CALCULATING THE REHABILITATION COST ESTIMATE FOR Om Aldalya STREET USING GIS LINEAR REFERENCING METHOD

BY:-

Anwar Bader   Mutasem Shreef   Hammam Natashe

Ismail Khalefa   Abdulrhmaan khader

Supervisor:

Eng. Maher Owaiwi

CIVIL & ARCHITECTURAL ENGINEERING DEPARTMENT

COLLEGE OF ENGINEERING AND TECHNOLOGY

PALESTINE POLYTECHNIC UNIVERSITY

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A PROJECT REPORT SUBMITTED IN PARTIAL FULFILLMENT OF REQUIREMENTS FOR THE DEGREE OF BACHELOR OF ENGINEERING IN CIVIL & ARCHITECTURAL ENGINEERING DEPARTMENT

SUPERVISED BY

ENG .MAHER OWAIWI

CIVIL & ARCHITECTURAL ENGINEERING DEPARTMENT

COLLGE OF ENGINEERING AND TECHNOLOGY

PALESTINE POLYTECHNIC UNIVERSITY

HEBRON- WEST BANK

PALESTINE

SEP- 2017

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CERTIFICATION

Palestine Polytechnic University

PPU

Hebron-Palestine

The Senior Project Entitled:

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Prepared By:

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In accordance with the recommendations of the project supervisors, and the acceptance of all examining committee members, this project has been submitted to the Department of Civil and Architectural Engineering in the College of Engineering and Technology in partial fulfillment of the requirements of Department for the degree of Bachelor of Science in Engineering.

Project Supervisors   **Department Chairman**

Name: ………………..   **Name:………………..**

SEP - 2017

إلى صاحب الفردوس المنير وشفيعنا النذير البشير محمد (صلى الله عليه وسلم)

إلى من سهر الليالي ... ونسي الغوالي ...وظل سندي الموالي ...وحمل همي غير مبالي ... والدي الغالي

إلى... من اثقلت الجفون سهرا ... وحملت الفؤاد هما ... الأيام صبرا ... وشغلت البال فكرا ... ورفعت الأيادي ... وأيقنت ...أغلى الغوالي .. العزيزة الغالية

إلى من علمنا النجاح قيمة ومعنى ... وعلمنا كيف يكون التفاني في العمل ... ومن معه لا مستحيل في سبيل ... العويوي

انطلاقا من العرفان بالجميل، فإنه ليسرد ي إلى بالكثير، والـ ن يوما عن مد يد المساعدة لـ في جميع المجالات....

إلى ورود المحبة .. وينابيع الوفاء ...إلى من رافقوني في السراء والضراء إلى اصدق .. إلى القلعة الحصينة التي إليها ...

إلى من ضحوا بحريتهم من اجل حرية غيرهم

إلى من هم ...
إلى هذا الصرح العلمي الفتي والجبار ... جامعة بوليتكنك فلسطين

إلى من احتضنتني كل هذا الكم من السنين ... فلسطين الحبيبة

فريق المشروع

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This project would not been possible without the assistance of many individual . We are grateful to these people who volunteered their time and advice , specially Eng . Maher Owaiwi; we thank you for your efforts to help us fulfill this project .

Finally, we extended our thank to members in the Civil Engineering Department , especially the part of Surveying Engineering, which help us in designing our project.

Project Team

STREET REHABILITATION SYSTEM USING GIS AND GPS TECHNIQUE

Palestine Polytechnic University

BY:-

Anwar Bader   Mutasem Shreef   Hammam Natashe

Ismail Khalefa   Abdulrhmaan khader

Supervisor:

Eng. Maher Owaiwi

Background

Linear referencing is the method of storing geographic locations by using relative positions along a measured linear feature. Distance measures are used to locate events along   the   line.
In our project Linear referencing Method will be used to:

- Identifying the location of different street events of Om Aldalya, such as streets centerline trenches, street cracks, painting, and many others.
- Using Linear referencing as a tool to associate multiple sets of attributes of Om Aldalya Street to portions of linear features without requiring that underlying lines be segmented (split) each time that attribute values change.
- Using Linear referencing as a tool to find the rehabilitation need's for streets.

Study Area:

Om Aldalya Street is located at the southern part of Hebron city, as is shown in Fig.1; it's almost 1.3 km length. It's one of the main street's that serves the industrial zone and a vital main street which links wade alharya with the industrial zone.

Fig1.

Objectives:

- **Main objective:**

  The overall objective of this study is to serve Hebron Municipality with GIS linear referencing method as an efficient tool for street rehabilitation.

- **Secondary objectives:**

  1. Surveying of Om Aldalya Street by using linear referencing method.
  2. Identifying several surveying features which may include: culvert, pole, traffic signs, manholes, pavement, paint, curbstone, along track crack, and cat eyes.
  3. Raise awareness and promote knowledge and skills of road GIS maintenance management support system, community service and international best particles.
  4. Introduce Hebron Municipality with linear referencing method as a tool for road GIS maintenance management support system.

حساب التكلفة التقديرية لإعادة تأهيل شارع أم الدالية باستخدام طريقة المراجع الخطية

:

أنور بدر   معتصم شريف   همام النتشة

إسماعيل خليفة

جامعة بوليتكنك فلسطين

:

م . ماهر العويوي

المرجعية الخطية هي طريقة لتخزين المواقع الجغرافية على الشوارع او المعلم و ذلك عن طريق تحديد المواقع حسب المسافة الخطية على طول معلم خطي.

و يهدف المشروع الى تحديد المواقع لمعالم مختلفة على شارع أم الدالية   أنابيب المياه و تشققات الشارع و دهان الشارع و الأرصفة وغيرها و من ثم حساب الكميات و الكلفة اللازمة لإعادة تأهيله باستخدام المرجعية الخطية.

فريق ال

TABLE OF CONTENTS

CHAPTER ONE	INTRODUCTION	1

CHAPTER ONE

INTRODUCTION

This chapter covers the following items:

1.1 GENERAL

1.2 PROBLEM DEFINITION

1.3 PROJECT AREA

1.4 OBJECTIVES AND ADVANTAGES

1.5 METHODOLOGY OF WORK

1.6 DEFINITION OF TERMS

1.7 LITERATUER STUDY

1.8 ORGANIZATION OF THE REPORT

CHAPTER ONE

INTRODUCTION

1.1 General

A well maintained transportation system of a country plays a pivotal role in its infra-structural development thus promoting sustainable development. Economically, transport is a livelihood of cities, and in most countries, including developing countries, cities are the major sources of the national economic growth (World Bank, 2002). This is to imply that the economic health of a region is directly linked to mobility. Transport accounts for an appreciable percentage of a country's Gross Domestic Product (GDP) and as such is central to development.

The provision, operation and maintenance of the physical infrastructure of a transportation sector and its related social services require a prior knowledge and manipulation of geo-information. Geospatial data are a foundation for relevant and critical information for planning, engineering, asset management, and operations associated with every transportation mode at all levels of government and administration, Transport Research Board (TRB, 2004).

The management of road transport, since it is the only used mode of transport in Palestine, plays an important factor in the country's development. The transport sector in Palestine contributes significantly to the economic growth and poverty eradication in the country through various ways, especially, through trade and tourism.

Dimitriou and Banjo (1990) discuss transport problems of third world cities. They include traffic congestion, impacts to the environment, and high road accidents. Even today, Palestine still faces problems of traffic congestion, high road accidents, weak

institutional support leading to poor definition of the problem at hand and differing technology transfer priorities in problem resolution.

Nowadays, however, the need for preventive maintenance is being appreciated in Palestine. For that, Palestinian Ministry of Public Work and Housing (MOPWH),indicated that roads maintenance needs are based on road inventory, condition and traffic data, all of which can be effectively collected and managed using Geographical Information System (GIS).

The understanding of GIS, effective use of geographical information and the knowledge of their advantages is critical to the planning and decision making process for asset management departments. Because a well maintained road network asset is very important for the economic development of the nation, Road Infrastructure Maintenance (RIM) is a prerequisite for the successful management of roads. The use of Geographic Information System (GIS) that is collected, managed and analyzed is very useful in decision making for RIM. More recently, it has become clear that GIS, together with Global positioning systems (GPS), aerial photography, remote sensing techniques, and other spatially related tools for decision making, comprise a larger array of complementary tools that can be grouped together under the more comprehensive rubric of "geographic information technologies" (GIT) (Teresa M. Harrison et al., 2007). The use of these technologies is known to simplify decision making to a non technical level and to support the stakeholders in sustainable-oriented decision making.

1.2 Problem definition

There have been many cases of poor transport services in Palestine. The road infrastructure was developed in a chaotic manner, with no plan for a coordinated and rationalized use of modes and routes. As a result, it has suffered from negligence leading to road infrastructure failure. Attempts to maintain roads have frustrated users

as they (the roads) almost immediately develop pot holes after repair. Worse still, road maintenance has proven ad hoc, thus making the transport system unsatisfactory. Also, in Palestinian cities, such as Hebron City, the decision to perform maintenance works on a road is initially based on; records of past expenditures on the road sections in question, availability of resources and traffic levels along these roads. However, most of the data required for road maintenance is spatial in nature. This makes Linear Referenced GISMethod relevant for the purpose.

The focus of this study is to advise strategies of enhancing the use of geospatial technologies as decision support tools in RIM in Palestine. For that, a Linear Reference GIS Model will be constructing for Om AldalyaStreet in Hebron City.

1.3 Project area

Hebron City is located in the southern West Bank, 30 km south of Jerusalem, figure 1.1. It lays 930 meters above sea level. It is locally well known for its grapes, figs, limestone, pottery workshops and glassblowing factories, and is the location of the major dairy product manufacturer.

Hebron City is considered to be one of the largest municipalities in West Bank with 48 Km² municipal area, and 250,000 inhabitants, (Palestinian Bureau of Statistic,2009). Its services vary from constructing new roads, maintaining old ones, supplying fresh water, managing wastewater, collecting solid waste and supplying electrical power, and many other services.
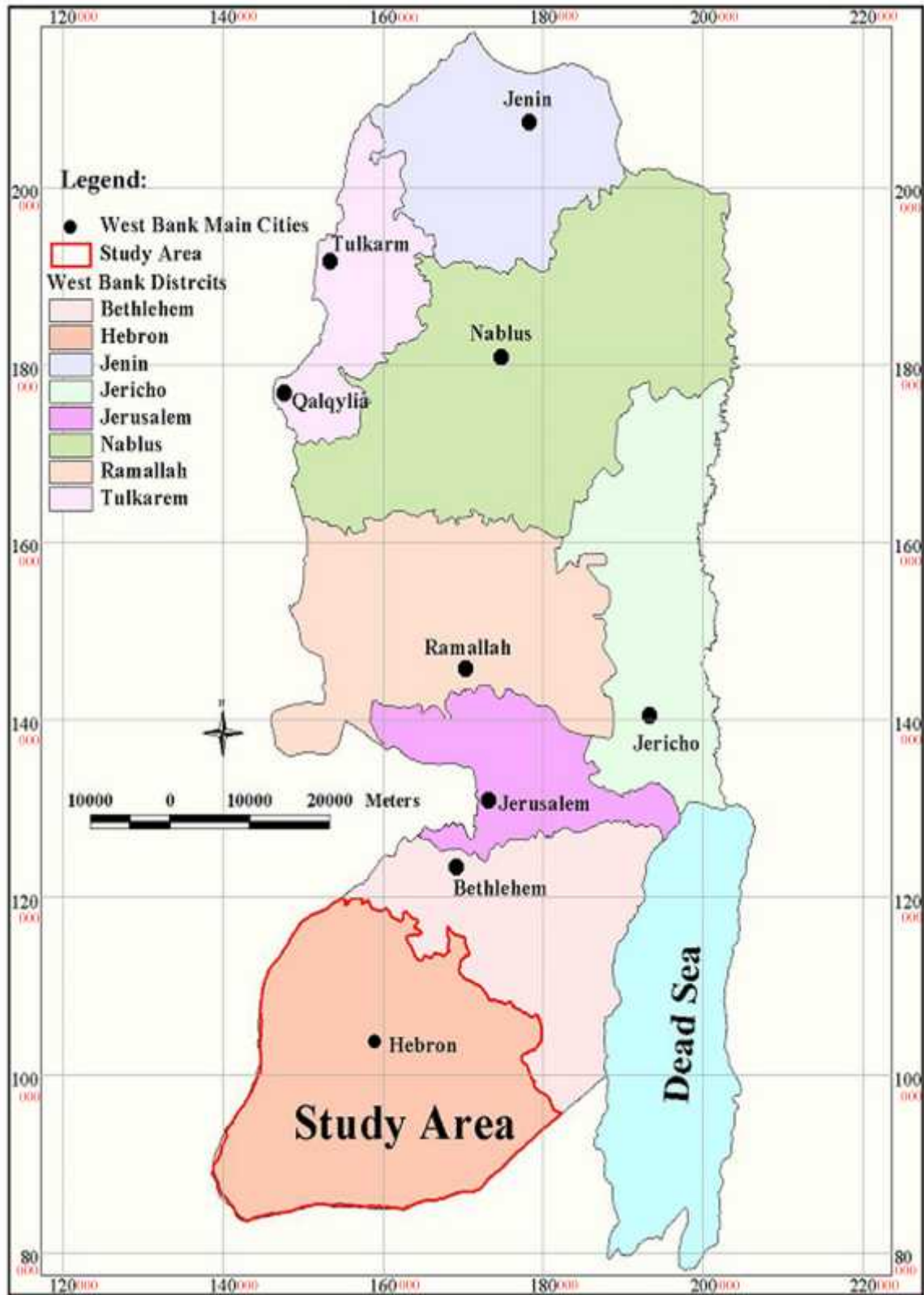
Figure (1.1): Hebron City, location map

Om Aldalya Street is located at the southern part of Hebron city, figure 1.2; it is almost1.3 km length. It is one of the main street that serves the in industrial zone and a vital main street which links wade alhrya with the industrial zone.

Figure (1.2): Location of Om Aldalya Street

1.4 Objectives and advantages

The overall objective of this project is to serve HebronMunicipality with GIS Linear Referencing Method as a tool for street rehabilitation. More specifically the objectives of this study may be summarized as:

1. Surveying of Om Aldalya street using Linear Referencing Method.
2. Identifying of different surveying elements. This may includes;

Culvert	Patch	Pole	Sign	Manhole
Ditch	Guardrail	Pavement	Paint	Wall
shoulder	Cat Eye	Jubbah	Along Track Crack	

3. Prepare performance budgets using the Linear Referencing Method.
4. Raise awareness and promote knowledge and skills on Roads GIS Maintenance Management Support System, community service and international best practices.
5. IntroducingHebronMunicipalitywith linear referencing method as a tool for Roads GIS Maintenance Management Support System.

1.5 Methodology of the work

The project consists of three phases, which is designed to be completed in according with schedule in table (1.1). The description of each of the three phases of the project tasks involved are listed below:

PHASE NO.	TITLE	DURATION (2017)			
		2/2017	4/2017	7/2017	9/2017
One	Data collection and Survey.	███			
Two	Design Model.		███		
Three	Writing the report and Other related jobs.			███	

Table (1.1): Phases of the Project with their Expected Duration

1.5.1 First phase: data collection and surveying.

During this phase, available data and information will be collected from different source. Moreover, many site visits to both project area and the related local organization will be conducted. First phase included the following tasks:

1. Collection of aerial topographical maps for the study area.
2. Using the tutorial and to get trained with the method of Linear Referencing.
3. Analyze the work.

1.5.2 Second phase: road surveying.

During second phase, the necessary survey will be conducted using the Linear Referencing Methods. This will include:

1. Surveyingof Linear Referencing Events using traditional methods and or GPS.
2. Establish Entering the event data and attribute data to the GIS
3. Building Linear Referencing Model and analyses, which include:

- Determining Route structure
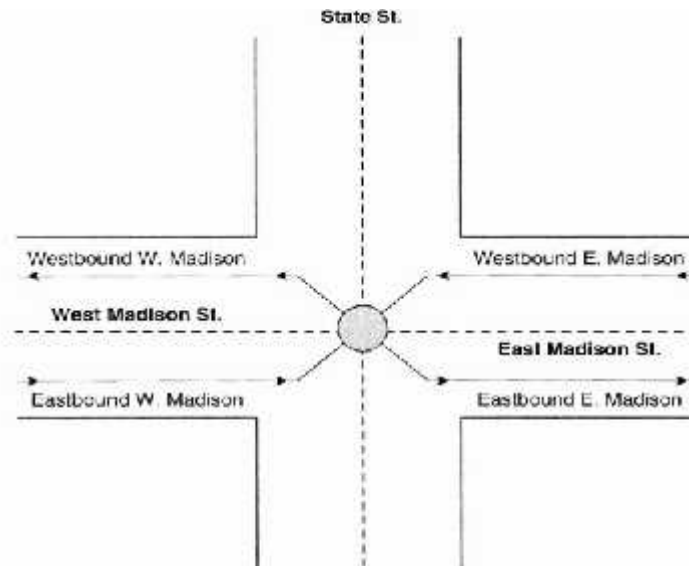
- Determining Measures
- Create Events
- Display Event Data, Cartographic Output

4. Construct the Roads GIS Maintenance Management Support System and prepare them to be used.
5. Preparing the final map.

1.5.3 Third phase: writing the report and other related jobs.

After finishing the construction of Roads GIS Maintenance Management Support System using Linear Referencing Method, the research team will prepare a dynamic map of street route and events that need to be maintained. The System will be a dynamic and the map feature will be changed automatically according to maintenance situation. A cost estimate of each modeled event as well as the overall budget will be estimated.

The reports of the project will be prepared and submitted to the Department of Civil and Architectural Engineering of Palestine University.

1.6 Definitions of Terms

This document introduces some vocabulary that is essential to understanding the linear referencing help. Some definitions are related to documents with thorough descriptions.

Term	Description
Route	A route is any line feature, such as a street, highway, river, or pipe, that has a unique identifier and a system of measurement. Routes are stored in a route feature class.
Route feature class	A route feature class is a collection of routes with a common system of measurement stored in a single feature class (for example, a set of all highways in a county). A route feature class differs from a standard line feature class in that, along with x- and y-coordinates, it also stores an m-coordinate (x,y,h). Learn more about route feature classes
Measure	A value stored along a linear feature that represents a location relative to the beginning of the feature, or some point along it, rather than as an x,y coordinate. Measures are stored as m-values on route vertices. Measures can be any unit of measurement, such as miles, meters, and time.
M-value	A measure that is added to a line feature. M-values are stored in the m-coordinate of each vertex on a route feature. M-values are used to measure the distance along a line feature.
Events	An event is a linear, continuous, or point feature that occurs along a route feature. Anything that occurs on or describes a route feature can be an event. In the transportation field, examples of events might include pavement quality, accident sites, and speed limits. Events are stored in event tables.
Event tables	Event tables contain information about assets, conditions, and events that can be located along route features. Each row in the table references an event, and its location is expressed as measurements along a route feature. There are two types of route event tables: point event tables and line event tables.
Dynamic segmentation	Dynamic segmentation is the process of computing the map locations of events stored and managed in an event table along route features and displaying them on a map. The term dynamic segmentation is derived from the concept that line features need not be split (in other words, "segmented") each time an attribute value changes—you can "dynamically" locate the segment.

Table (1.2): Definitions of Terms

1.7 Literature study

Alan Vonderohe, 1996, conducted a study to state a methodology for design of a linear referencing system for surface Transport. His study comes with the following recommendations address further advancement of the unified linear Referencing system concept, Technical Recommendations:

1. Resources should be devoted to development of a design tool. Such a toolshould allow the designer to interact with a spatial representation of thetransportation network, testing various configurations of datum and referenceobjects, various systems of measurements among those objects, and variousaccuracies of the measurements against a specified variance-covariancematrix for the linear referencing system parameters.

2. The design method should be tested, preferably after development of thedesign tool. The test should include national, state, and local levels of thelinear referencing system hierarchy. It should be performed over a limitedextent, perhaps at the district level, incorporating components of the ITSdatum, state highways, and local roads. At least one municipality should beincluded.

3. The test design should be partially implemented, with a subset of the datumand reference objects actually selected. The designed measurementsamong this subset of objects should be made and analyzed. The resultsshould be compared to the design criteria.

4. The model for linear distance error, $sl = (k2 + ppm^2)^{1/2}$, should be calibratedand validated for various measurement methods and equipment, includingcalibrated odometers and GPS.

5. The status of "as-built" information at the state and local levels should beassessed. Its potential for use is very high if it is accurate, consistent,current, and accessible.

6. The long-needed study that links spatial data accuracy requirements to riskin decision making should be undertaken. The assumption that the accuracyof linearly-referenced data should be compatible with that of two-dimensionalspatial databases might not be valid. Perhaps there are aspects of linearspatial analysis that require different accuracies.

Lydia MazziKayondo-Ndandiko, 2011. Conducted a PHD thesis for using Geographical Information Technologies for Road Infrastructure Maintenance in Uganda. This thesis is a documentation of research on Geographical Information Technologies (GITs) as decision support tools in Road Infrastructure Maintenance (RIM) in Uganda. The main objective is to develop an operational framework within which the use of geo-information technologies can be enhanced as decision support tools in road infrastructure maintenance works of Uganda. Specifically, the research identifies the gaps and limitations in the use of and access to GITs for RIM and defines an algorithmic framework to accentuate the use of GITs in RIM. The research undertook a participatory multifaceted approach that included a review of documentation both in academia, in form of articles, journals, books, reports and research theses and also reports and documents prepared by the road infrastructure maintenance sector. Participant observations, field visits and measures, interviews and workshops were also triangularly employed to obtain the inherent answers. Content and GIS analyses were made to arrive at the findings that are documented in the papers which are part of the thesis.

U.S. Department of Transportation, 2012, published a report on Best Practices in Geographic Information System-based Transportation Asset. In the executive summary of this report the Author stated that" Maps are powerful tools. They orient. They guide. They provide a sense of scale and distance. They are a universal language, accessible to people from different personal and professional backgrounds. In a transportation planning context, maps provide a flexible canvas for communicating important information such as the location of structurally deficient bridges and proposals for future improvement projects".

Geographic information systems (GIS), which are modern mapping technologies, allow transportation agencies to harness the power of maps more quickly and inexpensively than ever before. Agencies can use GIS to visualize information about their bridges, highways, and other assets. They can also use GIS to plan maintenance trips and evaluate design alternatives to manage their assets more effectively. Maps are becoming commonly used in transportation asset management (TAM) programs that help agencies to strategically invest in their infrastructure. GIS, when applied to TAM, can help agencies communicate technical information more simply, professionally, and persuasively.

This report provides background on GIS and asset management, describes how public agencies have been integrating the two, and identifies benefits and challenges to doing so. The information presented is gleaned from a literature review and interviews with several State departments of transportation (DOTs) and one county agency. The report also identifies some leading industry trends and new, innovative approaches to using GIS for TAM.

1.8 Organization of the project

The study report is prepared in according with the objectives, and scope of the work. The report consists of six chapters as:

Chapter one: Entitled (introduction), outline the problem, projects objective and phases of the projects.

Chapter two: Entitled (Geographic Information System (GIS)Overview), how we deal with software to carry out the projects, how it works, and the importance of these software.

Chapter three: Entitled (Linear Referencing Method), is contain the Linear Referencing Method definition and relation with GIS, and also Its importance in transportation.

Chapter four: Entitled (DataCollection,Preparation and Analysis), this chapter describes the field work procedures, Linear measurement and surveying of different street events, and the analysis of these data.

Chapter five: Entitled (Methodology and data analysis), this chapter illustrates the procedure to build dynamic model for street rehabilitation and cost estimate Model.

Chapter six: Entitled (Conclusions and Recommendations).

CHAPTER TWO

GEOGRAPHIC INFORMATION SYSTEM (GIS) OVERVIEW

This chapter covers the following items:

2.1 GIS DEFINITION.

2.2 KEYASPECTS OF GIS.

2.3 PROPERITIES AND DISTORTION IN MAP PROJECTIONS .

2.4 SUMMARY.

CHAPTER TWO

GIS OVERVIEW

2.1 GIS definition:

A geographic information system (GIS) is a system used to describe and characterize the earth and other geographies for the purpose of visualizing and analyzing geographically referenced information.

Many have characterized GIS as one of the most powerful of all information technologies because it focuses on integrating knowledge from multiple sources (for example, as layers within a map) and creates a crosscutting environment for collaboration. In addition, GIS is attractive to most people who encounter it because it is both intuitive and cognitive. It combines a powerful visualization environment using maps to communicate and visualize with a strong analytic and modeling framework that is rooted in the science of geography.

This combination has resulted in a technology that is science based, trusted, and easily communicated using maps and other geographic views.

As you get started using ArcGIS, it will be important to understand a few GIS fundamentals and how ArcGIS brings these to life when you use the software. In this section, you will read about some key aspects of GIS and how geographic information models build on a series of key map concepts.

2.2 Key aspects of GIS

A GIS utilizes a layer based geographic information model for characterizing and describing our world.

ArcGIS is a GIS software, which models geographic information as a logical set of layers or themes. For example, a GIS can contain data layers for the following:

- Streets represented as centerlines
- Land-use areas that represent vegetation, residential areas, business zones, and so forth
- Administrative areas
- Water bodies and rivers
- Parcel polygons representing landownership
- A surface used to represent elevation and terrain
- An aerial photo or satellite image for an area of interest
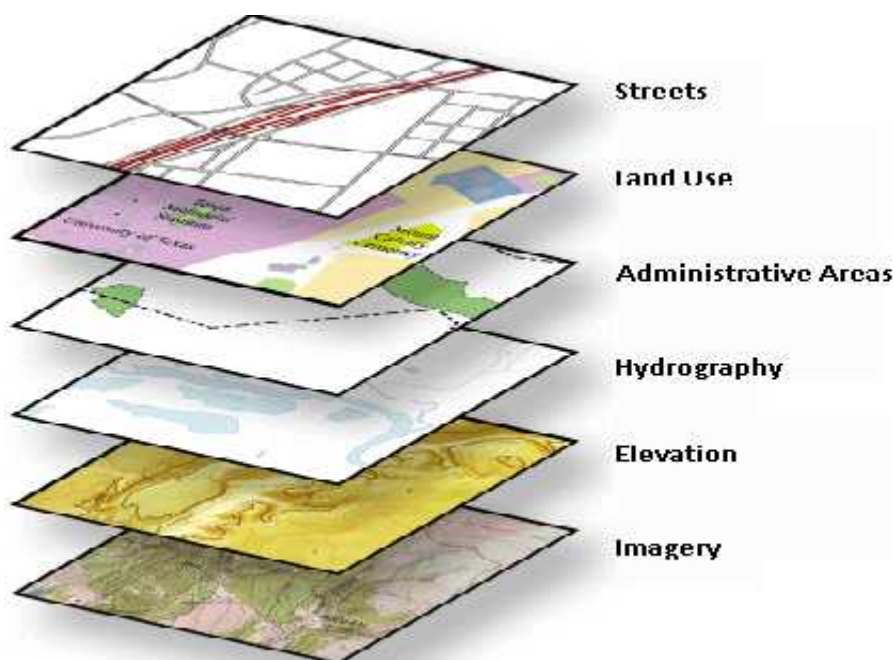
Figure (2.1): Layers

Geographic information layers such as those described here are represented using a few common GIS data structures:

- **Feature classes**: Each feature class is a logical collection of features of a common type (such as the four feature types shown here).

Figure (2.2): Feature Classes

- **Raster datasets**: Rasters are cell-based datasets used to hold imagery, digital elevation models, and other thematic data.

Figure (2.3): Raster Datasets

18

- **Attributes and descriptive information**: These are traditional tabular information used to describe features and categories about the geographic objects within each dataset.

Feature Class Table

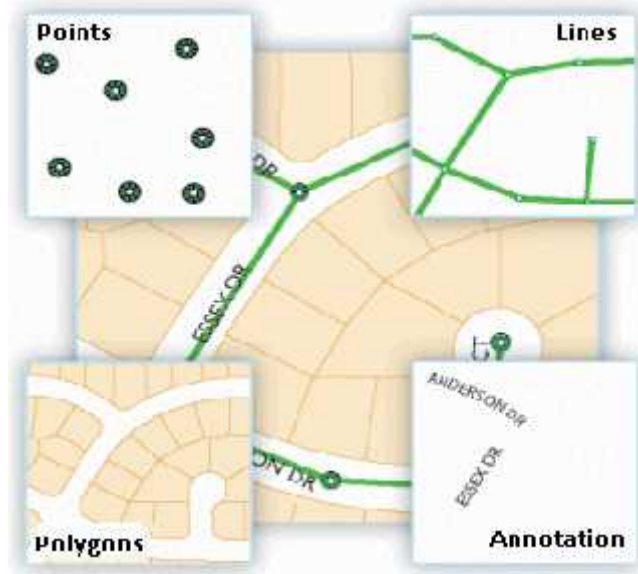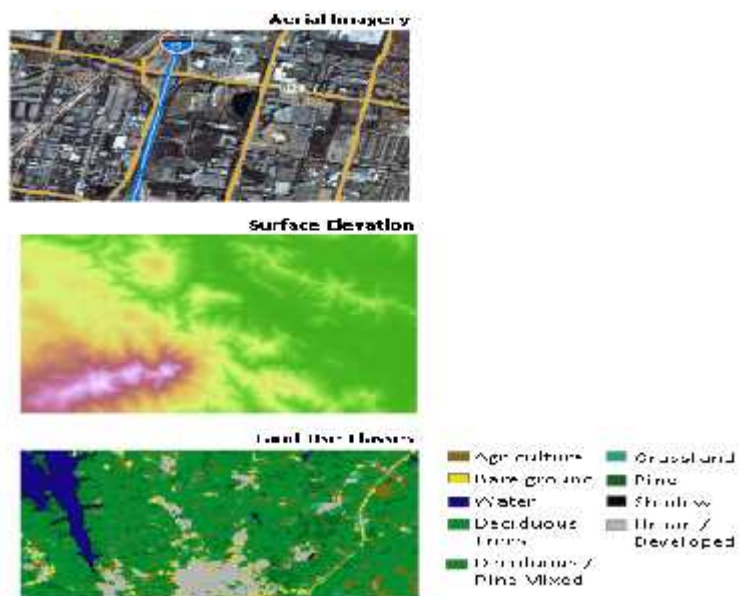| Shape	ID	PIN	Area	Addr	Code
	1	334-1626-001	7,342	341 Cherry Ct.	SFR
	2	334-1626-002	8,020	343 Cherry Ct.	UND
	3	334-1626-003	10,031	345 Cherry Ct.	SFR
	4	334-1626-004	9,254	347 Cherry Ct.	SFR
	5	334-1626-005	8,856	348 Cherry Ct.	UND
	6	334-1626-006	9,975	346 Cherry Ct.	SFR
	7	334-1626-007	8,230	344 Cherry Ct.	SFR
	8	334-1626-008	8,645	342 Cherry Ct.	SFR

Table (2.1):Feature Class Table Example

Like map layers, GIS datasets are geographically referenced so that they overlay one another and can be located on the earth's surface.A GIS uses maps to visualize and work with geographic information. Each GIS includes a set of intelligent, interactive maps and other views (such as 3D globes) that show features and feature relationships on the earth's surface. Various map views of the underlying geographic information can be constructed and used as "windows into the geographic database" to support query, analysis, and editing of geographic information. Maps can also be used to access geographic modeling tools that are used to derive new information.
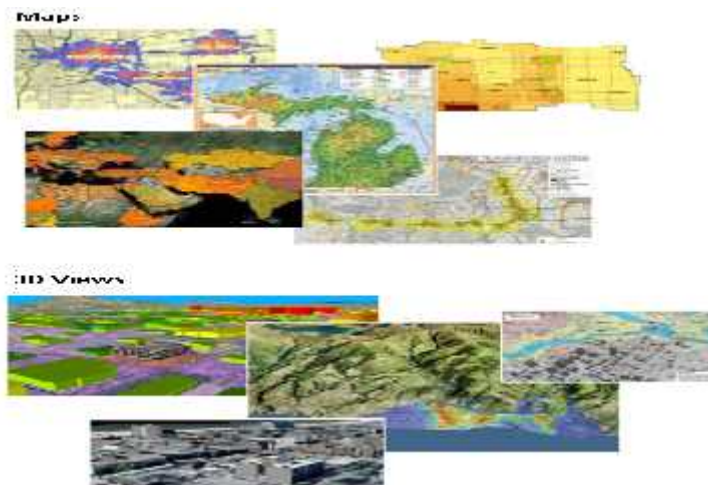

Figure (2.4):Maps & 3D Views

GIS maps are interactive and help to communicate vast amounts of information. You can reach "through" an interactive map to present any set of information that helps your end users meet their missions and do important work.

A GIS has a comprehensive set of analytic and data transformation tools to perform spatial analysis and data processing.

GIS includes a large set of geoprocessing functions to take information from existing datasets, apply analytic functions, and write results into new result datasets. There are numerous spatial operators, such as the Buffer and Intersect tools shown here, that can be applied to GIS data.

Each geoprocessing tool takes existing information as input and derives a new result, which can be used in subsequent operations. This ability to string together a logical sequence of operations so that you can perform spatial analysis and automate data processing all by assembling a model is one of the key elements of GIS.

2.3 Properties and distortion in map projections

Since the earth is spherical, a challenge faced by cartographers and GIS professionals is how to represent the real world using a flat or planar coordinate system. To understand the dilemma, consider how you would flatten half of a basketball; it can't be done without distorting its shape or creating areas of discontinuity. The process of flattening the earth is called projection, hence the term map projection.
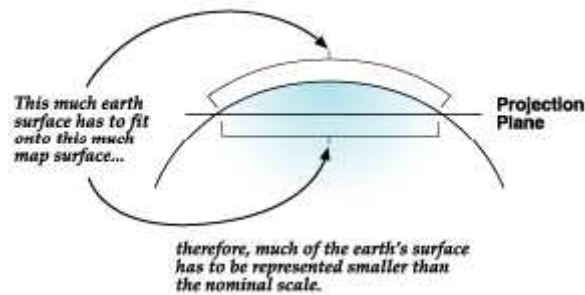
A projected coordinate system is defined on a flat, two-dimensional surface. Projected coordinates can be defined for 2D (x,y) or 3D (x,y,z) in which the x,y measurements represent the location on the earth's surface and z would represent height above or below mean sea level.
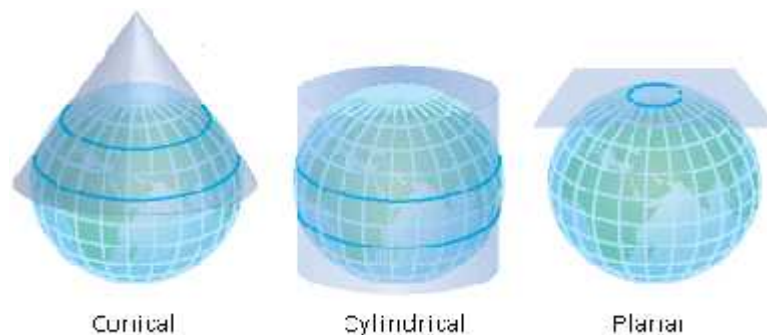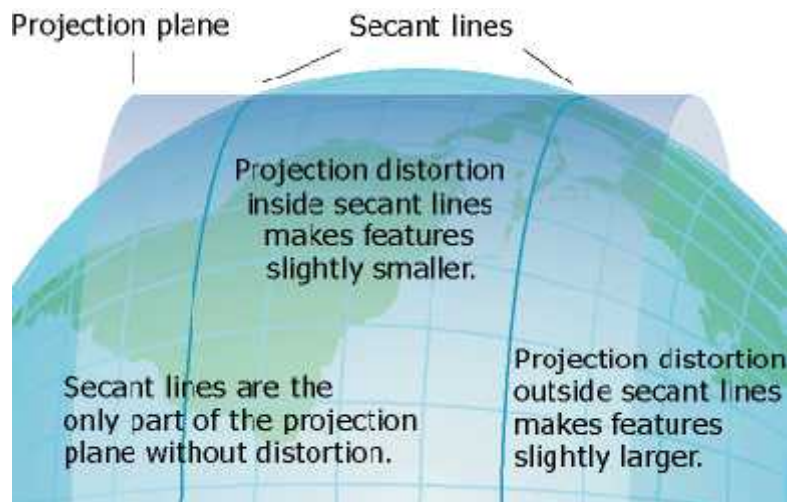
Unlike a geographic coordinate system, a projected coordinate system has constant lengths, angles, and areas across the two dimensions. However, all map projections representing the earth's surface as a flat map create distortions in some aspect of distance, area, shape, or direction.

Users cope with these limitations by using map projections that fit their intended uses, their specific geographic location, and extent. GIS software also can transform information between coordinate systems to support integration of datasets held in differing coordinate systems and to support a number of critical workflows.

Many map projections are designed for specific purposes. One map projection might be used for preserving shape while another might be used for preserving the area (conformal versus equal-area projections).

These properties the map projection along with spheroid and datum become important parameters in the definition of the coordinate system for each GIS dataset and each map. By recording detailed descriptions of these properties for each GIS dataset, computers can reproject and transform the geographic locations of dataset elements on the fly into any appropriate coordinate system. As a result, it's possible to integrate and combine information from multiple GIS layers regardless of their coordinate systems. This is a fundamental GIS capability. Accurate location forms the basis for almost all GIS operations.

2.7 Summary

All types of geographic information features, rasters, and attributes can participate in these spatial and attribute relationships. In a GIS, such relationships are modeled using extended data types such as topologies and networks. In addition, many types of spatial relationships can be discovered and identified by applying a series of spatial operators to the geographic objects. For example, you can create buffer zones of a given distance around features and perform a polygon overlay with another dataset to identify features that are near to others in your GIS.
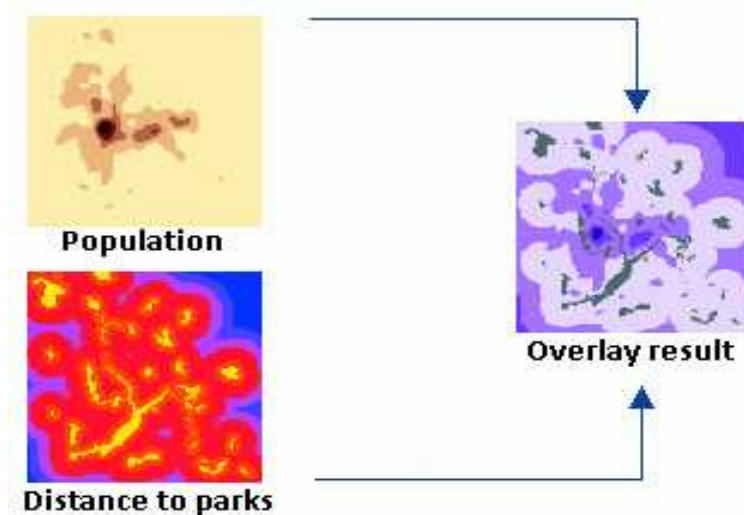
- **How a GIS represents and models geographic information**

All geographic information is represented and managed using three primary GIS data structures:

- Feature classes
- Attribute tables
- Raster datasets

These three fundamental data types can be extended with additional capabilities to manage data integrity, model geographic relationships (such as network connectivity and flow), and add important geographic behavior.

- **Each GIS has a collection of datasets**

Typically, a GIS is used for handling several different datasets where each holds data about a particular feature collection (for example, roads) that is geographically referenced to the earth's surface.A GIS database design is based on a series of data themes, each having a specified geographic representation. For example, individual geographic entities can be represented as features (such as points, lines, and polygons); as imagery using rasters; as surfaces using features, rasters, or TINs; and as descriptive attributes held in tables.

In a GIS, homogeneous collections of geographic objects are organized into data themes such as parcels, wells, buildings, orthoimagery, and raster-based digital elevation models (DEMs). Precisely and simply defined geographic datasets are critical for useful geographic information systems, and the design of layer-based data themes is a key GIS concept.

- **GIS datasets are logical collections of geographic features**

A dataset is a collection of homogeneous features for each theme. Geographic representations are organized in a series of datasets or layers. Most datasets are collections of simple geographic elements such as a road network, a collection of parcel boundaries, soil types, an elevation surface, satellite imagery for a certain date, well locations, or surface water.

In a GIS, spatial data collections are typically organized as feature class datasets or raster-based datasets.

Many data themes are best represented by a single dataset such as for soil types or well locations. Other themes, such as a transportation framework or surface elevation, are often represented by multiple datasets. For example, transportation might be represented as multiple feature classes for streets, intersections, bridges, highway ramps, railroads, and so on. The table below illustrates how surface elevation might be represented using multiple datasets.

Raster datasets are used to represent georeferenced imagery as well as continuous surfaces such as elevation, slope, and aspect.

- **Common GIS representations**

Theme	Geographic representation
Streams	Lines
Large water bodies	Polygons
Vegetation	Polygons
Urban areas	Polygons
Road centerlines	Lines
Administrative boundaries	Polygons
Well locations	Points
Orthophotography	Rasters
Satellite imagery	Rasters
Surface elevation	DEM rasters
	Contour lines
	Elevation points
	Shaded relief rasters
Land parcels	Polygons
Parcel tax records	Tables

Table (2.2): GIS Representation

- **Thematic layers become datasets. This is the key organizing principle in a GIS database.**

Each GIS will contain multiple themes for a common geographic area. The collection of themes acts as a stack of layers. Each theme can be managed as an information set independent of other themes. Each has its own representation (as a collection of points, lines, polygons, surfaces, rasters, and so on). Because layers are spatially referenced, they overlay one another and can be combined in a common map display. In addition, GIS analysis tools, such as polygon overlay, can fuse information between data layers to discover and work with the derived spatial relationships.

25

Administrative boundaries

Zoning and land use

Tax parcels

Lots

Cadastral framework

Orthophoto
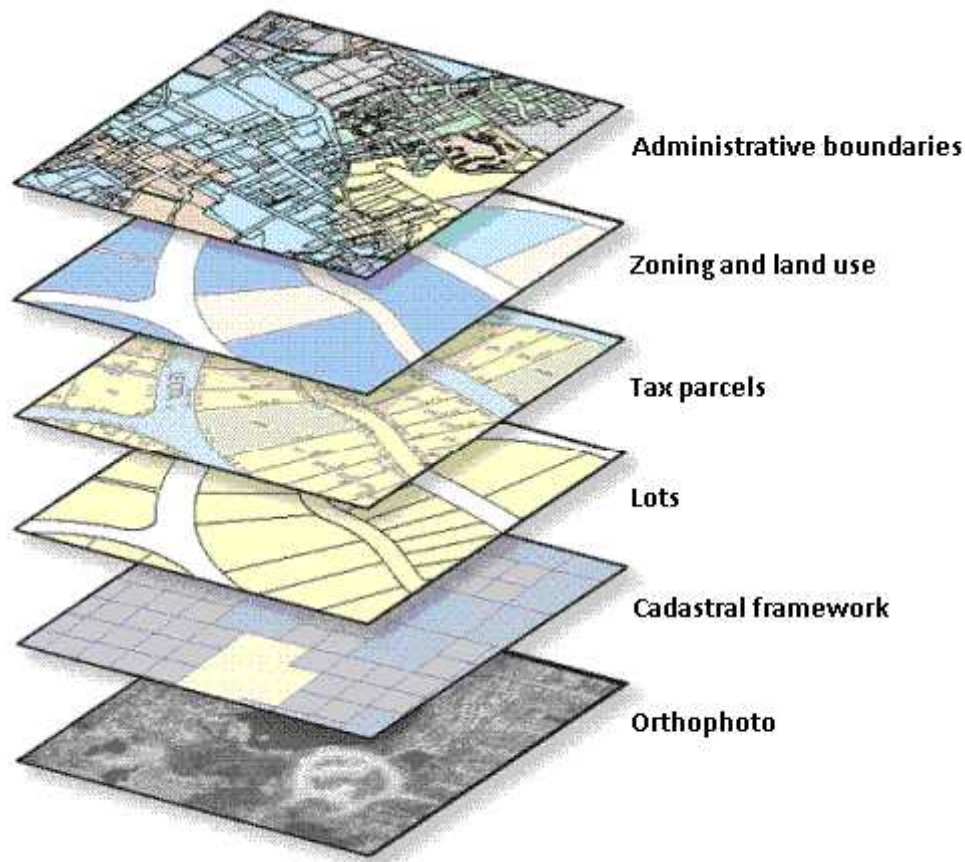
Any effective GIS database will adhere to these common principles and concepts. Each GIS requires a mechanism for describing geographic data in these terms along with a comprehensive set of tools to use, manage, and share this information.

- **How GIS users work with geographic information.**

Users work with geographic data in two fundamental ways:
As datasets, which are homogeneous collections of features, rasters, or attributes, such as parcels, wells, buildings, orthophoto imagery, and raster-based digital elevation models. As individual elements or subsets, such as the individual features, rasters, and attribute values contained within each dataset

- **Working with GIS datasets**

In ArcGIS, homogeneous collections of geographic objects are organized into datasets about common subjects, such as parcels, wells, roads, buildings,

orthophoto imagery, and raster-based DEMs.Many of the operations that users perform in ArcGIS work on datasets as inputs or create new datasets as results. Datasets also represent the most common method for data sharing among GIS users.

Datasets provide the primary data sources for each of the following:

Maps, globes, and 3D scenes: These views provide the principal display of geographic information as a series of map layers. Each map layer references a specific GIS dataset and is used to symbolize and label the dataset. In this way, map layers help bring your GIS datasets to life in your GIS.
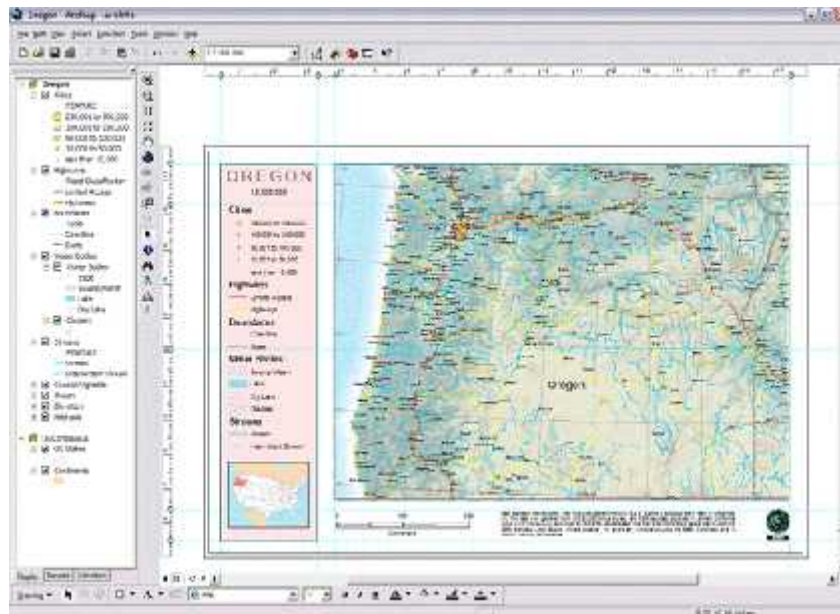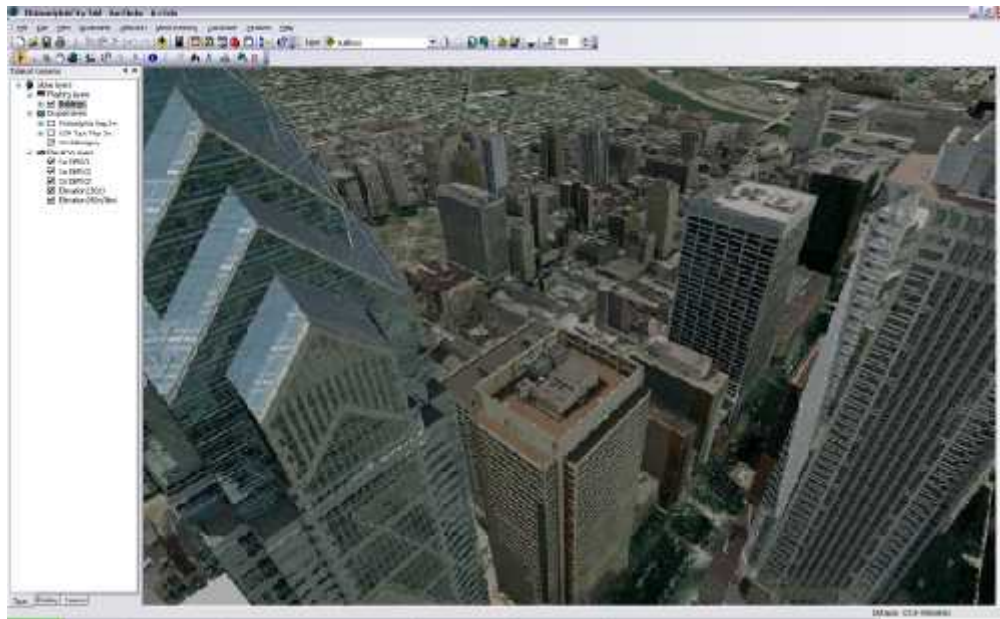
Map layers in 2D maps and 3D scenes are used to symbolize and label GIS datasets. This map has layers for cities, highways, state and county boundaries, water bodies, and streams. Each of these layers is used to portray a GIS dataset.

Geoprocessing inputs and derived datasets: GIS datasets are common data sources used for geoprocessing and are useful for automated data processing and GIS analysis. Datasets are used as inputs and new datasets are derived as results for various geoprocessing tools.

Geoprocessing helps you to automate many tasks as a series of operations so that they can be run as a single step. This helps to create a repeatable, well-documented data processing workflow. Users also work with ArcGIS datasets to perform spatial analysis.
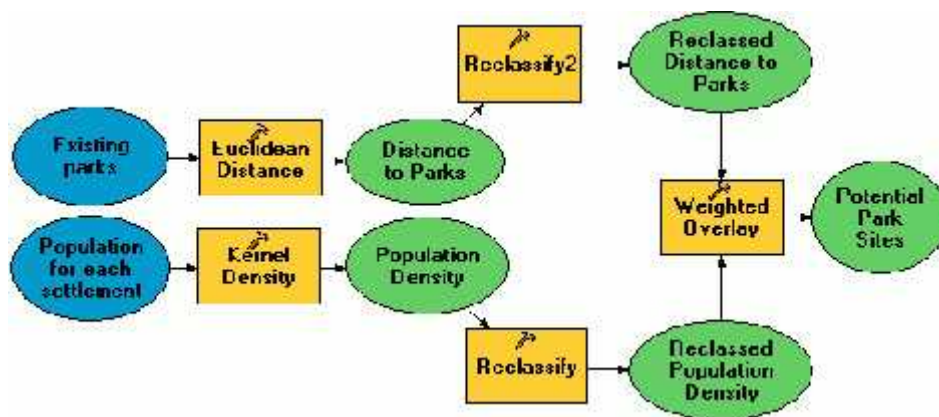
This model illustrates how to identify and rank potential sites for new parks. Good candidate locations must have high population counts and not be too close to existing parks.

- **Working with individual features and elements in datasets.**

In addition to working with datasets, users also work with the individual elements contained in datasets. These elements include individual features, rows and columns in attribute tables, and individual cells in raster datasets. For example, when you identify a parcel by pointing at it, you're working with the individual data elements in a dataset:

You work with individual data elements when you edit features as in this example for editing road centerlines:
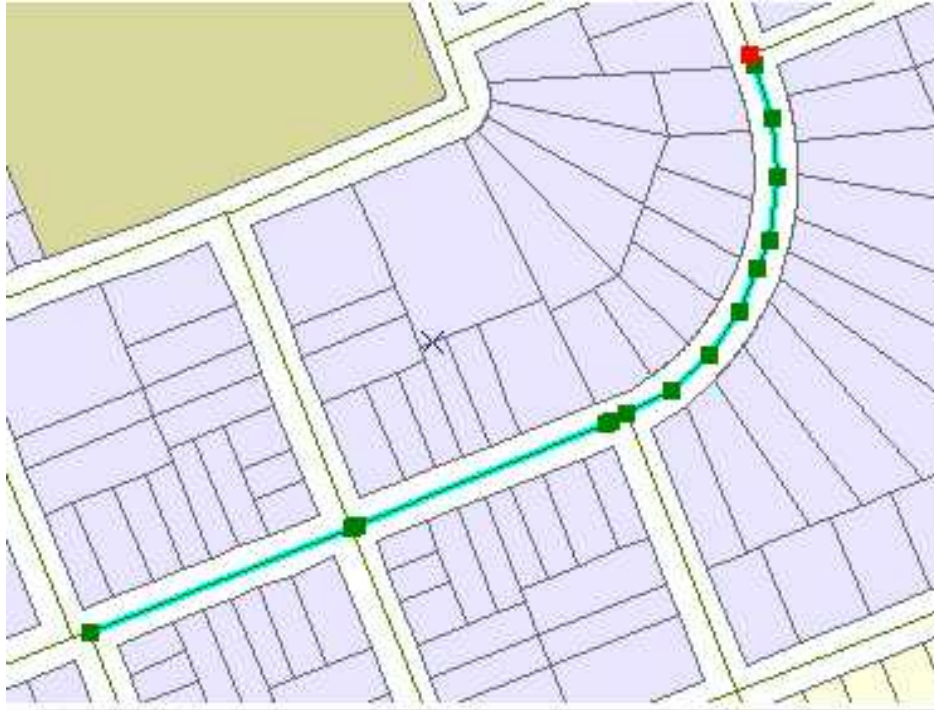
When working with tables, users work with descriptive information contained in rows and columns, as illustrated here:

- **Map applications provide the primary user interface for GIS**

GIS users work with interactive maps. There is a series of GIS map applications that provide the primary interfaces through which users work with ArcGIS. Map documents (ArcMap MXDs) and ArcGIS Web Maps are used to encapsulate maps that are used and shared across these applications.

- **Many kinds of GIS map applications**

GIS maps provide the primary user interface for many GIS applications. Users can point to map features to display information about them, discover new relationships, perform editing and analysis, and efficiently communicate results using geographic views. A number of alternative GIS map applications can be deployed in various application frameworks to support many types of users and tasks. They include the following:

- **Professional GIS maps**

ArcGIS Desktop users (users of ArcView, ArcEditor, ArcInfo, and often custom ArcGIS Engine applications) employ a rich set of mapping applications, such as

ArcMap, to perform their daily work. ArcGIS Desktop provides professional GIS applications for map authoring and map use, working with 3D scenes and globes, data compilation, running GIS analysis, and publishing GIS information products for use by others in your organization.

ArcMap

ArcScene

ArcGlobe
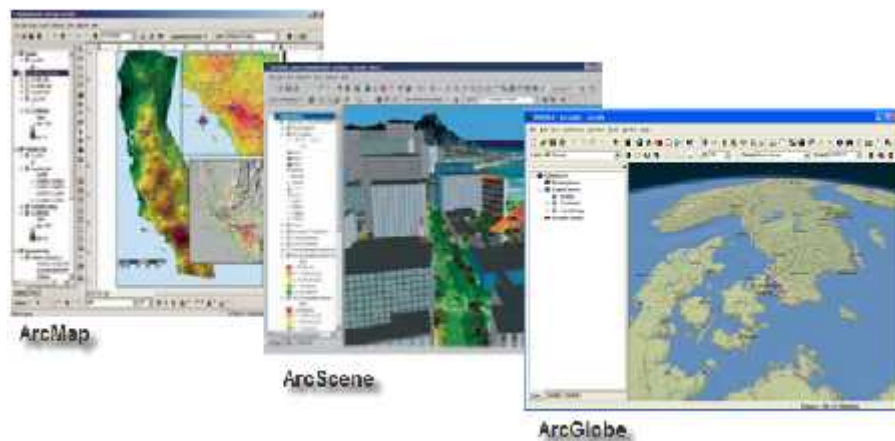
Typical tasks in professional GIS map applications include these:

- Author maps.
- Edit data.
- Perform spatial analysis.
- Visualize results.
- Animate geographic information.
- Chart data.
- Publish and share as desktop maps, Web maps, and ArcGIS Explorer maps.
- Print maps.

- **Web maps**

Web maps are used by a wide-ranging audience from citizens to field-workers, operations staff, managers, and executives and are published in concert with ArcGIS Server. Web GIS applications have a user experience much like many of the consumer Web maps such as Google Maps and Microsoft Bing Maps. You can create and share your own custom Web map applications powered by powerful, back-end map and geoservices hosted by ArcGIS Server. You can easily combine (that is, mash up) Web maps with one another.

- **Web applications**

A number of application program interfaces (APIs) are available for building and deploying Web maps with ArcGIS: JavaScript, Adobe Flex, and Microsoft Silverlight. Web mapping applications are useful for combining information from a range of Web maps and GIS servers.

Here is a list of some typical tasks that are used in custom applications:

- Map use with focused tasks identify, query, summarize, and so on
- Simple editing (for example, enabling citizens to compile and share their own information as a member of a community)
- Attribute and forms-based updates
- Access to status maps (situational awareness)
- Fusion of information from multiple servers

- **ArcGIS Explorer**

ArcGIS Explorer is a free application from ESRI that you can share with any of your users. Explorer is used to build interactive Web maps that provide 2D and 3D views of geographic information. These GIS maps can integrate many information sets. ArcGIS Explorer typically relies on ArcGIS Web and other Web services (KML, WMS, and so forth), but can also use local datasets.

Here are some ArcGIS Explorer characteristics:

- It can access any 2D or 3D base map published using ArcGIS Server along with the ability to overlay just about any GIS service (KML, OGC, Bing, and others).
- It supports advanced GIS tasks and access to geoprocessing services.
- The ArcGIS Explorer presentation mode is very effective at using maps and GIS to tell stories and communicate with and visualize your community.
- It helps users answer many questions that go beyond simple Web mapping:
- Where are my customers?

34

- o Where should I put new stores or facilities?
- o Who is impacted by this emergency? Where are the first responders? Where are the vulnerable populations, and how many are there? Where are the elderly who are affected? The children? Where should we place evacuation centers?
- o What is the best way to respond to a power outage? Can we pinpoint the outage location?
- o What are the most congested traffic areas of a city?
- o What is the projected tax base for land parcels under this proposed plan alternative?
- o What is the environmental impact of a new development?
- o What is the air quality impact on children near major roads?
- o What happens if the water level rises one meter?

- **Mobile GIS applications**

The wide adoption of mobile wireless devices (advances in cell phones) and the universal use of the Global Positioning System (GPS) are fueling the growth in mobile GIS. ArcGIS includes mobile capabilities that work on wireless devices (using the mobile Web) as well as devices with advanced GPS capabilities for field data collection and mapping applications. Mobile wireless appliances use standard Web map frameworks, while Tablet PCs and professional GPS devices use special maps that you can take to the field on your mobile appliance using ArcGIS Mobile technologies.

Figure (2.5): Mobile GIS Applications

CHAPTER THREE

LINEAR REFERNCING METHOD

This chapter covers the following items:

3.1 LINEAR REFERENCING DEFINITION

3.2 BENEFITS OF LINEAR REFERENCING

3.3 LINEAR REFERNCING AS A PROCESS

3.4 LINEAR REFERENCINGSCENARIOS

3.5 LINEAR REFERENCING APPLICATIONS

3.6 LINEAR REFERENCING DATASETS IN ARCGIS

CHAPTER THREE

LINEAR REFERNCING METHOD

3.1 Linear referencing definition

Linear referencing is the process of associating events to a network. The network may represent roads, rivers, pipelines, or any connected set of linear features. The events associated with the network may be pavement conditions, road sign locations, or any objects that are best located by their positions along the network. Linear referencing is a georeferencing process in which the underlying datum is a network rather than a coordinate system. In this entry, the elements of linear referencing are defined, the benefits of employing linear referencing are summarized, and a seven-step process for performing linear referencing is outlined.

A linear referencing system (LRS) is a support system for the storage and maintenance of information on events that occur along a network. A LRS consists of an underlying network that supplies the backbone for location, a set of objects with well-defined geographic locations, one or more linear referencing methods (LRM), and a set of events located on the network. A linear referencing method is defined as a mechanism for finding and stating the location of a point along a network by referencing it to a known location. A LRM determines an unknown location on the basis of a defined path along the underlying transportation network, a distance along that path location, andoptionally-an offset from the path.

Linear referencing is the method of storing geographic locations by using relative positions along a measured linear feature. Distance measures are used to locate events along the line:
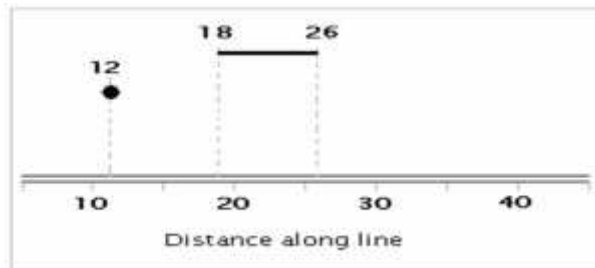
Measurements along features are used to locate point events and line events using a number of conventions. Here are some common examples:

A point can be located along the line in the graph below:

- At measure 12 along the line
- 4 units east of measure marker 10 along the line
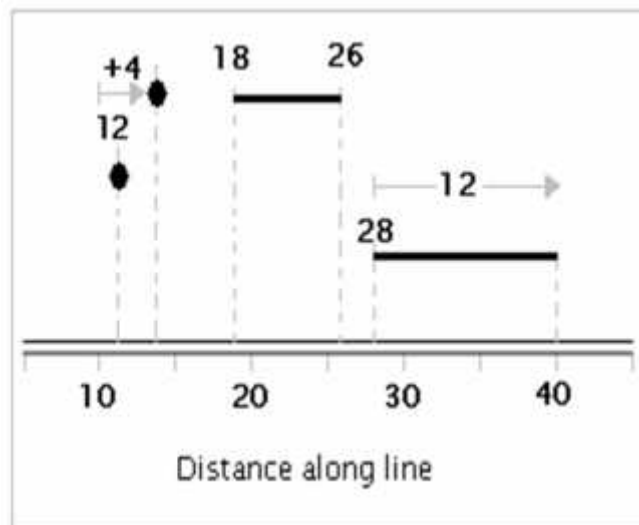
Line features can be referenced in a few ways. In this example above

- The line starts at measurement 18 and ends at 26.
- The line starts at measurement 28 and continues for 12 units.

## 3.2 Benefits of linear referencing

The primary benefit of using linear referencing is that it allows locations to be readily recovered in the field, since these locations are generally more intuitive than locations specified with traditional coordinates. Second, linear referencing removes the requirement of a highly segmented linear

network, based on differences in attribute values. More specifically, there are many network attributes that do not begin, end, or change values at the same points where the network is segmented. The implementation of linear referencing permits many different attribute events to be associated with a small set of network features. Moreover, linear referencing allows attribute data from multiple sources to be associated with the network, promotes a reduction in redundancy and error within the database, facilitates multiple cartographic representations of attribute data, and encourages interoperability among network applications.

Linear referencing is used for many reasons. The following are the two primary reasons:

1. Many locations are recorded as events along linear features—for example, locations of traffic accidents are recorded using a convention such as "27 meters east of reference mile marker 35 along State Highway 287." Many sensors record conditions along linear features using measures of distance or time along the lines—along pipelines, along roads, along streams, and so forth.

2. Linear referencing is also used to associate multiple sets of attributes to portions of linear features without requiring that underlying lines be segmented (split) each time that attribute values change. For example, most road centerline feature classes are segmented where three or more road segments intersect and where the road names change.

Users often want to record many additional attributes about the roads. Without the use of linear referencing, this could require that roads be split into many tiny segments at each location where attribute values change. As an alternative, these situations can be handled as linear referencing events along the roads as in the figure below:
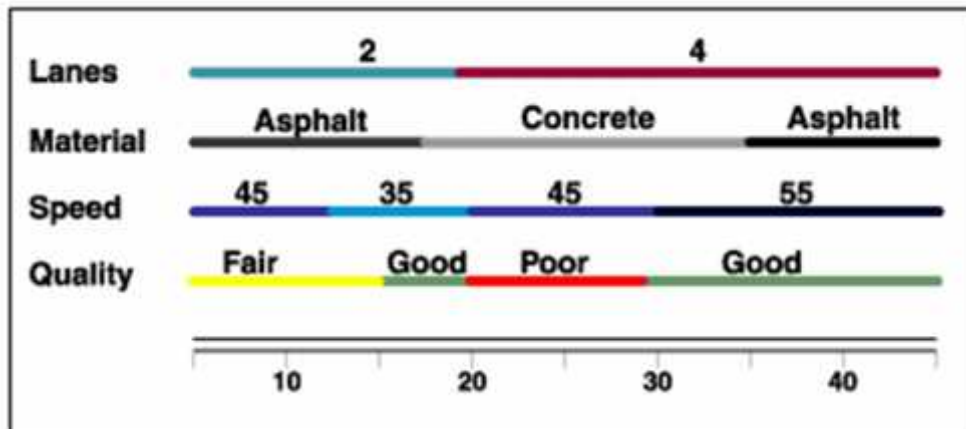
3.3 Linear Referencing as a Process

To implement linear referencing, several procedures must be completed. These procedures are presented as an iterative seven-step linear referencing process.

1. Determine Application, Representation, and Topology

There are fundamental differences in the structure of networks for different applications. Road and river networks, for example, do not have similar topological structures. The attributes and the analytical methods associated with different network types require different network representations. Therefore, the first step in a linear referencing process is to define which network data sets and spatial representations are to be employed for the application at hand.

2. Determining Route structure

The next step is to determine the route structure. The term route in this context is the largest individual feature that can be uniquely identified and to which events can be linearly referenced. Any linear feature can become the underlying element defining routes, but, generally speaking, a route should be longer than the events to be referenced so that event segmentation is minimized. For example, if streets are the target network for linear referencing, one may want to define the

routes as single entities that represent the entire northbound and southbound directions of travel along the street, even though there are many underlying features (different blocks of the street between intersections) in the network data set. Routes may be further divided if the street name or prefix changes somewhere along the length of the route. Figure I shows the definition of four routes along an arterial road, based on direction of travel, street name, and street prefix.
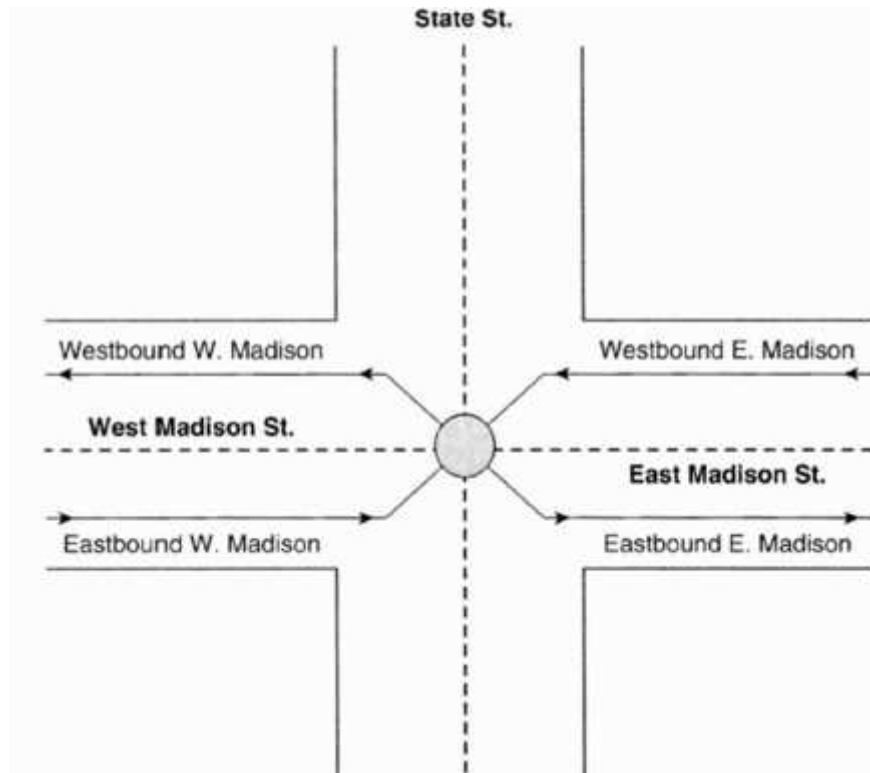
Figure (3.1): Defining routs

3.   Determining Measures

The third step is to determine measures along the routes. There are three considerations in doing so: the most appropriate unit of measure, the source for the measure values, and the direction of increasing measures. The most appropriate unit for measures along routes is a function of the application and the audience. The source of measure data has historically been of subject of intense debate. In some cases. data collected in the field and stored in databases external to the GIS are of higher quality. Increasingly. the capture of GIS data using remote-sensing technologies has raised the accuracy of spatial databases and encouraged their use for measurements along networks. The

direction of increase of measure values should be consistent with the needs of the application and should be logically consistent with the topological structure. For example, if linear referencing is to be used in the context of emergency response, the measures would best be designed to increase such that they are consistent with increasing address ranges along the streets.

4. Create Events

Given a set of routes and measure information associated with those routes, the next step is the collection of event data. Event data are occurrences along the network. Events can be point or linear in character. Point events represent objects located at specific measures along a route. Linear events have a consistent attribute along the network. There are an infinite number of possible events to locate along a network. Typical point events may be the locations of street signs or bridges along a road network. switches along a rail network, or monitoring stations along a river. Linear events could represent varying pavement conditions along the road, speed limits on a rail net work, or depths associated with a river. Events can be digitized from maps. collected in the field, or automatically generated by remote sensing technology.

5. Display Event Data, Cartographic Output

Linear referencing provides new information regarding network processes. But this can lead to poor cartography due to graphical clutter and information overload. Therefore, the next step is to carefully choose the parameters for display of the events. The display of linearly referenced events is referred to as dynamic segmentation. The decisions regarding display of event data are dependent on several factors. including the media on which the data will be displayed and the scale of the representations. One visual benefit of dynamically displaying event data is the ability to display multiple linear events along the same feature. accomplished through offsetting the events so that all events are visible in relation to the route itself and in relation to other events. A common example of this is seen on subway route maps. Figure 2 shows three types of events offset from the underlying road network in order to display them all simultaneously.

6. **Analysis With Linear Referencing**

With routes and event data in hand, analysis can be performed through techniques such as overlays, intersections. and other spatial analysis techniques incorporated in GIS. In some cases, linear referencing allows new database queries to be made that differ from those based on the underlying network. However, while significant analytic capability is added with linear referencing, other traditional GIS analytic capabilities are lost. Most important, events do not contain topological information that is mandatory for most network analysis. For this reason, both traditional network and event representations must be maintained coincidently.

7. **Data Maintenance**

To keep this newly created linear referencing system functional, it is important that the route and event data be maintained properly. Geometric changes during editing, changes in measure values with the movement of real-world features, and the addition of more precise measurements all demand an ongoing process of data maintenance.

3.4 Linear referencing scenarios

In most data models, linear features are split at intersections where they connect with two or more line features and frequently are also split where key attribute values change, such as a change in the road name.

However, users often want to record many additional attributes about the roads. This could require that roads be split into many tiny segments at each location where attribute values change. As an alternative, these situations can be handled as linear referencing events along the roads as illustrated in the concept figure below:
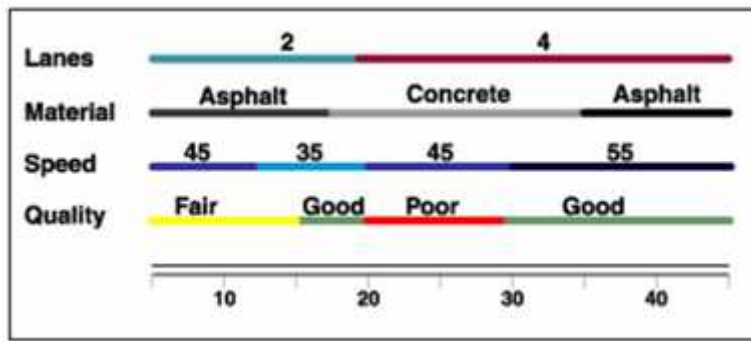
Certain linear features also have attributes that change frequently—for example, observations that describe the condition of segments along key infrastructure networks (roads, pipes, and so on). Plus, these observations could be made repeatedly over time. For example, the pavement condition of a road changes as pavement deteriorates and is subsequently repaired. Linear referencing can be used to accurately locate multiple observations of the pavement condition, as illustrated below.
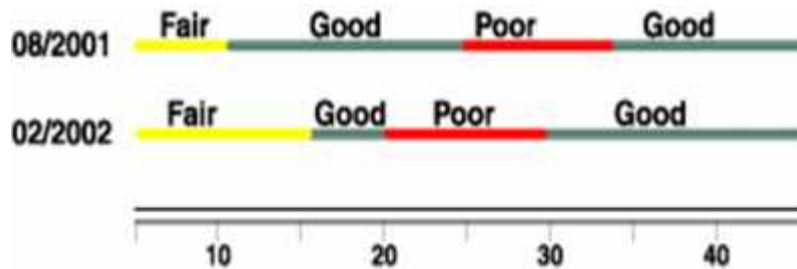
Segmenting linearfeatures on a frequent basis becomes even more problematic when you consider that you may need to store other attributes. In addition to road conditions, you might also want to record traffic volumes, lane information, surface material, speed limits, and accident locations.
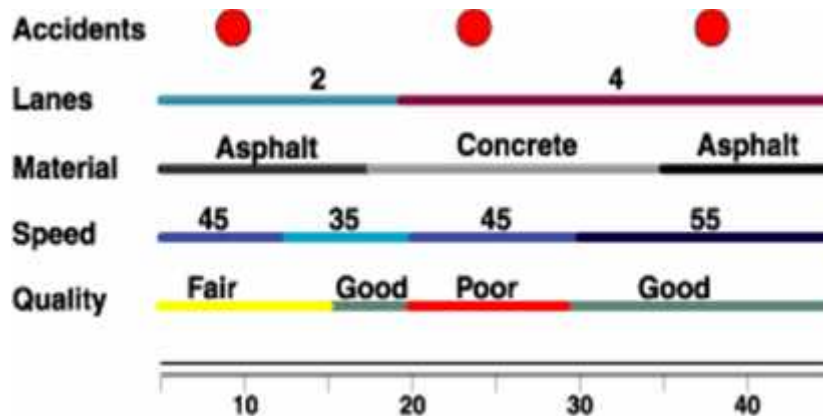
3.5 Linear referencing applications

Most applications that use linear features can benefit from linear referencing. Example applications are outlined in the sections that follow.

3.5.1 Highways and streets:

Agencies that manage highways and streets use linear referencing in a variety of ways in their day-to-day operations. For example, linear referencing is useful for the following:

✓ Assessing pavement conditions

✓ Maintaining, managing, and valuing assets—for example, traffic signs and signals, guard rails, toll booths, and loop detectors

✓ Organizing bridge management information

✓ Reviewing and coordinating construction projects

Linear referencing also facilitates the creation of a common database that traffic planners, traffic engineers, and public works analysts can use for cross-disciplinary decision support.

The following is an example displaying pavement conditions.
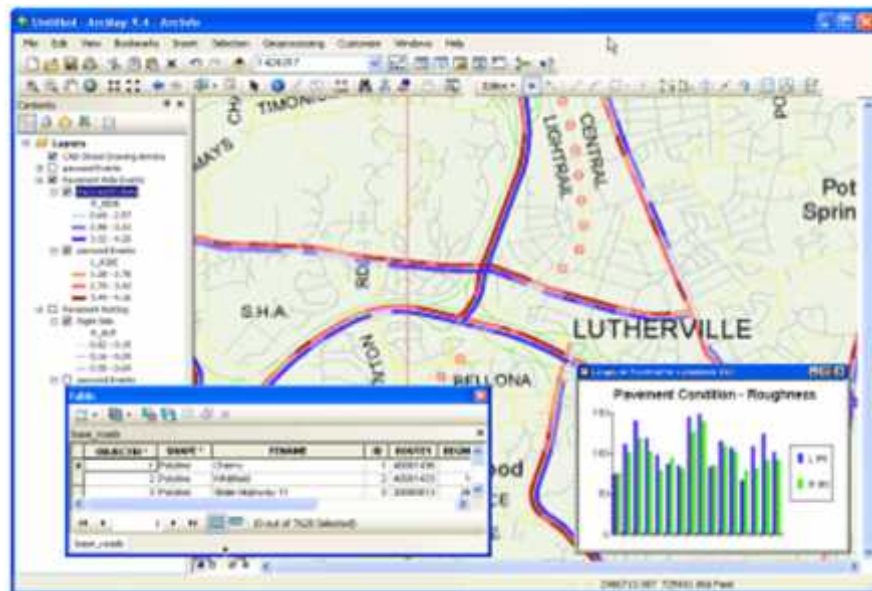
Figure (3.2): Pavement Conditions

3.5.2 Transit:

Linear referencing is a key component in transit applications, and it facilitates such activities as these:

✓ Route planning and analysis

✓ Automatic vehicle location and tracking

✓ Bus stop and facility inventory

✓ Rail system facility management

✓ Track, power, communications, and signal maintenance

✓ Accident reporting and analysis

✓ Demographic analysis and route restructuring

✓ Ridership analysis and reporting

✓ Transportation planning and modeling

The following shows the results of a corridor study, displaying the number of traffic accidents along a stretch of highway.
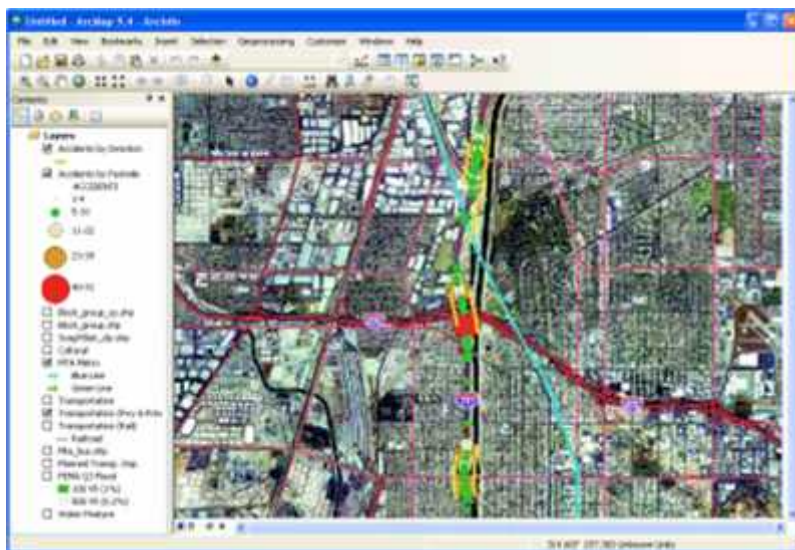
Figure (3.3): Traffic Accidents in a Corridor Study

3.5.3 Railways:

Railways use linear referencing to manage key information for rail operations, maintenance, asset management, and decision support systems. Linear referencing makes it possible, for example, to select a line and track and identify milepost locations for bridges and other obstructions that would prevent various types of freight movement along the route. Furthermore, linear referencing can be used to display track characteristics or view digital images of bridges and obstructions.

The following is an example of analyzing rail clearances along a rail line.
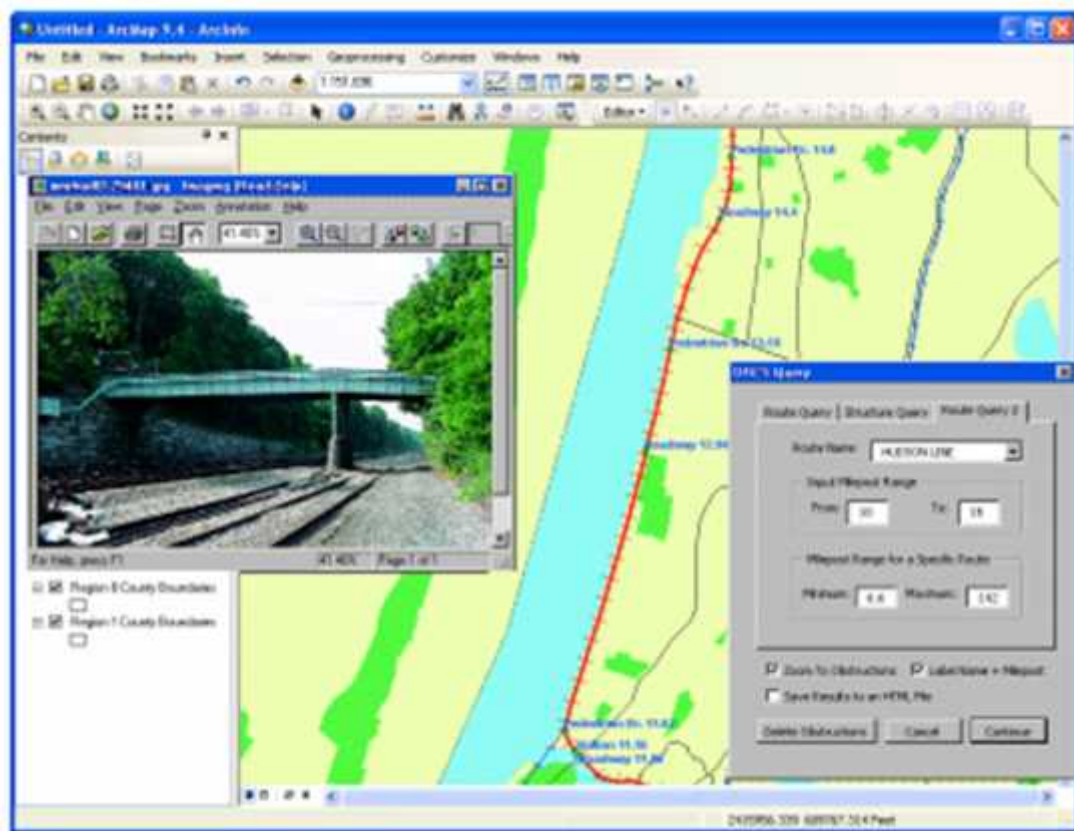
Figure (3.4): Analyzing Rail Line Clearance

3.5.4 Oil and gas exploration:

The petroleum industry manages tremendous volumes of data used in geophysical exploration. Seismic surveys, or shot point data, are used to help understand the underlying geology in an area. The nature of seismic data is that it must be represented as both a linear object- the seismic line- and a collection of point objects (the shot points). Both the seismic line and the individual shot points have attributes, must be maintained at the same time, and are used in modeling applications. Linear referencing helps solve this problem.

The following shows an example of posting and labeling seismic lines and shot points in the Gulf of Mexico.

Figure (3.5): Posting and Labeling Seismic Lines and Shot Points

3.5.5 Pipelines:

In the pipeline industry, linear referencing is often referred to as stationing. Stationing allows any point along a pipeline to be uniquely identified. As such, stationing is useful in these applications:

- ✓ Collecting and storing information regarding pipeline facilities
- ✓ Inline and physical inspection histories
- ✓ Regulatory compliance information
- ✓ Risk assessment studies
- ✓ Work history events
- ✓ Geographic information, such as environmentally sensitive areas, political boundaries (for example, state and county), right-of-way boundaries, and various types of crossings.

In the following illustration, pipeline coating material types are being examined.

Figure (3.6): Pipeline Coating Material Types are Being Examined.

3.5.6 Water resources:

In hydrology applications, linear referencing is often called river addressing. River addressing allows objects such as field monitoring stations which collect information about water quality analysis, toxic release inventories, drinking water supplies, flow, and so on to be located along a river or stream system. Furthermore, the measurement scheme used in river addressing allows the measurement of flow distance between any two points on a flow path.In the illustration below, monitoring stations along a hydrology network are identified.
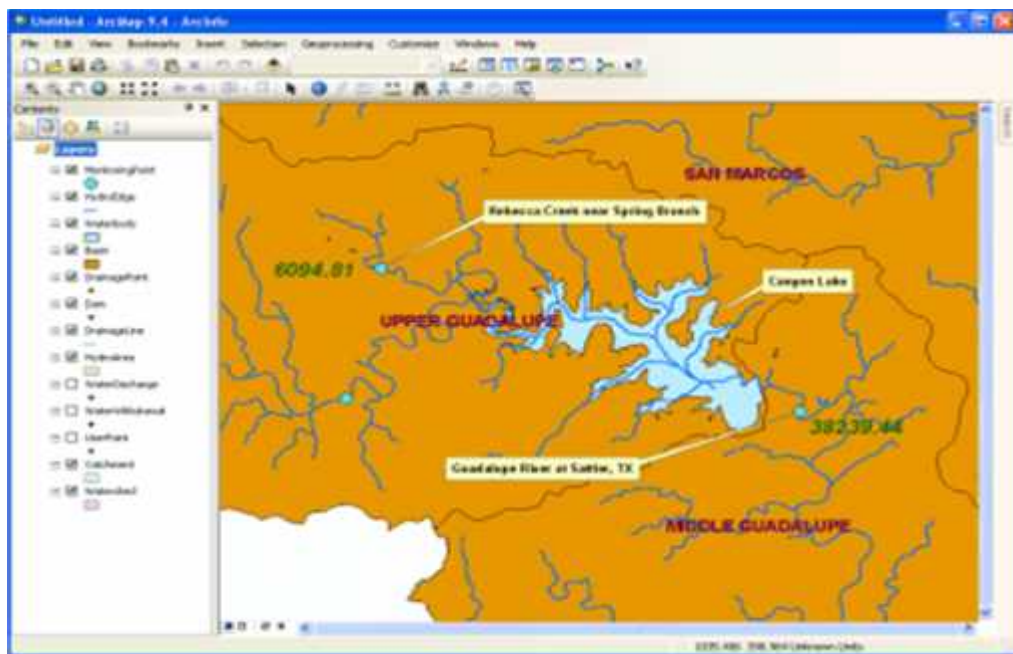

Figure (3.7): IdentifyingMonitoring Stations Along a Hydrology Network

3.6 Linear referencing datasets in ArcGIS

There are two primary data types that are used to implement linear referencing in ArcGIS:
- ✓ Route feature classes
- ✓ Event tables

Using dynamic segmentation, events from event tables are located on line features in a route feature class.

❖ Route feature classes

A route feature class is a line feature class that has a defined measurement system. These measurement values can be used to locate events, assets, and conditions along its set of linear features.
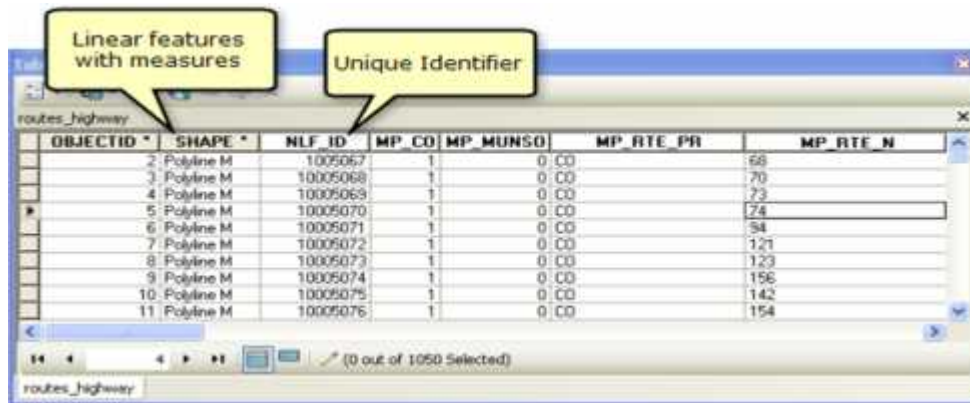
In ArcGIS, the term route refers to any linear feature, such as a city street, highway, river, or pipe, that has a unique identifier and a common measurement system along each linear feature.
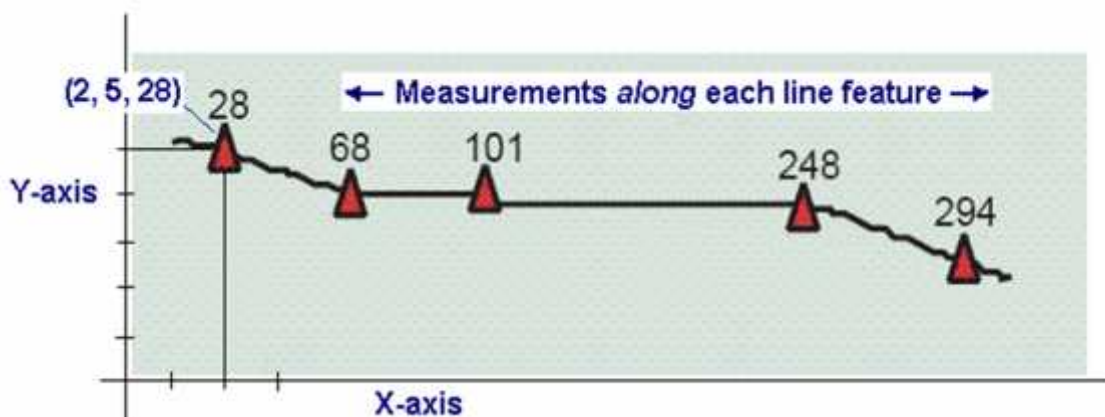
In simple terms, feature vertices in route feature classes include m-values (x,y,m or x,y,z,m). These measured coordinates form the building blocks for route features. In route feature classes, line features have their x,y (or x,y,z) coordinates that describe location as well as a measurement (m)

value along the line.

A collection of routes with a common measurement system is a route feature class. Each route in the feature class will also have a unique identifier. Line features with the same uniqu00e identifier are considered to be part of the same route:


Route feature classes are created and managed as line feature classes in the geodatabase. You can also use route feature classes from ArcInfocoverage's and polyline shapefiles that include route identifiers and measured features.

1. Route feature geometry

Route features have a measurement system stored with their geometry. Each measured line's segments have x-, y-, and m- (measure) or x-, y-, z-, and m-values. When a measure value is unknown for a particular vertex, its m-value is recorded as NaN (not a number) as illustrated in this example:
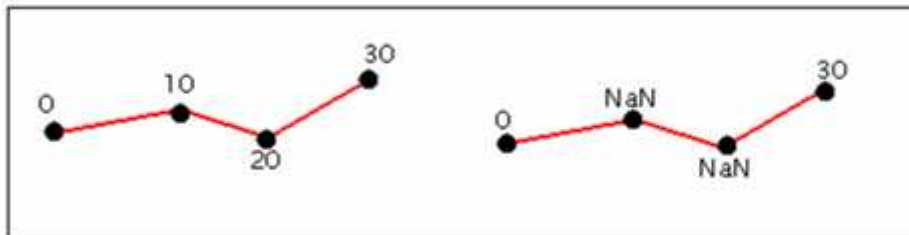
Simple linear features are represented by lines with one path. Complex linear features are represented by lines with many paths.

Line with a single path   Line with multiple, connected paths   Line with multiple, disjoint paths
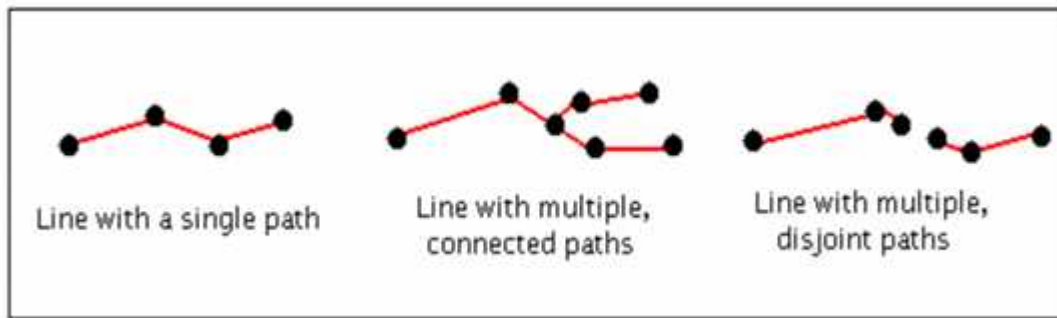
It is important to note that although most applications use measures to represent increasing distances along a linear feature, measure values can arbitrarily increase, remain constant, or decrease along line features.

Measure values are independent of the horizontal coordinate system of a feature class (and the vertical coordinate system as well if one is defined). That is, the measure values are not required to be in the same units as the feature class's x,y,z coordinates. For example, features stored in a feature class whose coordinate system is Universal Transverse Mercator (UTM) meters might havetheir measure values stored in feet or miles or time.

2. Event tables

Event tables contain information about assets, conditions, and events that can be located along route features.

Each row in the event table references an event and its location is expressed as measurements along named (identifiable) linear features.

There are two types of events: point events and line events. A point event describes a discrete location along a route (a point) whereas a line event describes a portion of a route (a line).

- A point event location uses only a single measure value to describe a discrete location -- such as "Mile 3.2 on I-91.".
- A line event uses both from- and to-measure values to describe a portion of a route -- for example,

"Mile 2 to mile 4 on I-91".

Because there are two types of route event, there are two types of route event tables: point event tables and line event tables. All event tables must contain a route identifier and measure location field(s) containing measure information. A point event table uses a single measure field to describe their discrete location. A line event table requires two measure fields (a from- and to- measure) to describe their location.

Route locations and their associated attributes are stored in an event table based on a common theme. For example, four event tables containing information on speed limits, year of resurfacing, present condition and accidents could be included and used to dynamically locate events on a route feature class.

An event table can be any type of table that ArcGIS supports. This includes INFO, dBASE, geodatabase tables, delimited text files, and database management system (DBMS) tables accessed via an Object Linking and Embedding database (OLE DB) connection.

❖ **Event table example**

Hydrologists and ecologists use linear referencing on stream networks to locate various types of events such as is illustrated in the example below. The route feature class for streams provides measures along the streams using river reach mile. Point and line event tables record the route ID and location along each river reach. These event tables can be used to locate point and line events.
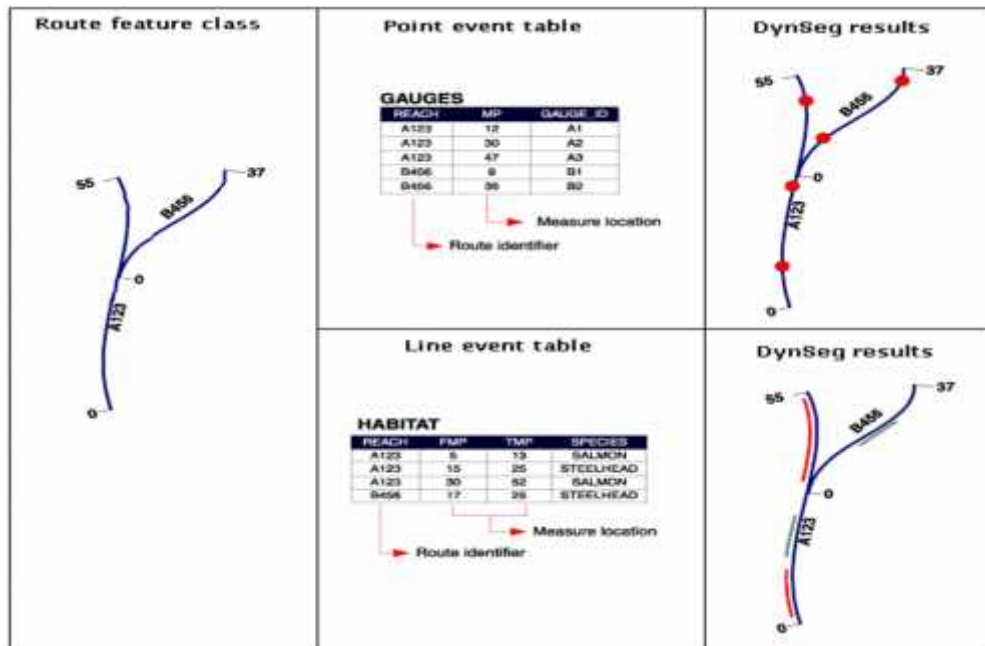
❖ Storing features using relative locations

With linear referencing, locations along linear features are referred to in terms of their route measure, or distance from a known point. For example, it often makes sense to describe the location of an accident as occurring at "12 miles from the beginning of the interstate" rather than at a GPS coordinate such as at "1,659,060.25, 1,525,238.97".

To determine a location along a linear feature, a system of measurement is required. When a measurement system is stored along with a linear feature, any location along that linear feature can be expressed in terms of the measure values.

56

In addition to making data more intuitive, storing data as a relative location along a linear feature has the added benefit of ensuring that spatial phenomena you know to fall on a linear feature is located on the feature. For example, in the absence of a very accurate base map, locating accidents using x,y coordinates may end up displaying accidents that do not fall on the road network as they should. This will not happen if the accidents are located using linear referencing.

CHAPTER FOUR

DATA COLLECTION PREPARATION AND ANALYSIS

This chapter covers the following items:

4.1 SURRVEYING OF LINEAR REFERENNCING EVENTS USING TRADITIONAL METHODS AND OR GPS

4.2 ENTERING THE DATA TO GIS

CHAPTER FOUR
DATA COLLECTION PREPARATION AND ANALYSIS

4.1 Surveying of Linear Referencing Events using traditional methods and or GPS

Fieldwork and field survey were basic modules in every aspect of this study, especially to confirm the data collected during the site visits, identify and mapping the existing target street characteristics.

The GIS was used as a tool and multi-layers were generated. Field measurements were carried out by means of Global Positioning System (GPS) to locate the coordinates of street events. A survey meter is used to measure street events dimensions, photos.

Photo 1: Cracks Event

The survey event is entered to Event tables contain information about assets, conditions, and events that can be located along route features. Each row in the event table references an event and its location is expressed as measurements along named (identifiable) linear features.

There are two types of events: point events and line events. A point event describes a discrete location along a route (a point) whereas a line event describes a portion of a route (a line). A point event location uses only a single measure value to describe a discrete location whilea line event uses both from- and to-measure values to describe a portion of a route.

Because there are two types of route event, there are two types of route event tables: point event tables and line event tables. All event tables must contain a route identifier and measure location field(s) containing measure information. A point event table uses a single measure field to describe their discrete location. A line event table requires two measure fields (a from- and to- measure) to describe their location.

Route locations and their associated attributes are stored in an event table based on a common theme. For example, four event tables containing information on speed limits, year of resurfacing, present condition and accidents could be included and used to dynamically locate events on a route feature class.

An event table can be any type of table that ArcGIS supports. This includes INFO, dBASE, geodatabase tables, delimited text files, and database management system (DBMS) tables accessed via an Object Linking and Embedding database (**OLE DB**) connection

With linear referencing, locations along linear features are referred to in terms of their route measure, or distance from a known point.

To determine a location along a linear feature, a system of measurement is required. When a measurement system is stored along with a linear feature, any location along that linear feature can be expressed in terms of the measure values.

In addition to making data more intuitive, storing data as a relative location along a linear feature has the added benefit of ensuring that spatial phenomena you know to fall on a linear feature is located on the feature. For example, in the absence of a very accurate base map, locating accidents

using x,y coordinates may end up displaying accidents that do not fall on the road network as they should. This will not happen if the accidents are located using linear referencing.

Photo 2: Asphalt Cracks Event

These events include:

Table 4.1: Line Events

NOTE	OFFSET_M	WIDTH_M	LENGTH_M	MAINTENANCE	CONDITION	MATERIAL	ITEM	Tmp	Fmp	R_ID
				Yes	Poor	Metal	Guardrail			
				Yes	Poor	Asphalt	Pav			
				Yes	Poor	Concrete	Ditch			
				No	Good	Metal	Guardrail			
				Yes	Poor	Asphalt	Pav			
				Yes	Poor	Concrete	Ditch			
				Yes	Poor	Metal	Guardrail			
				Yes	Poor	Asphalt	Pav			
				No	Good	Concrete	Ditch			
				Yes	Poor	Metal	Guardrail			
				Yes	Poor	Asphalt	Pav			
				No	Good	Concrete	Ditch			
				No	Good	Metal	Guardrail			
				Yes	Poor	Asphalt	Pav			
				Yes	Poor	Concrete	Ditch			
				Yes	Poor	Metal	Guardrail			
				Yes	Poor	Asphalt	Pav			
				No	Good	Concrete	Ditch			
				Yes	Poor	Metal	Guardrail			
				Yes	Poor	Asphalt	Pav			
				Yes	Poor	Concrete	Ditch			
				No	Good	Metal	Guardrail			

Photo 3: Pavement Section Event

Table 4.2 : Point Events

NO TE	OFFSE T_M	HEIG HT_M	DIAMET ER_M	WIDT H_M	LENG TH_M	MAINTE NANCE	CONDI TION	MATE RIAL	IT EM	R_ ID

Photo 4: Hole Event in the Middle of Street

4.2 Entering the data to the GIS

New event tables can be created in ArcCatalog, where there are tools for creating geodatabase, dBASE, and INFO tables. You can also create new event tables by locating existing point, line, or polygon features on a route. The resultant event table will contain the route and measure information of where the features intersect your routes.

Event tables can also be created by overlaying events, aggregating events, and transforming events from one route reference to another.

Beyond creating and displaying event data along routes, linear referencing provides tools to analyze your event data.

The ability to perform route event analysis is a very powerful capability of linear referencing. Spatial relationships between different events can be discovered by overlaying existing event tables. You can also summarize event data based on specific attributes by dissolving or concatenating (aggregating) event tables. Concatenating or dissolving events can be used to break up event tables with multiple descriptive attributes.

Route events can also be transformed from one route reference to another. This is valuable when supporting multiple route references or when updating event measure values to reflect the recalibration or realigning of a route.

Creating spatial related layers (GIS Layers) using ArcGIS GIS software: the target street events with the following attributes:

Table 4.3 : Attribute and Street Event

Table □ X

EVENT_TABLE_LINES   X

OBJECTID*	SHAPE*	RID	SHAPE_Length	ITEM	STATUS	NOTES	AREA	OFFSET	RD_WIDTH	l_PRICE(NIS)	UNITS	TOTAL_PRIC(NIS)
4	Polyline M	3	19.800435	bump	need to relief	<Null>	24	0	16	50	square meter	1200
6	Polyline M	5	18.89816	trensh	need to fill	<Null>	6.7	0	16	45	square meter	302
7	Polyline M	6	20.52037	bump	need to relief	<Null>	24	0	16	50	square meter	1200
8	Polyline M	7	299.752276	crack	need to repair	<Null>	0	0	16	10	lenght meter	2998
13	Polyline M	12	4.952135	trough	need to fill	<Null>	0.5	0	16	100	no	100
20	Polyline M	20	2.607058	trough	need to fill	<Null>	1	0	16	100	no	100
21	Polyline M	20	14.873242	bump	need to relief	<Null>	12	0	16	50	square meter	600
24	Polyline M	23	11.534661	bump	need to relief	<Null>	6	0	16	50	square meter	300
25	Polyline M	24	5.39721	crack	cross crack	<Null>	0	0	16	10	length meter	54
27	Polyline M	26	30.577191	trench	need to fill	<Null>	36	0	16	50	square meter	1800
28	Polyline M	27	26.095316	bump	need to relief	<Null>	32	0	16	50	square meter	1600
22	Polyline M	21	2.671355	trough	need to fill	1	0	0	16	100	no	100
14	Polyline M	13	5.332091	crack	need to repair	cross	0	0	16	10	lenght meter	53
1	Polyline M	1	7.669388	crack	need to repair	cross crack	0	0	18	10	length meter	78
9	Polyline M	8	6.051558	crack	need to repair	cross crack	0	0	16	10	length meter	61
10	Polyline M	9	5.844841	crack	need to repair	cross crack	0	0	16	10	length meter	58
11	Polyline M	10	6.014105	crack	need to repair	cross crack	0	0	16	10	length meter	60
15	Polyline M	14	5.553313	crack	need to repair	cross crack	0	0	16	10	length meter	56
23	Polyline M	22	4.868498	crack	need to repair	cross crack	0	0	16	10	length meter	49
16	Polyline M	15	8.121021	crack	need to repair	diagonal	0	0	16	10	lenght meter	81
5	Polyline M	4	9.10731	crack	need to repair	Diagonal	0	0	16	10	length meter	92
3	Polyline M	2	8.597809	crack	need to repair	linear crack	0	0	16	10	lenght meter	86

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EVENT_TABLE_LINES

CHAPTER FIVE

METHODOLOGY AND DATA ANALYSIS

- **This chapter covers the following :**

5.1   View the data and locate Om Aldalya road**.**
5.2   Select Om Aldalya route and put it in new layer
5.3   Creating routes .
5.4   Routes attribute table
5.5   Om Aldalya route
5.6   Lines and points event tables
5.7   Add route event to Om Aldalya route.
5.8   Line event table routes
5.9   Make a symbology
5.10   Calculating the cost of street maintenance

5.1 View the data and locate Om Aldalya road

In this section we obtaind the street center lines from Road department of Hebron municipality, then we merged and locate the field surveying with the data that we obtaind .
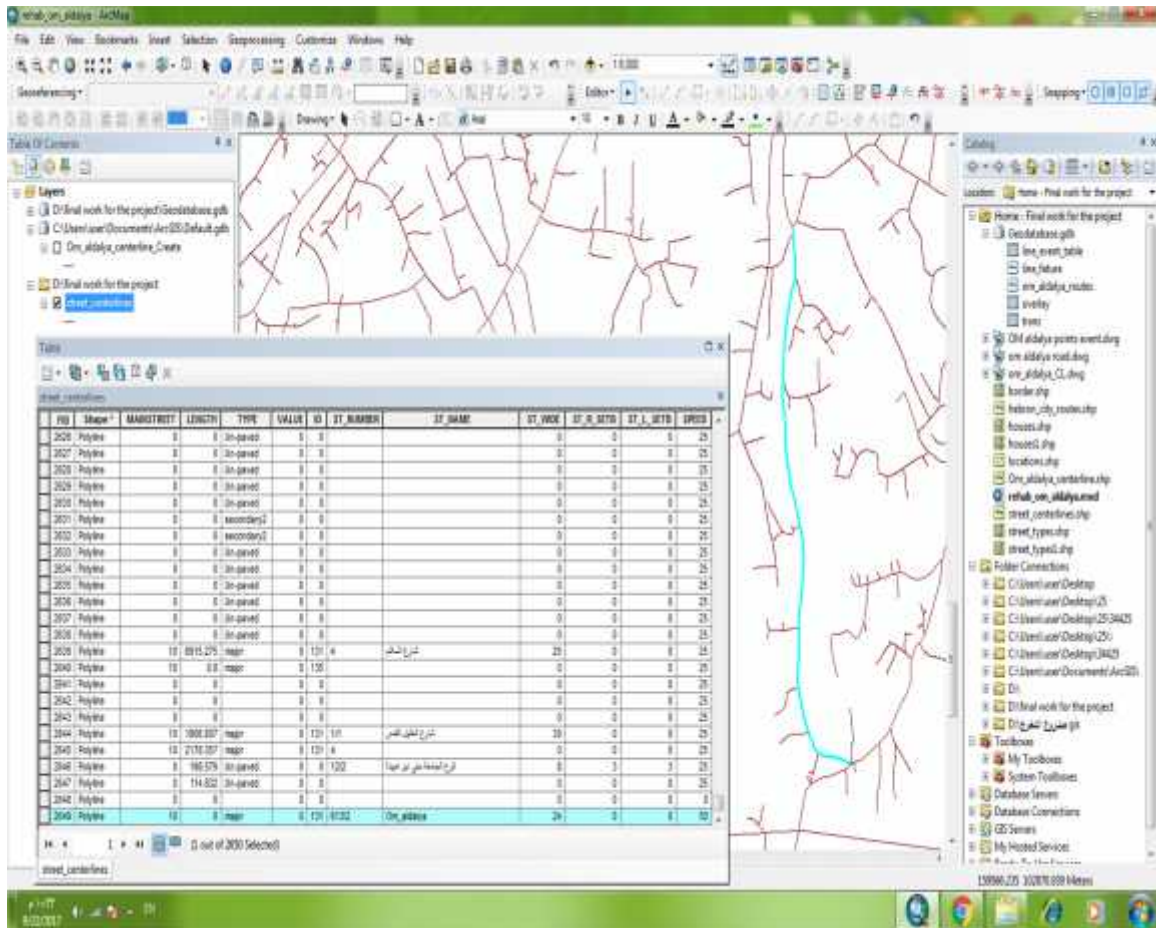
Figure (5.1): Choose the street of Om Aldalya

- The selected street on the figure(5.1) is the objected street for our study.

5.2 Selecting Om Aldalya street and put it in new layer

Since Om Aldalya street is our study case we will apply all the linear referencing method tools on it as a sample for the whole city streets.
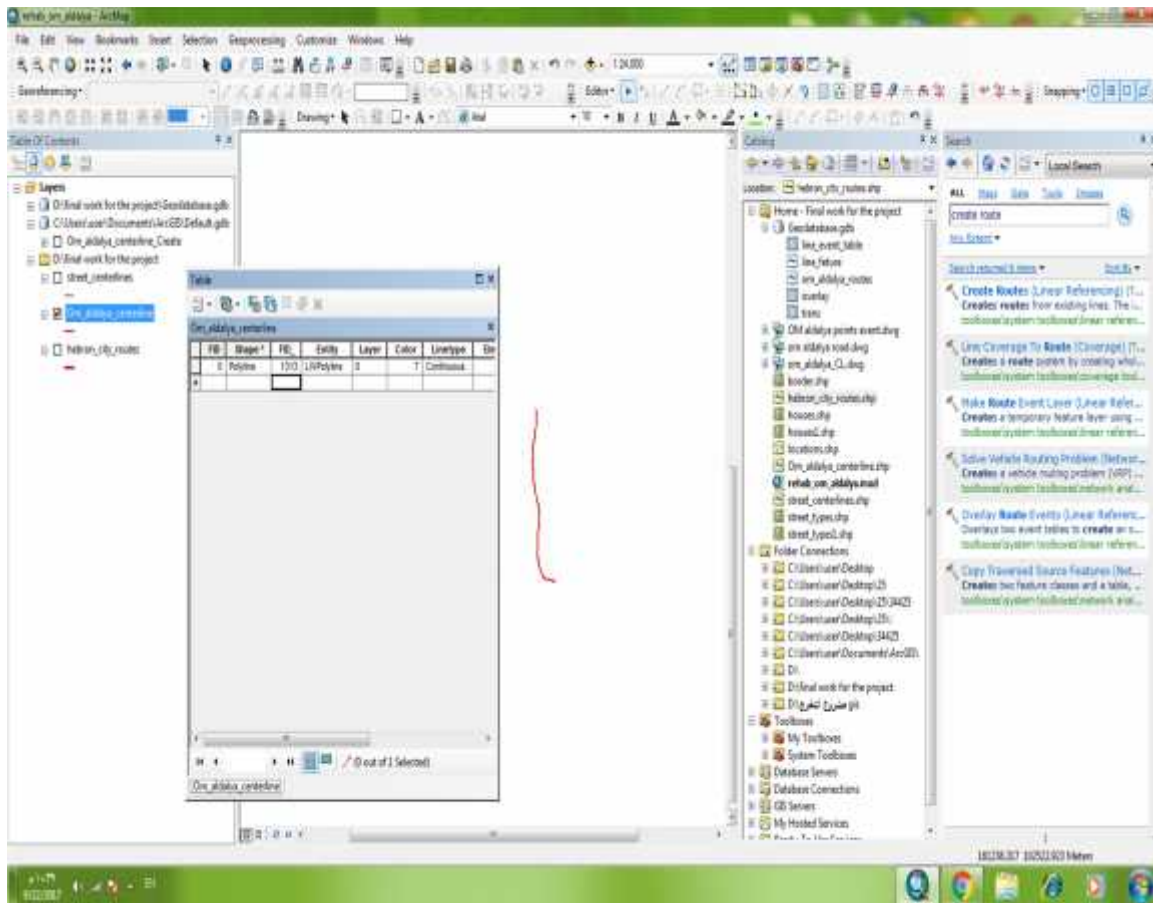
Figure (5.2): Take out the street in new layer

5.3 Creating routes

From linear referencing tools (arc tools) we applied "create route tool" on street center line layer in order to make the whole street as a route and the "ID" as the route identifier , and the "length" as a measure source.
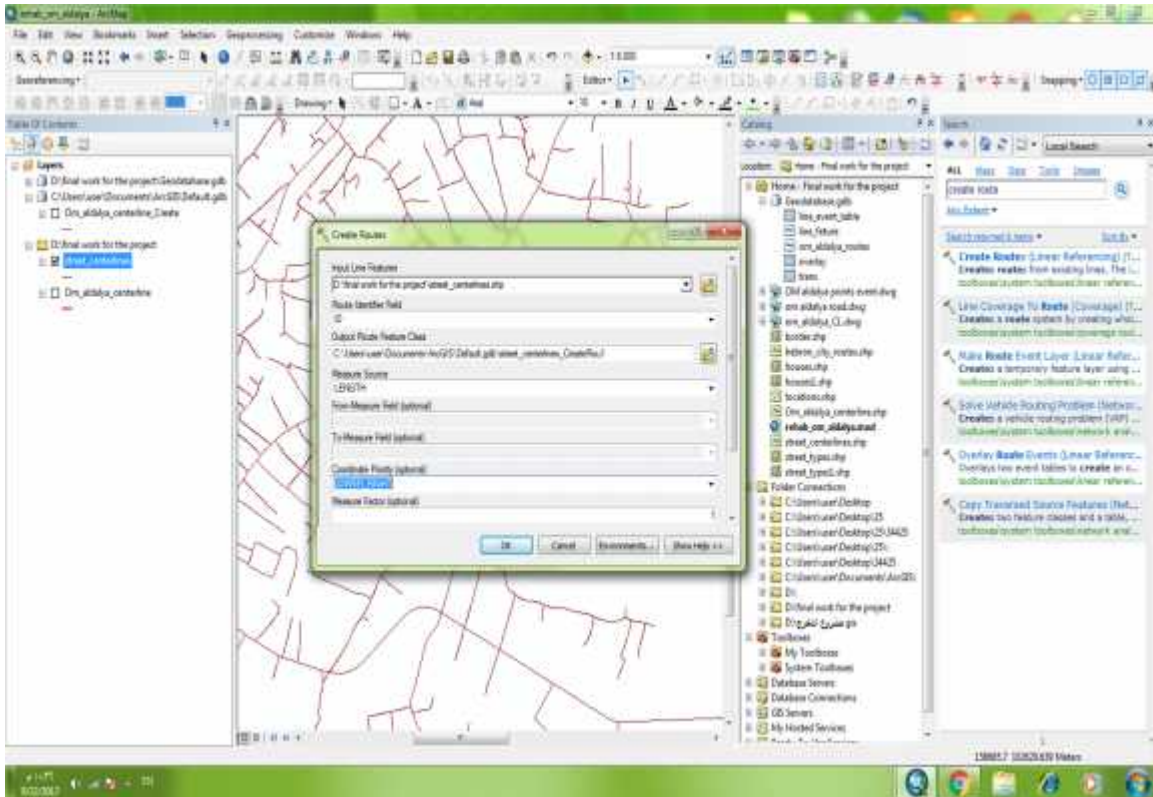

Figure (5.3): Creating routes

Usage
- The unique values in the Route Identifier Field are written to Output Route Feature Class.
- Use the Make Feature Layer or Make Query Table tools to effectively reduce the number of lines that will be used to create routes.
- If the Output Route Feature Class will be written to a geo database, an appropriate M Tolerance, M Resolution, and M Domain should be set.

5.4 Routes attribute table

After creating routes we opened the attribute table and make sure that the shape took the capital M, it means the streets "lines" became routes, and creating routes from existing lines. make the input line features that share a common identifier are merged to create a single route.
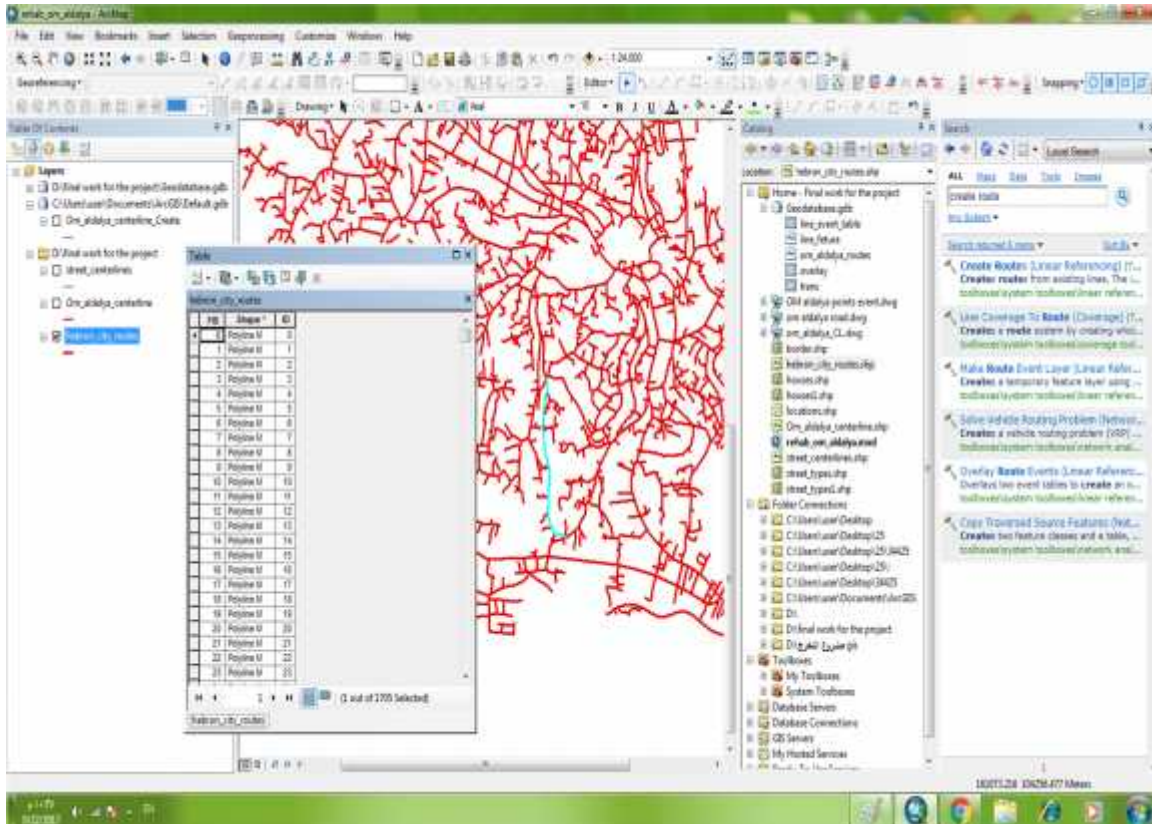

Figure (5.4): Routes attribute table

Usage

- Use a Measure Factor to convert between route measure units. For example, to convert from feet to miles, use a factor of 0.00018939394.

- Use a Measure Offset in applications where the start measure of each route needs to be a value other than 0.

- The Ignore spatial gaps parameter is not used when the TWO_FIELDS Measure Source option has been specified. This is because measure values are dictated by the From-Measure Field and To-Measure Field values.

5.5 Take Om Aldalya route in a single layer

 As we said Om Aldalya street is our study case so we put it in a layer in order to merge it with route events table "that will be explained in (5.7) section".
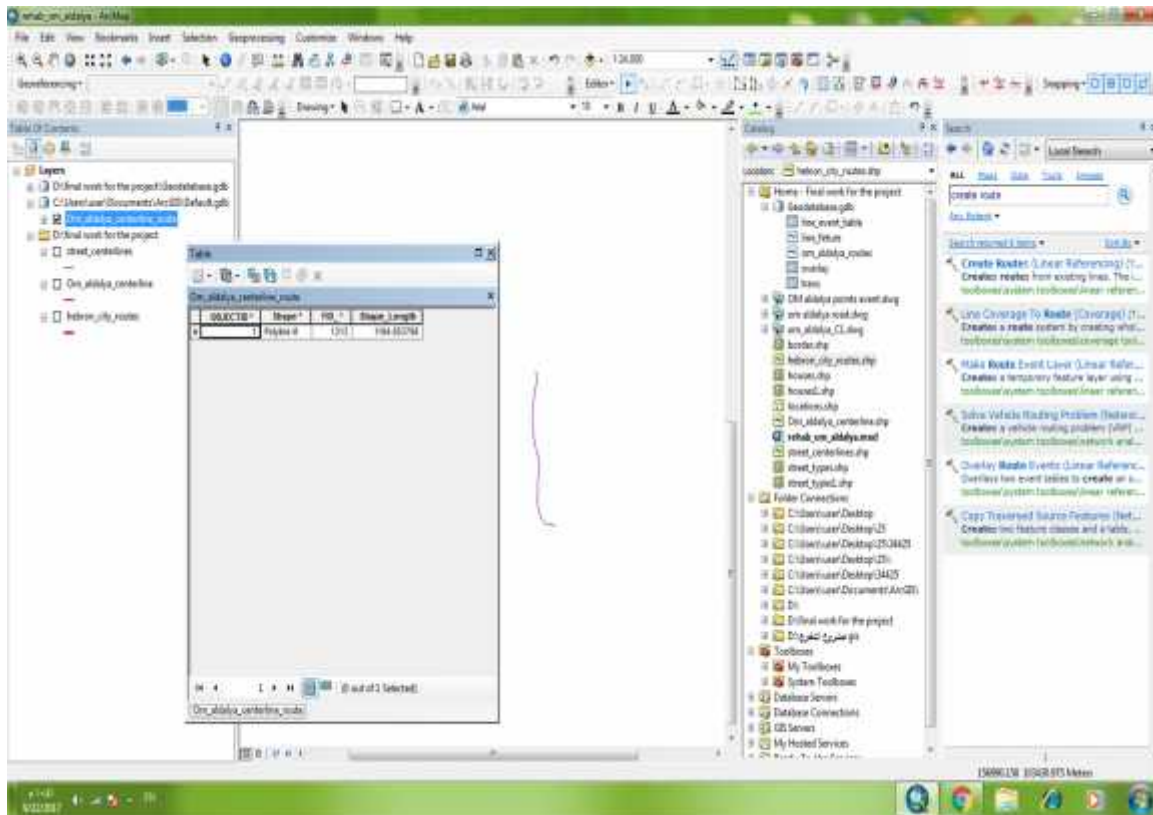

Figure (5.5): Om Aldalya route

- When the LENGTH or ONE_FIELD Measure Source option is used, the Coordinate Priority is determined by placing the minimum bounding rectangle around the input features that will be merged to create one route.

- When the TWO_FIELDS Measure Source option is used, it is not necessary to specify a coordinate priority because measure direction is implied by the values in the From-Measure Field and the To-Measure Field.

- An attribute index on the route identifier field speeds up the dynamic segmentation process. If you will be using the Output Route Feature Class for dynamic segmentation, it is recommended that you choose to have an attribute index created.

- If any features are rejected by the Create Routes tool, a text file is created in the temporary file path to store information about those features. For example, C:\Documents and

5.6 lines and points event tables

We have entered the data which we collected from field works by GPS and measuring tape into two tables, the first table include lines and the other include points.

- The line event table contains a from measure point(FMP) and to-measure point (TMP) that identify the beginning and end of every event.
- The point event table contains a measure location that identify its position.
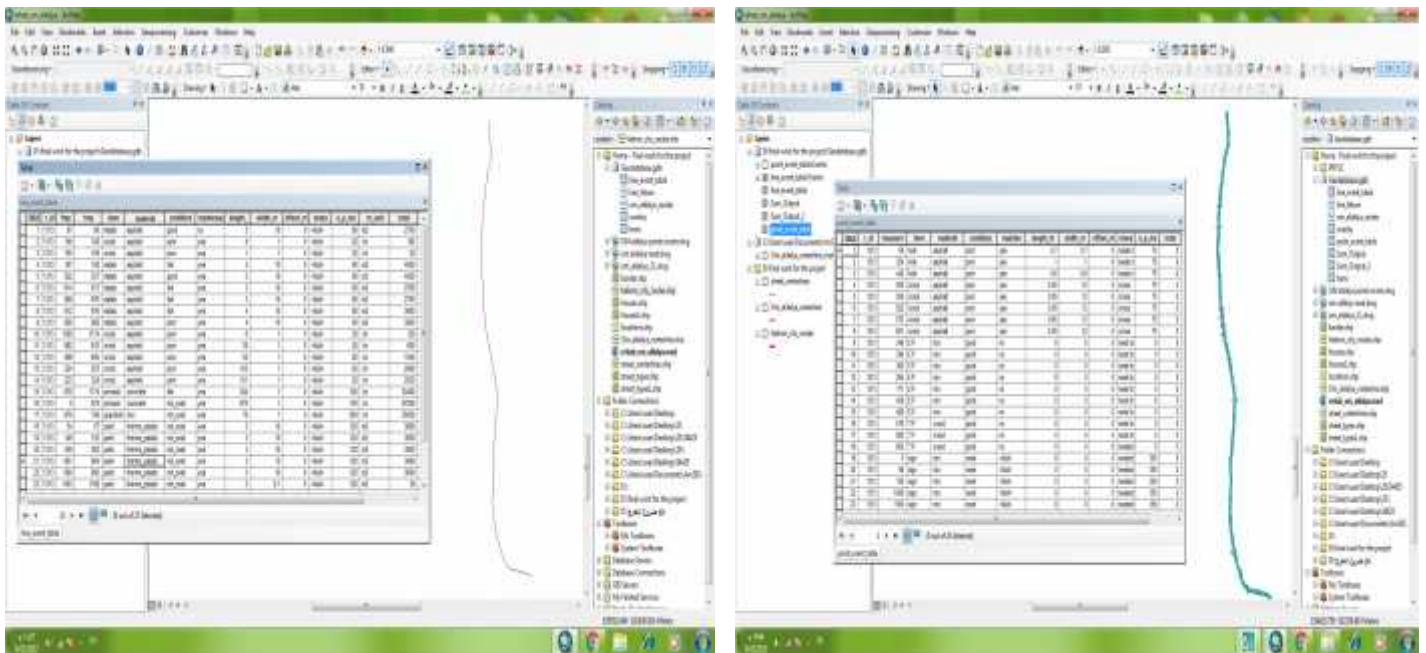

Figure (5.6+5.6.1): Lines and points event table

Overlays the event table with the route that we made create an output event table that represents the union or intersection of the input.

Usage

- Line-on-line, line-on-point, point-on-line, and point-on-point event overlays can be performed.

- The input and overlay events should be based on the same route reference.

- The input tables can be any type of table that ArcGIS supports. The output table can be a dBASE file or a geo database table.

5.7 Add route event table to Om Aldalya route

by this tool we add the data that we have entered to the tables to the routes and its merged and combined by the route identifier (RID)
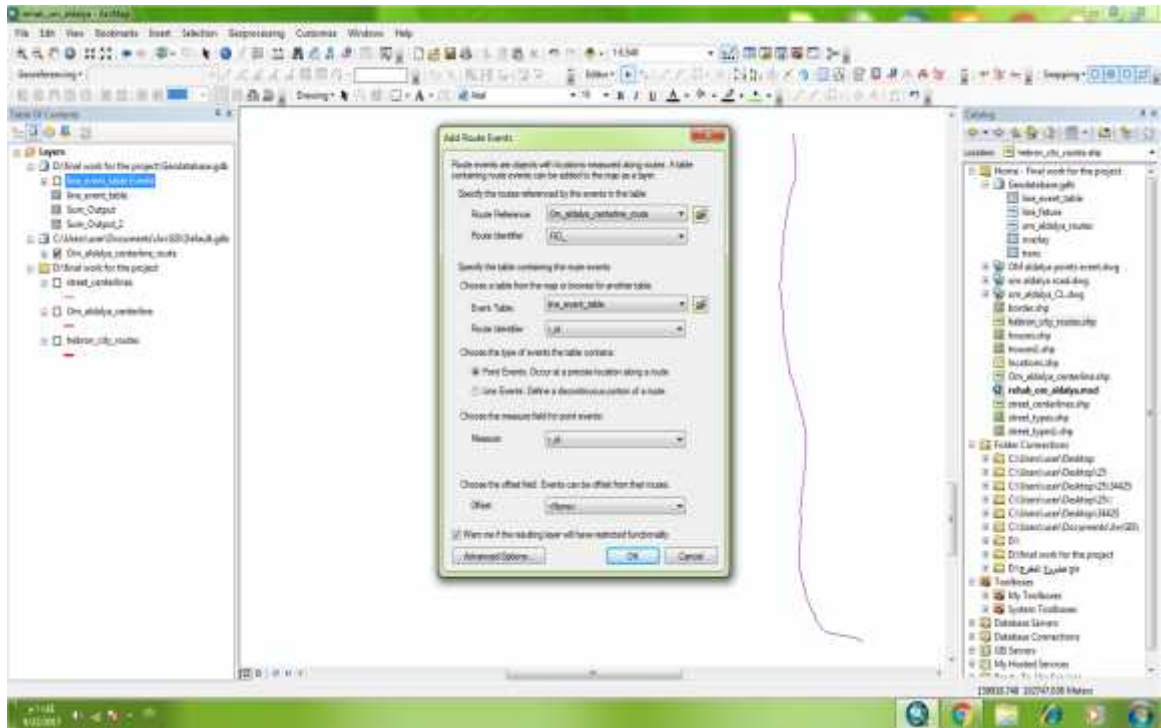

Figure (5.7): Add route event to Om Aldalya

This tool transforms the measures of events tables reference to another and writes them to a new event table.

Usage

- Transforming events allows you to use the events from one route reference with another route reference having different route identifiers and/or measures.

- Any whole or partial event that intersects a target route is written to the new event table.

- The best results will be achieved when the source routes and the target routes closely overlay.

    Using a large cluster tolerance to overcome discrepancies between the source and target routes can produce unexpected results.

- The output event type (POINT or LINE) must match the input event type.

5.8 Line event table routes

as a result of previous section, a table that contain a description of every item and its material was produced .

Figure (5.8): Line event table routes

Usage

- If both the input and overlay event properties are type POINT, the output event properties must also be defined as type POINT.

- If both the input and overlay event properties are type LINE, the output event properties must also be defined as type LINE.

- If either the input or overlay event properties are type POINT, the output event properties must be defined as type POINT when an INTERSECT overlay is performed. The output event properties must be defined as type LINE when a UNION overlay is performed.

- If both the input and overlay event properties are type POINT, only the points that have the exact same measure value are considered to intersect. There is no search tolerance.

5.9 Make a symbology

For increasing the appearance and distinction between the event at the map we make a symbology for the line and point event .

Figure (5.9): Routes attribute table

This tool applies the symbology from a layer to the Input Layer. It can be applied to feature, raster, network analysis, TIN, and geo statistical layer files or layers in the ArcMap table of contents. This tool is primarily for use in scripts or Model Builder.

5.10 Calculating the cost of street maintenance

Finally the purpose of our project to make an estimate cost for maintenance or rehabilitation of Om Aldalya street, and for that we add a field for the unit price cost for each item and we multiply it with the unit measure to have the total estimated price for every item and find the total project estimate cost.
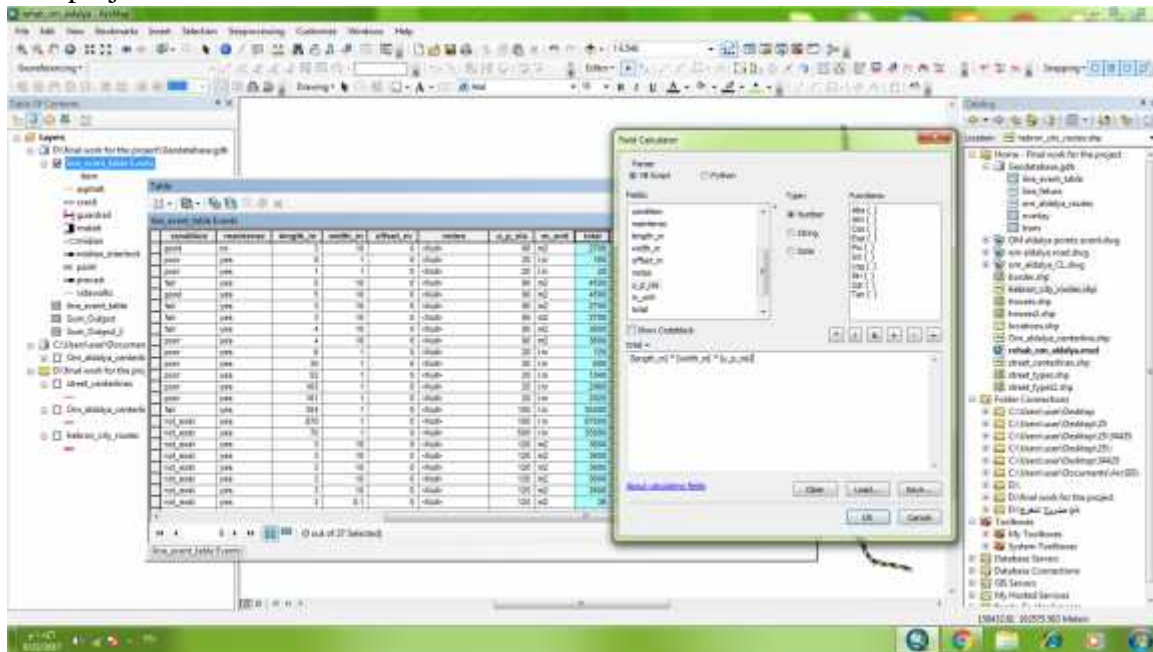

Figure (5.9): Routes attribute table

- How do we calculate total cost for every item:

Finding the area of event for polygons shape, its measure unit is m2 by multiply the length with the width then we multiply it with unit price for the item_ for example the midian interlock we have 1070 m length * 1 m width* 100 u-p-nis=107000 nis.

Finding the Longitudinally events, its measure unit is L.m linemeter
The maintenance cost for crack as an example will found by multiplying the length with u-p-nis
103 m length *20 u-p-nis= 2060 nis

The item with unit peace could found by multiplying the number of units with the u-p-nis
For example the culvert , If we have one culvert the cost will be
1 unit * 1400 nis = 1400 nis

The total cost will be the summation of total costs which equal=1489273 nis

❖ Note: we bring the unit cost for items from the average price of similar item Bids in Hebron municipality .

CHAPTER SIX

Results & Recommendations

- **This chapter covers the following :**

6.1 Results
6.2 Recommendations

6.1 Results :

1. A linear referencing system (LRS) is a support system for the storage and maintenance of information on events that occur along a network. A LRS consists of an underlying network that supplies the backbone for location, a set of objects with well-defined geographic locations. A LRM determines an unknown location on the basis of a defined path along the underlying transportation network, a distance along that path location, and optionally-an offset from the path.

We can say, LRS shows the different conditions of streets without any need to segment the original street by using an event table. So, we have one geometry and several routes.

2. The overall cost of rehabilitate Om Aldalya Street is 1489273 nis

6.2 Recommendations

As a result, it is highly recommended to use linear referencing method for managing streets day-to-day operations . It can be used for;

- Assessing pavement conditions
- Maintaining, managing, and valuing assets—for example, traffic signs, guard rails, precast concrete, sidewalks interlock, medians, asphalt and light pole.
- Reviewing and coordinating construction projects
- And calculating the cost of street maintenance.

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29. Adelino Ferreira Professor, Civil Engineering Department, Coimbra University, Polo II - Pinhal de Marrocos, 3030-290 Coimbra, Portugal, Tel.: +351.239797101; Fax: +351.239797146; E-mail: adelino@dec.uc.pt

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