatch systems to new apparatus with mobile data computers. One new technology that has made its way into the public sector and the fire service is Geographical Information Systems (GIS). Over the years fire service administrators and managers have used many different methods to identify public safety problems in their jurisdictions and to evaluate the effectiveness and efficiencies of their departments. These methods included various methods of capturing and analyzing useful data in order to monitor a department’s service activity, productivity, and efficiency. One method that has been employed over many years to track data is called a “pin map”. This map uses different colored stick pins that graphically display different types of calls for service within a jurisdiction’s boundaries. Today this old technology is being replaced with new Graphic Information Systems. Modern GIS not only replaces old pin maps it also provides the ability to track, analyze and display many different relational data bases that reside within a fire department.

GIS is a powerful software technology that allows a virtually unlimited amount of information to be linked to a geographic location. Coupled to a digital map, GIS allows a user to see regions, counties, neighborhoods, and the people who live in them with unprecedented clarity, showing layer upon layer of information such as demographic trends, soil types, income levels, voting tendencies, poverty rates, pollution levels, epidemics, cereal brand preferences, high school drop-out rates, college scholarship rates, television watching preferences, and Internet accessibility. The list is limited only by the
imagination. GIS also incorporates powerful tools to analyze the relationships among all these kinds of data. The effects of this new power on public policy are profound (Greene, 2000, Introduction).

The problem for the Casper Fire Department is that while a modern GIS currently exists within the City of Casper, the fire department and its personnel have limited knowledge and exposure to GIS and its capabilities. This has resulted in a work environment where GIS has been grossly misunderstood and underutilized. Having found GIS to be a valuable tool in limited application city wide, the City Manager is now strongly advocating the use of GIS throughout the entire organization.

The power of GIS is most leveraged at the enterprise-wide level. It is here that consistent information is available across the organization. Organizational decision makers get a clear picture of reality, data is consistently updated, more is shared, a wider-cast information net allows for better decision making, and duplication of effort is avoided (Tomlinson, 2003, p. 6).

The purpose of this research is to identify uses of GIS in the fire service and to also choose an effective planning model that will be used in implementing a department specific Geographic Information System for the Casper Fire Department. A survey was used to gain feedback on the use of GIS in the fire service. Three research questions were developed to guide this research project to a successful conclusion. Descriptive research will be used to answer the following research questions:

1. What is a Geographic Information System?
2. How are Geographic Information Systems being utilized by other fire departments and what value has it added?
3. How can the Casper Fire Department best implement and effectively utilize GIS?

**BACKGROUND AND SIGNIFICANCE**

The City of Casper Fire Department provides a multitude of public safety services to the citizens of Casper, Wyoming. Casper is located in central Wyoming and is a community of 50,000 people encompassing an area of 24 square miles. The Casper Fire Department is staffed with 73 sworn career firefighters and is supported by two administrative assistants. The department provides both non-emergent and emergent services to the citizens of Casper. In addition to providing services within its own jurisdictional boundaries, the Casper Fire Department has existing mutual aid agreements with the communities of Mills, Bar Nunn and Evansville as well as with the Casper Mountain Fire District and the Natrona County Fire Protection District.

As experienced in the fire service nationwide, many changes have occurred in the Casper Fire Department over the past twenty years. Statistics reveal that one significant change has been in the number of total calls for service. In 1983 the department responded to 1,426 total calls. Of these 1,426 calls, 272 were fires, 698 were EMS and 456 were a combination of false alarms, rescue calls, service calls and hazardous materials calls. Twenty years later, the C.F.D. responded to 4,298 total calls. 109 were fires, 3,106 were EMS calls and 1,023 calls were a combination of false alarms, rescue calls, service calls and hazardous materials calls. These statistics demonstrate an overall increase of 2,872 total calls over this twenty-year period. Statistics further reveal that between 1983 and 2003 calls for fires decreased by 163 or 27%, EMS calls increased by 2,408 or 345%, and a combination of false alarms, rescue calls, service calls and hazardous materials calls increased by 567 or 124%. In summary, statistics reveal an increase in all calls for service with the exception of fire calls.
While these statistics show that specific calls for service have both increased and decreased over the same time period, they only reveal outcome numbers and do not reveal the true public safety problem to fire department managers in Casper. In an effort to further analyze the fires in Casper the fire department has historically collected fire cause data that assists managers in understanding the true fire problem and developing solutions to remedy the problem. This type of analytical data has not been gathered for all other areas of calls for service. Therefore, administrators and managers in the fire department do not truly understand the scope of Casper’s Public Safety problem. This author and other Casper Fire Department managers know that EMS calls and other calls for service have risen significantly, but when asked why can only answer based on assumptions not factual information. Does the fire department respond to more EMS calls each year because more civilians better understand the EMS system in Casper and therefore call 911 versus drive to the hospital themselves? Are our police officers better
recognized medical conditions in people that they are dealing with and calling for EMS help? Are low income families beginning to use the fire department as home health care services? Are the elderly and handicapped using the fire department to assist them at home with minor health or physical problems that family used to provide? Is the fire department doing a better job of educating the public on our EMS system and as a result more people call for help? Has there been a demographic change in Casper and how has that affected our EMS calls? Are our EMS calls increasing because of illegal drugs or other crime activities? Is alcohol a factor? As a fire administrator, this author and my staff have asked ourselves many of these and other questions trying to figure out what is driving our increase in EMS calls. Similar questions are posed as to what is driving our increase in other calls for service as well. How do we as fire service administrators and managers more accurately discover the reason for the increase or decrease in the number of calls for service? And more importantly, how can we develop and implement preventive solutions to the problems if we don’t truly understand the public safety problem?

Approximately two years ago, this author began to ask questions about the City of Casper’s Geographic Information System (GIS). This is an advanced computer technology system that interfaces with existing relational data that can be displayed graphically on an electronic map. My questions were born out of the recognized need to gather and analyze existing and future data that would assist me and the department in determining our public safety problems. This author soon discovered that GIS may be the technological tool that will provide the fire department with the answers to many of our unanswered questions.

The City of Casper’s GIS has been in use since 1992. It originally was implemented to serve the Metropolitan Planning Organization (MPO) in analyzing transportation information for the community. As a matter of fact, it is not uncommon for this type of single project application
to grow into a city or enterprise wide GIS system. The International City Manager’s Association (ICMA) supports the utilization of GIS in single and enterprise wide applications and describes that it is being implemented by many governments nationwide. The ICMA also helps define GIS by stating that “This technology allows various data to be presented in graphical form tied to maps of the community. The information is of value to emergency planners but can also be helpful during an incident” (Association, 2002, p. 463). This geographical information has proved to be a very valuable analytical tool for MPO managers in Casper. Shortly after being implemented by MPO the City of Casper’s Public Services Department started using GIS as a tool to analyze existing traffic issues and problems throughout the community. The City Manager has experienced the benefits of GIS through its use in two out of the nine city departments. He is now urging all other departments in the City to utilize this technology to identify problems, create solutions and to better manage the daily activities of each department. It is this author’s intent to research what GIS is, how it is being utilized most effectively and to determine the most appropriate method for GIS application and implementation into the Casper Fire Department.

The relevancy of this applied research project and the National Fire Academy’s *Emergency Analysis of Fire Service Operations in Emergency Management* course lies in the use of GIS as an analytical, planning and management tool. GIS is a technology tool that graphically displays relational public safety data on an electronic map. This information can then be used by Casper Fire Department staff to identify and analyze a variety of public safety problems within our community. As a result, staff will have the added capability to effectively pre-plan and manage emergency events. As an element of this research, a survey was conducted to gain
information on the use of GIS in a sampling of fire departments nationwide. The survey was significant in evaluating the awareness, utilization, and benefits of GIS in the fire service.

LITERATURE REVIEW

The literature review for this project included information that was found in books, journal articles and reports.

One of the first aspects of this project is to define what a Geographic Information System (GIS) is. In David Davis’ book GIS for Everyone, Davis helps define GIS in the following manner.

A GIS is a kind of supermap, computer software that links geographic information (where things are) with descriptive information (what things are like). Unlike a flat paper map, where “what you see is what you get,” a GIS can have many layers of information underneath its surface (Davis, 1999, p. 2).

Davis continues to explain GIS by describing the difference between a paper and electronic map.

If you look at a road on a paper map, about all you see is a name and maybe a highway number. If you click on the same road on a GIS map, you might find not only its name, but also how many lanes it has, when it was built, what the road surface is made of, when it was last painted, and whether you can see that spot on the road from a mountain 20 miles away (p. 2).

Wallace (2002) defines GIS as “computer systems that endeavor to relate political, socio-economic, and environmental data to each other geographically. The result is the ability to access and compare large amounts of information by where and how they occur” (p. 21). He continues to define GIS by stressing the importance of geographic data. He writes, “GIS is a holistic
system where computer software effectively uses geographic data to relate information and aid decision-making. Without the data, there is no GIS” (p. 22). Wallace gives further examples of geographic data as “Road Centerlines, Address Point Locations, Emergency Service Number (ESN) Zones, Police/Fire Jurisdictions, Digital Aerial Photography, Municipal Boundaries, Water Features, etc” (p. 22).

William Weaver, Jr. describes GIS by writing, “A GIS system is a computer system capable of assembling, storing, manipulating, and displaying geographically referenced information on a computer monitor for enhanced decision making and analysis. The operative word here is analysis” (Weaver, 2001, p. 35).

One author who has experience in designing GIS software and applications provides yet another definition of GIS.

The term “geographic information system” is applied loosely to a large group of interrelated technologies. For local governments, a GIS is “a computer technology that combines geographic data (the locations of man-made and natural features on the earth’s surface) and other types of information (names, classifications, addresses, and much more) to generate visual maps and reports.” A GIS uses geographic location to relate otherwise disparate data and provides a systematic way to collect and manage location-based information crucial to local government (O’Looney, 2000, p. 5)

A definition and understanding of GIS is important in context with this research project. Another important element of this research is to determine how GIS is being utilized in the fire service today and from its use, what benefits are being realized.

In his book Disaster Response GIS for Public Safety, Gary Amdahl chronicles many different GIS case studies. In one example he writes about useful ways that GIS can be used.
One of the most useful ways GIS can be used in fire and rescue operations is to geocode individual incidents and display them on map backgrounds, or with pins on actual wall maps. Patterns and hot spots quickly emerge, allowing fire and EMS staff – as well as other interested parties, such as injury prevention advocates – to allocate resources where they will do the most good (Amdahl, 2001, p. 20).

Amdahl goes on to write about how GIS can provide information on how to most effectively deploy both human and equipment resources within a jurisdiction’s boundaries. He explains this by saying,

The nature of the fire hazards to which a municipality is susceptible determines strategies for suppression. Resources, in other words, are deployed where it seems they will do the most good. Conditions, however, do not necessarily stay the same from year to year. As communities grow, it becomes particularly important to maintain fire hazard data at a level of accuracy that allows decision makers to consider the needs and circumstances as they are, not as they have been (Amdahl, 2001, p. 16).

In citing different case studies of GIS in public services Andy Mitchell describes the following example to demonstrate how GIS is being applied and what benefits are being derived.

The City of Tacoma Fire Department used GIS to create response zones for its stations. The GIS determined the closest fire station to each street by calculating the travel time from each station outward along the streets. The resulting map provides accurate response zones, so firefighters from the closest station will be sent to the fire. The map also shows which stations are next closest, and so can be called for backup (Mitchell, 1998, p. 8).

Mitchell continues to provide examples in his book by referencing the City of Montreal,
Quebec and its ambulances.

Each ambulance carries a device that sends its current coordinates to the dispatch center. When a call comes in, the dispatcher gets the coordinates for the five ambulances stationed around the city. The GIS calculates how long it would take for each ambulance to get to the scene. Once it finds the closest ambulance, the GIS displays the fastest route for that ambulance, taking into account traffic, road construction, and current weather conditions (p. 8).

Another public safety example provided by Mitchell is the siting of new fire stations in Rochester, Minnesota. He writes,

The City of Rochester used GIS to help assess the need for new fire stations. A committee developed scenarios showing which part of the city could be reached within one, two, or three minutes from each possible location. “We had to…look at the city geographically and determine response times according to roads, speed, and congestion. We felt that using the GIS system would be the most appropriate way to do that,” says Ron Livingston, division supervisor for the Planning Department. Maps and reports were created for the city council members, who decided to build one new station and to look into possibly relocating two others (p. 42).

In a journal article documenting how GIS was used by the Wilson Fire/Rescue Services during Hurricane Isabel Don Oliver states, “Wilson Fire/Rescue Services had been experimenting with GIS for a few years as a poster fire department for the Commission on Fire Accreditation International, managing and tracking a variety of data critical to operations. (Oliver, 2003, p. 30).
Oliver continues to explain how GIS was used in various new ways before and after the hurricane.

- Pre-incident analysis of flood-prone areas. GIS mapping of flood-prone areas enabled us to prepare to block streets and to reposition resources in areas that might have no access in flooding conditions.
- Outage tracking. GIS enabled us to map the electrical distribution system and track feeder lines that historically lose power during a storm.
- Strategic response to critical-care patients. GIS enabled us to identify electric service customers who had critical medical situations requiring special equipment for survival – and to respond if they lost power.
- Real-time incident tracking. As the hurricane events began, GIS mapping was used to track incidents as they unfolded, providing staff in the emergency operations center a visual map of what was happening (Oliver, 2003, p. 30).

Macekura (2000) recommends that, “GIS applications for public safety, at a minimum, should incorporate location-of-structure mapping along with fire hydrants, water-source locations, road markers, utility features, schools, airports, terrain, station houses and an almost infinite selection of other databases” (p. 68).

Mitchell once again gives a procedural example of how emergency dispatchers in Kennebunk, Maine successfully use GIS in their daily functions.

You can use GIS to quickly find and map the location of a person, building, or event, that lets you see who or what is closest to the location and how best to get there. Emergency dispatchers in Kennebunk, Maine, use a GIS-based dispatch system to find the location of people calling for help so they can give exact directions to emergency crews.
What the system does…

1. Gets the information about the location. The dispatch system is tied into the police department’s phone line. When an emergency call comes in, the dispatch system automatically gets the caller’s phone number.

2. Searches the GIS database for a match. The dispatch system uses the phone number to find the parcel that matches.

3. Displays the location. Once the system finds the matching parcel, it draws the parcel in the center of the screen and shades it red. It also draws other features from the database, such as streets and building outlines. The dispatchers know exactly where the caller is located and can direct emergency crews to the scene (Mitchell, 1998, p. 7).

Mitchell’s research into how GIS is used in the fire service led him to Greenville, South Carolina, where one of their uses of GIS revolves around evacuation of civilians due to natural or man-made disasters. He cites the following example.

You can use GIS to get information about the people and things in a specific area. The Greenville, South Carolina, Fire Department uses GIS in case of a toxic gas leak or other emergency to find out which streets, schools, and hospitals need to be evacuated. The GIS also calculates the total number of residents within the area, so the Red Cross knows how many shelters are needed.
What they do…

1. Define the affected area. The fire chief uses a computer model to estimate how far the toxic plume is likely to spread, and in which direction. That becomes the evacuation area.

2. Draw the boundary in the GIS. The chief draws the boundary of the evacuation area on the computer screen using streets as a backdrop for reference.

3. Query the GIS database. The GIS uses the boundary to find the streets, schools, and hospitals that fall within it. It also overlays the boundary with census tracts to find the tracts inside the evacuation area.

4. Display the map and information. The GIS displays a map with the selected streets, schools, and hospitals highlighted. It also lists the address ranges for each street, and the name and address of each school or hospital. The GIS totals the population within the census tracts to find the number of residents affected. The chief relays the information to police and to the Red Cross so they can begin the evacuation (p. 43).

In a journal article entitled *Managing Disasters by GIS* author Andrew Carothers (1999) explains the use and value of GIS by writing,

Disaster response has become much more effective with the advent of advanced technologies like geographic information systems (GIS). As GIS has become easier to use, faster to implement, and less expensive, its lining of maps to multiple databases provides rescue workers and planners with a quick way to visualize disaster situations, prioritize needs, and respond quickly (p. 36).

Carothers goes on with his example by stating,
GIS technology was used extensively during the Red River “Flood of the Century” in North Dakota and Winnipeg, Ontario. Winnipeg is now using GIS for “Aftermath Mapping,” which involves detailing which dykes constructed during the flood response to prepare for future floods. Even the Oklahoma City bomb response used GIS to save precious hours by guiding the search and rescue teams in their life-saving efforts (p. 36).

O’Looney (2000) writes of three additional real-life uses of GIS in the fire service by saying, “In Wilson, North Carolina, a GIS was used to relocate existing fire stations. GIS analysis indicated that if two stations were relocated, an additional station would not be needed” (p. 108).

The author continues with the following statement.

The Fairfax, Virginia, fire and rescue department used the county’s GIS technology to look at the sources of repeat calls and the response time for these sources. The analysis showed that a good number of calls typically come from the freeway during afternoon rush hours. Therefore, the department is considering changing to a dynamic deployment of emergency vehicles (e.g., parking a number of vehicles near the freeway during part of the day). GIS staff reported that prior to the production of visual displays of the data, “you could not convince the router with table data that there were more accidents at rush hour on the interstate. With GIS you could.” (p. 109).

In a final case study the author continues to write about how Prince William County, Virginia, used their GIS in one specific instance.

A GIS analysis of the time it takes to respond to calls from different parts of the county resulted in the discovery that it would be cheaper to build a new bridge than to build a new fire station as was originally proposed (p. 109).
This literature review has provided many different examples of how GIS is being used and what value it brings to administrators, managers, employees and citizens of municipalities, counties and various agencies. Author R.W. Greene sums up the value of GIS by saying,

GIS portrays important information graphically – information that used to be available only as columns of numbers or, at best, colored charts. This simple innovation should not be underestimated. “GIS makes things graphic,” says Robie Hubley of the Massachusetts Audubon Society, “which is the way the human brain works, so the connections are so perfectly obvious.” Looking at a GIS map of crime rates shows a city council instantly how its public safety funding may need to be shifted; a map of low-weight births shows public health officials how their prenatal-care teen education program is working; a map showing areas where children have been exposed to lead paint gives a school board a clue to low achievement among some students. And these GIS tools are increasingly being made assessable to citizens, policy makers, and the media through the Internet, itself expanding at an exponential rate (Greene, 2000, p. xi Introduction).

The author continues to reveal in his writings that, in his opinion, GIS is so efficient that it is now being used in everyday decision making processes by stating that, “GIS is becoming an integral part of decision making itself, helping to shape and influence the context in which decisions are made. It is on this level that GIS may have its most profound effects” (p. xii Introduction).

One last example of another author making an argument for the value of GIS lies in the following statement.

Over the past 20 years, GIS has evolved from a luxury into an inevitability. Originally used as a planning and mapping tool, it has now become an essential item in the local
government toolbox, used for everything from helping manage welfare reform to helping fill potholes (Somers, 1998, p. 24).

This research and corresponding literature review has provided different definitions of GIS and its associated use and value in the fire service. This literature review will now focus on successful strategies used by others in the planning and implementation of an effective GIS into their organizations and/or agencies.

Somers (1998) recommends an implementation process for GIS that begins with understanding the local government model. She explains this by stating, “Understanding the local government GIS development model is the first step in creating an effective system” (p. 24).

This author continues her explanation of what model works best in government by writing,

The model for most city and county systems is a multipurpose, enterprise-wide system, based on large-scale map data, centered on parcel information with overlays and linkages to other land-related data and databases. Ultimately, most local governments need large-scale, parcel-based data to serve all their GIS needs (p. 24).

Somers finishes discussion on GIS planning and implementation by recommending the adoption of the following process.

- Planning. Project Planning involves developing a “vision” about how GIS will fit into the organizations future operations, considering any implications of that vision and determining the resources and activities required to achieve those goals. The organization must establish the scope of the GIS, identify the development team, gather background information and develop a preliminary
implementation plan. The planning phase represents the “top-down” view of what the GIS will be and how it will be implemented.

- Requirements analysis. Requirements analysis represents the “bottom-up” view which involves looking at the details required to fulfill the planned system goals. During this phase the functional and data requirements for the GIS applications and users must be determined; resources must be assessed; and opportunities and constraints within the organizational and institutional environment must be identified.

- Design. In the design phase, all the information from previous activities is coordinated to develop a detailed picture of GIS. A conceptual design for the system, database, applications and organizational components must be determined, and that design must be integrated with set goals and requirements. A detailed cost/benefit analysis can be performed and detailed component implementation plans developed.

- Acquisition and development. Software, hardware and data specifications for system selection and acquisition must be developed and the resulting systems installed.

- Operation and maintenance. Finally, the GIS must be integrated into the organization’s operating environment. This phase involves supporting users, and managing ongoing data and systems development and maintenance (pgs. 24-25).

Author David Macekura, of the Luzerne County, Pennsylvania, Emergency Services recommends a planning and implementation process as follows.
• Obtain permission from decision-making officials to investigate the feasibility of purchase, implementation and maintenance of a geographic information system.

• Form a project study team. The team, at a minimum, should initially comprise representatives from all interested departments/agencies and communities. Engineering and financial decision-making officials should always be integral members of the team. Examine the concept of GIS and address the following: does your agency need this technology?

• Discuss your findings with decision-making officials. (Special note: the next four points can be performed by the team; however, you may want to consider tasking them to an experienced professional consultant or firm in conjunction with the team’s leadership and guidance.)

• Assess and prioritize each department’s/agency’s needs and goals.

• Share and review findings as a team.

• Create a comprehensive needs-assessment document.

• Formulate a conceptual cost-estimate. Base the estimate on the needs-assessment document and a priority-of-implementation schedule.

• Review and analyze final findings as a team, develop a project recommendation and present the team’s findings for review and consideration to the appropriate final decision-making board of authority (Macekura, 2000, p. 68).

In Roger Tomlinson’s book *Thinking About GIS: Geographical Information Systems Planning for Managers* the author recommends a 10-stage methodology. He writes,

What has evolved from years of experience in planning large and small implementations in public- and private-sector companies is a 10-stage GIS planning methodology. The
size and nature of your organization will determine which of the component stages are most relevant to your situation. A full enterprise-wide implementation almost certainly requires all the stages to be undertaken in full while in other cases, it may be possible to complete some stages quickly or even eliminate some stages. It is important, however that you understand all of the stages in the process before adapting the methodology to suit your situation because all situations are unique (Tomlinson, 2003, p. 13).

Tomlinson’s 10-stage implementation methodology is described using the following process.

Stage 1: Consider the strategic purpose
Stage 2: Plan for the planning
Stage 3: Conduct a technology seminar
Stage 4: Describe the information products
Stage 5: Define the system scope
Stage 6: Create a data design
Stage 7: Choose a logical data model
Stage 8: Determine system requirements
Stage 9: Benefit-cost, migration, and risk analysis
Stage 10: Make an implementation plan (p. 13)

PROCEDURES

The purpose of this research is to identify uses of GIS in the fire service and to also choose an effective planning model for the use in implementing a department specific Geographic Information System for the Casper Fire Department. Descriptive research was employed throughout this research project to find answers to three research questions.
This applied research project began with data collection and literature review performed at the National Fire Academy’s Learning Resource Center. Subsequent data collection and literature review was conducted at the Casper College Library in Casper, Wyoming, and through the interlibrary loan process. The City of Casper City Manager’s library was also used to gain specific information for this project. Books, journal articles, reports, and a survey were utilized as the basis for research on this applied research project. The literature review was utilized to research applicable information on all three research questions. Research question one: What is a Geographic Information System? Research question two: How are Geographic Information Systems being utilized by other fire departments and what value has it added? Research question three: How can the Casper Fire Department best implement and effectively utilize GIS?

Additional information was acquired to answer research question one through an interview with the City of Casper’s GIS Manager.

Descriptive research was also utilized in the development, implementation and evaluation of a survey instrument. The survey was designed to further assist this author in gaining more information to answer research questions two and three. A cover letter explaining the purpose and expectations of the survey was developed and attached to the survey instrument. The cover letter and survey instrument are contained in Appendix A and B.

The next step in this applied research project was to identify a list of fire departments that would receive the cover letter and survey. Sixty-two fire departments were identified utilizing a mailing list from the publication entitled 2004 National Directory of Fire Chiefs and EMS Administrators. These 62 fire departments met the following criteria.

1. Fire departments in the United States of America
2. Fire departments that serve populations of 40,000 – 60,000
The above mentioned criteria were used to identify fire departments across the Country that are of similar size to the Casper Fire Department. Survey instruments and associated cover letters were mailed to all 62 fire departments. Twenty-eight surveys were completed and returned within the given time period, 34 surveys were not returned. This represents a 45.1% return rate of completed surveys.

The survey instrument asked the respondents nine questions. Question one sought information on whether the respondent was familiar with GIS. Questions two through six were designed to elicit information on how GIS was being utilized and what value it showed in their respective operations. Question’s seven and eight asked the respondents if they use mobile GIS solutions, and if so, what devices do they use? Question nine elicited results that gave this author answers to what type of conditions or information the respondents monitored or analyzed on a regular basis.

The results of the survey were tabulated and a number and percentage of Yes and No answers were compiled and documented for question one. The results of question two were tabulated and a number and percentage of Yes, No and Unsure answers were compiled and documented. The results of question three were documented in the form of a list of specific answers. The results of question four were tabulated and a number and percentage of Yes and No answers were compiled and documented. The results of question five were tabulated and a number of Yes, No and Unsure answers were compiled and documented. Question five also included a documented list of respondent answers as to why. The results of question six were compiled in a list and documented. The results of question seven were tabulated and a number of Yes and No answers were compiled and documented. Results of question eight were compiled in
a list and documented. Finally, the results of question nine were compiled and documented in a list. The final results of the survey are contained in Appendix C.

Assumptions and Limitations

During the development of the survey instrument an assumption was made that all respondents of the survey understood the meaning of all nine questions posed. Another assumption was made that the Fire Chief or his or her designee would personally answer the survey instrument. This author also made the assumption that the respondent would have enough personal knowledge and expertise to answer each question as accurately as possible.

Some limitations were experienced while developing this applied research project. First, of the 62 surveys sent out, only 28 fire departments returned a completed survey. This accounts for a 45.1% return rate. This limited return rate may affect the legitimacy of the documented results. Secondly, the wording of the survey questions may have confused the respondents. This could have influenced the validity of the responses.

Definition of Terms

The following terms were drawn from the book Beyond Maps GIS and Decision Making in Local Government (O'Looney, 2000).

- **Automated mapping** – ability to translate numerical data relating to facility size and location into a digital map or visual display
- **Geocoding and global positioning systems** – ability to identify a particular location with standard map coordinates
- **Statistical analysis or spatial analysis** – ability to generate statistics, including statistics based on user-defined geographic regions (e.g., compute average income for residents within a certain area) (p. 5)
RESULTS

The results of this applied research project have been compiled from extensive literature review and survey information. The following results are provided to answer each of the three research questions.

Research Question One

What is a Geographic Information System? The literature review on this question found numerous and varying definitions of Geographic Information System (GIS). However, common elements of each definition were obvious during this author’s research. Common themes included the words: software, map, electronic mapping, displaying graphic information, layers of graphic information, computer system, relational data, aids in decision making, manipulating, storing data, used for analysis, interrelated technologies, generates visual maps and reports and relates disparate data. The research on this question has led this author to select the following definition of Geographic Information System. This definition will be identified as the Casper Fire Department’s working definition of GIS.

The term “geographic information system” is applied loosely to a large group of interrelated technologies. For local governments, a GIS is “a computer technology that combines geographic data (the locations of man-made and natural features on the earth’s surface) and other types of information (names, classifications, addresses, and much more) to generate visual maps and reports.” A GIS uses geographic location to relate otherwise disparate data and provides a systematic way to collect and manage location-based information crucial to local government (O'Looney, 2000, p. 5).

Research Question Two

How are Geographic Information Systems being utilized by other fire departments and
what value has it added?

The literature review and survey instrument provided answers to this research question. This author found many different ways that GIS is being applied within fire departments and other government agencies. Research of literature discovered the following ways that GIS is being used in fire departments across North America.

- Geocode individual incidents and displays them on map backgrounds for analysis
- Allows fire and EMS staff to analyze patterns and hotspots on a digital map. This allows staff to allocate resources where they will do the most good.
- Maintains up to date fire hazard data so that fire managers can, in real time, consider the needs and circumstances of the community. This is then applied to pre-planning efforts and incident management.
- Creates response zones for fire stations
- Calculates driving and response times
- Locates apparatus via GPS and dispatches the closest unit to incident
- Determines fastest route, taking into consideration traffic, road closures, road construction and weather conditions
- Assess the need for new fire stations
- Manages and tracks a variety of data critical to operations
- Analyzes flood prone areas
- Maps critical utility infrastructure
- Identifies the location of civilians who have critical medical issues that require the use of special equipment for survival
- Tracks varying incidents in real time during hurricane
• Maps of water distribution systems and static sources
• Maps of road markers
• Maps of schools
• Maps of airports
• Maps of hospitals and medical facilities
• Dispatchers quickly find and map the location of a person calling for help or finding the location of a building or event
• Gives directions of travel to responding emergency crews
• Determines evacuation areas during a man-made or natural disaster
• Estimates and calculates the affects of toxic plumes in a community
• Detailing the location of dykes to prepare for future flooding
• Aids search and rescue teams in life saving efforts
• Analyzes the sources of repeat calls and deploys resources accordingly

The survey results provided sources of information to answer this research question as well. Survey question four asked the respondents if they use GIS in their fire department, 22 responded Yes and six responded No. Survey question five was a two part question. First, it asked the respondent how they use it. The following list represents the actual answers to this question.

• Mapping and wild land fire preparedness
• We have software on the rigs with mapping, which includes not only street mapping but hydrant locations, water mains, sewers etc.
• We have a comprehensive mapping compiled that includes all streets, buildings, hydrants, emergency items that are used in preplanning. This information is used
to plan for situations as well as represent data to the public.

- We use GIS in our strategic services, vegetation management, mapping, fire prevention and operations (command bus and air ops)
- Supply maps to field units plot incident data
- GIS “on-board” mapping, CAD system, “fire view” software (computer modeling for standards of cover program, fire prevention and life safety bureau, hazmat)
- GIS is being used to pre-plan buildings within the City of Toledo. We are also using GIS when completing Incident Action Plans for contingency planning of large events. GIS is being used by FPB in mapping structures by address that are deemed unsafe for entry by firefighters. FPB is responsible for planning water supply and is also using GIS with this project.
- Our dispatch center uses GIS to update CAD live routing and to dispatch closest truck
- Water, streets, engineering, airport
- Engineering planning
- Mapping only. We have MDT that incorporates GIS. Automatic Vehicle Locators (AVL) is proposed.
- It is used for preplanning purposes and for hazardous material incident plotting.
- To map subdivision, roads, wild land fires, rescue land medevac helicopters
- We have all buildings digitized and can access info as needed.
- Hydrant location, mapping, complex info. Water, mains
- On EMS units
- Plotting hydrants, incidents, growth projection and population density
• We can look up owner information but the same information is available in a data base.

• Planning/Short & Long Term. Sending closest resource to calls

The second part of question five asked the respondents if they thought that their GIS was beneficial to their organization, and if so, why? Twenty responded Yes six responded No and two were Unsure. The benefits listed by the respondents are documented below.

• Valuable for accuracy in computer generated maps

• It gives the first responders the information needed to help get to the scene as well as mitigate the incident with good viable information

• We are able to have a visual reference to statistics which are then easier to understand and communicate with the general public

• Pictures (maps, ortho photos) are much more meaningful in describing what’s happening

• We use this tool for data display and query that could not be done in tabular formats. We have integrated call data, land use, historical files such as oil wells and fire history, topography and infrastructure into one system. We can overlay the data and drill down through it to get the answers we need. I use GIS daily in my job as the strategic services chief. We have several advanced modeling programs to determine service needs and solutions.

• It provides up to date, factual data at a moments notice to assist with planning and decision making

• GIS is able to provide data and a visual picture for our planning process

• Streamlines dispatch ops also useful for ID where calls are occurring
• Exact location information, easier record keeping and lots of flexibility on kinds of maps, sizes, etc
• Assists in utility locates, permit issuance and development needs
• Key services include data development and conversion, mapping, data queries, geo-spatial analysis, application development and website support
• Lots of good information easily obtained from one program
• The ability to share information makes everyone’s jobs easier
• We have all buildings digitized and can access information as needed
• Hydrant locations, over head mapping and pre-fire planning is made easier because our GIS is on our network city wide and available for command vehicle
• Locating EMS units in an emergency
• Click of the mouse spatial information for immediate analysis of data. Drill down capabilities for more pertinent information i.e. on a particular hydrant flow, main size, fitting and pressure information attached; on a particular building, pre-fire planning, contact, special hazards can be identified on the map
• It can be useful to find owner and other property information
• Planning/short and long term. Sending closest resource to calls

**Research Question Three**

How can the Casper Fire Department best implement and effectively utilize GIS?

The literature review and survey instrument provided information used to answer this specific research question.
This author’s literature review revealed several different models recommended for use when planning for, and implementing GIS into an organization or agency. However, common principles such as developing the scope, purpose and vision of the proposed GIS were found in literary resources as well. Other similar principles such as team development, development of design, cost/benefit analysis, determining resources, integration into an agencies existing system and identifying an appropriate GIS application emerged as important issues also. These principles have revealed one planning and implementation process that would work best for the Casper Fire Department. This process was authored by Roger Tomlinson (2003). Tomlinson’s considerable experience in planning for GIS reveals a recommended 10 stage methodology for the planning, and ultimately, the implementation of a GIS into an agency or organization. This 10 stage process and model is adaptable to a specific organizations need. Tomlinson highlights this by stating, “…it may be possible to complete some stages quickly or even eliminate some stages” (p. 13). This author recommends a modified use of Tomlinson’s planning model based upon literature review that revealed common principles of methodology and personal knowledge of the Casper Fire Department’s current situation. The following process will be used by the Casper Fire Department in planning for, and ultimately implementing GIS. It will also help identify how the Casper Fire Department will utilize GIS.

Stage 1: Consider the strategic purpose.

Start by considering the strategic purpose of the organization within which the system will be developed. What are its goals, objectives, and mandates?
Stage 2: Plan for the planning

Commitment to the planning process is essential to a successful GIS implementation, especially in municipal government agencies and other bureaucratic public-sector organizations. The project proposal helps to secure the political commitment to the planning process.

Stage 3: Conduct a technology seminar

Once you have approval of your project plan, the in-house GIS planning team can be activated. Defining the specific GIS requirements is the primary task in the planning process. You must meet with your customers or clients (those who will use the system or use the output from the system) to begin gathering specifics about the actual requirements from the user’s perspective. A highly effective method of soliciting input on the needs of your organization is to hold one or more in-house technology seminars. In addition to its information-gathering purpose, the technology seminar is also an ideal opportunity for you to explain to key personnel the nature of GIS, its potential benefits, and the planning process itself. By involving stakeholders at this early stage, you help to ensure participation in the subsequent planning work ahead, so that all participants will appreciate the scope of the planning process. The technology seminar is also the place where initial identification of information products begins.

Stage 4: Describe the information products

Knowing what you want to get out of your GIS is the key to a successful implementation. The “stuff” you get from your GIS can be described in the form of “information products.” This stage must be carefully undertaken. You’ll need to talk to the users about what their job involves and what information they will need to perform their tasks.
Ultimately you need to determine things like how the information products should be made, how frequently, what data is needed to make them, how much error can be tolerated, and the benefits of the new information produced. This stage should result in a document that includes a description of all the information products that can be reasonably foreseen, together with details of the data and functions required to produce these products.

Stage 5: Define the system scope

Once the information products have been described, you can begin to define the scope of the entire system. This involves determining what data to acquire, when it will be needed, and the data volumes that need to be handled.

Stage 6: Choose a logical data model

A logical data model describes those parts of the real world that concern your organization. The database may be simple or complex, but must fit together in a logical manner so that you can easily retrieve the data you need and efficiently carry out the analysis tasks required. You should also consider data accuracy, update requirements, error tolerance, and data standards at this stage, as these issues will affect system design.

Stage 7: Determine system requirements

The system requirements stage is where you examine the system functions and user interface that are needed, along with the interface, communications, hardware, and software requirements. This should be the first time in the planning process that you examine software and hardware products. By reviewing the information product descriptions, you will summarize the functions needed to produce them. Issues of interface design, effective communications (particularly in distributed systems), and
appropriate hardware and software configurations should also be considered during this planning phase.

Stage 8: Benefit-cost, migration, and risk analysis

Following conceptual design, you need to work out the best way to implement the system you have designed. This is where you plan how the system will be taken from the planning stage to actual implementation. You may also need to conduct a benefit-cost analysis to make your business case for the system. Until now, the focus of the planning methodology has been on what you need to put in place to meet your requirements. The focus at this stage switches to how to put the system in place – an acquisition plan. Issues such as institutional interactions, legal matters, existing legacy hardware and software, security, staffing, and training are addressed at this stage. The acquisition plan that results from this stage of the planning process will contain your implementation strategy and benefit-cost analysis. This plan can be used both to secure funding for your system and as a guide for the actual implementation of the system.

Stage 9: Make an implementation plan

The final report equips you with all the information you need to implement a successful GIS. It will become your GIS planning book to help you through the implementation process. Developing the final report should be the result of a process of communication between the GIS team and management, so that no parts of the report come as a surprise to anyone. The report should contain a review of the organization’s strategic business objectives, the information requirements study, details of the conceptual system design, recommendations for implementation, time planning issues, and funding alternatives. (Tomlinson, 2003, pgs. 13-17).
In addition to the literature review, survey questions five through nine provided the following information to aid in answering the balance of this research question. Survey question number five, part two results:

- Valuable for accuracy in computer generated maps
- It gives the first responders the information needed to help get to the scene as well as mitigate the incident with good viable information
- We are able to have a visual reference to statistics which are then easier to understand and communicate with the general public
- Pictures (maps, ortho photos) are much more meaningful in describing what’s happening
- We use this tool for data display and query that could not be done in tabular formats. We have integrated call data, land use, historical files such as oil wells and fire history, topography and infrastructure into one system. We can overlay the data and drilldown through it to get the answers we need. I use GIS daily in my job as the strategic services chief. We have several advanced modeling programs to determine service needs and solutions.
- It provides up to date, factual data at a moments notice to assist with planning and decision making
- GIS is able to provide data and a visual picture for our planning process
- Streamlines dispatch ops also useful for ID where calls are occurring
- Exact location information, easier record keeping and lots of flexibility on kinds of maps, sizes, etc
- Assists in utility locates, permit issuance and development needs
• Key services include data development and conversion, mapping, data queries, geo-spatial analysis, application development and website support
• Lots of good information easily obtained from one program
• The ability to share information makes everyone’s jobs easier
• We have all buildings digitized and can access information as needed
• Hydrant locations, over head mapping and pre-fire planning is made easier because our GIS is on our network city wide and available for command vehicle
• Locating EMS units in an emergency
• Click of the mouse spatial information for immediate analysis of data. Drill down capabilities for more pertinent information i.e. on a particular hydrant flow, main size, fitting and pressure information attached; on a particular building, pre-fire planning, contact, special hazards can be identified on the map
• It can be useful to find owner and other property information
• Planning/short and long term. Sending closest resource to calls

Survey question number six results:
• Right now, only five people are using GIS in the department. We are trying to expand this by placing usable work product in the system for use. For example, we have developed maps for the wild land interface and ISO grading regions and placed them on our intranet for users to view. The next level is to be able to query an address and have it display on the screen along with the ISO rating and interface status.
• We intend to provide GIS information to responding units and command officers in order that they can better mitigate the incident they’re responding to.
• We are exploring using GIS as a surveillance tool in a suspected biological terrorism attack. We have used this capability during one of our tabletop exercises.

• Emergency management & maybe IMS

• Water supply in areas of town, also tracking run data

• Identify target hazards (hospitals, schools, etc), use information on the IC’s computer or other chief officers. Useful information during haz-mat incidents

• I have a very limited on scene access to this info, but we are looking toward fixing this.

• GIS applications serve an integral role in several county departments, including the Appraiser’s Dept, the county treasurer’s dept., the fire dept., 911 the emergency operations center, and the sheriff’s dept. Currently, DIO-GIS is integrating encoding functionality with database administration to provide long-term enhancements to Sedgwick County’s ability to respond to public safety emergencies.

• It would be nice to have onboard computers in apparatus to be used for finding streets and addresses.

• You are limited only by your imagination

• Our goal is to have our dispatch center send a signal to the mobile data terminal and the area building will automatically display

• Giving direction to calls with best route info if I had software and hardware in trucks
• Locating companies at a large incident. Pre-fire plan is essential for immediate analysis of data, drill down capabilities for more pertinent information on a particular hydrant flow, main size, pressure info attached, on a particular building pre-fire plan, contact, special hazards can be identified on the map.

• None at this time

• Future animations, department standards

• Geolocate fire incidents, response times, location of water sources

Survey question number seven results: Ten respondents answered yes and 15 respondents answered No.

Survey question number eight results:

• Hand held for wildland preparedness

• We have a water way in our jurisdiction. We have mapped it out using GIS coordinates. When searching that waterway we can give the device to the search team to help identify areas searched as well as areas to search. This can also be used for ground searches (elderly patients with Alzheimer’s)

• Handheld and Laptop (in Engines)

• We have handheld GPS units in all the command units and the helicopters. Line safety officers and field observer personnel are issued them too. This will allow them to plot locations and perimeters on fires. We also have Pictometry which is a system of aerial photo that are georegistered to the six inch pixel. We can locate points to this level of accuracy and verify them visually (maps are flown every other year) we are just now starting to look at Trembles for use in fire prevention and location such issues hydrants.
• Currently, the BC’s utilize GIS in their vehicles. Within the year, the Department will have a new, geo-centric CAD system with on-board computers in all FD units.

• AVL’S and computers in trucks GIS mapping

• AVL is being proposed

• We use GPS units to find and track locations. We also have an engineering program that builds data bases in order to track specific information such as hydrant location, flow, water main size, capacity and elevation

• Panasonic tough books

• Mounted on EMS units to locate them

• Mobile data computers, dispatching, hazmat, AVL, reporting

• Mobile Data Terminal, response information and data gathering and report writing

Survey question number nine results:

• Location of incidents in relation to previous years. Water supply vs. population density

• Alarm response times. We have a county ordinance that requires we are on scene within 8 minutes

• Weather, traffic conditions, other local departments responses.

• Unsure what this question means

• We are constantly adding to our list of layers. We keep a current streets layer, vegetation, topography, hydrants, fire station locations (our mutual aid) and resources within the stations, land use, and many others. We use Deccan software
to model performance and station locations. We use ESRI ArcView and Network Analyst for station catchment areas and circulation validation. We use MapInfo for building maps and doing GIS queries. We use GeoMedia to move GIS products between our Intergraph system and our other platforms. We use Intergraph for our Ops Mapping.

- Growth in city for future planning of stations.
- Water mains, fire hydrant, streets
- AVL is being proposed.
- Location & status of companies
- Out of service hydrants

**DISCUSSION**

The business of local government is to make decisions in the public interest. And citizens increasingly require these decisions to be based by information showing that the decisions will result in greater efficiency, equity, community viability, or environmental health – the four dimensions of value that ordinarily guide public decision making (O'Looney, 2000, p. 3).

The purpose of this quote is to emphasize the importance of quality decision making in local government. It is important that as administrators of government we strive to always make decisions that are focused on the greater need of the community that we serve. One tool that will help us make sound decisions is GIS. And while this is true in the public sector it is also true in the private sector as well as poor decisions in the private sector could spell the potential loss of profit. “GIS technology is helping people make better decisions…”, says David E. Davis (1999).
Davis goes on to further note how GIS has become a cost savings tool as well. He states, “It’s helping businesses streamline customer service operations, coordinate enterprise wide problem-solving, and revolutionize logistical planning. It’s saved millions of dollars through increased productivity and efficiencies” (p. 2).

To assist the reader of this research project in understanding the meaning of Geographic Information System (GIS) this author researched many different resources that described GIS in many different forms. While various GIS definitions were located one specific definition and explanation emerged as this author’s working definition of GIS. The following definition will be used by the Casper Fire Department during its GIS planning and implementation phase.

The term “geographic information system” is applied loosely to a large group of interrelated technologies. For local governments, a GIS is “a computer technology that combines geographic data (the locations of man-made and natural features on the earth’s surface) and other types of information (names, classifications, addresses, and much more) to generate visual maps and reports.” A GIS uses geographic location to relate otherwise disparate data and provides a systematic way to collect and manage location-based information crucial to local government (O'Looney, 2000, p. 5).

GIS is used within the City of Casper today and has actually been around since 1992. It was originally developed and used by the City’s Metropolitan Planning Organization (MPO). The MPO funded GIS and used it to assist them in local transportation planning efforts. Shortly after being implemented by MPO the Public Services Department began to utilize GIS for traffic and street planning. While Casper’s GIS was originally used in one department it has grown to a city-wide enterprise system serving many other departments. This continuum of GIS in an organization is not uncommon. O’Looney (2000) explains this continuum by writing,
“Responding to the potential of the technology, more and more local governments have moved away from having a GIS in a single department, such as planning, toward a multi-departmental GIS” (p. 29). The chart displayed below graphically explains this continuum.

As more and more departments share in the use of GIS the City Manager is seeing the benefits as well and he has become a champion for its use in all departments within the City. However, the fire department has yet to implement GIS into its daily operations. This is largely due to the staff’s lack of experience, understanding and associated capabilities of GIS. Existing data on fire hydrant location and maintenance information has been entered into the GIS by the Public Services Department. This is the only fire based information in our GIS today. Planning is underway in our Public Safety Communications Center to upgrade our existing Computer Aided Dispatch system. This upgrade will integrate with GIS to provide automatic vehicle locating and
subsequent automatic dispatching of closest units to an incident as well as the graphic display on
digital maps of originating 911 call locations. This new dispatching initiative will create a more
efficient dispatching service. A similar project was implemented in Rapid City, South Dakota
where the emergency services dispatch center is using an integrated real-time GIS tool that
graphically displays locations from which emergency calls originate (Dutton, 1997, p. 66). While
these GIS developments are positive the fire department has not taken full advantage of many
other GIS functions and capabilities. It is this author’s intent to introduce the fire department to
GIS in a simple form and then continue to evolve its application into advanced “What-If
Modeling.” A graphic example of this evolution from simple to advanced GIS applications is
referenced in Appendix D.

As Fire Chief of the City of Casper this author is responsible for the overall
administration and management of our organization. An important element of administration and
management is to ensure that the daily decisions being made by me and staff members are in the
best interest of the public we serve. This includes being cost efficient while at the same time
providing quality service to the community. Sometimes cost efficiency and quality service do not
mix due to the fact that services in many cases get cut because of increasing costs of doing
business. This is one area where GIS can make a positive difference. This author’s research has
shown that the utilization of GIS will aid in better decision making, problem solving, resource
deployment, and service delivery. In turn, this efficient decision making can yield cost savings
over a period of time; as Davis (1999) stated earlier, “It’s saved millions of dollars through
increased productivity and efficiencies” (p. 2).

Another important factor in emergency service delivery is operating efficiency and
effectiveness. How do I as Fire Chief truly understand how efficient and effective our firefighters
are? We have historically collected outcome data that only measures work productivity. It does not measure the efficiency and effectiveness of a work product. In an effort to solve this problem, the Casper Fire Department is currently developing and implementing a benchmarking program that will go a long way in measuring our efficiency and effectiveness. Thinking into the future, with the knowledge of this research, this author can foresee GIS as being a tool that will also help us increase our efficiency and effectiveness in the services that we provide. Research has revealed through survey results that 22 of the 28 respondents use some form of GIS in their fire departments today. Of the 22 who use GIS, many give information on how they use and apply GIS in their respective departments. These results and associated GIS uses are referenced in Appendix C. When asked if they find their GIS to be beneficial, 20 responded Yes and two responded Unsure. The respondents then documented why they thought that GIS was beneficial in their departments. These survey results are documented in Appendix C. It is evident to this author that the overwhelming majority of respondents use GIS and find its application to be very beneficial in providing daily operational and pre-incident planning services.

Another focus of this research is to identify a suitable GIS planning and implementation strategy or methodology for the Casper Fire Department. Results of this research have discovered several different methodologies on how organizations can plan for and implement GIS into their organizations. This author has chosen a methodology that is recommended by GIS planning expert Roger Tomlinson (2003). This methodology encompasses most of the major planning principles put forward by other authors on this subject. The selected planning methodology has been slightly modified by this author to create a planning tool that more accurately fits the current situation of the Casper Fire Department. This author took liberty to modify the methodology based on the following statement from Tomlinson, “…it may be
possible to complete some stages quickly or even eliminate some stages” (p. 13). The planning methodology that the Casper Fire Department will use is listed below. Specific elements of the process are detailed in the Results section and Appendix E of this research project.

Stage 1: Consider the strategic purpose
Stage 2: Plan for the planning
Stage 3: Conduct a technology seminar
Stage 4: Describe the information products
Stage 5: Define the system scope
Stage 6: Choose a logical data model
Stage 7: Determine system requirements
Stage 8: Benefit-cost, migration, and risk analysis
Stage 9: Make an implementation plan (p. 13)

One last element of this research is to identify possible uses of GIS in the Casper Fire Department. Both literary research and survey results have shown a wide variety of possible uses for GIS. It will be important to review these GIS applications during the planning methodology and implementation process. Along with the evaluation of possible uses, it will be extremely important to focus on describing the fire departments own information products. The careful evaluation of information products and data from this project’s survey results will assist the Casper Fire Department in implementing a meaningful GIS tool into the organization.

RECOMMENDATIONS

The following recommendations are based upon the problem and purpose statement of this research project as well as resulting research. As stated early on, the problem for the Casper Fire Department is that while a modern GIS currently exists within the City of Casper, the fire
department and its personnel have limited knowledge and exposure to GIS and its capabilities. This has resulted in a work environment where GIS has been grossly misunderstood and underutilized. The purpose of this research is to identify uses of GIS in the fire service and to also choose an effective planning model that will be used in implementing a department specific Geographic Information System for the Casper Fire Department.

The literature review and survey results have defined what GIS is and how other fire departments are currently using GIS in its daily operations. Research has also identified the benefits of GIS to fire departments across North America. These uses and benefits will be used by the Casper Fire Department during the planning and implementation phase of GIS. Lastly, research assisted this author in identifying a specific planning model that will ensure the successful implementation of GIS into the Casper Fire Department. The said planning model is referenced below and will be proposed to the City of Casper City Manager for approval.

Stage 1: Consider the strategic purpose
Stage 2: Plan for the planning
Stage 3: Conduct a technology seminar
Stage 4: Describe the information products
Stage 5: Define the system scope
Stage 6: Choose a logical data model
Stage 7: Determine system requirements
Stage 8: Benefit-cost, migration, and risk analysis
Stage 9: Make an implementation plan (Tomlinson, 2003, p. 13)

A detailed explanation of the proposed planning model is documented in Appendix E.
A recommendation to future readers of this Applied Research Project is to further research what specific types of hardware and software is being used to access GIS in the office and out on the streets. It would also be interesting to conduct in-depth research into a community or department who was negatively affected by a natural or man-made disaster and find out how their GIS lived up to local expectations.
References


Dutton, B. (1997). Rapid City, South Dakota...Dispatch Aided by GIS. APCO Bulletin, 63(9).


Appendix A
Survey Cover Letter

March 26, 2004

Dear Chief:

My name is Mark Young and I am the Fire Chief in Casper, Wyoming. I am in the process of completing an applied research project in conjunction with the Executive Analysis of Fire Service Operations in Emergency Management course through the National Fire Academy. The subject of my research project is “Geographic Information Systems”. The purpose of this letter and survey is to gather information that will give me some indication of how many fire departments are currently using GIS in their respective departments and how it is being utilized.

I would appreciate it if you would take a few minutes of your time to complete the attached survey. A self addressed, stamped envelope is provided for you to mail the survey back to me. You may also fax the survey to the number on the survey form. Please return the surveys by April 16, 2004

I want to thank you in advance for taking your time to answer the survey. If you would like a copy of the completed applied research project or the results of the survey please include your business card or e-mail me at myoung@cityofcasperwy.com and I will be happy to see that you receive one.

Sincerely,

Mark P. Young
Fire Chief

Enclosure
Appendix B
Survey Instrument

Geographic Information System Survey

1. Are you familiar with Geographic Information Systems (GIS)?
   YES  NO

   If you answered NO, please go to question #9 and complete survey.

2. Excluding your department does your municipality, county or district use GIS in some capacity?
   YES  NO  UNSURE

3. If you answered YES to #2, please describe what departments or agencies are using it within your jurisdiction.

4. Does your fire department utilize GIS?
   YES  NO

5. If you answered YES to #4, please describe how you are using GIS.

5. Part 2. Do you find your GIS to be beneficial?
   YES  NO  UNSURE

   Please describe why?

6. What other ways could your GIS be utilized to provide more meaningful information to you as a Chief Officer?

7. Does your department use any mobile GIS devices?
   YES  NO

8. If you answered YES to #7, please describe what mobile devices you use and how are they used in the field.

9. What conditions or information do you regularly monitor or analyze to do your job?
Please return this survey in the self addressed envelope or faxes it to:

Mark Young, Fire Chief
Casper Fire Department
307-235-8218

I would appreciate it if you could return the survey to me by April 16, 2004.

If you are interested in receiving a copy of my EFO project, please include your business card when returning this survey instrument. You may also e-mail me your request at myoung@cityofcasperwy.com.

Thanks for your time!
Appendix C

Survey Instrument Results

<table>
<thead>
<tr>
<th>Recd Reply</th>
<th>#1 Yes</th>
<th>#1 No</th>
<th>#2 Yes</th>
<th>#2 No</th>
<th>#4 Yes</th>
<th>#4 No</th>
<th>#5 Yes</th>
<th>#5 No</th>
<th>#7 Yes</th>
<th>#7 No</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

| | 28 | 27 | 1 | 24 | 2 | 22 | 6 | 20 | 10 | 15 |

Geographic Information System Survey

1. Are you familiar with Geographic Information Systems (GIS)?
2. Excluding your department does your municipality, county or district use GIS in some capacity?
3. If you answered YES to #2, please describe what departments or agencies are using it within your jurisdiction.

4. Does your fire department utilize GIS?

5. If you answered Yes to #4, please describe how you are using GIS.

5/part two. Do you find your GIS to be beneficial?

6. What other ways could your GIS be utilized to provide more meaningful information to you as a Chief Officer?

7. Does your department use any mobile GIS DEVICES?

8. If you answered YES to #7, please describe what mobile devices you use and how are they used in the field?

9. What conditions or information do you regularly monitor or analyze to do your job?

**Answers Given on Survey**

**3. If you answered YES to #2, Please describe what departments of agencies are using it within your jurisdiction.**

- Water, Streets, Engineering, Airport
- In the process of installing system for water dept., assessors, bldg dept
- City Development for mapping public works for utilities and parcels
- County dispatch for live routing in CAD
- Public Health, Toledo Police, Toledo Fire and Rescue, Lucas County Emergency Management Agency
- PD, GIS, Development & Engineering Services, Public Works, Streets, Revenue & Taxation.
- Redevelopment Authority, neighborhood development, inspectional services (Bldg. Dept.) water & Sewer Authority
- We use GIS in our Strategic services, vegetation management, mapping, fire prevention and operations (command bus and air ops)
- Municipality and County
- Basically all depts... Police, Fire and public works.
- Fire, mass transit, and all of the utilities
- Charleston County uses it for mapping planning etc.
- The county has a fiber optic network that links all state federal and local agencies together so that selected information can be shared at will
- Engineering department
- Sedgwick County Geographic Information Services provides integrated geographic mapping and analysis services and has become the primary provider of GIS data for the Wichita/Sedgwick County region. SCGIS is a service area within the Division of Information and Operations. Some of the key GIS map layers include property parcels, platted lots and blocks, election districts, tax units, city limits, annexations, parks, schools, hydrology, and railroads. In addition to data development, the SCGIS team provides map development services. GIS serves as a major resource to county staff and citizens for data conversion to support data mapping, queries, and geo-spatial analysis
- Mapping for countywide E-911 system, layers of utilities used by engineering
- Community development, zoning, Public works, police, fire
• Public work and fire- Hydrants, water mains, roads
• Police
• Planning and development, engineering public works, Streets and collections
• Building Dept.
• Public works, assessor
• Fire, Water, Irrigation, Planning, CAD, Police, County
• Department of Public Works, Police

(5) If you answered yes to #4, Please describe how you are using GIS.
• Mapping and wild land fire preparedness
• We have software on the rigs with mapping, which includes not only street mapping but hydrant locations, water mains, sewers etc.
• We have a comprehensive mapping compiled that includes all streets, buildings, hydrants, emergency items that are used in preplanning. This information is used to plan for situations as well as represent data to the public.
• We use GIS in our strategic services, vegetation management, mapping, fire prevention and operations (command bus and air ops)
• Supply maps to field units plot incident data
• GIS “on-board” mapping, CAD system, “fire view” software (computer modeling for standards of cover program, fire prevention and life safety bureau, hazmat
• GIS is being used to pre-plan buildings within the City of Toledo. We are also using GIS when completing Incident Action Plans for contingency planning of large events. GIS is being used by FPB in mapping structures by address that are deemed unsafe for entry by firefighters. FPB is responsible for planning water supply and is also using GIS with this project.
• Our dispatch center uses GIS to update CAD live routing and to dispatch closest truck
• Water, streets, engineering, airport
• Engineering planning
• Mapping only. We have MDT that incorporates GIS. Automatic Vehicle Locators (AVL) is proposed.
• It is used for preplanning purposes and for hazardous material incident plotting.
• To map subdivision, roads, wild land fires, rescue land medevac helicopters
• We have all buildings digitized and can access info as needed.
• Hydrant location, mapping, complex info. Water, mains
• On EMS units
• Plotting hydrants, incidents, growth projection and population density
• We can look up owner information but the same information is available in a data base.
• Planning/Short & Long Term. Sending closest resource to calls
(6) What other ways could your GIS be utilized to provide more meaningful information to you as a Chief Officer?

- Right now, only five people are using IS in the department. We are trying to expand this by placing usable work product in the system for use. For example, we have developed maps for the wild land interface and ISO grading regions and placed them on our intranet for users to view. The next level is to be able to query an address and have it display on the screen along with the ISO rating and interface status.
- We intend to provide GIS information to responding units and command officers in order that they can better mitigate the incident they’re responding to.
- We are exploring using GIS as a surveillance tool in a suspected biological terrorism attack. We have used this capability during one of our tabletop exercises.
- Emergency management & maybe IMS
- Water supply in areas of town, also tracking run data
- Identify target hazards (hospitals, schools, etc), Use information on the IC’s computer on other chief officers, useful information during Haz-mat incidents
- I have a very limited on scene access to this info, but we are looking toward fixing this.
- GIS applications serve an integral role in several county departments, including the Appraiser’s Dept, the county treasurer’s dept., the fire dept., 911 the emergency operations center, and the sheriff’s dept. Currently, DIO-GIS is integrating encoding functionality with database administration to provide long-term enhancements to Sedgwick County’s ability to respond to public safety emergencies.
- It would be nice to have onboard computers in apparatus to be used for finding streets and addresses.
- You are limited only by your imagination
- Our goal is to have our dispatch center send a signal to the mobile data terminal and the area building will automatically display
- Giving direction to calls with best route info. If I had software and hardware in trucks
- Locating companies at a large incident
- Pre fire plan is essential for immediate analysis of data, drill down capabilities for more pertinent information on a particular hydrant flow, main size, pressure info attached, on a particular building pre fire plan, contact, special hazards can be identified on the map.
- None at this time
- Future Animations, department standards
- Geolocate fire incidents, response times, location of water sources

(8) If you answered yes to #7, please describe what mobile devices you use and how they are used in the field.

- Hand held for wild land preparedness
• We have a water way in our jurisdiction. We have mapped it out using GIS coordinates. When searching that waterway we can give the device to the search team to help identify areas searched as well as areas to search. This can also be used for ground searches (elderly patients with Alzheimer’s
• Handheld and Laptop (in Engines)
• We have handheld GPS units in all the command units and the helicopters. Line safety officers and field observer’s personnel are issued them too. This will allow them to plot locations and perimeters on fires. We also have Pictometry which is a system of aerial photo that are georegistered to the six inch pixel. We can locate points to this level of accuracy and verify them visually (Maps are flown every other year) we are just now starting to look at Trembles for use in fire prevention and location such issues hydrants.
• Currently, the BC’s utilize GIS in their vehicles. Within the year, the Department will have a new, geo-centric CAD system with on-board computers in all FD units.
• AVL’S and computers in trucks GIS mapping
• AVL is being proposed
• We use GPS units to find and track locations. We also have an engineering program that builds bada bases in order to track specific information such as hydrant location, flow, water main size, capacity and elevation
• Panasonic tough books
• Mounted on EMS units to locate them
• Mobile data computers, dispatching, hazmat, AVL, reporting
• Mobile Data Terminal, response information and data gathering and report writing

(9) What conditions or information do you regularly monitor or analyze to do your job?
• Location of incidents in relation to previous years. Water supply vs. population density
• Alarm response times. We have a county ordinance that requires we are on scene within 8 minutes
• Weather, traffic conditions, other local departments responses.
• Unsure what this question means
• We are constantly adding to our list of layers. We keep a current streets layer, vegetation, topography, hydrants, fire station locations (our mutual aid) and resources within the stations, land use, and many others. We use Deccan software to model performance and station locations. We use ESRI ArcView and Network Analyst for station catchment areas and circulation validation. We use MapInfo for building maps and doing GIS queries. We use GeoMedia to move GIS products between our Intergraph system and our other platforms. We use Intergraph for our Ops Mapping.
• Growth in city for future planning of stations.
• Water mains, fire hydrants, streets
• AVL is being proposed.
• Location & status of companies
• Out of service hydrants
• Response by time of day, week, etc. train hours, vehicle repair down time, the usual
• Personnel records, staffing. Call volume and locations but this analysis can be done without GIS
# Appendix D

## Evolution of GIS Chart

### Simple Questions vs. Complex Questions

<table>
<thead>
<tr>
<th>Location</th>
<th>Condition</th>
<th>Routing</th>
<th>Pattern Modeling</th>
<th>Trend Modeling</th>
<th>What-if Modeling</th>
</tr>
</thead>
<tbody>
<tr>
<td>What is at 123 Broad Street?</td>
<td>What is the condition of the water treatment plant at 270 Fleet?</td>
<td>Which is the best way to send the recycling truck, given these pickup points?</td>
<td>What is the pattern of public spending in areas where the majority of residents are African American?</td>
<td>At this rate, how long will it be before 99 percent of all commercial buildings meet specifications?</td>
<td>What would be the economic impact if development were restricted within 1,000 yards of the river?</td>
</tr>
<tr>
<td>Where are all the fire stations?</td>
<td>Where is housing that has no plumbing?</td>
<td>Which emergency vehicle is closest to the accident?</td>
<td>Do more commercial buildings in earthquake zones meet quakeproofing specifications than five years ago?</td>
<td>What is the best site for the new landfill?</td>
<td></td>
</tr>
</tbody>
</table>

### GIS Data Manipulation Techniques

<table>
<thead>
<tr>
<th>Technique</th>
<th>Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relational database</td>
<td>Database queries</td>
</tr>
<tr>
<td>Graphic display; CAD drawing; referenced photo</td>
<td>Spatial statistical analysis; GPS; areal/distance calculation; network analysis</td>
</tr>
<tr>
<td>Statistical analysis</td>
<td>Statistical analysis</td>
</tr>
<tr>
<td>Space-time attributes modeling; forecasting</td>
<td>Automated modeling; expert systems</td>
</tr>
</tbody>
</table>

### Primary Visualization Techniques

<table>
<thead>
<tr>
<th>Technique</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Points; color-coded locational points; symbols that represent points within a map display</td>
<td>Lines; color-coded lines; lines of different widths representing different flow rates; lines with different attributes (e.g., dotted, dashed, and directional arrows)</td>
</tr>
<tr>
<td>Color-coded locational points; symbols that represent points within a map display; color fading of the points; links between points and other displays such as photographs and drawings</td>
<td>Polygons; shaded and patterned polygons; overlays of semi-transparent polygons; color-coded polygons</td>
</tr>
<tr>
<td>Polygons; shaded and patterned polygons; overlays of semi-transparent polygons; color-coded polygons</td>
<td>Sequenced maps and drawings; animations; progress bars</td>
</tr>
</tbody>
</table>

### Inventory vs. Analysis vs. Planning & Policy


(O’Looney, 2000, p. 7)
Appendix E
GIS Planning Model Recommendation

Stage 1: Consider the strategic purpose.

Start by considering the strategic purpose of the organization within which the system will be developed. What are its goals, objectives, and mandates?

Stage 2: Plan for the planning

Commitment to the planning process is essential to a successful GIS implementation, especially in municipal government agencies and other bureaucratic public-sector organizations. The project proposal helps to secure the political commitment to the planning process.

Stage 3: Conduct a technology seminar

Once you have approval of your project plan, the in-house GIS planning team can be activated. Defining the specific GIS requirements is the primary task in the planning process. You must meet with your customers or clients (those who will use the system or use the output from the system) to begin gathering specifics about the actual requirements from the user’s perspective. A highly effective method of soliciting input on the needs of your organization is to hold one or more in-house technology seminars. In addition to its information-gathering purpose, the technology seminar is also an ideal opportunity for you to explain to key personnel the nature of GIS, its potential benefits, and the planning process itself. By involving stakeholders at this early stage, you help to ensure participation in the subsequent planning work ahead, so that all participants will appreciate the scope of the planning process. The technology seminar is also the place where initial identification of information products begins.
Stage 4: Describe the information products

Knowing what you want to get out of your GIS is the key to a successful implementation. The “stuff” you get from your GIS can be described in the form of “information products.” This stage must be carefully undertaken. You’ll need to talk to the users about what their job involves and what information they will need to perform their tasks. Ultimately you need to determine things like how the information products should be made, how frequently, what data is needed to make them, how much error can be tolerated, and the benefits of the new information produced. This stage should result in a document that includes a description of all the information products that can be reasonably foreseen, together with details of the data and functions required to produce these products.

Stage 5: Define the system scope

Once the information products have been described, you can begin to define the scope of the entire system. This involves determining what data to acquire, when it will be needed, and the data volumes that need to be handled.

Stage 6: Choose a logical data model

A logical data model describes those parts of the real world that concern your organization. The database may be simple or complex, but must fit together in a logical manner so that you can easily retrieve the data you need and efficiently carry out the analysis tasks required. You should also consider data accuracy, update requirements, error tolerance, and data standards at this stage, as these issues will affect system design.
Stage 7: Determine system requirements

The system requirements stage is where you examine the system functions and user interface that are needed, along with the interface, communications, hardware, and software requirements. This should be the first time in the planning process that you examine software and hardware products. By reviewing the information product descriptions, you will summarize the functions needed to produce them. Issues of interface design, effective communications (particularly in distributed systems), and appropriate hardware and software configurations should also be considered during this planning phase.

Stage 8: Benefit-cost, migration, and risk analysis

Following conceptual design, you need to work out the best way to implement the system you have designed. This is where you plan how the system will be taken from the planning stage to actual implementation. You may also need to conduct a benefit-cost analysis to make your business case for the system. Until now, the focus of the planning methodology has been on what you need to put in place to meet your requirements. The focus at this stage switches to how to put the system in place – an acquisition plan. Issues such as institutional interactions, legal matters, existing legacy hardware and software, security, staffing, and training are addressed at this stage. The acquisition plan that results from this stage of the planning process will contain your implementation strategy and benefit-cost analysis. This plan can be used both to secure funding for your system and as a guide for the actual implementation of the system.
Stage 9: Make an implementation plan

The final report equips you with all the information you need to implement a successful GIS. It will become your GIS planning book to help you through the implementation process. Developing the final report should be the result of a process of communication between the GIS team and management, so that no parts of the report come as a surprise to anyone. The report should contain a review of the organization’s strategic business objectives, the information requirements study, details of the conceptual system design, recommendations for implementation, time planning issues, and funding alternatives. (Tomlinson, 2003, pgs. 13-17).