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El Cuerpo de Bomberos

GIS Development in Costa Rica

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Abstract

This report, prepared for El Cuerpo de Bomberos, the fire fighting division of Costa Rica´s Instituto Nacional de Seguros (INS), examines the feasibility of implementing a Geographic Information System (GIS) to assist in organizing, communicating, and analyzing information necessary at the scene of a fire. Through interviews and questionnaires, we studied the need for such a system, determined the information and system requirements, and created an implementation plan for El Cuerpo de Bomberos.

Authorship Page

This report, entitled GIS Implementation in Costa Rica, was written through the equal contributions of Shauna Malone, W. Lucas Churchill, Jimmy Cook and Felix Rieper. All four authors took part in writing and revising all sections of the report.

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Problem Statement:

El Cuerpo de Bomberos, the Costa Rican National Fire Department, has difficulties communicating all the necessary information in a timely manner during an emergency. For this reason, it is necessary to implement an information management system to improve fire response time and information availability.

The problem with communication that El Cuerpo de Bomberos is currently experiencing is not unique to Costa Rica. Fire departments throughout the world face the same difficulties in communicating the information required at the scene of a fire. One method for addressing this problem is the implementation of a Geographic Information System, or GIS. A GIS is a highly visual computer-based system that combines cartographic and demographic data to create a powerful organization and analysis tool. A correctly-implemented GIS gives fire fighters access to pertinent information, such as optimal route recommendations, hydrant locations, and information on hazardous materials, when en route to and at the scene of an emergency.

This project's primary focus was the analysis of El Cuerpo de Bomberos' need for a GIS. Secondary to this analysis, two other areas of study were identified. These areas were the determination of system requirements and the development of an implementation schedule for El Cuerpo de Bomberos.

Prior to determining El Cuerpo de Bomberos' need for a GIS, preliminary research on the benefits of a GIS for fire operations was conducted. This research included an extensive review of pertinent literature, correspondence with a U.S. fire department that recently implemented a GIS, and interviews with GIS specialists and fire operations experts.

To analyze El Cuerpo de Bomberos' need for a GIS, an examination of the current communication, information, and management system was conducted. In addition, the

opinions of fire fighters stationed throughout Costa Rica were collected through interviews and a questionnaire that was distributed to all permanent fire fighters. This area was investigated first because a lack of need for a GIS would eliminate the reason to undergo the determination of system requirements or the development of an implementation plan.

Once it was decided that the implementation of a GIS was the most beneficial step for El Cuerpo de Bomberos, an analysis of the system requirements, both technical and informational, was completed. The determination of system requirements was based on a review of current literature and an analysis of the GIS used by the fire department of Winston-Salem, North Carolina. To determine the information requirements of a GIS for El Cuerpo de Bomberos, the needs of the fire fighters were the primary consideration.

Through further analysis of the information gathered for the first two sections, an implementation schedule was designed. Based heavily upon Winston-Salem's successful implementation of a GIS, the developed schedule encompasses the needs and desires of El Cuerpo de Bomberos.

The analysis of all the collected information culminates in the fact that a GIS is able to solve many of the problems currently faced by El Cuerpo de Bomberos. It can improve communication, data analysis, and information management and availability. For these reasons it was concluded that the implementation of a Geographic Information System is a logical and beneficial step for El Cuerpo de Bomberos.

The current computer systems of El Cuerpo de Bomberos and the computer skills of the fire fighters are not sufficient for the implementation of a GIS. This conclusion was drawn from the analysis of the data showing that the computers currently in use do not meet the GIS system requirements described in our literature review. The findings also showed that 61 percent of the fire fighters in Costa Rica use a computer five or fewer hours per week, if at all.

Without the information critical to the fire fighters at the scene of a fire, as identified in this study, the GIS cannot be used to its fullest potential and the maximum benefits cannot be reaped from the implemented system. Currently, there are few regulations that allow the fire fighters to obtain the necessary information. This led to the conclusion that there is a need for further regulations and for the enforcement of existing ones regarding such topics as hazardous materials and building inspections.

Based on the findings and research of this study ten recommendations were developed for El Cuerpo de Bomberos.

1. *Undergo the implementation of a GIS.*
2. *Begin the implementation of a GIS for fire fighting in the San José metropolitan area.*
3. *Provide basic computer training for all permanent fire fighters.*
4. *Form a team of experts that will manage the nationwide GIS system.*
5. *Collect as much existing data as possible for the necessary data layers.*
6. *Use the fire fighters as a source of information and input regarding specific system needs.*
7. *Use the Winston-Salem Fire Department, a U.S. leader in GIS for fire fighting, as a resource for information regarding system implementation.*
8. *Encourage the development and enforcement of regulations that allow building inspections and the control of hazardous materials.*
9. *Contact CR·USA and other organizations regarding possible funding of the GIS implementation project.*
10. *Strive for a leadership role in GIS applications among the world's fire fighting community.*

CHAPTER 1: INTRODUCTION

Fire fighting has long been a profession of heroic actions and people. Throughout history, fire fighters have saved countless lives, often at the expense of their own. Though the general "put the wet stuff on the red stuff" attitude of fire fighters has changed little with time, the methods and tools used in fighting fires have evolved with society. In modern times, various informational factors have become critical in fighting fires. These factors include knowledge about the inhabitants of the area surrounding the fire, the layout of buildings, the location of hydrants and other sources of water, the best route to the fire, and numerous other considerations. Due to the current difficulty in managing and communicating all of this data, El Cuerpo de Bomberos, the fire fighting division of Costa Rica's Instituto Nacional de Seguros (INS), would like to implement a Geographic Information System (GIS) to aid them in their fire fighting efforts.

A GIS can be extremely expensive to implement and operate because it requires large amounts of constantly evolving digital information. For this reason, it was of great importance for Los Bomberos to determine the necessity of such a system prior to the purchasing of software and hardware. This determination was the original emphasis of our research. Once we determined the necessity of a GIS, our focus shifted to a study of the organization's system requirements. Along with this analysis, an implementation schedule was developed.

A portion of our time was spent familiarizing ourselves with the current data management system used by Los Bomberos so that it could be compared fairly to a GIS. To aid in the study of the need for a GIS, we conducted interviews with fire fighters, engineers and directors of Los Bomberos pertaining to the largest problems fire fighters in Costa Rica currently confront. The information collected from these interviews was used to determine if a GIS could lessen the problems currently afflicting Los Bomberos. Also, we administered a questionnaire to all the permanent fire fighters across the country, which was essential in our determination of whether a system was, in fact, necessary and also what information was most important for Los Bomberos to include in a new system.

We expected that any form of a GIS would be valuable to Los Bomberos. The capabilities of such a system are extensive and would help the fire fighters in many different ways. The lack of available resources, problems with the existing communications infrastructure, limited technology, inadequate technological awareness, and the need for extensive training of the system users were expected to be the major obstacles in the development of such a system. We also expected that the data might show that other problems should take priority over those that would be solved by the implementation of a GIS. If these obstacles proved too difficult to overcome or if we found that there were more acute problems that must be solved first. We were prepared to suggest the postponement of GIS implementation until these obstacles and problems are overcome.

The information that was gathered in this study will be of great assistance to El Cuerpo de Bomberos. The organization will use the recommendations formulated through this study to determine what their next step should be in the implementation of a GIS. The INS and specifically Los Bomberos feel that the purchase of such a system would be beneficial. However, as the implementation of a GIS is such a large endeavor, they plan to use our recommendations to decide if it really is necessary or if other steps need to be taken before a GIS is incorporated into their operations.

While in Costa Rica, we fulfilled the requirements of an Interactive Qualifying Project (IQP) for WPI. To fulfill these requirements, it was necessary that the project examine the link between technological and societal factors. While studying the necessity of a GIS for Los Bomberos, both factors were integrated heavily. A GIS is highly technological, but its usage and implementation depend greatly upon societal factors. Perhaps the greatest societal implications of such a system will be the ability to better fight fires, thereby saving many lives and resources.

CHAPTER 2: LITERATURE REVIEW

Guide to the Literature Review

GIS stands for Geographic Information Systems. The following literature review covers the background on what a GIS is and does, along with the benefits of using a GIS. Criteria for and steps in implementation are discussed, as well as the latest technology in this field. This discussion culminates in an analysis of the use of GIS for fire fighting. The information contained herein will help justify the need for El Cuerpo de Bomberos to implement a GIS.

Geographic Information Systems: Background

As Star (1990: 2-3) explains, a geographic information system (GIS) can be thought of as a high-order map; It is a system for analyzing data referenced by geographical or spatial coordinates. Martin (1996: 1) adds that although the data used for a GIS may not be observed directly, it is geographical in nature and relates to spatial information such as a bus route or patterns of unemployment in a specific town. Star explains that, like maps, a GIS can be designed for a specific need, but more information can be compiled into one GIS than into one map. Because of this feature, most of the original applications were for land resource and utility management; Martin (1996: 3), however, describes the more recent use in census mapping and socioeconomic applications. The full range of possible applications for GIS's is yet unknown.

Star (1990: 3-8) explains that a GIS can be either manual or automated; both types require a collection of data sets. These sets, called data layers or data planes, combine within a single system to form a database. Information in data layers may include administrative, abiotic, biotic, climatic, infrastructural, or other types of data depending on the requirements for the specific application. The types of information within a data set, such as vegetation or water areas, are called themes. Once collected into data sets, the data may be put into manual or automated form for analysis.

A manual GIS uses maps, transparent overlays, aerial and ground photographs, statistical reports and field surveys as data layers. A schematic example of the overlap of information is shown in Figure 1.

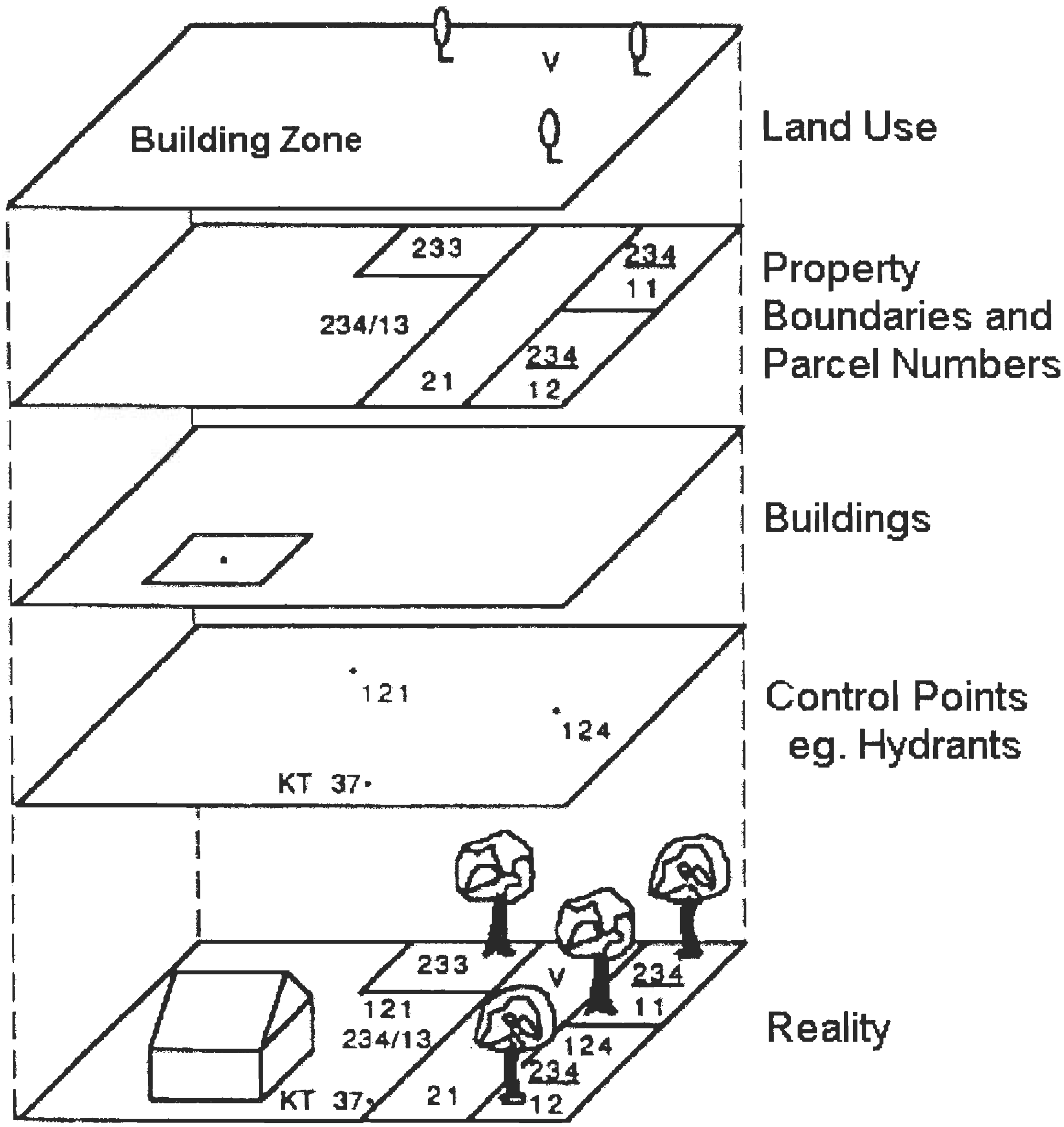


Figure 1. Schematic representation of data layer organization in a GIS
Source: Adapted from Frank, Andrew U. (1993). The Use of Geographical Information System: The User Interface is the System. In Hilary M. Hearnshaw & David Medyckyj-Scott (Eds.), Human Factors in Geographical Information Systems (pp. 3-14). London: Belhaven Press.

GIS Information for data layers may also be obtained using stereo viewers, transfer scopes, and mechanical or electronic planimeters. The most widespread problem with manual systems is that the different layers are usually not in the same scale. In order to accommodate analysis, and in combination with other data manipulation, cartographers redraw the maps to fit over pictures in a process called "registration." With everything properly fitted together, an analyst or planner may use transparent overlays to mark points of interest or add details for their studies. Star (1990: 19-20) explains that this type of analysis and manipulation is more difficult than that done in an automated system.

According to Star, the automated GIS, introduced in the 1960's, came into existence through refinements in cartography and digital computer development and a revolution in spatial analysis. These developments allowed the U.S. and Canadian governments to utilize GIS technology to a greater extent, although commercial use did not begin until the late 1980's. The difficulty with digital systems is that the data, such as maps, must undergo transference from paper to the computer, a potentially time-consuming and costly process. Once this data is in place, however, Star says that it is much easier to manipulate and analyze.

Decision to Adopt GIS

Obermeyer and Pinto (1994: 73) present four steps in the decision to adopt any information system. First, the organization identifies the need for a system such as a GIS. Second, the organization examines its options, taking into account as many alternative methods as possible. Obermeyer and Pinto emphasize this step in the process and recognize that GIS's exist among several types of available automated information systems. The third step is the selection of the method that best suits the needs of the organization. Finally, implementation of the chosen system occurs.

Criteria for Implementation

Schultz and Slevin (1979: 1-15) introduce three primary criteria for the implementation of an innovative system: technical validity, organizational validity, and organizational effectiveness. Technical validity refers to the ability of the system to complete the task at hand and to properly and logically solve the problem. Organizational validity is a measure of the compatibility between the organization and the implemented system. Obermeyer and Pinto (1994: 17) state that the innovation must be accepted by the people who will use it. Schultz and Slevin define organizational effectiveness as an improvement in the organization's decision-making as a result of the adoption of a new system such as a GIS. More specifically, they describe an improvement in productivity, efficiency or environmental effectiveness.

Implementing a System

Schultz, Slevin and Pinto (1987: 37) describe several distinct factors to be taken into account when implementing a system. The organization must contribute clearly-defined goals, sufficient resource allocation, top-management support, implementation schedules, competent technical support, adequate communication channels, feedback capabilities, and responsiveness to clients. They also point out that most of these factors are more managerial than technical in nature. Obermeyer and Pinto (1994: 29) concur, saying that the acceptance and fruition of an innovation are heavily dependent on human issues rather than technical difficulties or concerns.

According to Somers (1998: 24-34), even though a GIS can have a great number of applications and the system can vary greatly depending on each organization's needs, the actual implementation process requires the employment of several basic concepts. GIS implementation includes planning, designing, acquiring, installing, operating, and maintaining the entire system.

Planning

Elliott and Kelly (1992: 1) agree with Somers (1998: 24-34) about the importance of the planning stage in the implementation of a GIS. It is during this first stage, they say, that the background research should be done, surveys should be completed to determine the desired functions among primary users, the goals of the system should be determined, and available resources should be researched. GIS implementation can be very expensive, so it is of great importance to determine financial resources early in development. It is also important to determine the existing available data the system will use. Elliott and Kelly (1992: 1) point out that understanding the available data and how it will enter the system will help to identify issues regarding data accuracy and database content. Nacer (1991: 98) adds to this discussion the importance of determining existing communication infrastructures. Since GIS users constantly require such a great deal of data and information, it is important to uncover how they will retrieve all this data from the database.

Communication

According to Nacer (1991: 98), communication is a very important issue to consider when setting up a GIS. The communications infrastructure is responsible for transferring a great deal of data, and an efficient setup leads to decreased downtime during data transfer. This issue, he says, is especially important in a situation in which remote users will need to access the system. When creating an infrastructure, Nacer says it is of great importance to assess the needs of the remote users, including the regularity of use and the data and processing power required. Existing communication networks require examination and the location of the database must be determined based on needs.

Nacer (1991: 99-102) suggests a variety of communication methods applicable in various settings. For users located within close proximity to the server, a local area network (LAN) is the most efficient method for data transfer. Because current capabilities restrict its range to within a few thousand feet, a LAN is practical only among an individual office or division. Users located outside the range of a LAN require wide area networks, or WAN's. These networks are often significantly less efficient at moving data. A system of this sort can be established by processing data on a central computer. This allows access over a standard phone line, or even through cellular technologies, and thus creates a seemingly boundless range. If the remote users simply require "view-only" service from the system, the infrastructure setup can cost much less. The most important issue to consider when setting up a communication network is the inclusion of the remote users. Including the remote users in the development will help them better understand the capabilities and limitations of the system.

Design

The next step Somers (1998:24-34) illuminates is the actual design of the system. The information gathered in the planning phase, including the system requirements and goals, is applied and integrated into the design of the system. The design stage is also a good point in the development of the system to conduct a cost/benefit analysis and to propose an implementation plan.

Development

After completion of the design stage, Somers (1998:24-34) suggests selecting the software, hardware, and data specifications for the system. The article "Software, Hardware, and Data for New GIS Users" (1999) offers several suggestions.

Software.

It is important to determine what software is used by related organizations that may be able to share the data from the new system. This is beneficial because it allows the experienced users in the community to answer the questions of new users, which can supplement formal training.

Hardware.

According to Meyer (1995), the technical components of a Geographical Information System include a set of server machines to act as information resources, a set of workstations/terminals to provide an interface for the users, a physical communication network to tie these together, protocols to enable the transfer of information, and the software to process and analyze the information.

When selecting hardware it is important to realize that a GIS requires a great deal more power than standard word processing. Computers running GIS operations require a large storage capacity, high speed, and ample video memory to display the images. According to the 1999 article, workstations running a GIS should have: a Windows 95, 98, or NT operating system, at least a 300MHz processor with graphics refresh capability, a minimum of 128Megabytes of RAM, a hard drive with at least 8Gigabytes, an 8Megabytes RAM video card, a large monitor since many windows may be open at the same time, a color printer with at least 300x300 dots per inch resolution, a system to back-up data, and internet access.

Data.

The information contained in a GIS consists of spatial and spatially-related tabular data organized in large databases residing on the server machines. According to the

Environmental Systems Research Institute (ESRI), most organizations use a Data Base Management System (DBMS) to organize, manage, and maintain their data. The most commonly used DBMS's include the Oracle Data Base, Microsoft's SQL server, Informix, and IBM's DB2. Because all of the mentioned DBMS's use different formats in storing geometric data, ESRI has developed a system, called SDE, that handles all the types of spatial data stored in the database. Using this system, it is possible to provide the user with a high level of abstraction (ESRI).

Data should not be used unless details on the data source, including quality and reliability, are available. Data from a government source is often available for a very small fee and is easily assessed for data quality and reliability. Data is also available from commercial sources, but such data can often be expensive and is not always reliable.

Acceptance of GIS Within Organization

Frank (1993: 10-13) lists several obstacles to the best implementation and use of new technologies. He emphasizes that most of these obstacles are not hardware problems, but rather are informational, organizational, and usability issues. They include availability of base technology, data issues, personnel availability, training for use, ease of use, use of intermediaries, and GIS as user interface.

Availability of base technology, according to Frank, is no longer as forbidding an issue as in the past. The hardware and software necessary to implement a GIS are relatively affordable when compared to the cost of training users and collecting data.

Data issues include the collection, storage, and maintenance of large amounts of geographic data. Frank states that the acquisition of data is one of the major costs in setting up a GIS. Digitization of paper maps is becoming more affordable and the conversion of data to digital format is continually becoming less costly than the correction of errors present in current data. Quality control of data is another major issue. Data from different sources will have different formats, spatial attributes, and categorical resolutions.

Personnel availability is a major issue due to the increasing popularity of GIS's. Frank points out that several different experts are necessary to introduce and run a GIS, and the market for GIS specialists is very competitive.

Training to use a GIS is rather costly, not only due to the hiring of training personnel, but also because of productive time lost to training courses and experimentation as the system is learned.

Ease of use of a GIS is a major issue because, as Frank states, most users employ very few of the available functions. Users often limit their use because they either do not know what other functions are available, do not understand how they could be helpful, do not know how they work, or are afraid to use them because they are too complicated. The lack of knowledge of a system's functions often leads to ineffective use of the system and thus costs the organization time and money.

The use of GIS intermediaries causes a lag in efficiency because the organization's application specialists work through a GIS expert to interact with the system. The GIS specialist is often from outside the organization, so communication between the organization and the specialist is slowed by the necessity for both to learn new skills.

The existence of a GIS as both a method for data analysis and user interface causes several widespread interaction problems. According to Frank, because the GIS interface is the only part of the program seen by the user, it *is* the system to the user. As Frank states, the GIS is only as useful as the information users can gain from it. Thus, the usability of the system itself is a major factor in the selection and implementation of a GIS.

Obermeyer and Pinto (1994: 2-3) state that two hindrances to acceptance accompany the introduction of any innovation into an organization: the will and the skill necessary to properly manage the technology. By will, Obermeyer and Pinto mean the desire to find appropriate uses for the GIS and to help others accept and understand the technology. Their research and experience demonstrate that the willingness to invest in an information system and to seek uses for the innovation leads to much more positive perceptions of the technology within the organization.

In addition to the willingness to accept an innovation, Obermeyer and Pinto state that the skill to properly manage the technology is necessary. Successful management requires more than just knowledge of the technology; a GIS manager must master the technical aspects of the system as well as the geographical analysis required for use in a GIS. In stating this, Obermeyer and Pinto present what they claim to be a central thesis to their book: the success or failure of a new technology depends on the success or failure of the management of such a technology. Table 1 lists several GIS project activities versus the success or failure of the GIS project.

Table 1. GIS implementation activity characteristics versus project success or failure

	Characteristics of GIS Projects	
Activity	Success	Failure
Planning	Rigorous	"Run and gun" style
Requirements	Focused	Diffused
Appraisal of effort	Realistic	Unrealistic
Staffing	Dedicated, motivated, high continuity	High turnover
Funding	Adequate	Inadequate, conjectural
Time estimates	Thoughtful	Rushed or prolonged
Expectations	Balanced	Exaggerated

Source: Obermeyer, Nancy J. & Pinto, Jeffrey K. (1994). Managing Geographic Information Systems. New York: The Guilford Press.

Costs and Benefits

According to Obermeyer and Pinto (1994: 93), the costs and benefits of the implementation of a GIS are difficult to assess because they are often immersed in uncertainty. Smith and Tomlinson (1992: 254) explain that the costs of implementation are heavy early in the project. The benefits, however, increase from the beginning and later level off. Obermeyer and Pinto point out that costs and benefits are often over or underestimated at implementation. After using the system for a while, organizations often find new uses for the technology that offer increased benefits and cut costs.

Costs.

Obermeyer and Pinto (1994: 93) explain that the costs of a GIS extend beyond the purchase of hardware and software. The assembly and maintenance of data are, according to Frank (1993: 4), the major costs associated with a GIS. He explains that considerable savings are possible if the data is only collected once, maintained by a single organization, and then shared with other agencies that wish to use the geographic data. Another unexpected cost, according to Obermeyer and Pinto, is the training of staff in the methods and equipment used in a GIS. They describe three major areas of expertise in which GIS users should be knowledgeable: the specific field of implementation, general knowledge of GIS techniques, and a basic understanding of geography and cartography (68).

Benefits.

Obermeyer and Pinto (1994: 18) provide an extensive list of agencies that benefit from the implementation of a GIS. This list includes utilities providers, governmental planning agencies, scientists, and delivery services. They also provide a table of benefits adapted from the writings of W. E. Huxhold and S. Aronoff, as seen in Table 2.

Table 2. Benefits of GIS adoption

Huxhold	Aronoff
Cost reduction	Increased efficiency
Cost avoidance	New nonmarketable services
Increased revenue	New marketable services
	Better decisions
	Intangible benefits

Source: Obermeyer, Nancy J. & Pinto, Jeffrey K. (1994). Managing Geographic Information Systems. New York: The Guilford Press.

According to Huxhold (1991: 244), cost reduction results from increased productivity and efficiency of personnel. He describes cost avoidance as the prevention of future cost increases due to increased workload and workforce. Current employees will be able to do more not only upon implementation, but in the future as well (1991: 246). Finally, Huxhold insists on the possibility of increased revenue due to an improvement in data quality used to apply for grants, the increased efficiency in property tax collections, and the selling of data and maps. However, he warns that the selling of such information depends on the local regulations covering copyrights and the freedom of information (1991: 245).

Aronoff (in Obermeyer and Pinto, 1994: 96) defines increased efficiency and new marketable services in the same way that Huxhold defines cost reduction and increased revenue, respectively. Huxhold (1989: 260-261) describes new nonmarketable resources as previously unavailable useful products and services and warns that many of the benefits of new nonmarketable services will be unforeseen by the organization; thus, the benefits of such are difficult to assess until the GIS has been in use for a while. Better decisions, he posits, will be made due to the presence of more accurate information and more flexible analysis capabilities. Intangible benefits for an organization include better internal communication, improved morale, and an improved public image. Obermeyer and Pinto (1994: 97) explain that, while companies may include intangible benefits in a benefit-cost analysis, it is not possible to put a monetary value on such benefits.

Personnel for Operation and Maintenance

As indicated by Somers (1998:24-34), a GIS is such a large investment for a community or area to undertake that it is very important for users to receive proper training and for the system to receive proper maintenance.

According to Meyer (1995), the most important element, and usually the most costly, in any Geographic Information System are the personnel. The GIS staff must have a clear concept of how the various elements of the GIS work together and how the setting of standards and the elimination of redundancy can pronounce the inherent benefits of operating a GIS.

Antenucci (1991:16) points out that systems continue to fail because of staffing inadequacies. He believes that emphasis should be placed on quality staffing at both the managerial and technical level and that a dedicated, motivated staff working in an environment that provides continuity is essential.

Although individual positions are not dictated for every GIS, there are some standard skills that the implementation of any new system requires. In an article in ArcNews (1989) about implementing a GIS, staffing is categorized in the following manner:

Manager.

The GIS manager is the team leader. This person applies the GIS in order to benefit the organization and to market the technology to elements of the user community where potential benefits exist. The manager coordinates with the user community to make sure the team provides a product that meets the user's needs. The manager also secures funding to ensure an adequate level of support and must be able to develop accurate estimates and schedules for the implementation of each customer's application.

GIS analyst.

This person possesses specific technical knowledge and experience in applying a GIS to solve a user's problems. The analyst has the skills necessary to design and automate a GIS database and to perform analytic GIS procedures.

Database administrator.

The database administrator understands how to best organize the data and how to implement the database in a cost-effective manner. The database administrator manages the data automation and update process.

GIS processor.

This person implements the products defined by the GIS Analyst using technical knowledge of the hardware, software, and databases involved.

Photo interpretation specialist.

The photo interpretation specialist possesses adequate knowledge of mapping and imaging principles to ensure the accuracy of the raster information being input to the system.

Digitizers.

These people digitize and edit maps for input into the system. They may also be required for keying in tabular data.

Cartographer.

The cartographer is responsible for using the GIS to produce high-quality printed maps. The cartographer provides the expertise needed to develop automated procedures for others including standards for symbols, etc.

Computer systems administrator.

This person is responsible for configuring and maintaining the computer systems, including all hardware, software, and supplies. Creating file backups and maintaining network configurations are among the most important responsibilities.

Application developers.

These people create the macro systems for the various user interfaces to the system. The applications software should allow the end users to apply the GIS to their work with limited knowledge of the internal GIS itself.

End user.

The end users are the customers served by the GIS. They all possess detailed knowledge of their specific applications but do not need detailed knowledge about the GIS itself.

Development and Use of a Database

According to Star (1990: 24-27), there are five key elements in the set up and use of a database for any digital geographical information system. These elements are data acquisition, preprocessing, data management, manipulation and analysis. Data acquisition is the process of gathering data for the data layers. This data may include maps, pictures, surveys, and data found in archives. Star points out that this process is very important because the accuracy of a GIS is limited in accuracy by the data sets it holds. Preprocessing is the act of manipulating the data for entrance into the GIS. During this process, a consistent system of recording and specifying the location of objects in the data sets requires establishment; this step can be costly. Data management is the setup of a system of data entry, update, deletion, and retrieval. It is necessary, Star says, for users to adhere to the set system for a GIS to run well. The manipulation and analysis portion of a system contains the analytic operators that use the given data to derive new information. Product generation is the final output of the system and can consist of statistics, maps, or graphics.

Data Acquisition

Star (1990: 61-67) further explains that because a GIS must be able to accept a wide range of types and formats of data, data acquisition is one of the greatest problems and costs in setting up a GIS. The data acquisition process requires the gathering of two basic types of information. Graphic and tabular forms of data, such as maps, photographs, and records from specialists who visited the site in question, are gathered along with digital forms, such as computer records of demographics, ownership and topography. Within these forms exist different classes of data. Point data includes things that occur in one place, such as wells, buildings, and addresses. Networks are lines connected together, such as roadways, waterways, railroads, and communication lines. There is also continuous field data, such as elevation, biomass, and population density, and earth division, such as country and state lines. All these types of data compose the database. Often this data requires pre-processing prior to entering it into the system.

According to Star, it is also important to find information about the data contained in the data sets. Accuracy, precision, currency, scale, resolution, and spatial characteristics are all important factors to note. Date, criteria, and source should also be recorded within the GIS so that a user who needs the most current information will know which data sets to look at. All of this is costly and time-consuming. If spatial data is available in digital form already, the cost drops dramatically. Star claims there is a sizable amount of spatial data, collected and stored by government agencies, which can be accessed and used for a GIS. The most common form of spatial data is a map. A digitizing process allows one to extract information from a flat map and put it on a computer. Because maps are so common, they can often be found already in digitized form.

Remote sensing imagery is often used in GIS applications, explains Star. Satellite images can be obtained from such companies as Eosat and SPOT Image Corp. This type of data is very useful in the creation of the fire hazard maps mentioned in the fire and GIS section. Star states that aerial photographs also make good data layers, but visual perspective often poses a problem. Orthomaps, or aerial photographs combined with maps, eliminate this problem by taking perspective into account. Martin (1996: 73) adds that there are many accessible sources of socioeconomic data, such as census reports and postal code data. One can also create an original data set by performing research in the area of interest. With all of these options available, he believes that it is possible to find the proper data for any GIS application. However, he cautions that all of these different sources often make it difficult to link the data directly by location. Nevertheless, Star states that under proper management and with proper manipulation, all the sources will fit together nicely to create an appropriate database.

Preprocessing

All the information acquired during the data acquisition process must eventually fit together to make one database. When data is acquired, it is not all in the same format. The process that manipulates this data so it can be used together is called preprocessing. According to Star (1990: 76-118), essential procedures in preprocessing include format conversion, data reduction and generalization, error detection and editing, edge matching, rectification and registration, interpolation, and photointerpretation. Each of these methods is important in assuring the data can be used together. Star (1990: 77-188) explains what each method is. Format conversion is used to either modify one digital data type into another, or to convert data on paper to digital data. As the name implies, this process insures that all the data is in the appropriate format. Data reduction and generalization is used to change the scale of each data set. When more detail is available than needed, data reduction is used to determine the correct amount of detail to include in the system. When data is manipulated as stated above, certain errors may occur. A system must learn to identify certain boundary configurations that software does not always understand, and may be perceived as errors. Overlapping edges of shapes, as well as gaps between shapes must be able to be identified. The process that takes care of all this is error detection and editing. A common problem when paper maps are scanned into digital form is that often the maps are scanned in sections. The edges may not line up properly, and thus edge matching must be performed to make the sections of map a whole. In order for the user to study data as a single set, all the data needs to have a common coordinate system. Rectification manipulates data to correspond with a coordinate system. Registration changes the views of pictures so that they can fit together with maps with a coordinate system. There is not always data to fit every coordinate. When there is not, values must be interpolated by looking at given measurements. Finally, photo images must be analyzed in a process called photo interpretation. Size, shape, texture, shadow, and pattern can be analyzed to extract necessary data from a picture. All these processes form the data sets into a useful set.

Data Management

The database management system is software that allows more than one user to work with the data efficiently. According to Star (1990: 128), the database management system should include commands which allow a user to change, delete, or add data, as well as define or ask about the contents of the database. Information about the data is stored in a data dictionary, and includes such information as a definition of the data format and contexts, as well as value restrictions. In addition to information about the data, Star (1998:129) claims a database management system should provide some key functions, such as security, integrity, synchronization, minimization of redundancy, and physical data independence. Star (1998:130), also notes that efficiency must also be taken into account.

Data Manipulation and Analysis

Manipulation and analysis, according to Star (1998: 143) can often overlap, and will therefore be discussed in the same section. These are the operations which allow the user to move and change the data in order to come to a conclusion. Star (1998: 144) lists these operations as reclassification and aggregation, geometric operations, centroid determination, data structure conversion, spatial operations, measurements, statistical analysis, and modeling. These operations allow the user to overlap data layers, assure that they work together, and perform mathematical tests on the data to come to conclusions.

Shared Systems for a Government Organization

As Martin (1996:188) explains, one of the basic requirements for a good GIS is a good database with a variety of spatially referenced data. The difficulty with system use usually lies in the retrieval of this data. One solution to this problem is the creation of one large GIS for use by many agencies, along with the combination of the information these agencies already possess. Figure 2 represents such a shared system, and a more detailed table showing what agencies use what information is available in Appendix B.

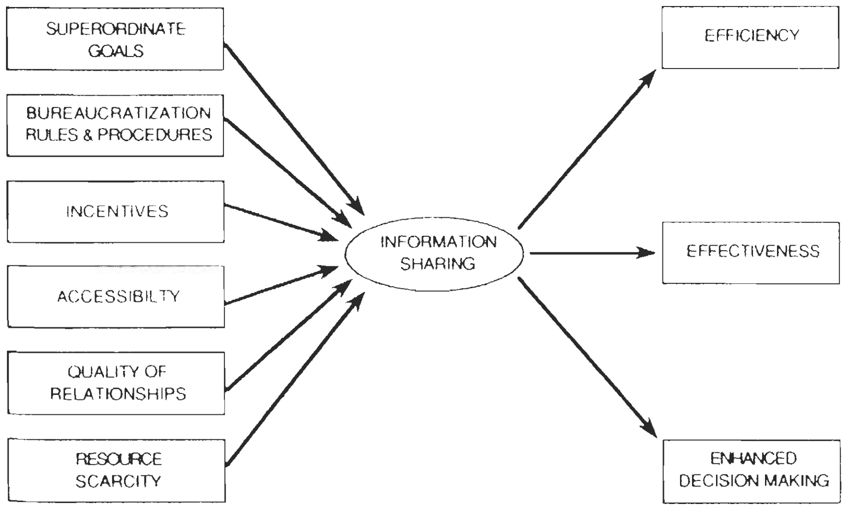


Figure 2. Pre- and post-information sharing characteristics
Source: Obermeyer, Nancy J. & Pinto, Jeffrey K. (1994). Managing Geographic Information Systems. New York: The Guilford Press.

Martin (1996: 91) points out that, since GIS's have such a widespread use, appropriate planning often creates a system that many branches of a municipality can utilize. For instance, census information is useful in determining such statistics as population spread, demographics, and unemployment. Fisch (1991: 8) offers several other possible uses for a GIS within a governmental infrastructure. Assessors' offices can use the information for their reassessments. School departments can use the information for the planning of bus routes and for the configurations of districts. Public work crews may implement a GIS to make their jobs safer and easier because they can repair roads without the fear of cutting through a buried electrical line. Police and fire departments can also apply the system so that they may respond more quickly to emergencies.

The model for a local government GIS, according to Somers, (1998: 24-29), is a multipurpose system with a central database of large-scale maps and links to other spatially-based data. This model supports a large range of data and applications but, Somers adds, can be very costly and time-consuming to implement. She continues, saying first that the planning of the project and the development of a vision are necessary. This vision, created by a development team, says Somers, should incorporate future use, what the system will be, and how it will take shape. Then a requirement analysis is necessary, which looks at the details needed to fulfill the goals determined, including data requirements, resources, opportunities, and constraints. After the determination of all the details comes the design of the system, database, applications, and organizational components. Somers believes that a cost/benefit analysis and a component implementation plan should be developed. The next step is the acquisition and installation of the software, hardware and data. Finally, the GIS requires integration into the operating environment, an approach that can cost millions of dollars.

While Somers suggests the development team approach, Ammerman (1998:12) suggests a "turnkey" approach. According to Ammerman (1998:12), the typical development team that implements the GIS usually has other jobs, and thus the GIS may take seven to ten years to implement. Just becoming acquainted with GIS can take the team a year in itself. The turnkey approach suggests hiring full service contractors who work full-time to plan the GIS. Ammerman (1998:1) suggests hiring contractors whose expertise is in identifying and securing outside funding in such areas as wetlands, water and air quality, accident investigation, traffic control, and economic development. Ammerman (1998:12) states that the return on a GIS investment is usually $2.50 for every $1 spent. In the turnkey approach, that return can be made more quickly because the job will be done sooner.

No matter which planning approach is used, Somers (1998: 27) claims, if a government examines closely what it really needs, low-cost, high priority systems are possible, as most local governments do not require high accuracy data and complex software to accomplish their goals. Low-cost offerings for data such as satellite imagery and street networks are available, as is powerful software for desktop systems. Many local systems have been most successful when started quietly with few funds.

No matter how broad the application, Somers (1998: 27-28) emphasizes that management is the key to a good system. This includes a good cost/benefit and risk assessment during the first stages of development. For a government system, one of the greatest benefits is the sharing of databases, facilities and skills by the multiple users. This can also, however, create a very complex environment, according to Somers (1998: 28). Many government systems use a team approach to coordinate user activity and establish uniformity. In this approach, a technical team provides information and guidelines on development and operations, while an executive committee provides policy guidelines.

Somers emphasizes that, in any approach, communication is of utmost importance. Uniform education and training should be provided and all users should be kept updated regarding changes to the system. Leadership is also important. Someone must be able to provide influence at a policy level and to manage the GIS implementation and operation. Often, this calls for more than one leader.

According to Somers, regardless of the number of leaders, management and control should be centralized in order to coordinate participants' needs and activities, data management, system support, database development, staff coordination, training, and user support. Staff is particularly important, as most GIS managers consider skilled personnel as part of their reason for success. Utilizing standardized procedures and well-managed systems, a shared GIS can be extremely useful.

Relevant Technologies

Unless otherwise noted, all information related to relevant technologies is taken from Antenucci (1991:10-12). He mentions a number of fields and related technologies, including computer science, information management, cartography, geodesy, photogrammetry, and data communications, that influence, shape, and contribute to geographic information technology. All of the mentioned technologies, he says, should undergo close observation since any advance in those technologies will most likely be incorporated in geographic information technology.

Computer Science

According to Antenucci, computer science provides the technology for data capture, manipulation, storage, and output. As such, computer science encompasses hardware, machine processing capabilities, software development, and computer programming languages. In the last decade this technology has progressed quickly and has become more suited to the specific needs of GIS. Some of the achievements made in computer science include significant increases in processing power accompanied by a reduction in processing cost, as well as a substantial improvement in the field of graphical processing. Moreover, greater performance results from improvements such as faster and higher-capacity storage media, higher-level query and programming, and the incorporation of standards in operating systems and data communication.

Information Management

Information Management identifies and codes the logical and mathematical relationships that govern the processes used to associate and manipulate data. Due to significant improvements in this area, organizations are able to maintain large databases because designs for both graphic and non-graphic databases are more sophisticated, making access to large volumes of data easier, faster, and less expensive.

Cartography

Antenucci defines cartography as the science of making maps. It has contributed to GIS the general conventions used to produce map products. These general standards include accuracy and precision, map projection and coordinate referencing schemes, and the graphic appearance of the map through symbols, line work and annotation. These cartographic conventions, as they have developed over time, continue to guide the construction of the graphic data elements within a GIS database.

Geodesy, Photogrammetry and Surveying

According to Antenucci, geodesy is a branch of applied mathematics that observes and measures the size and shape of the earth or a large part of its surface, and determines the exact location of points on its surface. Geodesy provides a framework for large-area databases.

He claims that surveying, a related field, is useful in defining the extent of land features in small and large area databases. It provides techniques for determining the area of any portion of the earth's surface, the length and directions of the bounding lines, the contour of the surface, and accurate delineation of the whole on paper.

Photogrammetry is the science of making reliable measurements through the use of photographs (mostly aerial) in surveying and map-making. It is frequently used to establish a foundation for other spatial data.

The Global Positioning System (GPS) supports geodesy, surveying and photogrammetric mapping. GPS simultaneously records the positions of multiple satellites with multiple sensors and then computes locational information for each sensor. Locating or moving the sensors throughout an area can establish a network of geographic coordinates. The acquired data can then be used as input to the three above schemes.

Remote Sensing

Remote sensing is the analysis and interpretation of images gathered through techniques that do not require direct contact with the subject. Antenucci explains that remote sensing uses aerial or space photographs, electronic scanners, and other devices to collect data about the earth's surface or subsurface. In the last two decades, remote sensing has increasingly made use of digital techniques for collecting and processing spatial data. Remote sensing products have provided important input to GIS.

Data Communications

According to Antenucci, data communication and networking have expanded the flexibility and processing power of computer technology by using distributed computer systems to divide the workload of one specific process among many computers. The development of more sophisticated network and communication protocols accommodates the reliable and efficient transfer of large volumes of data and also provides a high level of error recovery and security.

Software Applications

According to ESRI (2000), the advantages a GIS can bring to an organization have resulted in a tremendous need for software. The increase of GIS utilization in various industries has triggered the development of many GIS applications.

ArcView

According to the Environmental Systems Research Institute (2000), or ESRI, ArcView GIS is a powerful mapping software that supports a variety of features including GIS analysis and map presentation. Its group of users ranges from small utility companies to county and city governments. Applicable to a very diverse set of problems, ArcView handles the management of local zoning and land use, property tax assessments, tracking and analysis of crime, medical and fire incidents and many more.

ArcView enables the user to visualize categories of information, which are stored in a database, on a digital map. Built-in SQL, a database query language, provides for client/server database access that enables the user to add data residing almost anywhere in the organization to maps and analytic computations. The integration and linkage of multimedia or Internet data to a map is also supported.

ESRI further mentions ArcView's environment for data capture and editing. A geocoding feature is capable of automatically plotting street addresses and other address data on a map. It can match to any level of geography from country down to a single street address. ArcView also incorporates powerful tools for data queries and spatial data analysis, including the possibility of user-defined procedures for data analysis.

ArcView features an extensible software architecture that delivers a scalable platform for GIS computing. The architecture works as a series of plug-in modules that can be mixed and matched to significantly extend the capabilities of ArcView GIS. ArcView also provides a specialized object-oriented scripting language allowing the user to create customized applications in the ArcView environment. An example of an application derived from ArcView GIS includes the Omega Group's software FireView.

FireView

The Omega Group, an independent software company, released an application called FireView, a software package developed for fire and emergency response agencies, in January of 2000. According to the Omega Group (2000), FireView was developed in the ESRI's ArcView environment, which enables it to integrate fire and emergency response data with a GIS.

FireView displays data gathered from everyday operations on a digital map. It supports various types of data analysis, such as incident analysis, station location coverage analysis, and inspection tracking.

Incident Analysis includes an evaluation of when, where and how often incidents occur. Specific incidents can be displayed in predefined zones, like dispatch areas, demand zones, or the entire jurisdiction.

Station location coverage analysis allows the user to define the number of minutes a location is from the station and geographically display the response coverage over the street network. This type of analysis helps to identify areas where coverage should be improved.

Inspection tracking is used to determine the status of inspections, inspection deficiencies and where inspections have been completed. Incident data can also be compared with demographic information to help develop mitigation, staffing, education, and enforcement plans.

GIS in Fire Protection

GIS is already in use for purposes of fire protection. According to Smith (1998: 31), the United States Geographical Survey implemented a GIS within the past five years that combined road network maps and earth science information to determine the effect of an earthquake on fire and rescue squad response time in Salt Lake City, Utah. The government plotted the location of their fire departments on the road network, and used GIS analysis tools to calculate the amount of time needed for emergency vehicles to get from the department to the emergency area after extensive road damage. Space imagery is now being used to make fire hazard maps (Somers, 1998: 30). The high resolution, near infrared imagery helps the forest service identify vegetation types and determine areas at greatest risk of fire. After a fire occurs, these same types of images can be used to determine what areas need to take priority in order to prevent erosion.

Fire Simulation

According to Ross (1999:34), fire fighters in Nevada's Lake Tahoe Basin use a GIS to simulate fire scenarios and develop methods for fighting those fires. The system is able to simulate conditions that might be present in an actual fire including wind and other forms of weather, available fuel, elevation, and the local effort necessary to control the fire. Data included from previous fires helps the program to simulate and the users to understand possible fire behavior. The simulation program, FARSITE, is supported by ESRI's Arcview/Spatial Analyst GIS platform. The system is also capable of designing trails and roads that will allow fire fighters to access possible burn spots. It is true that this system is very helpful for planning methods of combating fires, but perhaps its largest and originally unexpected benefit is in the area of education. Karl Krauter describes the program as very graphic and as a good tool for simulation. Wildlife sightings can also be recorded in the system in order to increase public awareness of the wildlife that the fire fighters are protecting.

FARSITE

According to Bevins (September 1997), FARSITE is used to simulate wildfires and their behavior. It can also be very useful in predicting the paths of active fires. FARSITE simulates terrain, fuel, and weather conditions. The software can be supported by either Arc Info or Arc View, and requires data about terrain, fuel, and canopy.

Bevins (September 1997), suggests operating FARSITE requires expertise in prediction of fire behavior. There is also a 36-hour training session that must be attended for those who plan to use the system.

Case Studies in GIS for Fire Operations

The information for this case study was taken from the following site:
http://www.ci.winston-salem.nc.us/fire/infoproj/

According to Lesser (1999:28-29), the City of Winston-Salem, North Carolina established a GIS that allows the town's fire fighters to improve their efficiency and fire response time. Partially funded by a TIIAP grant from the U.S. Department of Commerce (see Appendix D), the system, known as Integrated Network Fire Operations (INFO), interconnects seventeen fire stations serving a population of nearly 171,000. It provides the fire fighters with critical information in geographical and demographical form by communicating it directly to the responding fire trucks. The city has built a detailed street-map data layer, called a centerline network, utilizing Global Positioning Satellite technology to provide the routing framework.

Using this centerline network and the location of the fire, the system is able to determine the best route to the site of the fire. Other vital information transmitted to the responding fire trucks includes location of hydrants, hazardous material, schools, railroads, and streams. With this system, the fire fighters are also able to retrieve floor plans, diagrams, and information about the occupants, which improves decisions made during an emergency. With this information, as well as other data determined through pre-fire surveys, the firefighters are able to plan for every unique problem, such as physically challenged occupants or hazardous material storerooms.

The system also makes it possible to divide the area of coverage into different zones, called Fire Demand Zones (FDZ). This process makes it easier to distribute responsibilities between fire stations, depending on how many trucks are available and what areas can be covered best by a fire station. By collecting data about response times, area of incidents, and other important information, the system is able to develop statistics that help the entire fire-fighting community by determining if their resources are being utilized properly.

The city maintains a GIS environment utilizing ESRI's ArcInfo and ArcView software. All data, which is organized in different informational layers developed by the Winston-Salem fire department, is stored on the several SUN Solaris GIS servers. The data is updated by individual fire stations, each of which keeps a record of inspections and other information gathered in their area of responsibility. Each fire station is equipped with a PC to support image creation, office automation, and online access to the Internet through an existing T1 link. Every PC is connected to the City's fiber-based FDDI network through ISDN circuits.

The fire trucks are equipped with a mobile data computer, MDC, running GIS and imaging software. This software is able to communicate with the base GIS system via radio. Since it is too slow a process to communicate geographic data via radio, all geographic data is stored on a monthly-updated CD-ROMs that are loaded onto the MDC's harddrive. To recieve current updates of traffic and other information such as location of hydrants and hazardous material, Computer Aided Dispatch information is passed via radio to the GIS routing application residing on the MDC's. This gives the fire fighters rapid access to very critical information during an emergency response.

When an emergency call comes in, the City's E911 Computer-Aided-Dispatch (CAD) mainframe system identifies the closest available fire vehicle for the incident type and location. Then, emergency dispatch information, including location of the emergency and details on the type of incident, is transferred via radio to all vehicles responding to the fire. The option of viewing a map defining the optimal route is immediately available for each vehicle. On this map, the capability exists to indicate the occurrence of a constraint such as a downed tree or power line and then to generate an alternate route. The fire fighter is also able to focus the map on the emergency location and identify all available fire hydrants and their capacities. Any known hazardous material in the area is listed. Upon selection of the actual emergency location, any additional information on the property is indicated. Specific information, such as floor plans or water and gas lines can be selected through a link to an imaging component. In case of an extensive emergency, additional information is available on the surrounding areas. Analysis can be done to assist with decisions regarding evacuation areas.

Implementation of the Winston-Salem system began in 1995, and was completed in December, 1998. While currently the system is working well, there were many obstacles to overcome during the four year implementation process. Five steps were taken in setting up the system, including the installation of ISDN network connections, the reworking of the communications network, the creation of the data layers, the standardization of pre-fire surveys, and the purchase of rugged mobile computing equipment.

Implementation began with the installation of ISDN network connections at each of the seventeen fire stations, linking them to the existing metropolitan area network. Each station then received a PC and printer. That step, which allowed the stations to communicate with one another while giving the fire fighters access to the Internet, was completed in April, 1996 after numerous problems were overcome. The original configuration of the routers was not one supported by the local phone company, which caused intermittent problems. It took six months to track down the actual cause of these problems. There were also issues with lightning, signal interference, switch maintenance, and training.

According to Lesser, there were a number of precautions that could have been taken to lessen the problems. He suggests that anyone else who sets up a system aquires a good technical team with experience in network protocols and routing. Careful research of all equipment, including all options and features, can also be extremely important, according to Lesser. He recommends consulting the telephone company before purchasing this equipment, to be sure that it will be supported, and negotiating with them to be sure all maintenance of the lines and equipment will be done by a technician who has expertise in ISDN. He also recomends keeping a log of all problems to help find the causes of these problems more quickly.

The second step in the GIS implementation process was the reworking of the communications network. As explained above, Winston-Salem already had a mobile data communications system (MDCS) with three subsystems: a central site, radio remote site, and mobile unit. Central to the system were two 800 MHz radio channels, the city-developed computer-aided dispatch system (CAD), and mobile computer equipment supplied by ElectroCom Communication Systems L.P. There was a central site located at the Public Safety Communications Center, where information from 911 calls was entered into the CAD system. The call was then routed to the fire dispatcher and all information was provided to the dispatcher by the CAD system.

The CAD system was developed by the city and integrated with the E911 system. It allowed maintenance of all data pertaining to fire emergencies. The system would check apparatus availability and make the first alarm. The ElectroCom message switch was also located at the central site. This switch was used to log all mobile data transactions and to route messages to the radio system. Messages were sent to the mobile units over one of the two 800 MHz radio channels. These mobile units were located in each of the fire engines. The mobile computers mentioned below would replace the terminals included in these units in order to run the GIS system in the trucks.

No changes needed to be made to the communications infrastructure. ElectroCom was contracted to enhance the then newly-released Win MDT interface with a routing application written by ESRI. The main problem was negotiations with the company; again Lesser found that certain realizations would have made this step easier. For example, he found that when working with software companies, the GIS implementee has to drive the negotiations. For this reason it is important that a person implementing a GIS knows what to look for and is familiar with recognized industry standards. Also, he found it is customary to make an initial payment of no more than 50 percent of the total cost to the company before they will begin working. Finally, as software takes time to develop, Lesser recommends that some time delays be expected. He claims that e-mail can be a wonderful tool to receive updates as quickly as they are made.

The third step in implementation was the creation of the actual GIS data layers. For the Winston-Salem system, these included a Centerline street network, fire demand zones, fire station locations, hazardous material locations, hydrant locations, hydrography network, multiple address locations, physically challenged locations, pre-fire survey locations, railway network, and school location layers. Once these were created, they were to be constantly updated as changes were made to the city. This process had the fewest major problems because the original layers were all at least 90 percent correct. Mostly the digitization of the data forced the fire departments to examine their territory more closely, as the most common problem came from overlaps in addresses of different points, such as hydrant locations, which cannot be matched to exact street addresses.

Like many other fire stations, stations in the city of Winston-Salem complete pre-fire surveys, which include a basic sketch of the building in question, along with detailed information on hazardous materials in the area. These documents are stored in a three-ring binder kept in the trucks and are completed for any building with features that may warrant a change in fire fighting procedure, such as hazardous waste or physically handicapped occupants.

There had always been problems with this system because each engine only had the pre-fire surveys for its own area, and if it needed to cover another area the firefighters in the truck had no access to the necessary information. Also, the drawings varied greatly from one station to another, making them difficult for an outsider to understand. Winston-Salem decided as their fourth step they would standardize these drawings in a Computer Aided design program and distribute them to the stations via CD-ROM. This idea also had its problems. The use of color-coding to show the locations of hazardous materials made the documents bigger. In order to distribute all 1400+ pre-fire surveys to all the stations, each station would need eleven CD's, making the location of information just as complicated as it had been with the old system. It was also difficult to standardize the currently varied methods of drawing the pre-fire surveys. Winston-Salem feels that they should have first examined their method of organization and then used it to exploit technology rather than trying to automate a faulty system. Lesser also stresses that in all steps of implementation, details are very important.

The final step in the Winston-Salem GIS implementation process was the purchase of the rugged mobile computing equipment with which each engine was to be equipped, and on which the INFO application would run. It was necessary that these machines be able to withstand the changes in temperature, vibrations, and dust that they would face in the fire engines. The fire department tested six different mobile computers before coming to their final decision. The main problem faced in this step was the lack of suitable units to test that had all the desired options.

In deciding on the best equipment, Winston-Salem suggests that a group start their search early so that adequate time is available to evaluate different units. They suggest that evaluations are completed by actually taking the computers in the trucks and seeing the pros and cons of each machine. Lesser also suggests using the vendors as much as possible. If a group explains to each company exactly what their project is, the vendors may be able to help find alternatives.

More information on this system is available at **http://www.ci.winston-salem.nc.us/fire/infoproj/.** That site discusses the successes of the established system.

Surveying

According to Priscalla Salant and Don A. Dillman (1994: 2), surveys are one of the most useful and powerful tools for both public and private organizations that need to know the characteristics and opinions of people they serve. They are often the only means of finding what percentages of people have a particular characteristic of interest.

Salant and Dillman (1994 35-37) differentiate among four distinct methods of surveying. The first method of surveying is the mail survey, which is sent out to a selected group of people, completed, and eventually mailed back by the respondents. Mail surveys require the least resources because it only takes a few people to conduct them. In addition, mail surveys are one of the easier for people who have no experience and no professional help to do, according to Salant and Dillman. Although the design phase may take a long time, there is relatively little to do once the survey has started. Another advantage of mail surveys is that they allow one to minimize sampling error at relatively low cost. It requires little effort to send out and process additional surveys. Mail surveys are also less sensitive to biases introduced by interviewers as well as the bias that results from the tendency for responders to give answers they think the interviewer wants to hear. A major weakness of a mail survey is that some people are less likely to respond to the questionnaire than others, which can result in a high non-response error. It is also very difficult for researchers to control what happens to the questionnaire after it is mailed. For example, questions might be answered in the wrong way or not answered at all. Salant and Dillman conclude that mail surveys are best suited for surveying people for whom a reliable address is available and who are likely to respond accurately and completely in writing. Salant and Dillman also claim that they are also suited for projects in which money, qualified staff, and professional help are very limited and an immediate turnaround is not required.

The second method of surveying dscussed by Salant and Dillman (1994: 38-40) is telephone interviews, which are conducted by calling a selected group of people, interviewing them, and recording the answers on the corresponding survey form. One great advantage of this method is its rapid turnaround and its quick results. Interviewers are able to conduct more interviews by telephone than they would be able to do in person, but less than they could do by mailed surveys. In addition to quick turnaround, telephone surveys offer the advantage of greater interviewer control. Over the phone, interviewers are able to clarify questions and also to encourage responders to answer all the questions. The possible problems with telephone interviews are high costs and the difficulty in contacting all members of a selected group. Another problem is that interviewers are not able to observe the respondents' reactions for clues as to whether the question is understood. Moreover, respondents can easily be influenced by leading questions from the interviewer. Salant and Dillman summarize by saying that telephone surveys are most appropriate when members of the population are very likely to have telephones, questions are relatively straightforward, experienced help is available, and a quick turnaround is important.

The third method of surveying is face-to-face interviews, which are conducted by interviewing a selected group in person and directly entering the results in the survey form. According to Salant and Dillman (1994: 40-43), face-to-face interviews offer enormous advantages under certain circumstances, such as, when surveying populations for whom there is no list, or who are not likely to respond willingly or accurately by phone or mail. However, this type of surveying is relatively costly and time-consuming, since it requires the interviewer to personally visit homes that maybe miles apart. Interviewers have to be trained in interviewing techniques in order to insure the respondent will not be biased in any way. Face-to-face surveys are used if questionnaires need clarification, or if there are appropriate funds and trained personnel to administer the questionnaire.

The fourth method discribed by Salant and Dillman (1994: 43) is the drop-off survey, in which people deliver questionnaires by hand to households or businesses. These are especially well-suited for small community or neighborhood surveys in which respondents are not spread over a large area. They work well for projects with a small staff but relatively large sample size and relatively short and simple questionnaires.

Salant and Dillman (1994: 53-59) also emphasize the importance of choosing the right sampling rate for doing a successful survey. A sample is defined as a set of respondents selected from a larger population. Sample surveys are very efficient, especially for large populations, because of their ability to obtain information from relatively few respondents that describes the characteristics of an entire population. However, sampling is not always necessary. For small populations, efficiency may not be a big concern, and surveying the whole population might be a better solution. The right sampling size depends on the size of the population and on how much sampling error can be tolerated.

Concerning result compilation, Salant and Dillman recommend using simple databases for entering and more sophisticated statistical programs for analyzing the acquired data.

CHAPTER 3: METHODOLOGY

Introduction

The objective of our project was to analyze the possibility of implementing a GIS for El Cuerpo de Bomberos, the fire safety agency in Costa Rica. In order to perform this analysis, we identified three areas that required close study. These areas are the assessment of need, the determination of system requirements, and the development of a schedule of implementation of the actual system. The assessment of need for a GIS was examined first, because a lack of need would have eliminated the reason to conduct an assessment of a GIS's system requirements and the development of an implementation schedule for the proposed system. After deciding that a GIS was a necessary and appropriate solution to the communication and information problems facing Los Bomberos, we determined system requirements and developed an implementation schedule for the proposed system. Since GIS is a relatively new technology that can require substantial financial and temporal resources, it was important that we examine the need and system requirements in detail before creating an implementation schedule and making further recommendations.

Hypotheses

Based on the background research performed for the formulation of our literature review and on the discussions performed early in the on-site portion of this project, we developed four hypotheses to test while in Costa Rica.

Hypothesis 1

The first hypothesis was that *the current computer systems used by Los Bomberos would not be sufficient to run a GIS for all of Costa Rica.* This hypothesis was based on our belief that Costa Rica would not have the available financial resources that the United States has for the purchase of advanced technology, and on the fact that a GIS requires a fairly sophisticated computer system, as described in our literature review.

Hypothesis 2

Our second hypothesis was that *the problems faced by the fire fighters and the information needs they had would differ between the San José metropolitan area and the remaining, more rural areas of Costa Rica.* This hypothesis developed from the existence of different overall situations between the two areas, such as traffic patterns and geographic proximity.

Hypothesis 3

Our third hypothesis was that *the problems the fire fighters viewed as the most severe would not necessarily be the ones they felt needed to be solved first.* We developed this hypothesis after our informal discussions with the fire fighters and our interviews with the chiefs revealed the possibility of this trend.

Hypothesis 4

Our final, and most important, hypothesis was that *a GIS would be the best solution to the current problems faced by El Cuerpo de Bomberos.* We developed this hypothesis based on the capabilities of GIS's and their use in fire fighting and on the understanding we gained about the types and extent of problems facing fire fighters in the United States and in Costa Rica.

Assessment of Need

In order to determine if a GIS were truly needed by Los Bomberos, we had to gain an understanding of the current information needs of and problems faced by fire fighters in Costa Rica. As stated in Hypothesis 4, we believed that a GIS was capable of presenting this information and solving these problems in a logical and effective manner. We decided that the best method for testing this hypothesis and collecting the data necessary to quantify such problems and needs would be to contact the fire fighters directly, because they would be able to supply the most accurate and beneficial data concerning these topics. However, we did not want to immerse ourselves in surveys for fire fighters without first familiarizing ourselves with the types of problems and information needs the fire fighters may focus on.

Therefore we conducted preliminary research through informal discussions with our liaison and with two fire fighters at Tibás Station. Through these discussions we gained an understanding of El Cuerpo de Bomberos' expectations of and needs for a GIS, as well as some of the problems faced by and information needed by actual fire fighters in emergencies. We also reviewed a proposal written by our liaison, Ana María Ortega, to gain a basic understanding of the current methods of organization and communication used by Los Bomberos. From this report, we were also able to gain information about the current computer resources available to Los Bomberos.

This background information served as the starting point on which all our further studies hinged. We were able to begin the process of determining whether a GIS was technically valid, organizationally valid, and organizationally effective for Los Bomberos, as mentioned in our literature review. If Los Bomberos had had unrealistic expectations of a GIS, the need for such a system would have required rethinking and comparison against other alternatives. Because the period of time required for the development and adaptation of a GIS to a specific location can be longer than expected, our team had to keep in mind that an alternative use of resources, such as an investment in fire fighting equipment, might be more beneficial to the community than a slowly-developing GIS.

Formal Interviews

The information collected through the informal discussions was also useful in constructing the format of our more formal interviews. The purpose of these interviews was to further develop our lists of problems and needed information in order to create a thoroughly-planned questionnaire. We also took advantage of the personal contact by adapting our questions to accommodate the conversation. We were able to discuss the problems and needs raised previously but with a base of knowledge that allowed us to discuss the topics in more detail and with a sense of familiarity that helped us lead the interviews more comfortably. First, we performed a group interview with three chiefs of operations at San José's Central Station. We then conducted an interview with a chief of communications in the office of communications at Santo Domingo Station, during which we were able to observe a demonstration of the current information system. Our final formal interviews were with three engineers of prevention in the INS office in downtown San José. These interview sessions supplied us with very useful data and opinions pertaining to the need for a system such as a GIS and the requirements of such a system. An important advantage of interviewing these individuals was that the information and opinions we gathered were from the standpoint of people who deal with the problems and needs faced by the fire fighters, but on a more administrative level.

The Questionnaire

The final step in our data collection concerning problems and needs involved the development of a questionnaire administered to the fire fighters (See Appendix E for a copy of the Questionnaire). We decided to submit the questionnaire to all the permanent fire fighters in Costa Rica. Our decision to survey only the permanent fire fighters was based on our belief that, if a GIS were implemented in Costa Rica, the career fire fighters would have the most extensive contact with the system. Our reasons for surveying the entire population of permanent fire fighters instead of choosing a random sample were that the population of only three hundred permanent fire fighters could be reached at no cost and we wanted as small a sampling error as possible. We could also be assured of a high return rate because the surveys would be returned by station. Taking these factors into account, we decided that a population survey was a reasonable and effective method to receive the most accurate information.

In developing the questionnaire, we divided the questions into four basic sections. The first section focused on demographic information intended to give us an idea of the variety of people supplying us with information and to allow us to observe any relationships between this information and the numerically-scaled data collected in the later sections, which focussed on the problems and information needs of the fire fighters. For instance, we could compare the problems fire fighters in the San José metropolitan area find most severe to those that fire fighters in more rural areas find most severe.

The second section, in keeping with the organizational validity criterion for implementation, focused on computer access and use patterns. Organizational validity, as discussed in our literature review, refers to the compatibility between the organization and the proposed system. We wanted to learn how familiar the fire fighters were with computers and for what purposes they tended to use computers most. We included this section because we felt that the more familiar the fire fighters were with computers, the more willing they would be to accept a new system such as a GIS.

The third and fourth sections presented lists of topics and asked the fire fighters to rank each according to a Likert scale. The third section of the questionnaire dealt with what information the fire fighter finds important when responding to and fighting a fire. This section was very important because it supplied us with hard data regarding an important system requirement: the information a GIS would need to contain in order to improve the system of fire fighting in Costa Rica.

The fourth and final section of the questionnaire focused on the problems faced by fire fighters when responding to and fighting a fire. This section produced data that allowed us to analyze these problems and the ability of a GIS to solve them in a manner consistent with the needs and resources of El Cuerpo de Bomberos. This section also contained a question requesting that the fire fighters prioritize the three problems they thought needed to be solved first. The reason for including this question, in addition to the ranking of the problems, is that we hypothesized that there would be a significant difference between those problems the fire fighters viewed as most severe and those they thought should be solved first.

Before the survey was distributed, it was revised five times in English and then translated into Spanish. Once the survey had been translated, we performed a pre-test with former and current fire fighters in the INS building to be sure that the questions were clear and appropriate. With the help of our liaison, our questionnaire was rewritten based on the results of our pretest and sent to all the permanent firefighters in Costa Rica.

We chose to mail the surveys to the fire stations because it was the most efficient method in our case, considering our time constraints and limited resources. The main reasons for not doing face-to-face or telephone interviews were the English-Spanish language barrier and our inexperience in conducting professional interviews; we did not want to run the risk of biasing our respondents. Mailing surveys required us to spend an extensive amount of time in the design phase, but once the final survey was designed and mailed, we only had to wait for responses. To ensure our receiving as many responses as possible, we contacted most fire stations to remind them to return the surveys completed by the fire fighters. In addition, because we visited several fire stations personally to drop off the survey, we had the opportunity to clarify the questions for the fire fighters and also to get a personal impression of the fire stations.

After receiving the completed surveys, we entered the data into SPSS using a classification system we developed to allow us to quantify the survey results. We then used SPSS to organize this data into statistical charts relating back to our hypotheses.

Determination of System Requirements

After collecting data for the assessment of the need for a GIS, we moved into the preliminary design stage of the system. This stage required the determination of the specific hardware, software and, most importantly, information requirements of the system.

Hardware and Software

In order to gain an understanding of the hardware and software requirements of the system, we undertook a two-fold study. Beginning with a general understanding of the hardware and software requirements and capabilities, as defined in our literature review, we first researched existing GIS systems that are currently being used by fire departments in other parts of the world. We did this because the study of existing systems is a logical and efficient method for analyzing available technology and established techniques.

We focused on the well-documented system used by the fire department in Winston-Salem, North Carolina. Winston-Salem's Integrated Network Fire Operations (INFO) project is one of the most extensively-developed and successful fire fighting GIS's in the U.S. Starting by examining all the online-resources provided by the fire department of Winston Salem, including a completed research paper authored by Winston-Salem's GIS analyst, Tim Lesser, we then decided to contact the project manager, Tom Kurczeka, to ask for information on the specifics of the project. The INFO team was able to provide us with information that was most valuable to our project and to El Cuerpo de Bomberos. Based on that fact, we decided that it would be extremely beneficial for El Cuerpo de Bomberos to establish good communication with Winston-Salem.

For the second part of our hardware and software analysis we contacted twenty hardware and software providers worldwide. In choosing the companies to contact, we narrowed our search to the companies we felt could best meet the system needs of El Cuerpo de Bomberos, based on company reputation and overall relevance to our query. We described the system in full to the potential suppliers and told them exactly what we wanted the system's capabilities to be (See Appendix F for the list of companies contacted and a copy of the letter sent to these companies). We asked each company to submit a formal proposal offering a system of computers and software that met our needs.

Using the information collected from the returned proposals, from the research and correspondence with Winston-Salem, and from the findings of the literature review, we were able to propose several possible systems that we thought would adequately meet the requirements of El Cuerpo de Bomberos.

Information

Since a GIS's primary purpose is to maintain and communicate information, it was critical that the required system information be carefully determined. In order to determine what information Los Bomberos required, we again decided that it would be most effective to utilize our questionnaire to acquire input directly from the fire fighters. The third section of the questionnaire was aimed at addressing the information required by fire fighters en route to and at the scene of a fire, and it allowed the fire fighters to add information that we may have overlooked when creating the list. In addition to the survey, we consulted the

Winston-Salem contacts regarding what specific information they found most useful and most important.

Implementation Schedule

The final phase of our project was the development of a schedule of and list of recommendations for the preparation for and implementation of a GIS. These steps were based on the information in our literature review, our research of the Winston-Salem system, the current condition of the computer systems of Los Bomberos, and a brief cost analysis.

We first created a list of the various steps necessary to fully prepare for and implement a GIS for fire fighting purposes. Then, based on the current computer systems and information availability, we were able to prioritize this list and to determine the order in which the steps should be undertaken to efficiently initiate and carry out the implementation process. Based on the information in our literature review and our contact with Winston-Salem, we attempted to create an accurate timeline of how long Los Bomberos should plan or expect to spend in each step.

Finally, we included a list of other recommendations of other methods that may help Los Bomberos improve communication and information management. This list was a collection of ideas formulated throughout our seven weeks working in Costa Rica and was meant to be taken only as a list of suggestions, not of necessary steps or methods in the improvement of Costa Rica's fire fighting system.

CHAPTER 4: DATA PRESENTATION AND ANALYSIS

The following data is, in part, the result of a survey that was administrated to all the permanent firefighters in Costa Rica. Of the fire stations that have permanent fire fighters, only three stations did not return our surveys. In total, these stations have fourteen permanent firefighters, and are spread through the country. Therefore, we believe this data is representative of the population of Costa Rica's firefighters.

Hypothesis 1

The current computer systems used by Los Bomberos are not sufficient to run a GIS for all of Costa Rica.

According to our literature review (page 10), the basic technical components of a Geographic Information System include a set of servers to act as information resources, a set of workstations/terminals to provide an interface for the users, and a physical communication network to tie these together. Workstations running a GIS should have: a Windows 95, 98, or NT operating system, at least a 300MHz processor with graphics refresh capability, a minimum of 128 Megabytes of RAM, a hard drive with at least 8G, an 8 Megabyte RAM video card, a large monitor since many windows may be open at the same time, a color printer with at least 300x300 dots per inch resolution, a system to back-up data, and internet access.

We compared these components to the hardware currently used by Los Bomberos to determine if the system was adequate for GIS operation. In a March, 2000 proposal intended to inform the directors of El Cuerpo de Bomberos of the need for GIS implementation, Bach. Ana María Ortega O., the Leader of the Information Project for Los Bomberos, assessed the hardware and software currently used by El Cuerpo de Bomberos. A copy of her proposal can be found in Appendix G. According to the proposal, while 90 percent of the fire stations have computers, most of them can be used only for basic word-processing due to insufficient hard drive space and faulty fax modem cards. Only the machines at the metropolitan stations in Heredia, Limón, and Alajuela have sufficient resources, including functional modems.

The proposal further explains that the Prevention Engineering Department has thirteen computers, ten of which are outdated, and of the remaining three, only two are connected to the INS network. Of the thirteen, two have defective hard drives and four are not functioning at all. The office of the Direction of Bomberos, on the other hand, has more technologically-advanced machines, but not enough to run a full GIS. As for the newest section of El Cuerpo de Bomberos, General Services has three computers: two with Pentium processors and one with a 486 processor without network access. None of these, with the possible exception of the Director's computers, is sufficient for running a GIS workstation.

Our literature review also suggests the need for a wide area network (WAN) for communication with remote users. There are a number of small networks within the Direction of Bomberos, and the Communications Office has a direct line connecting it to the INS, but there is currently no network in place connecting the stations.

Computer Access and Use

We extended the analysis of the current computer situation to include an investigation of the fire fighters' computer literacy. We felt that in order for a GIS to comply with the criterion of organizational validity presented in our literature review (page 7), the fire fighters must have access to and a working knowledge of computers. Figure 3 shows the percentage of permanent fire fighters in Costa Rica that have access to a computer.

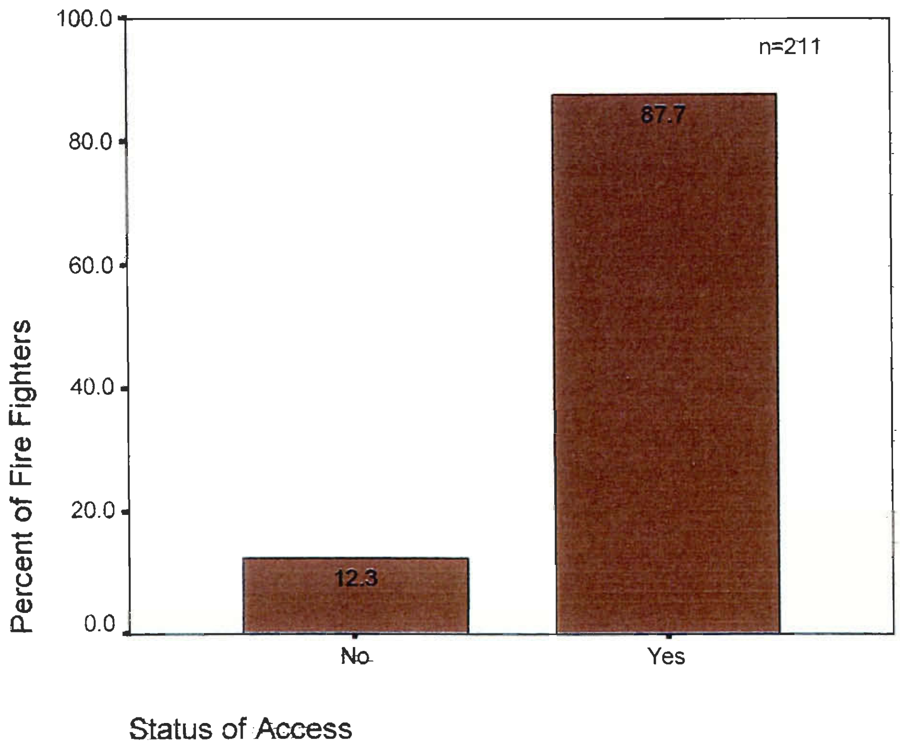


Figure 3. Graph showing the percentages of fire fighters that do and do not have access to a computer

Figure 3 shows that most of the fire fighters, 87.7 percent, have access to at least one computer. However, 48.8 percent of fire fighters have access to computers but use them five or less hours a week, as shown in Figure 4.

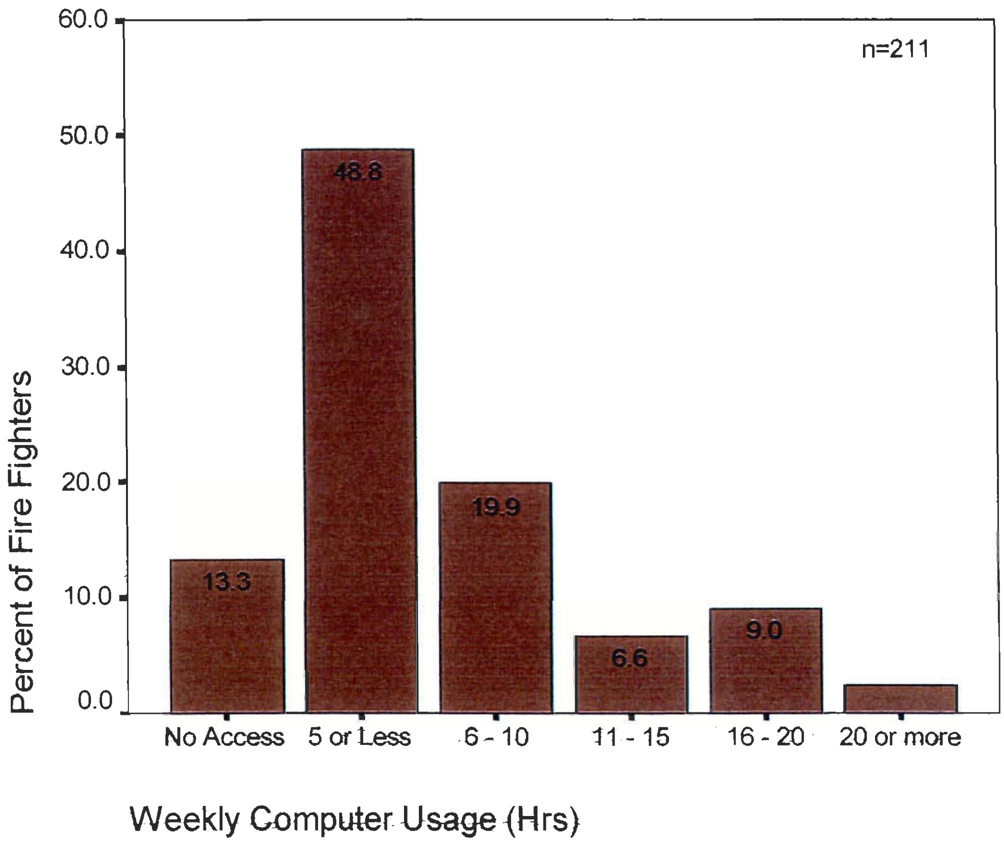


Figure 4. Graph showing what percentages of fire fighters use a computer for various hours per week

In total, 62.1 percent of the fire fighters in Costa Rica use a computer for five or fewer hours per week, if at all. These numbers suggest that although a large majority of the fire fighters may have at least marginal familiarity with computers, they may not have much experience and, therefore, may be reluctant to accept a GIS.

These findings support our hypothesis that the current computer system is not adequate for the implementation of a GIS. Also, the fire fighters' lack of familiarity with computers suggests that a basic course in computer usage would be required during the implementation phase if a GIS were to be an organizationally valid innovation for El Cuerpo de Bomberos.

Hypothesis 2

The problems faced by the fire fighters and the information needs they had would differ between the San José metropolitan area and the remaining, more rural areas of Costa Rica.

It is possible that the different areas throughout the country would not share the same need for a GIS. In that case, the steps for implementation within the areas would have to differ. Also, the ability to separate the data pertaining to the metropolitan area from that pertaining to the rural areas is important because the metropolitan area would be the first to receive a GIS if one were implemented in Costa Rica. Only in the San José metropolitan area are fire emergency calls routed through a central communications office (OCO); in rural areas, every call is directly connected to the closest local fire station. Since a GIS relies on a central communication office from which all calls are dispatched to the appropriate station, San José would be the most logical starting point for a GIS system at the moment. Figure 5 shows how many of the respondents serve within the San José metropolitan area and how many serve the more rural areas.

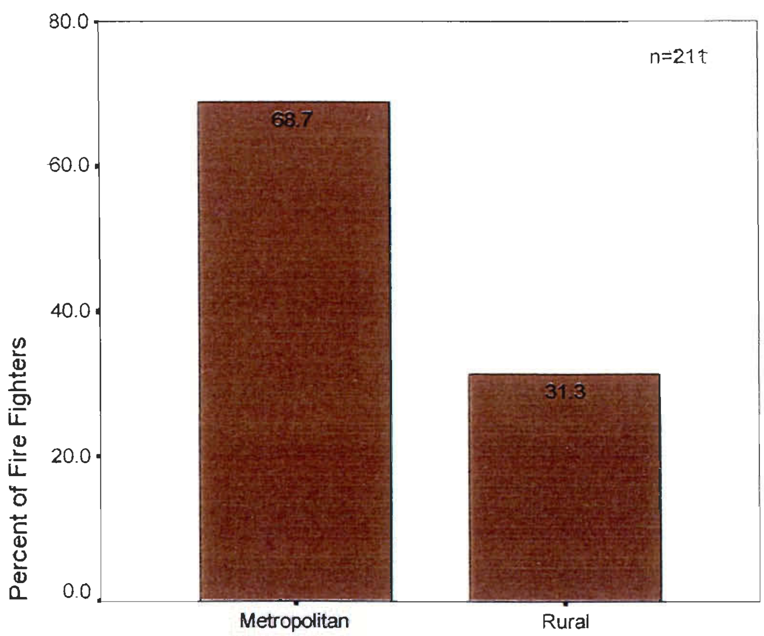


Figure 5. Graph of percentages of metropolitan versus rurally-stationed fire fighters

As Figure 5 shows, more fire fighters are stationed within the much smaller San José metropolitan area than in the rest of Costa Rica. This is due to the much higher population density in the San José area and to the fact that San José is the organizational center of El Cuerpo de Los Bomberos.

With the data that we collected through our questionnaire, we conducted a t-test on the mean scores for different information needs of fire fighters in the rural versus the metropolitan areas using a scale of one to five, with five being the highest importance that could be assigned to each need. From this test we determined that, statistically, there were no differences in the needs of the fire fighters in the two areas. This means the information needs of fire fighters are the same throughout Costa Rica and the data does not need to be separated by region.

We conducted the same test on the problems facing fire fighters and found only one problem that differed statistically between the metropolitan and rural areas. Traffic congestion was a more severe problem in the metropolitan area, showing a mean of 4.07 as opposed to the rural area where the mean ranking was 3.24. The t-test reported there was a 0.6 percent possibility that this difference was due to chance. This was expected because the numbers of cars driven in San José currently exceeds the capacity of the street network. In the rural areas there are fewer cars so it was anticipated that traffic congestion would be a less severe problem.

The data presented shows that, for the most part, the fire fighters of Costa Rica have similar views concerning the problems they face and the information they need, despite geographical differences.

Hypothesis 3

The problems the fire fighters viewed as the most severe would not necessarily be the ones they felt needed to be solved first.

Figure 6 shows the rankings of the largest problems currently faced by fire fighters in Costa Rica. Because hypothesis 2 was largely refuted, the data collected from the fire fighters does not need to be separated between rural and metropolitan areas. As mentioned in the Methodology, each problem on the questionnaire was ranked from one to five in order of severity, with five being of highest severity. In creating this graph, we averaged the rank points for each problem provided, allowing for a maximum of five points.

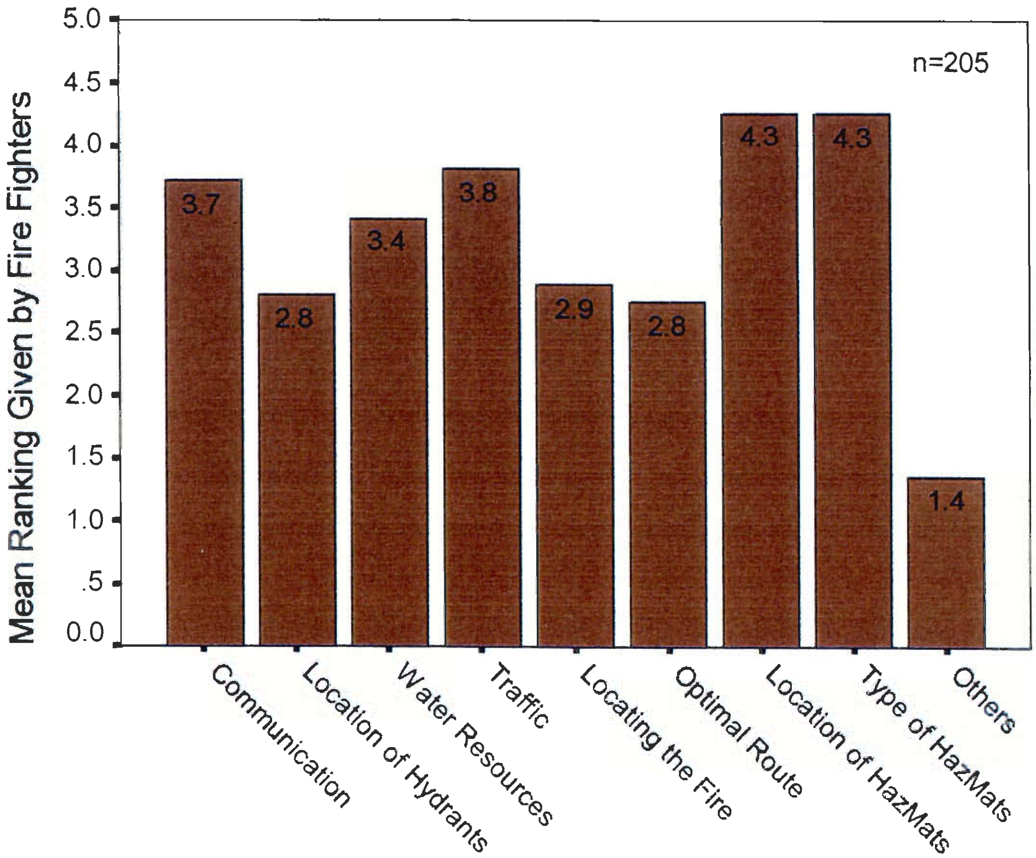


Figure 6. Graph showing the mean rankings fire fighters assigned to problems they face

The data shown in Figure 6 supports and quantifies the findings of our qualitative interviews with officials and chiefs of Los Bomberos. The types of problems they raised as important issues are the same as those the fire fighters ranked highly. Problems with the location and type of hazardous materials, which we called HazMats for ease of labeling in our charts, were expected to receive a high ranking, since our preliminary research had shown that fire fighters worldwide worry about these issues (See Appendix I for summaries of preliminary interviews). According to our interview with El Cuerpo de Bomberos' Chiefs of Operations, there is little information available regarding hazardous materials in Costa Rica due to a lack of regulations and a poor enforcement of the existing ones. Whenever hazardous materials are brought into the country they are reported to the Ministry of Health; however, once they are in the country there are few laws controlling the trade, transport, and storage of these chemicals. The chiefs explained that businesses can deny firefighters the right to access their buildings to determine what chemicals are present, a denial that is especially prevalent among smaller companies. In addition, the chiefs explained that normal household chemicals can also cause problems and homes may be used as pharmacy storehouses. According to the chiefs and our survey results, these problems make hazardous materials completely unmanageable.

We also expected high rankings for traffic and communication problems. Due to Costa Rica's mountainous terrain, communicating essential information over the radio can be difficult or even impossible as was explained to us by Héctor Monge Montero, the Director of El Cuerpo de Bomberos. Traffic also represents a severe problem faced by fire fighters, especially in the metropolitan area as was explained in our analysis of Hypothesis 3.

Even though the three problems discussed above and shown in Figure 6 are the most severe problems, they are not the first problems that must be addressed and solved by El

Cuerpo de Bomberos, according to the fire fighters. Figure 7 shows the problems fire fighters believe should be solved first.

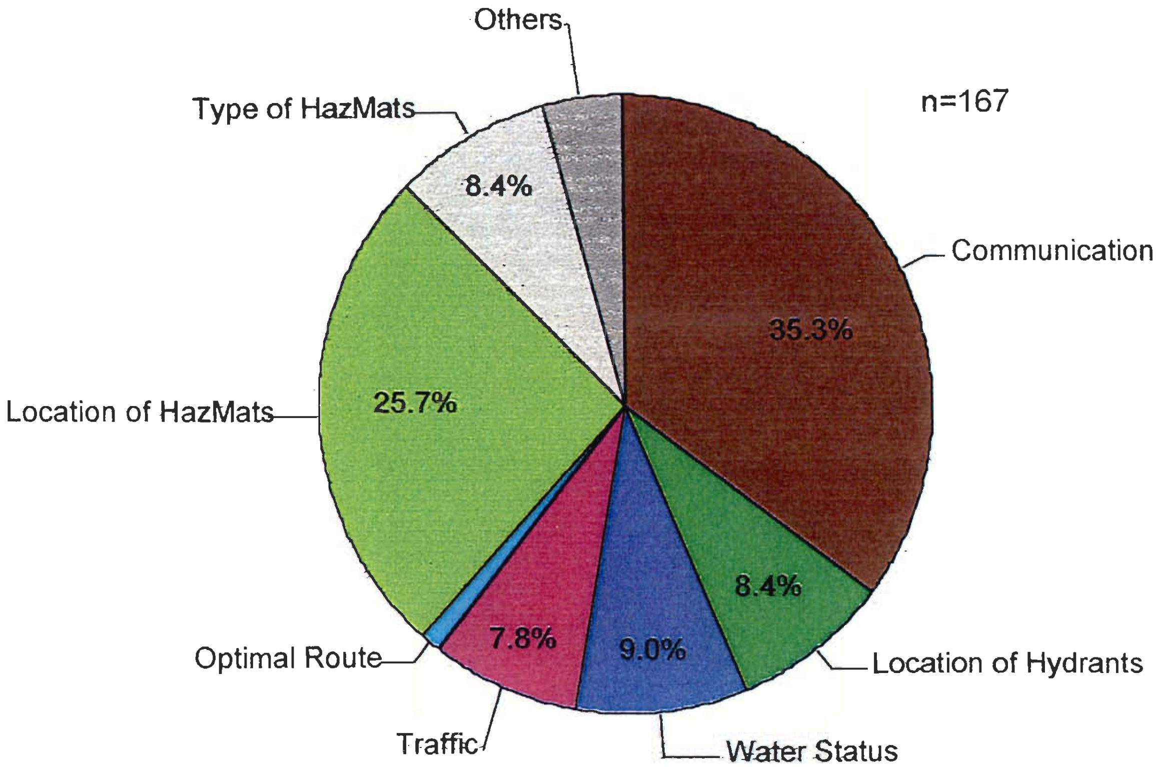


Figure 7. Pie chart showing the problems fire fighters ranked as first to solve

Figure 7 supports our hypothesis that the problems fire fighters consider to be the most severe are not necessarily the problems that they believe should be solved first. Even though communication is ranked as the fourth most severe problem, it is the problem fire fighters believe must be addressed first. This could be because many of the other problems, such as not knowing the location of the nearest water source, could be alleviated by a properly functioning communication infrastructure. Although the location of hazardous materials could be communicated over a properly functioning infrastructure, access to this information is currently limited. For this reason, the lack of information about the location of hazardous materials ranked as the second most important problem to solve.

Hypothesis 4

A GIS would be the best solution to the current problems faced by El Cuerpo de Bomberos.

Because this hypothesis holds such important implications for this project and because it alone is too broad a topic to cover in itself, we have broken this hypothesis into four sections.

Communication Need

One of the most important aspects of a GIS is that it can act as a means of communication of important information across a network. As such, a GIS would help solve the problem the fire fighters believe should be solved first, as mentioned above. The current communication system of El Cuerpo de Bomberos is shown in Figure 8.

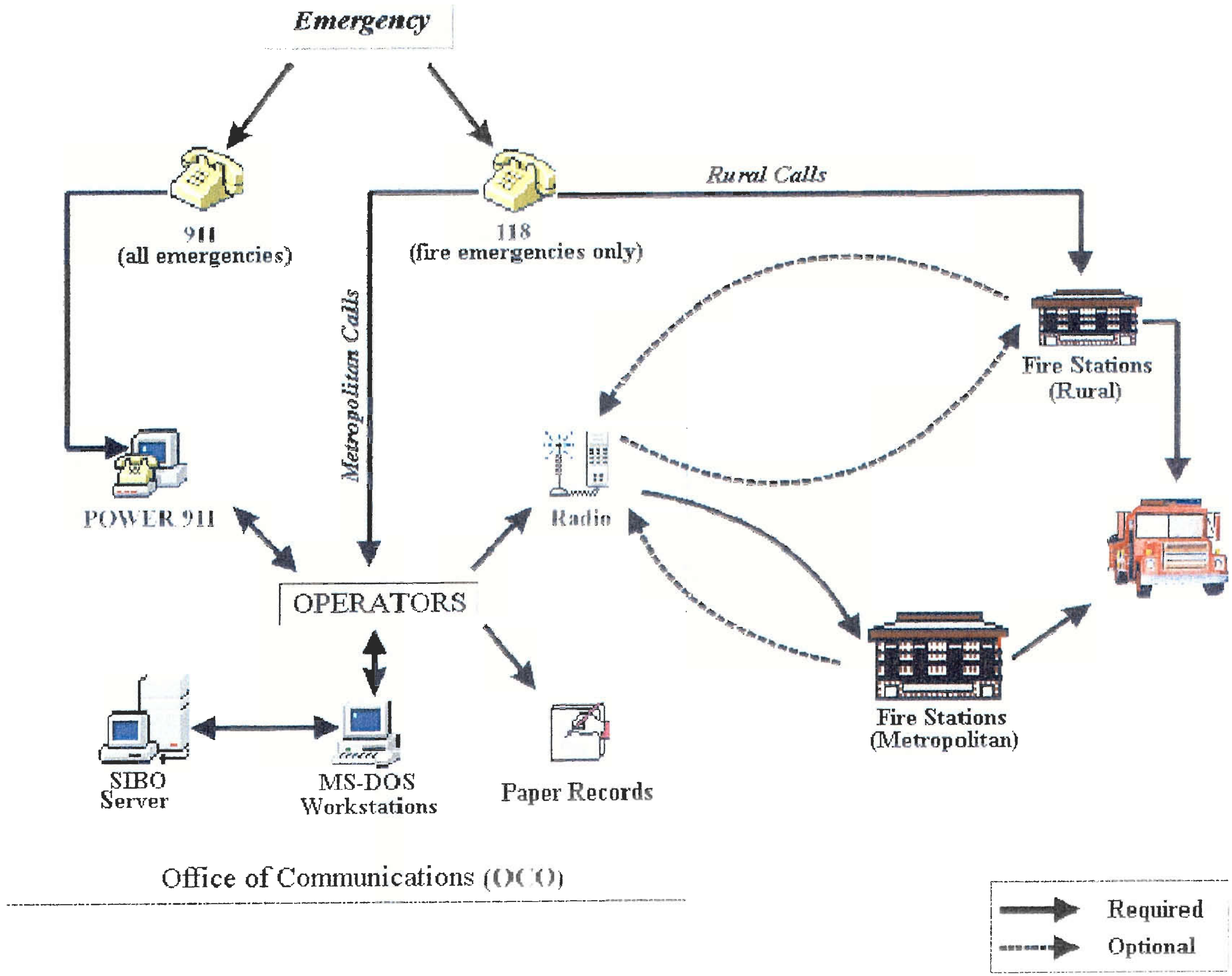


Figure 8. Current Communication system

At the moment there exist two types of emergency calls. One is the 118 call, which is solely for fire emergencies, and the other one is the 911 call, including all emergencies. 118 calls conducted from the metropolitan area and every 911 call and are received by the Office of Communications (OCO) in Heredia. Due to the lack of antennas distributed throughout Costa Rica, it is currently very difficult to establish a radio connection between OCO and some of the rural fire stations. For this reason most 118 calls conducted from rural areas are dispatched directly to a local fire station instead of to OCO.

For the reception of 911 calls, OCO utilizes a recently-installed Windows NT based system, called POWER 911, that automatically displays the address and phone number of the location the emergency call was conducted from. However, due to modem compatibility problems this system is not yet operational. Therefore, both 911 and 118 calls are currently handled manually by the operators at OCO.

When an emergency call comes in, the operator asks the caller questions about the location of the fire, possible injuries, and other important information. All the acquired information is written down on paper before being entered into the SIBO database. SIBO is the database program currently employed by El Cuerpo de Bomberos that stores pertinent information about the location of hydrants and hazardous materials, personnel, stations and fire vehicles. However, only information collected after 1991 is stored in the SIBO database. All information gathered anytime between 1970 and 1991 is still kept on paper records. Currently, the SIBO system runs under MS-DOS, which is solely text-based and, therefore, unable to display any kind of graphical information.

Once the operator knows about the emergency situation, he accesses the SIBO database through the MS-DOS workstations to obtain additional information about the incident location. Since there is no map available that divides the country into districts such as fire demand zones, which has been done in the city of Winston-Salem, it is solely up to the operator to decide, based on his geographical knowledge and memory, which station is the closest or the best suited to respond to the incident. Once the decision has been made, the operator contacts the responding station via radio, transmitting the location, the degree of the fire, and the location of any existing hazardous materials. If the station determines it does not have enough resources to successfully fight the fire, it will respond to OCO and ask for further assistance.

In case of a call that is not routed through OCO, such as a call conducted from a rural area, the receiving fire station will contact OCO via radio if further information on the incident location is needed.

Once the fire has been extinguished, all data concerning the incident is transmitted to OCO via radio and eventually entered into the SIBO database. This statistical data is mostly used in case of legal issues or insurance problems.

In the current communication system too much responsibility is placed on the operator, his geographical knowledge and memory. A small mistake on his part can have a great impact on the successful completion of the overall operation. Moreover, the fact that all the information in the SIBO database is solely stored in a text-based format makes it very hard for the operator to convey any kind of geographical information via radio.

Costa Rica also does not have a sophisticated address system, which results in a more time consuming process of transmitting the incident location over the radio. Due to the difficulty of updating the information stored in the SIBO database with data gathered at different fire stations, updates are done very irregularly, causing a severe problem to the current system and its reliability.

Another problem arises with the distinction between calls conducted from the metropolitan area and the ones conducted from rural areas. Since rural emergency calls are directly dispatched to the local fire station, the process of acquiring all pertinent information from OCO becomes very time consuming. The fire station needs to contact the operator in OCO, who then has to look up the information and send it back to the station, which can take a significant amount of time. Finally, a lot of pertinent information is still stored on paper records, which are hard to access, modify and organize. Thus, the current communication system is very complicated and inefficient.

Based on the analysis of system requirements, the correspondence with the fire department of Winston-Salem and a proposal made to El Cuerpo de Bomberos by GeoTechnologias Inc., we proposed one possible enhanced communication system that will alleviate many of the problems currently faced by El Cuerpo de Bomberos. This proposed system is illustrated in Figure 9

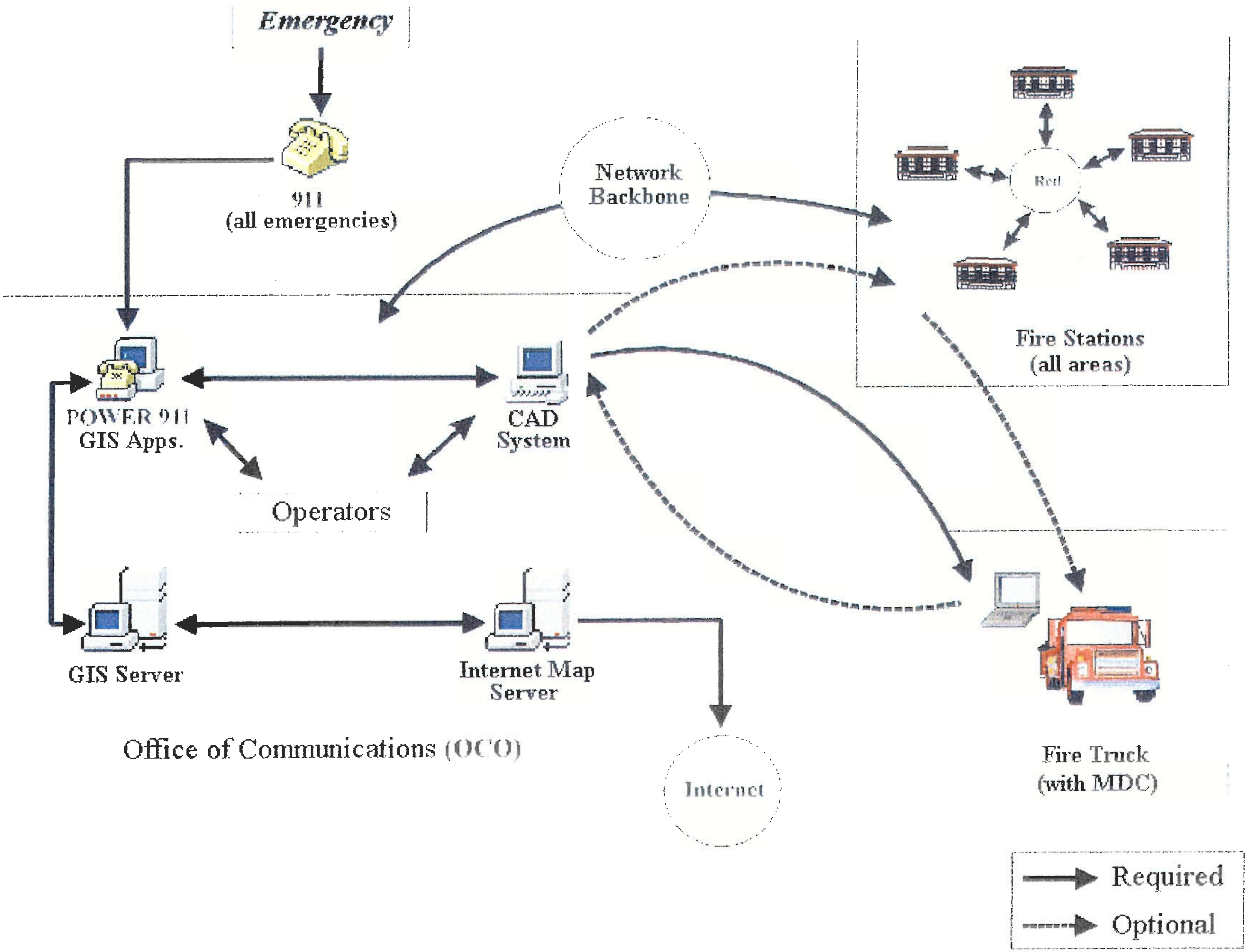


Figure 9 A communication system utilizing GIS technology

The main purpose of proposing this system is to simplify, improve, and extend the current communication system. We assumed, based on our discussion with the director of El Cuerpo de Bomberos, that the 118 call is going to be replaced within the next three years by the 911 call, which will then be the only official emergency number throughout Costa Rica. Once this change has been made the Office of Communications (OCO) will receive every fire emergency call, whether it is conducted from the metropolitan area or from any of the rural areas. This reorganization, in itself, will significantly simplify the current communication system and will turn OCO into the center of communications for all of El Cuerpo de Bomberos. As the center of communications, OCO will be the optimal location for the installation of an initial GIS server and the required workstations.

For a GIS to be implemented, the current computer setup in OCO must undergo organizational changes. The SIBO server will be replaced by a more powerful GIS server containing geographic and demographic data in a graphical format. This data will be organized in a common database relating spatial and tabular data. Several workstations equipped with the POWER 911 system as well as GIS applications will be connected to this newly installed GIS server.

In addition to the Power 911 system, a Computer Aided Dispatch (CAD) system will be implemented and connected to the workstations. This system will be responsible for identifying available fire vehicles and automatically sending pertinent information via radio to the dispatched units.

The existing network between OCO and the administrations office of El Cuerpo de Bomberos at INS, illustrated here as the network backbone, will be extended to all fire stations, starting with those in the metropolitan area. This will provide each fire station with the ability to easily update the central database with current information gathered in its district. Additionally, each fire station will be able to access the Internet/Intranet and e-mail through the newly created network. In order to realize this, each station will need to be equipped with a network-supporting PC running GIS imaging software. One solution to the problem of networking all the fire stations could be the utilization of Integrated Services Digital Network (ISDN) technology, which will be very cost-effective while providing quality network services to the users.

Once this network is in place, an Internet interactive map server needs to be installed and connected to the GIS database. This will allow web access to some of the newly installed applications, thus providing GIS functionality to a user for just the cost of a Web browser on their PC. It will also aid in publicizing information for clients or employees over the Internet.

In addition, every fire truck will be equipped with a Mobile Data Computer (MDC), a laptop computer resistant to water, vibrations and other outside influences. The MDC will have all relevant GIS data, images, and applications loaded on its hard drive, and will be equipped with a CD-ROM that will be used for monthly updates to ensure the accuracy of the data.

When a 911 call is received by OCO, the POWER 911 system will immediately identify and display address and phone number of the location the call was conducted from. The operator will then transfer the acquired information to the CAD system and enter additional information about the incident. The CAD system will then automatically identify the closest available fire vehicle that is appropriate for the incident type and location. The operator will solely be required to accept or reject the recommendations made by the CAD system and will not need to rely entirely on his own geographical knowledge and memory. Upon acceptance of these recommendations, emergency dispatch information such as the location of the emergency site, details on the incident type, other responding units and the location of hazardous materials will be transmitted over radio frequencies to the MDC in each fire vehicle dispatched to the incident. This information will be passed to the routing application installed on the MDC, which will immediately determines the optimal route to the incident. If more information is needed, the fire fighter in the truck will send out a request to OCO by simply touching a button on the MDC display. Once the fire is extinguished, all acquired data about the incident could be easily entered into the system via the established network, ensuring regular and accurate updates of the information stored on the GIS server.

Having all pertinent information readily available in the fire truck and ensuring that this information is highly accurate will greatly increase the fire fighters' efficiency and reduce the time it takes the fire fighters to respond to a fire.

Information Requirements of El Cuerpo de Bomberos

The information requirements of the fire fighters throughout Costa Rica that we gathered through the questionnaire are presented in Figure 10.

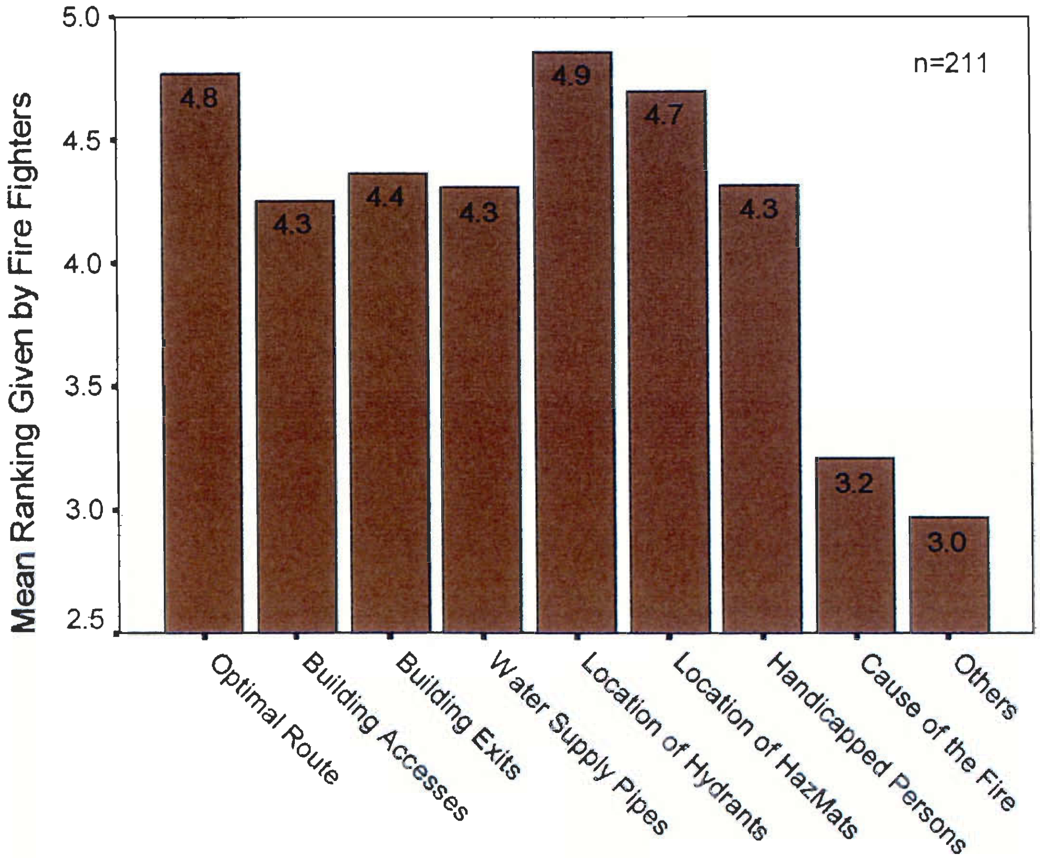


Figure 10. Graph showing the mean rankings assigned by fire fighters to the pieces of information they find important

As mentioned in the Methodology, the information requirements of fire fighters we gathered in our preliminary research were listed in the questionnaire. Each item in this list was then ranked from one to five in order of importance, with five being of highest importance. The rankings of the information are all quite close, but considering the size of our response pool, even a difference of a few tenths-of-a-point may conceptually signify an important difference in the need for information. Therefore we have categorized needed information by the order of importance the fire fighters gave each.

Highest priority.

According to the fire fighters' responses, the most necessary information includes the optimal route to a fire, the location of water sources, and location of hazardous materials which all received a mean ranking of 4.7 or above. The location of water sources, which received a ranking of 4.9, is, of course, a very important piece of information. Knowing the nearest source of can save priceless time and resources. As was told to us in an interview with the chiefs of Operations, when fighting a fire at a Costa Rican hospital, the fire fighters used a hydrant hundreds of meters away because they thought it was the nearest source of water. Had they known at the time that there was a water tank under the hospital, they would have saved precious minutes and energy. Also, knowing this information can alert the fire fighters to the need for longer hoses or a stronger pump for retrieval of the water.

Knowing the optimal route to the fire received a ranking of 4.8. This is especially important in Costa Rica, where the lack of formal street addresses makes locating a fire particularly difficult. A GIS could map out the optimal route to the fire based on the beginning point and the final destination, which the fire fighters could view on the screen of the laptop in the truck and zoom in or out as needed.

The location of hazardous materials received a 4.7, which is the lowest ranking given highest priority. Information regarding hazardous materials is important because the presence of such substances can create unpredictable dangers for the fire fighters. Knowing where any hazardous materials are located can prevent the unnecessary loss of lives. Also, if the fire fighters know about the presence of hazardous materials, the Hazmat team can be properly prepared upon receiving the call from OCO.

The information categorized as highest priority was ranked *by the fire fighters* as the most important when fighting a fire. These may have received the highest rankings because it is all information that is necessary *before* arriving at the fire. Knowing this information before arriving at the fire can allow for the creation of a more efficient strategy for combating the fire and can save invaluable time and lives. All the information needed in a fire fighting GIS is important, but it is impossible to gather all the data simultaneously. For this reason, El Cuerpo de Bomberos may want to give priority to these pieces of information when gathering data for the GIS, especially since a GIS is a powerful tool even if it is lacking all of the information it is intended to contain.

Second priority.

The second category contains four topics, all with rankings between 4.2 and 4.4, inclusive. These topics include the presence and status of handicapped building occupants, the location of building exits, the location and status of water supply lines, and the location of building accesses. While important, such information is of second priority because it does not affect the planning and preparation of the fire fighting strategy as much as the information in the highest priority category. Although having this information is very helpful, it can all be observed upon arrival at the fire and therefore a lack of access to the information does not greatly impede the fighting of the fire.

Lowest Priority.

The two topics receiving lowest ranking are the cause of the fire, with a 3.2 ranking, and the "Other" category, with a 3.0 ranking. As was expressed to us in our preliminary interviews, the fire fighters do not place the cause of the fire as a high priority because their goal is to extinguish the fire, no matter how it was started. However, this information is important to the engineers who analyze the statistics regarding the fires for insurance and prevention purposes.

The "Other" category received a low ranking because only seventy-six of the 211 respondents listed other types of information that are important in fighting a fire. Of these seventy-six, forty-three (57 percent) said that they needed more information about the type of structure with which they were dealing. For example, they wanted to know whether the surrounding area is residential, commercial, or industrial, for what the building itself is used, the size of the building, and what material was used in its construction. Twenty people (26 percent) expressed a need for information on what people and units were available if back up was needed. Information on the victims, including handicap information, was requested by fourteen people (18 percent). Exposure, time of fire, and more information on water were the next top ranking information needs. Other expressed concerns were vehicles access and alternate routes, geography, and systems in place for fire protection. Though these topics received the lowest rankings, all information about fires is important and can be easily entered and analyzed with the use of a GIS. Because these were all information needs expressed by multiple firefighters, they should be investigated as possible data layers.

Need for an Information Management System

Some of the problems facing the firefighters of Costa Rica could be alleviated with a properly managed information system. Information is centrally stored in SIBO; however, stations have very limited access to this information. According to our interviews, in order to collect and manage information, stations fill out paper forms containing the layout of the building, locations of hazardous material, the nearest sources of water, and other important information (See Appendix J for a copy of this form). The problem with this organization method within the metropolitan area, according to the Chief of Operations, is that there are often too many of these forms to carry in the truck or to reference quickly, so they rarely get used. At other times the papers become damaged or are misplaced. The remaining information is stored in the memories of the firefighters. According to the Chief of Operations, the accuracy of this information may vary from person to person, and is often lost when a firefighter dies or changes stations.

The information within a GIS is managed in a way that allows access to pertinent information, such as maps of the area, as well as more specific information about building layout and dangerous situations, even without communication with the central server. This information will already exist within the stations' servers and is easily transported to the fire in the laptops that will replace the notebooks that used to get left behind in an emergency because of their overwhelming bulk. Communication with OCO will provide minimal necessary information such as the location of the fire and any other specifics about the particular incident. This allows fire fighters to respond to a fire even if the only information they have from OCO is the location of the fire.

Also, the information within a GIS is easily updated from either the stations' servers or laptops. For instance, if someone with access to the GIS's information learns of an incident such as a landslide, any roads closed because of that landslide can be flagged as impassable on all the computers on the network at the simple click of a button.

Need for an Analysis Tool

Mauricio Elizondo is responsible for researching fires for insurance purposes or when crime or hazardous materials are involved. The statistics he generates require information on the zones where the most fires occur and, within these zones, the size, cause, location, area threatened, area saved, and the area burnt by a fire. Currently all this information is kept in paper form or in SIBO; there is no visual representation of this information.

According to Francisco Bermudes, who evaluates fire risk and human security for El Cuerpo de Bomberos, there is a plethora of information needed about older buildings. This needed information pertains to the location and condition of fire extinguishers, emergency lights, emergency plans and exits, emergency alarms, hazardous materials, and machinery. Currently all this information is recorded on a paper form upon each visit, but is not filed with similar information of equal importance. Bermudes says that a computer-based system to organize all of this data would allow him to create statistics on the types of buildings in an area and the level of danger each possesses.

Walter Mora, who studies fire protection in new buildings, ensures that companies are building safely. The organization of necessary information for each building is a problem. Currently, blueprints of all new buildings are housed in INS, and information about emergency exits, extinguishers, building materials, sprinkler systems, costs, location and final analysis are organized on spreadsheets. This information is gathered and entered manually. In the past, the engineering department of El Cuerpo de Bomberos used a CAD system that allowed contractors to bring their blueprints in on disk. The engineers preferred that system, but there was a problem with licensing, and, therefore, they are no longer able to use this program. According to Mora, his department could profit from a computer-based system to prevent the loss of information and to improve analysis. More specifically, his department would benefit from a database with information that could be linked to the stations, so when a new building is being constructed in a specific area, the firefighters in that area could be aware of any possible problems.

The analysis of the aforementioned information is a task that could be greatly simplified by a GIS. For example, the fire fighters could create a data layer within the GIS that shows the location of all the chemical fires in the Guanacaste province in the past year. The ability to visually display information as specific as this, for which all the engineers we interviewed expressed a need, is important when considering the need for improved fire fighting resources or techniques in Guanacaste. This is a very specific example, but it clearly shows the potential that a GIS holds as a powerful information analysis tool.

Vendor Response

Of the twenty companies we contacted, as mentioned in our methodology, only two replied. The first company informed us they were unable to assist in our project. The second company, The Omega Group, expressed interest in aiding El Cuerpo de Bomberos with this project, and in the possibility of working with them in translating the FIREVIEW software into Spanish. Because this is beyond the scope of our project, further details are not included in the body of this text. For more information, see Appendix F.

Funding

As mentioned in our literature review, the implementation of a GIS can require extensive financial and personnel resources, especially upon initiation of the system. (We will include numbers and more details soon). For this reason we assumed before our arrival in Costa Rica that funding would be an obstacle to the implementation of a GIS for El Cuerpo de Bomberos. However, during an interview with our liaison, we learned that cost was not to be considered an obstacle in our investigation. Despite this assurance, we decided that El Cuerpo de Bomberos would benefit from an investigation into possible sources of external financial assistance.

CR·USA

CR·USA is non-political alliance between Costa Rica and The United States of America that aids in the funding of programs for the general improvement of the country of Costa Rica. According to the CR·USA web page (www.crusa.org.cr), the goal of CR·USA is to promote the best collaborations possible between the governments and people of both countries. This may be done through exchanges or through support for projects.

Currently, the foundation provides funding for programs that seek to transform institutions, improve policies, and improve the sustainable development of Costa Rica in five areas. These areas are institutional transformation, globalization, environment, science and technology, and education. Grants are provided to governmental and non-profit organizations whose goals fit those of the foundation (both an English and Spanish copy of the grant application can be found in Appendix K). CR·USA does not provide funding for individuals, feasibility studies, the recurrent operating expenses of organizations, or the purchase or construction of physical assets such as equipment, buildings etc., unless the latter are related to specific project goals.

Successful proposals contain certain characteristics such as the potential to make an impact at a local or national level. Project proposals must demonstrate that leaders have the vision and capability to carry the project to its full potential. There should be a well thought out plan to achieve the project objectives. In addition the organization should have the financial and organizational capabilities to carry out the project, and in some cases, other sources of funding.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Based on the data we have collected and analyzed we have developed the following six conclusions.

Our first conclusion is that the implementation of a Geographical Information System is the most logical and beneficial step for El Cuerpo de Bomberos. All of the information we have collected and analyzed culminates in the fact that a GIS can solve many of the problems faced by El Cuerpo de Bomberos. It can improve communication, information management and availability, and data analysis. These improvements contribute to the efficiency of the fire fighters, the chiefs, the engineers, and El Cuerpo de Bomberos as a whole. Though the costs involved in implementing a GIS are heavy, the many benefits outweigh the negatives in enough ways that implementation would inevitably lead to a highly successful fire-fighting program.

Our second conclusion, that the current computer systems of El Cuerpo de Bomberos are not adequate to run a GIS for all of Costa Rica, was drawn after analysis of the data concerning our first hypothesis. Our research and observations have shown that the computers currently in use (see pages 52 and 53) do not meet the system requirements described in our literature review. Most of the machines are outdated and many are not in full working order. GIS technology requires up-to-date computer systems that El Cuerpo de Bomberos should obtain before continuing with the implementation process.

Our third conclusion is that the fire fighters as a whole lack the computer skills necessary to effectively work with a GIS. A GIS is a heavily computer-based program that requires a level of comfort and proficiency with computers that we feel most of the fire fighters do not have. Because 61 percent of the fire fighters use a computer five or fewer hours per week, if at all, most of the fire fighters would need to undergo computer training in order to reach the necessary level of comfort.

Our fourth conclusion, that the differences in problems faced by and information needed by fire fighters in the rural and metropolitan areas are not significant enough to require treating the two groups differently, was developed as a result of the data analysis related to our second hypothesis. We had expected to observe distinct differences in the data collected from the rural and metropolitan areas. However, after performing statistical tests on our data, we determined that there were few significant differences between the two groups. While there were some statistical differences present, we determined that they were not substantial enough to justify treating the two geographic groups differently. Therefore, El Cuerpo de Bomberos can treat the needs of and problems in the two geographical areas equally when implementing the GIS.

The fifth conclusion, that the problems the fire fighters find most severe are not the same as those they think should be solved first, was based on the analysis of data collected through our questionnaire. We expected to observe this trend because problems with communication, which the fire fighters said should be solved first, often lead to other problems, such as locating hydrants and knowing the type of hazardous materials present. In many cases the information that would alleviate these problems is available, but has no efficient way of being communicated to the fire fighters. A GIS is an excellent tool for storing this information and for allowing remote users, such as the fire fighters, to access the information when they need it.

Our sixth and final conclusion is that there is a need for further regulations and the enforcement of existing ones regarding such topics as hazardous materials and building inspections. We came to this conclusion because there are currently few legal regulations that allow the fire fighters to obtain the information they need in order to successfully do their job. Without this information, the GIS cannot be used to its fullest potential and the maximum benefits cannot be reaped from the implemented system.

Recommendations

Based on our conclusions and the findings of our study we have developed a list of recommendations for El Cuerpo de Bomberos.

11. *Undergo the implementation of a GIS (For implementation schedule see page 85)*
12. *Begin implementation in the San José metropolitan area*
13. *Provide basic computer training for all permanent fire fighters*
14. *Form a team of experts that will manage the nationwide system*
15. *Collect as much existing data as possible*
16. *Use the fire fighters as a source of information and input regarding specific system needs*
17. *Use the Winston-Salem Fire Department as a resource for information regarding system implementation*
18. *Encourage the development and enforcement of regulations that allow building inspections and the control of hazardous materials*
19. *Contact CR·USA and other organizations regarding possible funding of the implementation project*
20. *Strive for a leadership role in GIS applications among the world's fire fighting community*

<u>Recommendation 1</u>

We recommend *that El Cuerpo de Bomberos implement a Geographic Information System for the improvement of communication, analysis, and management of information.* As a communication tool, a GIS will provide the fire fighters with vital information at the scene of a fire. As an analysis tool it will allow the engineers of El Cuerpo de Bomberos to visually evaluate risks and human security issues throughout Costa Rica. As a management tool, a GIS will allow the organized storage and handling of a vast amount of information.

We have developed a schedule for El Cuerpo de Bomberos, outlining the steps necessary for the successful implementation of a GIS. This implementation schedule is an adaptation and enhancement of the one used by the Winston-Salem Fire Department in their successful implementation of a GIS. We have presented this schedule on page 85 of this report.

<u>Recommendation 2</u>

We recommend *that El Cuerpo de Bomberos begin the implementation of a GIS in the San José metropolitan area.* It is most efficient to test the system in the metropolitan area for the following reasons:

1. The small area and greater concentration of fires, population, and stations, allow a more immediate positive impact of the GIS,
2. The Office of Communications, located in nearby Heredia, is the central dispatch location through which all metropolitan emergency calls are routed,
3. The existing network between OCO and INS allows the surrounding fire stations to be connected to the network in a cost effective manor,
4. The established radio and telephone communication infrastructures are more developed and reliable in San José than elsewhere,
5. The organizational center of El Cuerpo de Bomberos is located in San José.

Recommendation 3

We recommend *that all fire fighters in Costa Rica receive basic training in the use of computers*. This training will ensure that the fire fighters are more familiar with computers and thus more accepting of a GIS. Training could be completed through courses at the University of Costa Rica or in the stations with the use of the computers that will be installed.

Recommendation 4

We recommend *that El Cuerpo de Bomberos form a team of experts devoted solely to the development, implementation, and management of the GIS.* As was discussed on page 16 of our literature review, the selection of this team is of utmost importance because failures in implementing an innovative system are often due to staffing inadequacies. An appropriate team consists of experts in various fields, as described on page 17 through 19 in our literature review. A list of team members employed by Winston-Salem, and a description of their duties, is included in Appendix D.

Recommendation 5

The most time-consuming and costly aspect of implementing a GIS lies in the gathering and creation of the data to be stored in the system. Much of this information already exists, both on a large-scale level, as with digitized maps of the country, and on a small-scale level, as with maps of the water mains in San José. We recommend *that El Cuerpo de Bomberos attempt to locate as much of this information as possible*. Though much of the information will need to be purchased, the resulting cost will be much less than that of paying someone to create the information from nothing, and the time saved will prove to be invaluable. However, it is important to verify that *all* information, whether collected from an outside source or created within El Cuerpo de Bomberos, is as accurate and as close to reality as possible. Though no information will be intentionally incorrect, mistakes are often made when dealing with the amounts of information that a GIS can handle.

Recommendation 6

We recommend *that El Cuerpo de Bomberos use the fire fighters as a source of information and input regarding specific system needs.* This includes asking for their opinions on important issues that arise during implementation and considering their needs while developing the system. The recommendations that we have made are based heavily upon the needs of the fire fighters, and, by keeping them involved throughout the implementation, El Cuerpo de Bomberos will be increasing the odds of success and acceptance of the new system.

Recommendation 7

We recommend *the use of the Winston-Salem Fire Department as a resource for information regarding system implementation.* The fire fighters and GIS staff of Winston-Salem have first-hand experience with the system and how successful it can be when applied to fire fighting. They have very recently completed the full implementation of a GIS and can offer abundant amounts of useful input regarding the requirements of and problems with GIS implementation. We have initiated contact and have verified that the GIS manager from Winston-Salem is interested and eager to help El Cuerpo de Bomberos' future meeting between the two organizations is very possible.

Recommendations 8

We recommend *that El Cuerpo de Bomberos, with the support of the INS, encourage the further development and enforcement of regulations allowing for building inspections and the control of hazardous materials.* Currently, the fire fighters do not have the authority to attain the information they need regarding the presence of hazardous materials and other, more general, human safety concerns. Because an information system such as a GIS is only as good as the information it contains, all needed information must be attainable in order for the GIS to suit the needs of the fire fighters.

Recommendation 9

We recommend *contacting CR·USA and other organizations regarding possible funding of the implementation project.* Contact with CR·USA, has already been established, and although all funding for this year is exhausted, they have expressed interest in this project for El Cuerpo de Bomberos. Contact information and a copy of the grant application are included in Appendix K. We also suggest a search for other organizations that may provide funding for this project.

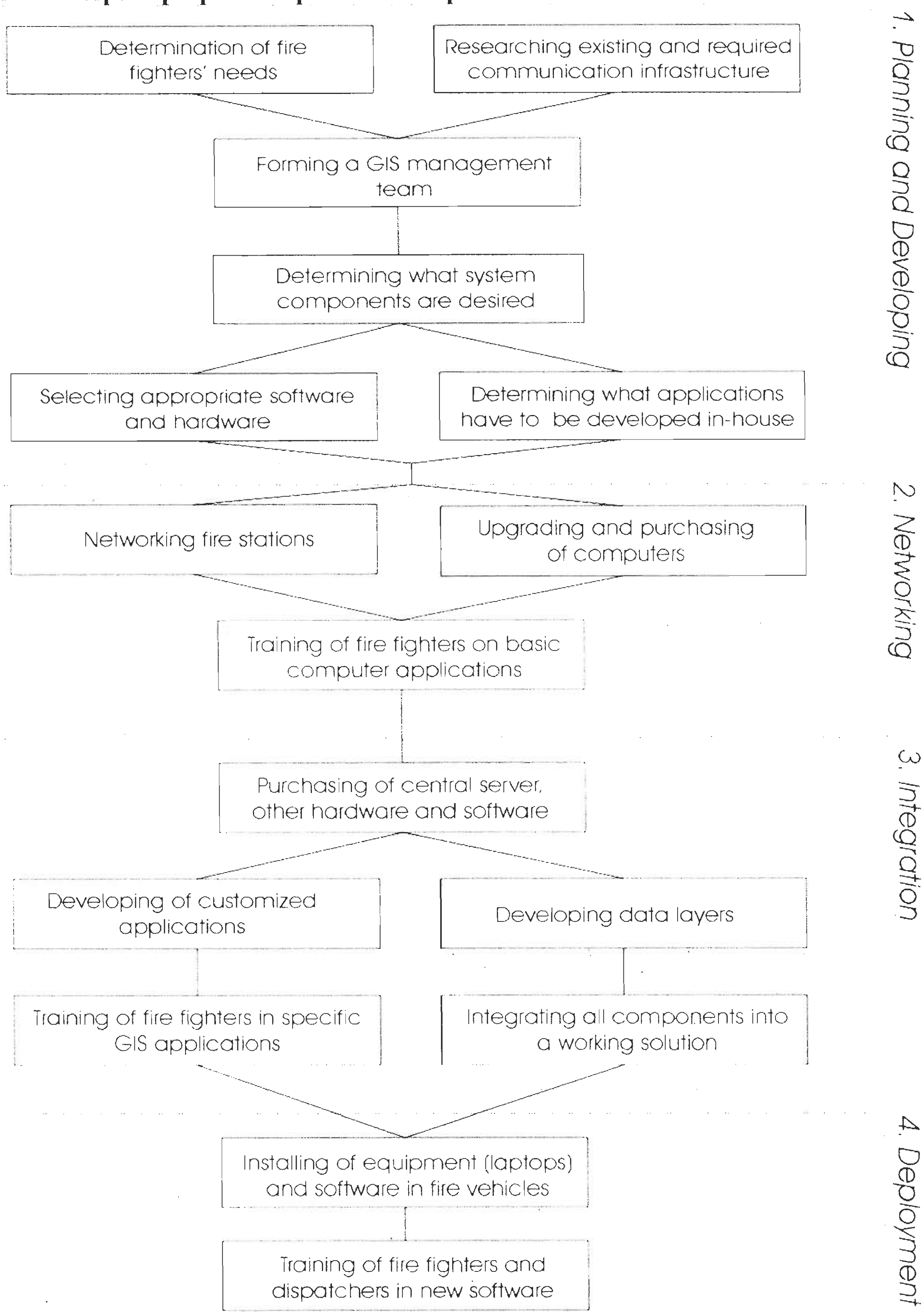
Recommendation 10

Our interviews revealed El Cuerpo de Bomberos' desire to become a world leader in fire fighting technology and methods. The fire protection engineering program with UCR is one of the few formal fire protection programs in the world and is a prime example of this pursuit. In continuation of this pursuit, we recommend *that El Cuerpo de Bomberos strive for a leadership role in GIS applications among the world's fire fighting community.*

Implementation Schedule

Based on our research and communication with the fire department of Winston-Salem we developed a schedule for El Cuerpo de Bomberos' implementation of a Geographic Information System. The important steps of this implementation plan, organized into phases, are illustrated in Figure 11

Figure 11—Steps in proposed implementation plan



Planning and Development

The first step in the planning and development phase consists of an analysis of the existing communication infrastructure. The data acquired in this process needs to be compared to the communication prerequisites an implementation of a GIS would require. This comparison will result in the determination of what upgrades and improvements need to be made to the existing infrastructure to allow the successful implementation of a GIS.

This first step also includes the identification of information most critical to the fire fighters at the scene of a fire. This information can be used in a later implementation phase in order to define the some of the data layers that a GIS should include. Besides critical information, features that need to be incorporated in the GIS software should be researched. Parts of this step have been completed by our study, including the identification of critical information needed at the scene of a fire. For more information on the completed parts refer to the results section of our paper

The second step in this phase includes the forming of a GIS management and development team. Forming this team includes the hiring of specialists and selecting experienced and trained personnel. This team will consist of experts in communication, computer science, fire engineering, cartography and various other fields.

In the third step of the planning and development phase, all major components the desired system will include need to be determined and the implementation of those needs to be divided into defined phases.

The fourth step includes the selection of appropriate software and hardware required by the desired system. At the same time, it needs to be determined what GIS applications and tools can be developed in-house and what applications need the consultation of an outside company. Developing an application in-house can be very cost-effective and allows a high degree of adaptation. At that point, a cost/benefit analysis needs to be conducted, in order to provide El Cuerpo de Bomberos with information about the most cost-effective system.

Networking

The first step of the networking phase includes establishing a network among all fire stations and connecting them to the existing network backbone between. Such a network will allow the stations to communicate with each other and also have access to the Internet. In order to create an adequate and effective network, the purchase of new computers and the upgrade of existing ones will be necessary. This step is an ongoing and very time-consuming process that may stretch over several phases of the implementation. However, at this point the second phase, including the training of fire fighters in basic computer applications and use, can be initiated.

Integration

The integration phase consists of three steps starting with the purchase of the central GIS server, workstations and commercial software. The database server and workstations should be installed at OCO, since it represents the center of communication of El Cuerpo de Bomberos.

The second step of this phase consists of the development of specialized applications that have been determined in the planning and developing phase of the implementation process. Based on the data collected in earlier stages the development of the different data layers incorporated in the GIS should be initiated. This process needs careful planning and might require the consultation by an outside company as done by the fire department of Winston-Salem when creating their centerline network layer.

The third step consists of the integration of all developed system components into a working solution. It will include extensive testing of software and hardware as well as trouble shooting of the finalized system. This step also includes training of the fire fighters in newly created GIS applications as well as in commercial GIS software, which is required to ensure the proper use and management of the system.

Deployment

The final phase in the implementation schedule represents an additional phase relatively independent from the other implementation steps. Its first stage comprises the purchase of additional laptop computers and the installation of hardware and software in the fire vehicles. Following this step is the training of the dispatchers working at the Office of Communications (OCO) and other fire fighters in the use of the new system. For more detailed information of a possible implementation of a GIS please refer to the data analysis of our paper.

APPENDIX A: Company Information

The Instituto Nacional de Seguros (INS) was created in 1924 by Minister of the House Tomas Soley Guell, under President Ricardo Jimenez Oreamuno. This office set out to establish basic guidelines for the handling of accidents on the job, in the street, or at home. Today, INS contains eleven agencies, three offices, and twenty-one dispatch locations in such Costa Rican municipalities as Nicoya, Cartago, Limón, and Quepos.

According to INS documents, they continue to strive to provide a strong infrastructure for social security. One method of achieving this is through the continued modernization of all its structures, resulting in an increased ability to provide for the public. The modernization improves administrative, technical, and human aspects, thus making security services more easily and rapidly available for the Costa Rican population (INS Guia Servicios 4-5).

El Cuerpo de Bomberos de Costa Rica, the Costa Rican fire department, is one of the bodies of INS. Before El Cuerpo de Bomberos came into existence, the country was extremely vulnerable to the dangers caused by fires. After numerous fire-related tragedies, the executive branch of the government approved the purchase of a fire pump from the United States on July 27, 1865, thus allowing the creation of the first fire department in San José. Fire-related problems grew in the early 1900's, as did El Cuerpo de Bomberos. In 1914, the chiefs and fourteen firefighters resigned after receiving negative criticism from governmental officials. By 1917, the number of fire fighters dwindled to the point where El Cuerpo de Bomberos was forced to merge with the police department. Without a strong fire department, problems with arson grew.

Beginning in 1921, dishonest merchants who had financial problems began to burn their property in order to collect insurance money. The government, realizing this was a serious problem, passed the Law of Insurance on October 2, 1922. This law was intended to end the insurance fraud and devote money towards the purchase of new fire fighting equipment. Once again, the fire department was able to grow. More equipment was purchased, more staff was hired, and fire trucks were acquired. In May of 1925, El Cuerpo de Bomberos became part of INS by national decree (an organizational diagram of INS can be found at the end of this appendix).

Today, the fire department has three hundred paid firefighters, one thousand volunteer firefighters, thirteen paramedics, two fire investigators, and multiple fire engines and ambulances situated in fifty-one stations throughout the country (Costa Rican Fire Dept. web page: http://www.ins.go.cr/bomberos/). All of these stations are run by an organized central administration, headed by the Director of Bomberos. The structure of El Cuerpo de Bomberos is also shown in a diagram at the end of this appendix.

Below the Director of Bomberos are the Technical Sub-director, who oversees the offices of operations and all of the stations as well as the engineers for prevention, and the Administrative Sub-director, who is in charge of administrative services and general services. The volunteer fire fighters' equipment is paid for by the INS, but outside of this there is an entirely independent structure of government for the volunteers. These areas strive for the same goal: to better the services the firefighters offer to the Costa Rican community.

In order to improve the services offered by El Cuerpo de Bomberos, the fire department coordinates and develops programs for fire prevention and protection. The Bomberos feel that with their knowledge and with the proper equipment, they can control fires and rescue people in various emergencies including fires, motor vehicle accidents, floods, earthquakes, medical emergencies, and other such emergencies that occur either regionally or nationally. The Bomberos also have the knowledge to assess and investigate the risks of fire, to make plans, and to create brigades for the control and combat of fire (INS Guia Servicios 29). All of its actions, El Cuerpo de Bomberos strives for excellence in public service based on the principles of self-denial, honor, and discipline (Costa Rican Fire Dept. web page: http://www.ins.go.cr/bomberos). Through these actions, the organization is able to continue to grow and evolve.

ORGANIGRAMA ESTRUCTURAL FUNCIONAL
DEL INSTITUTO NACIONAL DESEGUROS
Diciembre 1999

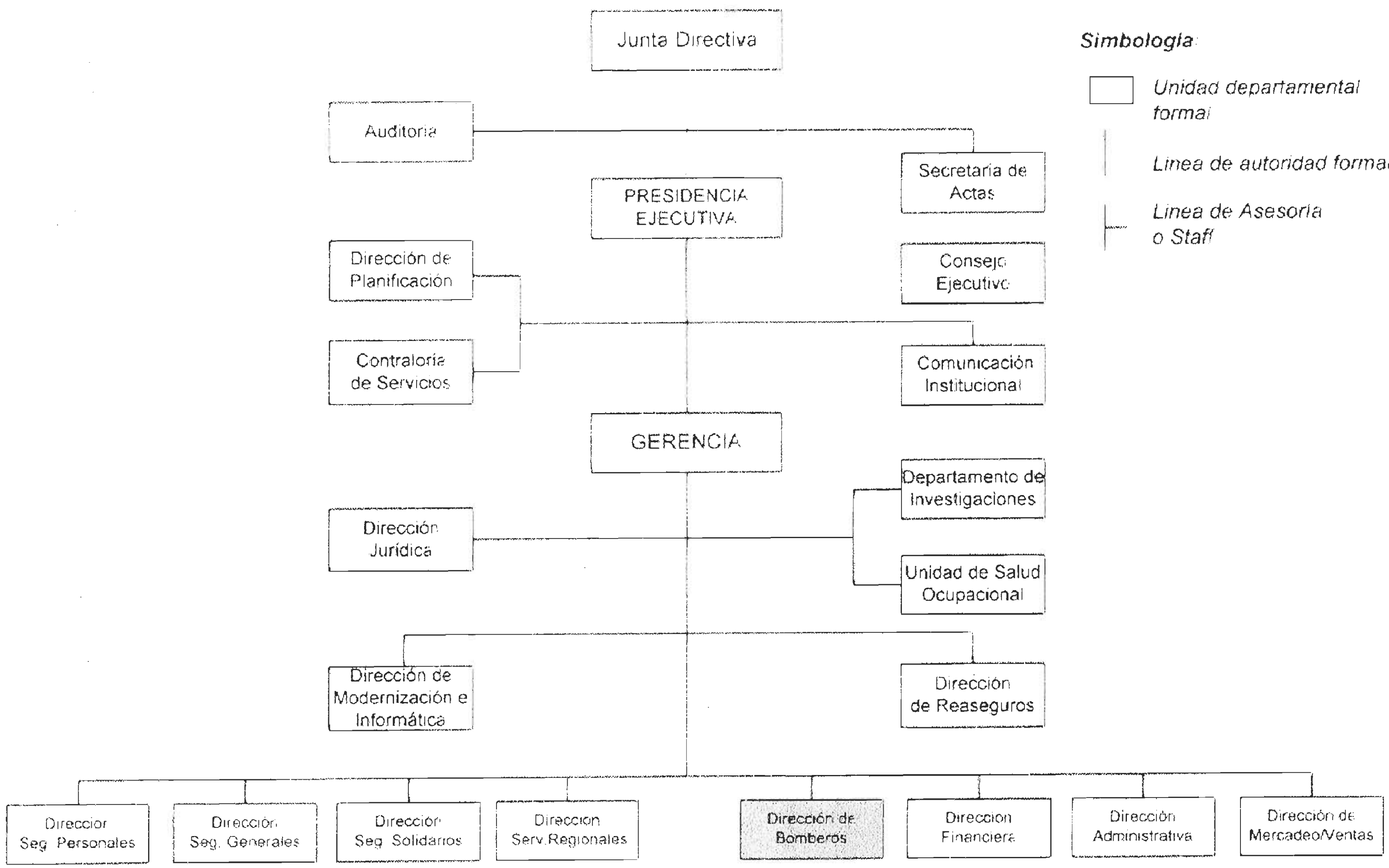


Figure 12. Organizational diagram of El Instituto Nacional de Seguros

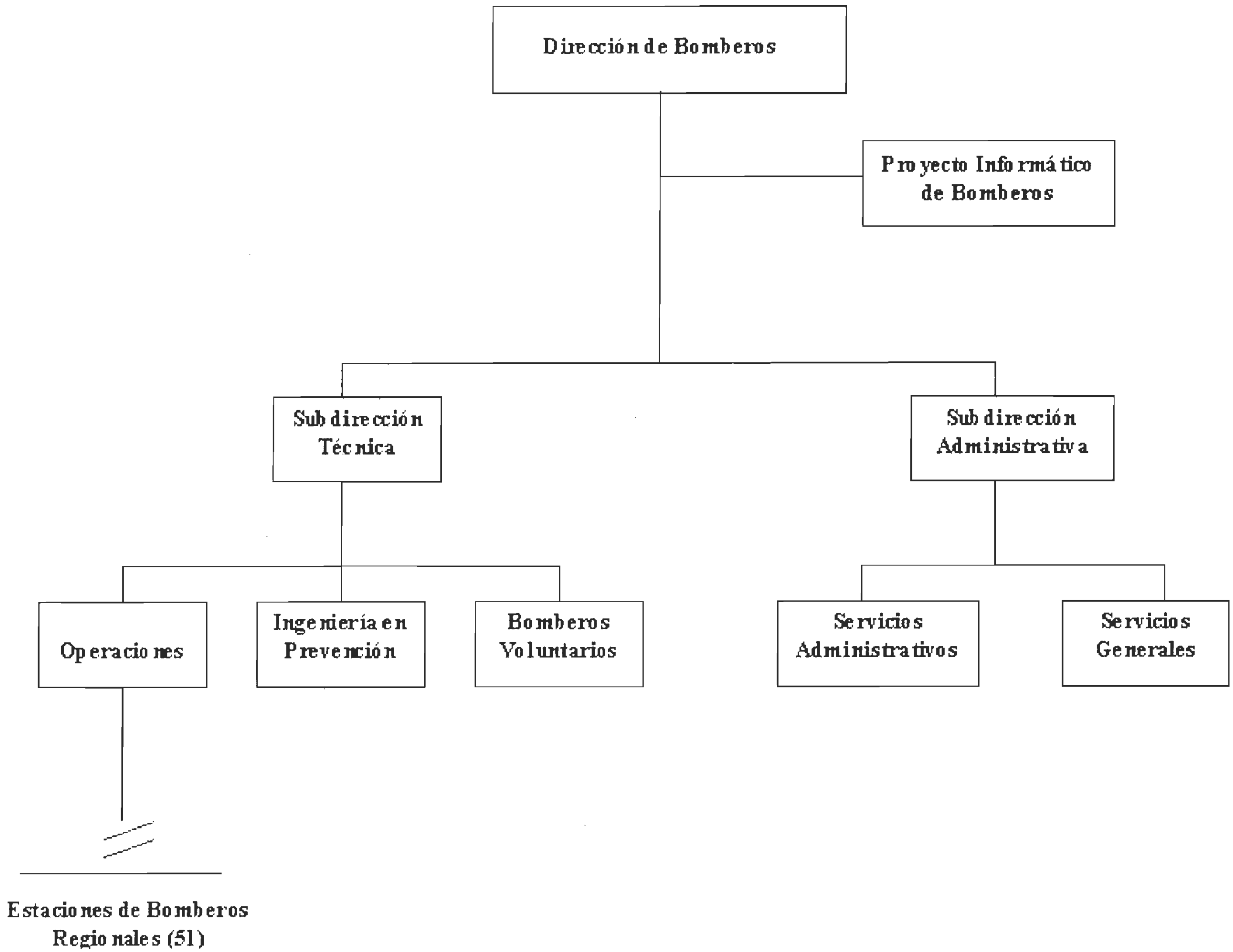


Figure 13. Organizational diagram of El Cuerpo de Bomberos

APPENDIX B: Figures and Tables

Table 3: Uses of a Shared System

APPLICATION / USER	City Engineer	Planning Department	Building Inspector	Tax Assessor	Traffic Engineering	Election Commission	Cable TV Administration	Health	Mayor's Office	Community Development	Fire	Police	Sanitation	Water Works	Forestry	Common Council	Street and Sewer Maintenance	Municipal Equipment Management	Outside Agencies	Public Information
Quarter Section Mapping	■	■	■	■	■		■	□	◩		◩	◩	◩	■	◩	◩	■		■	◩
Construction/Paving Plans	■		■		■									■			■			
Curb Lines	■	■	◩	◩	■		■					□		■	□		■		■	◩
House Number Atlas	■	■	■	■	■		■	■			■	■	■	■	■	□	■		■	□
Land Use Maps	□	■	■	■	◩		◩	□	□		◩	◩	□	□	□	□	□		■	□
Choropleth Maps	□	■	◩	◩	◩	□	◩	◩	◩	◩	◩	◩	◩	□	□	◩	◩		◩	◩
Zoning		■	■	■					□							◩			◩	◩
Plan Examination			■	□												□				□
Inspection Workload			■													□				
Violation Mapping		◩	■				◩	◩	□							□				□
Redistricting			■				□	□								□				
Tax Plat Mapping	■	■	■	■	■		■	□	□		□	□	□	■	■	◩	■		■	◩
Street Light System			□		■		◩							□		□	□		◩	□
Underground Conduit			□		■		□							□		□	□		◩	□
Traffic Signal Records			□		■		□					□		□		□	□		◩	□
Traffic Control Maps			□		■		□					□		□		□	□		◩	□
Accident Data		◩			■				□			◩				□			□	□
Election District Maps	◩	◩	◩	◩	◩	■	◩	◩	■	◩	◩	◩	◩	◩	◩	■	◩	◩	◩	◩
Reapportionment	◩	◩	◩			■			■							■				□
Cable TV Monitoring		□	◩		◩		■		◩					◩		■	◩		■	□
Violation Inspections		◩	■				■		◩							■				□
Inspection Management								■								□			□	□
Violation Mapping		■	■					■	□			□	□			□			□	□
Arson Investigation									◩		■	■				◩				
Incident Maps		◩							◩		■	■				◩				
Resource Allocation-Fire									◩		■	■				◩				
Crime Statistics									◩		◩	■				◩				□
Resource Allocation-Police									◩			■				◩				
Automated Dispatch												■								
Garbage Collection								◩					■			◩		■	◩	□
Snow Removal									◩		◩	◩	■			◩		■	◩	□
Off Street Parking		◩											■			◩		■	◩	□

Key: ■ = Used Continually ◩ = Used Frequently □ = Used

Source: Huxhold, W. E. (1991). An Introduction to Urban Geographic Information Systems. New York: Oxford University Press.

APPENDIX C: Glossary

Centerline Network: "a digital street map frequently used as a basic data layer in a GIS. Its level of detail is defined by various data attributes such as address ranges, speed limits or directions of one way streets. Centerlines are commonly created utilizing Global Positioning System (GPS) technology for the necessary data acquisition."

Centroid: "The center of mass for a two- or three-dimensional object."

FDDI network: "Fiber-Distributed Data Interface--a standard for data transmission on fiber optic lines in a local area network (LAN) that can extend in range up to 124 miles. In addition to being geographically large, an FDDI local area network can support thousands of users."

ISDN circuits: "Integrated Services Digital Network--a set of standards for digital transmission over ordinary telephone copper wire as well as over other media. In concept, it is the integration of both analog or voice data together with digital data over the same network."

LAN: "Local Area Network--a network of interconnected workstations sharing the resources of a single processor or server within a relatively small geographic area. Typically, this might be within the area of a small office building. Usually, the server has applications and data storage that are shared by multiple workstation users. A local area network may serve as few as four or five users or, in the case of FDDI, may serve several thousand."

Lickert scale: "A five-point scale, typically a graduated series of statements ascending from dislike to like, or low to high priority, used for statistical analysis."

MDC: "Mobil Data Computer--a laptop computer resistant to water, vibrations and other outside influences for use en route to or at the site of emergencies."

Planimeters: "An instrument for measuring the area of a plane figure by tracing its boundary line."

Stereo viewers: "A tool to aid in seeing pictures in three dimensions."

T1 link: "The most commonly used digital line in the United States, Canada, and Japan. T1 lines use copper wire and span distances within and between major metropolitan areas."

Transfer scopes: "An optical device for superimposing photographs or graphics on top of other graphics or maps, often used to quickly update maps by tracing."

APPENDIX D: Winston-Salem Information

Grant Information

In October 1996 the fire department of Winston-Salem, North Carolina initiated the "Information Network for Fire Operations" (INFO) project, which enables the fire fighters of Winston-Salem to communicate pertinent information in graphical form directly to the fire trucks and therefore increase efficiency in fighting fires. The INFO system was developed in cooperation with the Office of Telecommunications and Information Applications (OTIA), the Institute for Transportation Research and Education (ITRE), the Environmental Systems Research Institute (ESRI), CadZone and Altris Software Inc.

<u>OTIA</u>

The Office of Telecommunications and Information Applications (OTIA) is part of the National Telecommunications and Information Administration (NTIA) of the U.S. Department of Commerce. It assists state and local governments, educational and health care entities, libraries, public service agencies, and other groups in effectively using telecommunications and information technologies to better provide public services and advance other national goals. This is accomplished through the administration of the Telecommunications and Information Infrastructure Assistance Program (TIIAP)

TIIAP promotes the widespread use of advanced telecommunications and information technologies in the public and non-profit sectors. The program provides matching demonstration grants to state and local governments, health care providers, school districts, libraries, social service organizations, public safety services, and other non-profit entities to help them develop information infrastructures and services that are accessible to all citizens, in rural as well as urban areas.

Winston-Salem's INFO project was funded through a matching funds TIIAP grant by the Office of Telecommunications and Information Applications (OTIA) in October 1996. The grant covered approximately fifty per cent of the total project cost of $1,096,505.

Contact:	Mr. Dennis Newman
Address:	102 West Third Street Nations Bank Building, Suite 600 Winston Salem, NC 27101
Phone:	(336) 727-2846
Web page:	http://www.ntia.doc.gov/otiahome/otiahome.html

ITRE

Chartered by the North Carolina General Assembly in 1978, ITRE conducts research, education, and technical assistance projects on a wide variety of surface transportation and municipal issues. These projects include extensive work for the North Carolina Department of Transportation's Division of Highways and Public Transportation Division, as well as other state and municipal agencies in North Carolina and surrounding states.

Administered by North Carolina State University and located on Centennial Campus, ITRE is part of an advanced academic community that facilitates the performance of research, training, and technology development to solve problems and to create new products, better services, and smarter workers.

As a non-profit, systemwide university transportation center, ITRE draws from the professional and technological resources of the 16-campus University of North Carolina system and Duke University in addition to universities throughout the Southeast. ITRE's strategic alliances with other federal, state and local entities, and private consulting firms enhance the breadth of its services to the transportation community.

Contact: Environmental Systems Research Institute

E-mail: info@esri.com

The CAD Zone

The CAD Zone Inc. was founded in Beaverton, Oregon in 1990. Besides offering consulting in computer-aided design, training, and other CAD related services, The CAD Zone primarily focuses on application development in the field of computer-aided design.

In 1992 The CAD Zone developed a CAD application called Fire Zone™, which is an imaging tool that aids fire fighters in creating and re-drawing pre-fire plans. Currently Fire Zone Version 4.0, developed for Microsoft® Windows™ 95/98/NT is being used by several fire departments throughout the U.S. including the fire department of Winston-Salem.

Winton-Salem´s fire department purchased Fire Zone in order to be able to re-draw all of their pre-fire plans in a more accurate manner. Moreover, Fire Zone enabled the fire fighters to digitize all pre-fire plans and therefore incorporate them in their GIS.

Contact: The CADZone

Address: 7950 SW 139th Ave
Beaverton, OR 97008

Phone: (800) 641-9077
(503) 641-1342

Fax: (503) 641-9077

Email: info@cadzone.com

Altris Software Inc.

Altris Software Inc was created through the fusion of three imaging software and hardware companies in 1996. It develops robust, scalable and highly innovative solutions that manage, control and disseminate the knowledge contained within an organization's

From this network of resources and strategic alliances, ITRE provides quality end products and technical support that improve the transportation systems of the region and nation.

In 1996, ITRE developed a Municipal Street Centerline Network for the fire department of Winston-Salem in order to provide a basic routing framework for their system. The development of this centerline network involved utilizing Global Positioning satellite (GPS) technology in order to create basic street maps of the area that is to be covered by the fire stations. This centerline network can be utilized by GIS software to determine the optimal route to the site of an incident. The cost of the centerline network was approximately $50,000.

Contact: Greg Bowles, MA, Director

Address: North Carolina State University
Box 8601, Centennial Campus
Raleigh, NC 27695-8601

Phone: (919) 515-8038

Email: gbowles@unity.ncsu.edu,

ESRI

The Environmental Systems Research Institute (ESRI) was founded in 1969 as a privately held consulting group. ESRI offers a wide variety of GIS software and services, including training and consulting.

During Winston-Salem's implementation of a GIS, ESRI supplied all of the GIS specific software upon which the routing application, RouteMap, was constructed. ESRI was also involved in much of the design and development work of RouteMap, and offered some consulting during the implementation.

documents, enabling an organization to gain e-business competitive advantage. Altris Software also provides documents as a service to customers' line-of-business and other critical applications, which manage the change of information content throughout the document lifecycle.

contact: Altris Software Inc.
Email: info@altris.com

Correspondences

Dear Mr. Kureczka,

My partners and I are students at the Worcester Polytechnic Institute and are currently involved in a project concerning the implementation of a GIS for El Cuerpo de Bomberos, the fire department of Costa Rica. After determining the necessity and feasibility of a GIS for Los Bomberos, we are now looking for the most adequate system.

In order to find the best system we were looking at several case studies including the Winston-Salem project. It seems to us that most parts of the system used in Winston-Salem could also be applied to Los Bomberos' situation in Costa Rica. We were wondering if you would be able to answer a few questions concerning the implementation of the GIS in Winston-Salem. First we like to give you some background information about the current situation in Costa Rica and the problems Los Bomberos is facing.

The system of collecting, maintaining and utilizing data, which is currently used at Los Bomberos is mainly depended on paper records or even the memory of a single fire fighter. Moreover, the communication starting with the incoming call until the final dispatch to the appropriate unit is difficult and rather complicated, since it is solely depending on radio transmission.

When a 911-call comes in, it gets automatically connected to the Communication Center of Los Bomberos. There, an operator receives the call and writes down the most important information about the incident. Now the local database, residing on a server at OCO, gets searched for the location of the incident. The information stored in the database includes information about hazardous material and hydrants. Additionally to that information, the location and type of fire gets transmitted over radio to the responding unit.

The currently used database, SIBO, is able to display available fire trucks, so the operator can manually choose, which fire truck should respond to the incident. Unfortunately, SIBO is totally text based and the information included is very limited.

According to our research, including interviews with chiefs and engineers and also a survey that was distributed among all permanent fire fighters, the information that is needed at the site of the incident is much more than the information that is actually provided. We came to the conclusion that a GIS will be the best solution to fix the mentioned problems.

However, we do realize that a project like Winston-Salem was done on a much smaller scale than it would be in Costa Rica. Los Bomberos has 50 fire stations distributed all over the country. The current population is about 2.8 Million. At this point we are not exactly sure, if there is an existent MAN or if there is any kind of network installed that could be used as a basis for a GIS.

We hope this little background information is enough to understand Los Bomberos' current situation. The following is a list of questions that came up, when reading through the Winston-Salem presentation paper:

1. Data acquisition.
   At the moment there exist no basic street maps in a digital format. Los Bomberos will have to build up a street centerline network. Do they have to hire a company to do that for them? How much effort and time is involved in such a procedure?
2. Network requirements.
   What are the minimum network requirements to interconnect all stations and enable GIS communication? Do you think a system like the one in Winston-Salem will be scaleable to the size of Costa Rica?
3. Data digitizing.
   How time consuming is digitizing all basic data? How high are the costs approximately? Did you hire GIS experts?
4. Other applications.
   Did you consider using fire-specific GIS applications if they existed at the time of the Winston-Salem project. What are your thoughts on FireView (An Application that was released by the Omega Group in January 2000)?
5. Addresses.

Costa Rica does not have a sophisticated addressing system. Do you think a GIS will still be able to work for Los Bomberos?

6. Training.
   How much training is necessary? What are the essential positions for a GIS management (GIS Manager, Analyst, etc.)?
7. After implementing a GIS for Winston-Salem, do you think that this system improved the situation for the fire fighters?

Your response is very important for us and Los Bomberos. Thank you very much for your help and time.

Best Regards,

Felix Rieper
Lucas Churchill
Shauna Malone
Jimmy Cook

Hi Felix-

I hope I provide some insight for your project.

1. Data acquisition.
At the moment there exist no basic street maps in a digital format. Los Bomberos will have to build up a street centerline network. Do they have to hire a company to do that for them? How much effort and time is involved in such a procedure?

If you want an accurate centerline (graphic and attribution), yes, I would consult out to acquire this layer. Unless there is an agency who can develop it in-house. This will be your most pertinent data set. Get it right the first time.

Planning for this type of data acquisition takes some time for database design conceptualization. Questions like ... What data attributes (items) do you want in the centerline besides the address ranges, etc ... during GPS capture ? Who will maintain such a coverage (not to mention the entire system maintenance and other data sets) ? should be asked.

2. Network requirements.

What are the minimum network requirements to interconnect all stations and enable GIS communication? Do you think a system like the one in Winston-Salem will be scaleable to the size of Costa Rica?

With INFO, all the GIS data resides on the laptops in the fire vehicles. Communication from dispatch (radio) communicates the incident address with the appropriate haz mat, physically challenged, and pre fire flags to the designated station (laptops) ... which dispatch software captures and then passes the address to the routing and imaging application on the laptops.

Sure. I believe you can package (zip) the updated data sets on a periodic basis and FTP it to the 50 stations ... then load and explode it on the devices. The amount of locations 2, 17, or 100 ... it should not matter ... as long as you have procedures/methods/scheduling in place.

3. Data digitizing.
How time consuming is digitizing all basic data? How high are the costs approximately? Did you hire GIS experts?

The centerline was the only data set we consulted out (~ 50K+ at the time). All other data sets, we digitized in-house (hydrants, fire station locations, fire demand zones), or already existed (we enhanced hydrography and railway), or address matched (pre-fire, haz mat, physically challenged, multiple addresses) on the centerline that was GPS'd.

We hired a part-time GIS tech to digitize the hydrant point data (with an unique key) that was located on hard-copy maps derived from the FDZ's. Each fire home territories (station areas) inventory their areas for hydrants, etc ... we captured this and developed the hydrant coverage.

I would say data acquisition is very important. Your application is as good as your data. Spend time on developing the data correctly (verify/QA/QC is a must) or it will come back to haunt you later when your in maintenance mode.

4. Other applications.
Did you consider using fire-specific GIS applications if they existed at the time of the Winston-Salem project. What are your thoughts on FireView (A Application that was released by the Omega Group in January 2000)?

FireView was not available at the time. We wouldn't of utilized this type of application or software ... The Fireview package is an "after the fact" analysis tool. No good for LIVE (on the fly) suppression activities that we are conducting here at the City. We opted for MapObjects that was customized/integrated to our environment. Each situation will be similar and different in many aspects. FireView can be helpful to Fire Administration for tactical purposes. I can see this to very helpful in this regard.

5. Addresses.

Costa Rica does not have a sophisticated addressing system. Do you think a GIS will still be able to work for Los Bomberos?

Yes, There is always a way. This will have to be looked into concerning your dispatch and phone systems. If address ranges are sparse (my guess in the rural areas) I would look to utilize possible
x,y location identifiers to find the closest road to route to. Also maybe instead of utilizing the centerline to interpolate, like INFO (address matched data points (haz mat, phy chal, pre fire in our case), digitize the pre-determined building locations with an identifier (x,y / new address, etc) so the address or this new identifier can be identified from your CAD dispatch system and go directly to the point instead of geocoding on the centerline.

6. Training.
How much training is necessary? What are the essential positions for a GIS management (GIS Manager, Analyst, etc.)?

GIS is just a part of the whole solution. Obviously, dedicated/experienced personnel from Information Systems, Telecommunications, CAD dispatch, Imaging, GIS, and Fire disciplines must be involved during the entire process. Definitely a team approach.

GIS experience wise, I would say DB design, development, application development and maintenance experience (app dev for maintenance routines for the users) should be in check.

Also the ability to be flexible on what if scenarios (see the big picture - open mindedness is key).

7. After implementing a GIS for Winston-Salem, do you think that this system improved the situation for the fire fighters?

Yes. The ability to have "all" the information needed at the site, routing from a origin and to an incident quickly, etc ... is pertinent. The data is presented to the fire fighters in the field so they can make quick decisions at the incident to save lives ... INFO does this well.

Tim Lesser
Senior GIS Analyst
City of Winston-Salem Information Systems
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(336)727.2846 ext.3439
(336)727.2874 fax
timl@ci.winston-salem.nc.us

Tom:

El Cuerpo de Los Bomberos and we would like to thank you for your help and assistance with our project. Winston-Salem s INFO project is probably the best example of a successfully working GIS system for fire fighting. You already encountered many problems, which Los Bomberos is still going to face during the implementation of their system. They are planning on implementing the system in the coming three years. We believe that Los Bomberos can learn a lot from the INFO project, even use it as a guideline in the implementation of their system. Most features and requirements of the system for Los Bomberos are very similar to the ones of the INFO project, although the location and environment is obviously different in Costa Rica. For all these reasons, we would like to upkeep a good communication between
Winston-Salem and El Cuerpo de Los Bomberos in the future. We were wondering if it might even be possible that Costa Rican fire chiefs come and visit the fire department of Winston-Salem to take a look at your system or setup some kind of conference. Since a system similar to the INFO project is a major investment for Los Bomberos, it will be very important for them to see a system like this in action. Please let us know, what you think about this idea. Thank you very much for
your help.

Regards,

Felix Rieper

Hi,

I am glad to hear that the information on the INFO technology was of value to your group. I was happy with the response Tim Lesser put together to your list of questions.

In regards to a visit to Winston-Salem - We in the I.S. Department will accommodate a visit and spend time with you the best we can around our schedules.

I suggest that you work directly with the Fire Department on a site visit. We in I.S. work closely with them, and we would coordinate time with your staff. They would be critical to a successful visit, and could work with you in scheduling demonstrations and time with Fire personnel. I have copied the two key contacts in the Fire Department on this response to keep them aware of your interest. They are Chief John Gist and Carolyn Bailey.

Regards, Tom Kureczka

Felix,

Tom K has asked me to respond to your specific questions regarding CAD and the MDCs. By way of introduction, I'm a COBOL programmer. I maintain the Police and Fire CAD systems and was a member of the INFO project team.

1) I assume the E911 Computer-Aided Dispatch mainframe system is located at a central location in the City of Winston-Salem.

You assume correctly. Mainframe is located in City of W-S Data Processing Center at Liberty Street Plaza - 102 W 3rd St. Police/Fire Communications is located at 725 N Cherry St - about 4 blocks north.

2) When an emergency call is received, does the CAD information get automatically transferred to the MDC s in the fire trucks? How much does the operator do in this process?

Sort of. E911 call comes in. Caller, address info, etc. transferred to CAD using a function key. Additional info entered by Calltaker. Call then transferred to Fire Dispatcher at another work station in the same room. Dispatcher displays call, CAD recommends apparatus based on location, availability and type of fire. Dispatcher dispatches alarm. CAD determines if apparatus' MDC is logged on. If so, call is transferred to MDC via COMS and radio.

3) Does the operator access the GIS database to get the pertinent CAD data and then transfers it to the dispatched truck or is the CAD mainframe itself connected to the GIS database?

Neither. GIS information pertinent to CAD is on the hard drive on the MDC. DataLink message switch sends 2 copies of dispatch record to MDC. One displays in the dispatch buffer on the DataLink window. Second is passed on the the Routing program which draws the map from the fire station to the alarm location.

4) Does the fire station the fire truck belongs to get notified at the same time?

Yes and no. There is no computer notification at the station. Only the audible via radio.

5) Does the fire station also communicate to the dispatched vehicle or just the central communications office?

Yes and no. Again there is no computer communications but there is radio communication.

If I can be of further assistance, please feel free to contact me directly. Looking forward to your visit!

ESRI Report

Final Project Report
City of Winston-Salem, NC
Integrated Network Fire Operations (I.N.F.O.)
Grant Number 37-40-96007

Project Goals and Objectives

The City of Winston-Salem was awarded a Demonstration project grant by the Telecommunications and Information Infrastructure Assistance Program. The project was in the area of Public Safety and titled Integrated Network Fire Operations (I.N.F.O.). The primary goal of the project was to provide critical information in graphical form to firefighters in emergency vehicles. The intent was to reduce the time to respond to emergencies and to provide information that would improve decision-making by firefighters during an emergency. Another goal was to provide access for Fire Department personnel assigned to various remote stations throughout the City to the information network utilized by other City personnel. Both of these goals were directed towards enhancing the services of the Fire Department for City residents and surrounding communities. Our success in achieving these goals can be measured in saved lives, a decrease in injuries, reduced property damage, and other service metrics. These metrics are defined and discussed in more detail in the accompanying 'Formal Project Evaluation' report.

One of the objectives of the project was to make effective and efficient use of computer technology to provide the firefighters more timely access to accurate data. Available technologies could provide the firefighters with data in an electronic graphical format that would greatly improve the effectiveness of paper maps and notebooks. Examples of important information include hazardous material, fire hydrant locations, building floor plans, physically challenged occupants, and utilities data.

Another objective was to build upon the City's existing information technology infrastructure and the staff's technical skills. Our approach in regards to providing network access for the remote fire stations was to utilize Integrated Services Digital Network (ISDN) technology with our existing Fiber Distributed Data Interface (FDDI) based metropolitan area network. We had in place a strong Geographical Information System (GIS) infrastructure based on the product suite available from Environmental Systems Research Institute, Inc. (ESRI). We had some core GIS coverages that we knew we could build upon for the I.N.F.O. project. We also had in place a proven Computer Aided Dispatch (CAD) system on one of our mainframe enterprise servers, and an interface between CAD and Mobile Data Terminals (MDT) in all fire vehicles. Our plan was to integrate all of these proven technologies, with the addition of new technologies such as Global Positioning System (GPS) and Electronic Document Management, into an integrated solution running on our City network. In addition, this integrated solution needed to be implemented in a manner that would allow for future growth and upgrades.

Project Accomplishments

As part of preparing our application for the TIIAP grant we had prepared a requirements definition of the project, a budget, and a high level project plan showing major tasks and milestones. Upon receiving the grant we organized our team and held a project kick-off led by the Fire Chief and the Information Systems (I.S.) Director. We also began expanding the project plan to much finer levels of detail.

The original structure of our core team makeup, as defined in our grant application budget narrative, was a Project Manager, Lead Systems Analyst, GIS Administrator, and an End User Trainer. All of these roles were to be filled by I.S. personnel. This core team was soon augmented by additional Fire and I.S. personnel. From I.S. we added a Telecommunications Specialist, an Imaging Analyst, and a mainframe Systems Analyst. The amount of time each participated in the project varied throughout the two year duration based on need and appropriateness. We also had several members of the I.S. Technical Services staff provide support at times. The Fire Department provided a Fire Planning Officer who was on the core team and acted as the Fire Department's leader for the project. In addition, several senior firefighters were on the team.

Besides the City staff that were on the project team our resources were expanded by several vendors that played key roles in the project's implementation and success. Each of these vendors provided one or more individuals to the project . The vendors included:

- Environmental Systems Research Institute, Inc. (ESRI) - they provided the product set that the routing component is built upon, consulting, and programming services.
- Institute for Transportation Research and Education (ITRE) - they provided consulting for the GPS data collection and creation of the street centerline file.
- ElectroCom Communication Systems - they provided a windows based version of the existing software that was running on all Mobile Data Terminals (MDT) in each fire vehicle.
- GhostWriters - a local technical consulting firm, for the provision of a training and technical writing consultant. We had determined that the use of an outside contractor was more practical and efficient then the original intent of hiring a part-time City employee for this work.
- DataServ - a subsidiary of BellSouth that provided contracting assistance with the installation of the ISDN network.
- RCS Communications Group - a local mobile radio dealer that provided contracting resources for the installation of the equipment into the fire vehicles and the integration of the solution into our existing radio network.

One of the obstacles we had to overcome was the resignation of the project leader approximately one year into this project. I.S. did not have another staff member with the required project management skills available to lead the project. It was decided that we would manage the project with a partnering solution. The I.S. Applications Supervisor and the Fire Planning Officer were asked to jointly lead this project to completion. This approach included the division of some tasks such as vendor interface and negotiations, budget tracking, management reporting, and resource scheduling; and collaboration on other project management tasks such as project status tracking and coordination of activities. These two individuals worked very closely over the remainder of the project while continuing to perform their other job assignments. One of the reasons this approach to the staffing obstacle was successful was the willingness and ability of the other project team members to step up in their contributions and leadership towards the project. This issue reinforced the need for cooperation between Fire and I.S. staff not only at a technical level but also at a management level.

We used several mechanisms to keep people informed of our progress. We met as a team on a weekly basis to review status, including prior week's accomplishments and missed milestones, scheduled tasks for the next week, and issues and concerns. We published a project newsletter on a regular basis to keep all interested parties informed on the project's progress. Additionally, Web technology was utilized to distribute information on the project to a wider audience. This included I.N.F.O. Web pages on both the Internet and the City's Intranet as well as e-mail utilization. One advantage of using the Web was the capability to work with both ESRI and ITRE to create hot link buttons to each associated Web site. We have made many presentations on the project to outside organizations, as listed in the accompanying document. These communication channels have proven to be valuable in meeting one of the requirements of receiving a grant as a Demonstration project -

"...demonstrate new, high-impact, useful applications of information infrastructure which hold significant potential replication in other communities".

The project was defined with three distinct phases. The first phase was to design and implement the ISDN network for all 17 fire stations and to install personal computers in each station, providing access for these stations to our City-wide network. The second phase included the development of the software applications and the related data files and GIS coverages. The third phase included the installation of the equipment and software in all fire vehicles and rolling out the application into our daily operations.

The first phase was successfully implemented as originally planned. The computer and network hardware was procured for all 17 stations. The ISDN lines were installed at each station and integrated into the ISDN network cloud that is connected to the City network. The expenditures for this stage are listed along with all project expenditures in the accompanying 'List of Project Expenditures' report. The City's standard desktop software was installed at all stations, providing each station access to e-mail, office automation tools, and the Internet. A server and personal computers were also installed at the central Fire Administration Office, all with the same office automation and Internet software. The server is directly linked to the FDDI network and provides access to our network for Fire administrative staff. Training was conducted for Fire personnel for all of this new software and equipment.

We experienced some initial technical problems with the ISDN lines. After a short period of experiencing these start-up problems we were able to stabilize the ISDN cloud. Presently the users are part of the City's Novell Directory Services (NDS) tree structure. The use of ISDN technology for remote fire stations has proven to be very cost effective while providing quality network services for the users. The success of the I.N.F.O. project's use of

ISDN technology supported the decision to use an ISDN solution in follow-up network installations involving the Office of Emergency Management Services, again with pleasing success.

The second phase was centered around the development of the software applications and the related data files and GIS coverages. This phase consisted of several major milestones which were accomplished through sub-tasks that included much work in parallel. These milestones were:

- Detail design of the integrated solution
- Creation of City and County street centerline files
- Creation of supporting GIS coverages
- Development of the GIS based routing application (RouteMap)
- Development of the Imaging application and data structures (INFOImaging)
- Development of windows version (DataLink) of the existing Mobile Data Terminal software
- Integration of these components with the CAD system into our Radio network

We held design sessions with the various vendors to produce a detailed design flow document. Mounted in each fire emergency vehicle is a ruggedized Mobile Data Computer (MDC), also referred to as a RoadRunner Laptop, equipped with the DataLink, RouteMap, and INFOImaging software components. Graphical data including street and address locations and floor plans are also available. The City's E911 Computer-Aided Dispatch (CAD) mainframe system identifies the closest available fire vehicle(s) for the incident type and location. Emergency dispatch information is transferred over radio frequencies to the MDC in each fire vehicle dispatched to the incident. The CAD dispatch information received by the DataLink software includes the address location of the emergency site, details on the incident type and other responding units, and indicates whether pre-fire survey, hazardous material, physically challenged occupant, and/or multiple address information is available for the location. The Computer Aided Dispatch information is passed from DataLink to the RouteMap application where it is used to determine and display the quickest route to the emergency site.

If the location has a pre-fire survey, hazardous material, physically challenged occupant, and/or is a multiple address location(i.e. apartment complex) an imaging system button is enabled and the firefighter can graphically view the information by pressing (touching) this button. Once the firefighter initiates this process RouteMap passes the incident address to the imaging control and the associated information is automatically displayed. If several documents exist for the location, (for example, a location may have a pre-fire survey and hazardous material data associated with it) the firefighter is presented with a list of documents from which to choose. Moreover, any one of the GIS point coverage icons, which were derived by way of address matching, (pre-fire survey, hazardous material, physically challenged, multiple address, as well as hydrants, schools, fire stations) when touched, immediately passes the associated unique key contained in the GIS shape file to INFOImaging where the information is displayed.

Our original plans were to produce a street centerline file using the City's existing Planning and CAD street files and GIS cadastral coverage. As we proceeded we soon realized the amount of manual effort, research, and reconciliation that would be required, and became concerned with the impact this would have on our schedule and the quality of the final product. We discussed this issue with ITRE and worked with them on a proposal that detailed ITRE providing consulting services to assist us in producing a centerline file. This work included Global Positioning System (GPS) data collection of all City streets, data preparation, and post processing. We followed this up with the same procedures to produce a County wide centerline file, working closely with our peers in Forsyth County. Crews from

ITRE, Winston-Salem, and Forsyth County drove along all street segments inside the county collecting data. Many staff members from the City and County performed quality assurance checks and updates to the file once we received it from ITRE. On-going maintenance continues to be a joint effort.

The City and County are working together to ensure that timely and accurate maintenance of the centerline files continues. The files are consistently being maintained by way of GIS applications developed with Arc/Info. Centerline data includes address ranges, arc segment(s), a.m./p.m./normal impedances, relative overpass elevations, turning movements allowed, a.m./p.m./normal MPH speed limits, and one-way streets. To ensure the quality of this information a form has been created and disseminated to various government agencies to be completed as new roads are established.

The success of RouteMap depended on the development and availability of several GIS coverages in addition to the centerline file. The development of the database involved data collection from multiple sources, including paper maps, city and county mainframes and existing GIS coverages. New GIS coverages that were developed are briefly described below, with more detailed descriptions found in the accompanying 'Data Bases and Structures' report.

Fire Demand Zones (poly)

The fire demand zone (FDZ) coverage was initially developed for this project using screen digitizing with paper maps as reference. It continues to be updated/corrected as the Fire Department reviews the hard-copy hydrant maps plotted for each home territory cluster. The maps are encouraging the Fire Department to analyze more closely their territory and to correctly locate and edit FDZ lines. This process is critical because hydrants have a unique numbering scheme based on their assignment to FDZ polygons.

Fire Station Locations (point)

Initially, the fire station address locations were parcel address matched to the cadastral coverage. Although the majority of stations matched on the first run, others were address matched via Fire Department feedback. This was due to the lack of address attribute information in the cadastral coverage. Since the fire station locations will be used in the majority of origin points for the RouteMap application, address matching to the centerline was pertinent. These locations, when address matched, were positioned near the centerline rather than within parcel polygons as before.

Hazardous Material Locations (point)

Hazardous material location address data was extracted from the CAD mainframe and address matched to the centerline for the entire city. This hazardous material information is uploaded to CAD from Emergency Management for locations meeting Right-To-Know reporting requirements. Only attribute data will be displayed for hazardous material locations without a pre-fire survey. Locations are linked to the INFOImaging application via an address attribute in the GIS point coverage.

Hydrant Locations (point)

Hydrant address data existed in the CAD mainframe, but the addresses were not accurate to the exact spatial locations. Moreover, there were many instances where multiple hydrants had the same address, i.e. shopping centers, hospitals, etc. The address matching in this case would place several hydrants on top of one another, hence incorrectly. The solution was to create hard-copy maps for each fire home territory cluster (clusters being "sub-set" areas within a home territory) showing FDZ polygons. The fire department identified the hydrant locations on the maps that were later digitized into the coverage. The unique hydrant number used in CAD requires the FDZ number in addition to the hydrant number within the specific FDZ. Using the same key in the coverage allows CAD hydrant information to be joined to the hydrant points via this unique hydrant number.

Hydrography Network (arc)

The hydrography coverage already existed for the entire county. To improve utilization of this coverage attribute items of name were added. Flow-rate is to be added in the future. The Fire Department can identify a stream, river, or a water body and its flow-rate in event of a chemical/hazardous material incident. For example, neighborhoods down stream of an incident can be alerted of the danger and evacuated if necessary.

Multiple Address Locations (point)

The multiple address location (MAL) coverage identifies locations without a pre-fire survey that have an overview diagram identifying the sub-address locations. These images of the entire layout of apartment complexes, mobile home parks, and offices can be displayed to the Fire Department to locate sub-addresses. RouteMap was designed to route only to the "main" address point which is interpolated to the centerline address ranges. Points of MAL's have this "main" address linked to INFOImaging to display the layout of apartment and mobile home buildings and numbers, as well as floor plans of office buildings.

Physically Challenged Locations (point)

These point locations are address matched from CAD generated addresses to the centerline. Main address data for physically challenged locations is matched to the points and "sub-addressed" data (apartment, suite, lot locations) is displayed in INFOImaging application. The floor plan of the physically challenged occupant's location will be displayed through the image.

Pre-fire Survey Locations (point)

Pre-fire survey location address data was extracted from the CAD mainframe and address matched to the centerline for the entire city. This process identified corrections needed to the centerline. Each pre-fire survey location links to INFOImaging via an address attribute in the GIS point coverage.

Railway Network (arc)

Only railway graphics of the county existed, with no attribute data attached. The name attribute was added and populated into the coverage to detail and identify the ownership of the networks.

School Locations (point)

School point locations were derived from address matching from the parcel (cadastral) coverage. Updates and/or corrections will be made when new schools are built and changes in name or address are determined.

Development of the GIS based routing application, RouteMap, involved much design and development work with ESRI. The firefighters on the project team played a very critical role in the design of this application, bringing their many years of experience to the project.

RouteMap was developed using Microsoft Visual Basic 5.0 and MapObjects and NetEngine software (Environmental Systems Research Institute, Inc.). This application was the first integration of MapObjects and NetEngine by an ESRI customer. Some major features of this application include:

- Recommends quickest route to the destination emergency site
- Provides text description directions of route
- Provides graphic pan/zoom capabilities to display route or part of route, and undo to previous map extents
- Identifies fire hydrant locations
- Highlights the presence of critical information within the vicinity of the emergency site, such as hazardous materials, pre-fire surveys, and physically challenged occupants
- Provides link(s) to the imaging component
- Identifies multiple address locations such as apartment complexes, mobile home parks, office buildings
- Allows change to origin or destination of a route through address key-in, x,y SP-NAD83 coordinates, and cursor input
- The ability for routing to bypass long term arc segment road closures coded in the centerline pre-process
- Provides the capability of closing and opening street segments from routing use and to regenerate route "on the fly", in case of temporary blockage, such as impassable street segment(s) from ice storms or trees down
- Allows selection of optional map layers to display, including FDZs, home territories, schools, hydrography, and fire stations
- Provides ability to select all feature icons and view GIS tabular data
- Allows routing directly to existing pre-determined GIS point addresses that match incident address for pre-fire, hazardous material, physically challenged, and multiple address coverages, eliminating the additional step of geocoding

Development of the imaging application (INFOImaging) was performed in-house by I.S. staff.

It was designed to provide detailed information to firefighters while en-route and on the scene. It was developed using Microsoft's Visual Basic 5.0 and Lead Technology's LeadTools Pro Express software development products. It was written utilizing a custom ActiveX control, which enhanced the interfaces of the component with other I.N.F.O. components and improved response time performance.

Our original plan was to scan all existing pre-fire and related documents into the imaging server that was installed at the Fire Administration offices, and then to roll these out to the MDC's in the vehicles via CDs. Each station would then receive regular data updates via new CDs produced with the CD Duplicator located at Fire Administration. We determined that scanning all existing documents was not the best strategy. Instead we decided to create new documents with the software product FireZone from CADZone Inc. This decision was made because of the manual time required to scan the existing documents, the quality of the existing documents, and the fact that no standards had been used by the various stations in creating the paper drawings. The Fire Department produced standards for new documents and the existing documents were re-created. This work was performed by Fire personnel, who are continuing to maintain the images with the same software and process.

The development of DataLink software required us to work closely with the vendor, ElectroCom. They were very interested in our project as it provided an opportunity to port their Mobile Data Terminal (MDT) based application that we were using to a windows based software application. The primary function of DataLink is to provide firefighters remote access to the CAD system. They perform on-line queries and interactive updates in addition to receiving dispatch information. The challenge was to make a seamless transition from the MDT to the Mobile Data Computer platform. This work also required an enhancement to the software to accommodate the passing of address information to the RouteMap application.

The final milestone in the second phase of the project was to integrate all of the components into a working solution. Our ability to accomplish the ultimate levels of service and safety concerning fire response could only be realized through the integration of technologies. All components needed to function concurrently to enable fire personnel to access information in a timely manner.

This particular sub-task proved to be one of the most difficult and challenging of the entire project. The software components we had to integrate were:

- Existing CAD system on the Unisys enterprise mainframe
- New DataLink application written by ElectroCom
- RouteMap application written by ESRI
- INFOImaging application written by City I.S. personnel

This information flow begins on the mainframe and travels over our existing radio network, triggered by a dispatch by Communications Dispatch personnel, to radios integrated with the RoadRunner MDCs in the vehicles. The integration of mainframe and MDC operating systems, radio network traffic through a message switch, DDE and ActiveX data exchanges, and applications written in COBOL, C++, Visual Basic all contributed to a difficult task of isolating problems during testing and determining the best corrective action. Our biggest problems were encountered with the interface between the DataLink and RouteMap applications. One primary reason this particular interface was problematic was the difficulty in establishing a working relationship between the two vendors. The City project managers spent time negotiating between the two vendors when issues arose during testing of this interface.

The third phase involved the installation of the equipment and software in the vehicles, training of the firefighters, modification of the message switch and radio network to incorporate the new DataLink software and interface, and a phased rollout to production.

We worked with ElectroCom regarding the development of the new DataLink software. The functionality of DataLink required some modifications to the existing message switch software that manages data transmissions to radios in the vehicles. This was to incorporate the passing of information from the CAD system to the vehicles, including specific address information if the location has a pre-fire survey, hazardous material, physically challenged occupant, and/or is a multiple address location. We were able to coordinate the message switch and DataLink interface work with a hardware upgrade that allowed our mobile users with the proper radio terminals to operate at over-the-air transmission rates of 19.2 kilobits per second as opposed to the existing 4800 bits per second. All fire vehicles were equipped with proper radio terminals to take advantage of this capability.

The equipment was custom installed in each vehicle, with the vehicles varying in design and space availability. The vendor RCS Communications Group performed much of the installation work on a contracted basis. The RCS employees worked closely with project team members and City employees assigned to maintain the fleet of fire vehicles. The installation process took an average of four to eight hours per vehicle.

The training was led by the training consultant from the local firm GhostWriters. Training was conducted for all Fire personnel, including the firefighters and administrative staff, and the support staff from I.S. The approach on training proved to be very effective. Five RoadRunner units were installed in a classroom setting at one of the fire stations. Fire personnel were able to receive test CAD dispatches from our test CAD system over the radio network, communicate as if in route and arriving at the scene of the incident, work with the routing application, and access the electronic images stored on the unit's hard drive.

Partnerships

The primary partnership for the project was between the Fire and I.S. Departments, and while the project is officially completed this partnership continues to grow as on-going support issues and enhancement requests are addressed. The Fire Department continues to build an expertise of the applications while performing data entry and analysis as part of their daily operations.

There are several other municipalities and organizations that have been interested in this project from the initial conception. These include small municipal and volunteer fire and rescue departments throughout Forsyth County that have an interest in the data we have assembled. The role these partners had in the actual development and implementation of the I.N.F.O. application was minimal. We have shared ideas, information, and our project status with these agencies at various times on an individual basis. The partnering with these community neighbors should actually increase now that we have a finished software product and data to share with these agencies. They will now be able to take advantage of our work and implement similar solutions

in their communities as their time and budget permits. These agencies and contacts include:

Jerry Brooks	Fire Chief	Clemmons, NC
Jerry Lewis	Fire Administrator	Forsyth County FD
Curtis Teague	Asst.. Fire Chief	Kernersville, NC
Ray Flowers	Fire Chief	Greensboro, NC
Bill Sides	Dir. Facilities Management	Winston-Salem, NC
Chip Logan	Sr. Engineering Tech	Winston-Salem, NC
Sally Young	Fire Dept Planner	Charlotte, NC
Paul Miller	Executive Secretary for NC Firemen's Association	Farmville, NC

The working partnership between the City of Winston-Salem and Forsyth County has also grown as a result of this project. One of the main items of common interest is the maintenance of the street centerline files for both the City and County. Several departments from both agencies provide data for the maintenance of the centerline data, which is continuously updated to reflect progress and development in our community. Other outside agencies also provide us with data, including the State Department of Transportation and smaller municipalities throughout the County. A task force has been established to maintain the data, with representatives from all groups. The Fire and I.S. Departments continue to play a leading role of this task force. All involved parties realize the tremendous value of this data and the work that has been performed in a very cooperative spirit and manner.

Community Impact

The Winston-Salem Fire Department includes 17 different fire stations serving a population of 170,921. The Fire Department is composed of 254 fire fighters and 12 support personnel, distributed over 106.5 square miles. Each station is occupied at all times and ready to respond to an emergency. Beyond their professional training, the ability of the Fire Department to save lives and minimize property damage is dependent on the quality and quantity of available information. The fire fighter's ability to serve the public safety is significantly improved by timely access to the existing data.

Since the installation of the ISDN lines and equipment at all fire stations, and the equipment and software in the 30 fire vehicles, access to critical information has been greatly improved. This has contributed to improved response times, decision making, and quality of services to our residents. All fire fighters are seeing the most current information presented in a standard and consistent manner. In addition, fire fighters now have immediate access to all information for the entire City, as opposed to information pertaining to only their station or fire home territory. This greatly enhances the ability of stations to overlap their coverage when it is required.

The benefits can be measured in saved lives and reduced property damage as a result of the ability to make faster and better decisions. The implementation of the components of this project have had a large impact on the services provided to our community. The results shown in the accompanying 'Formal Project Evaluation' report demonstrate the impact the project has had on our ability to protect and serve our citizens.

Lessons Learned

We learned many things during the duration of this project. We ran into some hurdles and obstacles that had to be addressed, some of which have been discussed. earlier. Some major changes to our original plan were made, the biggest being how we created the street centerline file. Other areas that required us to look at alternative approaches included the creation of the fire hydrant coverage, the use of a part-time position for training, and the design of the interfaces between the components. Our staff gained experience with GIS and Electronic Data Management System (EDMS) technology and we gained valuable experience in managing and integrating a project of this proportion and scope with multiple parties involved. Some items that could be considered as lessons learned or ideas that proved to be valuable which may help others are:

- We should have included in our project budget funding for the purchase of additional MDC's for the support staff for use in project development and testing, on-going support, and as hot-swap replacements. With the number of people involved with the project there were times when MDC resources were a constraint.

- Our hardware was selected and ordered fairly early in the project time line. This was in response to the anticipated time required for spending approval, vendor order filling, delivery, inventorying, and installation. This was a factor we just had to deal with, unfortunately this reduced the amount of time we could wait for product enhancements and technology improvements of products that are being replaced with a 'next' generation at a very fast pace. The software applications that were developed are still advanced, but the hardware today is considered as standard at best.
- We have been investigating the possible upgrade of memory for our MDC laptops. Upgrades have not been very well supported by the vendor. We are currently working with a local vendor on providing upgrades. The ability for future upgrades should be considered when evaluating equipment vendors.
- In working with the vendors we should have defined in more finite detail the work and expectations in regards to the interfaces. This would have been particularly beneficial for the interface between the RouteMap and DataLink components, for which ESRI and ElectroCom were primary consultants. This finer scope of work could have included a more definitive interactive work items for the vendors instead of them providing the City with separate solutions that we ultimately had to make work together. One possible option could have been working solely with one as the primary vendor, who would in turn partner with the other as a sub-contractor. We could have coordinated more closely with the vendors in regards to the development software and operating systems they were using in their offices. Our project was being developed for a Windows 95 environment. One of the vendors, ESRI, performed their development and testing in a Windows NT environment. At times this created some compatibility problems when integrating their code into our testing environment.
- We found that the weekly team status meetings were instrumental for brainstorming and managing tasks assignments and progress. The week between meetings was an appropriate time period to accomplish established tasks and investigate and resolve issues that were identified. We tried to keep the agenda for these meetings to a specific list of objectives. We regularly held two other type of meetings in addition to the weekly team status meetings, these being detailed design workshops and Steering Committee review meetings. We strived to keep these meetings separate and focused on distinct objectives appropriate for the attendees.
- We have worked with Human Resources and the Budget Office on the creation of a position within the Fire Department to provide on-going support for the application and data maintenance. This position was filled with the individual who performed our training work from the local contracting firm GhostWriters. This has proven to be very valuable as this individual made a seamless transition from contractor to employee. Being the trainer and technical writer for the project has greatly helped with his ability to step in and play the role of daily support staff member for the Fire Department.

- One of the major reasons this project was implemented successfully was the makeup of the project team. Our team consisted of individuals with appropriate skills and knowledge from the Fire Department, I.S., and other organizations. The subject matter experts for both the technology and business components were integral members of the team. The end user, in this case the firefighters, played a critical role in the design of the component applications. They brought many years of experience in fighting fires and responding to emergency situations that the technical personnel in I.S. did not have.

Future Plans

The INFO project has made an impact on the creation of new GIS data sets and the tools to maintain them. A highly intelligent centerline is now complete for the entire county to be utilized by all City departments, as well Forsyth County. All tabular and hard-copy fire related information such as fire demand zones, fire station locations, hazardous material locations, hydrant locations, multiple address locations, physically challenged locations, and pre-fire survey locations are now GIS coverages. We have begun to utilize software tools available from ESRI to perform analysis of this data. This will help the Fire Department understand trends and needs and respond accordingly through staffing, scheduling, and training. Existing coverages of hydrography and railway were enhanced as well. These coverages were originally built by newly created Arc/Info menu applications. These same applications are being used to maintain the data to augment fire fighters' emergency decisions.

We have already used our experience with the I.N.F.O. project to solve problems in other departments. A example is a recently implemented Engineering application that integrates Electronic Document Management and Imaging capabilities with GIS data to provide the users information in one application that before they would need to obtain from multiple applications and paper documents. The experience our staff gained while working on the I.N.F.O. project contributed greatly to the success of the Engineering project. These type of projects are bringing together our in-house 'experts' on various technologies to work together on integrated solutions. We will more and more continue to develop enterprise applications for our users in the City in this manner, bringing in outside subject experts and consultants when necessary to augment our staff.

The human collaboration of different expertise to facilitate the successful technological integration of this complex project has made a major impact on team building. The coordination and communication the I.N.F.O. team made between different departments and outside vendors reinforced the concept of teamwork. We will continue to exercise teamwork for planned integrated application solutions and analysis that will be a "spin-off" of the I.N.F.O. project. These solutions include meter reading and utility crew routing, sanitation pickup scheduling, building inspection routing and scheduling, police crime incident routing, and fire incident and crime analyses. With our existing Internet and Intranet architecture and the Web enabling features of MapObjects we are planning to provide Web access to some of these new applications, thus providing GIS functionality to a user for just the cost of a Web browser on their PC.

We continue to get inquires from organizations throughout the country regarding this project. We are responding to these inquiries and requests, sharing information and our experiences. These request range from inquiries about hardware selection to software consultants to GIS and Imaging technical issues to staffing and funding questions. We have had inquiries from technical professionals, upper level management, and professional organizations. We will continue to share what we can when we can, partly because of our commitment to sharing our experience through the grant project, and also because we realize the value of sharing with our peers in other municipalities.

Budget Information

The budget for the National Telecommunications and Information Administration Award Number 37-40-96007 totalled $1,096,505. This budget is composed of funds from the federal government and non-federal funds from the City of Winston-Salem. The breakdown of these funds into categories is as follows.

The personnel category includes salaries and fringe benefit expense paid to employees of the City of Winston-Salem for time spent working on the Integrated Network Fire Operations project. The City employees involved in this project were City employees prior to implementation of this project. The funds associated with the personnel expense only reflect partial salaries of project team members since they maintained their original workload in addition to INFO assignments.

The equipment category includes funds used to purchase durable goods.

The contractual category includes funds that were spent to utilize the services of outside vendors.

The other category includes the cost of software and miscellaneous charges necessary for the completion of the project.

A breakdown of these categories and their expenses is attached.

Personnel Costs		Man-hours	Cost	Responsibilities
non-federal				
Project Manager - Fire		1,135.5 hours	30,293.06	coordinate with the project team members from Fire, coordinate testing and implementation, and manage day to day project tasks
Project Manager - Information Services		1,477. hours	43,095.25	coordinate with the technical team members and hardware and software vendors and contractors
Lead Systems Analyst		1,830.9 hours	62,538.01	convert existing mainframe data to GIS format
GIS Administrator		1,730.5 hours	46,506.34	coordinate the data sharing between existing GIS data layers and the GIS requirements for the Fire Dept.
Programmer/ Analyst		857.5 hours	26,595.82	make required changes to the Computer Aided Dispatch system and mobile data terminal application to interface with the new routing application
Communications Engineer		89.5 hours	2,553.68	implement the radio communications between the Communications Center and the mobile computers
Imaging/ Document Management Specialist		779.5 hours	23,876.55	research appropriate imaging hardware and software; create and implement the imaging application

Network Administrator		96.5 hours	2,681.38	coordinate installation of ISDN network
Driver for Street Centerline Data Collection		150.5 hours	1,916.22	drive City vehicle for contractor to collect street centerline data using GPS technology
Total Personnel Costs			$240,056.31	

Equipment	Vendor	Purchase Order	Cost	
Personal Computers				
non-federal				
2/28/96	Logical Choice	PO 3-34603	106,271.	
Network server				
non-federal				
2/28/96	Logical Choice	PO 3-34603	30,687.	
Desktop printers				
non-federal				
2/28/96	Logical Choice	PO 3-34603	19,200.	
mobile data computers				
non-federal				
1/28/98	ElectroCom	PO 3-52298	12,750.	WinMDT software
2/27/98	Preeminence	PO 3-52900	98,934.29	laptops (13)
6/22/98	The Dize Co.	PO 3-54981	300.	bags for keyboards
10/1/98	RCS Communications		11,727.54	installation of equipment
	ElectroCom	PO 3-54134	25,975.	radios
Total			$149,686.83	
federal				
11/21/97	The Computer Network	PO 3-51049	15,212.	laptops (2)
2/10/98	Piedmont Fire & Safety	PO 3-52552	229.	battery charger
6/25/98	Southern Public Safety	PO 3-54037	3,523.64	mounting hardware

6/22/98	Piedmont Fire & Safety	PO 3-54983	4,800.	battery chargers
11/24/98	RCS Communications	PO 3-55764	1,147.50	radio antennas
10/1/98	RCS Communications	RC 20435	366.79	installation of equipment
8/6/98	The Computer Network	PO 3-52899	114,782.71	laptops (15)
10/15/98	ElectroCom	PO 3-54134	24,000.	radios
Total			$164,061.64	
ISDN routers				
non-federal				
3/13/96	Logical Choice	PO 3-35094	53,279.14	
Scan station				
federal				
1/21/98	CompuCom	PO 3-52139	2,808.	Compaq DeskPro
1/21/98	DataLink	PO 3-52135	1,189	Monitor
2/2/98	CompuCom	PO 3-52336	370.	UPS
Total			$4,367.	
GIS and Imaging Server				
non-federal				
10/6/94	Strategic Technologies	PO 3-21181	62,912.	
Additional GIS/imaging server storage				
federal				
11/20/97	Sun MicroSystems	PO 3-51038	2,098.50	

CD-ROM publisher				
federal				
3/9/98	JMK Interactives	PO 3-53039	6,200.	
CD-ROM media				
federal				
3/9/98	JMK Interactives	PO 3-53039	630.	
Total Equipment Costs			$599,393.11	

Contractual	Vendor	Purchase Order	Cost	
ISDN implementation				
non-federal				
7/8/96	DataServ	PO 3-34453	12,053.	configuring the ISDN connection
6/5/98	Logical Choice	PO 3-54725	539.60	protection for ISDN lines
Total			$12,592.60	
Labor for GIS street centerline file				collection of street centerline and associated attributes using GPS technology
non-federal				
1/13/97	ITRE	PO 3-42806	22,000.	
10/28/97	ITRE	PO 3-50363	36,067.	
Total			$58,067.	
federal				
5/2/97	ITRE	PO 3-45766	41,438.	
10/28/97	ITRE	PO 3-50363	22,662.	
Total			$64,100.	
Application Development				
federal				
7/2/97	Guarino	PO 3-47418	600.	MDC and GIS database interface
1/13/97	ESRI	PO 3-42807	42,700.	Phase I contract

6/5/97	RCS Communications	RC 184775	70.	troubleshoot problems with radio transmission
7/29/97	RCS Communications	RC 201484	280.	
10/22/97	RCS Communications	RC 201374	210.	
	ESRI	PO 3-48654	122,640.	Phase II contract
1/28/98	ElectroCom	PO 3-52298	33,230.	Routing/ WinMDT interface
10/13/98	ESRI	PO 3-55629	1,452.	Redesign of routing interface
Total			$201,182.	
End-User Training				
federal				
12/18/97	GhostWriters	PO 3-51594	47,617.50	training for users
Total Contractual Costs			$383,559.10	
Other	Vendor	Purchase Order	Cost	
ISDN telephone line installation				
non-federal			6,861.	telephone company charges for installing ISDN
Relational database software				
non-federal				
5/20/96	Oracle	PO 3-36920	42,770.	Oracle software
12/17/97	ESRI	PO 3-51565	5,500.	MapObjects

12/31/97	STREAM	PO 3-51727	4,323.60	Visual BASIC
1/12/98	ESRI	PO 3-51983	2,010.	MapObjects
Total			$54,603.60	
Imaging software				
non-federal				
5/30/97	STREAM	PO 3-46515	450.	Visual BASIC
federal				
5/30/97	STREAM	PO 3-46515	1,091.00	Visual BASIC
12/5/97	STREAM	PO 3-51326	647.01	Win95
1/22/98	New Team Software	PO 3-52127	615.00	Integrator software
1/22/98	Visionary Solutions	PO 3-52130	189.35	Imprint Bitmap Driver
2/4/98	Lead Technologies	PO 3-52128	3,091.	LeadTools Express
Total			$5,633.36	
CAD Software				
federal				
6/27/97	The CADZone	PO 3-47209	409.	FireZone software
6/27/97	The CADZone	PO 3-47210	3,689.	FireZone software
Total			$4,098.	
City vehicle for Street centerline data collection				

non-federal				
			336.08	City street mileage - 1200.3 - calculated at 28 cents per mile
Total Other Costs			$71,982.04	
TOTAL EXPENSE			$1,294,990.56	

APPENDIX E: The Questionnaire/El Cuestionario

Questionnaire

This questionnaire is part of a study that seeks to understand the situation the fire fighters face before arriving at a fire. Your assistance in completing and promptly returning this questionnaire is greatly appreciated and your responses will be taken into account when determining the necessity of such improvements.

Your name (optional—we may wish to contact you in the near future):

____

Station name: ______________________________

How many years have you been a firefighter? ______

What is your position in the Fire Department? ______________________

1) Do you have access to a computer (Circle one) Yes No
(If you answer no, continue to question 4)

2) On average, how often do you use a computer per week? __________

3) For what purposes do you use a computer? (Circle all that apply)

Word Processing	Internet	Other (Please Specify)
Email	Spreadsheets	____________________
Games	Programming	____________________

4) What information is important to you when responding to and fighting a fire? (Please rank by importance, 1 being low and 5 being high)

	low				**high**
Best route to fire	1	2	3	4	5
Location of building's exits	1	2	3	4	5
Location of building's stairways	1	2	3	4	5
Water mains feeding the nearest hydrants	1	2	3	4	5
Location of nearest hydrants	1	2	3	4	5
Existence of hazardous materials inside the building	1	2	3	4	5
Information or special needs of people inside the building	1	2	3	4	5
Cause of fire	1	2	3	4	5
Other (Please Specify): ____________________	1	2	3	4	5
____________________	1	2	3	4	5
____________________	1	2	3	4	5

4) Listed below are some problems commonly faced by fire fighters. (Please rank by severity, 1 being low and 5 being high)

	low			high
a. Difficulty in communicating necessary information	1	2	3	4	5
b. Hydrant's location unknown	1	2	3	4	5
c. Water availability and pressure of hydrant unknown	1	2	3	4	5
d. Congested traffic	1	2	3	4	5
e. Difficulty in finding location	1	2	3	4	5
f. Lack of information for selecting best route	1	2	3	4	5
g. Location of hazardous materials unknown	1	2	3	4	5
h. Types of present hazardous materials unknown	1	2	3	4	5
i. Other (Please Specify): ____________________	1	2	3	4	5
j. ____________________	1	2	3	4	5
k. ____________________	1	2	3	4	5

5) Of the above problems, which three need to be solved first (please list with letters given to problems above)? How would you solve them?

____

____

____

____

Thank you very much for your time and cooperation,

Fire Fighters' Information Project

Cuestionario

Este cuestionario es parte de un estudio que pretende reflejar la realidad de la situation de los bomberos antes de llegar a atender un incendio. Agradecemos su colaboración en completar y devolverlo lo antes posible, sus respuestas serán tomadas en cuenta para determinar mejoras.

Su nombre (opcional—tal vez queramos contactarlo en el futuro cercano):

____

Nombre de la estación:__________________________

¿Cuantos años ha sido bombero?______

¿Cuál es su puesto en el Estación de Bomberos?___________________

1) ¿Tiene usted acceso a una computadora? (Encierre en un círculo) Sí No
(Si contesta no, continue a la pregunta numero 4)

2) ¿Más o menos cuantas horas usa la computadora por semana? ________

3) ¿Para que propósitos usa la computadora? (Encierre en un círculo los que corresponden)

Procesador de Palabras	Internet	Otros (Por favor especifique):
Correo Electrónico	Hoja Electrónica (ej. Excel)	___________________
Juegos	Para Programación	___________________

4) ¿Que información es importante o esencial para responder a una emergencia y combatir un incendio? (Por favor marque por orden de importancia; 1 es poca y 5 es mucha)

	poca				**mucha**
Conocer la mejor ruta de accesso a un incendio	1	2	3	4	5
La ubicación de los accesos a la estructura incendiada	1	2	3	4	5
La ubicación de las salidas de emergencia del edificio	1	2	3	4	5
La cañería que alimenta los hidrantes más cercanos	1	2	3	4	5
La ubicación de los hidrantes más cercanos	1	2	3	4	5
Existencia de sustancias inflammables dentro del edificio, sustancias químicas, u otros	1	2	3	4	5
Informacíon o características especiales de las personas dentro de la estructura	1	2	3	4	5
Causa del incendio	1	2	3	4	5
Otras (Por favor especifique) ____________________	1	2	3	4	5
____________________	1	2	3	4	5
____________________	1	2	3	4	5

5) La siguiente es una lista con algunos de los problemas comúnmente enfrentados por los bomberos. (Por favor marque según la gravedad; 1 es poca y 5 es mucha)

	poca				mucha
a. Dificultad en la comunicación de la información necesaria	1	2	3	4	5
b. Ubicación del hidrante es desconocida	1	2	3	4	5
c. Disponibilidad y presión del agua del hidrante son desconocidas	1	2	3	4	5
d. Congestionamiento de tráfico	1	2	3	4	5
e. Dificultades en encontrar la ubicación	1	2	3	4	5
f. Falta de información cuando se decide que ruta tomar	1	2	3	4	5
g. Ubicación de materiales peligrosos es desconocida	1	2	3	4	5
h. Tipos de materiales peligros son desconocidos	1	2	3	4	5
i. Otros (Por favor especifique): ______________________	1	2	3	4	5
j. ______________________	1	2	3	4	5
k. ______________________	1	2	3	4	5

6) ¿De estos problemas, cuáles necesitan ser solucionados primero (Por favor escriba la letra que denomina el problema)? ¿Cómo los solucionaría usted?

____

____

____

____

____

____

____

Muchas gracias por su tiempo y colaboración.

Proyecto Informático de Bomberos

APPENDIX F: Vendors Information

Vendor E-mail

May 31, 2000

To whom it may concern:

We are currently consulting Los Bomberos, the Costa Rican national fire department, with the development of a Geographic Information System. Los Bomberos has expressed strong interest in purchasing the software and training required for such a system. We are contacting your company because we believe that the services you offer are appropiately suited for this project.

The GIS is expected to greatly assist Los Bomberos in its objective to fight fires. The system will require a database of demographic and geographic data placed on a central server. That server needs to be accessed by a number of fire stations throughout Costa Rica. The information must be accessable, through a wireless connection, by portable computers located in the fire trucks.

The information needed by Los Bomberos wants the GIS to contain includes, but is not limited to, the following:

1. Basic street maps, including traffic considerations and indication of the best route
2. Building layout and other essential information about the building
3. Information about water sources at the site (including location, pressure, volume, etc.)
4. Location and type of hazardous materials
5. Indication of individuals with special needs who may be located at the site.

We believe that education about the proper use of a GIS is an important factor in the successful implementation of a GIS. Therefore, the proposal of such a system must include a training program that will ensure the success of the system.

If your company is able to meet the needs of this project, we would appreciate your sending a proposal, including system recommendations and a cost breakdown. We are working on a tight time schedule and would like to receive your comments by fax within one week.

We thank you in advance,

Felix Rieper
Ana María Ortega O.

Fax: 011 506 2439914
011 506 2573006

List of Companies Contacted

Companies	**E-mail Addresses**
Byers Engineers	Julie.Bennett@byers.com
Smallworld-us	info@smallworld.co.uk
PCI Geomatics	info@pcigeomatics.com
	hougham@pcigeomatics.com
Bentley	sales@bentley.com
Blue Marble	geoinfo@bluemarblegeo.com
Caliper	sales@caliper.com
ESRI	info@esri.com
Etak	sales@etak.com
Idrisi	idrisi@clarku.edu
Mapcom Systems	mbowman@mapcom.com
Mapinfo	latin.sales@mapinfo.com
Microimages	info@microimages.com
North Wood Tech	info@nothwoodtec.com
The Omega Group	info@theomegagroup.com

Fireview E-mail

Date: Thu, 8 Jun 2000 14:33:33 -0700

Felix Rieper and Ana-Maria Ortega O.:

Thank you for your interest in FireView. I would like to send you a multi-media demonstration CD of FireView so you can get a better feel of the capabilities. If you can provide a mailing address we would be happy to send you the demo. We are able to address the five areas you mentioned. I have briefly summarized each.

1. Basic street maps, including traffic considerations and indication of the best route. FireView contains a shortest path feature. It allows you to specify origin and destination and the program will map the shortest path.
2. Building layout and other essential information about the building. Building footprints and/or digital photos can be mapped in FireView. Any information about the building can be linked to a table.
3. Information about water sources at the site (including location, pressure, volume, etc.) Yes, FireView can map fire hydrants and contain informaion about water pressure, etc.
4. Location and type of hazardous material. Yes. If the client has this information in a data base with an address location, then the information can be mapped.
5. Indication of individuals with special needs who may be located at the site. The answer to number four applies here too.

I hope this helps. Email me if you have further questions. Thank you for your interest.

Milan Mueller
President
The Omega Group
milan@theomegagroup.com
www.theomegagroup.com

APPENDIX G: Proposal Prepared by Bach. Ana María Ortega O.

PROPUESTA

PROYECTO DE INTEGRACION INFORMATICA

PARA EL CUERPO DE BOMBEROS

El acelerado avance tecnológico que experimenta el mundo en los últimos años; ha llevado a las organizaciones de todo el mundo a adoptar medidas de actualización y desarrollo, en lo que se podría denominar, la era de la información globalizada.

Cada día es mayor el flujo de información que transita en los medios de comunicación, televisión, radio, teléfono, internet, correo electrónico, etc. La transmisión de datos por medios electrónicos se hace mucho más fácil al integrar los satélites y las redes de fibra óptica. Compartir información y recursos disminuye los costos de operación e incrementa la productividad de las instituciones.

El control y la buena administración de las organizaciones se evalúan por medio de los sistemas informáticos que se tienen, pues en ellos se registran todas las transacciones que se llevan a cabo para un posterior análisis y para generar estadísticas para la toma de decisiones a nivel administrativo u operativo.

Antecedentes

El Cuerpo de Bomberos es una organización que crece conforme el país avanza en desarrollo industrial y humano, la estructura actual distingue dos áreas de mando de relevancia, administrativa y operativa.

Cada una determina sus propias políticas de acción en busca de un mismo objetivo, mejorar el servicio que el Cuerpo de Bomberos brinda a la comunidad costarricense.

La visión que la Dirección de Bomberos maneja para el año 2005 es lograr una organización capaz de evaluar, prevenir y mitigar los efectos de los desastres relacionados con su actividad, con personal de alta calidad profesional y un desarrollo tecnológico avanzado de acuerdo con las exigencias de la época.

Se debe resaltar la importancia de contar con tecnología actualizada para lograr los objetivos que se propone la administración, pues de esta dependerá la capacidad de evaluar y difundir las técnicas de prevención con la proyección necesaria para toda la comunidad.

Esto nos obliga a que el servicio que presta se respalde con una organización administrativa bien estructurada y con permanente retroalimentación de información, que permita a las personas encargadas de administrar los recursos materiales y humanos establecer prioridades, crear planes de contingencia, de evacuación, educación, prevención, capacitación e investigación de forma acertada.

Análisis de la situación actual

- *Sistemas de Información*

En la actualidad el Cuerpo de Bomberos tiene un desarrollo informático regular basado en cuatro sistemas automatizados que ayudan a realizar las labores de presupuesto, inventario de repuestos del Taller Mecánico, control de alarmas de incendio, control de inventario de suministros y vestuario de bomberos, a saber: SIABO, SITBO, SIBO y SUMBO respectivamente.

Estos sistemas fueron desarrollados en una herramienta llamada CLIPPER y manejan tablas .DBF como bases de datos, que soportan procesos de FOX y FOX PRO.

Dichas aplicaciones originalmente fueron implementadas para ser corridas en ambiente DOS, sin embargo, debido al cambio que los sistemas operativos han sufrido, se ejecutan desde Windows 95. El cambio de plataforma en el sistema operativo, afecta radicalmente la velocidad de los procesos que se realizan, pues la cantidad de archivos que se cargan por cada proceso es mayor que cuando se ejecuta el programa en DOS.

La interface con los usuarios también se ve afectada, pues el ambiente gráfico de Windows 95 ofrece mayor facilidad y es más amigable con el usuario que el ambiente de texto del DOS.

Por su parte las estaciones de bomberos que cuentan con equipo de cómputo apto tienen instalado un sistema llamado SICUB, desarrollado en ACCESS 97, el cual registra las salidas de cada estación y se emite un reporte de servicio por cada alarma, así como la utilización de equipo especializado y personal en la atención de siniestros y rescates.

La información generada de este sistema es utilizada por la subdirección técnica (Operaciones) para calificar estrategias de trabajo de los grupos, determinar el rendimiento de cada estación en las emergencias, evaluar el desempeño de los equipos utilizados (vehículos, equipo de combate de incendios) y del personal que lo maneja, controlar el inventario de recursos existentes, mantiene un expediente individual del perfil profesional de cada bombero, entre otros.

Basados en esta información se generan los informes que llegan a la Dirección de Bomberos, dependencia encargada de dictar las políticas de trabajo, mejorar los procesos de capacitación de personal, compra de equipo y el soporte en las áreas de interés para mejorar la función básica y especializada de cada estación en busca del perfeccionamiento de las técnicas y la profesionalización del personal.

- *Comunicación*

El Cuerpo de Bomberos está distribuido en todo el país y su principal medio de comunicación se basa en radios programados en frecuencias por zonas, secundariamente se encuentra el teléfono, sin embargo no existe un medio de transferencia de datos electrónicos que permita concentrar la información y estandarizarla en un punto para su respectiva distribución según las áreas de interés.

Por el contrario, se cuenta con redes internas (ethernet) ubicadas en la Dirección de Bomberos cuenta con una red de computadoras propia que interconecta al grupo de servicios administrativos para compartir la información de los sistemas SIABO y SUMBO, asimismo comparte recursos como impresoras y algunos paquetes de software.

Las máquinas del área de secretaría, presupuesto y compras, Director, el Subdirector, entre otros, se encuentran dentro de la red del INS, por medio de estas se accede al correo electrónico de la Institución y a algunos servidores como el de Recursos Humanos, Soporte, etc.

Sin embargo, la información que se obtiene se encuentra aislada del resto de los usuarios de la red de Bomberos.

Por su parte, la Oficina de Comunicaciones OCO cuenta con una red propia con un servidor similar al de la Dirección de Bomberos, Compaq Proliant 800 y comparte el sistema SIBO, para el control de alarmas de emergencia y de unidades extintoras, mismo que se accede desde el Departamento de Ingeniería en Prevención, el cual realiza consultas y emite reportes para el área de Investigación de Incendios. Además se posee un router 1500 y una línea telefónica dedicada por medio de la que se conecta directamente al INS e ingresa al correo electrónico e Internet.

- *Equipo de Cómputo*

Estaciones de Bomberos

El 90% de las estaciones de bomberos del país cuentan con microcomputadora, en la mayoría de los casos, sólo puede ser utilizada para transcribir informes por su capacidad limitada, poca memoria, falta de tarjeta fax-módem y discos duros pequeños.

En Alajuela, Limón y Heredia las características de las máquinas son superiores cuentan con tarjeta fax módem para conectarse a la Dirección o al INS y tener acceso al correo electrónico, no obstante, el resto de las estaciones se mantienen aisladas por falta de equipo actualizado y en algunos casos por falta de licencias del software de correo electrónico.

El mantenimiento preventivo que se brinda a las computadoras de las Estaciones de Bomberos es nulo, pues solo hay una persona encargada de atender los reportes y necesidades de las estaciones y dependencias administrativas. Lo que no es permite dar un seguimiento real al equipo que tiene cada estación. Los tiempos de respuesta en la atención de reportes es lento porque las estaciones están dispersas geográficamente en todo el país y desplazarse es un inconveniente, pues significa descuidar otras áreas de interés administrativo para la Dirección de Bomberos.

Es importante también aclarar que el presupuesto que año a año se aprueba para reparaciones y repuestos en la Dirección de Bomberos no es suficiente para contratar los servicios de mantenimiento correctivo en todas las estaciones, se contratan solo en casos de extrema necesidad de la estación, tomando en cuenta su ubicación geográfica, la urgencia de reparar la falla, el costo y las características del equipo.

Los reportes de fallas de cada estación, son atendidos con ayuda del área de Soporte Técnico del INS, en cooperación con la persona encargada del Proyecto Informático de Bomberos, se alterna la atención de reparación de PC'S, instalación de software y/o revisión de fallas en las computadoras.

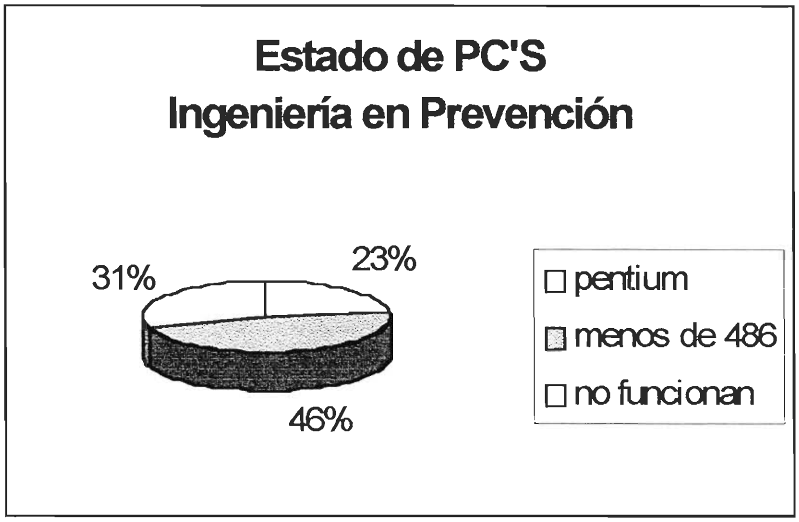
De lo anterior se concluye que el mantenimiento preventivo no se puede dar, en sustitución a este solo se practica el mantenimiento correctivo.

Ingeniería en Prevención

Este departamento cuenta con 13 computadoras, de las cuales 10 son de generaciones inferiores a la 486 y trabajan en modo DOS, las 3 restantes son pentium, 2 de estas están conectadas a la red del INS para utilizar el correo electrónico, Internet, acceder al SIBO en OCO, usar la cámara digital, etc.

Como se aprecia en el gráfico 1 la relación entre el estado de las computadoras es desequilibrado tomando en cuenta las labores que se realizan en el departamento.

De las 13 PC'S que se tienen 4 no funcionan, 2 tienen malo el disco duro y 2 no trabajan debido a que no pasaron el año 2000.



El recurso humano no se aprovecha al máximo puesto que no tiene el equipo adecuado o no está en las mejores condiciones lo que produce retrasos en emisión de informes de una investigación o de evaluación de incendios, el área de Visado de Planos no posee una computadora para analizar planos o diseñar propuestas con un software acorde a las funciones que ahí se realizan.

Dirección de Bomberos

Unificada por medio de una red interna, que es accedida por las áreas de Compras y Presupuesto, para compartir información y hacer uso de los sistemas existentes.

El equipo de cómputo es bueno, las áreas tienen suficientes máquinas que responden satisfactoriamente a las necesidades de cada puesto.

Sin embargo, se requiere modernizar los sistemas existentes, crear nuevos módulos, mejorar la comunicación con las estaciones de bomberos y las oficinas administrativas que se encuentran fuera del edificio central del Instituto por ejemplo OCO y Operaciones.

Servicios Generales de Bomberos

Este es un departamento de reciente creación en él se realizan los contratos de reparación de máquinas extintoras, mantenimiento de edificios, administración de la bodega de equipo de protección personal de bomberos y menaje, repuestos, entre otros.

En esta área se cuenta con las siguientes PC'S:

- 1 Pentium, con acceso a la red de INS, perteneciente a la jefatura de la Dependencia
- 1 Pentium, para uso exclusivo de los oficinistas, por medio de la cual se accesa el SITBO, para controlar la bodega de repuestos con que se cuenta.
- 1 486 sin acceso a la red, perteneciente a la secretaria, esta máquina requiere ser sustituida a la mayor brevedad, pues el puesto requiere el control y emisión de correspondencia por medio del correo electrónico, fax-server, entre otros.

En conclusión se determina que las condiciones tecnológicas en las que se encuentra el Cuerpo de Bomberos debe ser mejorada a corto plazo con una distribución de acuerdo a la importancia de funciones, solo de esta forma se logrará cumplir la visión planteada para los años venideros.

Propuesta

La integración del Cuerpo de Bomberos como unidad es fundamental, lograrla conlleva establecer medios de comunicación ágil entre las áreas de trabajo, transmitir información de forma eficaz y eficiente y por ende, permite a la administración obtener un control total de las operaciones que se realizan.

Crear la red informática da paso a esta integración de todas las áreas administrativas y estaciones de bomberos y centralizar en un solo punto el procesamiento de la información.

La red admite compartir recursos y datos, minimiza costos operativos y esfuerzos humanos, aumenta la productividad del personal y agiliza la toma de decisiones al tener acceso inmediato a la información.

No obstante, para obtener una integración como la que se plantea, es indispensable contar con equipo moderno que permita realizar las conexiones necesarias, que brinde efectividad en el momento de realizar los procesos, que ofrezca la herramienta apropiada para cumplir las funciones de forma eficiente.

Así mismo, surge la necesidad de generar datos estadísticos que brinden ante la administración superior datos concretos sobre el rendimiento de bomberos.

Por la naturaleza del trabajo que se ejecuta en Bomberos la integración vendía a ser completa con la adquisición de un sistema que consienta la referenciación geográfica para estandarizar la información que se manipula a nivel operativo e integrarla con los datos estadísticos requeridos.

Como solución a esta problemática se propone:

- La sustitución total de todo el equipo de cómputo obsoleto de las estaciones y oficinas administrativas con equipo nuevo.
- Crear una red informática para bomberos, que integre en su primera etapa al menos 10 estaciones, OCO y las dependencias administrativas.
- Adquirir un equipo y sistema GIS que permita administrar gráficamente la información requerida por bomberos en el combate de incendios y a su vez permita generar estadísticas y mejorar las funciones administrativas de las dependencias de la Dirección. Ver anexo 1

APPENDIX H: Professor Interview Summaries

Summary of Interview with Professor Lucht
April 25, 2000

- We began by explaining the project
- started the fire protection engineering degree program 20 years ago.
  - Only one other program like it in the US.
  - Costa Rica is slowly starting their own Fire Protection Engineering program.
  - Program doesn't really deal with fire fighting, such as response time, but more with infrastructures, such as water supplies.
- just thinking out loud
  - you need to get them (Los Bomberos) to determine what key information needs they have on site.
    - Where the hydrants are
    - where the fire is, best route
    - traffic problems
    - how much water a hydrant will put out (town records should have this)
    - information about hazardous material: what it is, what are the characteristics? (Most important in industrial buildings rather than homes)
    - Take a look at the IQP done in Venice on Ambulance Response time
  - order them by priority.
    - Ask "What is the most important thing you need to know once you get to a fire?
    - What is the second most important thing?"
- Organization in US
  - when they are not fighting fires, visit industrial properties with notebooks
    - sprinkler shut-offs
    - hazardous waste information
    - power generator information
    - Kept in trucks. (NOTE: this may be a way to get info in costa rica without extra cost)
- Useful
  - yes but money may be spent on something else
  - better trucks.
  - Maybe other agencies would benefit more from such technology.
- Places to look at in US
  - Look at the Phoenix Fire Dept.

- Reason for lack of use in Fire depts.
  - The culture of the fire service is very traditional.
  - "We put wet stuff on red stuff."
  - job as putting water on fire
  - Fire depts. don't see and embrace new technology very quickly
  - especially in New England
  - not high on the political agenda.
  - No one ever thinks a fire is going to happen to them.
  - budgets do not get approved for new technology.
  - The frequency of fires are also fairly low
- Money
  - cost vs. benefit
  - travel time
  - better equipment
  - more staff?
- Related
  - WPI fire fighter tracking system
    - A sensor would be placed on the helmet
    - send a signal to the truck or central receiving station
    - each fire fighter could be tracked in the burning building
    - breathing and heart rate would also be transmitted.
    - Contact Willam Michalson ( ) for more information
- Other Considerations
- fire fighter's point of view: talk to Jim Callery
  - WPI grad
  - division chief in Worcester.
  - know a lot of the fundamentals
  - ask if a GIS would really be helpful
  - information should be included.
- timeline of a fir ignited at time=0
- fire increases every minute
  - more damage
  - more likelihood that someone could get killed
  - goal is to stop the growth as soon as possible
  - critical moment
- full scale building fire tests conducted by IITRI, and maybe other books in the WPI fire library.

Summary of Interview with Professor Robert Fitzgerald
April 28, 2000

- Civil Engineering Professor, specializing in Fire Safety
  - Has worked on over 100 projects with WFD
- Two categories of building fires
  - Residential
    - Most common and usually not a big problem
  - "Special" group
    - Buildings that have stuff in them
      - Laboratories--usually make firefighters a little hesitant
        - Nuclear, biological, or chemical?
      - Hazardous wastes
- Two kinds of buildings
  - Sprinklered
    - How reliable and effective are the sprinklers?
    - Is supplemental water needed?
    - Where are the shutoffs?
  - Non-sprinklered
    - How effective are the structural fire barriers?
    - How effective is the Fire Department?
    - What is the detection and notification system?
    - Where are the hydrants?
- Pre-fire Planning
  - Understanding what you're doing before you get there
  - GIS could be instrumental in development of pre-fire planning
- GIS should pinpoint buildings that need special attention
  - Unusual life safety
    - Retirement homes
    - Nursing homes
  - Use a lot of electricity, gas or water
  - Big Buildings
  - Anything that creates a potential for a large fire
- In dealing with firefighters
  - Be honest and respectful and they're all yours
  - You're there to ask, not tell
  - Find a way to get them to do the work
    - Let them find info, you just organize it
  - Ask them to tell how they do their job
  - What are major problems they run into?
  - Get description of how they fight fires in big buildings
  - Work with them on organizing and systemizing
  - Find out what info they want at the scene

    - What are their causes of concern when fighting a fire?
        - Laboratories again
- GIS in general
    - Useless by itself
    - Valuable if used with the right info
        - Utility shutoffs
        - Emergency lighting?
        - Emergency generators?
        - Hazardous materials?
            - Nuclear
            - Biological
            - Chemical
        - Architecture of the building
    - Tremendous amount of promise
        - Training
            - If firefighters are exposed to it often, they'll know what to do when the time comes
            - If they only use it twice a year, they won't know what to do when the time comes
        - Operation
            - Can supply a lot of good info in an emergency
        - Inspections
- What to do:
    - Visit National Fire Protection Agency in Quincy
        - Talk to Mr. Peterson
        - Use their library
            - Call before and the librarian will find stuff
        - Find out about Pre-fire Planning and GIS
    - Talk to Chief Medderville, WFD
        - He uses GIS, too
    - Use the books he gave us
        - The Anatomy of Building Firesafety: Volume 1- A Way of Thining
        - Chapter 7 in Volume 2
            - Diagrams on pp. 27&28
        - May still be available in book store
    - WPI has 2nd largest collection of fire literature in the country (if not the world)
    - Talk to Chilean and Brazilian Fire Departments

APPENDIX I: Professional Interview Summaries

Summary of Interview with Hugo Cardenas
April 25, 2000

- Hugo works for Worcester, setting up GIS and other geographic stuff
- Worcester has a GIS in operation for Fire Response
    - Currently three laptops- 1 for inspector, 2 in trucks (command vehicles)
    - Similar to Winston-Salem system
- Current communication system
    - Working on city-wide antenna to broadcast to laptops
    - TCP/IP-type connections
        - Only connected when necessary
        - Server doesn't care what laptop does with info
    - Servers only relay changing info
        - Weather conditions
        - Road conditions
    - Laptops have permanent info
        - Building blueprints
        - Building residents/tenants
- Hardware/Software
    - Databases
        - Oracle stores and handles data
            - 20 licenses @ $1,000 each
        - Spatial Database Engine (SDE) requests info from Oracle
    - Main Server
        - PIII 500MHz Xeon Quad Processors
        - 3Gb RAM
        - 5-18Gb Hard Drives
        - $56,000
    - Station Servers
        - PII 450MHz Xeon Dual Processors
        - 520 Mb RAM
        - $18,000
    - Panasonic Laptops
        - Very Rugged
        - 3 Gb Hard drive
        - Glow-in -the-dark keyboard
        - Water-resistant
        - $7,000
        - Goal=15 to 20 laptops city-wide
    - Router/Switch PC
        - Licenses purchased in groups of five
        - $5,000 extra per laptop
            - includes license, modems, software
    - Systems should be up-to-date for next five years

  - Software and other applications cost $40,000
- GIS Layers
  - Highway exits
  - Fire Stations
  - Inspection Areas
    - Actual city inspectors
    - Commercial inspectors
  - "Call Boxes"
    - Small geographic segments of the city
    - Established by Chief Howe
  - Hydrants
  - Past fires
    - Listed by personal assessor number
    - Categorized by cause/severity
- Current Timeline
  - Established how fire response worked in the past
  - Make "run list" more efficient
    - Shows which trucks cover which areas
  - Create database of hydrants
    - Firefighters will know distance to nearest four hydrants
- GIS response
  - Call to dispatcher
  - Address and conditions zapped to laptop
  - Laptop calculates route
- Jeff Jones
  - Currently in Torealba(sp?), CR
  - Works for CATIE
    - Central American research intitution
  - Wants to implement GIS for all of Central America
  - Is trying to get Hugo to work for him in CR
  - Has lots of extra money
  - Got contact info
- Chief Howe
  - Has been working closely with Hugo to establish databases and systems
  - Will know how much time each step takes
  - Will contact him ASAP
- Funding
  - Federal grants for all but desktop software development
  - Talk to Jeff Jones
- Necessity
  - GIS *should* be implemented in CR
  - Should be done slowly to ease users into it
    - Once they see it will work, they will love it

Summary of Interview with Chief Stewart Howe
April 27, 2000

- First, he showed us the laptop
  - Addresses and fire hydrants
  - Cellular communication
- Moved to office for Question and Answer time
- A part-time project for Howe
  - No time or money
  - Moving very slowly
  - A full-time person would speed things up
- Idea began 5 years ago
  - Computers purchased 4 years ago
  - City purchased software
- Got laptops two months ago
  - Currently one in Howe's truck, one in Fire Prevention
  - 2 District Chiefs will have in trucks
  - 1 in closet waiting to be put to use
- Maps show reality, not what city thinks is there
  - Current system
  - Exact directions not necessary in small areas such as Worcester
  - Call boxes
  - Laptop shows area of fire, not best route
  - Also mapping vacant buildings
  - Lots of redistricting
- Visualization
  - Mostly used for analysis so far
  - Would be good to map college campuses and other sites with multiple building at one address
- Info at fire
  - Utilites
  - Where shutoffs are located
  - Elevator rooms
  - Sprinkler systems/shutoffs
  - Hazardous materials
  - Drastic changes in floor levels
  - Building access
  - Pics of building
  - Who's inside

- Training
    - He's the only one trained so far—by Hugo
    - ArcView not very easy to use
    - Training for Windows NT cost several thousand dollars
    - Can take training course at colleges for free
- Seattle
    - System in Command Vehicle
    - ArcView resolves to block, not to lot
    - Hydrants
    - Topography
    - Earthquake problem area
    - Building plans
    - No routing
- Funding
    - Grants through Copsmore(sp?)
- For police protection
    - City bought software (ESRI)
    - Lack of funding because other needs take precedent
- Computers don't put out fires
    - People don't fear fires like they do crime—Police get more funding
    - Bill going through Congress to give comparable funding to fire and police
    - More exposure/results could lead to more funding
- Problems
    - Keeping updated
    - Equipment issues
    - Extra fees
- Telephone service
- Possible future developments
    - Palm Pilots
        - More convenient
        - Easier to lose
        - Much cheaper
        - Not indestructible

Summary of Group Interview at Estacion Central
W/ Dagoberto Arias, Luis Fernando Salas, and Apolonio Rodriguez
May 22, 2000

- Organization
  - Fire Chief who manages all decisions about fires
  - Assistant Chief
  - Four supervisors who each manage one of the four sections into which the country is divided
- Problems
  - Training (No formal training until recently)
  - The is no organized system of addresses across the country
    - No formal way to give directions
    - Fire fighters need to be familiar with the region, and when a fire fighter is lost that information is also.
    - Cities are growing unmanageably, which causes increasing problems with directions
    - In metropolitan areas there are streets and avenues that are named but citizens still rely upon land marks
  - Hydrants
    - No knowledge of what mains go to certain hydrants
    - No knowledge of pipe size that affects water pressure
  - Chemicals and hazardous materials
    - All hazardous materials are **supposed** to be reported to the ministry of health, but companies can refuse to do this
    - Trucks carrying hazardous materials are often mislabeled (depending upon the day of the week and which label looks the prettiest
    - Gas and petroleum are the only two chemicals that they are always aware of because of well enforced laws
    - Private homes are often used as storage for a business such as a pharmacy
    - Hardware stores can have everything from "nails to atomic bombs"
    - Law does not allow Los Bomberos to conduct inspections prior to an emergency (accept for high risk areas, which they can inspect twice a month with businesses permission)
      - Most large businesses will allow inspections, but smaller ones often do not

- Organization of data
    - In the cities it is very difficult for fire fighters to store everything in their memories, so they have recently begun to write down the information on paper that is kept at the station. (See Appendix J)
        - On one side of paper the floor plan of the inspected building is shown, on the other are the nearest fire hydrants
            - This visual planning greatly improves fire fighting at these buildings, however the information is kept at the station and therefore must be transmitted over the radio (it would be ideal to this information in the truck)
- Standard operation procedures (SOP)
    - SOP's were implemented about three years ago, but have been kept flexible in accordance with the beliefs of Chief Dagoberto Arias
    - Steps have been broken down into sections, with individual's responsible individual areas.
    - There is no command vehical. All are equally trained and the first truck on the site takes command, or if a fire is bad, they call a chief.
- Training
    - The firemen have always had training in what they need to do, but they have not been able to have a career in firefighting (with a degree)
    - Some chiefs went to Denver for more training
    - A school will be starting very shortly that will give a degree for firefighting, and will serve as an example for other latin American countries.
- GIS
    - The education problem is being solved, but the organization is still a problem.
    - The firefighters need a more visual method of organization for data, and they believe they need a GIS
    - By the end of this year, 90% of the chiefs will be trained in basic computer skills, and 100 more will be getting training.
    - Costa Rica is getting better with computers and INS has a budget for basic training and computers
    - All the information is in people and paper, and get lost easily, the firefighters need an easy way to access the information they need.
    - They need information on hydrants, storage, hazardous waste, and something that will work on holy week.
    - MapInfo

Summary of Interview with Jamie Gonzalez OCO
May 23, 2000

- Computer System
  - SIBO
    - System of Information for Firefighters
    - Text based only
    - DOS
  - Age
    - The system is one year old
    - Workstations are 1 year old
    - Server is 2 years old
  - Contents (info on)
    - Hydrants
    - Personnel
    - Stations
    - Units
    - Hazardous Waste
    - Airplanes
    - Log of the day
    - Log of repairs
    - Records after 1991
    - Updated 2 times a day
    - Lots of backup
  - Use
    - Stats
    - Legal problems
- The 2 numbers
  - 118
    - SIBO information
    - Fire emergencies only
    - Operators have to get and write down all information
  - 911
    - New system (Windows based) is not working
    - All emergencies
    - Same as US (Name and address appear)
    - Want more automated
    - Compatibility with Modem problems
  - The two are NOT the same and are not really connected
- Training
  - 25 People trained in DOS
    - 15 permanent
    - 11 volunteer
  - More trained in Windows

- What happens when there is a call (118)
  - Operator starts asking questions
    - Operators need to know about the entire country
    - There are no addresses
  - Information is sent to the fire fighters
    - Hazard info is radioed or faxed
    - Hydrant info the stations have
    - Location and type of fire is sent
  - Extra Trucks
    - Only for big fires
    - There are 2
    - Have laptops, radios, cell phones
    - Info is in laptops, not connected
    - Trying to get a modem
- GIS
  - Would be great to visualize
  - MAPINFO
    - They saw it and they wanted it
    - No one knew how to use it
    - It sat unused for 2 years
    - Got sent to INS and got lost
    - 8 years ago
  - Big Map
    - Will be done in 2 years
    - Used for rescue
    - Scale of 1-50 thou
    - See big map of San Jose
- Problems

Summary of Interview with Three Engineers of INS
Friday May 26

Maricio Elizondo

- Job
  - Research fires
  - 2 People for the whole country
  - when people have insurance, always investigate
  - when no insurance had, only if they are asked
  - when people die or are hurt, the police get involved
  - when hazardous materials are involved, investigation is done
- Information Use
  - Used for insurance claims
  - Stats are made (see the ones we already have)
- Current storage
  - Can access OCO SIBO log
  - Use computer text based system
  - Nothing visual
- Problem areas
  - Empty buildings (drug addicts)
  - Vacation homes
  - Hazardous materials (no laws)
- Needs from a GIS
  - Zones where most fires start (Most Important)
  - How big
  - What started it
  - Area Burnt
  - Area Threatened
  - Area Saved
  - What type of building it started in
  - Best Route to the fire
  - VISUAL

Walter Mora

- Job
  - 2 people
  - Mapping of new buildings
  - Fire protection
    - Emergency exits
    - Extinguishers
    - Building materials
    - Fixed systems
    - Hydrants in residential areas
    - Sprinkler systems
  - Buildings
    - Hotels
    - Offices
    - Places where people will spend lots of time
- Code
  - There is a code saying how you have to build
    - Very ambiguous
    - No Specifics
    - You need fire escape but not how high it needs to be
  - Rewriting code
    - Very specific
    - In process of being passed
    - New norms
- Current Problems
  - No say
    - Not the ones to say who can or cannot build
    - Suggestions only
    - Ask for support
    - Send not to the ministry of health
    - Not all codes are enforced
- Current Records
  - Paper Blueprints
    - Only the 2 have access
    - Others can ask to look at them
  - Computer
    - Used to have blueprints on disk
    - License Problem
    - Spreadsheets
  - Info on spreadsheets
    - Costs
    - Location
    - Analysis
- Need for GIS
  - Blueprints can be brought in on disk (used before)

- Link to stations
  - Stations could know about new buildings
  - Could see analysis of other buildings

<u>Fransico Bermudes</u>

- Job
  - Evaluation of fire risk
  - Human Security
  - Older Buildings
  - On request only
    - 80% volunteered request by owner
    - 20% insurance or ministry of health
- What is evaluated
  - Fire extinguishers
  - Emergency lights
  - Emergency plans
  - Alarms
  - Vapor makers
  - Flammable substances
  - Chemicals / reactants
  - Any hazards or fire safety related things
  - GAS
  - LPG – Liquid Petroleum
  - Order
  - Cleanliness
  - Human security
  - Emergency exits
  - Training / Drills
  - Capacity
  - Recommendations
- Current Problems
  - RED TAPE
    - No final say (Ministry of health)
    - Law in the works
  - No statistics
    - Accessible database of recommendations
    - Types of buildings
    - Exact locations
- Wants from GIS
  - Statistics
    - Types of businesses in an area
    - Color code-able map
    - What has been inspected recently
    - Findings
  - Link to stations
    - Information stored at OCO and sent out to trucks
    - Would know type of possible hazards
    - Also know exits and systems inside of evaluated buildings
    - Would know if buildings had been evaluated

APPENDIX J: Forms Used by Fire Fighters

PAG. de Indice alfabetico: GIS-Bomberos172

DIRECCION

NOMBRE DEL EDIFICIO

ROCIADORES SI/NO

PELIGROS A LA VIDA SI/NO

MATERIALES PELIGROSOS SI/NO

Nº PISOS

ESTACION:

GPM:

PISO Nº

NIVEL II DISPONIBILIDAD

Hecho por / fecha

APPENDIX K: Correspondence with CR·USA

To whom it may concern,

I am a student from Worcester Polytechnic Institute working with el Cuerpo de Bomberos in Costa Rica. For the past two months three other students and I have been working closely with the fire fighters on the idea of implementing a Geographic Information System (GIS)in order to improve methods of fire fighting, data organization, and analysis for el Cuerpo de Bomberos.

A GIS is a computerized system of visual organization. Simply, it is a number of digitized maps, called data layers, that can be viewed individually or over-layed, depending on the information that is needed. The actual abilities of the system are much more complex. With a GIS, the fire fighters would be able to view the best route to an emergency, the locations of hydrants, and the locations and types of hazardous materials, among others, before arrivingg at the scene of a fire. In addition, engineers for el Cuerpo de Bomberos would be able to analyze high risk areas, dangerous buildings and other problems. Although this system has multiple benefits, it is also very expensive. Costs of hardware, software, information and training all need to be taken into account. My group plans to recommend the implementation of such a system, as we have been assured that the INS will cover much of the costs, but we will be stressing to el Cuerpo de Bomberos that this will take numerous financial and temporal resources.

I learned of your program through Professor Juan Jose Gutierrez of The University of Costa Rica's Fire Protection Engineering program. I am writing to determine if this GIS implementation is the type of program that your organization would be interested in funding. I am aware that for the year 2000 this does not fit the type of projects that you are looking to support. However, as I mentioned before, the GIS will take many steps and much time to fully implement, and your help would be greatly appreciated in the future.

If possible, please send me information as soon as possible, as my group only has two more weeks here. If you would like more information on our project, I would be happy to send it, or we would love to have a representative from your organization attend our final presentation on July 4, at 3:00 in the auditorium on the first floor of the INS building in down town San Jose.

Please let us know if you would like to attend.

Thank you for your time.

Sincerely,

Shauna Malone

Dear Ms. Malone,

Thank you very much for your interest in working with CR-USA on the Geographic Information System (GIS) implementation program.

As you well know, we are currently working with Ing. Juan José Gutiérrez and Worcester Politechnic Institute in the Fire Prevention Engineering Project, project of which we are very proud and have high expectations.

In regards to your concern, I am afraid that the window for the reception of Project Proposals closed this past May 31st. Unfortunately, and for future reference, if you have the chance to visit our web site at www.crusa.or.cr, there you may notice that we are somewhat limited, by estatutes, when it comes to the purchase of software and equipment per se, unless they are part of a larger project, approved by the Board. Please feel free to express any other concerns you may have and we will be more than happy to respond promptly. Nevertheless, we will be more than glad to attend your presentation on July 4th.

Best Regards,

Camilo Acosta N.

Program Officer

CR-USA Foundation

CR-USA

PRESENTACION DE PROYECTOS

El documento debe presentarse en idioma español.

original y copia, más una copia en diskette, versión en Word 7.0.

Los presupuestos deben ser presentados en la moneda local (colones)

Por favor, lea y complete cuidadosamente la siguiente información básica de la institución y del proyecto. Incluya la firma del jefe institucional en el sitio que se indica al pie de esta primera página. Para aclarar cualquier duda referente a esta solicitud, por favor comuníquese con CRUSA al teléfono 283-0665, al fax 283-0981 o al e-mail: fcrusa@sol.racsa.co.cr.

Información del Proyecto

Información básica

Institución solicitante			
Nombre del Proyecto:			
Jefe institucional:		Tel: Fax:	
Jefe del proyecto Cargo actual:		Tel: Fax:	

Dirección Física:				pdo. ostal:	
Fondos solicitados a CR-USA Presupuesto total:	____________ ____________	Duración del proyecto (meses): Fecha de inicio:		Prioridad de financiamiento de CR-USA (elija una en objetivos de la página *web*):	

Otras fuentes de financiamiento

Otras fuentes de financiamiento (Favor indicar qué otras instituciones han sido contactadas para obtener financiamiento, el monto solicitado y el estado de la solicitud. Incluya quién finacia, el monto y el estado.)	

X Firma del jefe institucional (fecha):

1.0 Presentación del problema o la necesidad fundamental que será atendida por el proyecto.

En el espacio en blanco que se ofrece a continuación, explique brevemente el problema o la necesidad fundamental que será atendida por el proyecto propuesto. (Favor no exceder el espacio asignado).

2.0 Justifique la relación de cooperación entre Costa Rica y los Estados Unidos de Norteamérica, en el proyecto propuesto.

3.0 Descripción del proyecto

A continuación, sírvase brindar una explicación general del proyecto propuesto. Señale el objetivo, lo que planea hacer, cómo beneficia y a quién lo hace –identifique el enfoque geográfico y la población o sector que será beneficiado. (Favor no exceder el espacio asignado).

4.0 Descripción de la institución solicitante

Describir los aspectos más importantes de la institución, a quiénes sirve, su presupuesto anual, años de existencia y la experiencia, logros relevantes y nivel de organización para ejecutar el proyecto. (No olvide indicar el estatus público o sin fines de lucro de su institución).

5.0 Jefe de proyecto

Experiencia en el campo relacionado con el proyecto y cargo actual.

6.0 Referencias bibliográficas

Cualquier referencia utilizada para los hechos o estadísticas presentadas como respaldo al proyecto propuesto.

7.0 Sostenibilidad (Cuando aplica, si no aplica explique la razón)

Cómo se va a financiar el proyecto una vez que concluya el financiamiento de la Fundación.

Presupuesto Detallado y Plan

8.0 Presupuesto Detallado

Sírvase responder el siguiente formulario para detallar los rubros del presupuesto de su proyecto y para brindar una justificación sencilla de los mismos. Aquellos rubros que no correspondan a su proyecto pueden ser ignorados o eliminados, y se puede incluir cualquier categoría particular que sea necesaria. Asegúrese de justificar esto último con mucho cuidado. Todos los rubros que incluya deberán estar directamente relacionados con su proyecto.

RUBROS	Solicitado a CRU-SA (Columna A)	Aporte de la Institución (Columna B)	Otras fuentes de Financ. (Columna C)	TOTAL (Columnas A+B+C)
SALARIOS DEL PERSONAL(cite el cargo, % de tiempo en el proyecto)				
Subtotal, personal menos beneficios				
+ beneficios (% personal)				
Subtotal personal				
GASTOS DEL PROGRAMA				
Consultores (citar el cargo y las horas)				
Alquiler				
Teléfono				
Viajes (transporte + viáticos)				
Suministros de oficina				
Impresiones/correspondencia				
Compra de materiales (educativos, etc.)				
Subtotal gastos del programa				

TOTAL DE GASTOS **(Personal + Programa)**				

9.0 Plan detallado del proyecto

Utilice solamente el espacio necesario para describir los objetivos, actividades principales, tareas y resultados del proyecto presentado. (No se sienta obligado a definir 12 actividades principales si los objetivos de su proyecto se pueden cumplir con menos).

Instrucciones para llenar el Plan (refiérase al formato que esta en la siguiente página).

(1) Haga una lista de los objetivos de su proyecto en la sección A.

(2) En una hoja de papel aparte, haga una lista de las actividades principales que se realizaron en el proyecto presentado.

(3) Retome su lista de actividades y haga una lista detallada de las tareas que deberán ser realizadas para llevar a cabo cada actividad. Luego, elabore una lista de los resultados (resultados o productos) que se lograrán con el cumplimiento de cada actividad.

(4) Defina una fecha límite para cumplir cada una de las tareas y resultados.

(5) Regrese y revise que su lista de actividades y resultados le permita lograr todos los objetivos del proyecto propuesto. De no ser así, agregue nuevas actividades que permitan la consecución de cualquier objetivo incumplido. (Nota: la relación entre objetivos y actividades no es necesariamente uno a uno. Esto quiere decir que un objetivo puede estar relacionado con varias actividades y una actividad puede estar relacionada con más de un objetivo).

(6) En la sección B identifique cada actividad, con sus correspondientes tareas y resultados. Marque el año y el cuatrimestre en el que cada tarea y resultado correspondiente será cumplido.

(7) Adjuntamos un plan de proyecto guía como ejemplo para utilizar este formulario.

PLAN DEL PROYECTO

Sección A

Objetivos del proyecto (haga una lista de los objetivos del proyecto en la columna derecha)	

Sección B

Actividades, tareas y resultados	**I Año**			**II Año**		
	Cuatrimestre			**Cuatrimestre**		
	CR1	**CR2**	**CR3**	**CR1**	**CR2**	**CR3**
Actividad #1 - - *tarea* - *tarea* - *tarea* Resultado #1:						
Actividad # 2 - *tarea* - *tarea* - *tarea* Resultado #2						

Actividad #3 *- tarea* *- tarea* *- tarea* Resultado #3							
Actividad #4 *- tarea* *- tarea* *- tarea* Resultado #4							
Actividad#12 *- tarea* *- tarea* *- tarea* Resultado #12							

CRUSA – Ejemplo de un plan de proyecto

Descripción del proyecto

Amigos del Aprendizaje (ADA) es un programa piloto de tutoría/consejería para niños de educación primaria, el cual involucra a estudiantes de secundaria pertenecientes a colegios privados líderes, con el apoyo de adultos. Ofrece tutoría personalizada a niños del sistema educativo primario público que viven en comunidades urbanas marginales, quienes han sido identificados por sus maestros como posibles candidatos a perder el año o a desertar.

Sección A

Objetivos del proyecto (haga una lista de los objetivos del proyecto en la columna derecha)	〈 ***Intervención temprana*** – El Proyecto se enfoca en los niños de 1° a 3er grado para influenciarlos y evitar que los malos hábitos se arraiguen. 〈 ***Fortalecimiento de habilidades básicas*** – La tutoría se enfoca en el fortalecimiento de las habilidades matemáticas, de lectura y escritura. 〈 ***Modelos alternativos*** – Los estudiantes de secundaria sirven de modelo alternativo a los niños que acompañan. 〈 ***Hacer del aprendizaje una diversión*** – La tutoría hace un énfasis en el uso de varios sentidos, aprender haciendo y juegos. 〈 ***Creación de puentes entre comunidades*** – El Proyecto construye a partir de la confianza y las experiencias compartidas.

(ejemplo de un plan)

Sección B

Actividades, tareas y resultados	Año1 Cuatrimestre			Año 2 Cuatrimestre		
	CR1	**CR2**	**CR3**	**CR1**	**CR2**	**CR3**
(1).Actividad #1 – Tutorías para niños "en riesgo" (2) Tareas: ☐ Selección del maestro de los niños "en riesgo". ☐ Reclutamiento de los tutores de colegio. ☐ Desarrollo de un módulo de enseñanza. ☐ Desarrollo de una agenda de tutorías. ☐ Capacitación de los tutores ☐ Inicio de las tutorías. ☐ Presentación al final del curso lectivo de los niños. (3) Resultado #1: 29 horas de tutoría completadas						

(1) Actividad #2 – Asegurar la infraestructura necesaria. (2) Tareas: ☐ Obtener donación de alimentos para los niños. ☐ Asegurar el transporte de los niños. ☐ Conseguir el permiso de los padres para manejar un bus ☐ Asegurar tres aulas para las tutorías. ☐ Obtener suministros materiales para las tutorías (lapiceros, lápices, papel, crayolas, etc.). (3) Resultado #2: Infraestructura asegurada						

CRUSA

GRANT APPLICATION

The documents should be submitted in spanish. Present one original and one hard copy of this document, along with a diskette using Word for Windows '95.

Budgets must be presented in local currency (colones)

Please read and fill in the following *contact information* and *project information* with care and include a signature of the institutional head, where indicated on this first page, prior to submission to CR-USA. For questions regarding this application please communicate with CRUSA via telephone 283-0665, fax 283-0981 or e-mail: fcrusa@sol.racsa.co.cr.

Part I - Project Information

Basic Information

Applicant Institution:			
Proyect Title:			
Institutional Head:			
Project Leader: **Current Position:**			

<table>
<tr><td>Physiscal Address:</td><td colspan="3"></td><td>#</td><td></td></tr>
<tr><td>Funds Requested To CR-USA:

Total Budget:</td><td></td><td>Project Duration: (months)

Start Date:</td><td></td><td>CRUSA Funding Priority: (Choose one from Web Page)</td><td></td></tr>
<tr><td colspan="2">Other Funding Partners: (Please indicate which other institutions you have contacted for funding; the amount and status of the request. List founder, amount, and status.)</td><td colspan="4"></td></tr>
</table>

X Signature of the Institutional Head (Date):____

1.0 **Statement of the Fundamental Problem or Need to be Addressed by the Project**

Please provide a brief explanation of the fundamental problem or need to addressed by the proposed project within the space provided below. (Please do not exceed the space allotted.)

2.0 **Justify the cooperative relationship between the United States of America and Costa Rica within the proposal.**

3.0 Project Description

Please provide a brief overview of the proposed project below. Indicate its purpose, what it plans to do, how and who it benefits -identify the geographic focus and the population or sector benefited. (Please do not exceed the space allotted.)

4.0 Description of the Applicant Institution

In the space below please describe the applicant institution in terms of its institutional purpose(mission), who it serves, its annual budget, years in existence and its relevant experience and accomplishments in the project area. (Be sure to indicate the non-profit or public status of your institution.)

5.0 **Description of the Project Leader**

In the space below, please describe the qualifications of the project leader in terms of the project proposal: education and experience. What is his/her current position?

6.0 Bibliographic References

Please list any references for facts or statistics provided in this application in support of the proposed project.

7.0 **Financial Sustainability**

How do you plan to support the project at the end of the proposed funding period? Or indicate that the project will be discontinued, and why, at the end of the funding period.

Detailed Project Budget and Measurable Plan

8.0 **Detailed Budget**

Please use the format below to detail the items in your project budget and to provide a simple justification of the line items. Those items not pertaining to your project can be ignored, or deleted, and any special categories can be added if necessary - be sure to justify these carefully. All line items included should be directly related to your project.

ITEM	Requested from CRUSA (Column A)	In-kind donnations (Column B)	Funds other Sources (Column C)	Total Budget (Columns A+B+C)
PERSONNEL/SALARIES (list title, %time on project)				
Subtotal, Personnel less benefits				
+ Benefits (___%person				
Subtotal Personnel				
PROGRAM EXPENSES				
Consultants (list title & hours)				
Rent				

9.0 Measurable Project Plan

Use only the space needed to describe the objectives, major activities, tasks and outcomes of the proposed project over time. (Do not feel obliged to define 12 major activities, if less fulfill your project objectives.)

Instructions:

(1) List the Objectives of your project in the first box below.

(2) On a separate sheet of paper list the Major activities that will take place under your proposed project.

(3) Go back to your activity list and detail a list of tasks that need to be carried out in order to complete each activity. Then draw up a list of outcomes (results or products) that the completion of each activity will result in.

(4) Set a completion date for each task and outcome.

(5) Go back and check that your activity and outcome list allows you to achieve all of the proposed project's objectives. If it does not, add new activities that achieve any unfulfilled objectives. (Note: the relationship between objectives and activities is not necessarily one to one. That is one objective may relate to several activities and one activity may relate to more than one objective.)

(6) In the second set of boxes below list each activity, the tasks required to fulfill it and the outcome its completion leads to. On the right, mark off the year and quarter - 3 month period - in which each task and outcome will be completed.

(7) An educational project plan is attached as an example of how to use this format.

Project Objectives (To the right, list the major objectives of the project.)	

Activities, Tasks & Outcomes	Year 1			Year 2		
	Qtr 1	**Qtr 2**	**Qtr3**	**Qtr1**	**Qtr2**	**Qtr3**
Activity #1 - - *task* - *task* - *task* Outcome #1:						
Activity # 2 - - - Outcome #2						
Activity #3 Outcome #3						
Activity #4 Outcome #4						
Activity #12 Outcome #12						