KING FAHD UNIVERSITY OF PETROLEUM & MINERALS

# TERM PAPER

# USE OF GIS IN EFFECTIVE PLANNING AND MANAGEMENT OF FIBER OPTICS CABLES

## CRP 514: INTRODUCTION TO GIS TERM 121
## 20TH OFFER

## DR. BAQER AL-RAMADAN

*PREPARED BY:*

ABUBAKER AHMED ELOBIED

ID: 201002960

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## Introduction

Geographic Information Systems (GIS) have widespread application to many of the problems and activities of communities. An emerging area of interest for communities is telecommunications and as this guide will demonstrate GIS can serve as a powerful tool to inform policy decisions in this realm. This guide is intended to serve as a reference for those who are new to GIS as well as those with some prior GIS experience that want to learn more about how to leverage it towards problems relating to community telecommunications. "Community Telecommunications" is a general term that refers to a wide range of activities that relate to the improvement of an area’s capacity for data transmission such as:

- Planning
  - Identifying concentrations of population
  - Locating potential subscriber premises
  - Classifying potential subscriber premises by levels of service required
  - Locating existing infrastructure
  - Locating rights-of-way
  - Identifying optimal routes for wired infrastructure and distribution points For wireless infrastructure
- Engineering
  - Detailed physical network design
    - Cable route layout
    - Switching and access locations
    - Outside plant equipment inventory
  - Cost estimation
  - Association of network equipment with network switching and access Locations
- Management
  - Asset/Facilities management
  - Maintenance and expansion planning

*What is GIS?*

GIS software systems link features on a map to descriptive information known as attribute data. This allows GIS uses to simultaneously leverage both the visual advantages of a map and the data storage and retrieval advantages of a relational database. The old adage that "a picture is worth a thousand words" is very relevant in this context as many organizations have substantial amounts of data in tabular form that when displayed on a map become much easier to understand and analyze. GIS allows users to answer spatial questions of location, proximity, and geographic distribution. As shown in Figure 1 GIS represents multiple attributes of geographic space as a set of overlapping layers. Layers may be turned on or off and new relationships between layers can be discovered both through simple observation and through the application of advanced spatial analysis techniques.

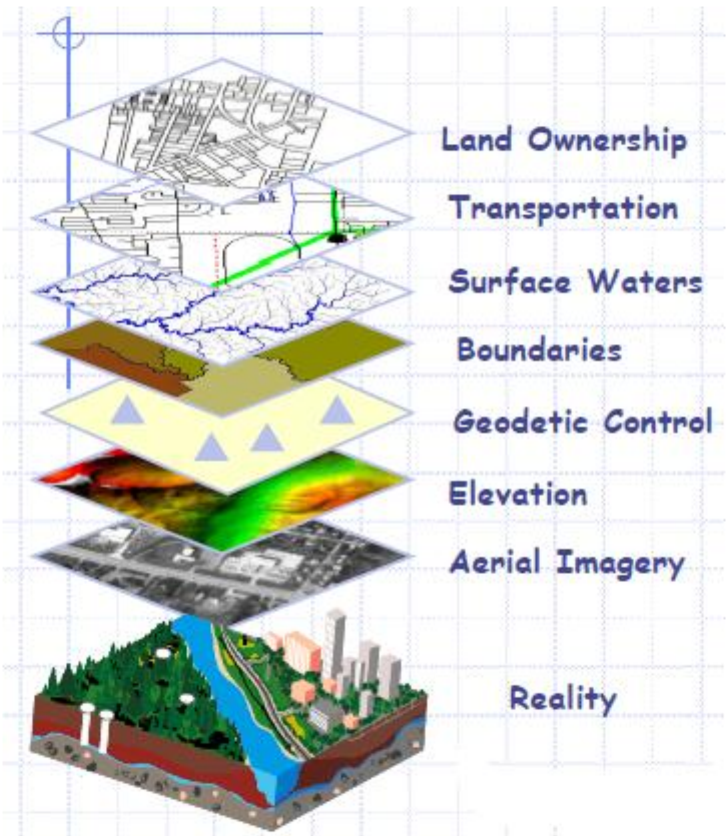


Figure1. GIS Data Layers Example (Dr. Baqer, 2013)

## Background of study

Fiber optic cable network providing high speed internet services to customers. Fiber optic GIS database is implemented for serving the business needs of the enterprise. This paper will attempt to study the role of GIS in Planning and management of fiber optic cable in urban centers as used by the company. To support and make the planning process robust, GIS can be employed. GIS is a computer based system which is used to capture, retrieve, process, represent, and analyze both spatial and non-spatial data. Spatial data includes the points, lines and polygons etc., whereas non-spatial data consist of textual information. This information can be stored in separate databases and can be accessible by GIS tools. There are two major methods of representing maps, raster maps and vector maps. Raster maps consist of bitmap form and vector maps consist of points, lines and polygons. Vector maps are more useful for supporting various calculations for planning. To support management Fiber Cable as built routes and components has to be precisely capture and stored in the GIS database.

Geographic Information Systems (GIS) have widespread application to many of the Business challenges. An emerging area of interest is fiber optic cabling planning and management in telecommunications industry. GIS can serve as a powerful tool to inform policy decisions in this realm. This paper is intended to establish that critical role of GIS in planning and management of fiber optic cabling in attempt to leverage it towards solving problems relating to Fiber optic cable deployment.

## Problem Statement

The arrival of fiber optic technology in the world has resulted to tremendous growth in ICT sector. Service providers have been in the rush to out compete each other in connecting subscribers; this has seen chaotic and massive digging within the city and along many streets in many urban centers as well as along highways in order to connect towns, telecommunication masts, banks, schools, office and homes. Currently there is need to connect homes and as a result there is a new product dubbed Fiber to the Home. The demand for reliable connectivity has resulted in the need on the part of service providers to use better tools and techniques for planning, engineering and maintenance of fiber cable infrastructure in order to meet customer satisfaction and remain relevant in the market. Some of the challenges identified in the course of fiber project implementation have since been identified as planning which include identifying concentrations of population, locating potential subscriber premises, classifying potential subscriber premises by levels of service required, locating existing infrastructure, locating rights-of-way and identifying optimal routes for cable infrastructure and distribution points. A second set of challenges are engineering in nature and includes detailed physical network design, cable route layout, switching and access locations, outside plant equipment inventory, cost estimation and association of network equipment with network switching and access location. The third challenge is management and includes as built records, fault localization to facilitate quick responds in time of network disruption, maintenance and expansion planning. This paper propose to study how GIS can be used to solve the above mentioned challenges as it will attempt to organize, store, relate and display trends and relations among this challenges and provide a better planning and management solution for fiber optic cable infrastructure implementation.

## Objectives

The objectives of this study are to provide managers and maintenance crews with easy access to fiber optics detailed information, conduct proximity infrastructure buffer analysis, and generate what-if "smart map" to support decision analysis.

## Scope of the study

This study will investigate the roles of GIS in Fiber optic Cable planning and management. The Study will further develop a geo database for fiber optic Cable infrastructure.

## Methodology

The first step for Business in planning for fiber optic cabling is some type of assessment. Assessments usually seek to determine the extent of existing telecommunications infrastructure and services, and the location of potential customers. If the assessment reveals a deficiency in supply relative to the estimated demand for telecommunications services, GIS can be used to design scenarios for bridging the gap.

- **Data**
  - Road network
  - Business points
  - Buildings
  - Fiber optic cable routes
  - Fiber optic Network nodes
- **Procedure**
  - Determine business Information Needs
  - Design Database
  - Design Tools
  - Build Database
  - Implement in Your Management
  - Maintain Database
  - Analyze Database

## Mapping Population Densities

A useful first step in identifying areas of broadband demand is developing an understanding the local population distribution. Using Census Block-level demographic data, it is relatively easy to create a map of population density. Mapping population patterns at the block level the smallest unit of Census geography can yield insights into the general location of potential subscribers and can help to ensure that isolated pockets of population are not left out of the planning process.

## Mapping of Business Points

Another critical step is an analysis of business locations "Business Points" which can be obtained from a variety of sources such as yellow pages, telemarketing lists, Modality website and other publications. Each point will be associated with attributes such as industry sector, employee count and annual sales. To map the data it will be necessary to first convert into Shape file format with addition of attribute fields for the full name of the industry sectors. This allowed concentrations of large businesses to be easily identified and showed relationships between the location patterns of different business types.

## Classify Building Structures

An alternate method to supplement business points in fiber cable planning is the classification of buildings based on their use; residential, business, or government this will help guide the capacity of cable to be deployed.

## Literature Review

Fiber optic is strands of flexible glass as thin as human hair that is used for telecommunications. These strands carry digital signals with light. Even though these cables are made of glass, they are not stiff and fragile. They can bend kind of like wires and are very strong. When hundreds or even thousands of these strands are arranged in bundles, it is called an optical cable. These glass cables are covered with a special protective coating called cladding. The cladding is made from a material that reflects the light back into the core or center of the cable. This cladding creates a mirror-lined wall. The final outer layer is a buffer coating to protect this special glass cable from damage and moisture. Fiber optic cable is of two main types Single-mode and multi-mode. Single-mode fiber cables send signals using laser light and are smaller in thickness than multi-mode. Multi-mode fibers send signals using light-emitting diodes or LEDs and are bigger in thickness or diameter than the single-mode cables. Fiber optics work using the *total internal reflection principle.* When light is transmitted into the glass cable the light bounces off the reflective cladding on the sides of the glass cable so the light can travel around corners. In other words the light bounces off the inside of the cable until it gets to its destination. There are more parts to the fiber optic system than the cables. The first thing is the **transmitter** which produces the signals that will travel through the cable. The **optical regenerator** is needed when the light signal is weakened by traveling over a long distance and needs a re-boost or strengthening. Actually, the light signal is copied and a new one with the same characteristics is sent by the regenerator. Finally there is the **optical receiver**. It receives the light signals and encodes them into a readable form for the device at the end. Fiber optics finds its use in internet and telecommunication. It is a perfect application because it is digital information and the fiber optic cables send digitally. Telephones were one of the first uses for fiber optics. Many times internet and telephone signals travel over the same cables. Digital television (also known as cable TV) is often making use of fiber optic cables. Fiber optic cables without optical regenerators can be up to about one kilometer in length. With regenerators, they can go on almost forever. They can be placed in buildings, up on power lines, buried in the ground or even placed in the ocean. In case of damage to Fiber optic cables accidentally they can be repaired using a technique called splicing where a technician cuts off the broken ends and reconnects those using special adhesives, heat, or special connectors with help of splicing machines. Fiber optic technology has been used as the main communication technology over satellite communication and copper technologies due to the following advantages: (Hecht. J, 2006)

Less Expensive

Fiber optics is less expensive than copper wire. Both customers and service providers (the companies that own the communication system) save money. This is because many miles of optical cable are easier and less expensive to install than the same amount of copper wire or cable.

Thinner

Fiber optics is thinner than copper wire cables, so they will fit in smaller, more crowded places. This is important for underground cable systems like in cities where space needs to be shared with sewer pipes, power wires, and subway systems.

Higher Carrying Capacity

A fiber optic cable offers greater bandwidth capacity as compared to satellite and copper wired technology.

Less signal degradation

Fiber optic cables don’t lose as much signal (information) as other kinds communication media.

Use Light Signals

Because fiber optics use light signals instead of electricity, the signals don’t interfere with each other. This makes the signals clearer and easier to understand.

Low Power

Optical fiber signals are created using low-power transmitters because the signal degrades less (instead of high-power electric transmitters used for copper wires). Lower power use saves money for users and providers.

Digital Signals

Computer networks need digital information, since fiber optic cables send information digitally; they are the best thing to use for computer networks.

Non-flammable

Since fiber optics send light instead of electricity, fiber optics are non-flammable. This means there is not a fire hazard. Fiber optics also do not cause electric shocks, because they do not carry electric currents.

Light weight

Fiber optics is easier to install and transport than copper wires. That is good news for technicians

Flexible

Since fiber optics is more flexible, they can go around corners and into tighter places than traditional cable. This is important in computer and very big office networks.

## Metro Fiber Optic Communication System

Metro city fiber optic topology is based on a three levels model: main network, distribution network and access network with three types of nodes in the system which is Main Nodes, Distribution Nodes and Access Nodes. The main network consists of a number of main nodes that are connected directly between each other. In the main network, there must be some direct redundancy between main nodes which are close together. This means that it must be possible from one main node to reach the main nodes next to it without passing through the active equipment of another node. The optical cables should be laid without a break between the main nodes so as to achieve high operational dependability. The main network's optical cables that connect different main nodes are to be separately ducted. The number of fibers between the main nodes in the main network in a municipality ought to be not less than 72 per optical cable. This number results in each distribution node collecting traffic from eight access nodes approximately as designed in the technical studies for the development of the networks. Each access node gathers two pairs of fibers (one uplink and one backup) thus each optical cable should have at least 4 x 8 = 32 fibers plus 32 for alternative routes in the distribution network. The available cables usually provide 48, 72 and 96 fibers so 72 is the lower acceptable optical cable. If main nodes in different municipalities are long distances apart with a smaller number of distribution nodes the number of fibers may possibly be smaller if this is justified by great differences of fiber cost. The distribution network consists of the distribution nodes which shall connect to a main node and shall be planned to have a redundant connection to another main node. The optical cables should be laid without a break from each main node to any distribution node. Alternatively an optical cable loop is laid with two or three distribution nodes where the need for each distribution node is hived off. Over long distances this will be a cheaper but more vulnerable option. The number of fibers in the distribution network is affected by the number of access nodes connecting with each distribution node number of operators needing connections in the distribution network and leasing of dark fiber to other actors. The access network consists of the access nodes. A number of buildings are connected to an access node through a fiber cable with at least four fibers (two pairs of fibers, one uplink and one backup). Regarding the fiber infrastructure, the additional optical cable will be installed in order to handle situations that are possible or anticipated penetration in the area, a large number of Internet operator's active in the area, the positioning of active equipment and the degree of redundancy in the networks. As a general rule if existing ducting is to be used a careful assessment must be made of the best way to use it. If the number of existing optical pipes is small an optical cable with many fibers will have to be laid so as to make maximum use of the ducting. For the part of the network that will provide connectivity to the public sector's buildings the Ethernet technology is utilized. Ethernet switches are used on access nodes and aggregate the traffic from the buildings with each building has a 100Mbps or one Gbps connectivity through Base-LX SFPs. The distribution nodes do not have any active equipment but only passive. The main nodes have Gigabit Ethernet switches with advanced features. Those switches connect the Ethernet switches of access nodes as well as the buildings that have dedicated fiber connections (Hecht. J, 2006)

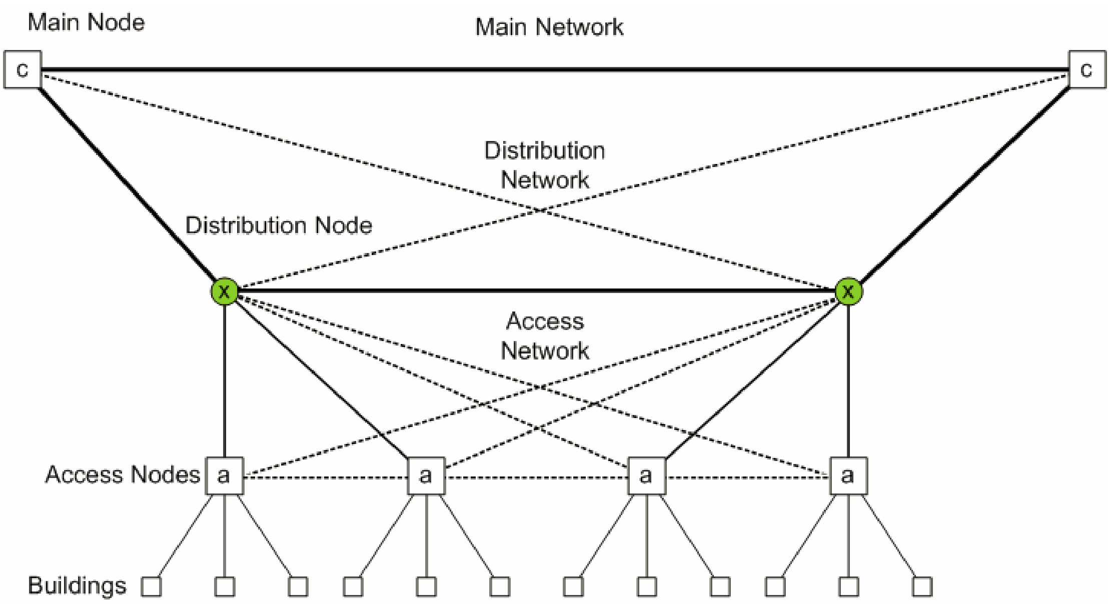


Figure2. Generic Metro and Local Access Networks (Hecht. J, 2006)

# Case study: The City of El Paso Texas (C. Chang-Albitres. 2011)

## Development of a GIS Fiber Optics Asset Management System

**ABSTRACT**

This paper describes a GIS Fiber Optics Asset Management System (GFOAMS) developed for the City of El Paso Texas. The objectives of GFOAMS are to provide managers and maintenance crews with easy access to fiber optics detailed information, conduct proximity infrastructure buffer analysis, and generate what-if "smart map" to support decision analysis. GFOAMS uses a GIS map-driven interface composed of three main modules: inventory, documents, and images interacting with a multilayer data structure containing the information for junction boxes, conduit runs and cables for thirteen fiber optic systems across the city that connect police departments, fire departments, municipal courts, health administration, building, public transportation facilities, libraries and others. GFOAMS has been used for planning daily operations, managing leasable fiber optics conduits and developing new fiber optics subsystems to the existing networks; saving time and money for the City of El Paso (C. Chang-Albitres. 2011).

## Introduction

Fiber optics networks are effective data-intensive communication systems able to provide the information needed to respond quickly minimizing the negative impacts of the emergency. The importance of fiber optics is due to the data-intensive nature of the telecommunications and an undergoing transition from narrow-band to broadband. Applications of fiber optics technology are widespread and involve the transmission of voice, data and video over distances of a few feet to hundreds of miles. In public local agencies fiber optics is crucial to the operations of Intelligent Transportation Systems (ITS) and efficient telecommunications between departments located in different buildings. This paper describes the GIS Fiber Optic Asset Management System (GFOAMS) developed for the City of El Paso Texas to manage their fiber optics network system across the city. The communication network system connects department inner networks, city buildings and main facilities such as police and fire departments among others. Besides, being the City of El Paso located on the border with Ciudad Juarez in Mexico some officials have raised their concerns about illegal immigration and potential sprouts of violence due to drug traffic demanding the need for the El Paso Police Office to implement Closed-Circuit Television (CCTV) systems running through fiber optics. The purpose of the paper is to describe the development functionalities of GFOAMS as a well-structured and robust system that can be used by a City as a model to efficiently manage nontraditional assets like fiber optics (C. Chang-Albitres. 2011).

## Asset Management Systems

Asset management systems are goal driven and data oriented and include components for data collection, inventory, condition assessment, needs analysis, future performance, technical and economical evaluation of what-if scenarios budget preparation and prioritization of maintenance and rehabilitation interventions when funds are constrained. Through asset management systems governmental agencies can improve infrastructure information accessibility, enhance and sharpen decision-making make more effective investments and decrease overall operating costs

## Geographical Information Systems for Asset Management

Geographical Information Systems (GIS) stands out as a great tool for asset management. GIS is used for geospatial data storage, exchange, mapping and what-if scenario analysis. GIS integrates all forms of geographically referenced information allowing the user to display and query data, revealing patterns and trends through maps, charts, and reports. GIS relates database records and their associated attribute data to a geospatial location, creating "smart maps" to visualize the assets in a what-if scenario context to analyze the relationships and potential impacts of the decisions Visualization of the generated smart maps is enhanced by the data layering capabilities. GIS can assist in managing spatial data and modeling applications that would otherwise be compromised or impossible to store in aspatial databases. The interactive character of GIS leads to the discovery of spatial relationships among parameters which become tangible to the user. This capability allows public agencies:

- To improve communication among departments when working in multidisciplinary team projects
- To enhance the decision making process when developing management plans due to better communication and analysis tools
- To maximize cost savings resulting from greater efficiency in management and operations (C. Chang-Albitres. 2011).

## GIS Fiber Optics Asset Management System for the City of El Paso

During the last 20 years, the City of El Paso has been developing a fiber optics network to connect main facilities such as police and fire departments, municipal courts, transportation or municipal service facilities across the city. Due to the large span of time in which installations, additions and repairs to the fiber optics network have been made many department heads and technicians involved in their development either retired or were transferred to other departments. As a consequence fiber optics data for the multiple network systems was dispersed or lost. In 2006 the City of El Paso started unification efforts to centralize the management of the fiber optics network thereby enhancing the efficiency of the process. According to managers and maintenance crews it soon became evident that it was necessary to have a reliable database of their assets with a user-friendly interactive interface.

GFOAMS is part of an overall ongoing cooperative project between the University of Texas at El Paso and the City of El Paso to develop a Sustainable Infrastructure Management System. The project focuses on critical infrastructure components for the City and includes: drainage, communications and transportation as shown in Figure 3. The first component of the integrated infrastructure management system is the "Storm Water Drainage Infrastructure System". The development of this component started in May 2007 and was fully implemented in June 2009. The second component is the "GIS Fiber Optics Asset Management System" (GFOAMS) and was completed in April 2011. The third component is the "Transportation Infrastructure System". Its planning stage started in November 2010. All these components are integrated through a Geographic Information System (GIS). The GFOAMS project started in 2009 and involved:

a. reviewing existing records to extract data for the fiber optics network
b. performing field surveys to verify and collect data for the fiber optics network
c. integrating fiber optics data into GIS and adding attribute information
d. developing the GFOAMS platform
e. recommending practical applications for the system

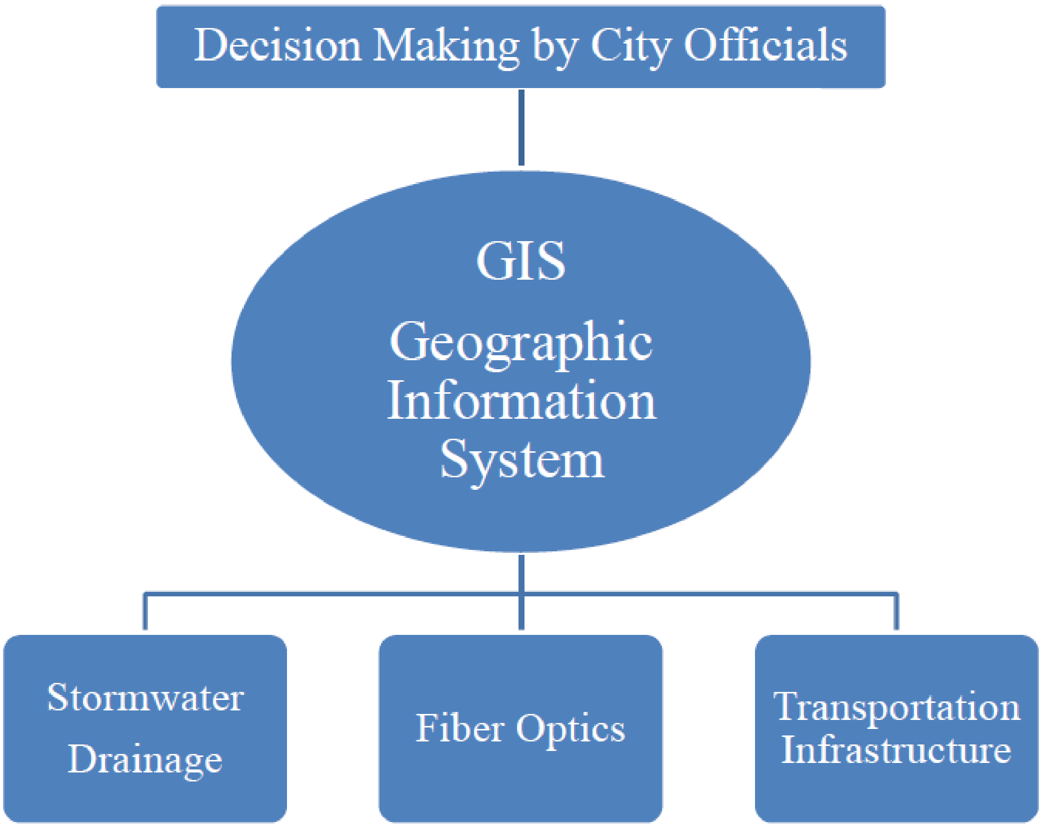

Figure3. Components of the Infrastructure Management System for City of El Paso (C. Chang-Albitres. 2011)

GFOAMS is currently not only used by managers for planning purposes to determine what to fix first but also by maintenance crews who conduct daily inspections to assess fiber optics condition and avoid deferred maintenance. In order to fully address Vanier's asset management questions the next frontier for GFOAMS is to integrate performance models to predict future fiber optics condition as well as their remaining life. GFOAMS was the tool needed to reduce outsourcing and conduct maintenance operations with in-house resources. Concerns from the inspectors and maintenance crews where addressed by having their members participate in the project. This approach proved to be successful and ensured that the final product delivered to the City of El Paso met their expectations. The major challenge during the development of the GFOAMS project was to locate fiber optic conduits in the field and identify their routes. Visual inspections on the field were conducted to map the fiber optics network. These surveys were guided by senior maintenance personnel from the City of El Paso. Graduate and undergraduate students from the University of Texas at El Paso participated in the surveys. The cooperation between the City of El Paso and

University of Texas at El Paso reduced the cost of field data collection and provided a unique experience to the students. Existing fiber optics information from current maps was reviewed prior to the surveys. These maps did not always match with what was found in the field. Elements of the fiber optics network were physically located in the field and registered using a Global Positioning System (GPS). Data from junction boxes, conduit runs and fiber optic cables was manually collected with Portable Digital Assistants (PDAs) and incorporated directly into GIS minimizing the risk of errors in data transcription. GFOAMS includes more than 330,000 feet of underground conduit that house fiber running through twelve fiber optic network systems across the city. They are called Backbone, North Doniphan, Downtown, Fonseca, Redd Road, Doniphan, Piedras, Hawkins/Airport, TMC-1 (Airway Boulevard), TMC-2 (George Dieter Drive), TMC-3 (Sunland Park), Yarbrough, and Zaragoza as shown in Table 1 provides information about each system including location, general direction and number of junction boxes, conduit runs, and cables.

Table1. Fiber Optics Systems in GFOAMS (C. Chang-Albitres. 2011)

| System Name | Location | Direction | From | To | Junction Boxes | Conduits | Cables |
|---|---|---|---|---|---|---|---|
| Backbone | City-wide | East-West (Misc.) | N/A | N/A | 88 | 99 | 15 |
| N. Doniphan | Westside | North-South | Mesa | Borderland | 31 | 30 | 19 |
| Downtown | Downtown | Misc. | N/A | N/A | 128 | 163 | 43 |
| Fonseca | Eastside | North-South | Cesar Chavez | Delta | 14 | 13 | 1 |
| Redd Rd. | Westside | East-West | I-10 | Mesa | 14 | 13 | 3 |
| Doniphan | Westside | North-South | Osborne/ Sunset | Doniphan P. | 23 | 24 | 3 |
| Piedras | Central | North-South | Montana | Wyoming | 6 | 5 | 2 |
| Hawkins/Airport | Eastside | Northwest-Southeast | Stinson | L. Term Lot | 45 | 43 | 4 |
| TMC-1 | Eastside | North-South | 1-10 | Founders | 43 | 42 | 19 |
| TMC-2 | Eastside | North-South | Vista del Sol | Montana | 35 | 34 | 16 |
| TMC-3 | Westside | East-West | Mesa | Doniphan/ Frontera | 49 | 49 | 30 |
| Yarbrough | Eastside | North-South | Vista Del Sol | San Paulo | 21 | 27 | 6 |
| Zaragoza | Eastside | North-South | Rojas | Cesar Chavez | 80 | 80 | 30 |

For each system, the three most important components of the fiber optics network were recorded:

a. Junction Boxes housing the splices (connection points within a two fiber strands joined together) and allowing the handling of the cable.
b. Conduit Runs connecting point A to point B through longitudinal stretches of underground conduits.
c. Cables carrying the information.

Figure 4 shows a descriptive image of the interior of the junction box.

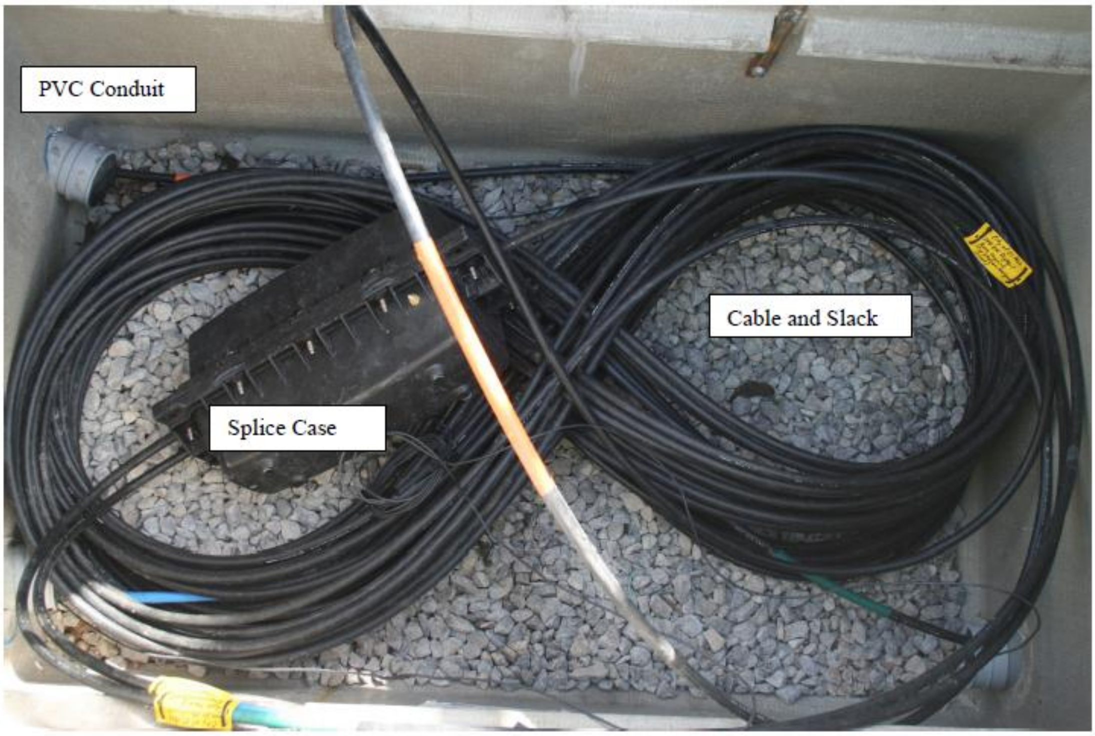


Figure4. Example of a Junction Box Interior (GFOAMS) (C. Chang-Albitres. 2011)

## GFOAMS Framework Structure

The GFOAMS framework structure is composed of three modules: inventory, documents, and images. The data is stored in three main layers: Junction Boxes, Conduit Runs and Cables using a GIS map-driven interface to display the information and results of the analyses as shown in Table 2. Figure 5 shows the GFOAMS framework structure. GFOAMS structure design is flexible enough to be modified and expanded with new modules. A description of GFOAM modules follows.

Table2. Data Dictionary Summary (C. Chang-Albitres. 2011)

| Junction Boxes Layer | Conduit Runs Layer | Cables Layer |
|---|---|---|
| Comments | Application | Actual Db Loss |
| Conduit 1 | Cable ID 1 | Calculated Db Loss |
| Conduit 2 | Cable ID 2 | Cable Size |
| Conduit 3 | Cable ID 3 | Comments |
| Conduit 4 | Cable ID 4 | Conduit ID |
| Conduit 5 | Cable ID 5 | Construction Year |
| Conduit 6 | Cable ID 6 | Cumulative Db Loss |
| Depth | Cable ID 7 | Cumulative Length |
| Document Link 1 | Cable ID 8 | Dark Fiber Strand(s) |
| Document Link 2 | Color | Input Date |
| Document Link 3 | Comments | Editor Name |
| Input Date | Conduit Location | Fiber Count |
| Editor Name | Conduit Size | Fiber Owner |
| Grantee | Conduit System | Identification Number |
| Identification Number | Conduit Type | Lit Fiber Strand(s) |
| Images | Input Date | Maintenance |
| Image Link | Editor Name | Manufacturer |
| Image Link 2 | Fiber User | Mode |
| Junction Location | Grantee | Object Identification Number |
| Junction Type | Identification Number | Shape* |
| Length | Image Link | Shape Length |
| Maintenance | Maintenance | Sheath Number |
| Object Identification Number | Material | Subsystem |
| Online Link | Object Identification Number | System |
| Shape* | Service Area | Type |
| Splice | Shape* | |
| Subsystem | Shape Length | |
| System | Street(s) | |
| Width | | |

## Inventory module

The inventory module consists of three tables that represent a component of the fiber optics infrastructure system for the City of El Paso Each table stores information on the main attributes of a type of asset (e.g. a conduit run, a single cable or a traffic management cabinet). The attributes are related to inspection date, material, depth and others. The layers are interrelated and contain hyperlinks that connect the inventory with the other modules for a user friendly access while browsing the information on a map.

## Documents module

The documents module consists of drawings, maps design and as-built plans, schematics and any other documents relevant to the features spatially represented in GFOAMS. Before the implementation of the GFOAMS the established system was structured in paper records and isolated electronic files. GFOAMS provides the ability to spatially relate all features and attributes in an interactive map giving the user the capability to link all the relevant files. This is a great improvement from the paper document system (or its electronic equivalent, with files and folders) piled up in storage rooms where relevant documents are out of hand obstructing effective retrieval for management and planning purposes.

### Images module

The images module is the database repository where all the photos relevant to the fiber optics network system are stored. The layout of the cables can be so cumbersome that photos are needed to provide further details for repair, renewal or replacement. Photos complement the data stored in the tables and are accessed through Hyperlinks defined in the Junction Box table. GFOAMS contains photos for junction boxes, cables, and conduit runs connecting through them.

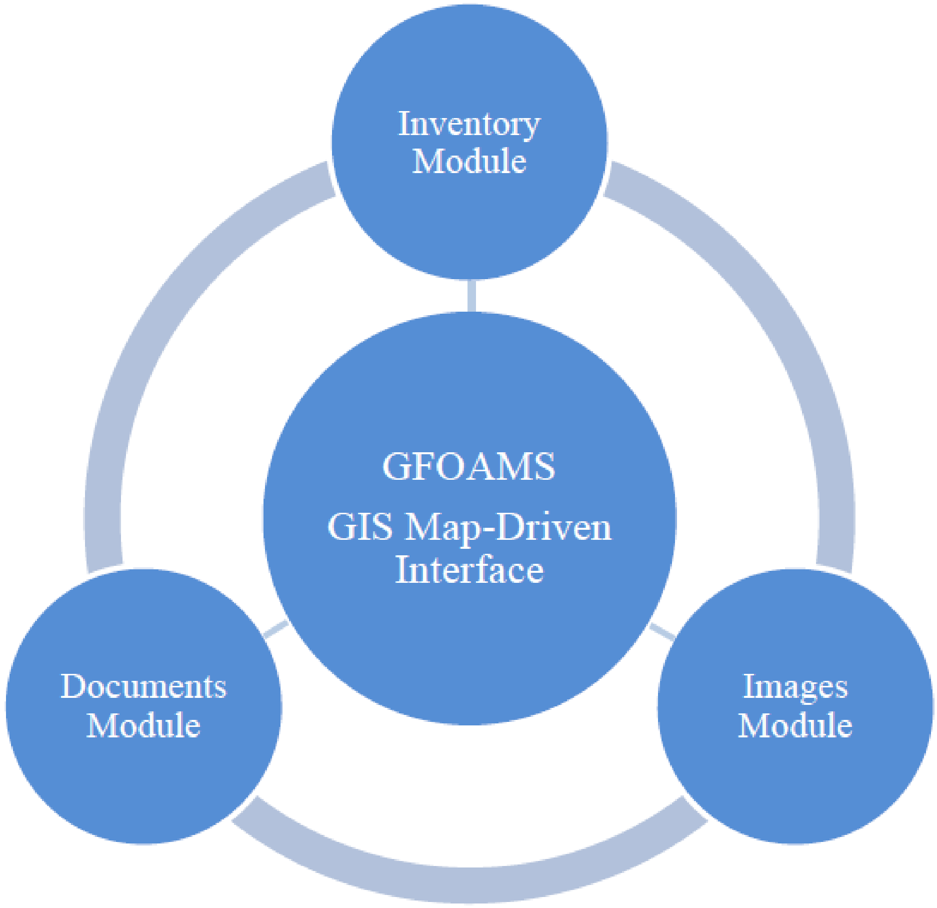


Figure5. GFOAMS Framework Structure (C. Chang-Albitres. 2011)

## GFOAMS Applications

The main purpose of GFOAMS is to assist the City of El Paso managing the fiber optics network system. GFOAMS is currently fully implemented by the City of El Paso. GFOAMS includes tools to facilitate access to the inventory and visualize any specific details of the fiber optics conduit network. These tools allow the generation of smart maps of specific fiber optics elements in the sub-system network. GFOAMS allows the City quick access to reliable information enhancing their maintenance program to avoid any telecommunication disruptions as these would have an adverse impact not only in the emergency relief programs to mitigate disasters but also in daily operations such as planning and maintenance. Another major application that is currently migrating to the fiber optics network is the Intelligent Transportation System (ITS) for traffic management control and camera activated signal timing. Four different sample applications are described here:

### Accessing Key Fiber Optics Information through Hyperlinks

One of the most important resources that an asset manager can have is to get quick access to the documents relevant to features of interest. In the past asset managers had to rely solely on huge paper records to access information for the diverse systems that they managed; cabinets and map drawers would fill up document rooms to the point of being unpractical and problematic to retrieve documents. With the advent of computing systems and electronic versions of the documents the task became in a sense easier but still accessing documents could be a daunting task as the information was dispersed in the different computers, servers and databases used for this purpose. The documents module deals specifically with the need to access documents while browsing features in the map. Figure 6 shows access to fiber optics information stored in an external document e which was accessed directly through GFOAMS. GFOAMS has the capability to store and access photos from fiber optics taken by field inspectors. Costly mobilizations to the field can be minimized to swiftly make decisions on-the fly from the office. For instance in the case of a rupture of the conduits and/or fiber optic cables inside the asset manager can dispatch an emergency repair team with all the necessary tools to open the nearby junction boxes and repair the damage and reestablish the service. An example of such scenario is shown in

Figure 7 where it can be seen a malfunction in the lid opening system of a Junction Box quite possible due to soil displacements. This malfunction was detected in the field by an inspector, and automatically uploaded to the system for immediate action.

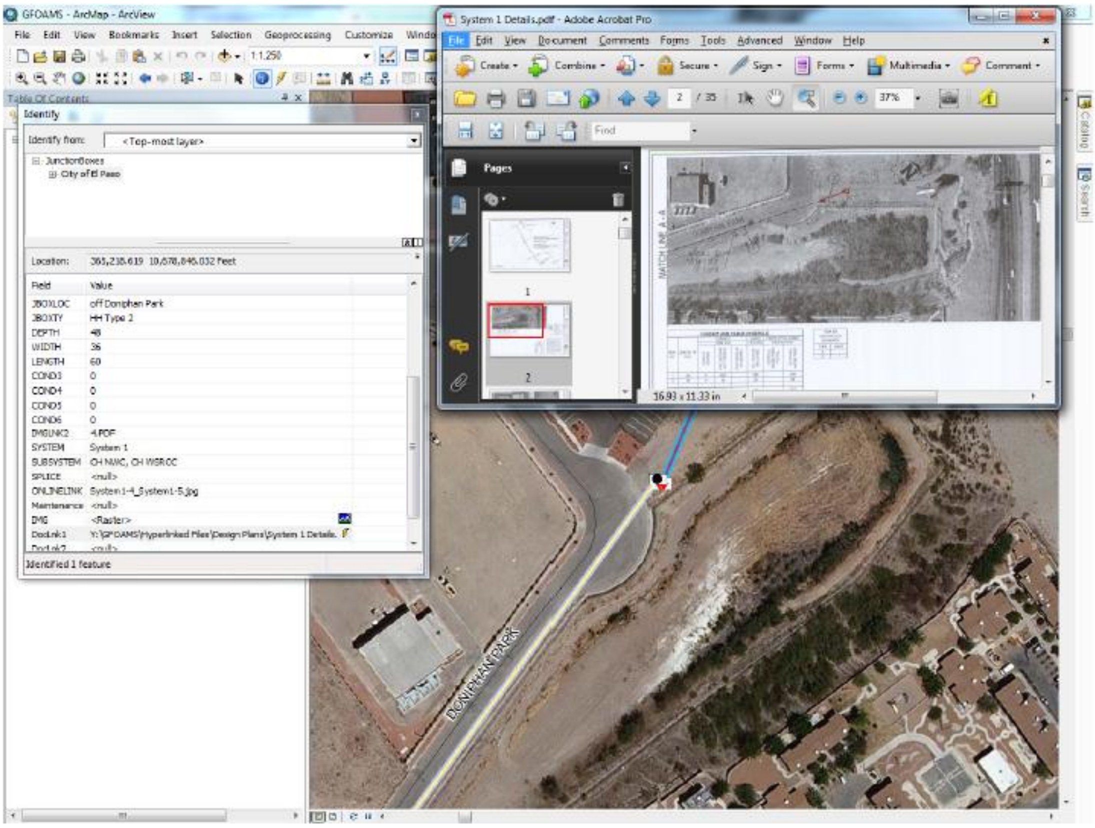


Figure6. Accessing Fiber Optics Documents and Photos (C. Chang-Albitres. 2011)

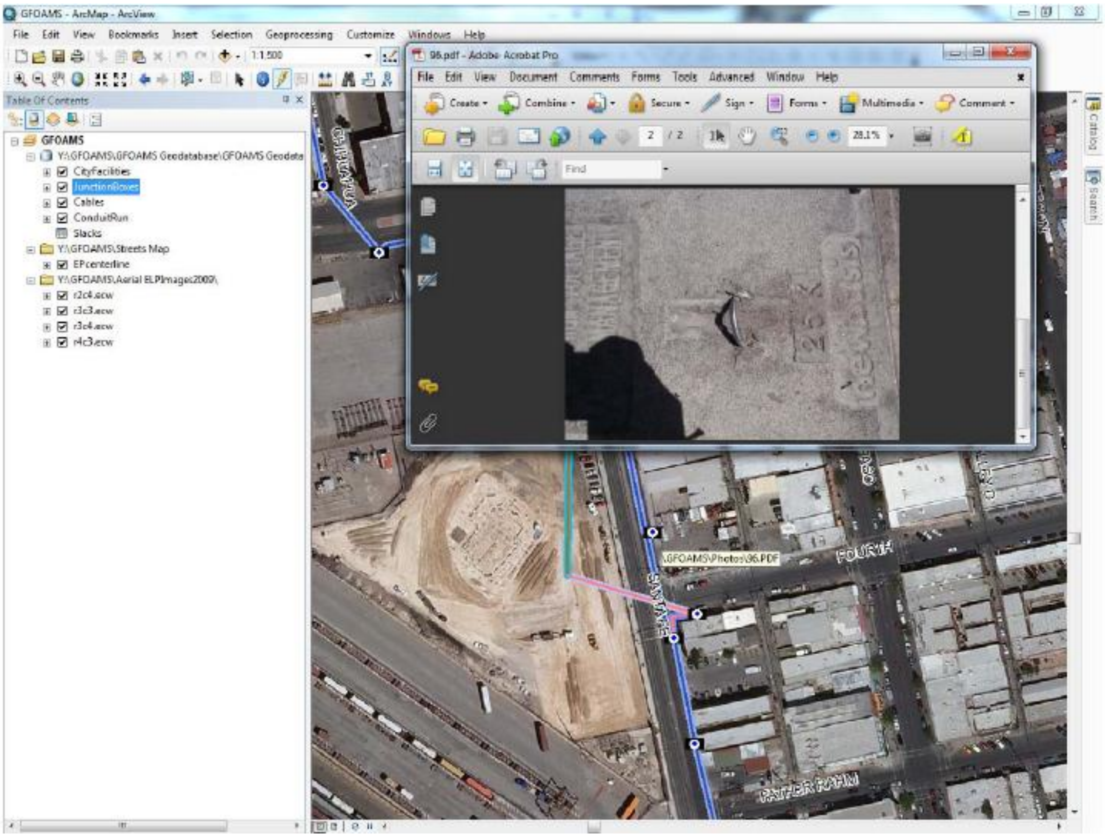

Figure7. Jammed Junction Box Lid Observed through GFOAMS
(C. Chang-Albitres. 2011)

## Planning Fiber Optics New Developments

In order to better coordinate with the stakeholders involved in new fiber optics developments, asset managers need to discuss the alternatives. With GFOAMS all planning documents, drawings, and specifically paths for future fiber optics networks are rendered much simpler and more efficient. Moreover the visualization of the georeferenced new system allows for analyzing the interactivity between the existing network system and the proposed additions. In Figure 8 the path of a proposed new fiber optics conduit is shown in what-if scenario smart map generated for further evaluation using the GFOAMS capability of showing detailed in-site information. This functionality not only makes the process swifter but also ensures cost-effective investments.

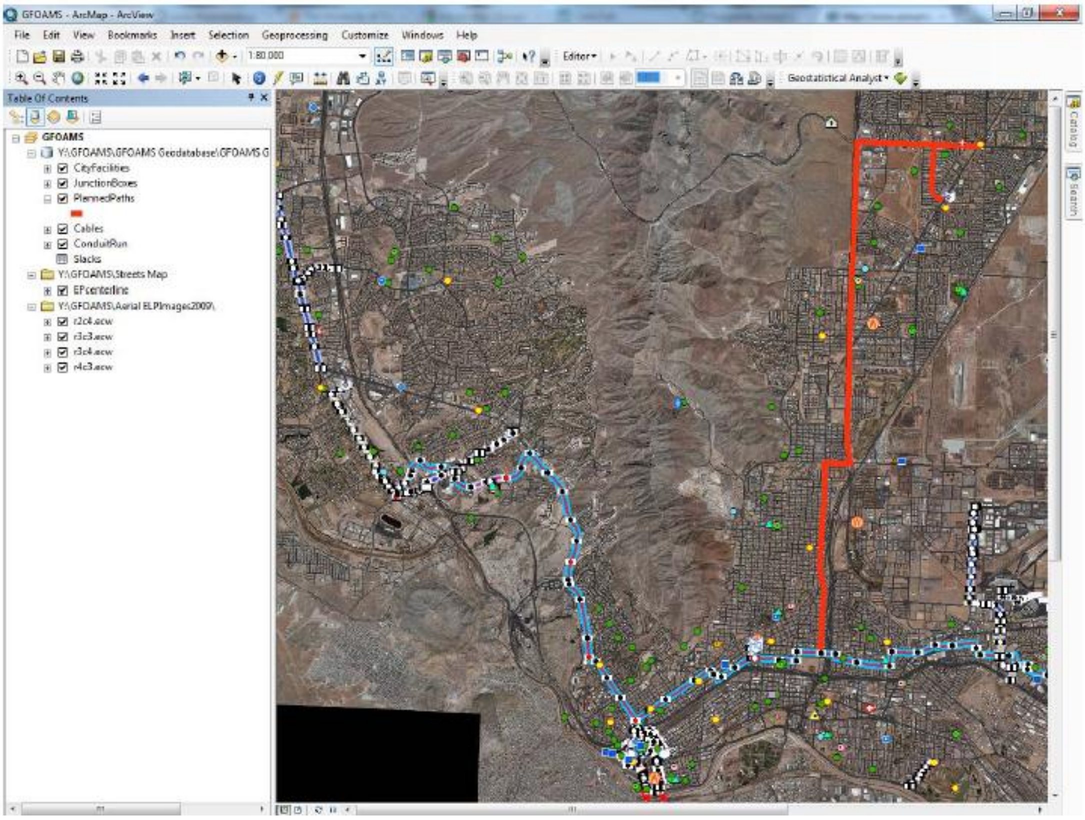


Figure8. Planning Fiber Optics New Developments with GFOAMS

(C. Chang-Albitres. 2011)

## Managing Leasable Fiber Optics Fiber Conduits and Strands

Another advantage of a fiber optics asset management system is that it can help municipal agencies to lease their assets. In the case of fiber optics extra space in city-owned conduits can be leased to install additional cables. Also unused or 'dark' fiber strands which are the individual fiber optics strands bundled in a cable containing up to 576 strands in some cables in El Paso can be leased to third parties. The City of El Paso is currently reviewing the right-of-way leasing scheme for new installation of fiber optics by telecommunication companies. With the usage of GFOAMS and through a better management of the fiber optics asset a new leasing process could enable the city to increase revenues by leasing existing conduits and cables. An improved knowledge about the fiber optics infrastructure will certainly aid the Financial Departments to establish adequate fees within the new leasing scheme. To illustrate the possibilities what if analysis for different scenarios can be conducted by GFOAMS Figure 9 shows a stretch of city-owned fiber optics assets with a length of almost 20,000 feet. According to a study by Atalah et al. in Bowling Green State University the construction cost per 1,000 feet ranges from $20,000-$25,000 using Horizontal Directional Drilling or in-sewer installation using the Sewer Telecommunication Access by Robot and up to $60,000 using open trench methods. Based on these estimates a telecommunications company would invest between $400,000 and $1,200,000 in addition to the right-of-way fees that must be paid to the City. These numbers show that there can be a large amount of increased revenues for the City due to the incomes generated with the new leasing scheme. At the same time this leasing scheme can save money for the telecommunications company by using the existing fiber optics network owned by the City instead of building their own.

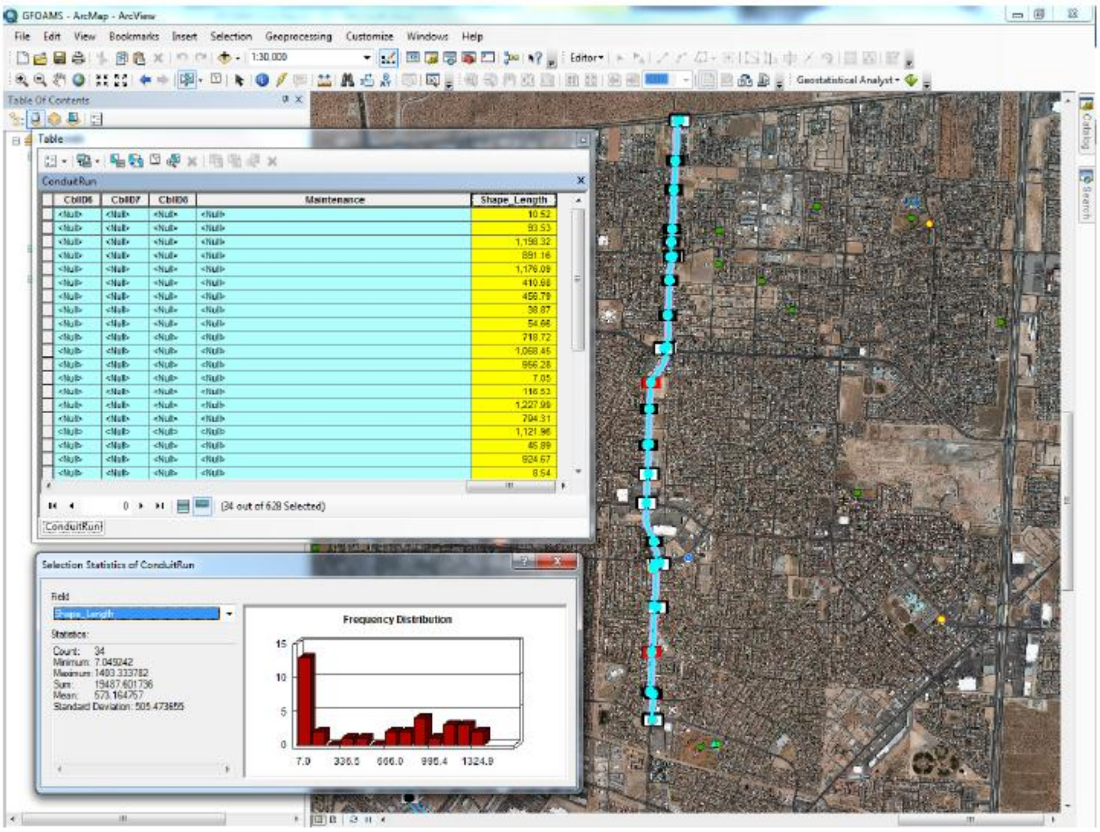


Figure9. Estimating Leasing Revenues Using GFOAMS to Determine Conduit Length (C. Chang-Albitres. 2011)

## Proximity Infrastructure Buffer Analysis

Using ArcMap's built-in functions, GFOAMS can be used to identify zones located 100, 500, 1000 and 2500 feet from the existing conduit runs as shown in Figure 10. Different buffer zones can be established for analyzing alternative scenarios when planning new routes. Smart maps generated from buffering analysis allow the user to visualize the facilities located within certain ranges of the existing fiber optics system and see if they are connected to the network. This type of analysis helps the planning of new additions to the fiber optics network. According to the City of El Paso the public's safety is the current focus. The priority for extending the fiber optics network to remaining unconnected buildings is in the order presented: police departments, fire departments, municipal courts, health administration building, public transportation facilities/Sun Metro and libraries.

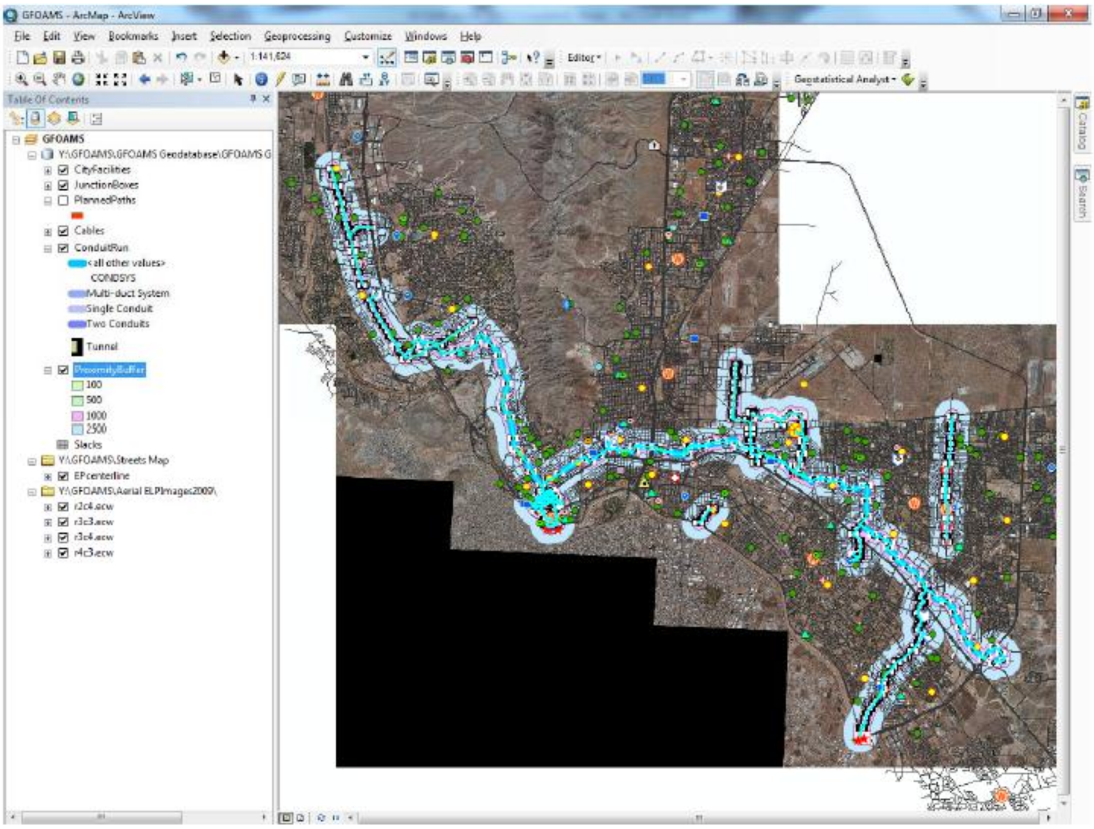


Figure10. Proximity Infrastructure Buffer Analyses of the Conduit Runs

(C. Chang-Albitres. 2011)

## Conclusion

Geographic Information System is a computer system used to store, edit, analyze and display geographically referenced information. Using GIS to map out where fiber cables are installed and used, it provides valuable information to telecommunication companies about their fiber optic cable systems and allows businesses to see where they can better connect into a fiber system. GIS in fiber optic cable are used to play critical roles such as fault localization, call before you dig, operation maps, annual reporting and ad hoc reports, system planning and expansion and system analysis and visualization.

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