GIS Applications for Fire Department

By

Ra'id K. Al-Dakhil

I.D# 907698

For

CRP 514; GIS

Term 021
(9th offer)

Instructor

Dr. Baqer Al-Ramadan

Jan. 21, 2003

CONTENTS

LIST OF FIGURES

ABSTRACT

Why should fire departments utilize geographic information system (GIS) technology? Fire departments have the responsibility to protect lives and property but have a limited amount of resources. It is critically important that the deployment of resources is effective, efficient, and based on the best information possible. GIS is a computer based data processing tool used to map, manage, analyze, display, and model spatial information. The advantage of a GIS compared to a fixed map is the ability of the user to quickly modify the analysis by updating data, introducing new data, or changing the assumptions. This technology allows fire officers to view all of the necessary deployment data in place. This technology offers managers the ability to eliminate much of the guesswork that has been the norm in tasks such as siting stations or deploying apparatus.

GIS can do many important things with less time and less effort. Siting fire stations is a challenging task that is often oversimplified. GIS package and its Network Analyst allow an organization to test station locations using average travel speeds to determine coverage capabilities within specified times. One of the most powerful tools provided by a GIS is the ability to geocode individual incidents and displays those incidents on jurisdictional basemaps. GIS provides the ability to quickly query the database. The tools have eliminated the need to wait while paper maps are produced, allowing real-time problem solving by staff officers and others. Firefighters are using helicopters, GPS units, laptop computers, ArcPad, and GIS software to map the perimeters of wildfires. That will provide fire managers with up-to-date information for sound tactical decisions.

Urban fires are often overwhelming resulting in the loss of property worth millions and the lives of many. On January 25, 1990, a Boeing 707 being flown by Avianca Airlines crashed killing 73 persons and triggering the largest emergency response in Nassau County history. Nassau County is located in New York City, and its facility has a non-geographical geographic locator system, which could not generate a map of the site. For that reason, and in addition to many dead-end streets, Rescue services didn’t do there suppose job. However, The Fire Rescue Service in Wilson, North Carolina, is using more advanced GIS software called FireView. It has improved the speed and quality of its response systems, identified and reduced many previously unidentified hazards, attacked problems that were previously beyond its capabilities, prepared for major disasters, and significantly increased the safety of the City’s firefighters. Through the use of GIS, the Wilson Fire Rescue Service also improved the safety of firefighters.

GIS applications, unfortunately, have not been used yet in Fire Station of Dammam District#91, Saudi Arabia. The firefighters of the district are still using hard copy maps to reach any incident. The district’s population of nearly 40,000 is served only by one fire station comprised of 20 members and has only three vehicles. It’s Streets are not numbered or labeled and always under constructions. So, those make the firefighters have difficulties to reach to the incident in short time and short.

1. INTRODUCTION

Fire departments have the responsibility to protect lives and property but have a limited amount of resources. It is critically important that the deployment of resources is effective, efficient, and based on the best information possible (Ref.#1). Effective deployment is based on numerous complex issues: fire demand, effective fire fighting force, occupancy, historical occurrence, response time, and others. Traditional planning methods require the use of numerous maps, reports, tables, and historical records. This data is often found in a variety of different locations and formats, and requires a great deal of time to acquire, prepares, and formulate into a useful format. Resultant deployment plans are often completed, implemented, and shelved. Deployment planning in the traditional sense is more of an event than an ongoing process (Ref.#2).

GIS is one of the fastest growing career fields in the world. GIS is a computer based data processing tool used to map, manage, analyze, display, and model spatial information. A GIS is an automated data management and manipulation system capable of analyzing patterns and relationships between many different layers of mapped data simultaneously. The advantage of a GIS compared to a fixed map is the ability of the user to quickly modify the analysis by updating data, introducing new data, or changing the assumptions. GIS can be used in many departments such as; business, communications, engineering, environmental management, health and human services, transportation, utilities, civil defense.

GIS allows fire officers to view all of the necessary deployment data in place. Data can be added, subtracted, or modified with computer mouse operations. Alternative plans can be created, analyzed, and modeled by a group or staff of fire officers using GIS. Once a GIS database has been created, deployment analysis can be reviewed and updated at any time with little effort. GIS allows deployment analysis to become a process rather than a periodic event (Ref. #6).

.

Although computerized mapping systems have been around for many years, recent improvements have made GIS software available on the desktop and on laptops. GIS applications developed specifically for fire departments provide tremendous functionality through a user-friendly interface. Nonspecialists to improve planning, analysis, and response can now use GIS software. These tools offer managers the ability to eliminate much of the guesswork that has been the norm in tasks such as siting stations or deploying apparatus (Ref. #2).

2. PROBLEM STATEMENT

Fire departments must protect lives and property with a limited amount of resources. It is critically important that the deployment of these resources is effective, efficient, and based on the best information possible. GIS is Providing the ability to manipulate and analyze data in ways that are not possible manually.

The Fire Department sees GIS as a tool they can use to make such a place as a safer community and to make their jobs as fire fighters safer as well. Some fire surfaces don't know about how GIS technology can maximized the efficiency and effectiveness of their work. They have not noticed yet how much time they spend to update their maps manually, how much time they waste just to look at to such important.

3. OBJECTIVE

This paper will describe how GIS can be used for fire departments. The major objective is to present the increasing work efficiency for fire departments that are using GIS. Two Case studies will be highlighted in this paper to show the importance of GIS technology for Fire Services. This paper will focus then on the Fire Station of Dammam District#91 and the benefit of the GIS technology this station miss.

4. POTENTIAL FIRE DEPARTMENT GIS APPLICATIONS; REVIEW OF LITERATURES

Every fire service should be thinking about implementing GIS into the management and incident management process. One of the primary challenges for implementing GIS is obtaining geographic data. If reasonably accurate digital basemaps are already available in the community (and the fire department has access), the biggest obstacle has been overcome. Following are what GIS applications can do/provide for the Fire Services and Fire Management.

4.1 Optimum Siting for Fire Stations

Siting fire stations is a challenging task that is often oversimplified. In its most basic form, many stations are sited using a simple radius coverage scheme that is believed to relate back to the time of horse-drawn fire apparatus. Other formulas presume that fire departments protect only real property where travel speed is constant at all hours of the day, and that emergency events occur randomly with respect to time. In truth, fire department response workload involves nonfire (medical and service) responses, travel time changes at various times of the day, and emergency events are not randomly distributed but are predictable within certain limits (Ref. #2).

The ability to test potential fire station locations for area coverage is very important, because of the constant changes in street networks. Historically, this testing was accomplished by sending a fire vehicle equipped with a stopwatch to drive an area and mark travel times over the street network. The varying speeds, distances, and the availability of crew time in the face of competing duties limit this approach. It is also not possible to test areas where streets have not been completed or where the street network is subject to change (Ref.#3).

For example, ArcView GIS package and its Network Analyst extension can assist in siting fire stations optimum locations. ArcView GIS and its extensions run on desktop PCs running Windows95 or later, or Windows NT. ArcView Network Analyst allows an organization to test station locations using average travel speeds to determine coverage capabilities within specified times (Ref. #2).

4.2 Response Performance Zones Creation

In developing standards for coverage, it is necessary to examine areas and perform statistical analyses of response performance within those areas. Using GIS, calls can be geocoded to their specific locations, creating a very busy pin map supported by all of the data pertaining to each call Groups of calls can then be captured using the GIS and exported to a statistical analysis program for evaluation. Response zones can then be created based on workload, fire demand, and response times rather than traditional response time criteria (Ref. #2).

One of the most powerful tools provided by a GIS is the ability to geocode individual incidents and displays those incidents on jurisdictional basemaps. Fire agencies can use geocoded data to make decisions about the need to purchase and assign additional extrication tools and to strategically position brush fire fighting units or other specialized units for optimal response. Fire prevention requirements and other mitigation strategies can be determined through GIS incident analysis (Ref. #4).

Incident data can be readily examined via GIS and deployment adjusted accordingly. GIS provides the ability to quickly query the database and perform what-if scenarios. The tools have eliminated the need to wait while paper maps are produced, allowing real-time problem solving by staff officers and others (Ref.#3).

4.3 Mobile Data Computers

Dynamic GIS in the cab of emergency response apparatus is rapidly expanding. This exciting development will eliminate many of the difficulties associated with too many three-ring binders, outdated map books, transfer of personnel, and rapidly developing communities. Firefighters will be able to obtain maps, travel directions, prefire plans, and a variety of other information from their vehicular computers (Fig., 1).

In recent years, firefighters have been using helicopters, GPS units, laptop computers, and GIS software to map the perimeters of wildfires. The technical specialists who perform this type of mapping typically carry a full-sized, 10-pound notebook computer; a GPS receiver weighing several pounds; a cell phone, and a full complement of extra cables, batteries, and other necessities in a helicopter or on the fireline to provide fire managers with up-to-date information for sound tactical decisions. While these efforts have been very beneficial, juggling computers, cables, and GPS units within the tight confines of a helicopter or truck cab is challenging (Ref.#4).

4.4 Large Incident Management

Large-scale incident management can be greatly enhanced through timely application of GIS technology. Incident commanders faced with wildfires, floods, earthquakes, or other events impacting large numbers of people, the municipal infrastructure, or large geographic areas will be better able to manage events aid resources if timely and accurate map data is available to an Incident Command System (ICS) and other members of the incident management team (Ref.#3 and Ref.#8).

Figure 1. Vehicular computer

GIS has proven so valuable to Califomia's fire service that *FIR ESCOPE* (the State-wide all-incident mutual aid program) has GIS specialists assigned to its overhead incident management teams, utilizing common basemaps, map symbology, and fire planning data. When large numbers of resources must be mobilized and accounted for as the event progresses, GIS can prove an invaluable asset (Ref.#2).

5. CASE STUDIES:

5.1 GIS Would Have Made A Difference; Flight Crash in Nassau County

On January 25, 1990, a Boeing 707 being flown by Avianca Airlines crashed killing 73 persons and triggering the largest emergency response in Nassau County history. Nassau County is located on Long Island between New York City's Queens County to the West and Suffolk County to the East (Fig., 2). Its population of nearly one and one-half million is served almost entirely by volunteer fire departments comprised of ten thousand members.

In addition to the 2,350 member County Police department, there are 22 smaller departments providing protection to the two cities and 20 of the incorporate villages in the county (Ref.#7).

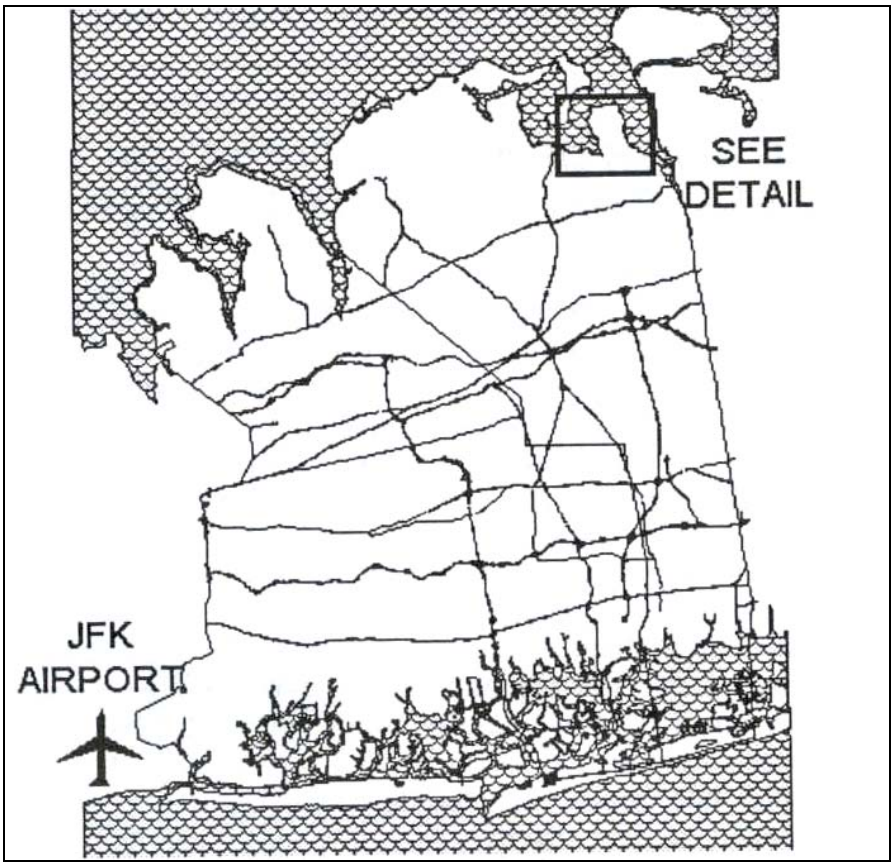

Figure 2. Nassau County & its major highways

As the airplane was circling back toward the JFK airport to make another landing attempt, the fuel ran out and the plane with its 157 passengers and crew slammed into a wooded hillside in the Incorporated Village of Cove Neck (Fig. 3). Cove Neck Village sits on hilly woodlands on the shore of Long Island Sound. It has its own small police department and lies within the Oyster Bay Fire District. The homes occupy multi-acre sites with private secluded driveways and many dead end streets and cul-de-sacs. Many visitors have found themselves lost and confused on the roads of the Village and even persons with a superficial familiarity with the streets would be hard pressed to find a particular house at night.

5.1.1 Problems in Emergency Response

The Airplane came to rest in three pieces within yards of a home, with its tail section blocking the narrow, crested roadway, which served as the sole access to the site. A resident heard some noise, went to investigate and then called the police. Nassau's E-911 system is supported by a separate Fire/Rescue dispatch, communications and command

center. This facility has a non-geographical geographic locator system which could not generate a map of the site. As County Police responded to an area served by local police they were unaware that the airplane had come down in a spot accessible only via a narrow one-way Street, which almost immediately became impassible except by foot. Fire & Rescue responders could not reach staging locations because traffic quickly blocked access and emergency medical crews were stymied in their efforts to move victims to area hospitals (Ref.#7).

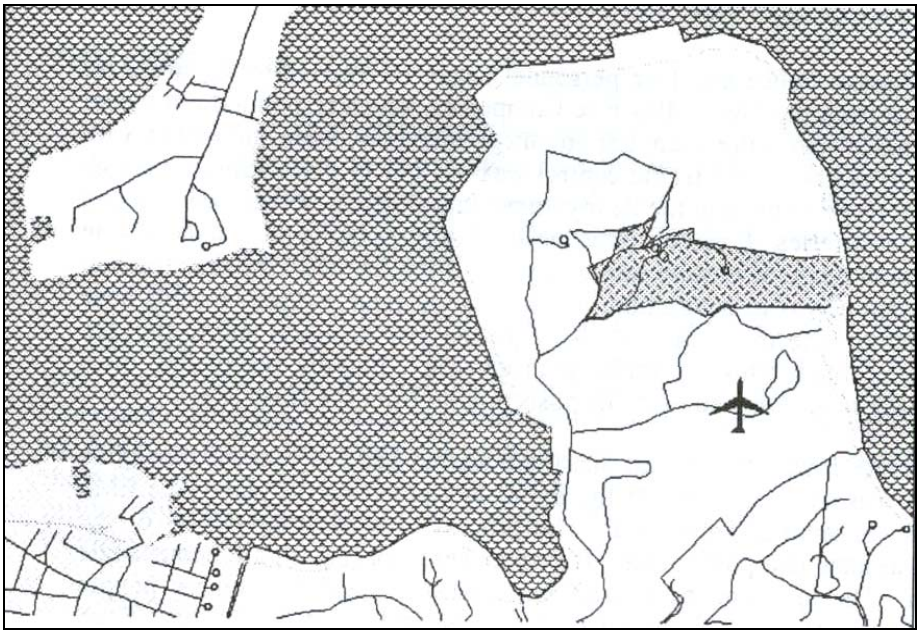

Figure 3. The crash site in Cove Neck

It is really important to say that if the County's Police Communications and the Fire/Rescue Communications Center staff had instant access to a common map they could and certainly would have been able to determine the most likely staging area locations and to spot the obvious problem sites for traffic management. Initially responding units could have been assigned to traffic posts remote from the crash site

5.1.2 What GIS Would Have Made?

The problems encountered in the emergency response phase might have been avoided or reduced through the presence of a map based response procedure using GIS. In addition to that, there were several other complications encountered in this incident which might rightfully have been headed off by using a modern GIS. Fire/Rescue and other emergency vehicle operators responding into the unfamiliar North Shore area not only had difficulty finding the crash site but then they were directed to hospitals in other areas even more remote from their home districts. GIS maps with traffic control and routing data already in place could have been transmitted to the scene via fax or modem and made available to the responders. Helicopter pilots from New York City who responded on mutual aid might also have had the advantage of such maps in locating receiving hospitals from the air.

The Long Island Lighting Company (LILCO), Nassau's primary electric and gas utility, dispatched units to restore electrical service to the area almost simultaneously with the callout of fire and rescue mutual aid. They were hampered in their response by the same conditions experienced by everyone else. The County is including LILCO in the development of their GIS so that the common map and associated layers can provide the utility with routing and traffic control information during any future incidents.

5.1.3 After the Incident

Fire & Rescue Services were one of the first agencies to be contacted for inclusion in the creation of the County's GIS. The results of a user needs survey which was conducted very early in the process of developing a County-wide system clearly demonstrated that emergency response was a legitimate and pressing use for GIS. With that in mind the GIS Technical Committee has moved to incorporate traffic control devices, fire district and police sector boundary lines, definitive identification of potential staging sites (parking lots, open fields, wide thoroughfares, etc.), helicopter landing sites, and building footprints and elevation data as well as the many other features commonly found in GIS databases

Now, all Nassau County emergency response agencies are able to access a common map. They are looking at the same data and basing their life and death decisions on accurate and reliable information (Ref.#7).

5.2 GIS Makes Wilson Fire Department More Effective and Efficient

The Fire Rescue Service, the fire department serving Wilson, North Carolina, recognized and limited dangerous gas leaks using a GIS application from The Omega Group called FireView. Before the installation of FireView, the Department was not always using accurate data. The Wilson Fire Rescue Service had assumed that the numerous gas leaks reported were due to construction activity on the northwest side of the City. However, mapping the calls for service with FireView revealed that this assumption was inaccurate. The greatest volume of calls originated on the east side of the City.

The Wilson Fire Rescue Service shared this information with the Risk Management and Gas Divisions. Then, these divisions dispatched a successful public program that has led to fewer gas leaks and created a safer environment for both citizens and firefighters. The Wilson Fire Rescue Service has been transformed into a more informed, efficient, and effective force, because of the efforts of The Omega Group, ESRI, Wilson Fire Rescue Service, Wilson GIS Department, and COMPAQ Computers.

The Wilson Fire Rescue Service can now anticipate potential problems and implement appropriate preventive measures by using FireView. It has improved the speed and quality of its response systems, identified and reduced many previously unidentified hazards, attacked problems that were previously beyond its capabilities, prepared for major disasters, and significantly increased the safety of the City's firefighters (Ref.#1).

Previously, the Wilson Fire Rescue Service was not able to take advantage of the City's valuable GIS information. With the installation of FireView, the Department can now fully utilize the City's GIS resources and access the City's records management data. Even the Department gets an accurate and up-to-date picture of the current status of each of its fire districts. Existing boundaries, planning and response zones, demographics, and hot spots can easily be identified. This fast identification is very useful in clarifying priorities and designing solutions. Consequently, the Department can review standards of coverage, insurance evaluations, reassign apparatus, and select new station locations to maximize response coverage based on calls for service (Ref.#5).

FireView provides the ability for the Department to address many issues. Analysis using the new information available through GIS exposed that some areas of the City had insufficient water supplies. When the Department mapped all the hydrants and the water pressure associated with each, it discovered that one school, and the residential area surrounding it, had hydrants that flowed at 500 gallons per minute (gpm) or less, which is below the normal flow rate. It's really a serious public safety issue that should be considered. The Department presented a map and report on this problem to the director of Public Services and the Water Resources Division. The problem was solved within two weeks. Now all parts of the City have sufficient water flow to support fire protection (Ref.#1, and Ref.#5).

Through the use of GIS, the Wilson Fire Rescue Service also improved the safety of firefighters. By creating a data layer that identified all vacant commercial structures and assigned hazardous condition ratings, engine companies are now able to identify potentially dangerous situations and implement predetermined emergency response procedures designed for specific structures.

The Department has also found that FireView helps utilize staff resources more productively. Now staff members spend more time training on fire and rescue services and less time on data entry and office work. Wilson Fire Rescue Service and FireView have maximized the efficiency and effectiveness of the Department, increased the safety of its personnel, and given greater peace of mind to the residents of Wilson, North Carolina (Ref.#1).

5. WOULD GIS BE APPLIED IN FIRE STATION OF DAMMAM DISTRICT#91

GIS applications, unfortunately, have not been used yet for the Civil Defense in Saudi Arabia. Although Saudi Arabia hosts one-third of the world's total oil reserves, the firefighters are still using hard copy maps to reach any incident. I take the opportunity to discuss about how the fire station of Dammam District# 91 finds out the fire locations and how such this important department can benefit from GIS technology.

Dammam District# 91 is considered as the largest district in Dammam City and the closes to the Dammam Airport (Fig., 6). Its population of nearly 40,000 is served only by one fire

station comprised of 20 members and has only three vehicles! (personal communication, 2002). In addition, not all of the fire equipments are available in the station. The firefighters are still using a hard copy map for the area to reach the fire location. Streets of the District are not numbered or labeled, so if the burning building is not located in one of the main roads of the area or well-known area, the chances to get their quickly become lesser. Added to that, road maintenances that are happening frequently due to the bad construction planning, affect on how to get there as shorter time as possible. So, if you want to make sure that the firefighters reach to the incident quickly, wait for them at the closest main road! (personal communication, 2002).

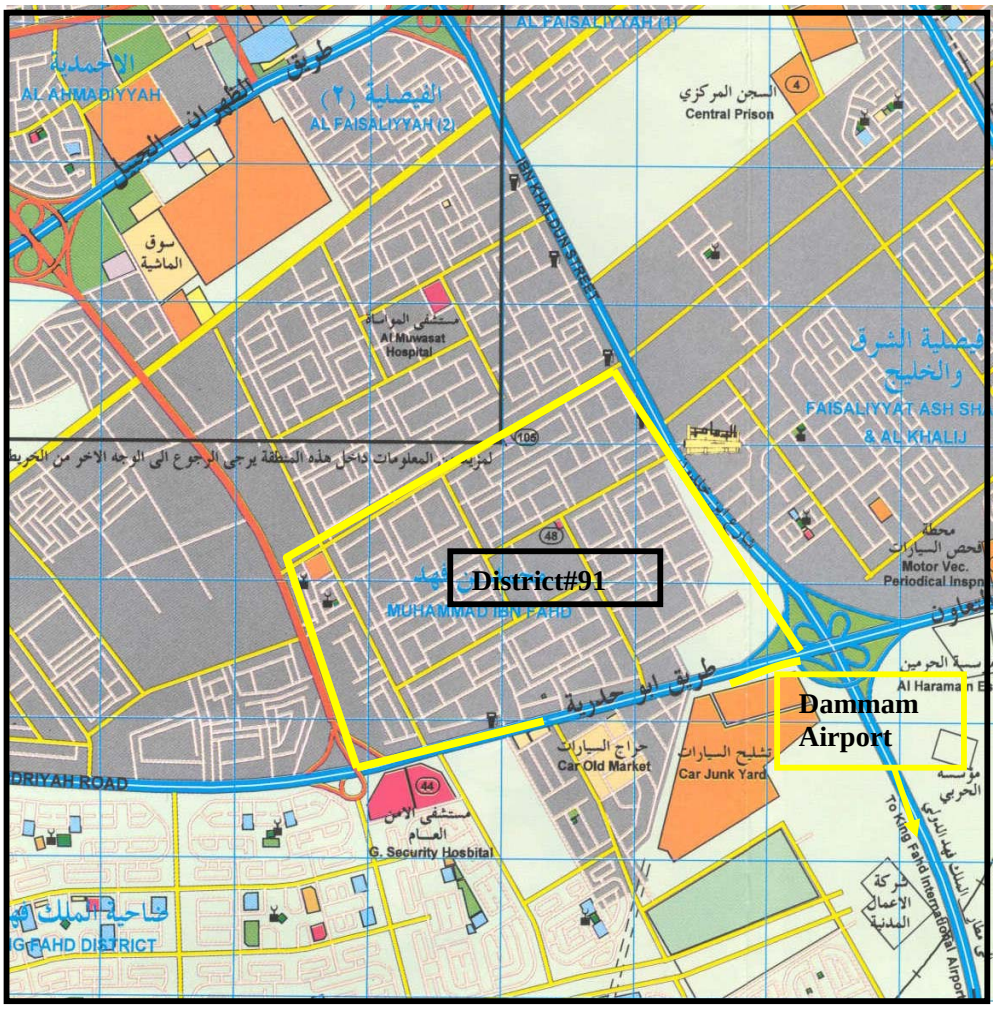

Figure 5. Dammam District#91 location

Four weeks ago, the firefighters were heading to a burning house that where located in area under maintenance (Fig. 4). They entered into very narrow and dead-end road that took those about five minutes to get out from there. The time is very critical and important matter to such incident and you imagine how these five minutes reduce the damages. What if this fire station has GIS technology that could generate the up-to-date map of the site? In

fact, the lack of proper database has been the bane of the fire service and has gone unnoticed by the authorities and bureaucrats alike.

What if GIS technology is applied for this Fire Station? The firefighters will have database that includes roads (should be numbered and labeled), water supplies, fire history, schools, buildings, areas under maintenance, hazardous material locations, station location needs, fire equipments, and other key requirements can be analyzed. The application will be able to display a map showing the optimal route to the emergency. This route can be instantly modified to take into account streets that are blocked. The application also can provide information on all available fire hydrants, any known hazardous materials in the area, the locations of special needs populations, and other relevant information. That will increase the efficiency and effectiveness of the Fire Station of District#91. .

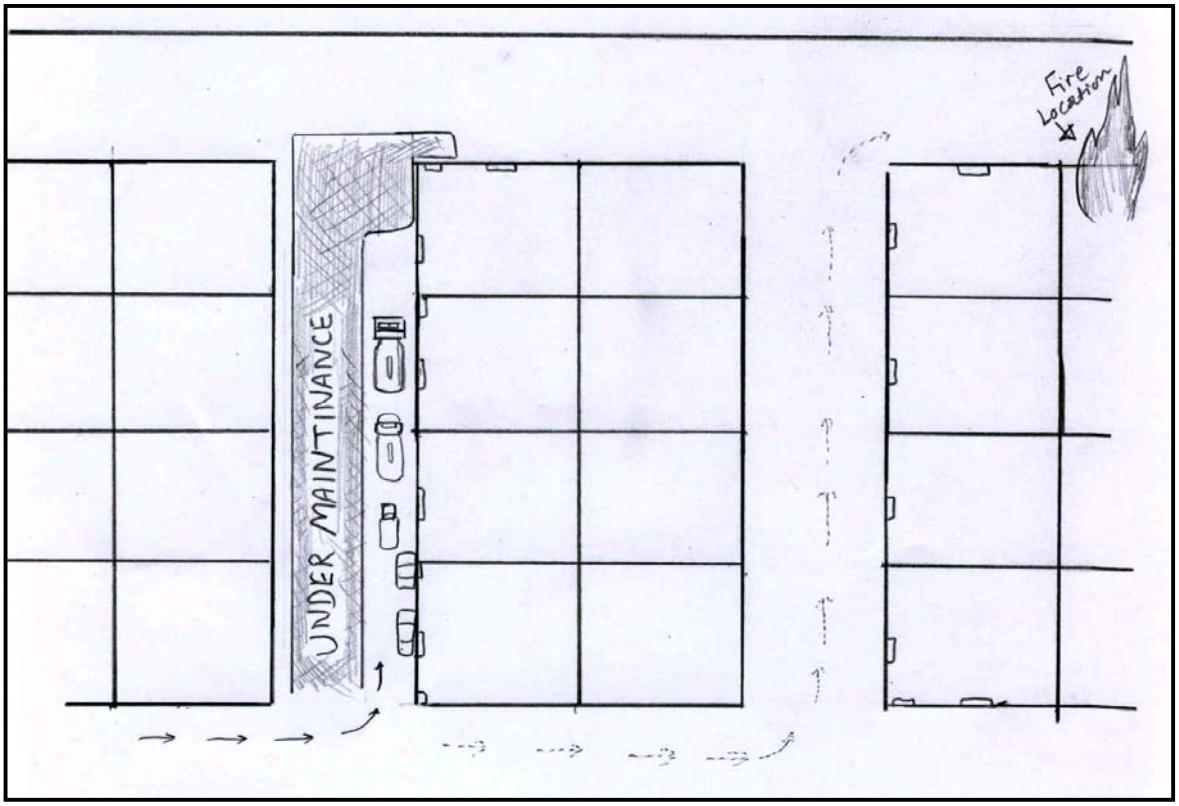

Figure 5. Schematic section of dead end road and fire location in District#91

GIS will show that District#91 must have more fire vehicles with up-dated technology, more members, more water hydrants, and more fire equipments. That means, the District needs huge budget to resolve all these serious public safety issue. The huge budget is not possible these days (personal communication, 2002). Dammam District#91, unfortunately, has a dark future.

6. CONCLUSION AND RECOMMENADATION

Ronny I. Coleman, Retired California State Fire Marshall, stated:”100 years ago, the way fire officers displayed their fire protection problems was on Sanborn maps. Drawn by hand, building-by-building, block-by-block, they were eventually abandoned because they were too labor intensive. Today fire officers need specific information on fire problems more than ever. And they have a new tool: GIS. Just like firefighters no longer fight fires with steamers, they should not be using century-old techniques to define fire problems with a pad of paper and a pen. Electronic fire management means using a computer to achieve excellence in fire planning” (Ref. #2).

The opportunities to utilize GIS for planning, managing, and evaluating fire service operations appear to be virtually limitless. Mapping of hazardous materials storage sites, residences of physically challenged persons, municipal hydrants, dry hydrants and drafting points, planning facility locations, emergency event modeling, and a host of other tasks can be simplified, shortened, and more efficient through the application of GIS technology.

Developments in GIS technology can provide tremendous enhancements to today's fire service managers. Future developments will further change the way we do business, automating and improving efficiencies for responders and fire prevention personnel as well as managers and supervisors. Current and future fire service leaders should be encouraged to develop a growing awareness of the applications of GIS technology to their business.

REFRENCES

1- GIS Makes City More Effective and Efficient. Government Matters, Winter 2002. http://www.theomegagroup.com/downloads/govmatwin02.pdf

2- Johnson, Russ, "GIS: A Powerful New Tool for Fire and Emergency Services". http://www.gis.com/specialty/government/gisforfire.html.

3- GIS Takes Oregon Firefighters a Long Way from the Bucket Bridge. ArcNews, vol# 21, issue# 4, Winter 1999-2000. http://www.esri.com/news/arcnews/winter9900articles/42-gistakesoregon.html.

4- Clark, Timothy E."GIS Provides Critical Support for Wildfire Response". Arc User Magazine, 2001.

5- Fire Agencies Improve Response with GIS. Arc User Magazine, 2000. http://www.esri.com/news/arcuser/0100/firetools.html

6- Johnson, Russ. "GIS for Fire Deployment Analysis". Second International Conference on *Fire Service Deployment Analysis*, 2002. http://ife-usa.org/2002/Papers/GIS%20for%20Fire%20Deployment%20Analysis2.pdf

7- Meade, Peter W., 1994 "The Crash of Avianca Flight 052: GIS Would Have Made a Difference". Annual Conference of the *Urban and Regional Information Systems Association.*

8- GIS/GPS Application for fire management: A case study. GIS Development Magazine, November-December, 1997. http://www.gisdevelopment.net/magazine/gisdev/1997/nov-dec/fire.shtml

APPENDICES