KING FAHD UNIVERSITY OF PETROLEUM AND MINERALS
Collage of environmental design
Architectural Engineering Department

CRP 514

Introduction to GIS

Term Project Report

Designing Cross-Country Pipelines for Saudi Aramco using GIS

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Introduction

Geographic information system (GIS) is a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data (Wikipedia). In other words, it is a data which will specify the exact location of geographic features, man-made or natural and their descriptive attributes (Al-Ramadan, 2005).

A vast of networks of pipelines are utilized in the transportation of resources from one location to another like Crude oil, natural gas, water, finished petroleum products etc. (Abdul-Lateef Balogun, 2012) .

Presently in Saudi Arabia over 275 individual pipelines, totaling approximately 22,000 kilometers of pipe, carry a wide variety of crude oil, gas, and hydrocarbon products between GOSP's and downstream processing and terminal facilities. These pipelines have diameters that vary from 6" to 56" and range in age from new to over 70 years. Existing pipeline corridors are congested with those pipelines and it is a challenge to construct a new ones.

Figure 1: A map shows the congested crossing at Berri junction (source: Google Earth)

The aim of this paper is to investigate how GIS applications can help in designing the new pipelines for Saudi Aramco.

Study Limitations

This study will be limited to the following:

- Designing Standards for Saudi Aramco.
- Identifying the suitable route for the pipeline only.

Case Study

The case study was made on a paper which helped in developing this paper. The paper was made by Transportadora de Gas del Sur S. A. (TGS). It is a leading company in gas transportation in Argentina (Lara). This paper describes the company experience in developing GIS use in pipeline integrity analysis and the advantages obtained from the application of this tool.

The main points have been extracted to help in this report was as follows:

- Stakeholders usually focusing more on choosing the shortest, most direct route believing that this will save in the capital cost.
- Several other factors apart from cost have to be considered in the route selection process as:
    - Satellite images
    - Land registry maps
    - Specific field surveys:
        - Soils
        - Potential
        - defects
    - Information on rights of way:
        - Roads
        - Rivers
        - Lakes
        - Entry and exit.
    - Digital elevation models
    - Identification of buildings close to Gas Pipeline

Also, the showed the integrity system shown look like (refer to the below figure).

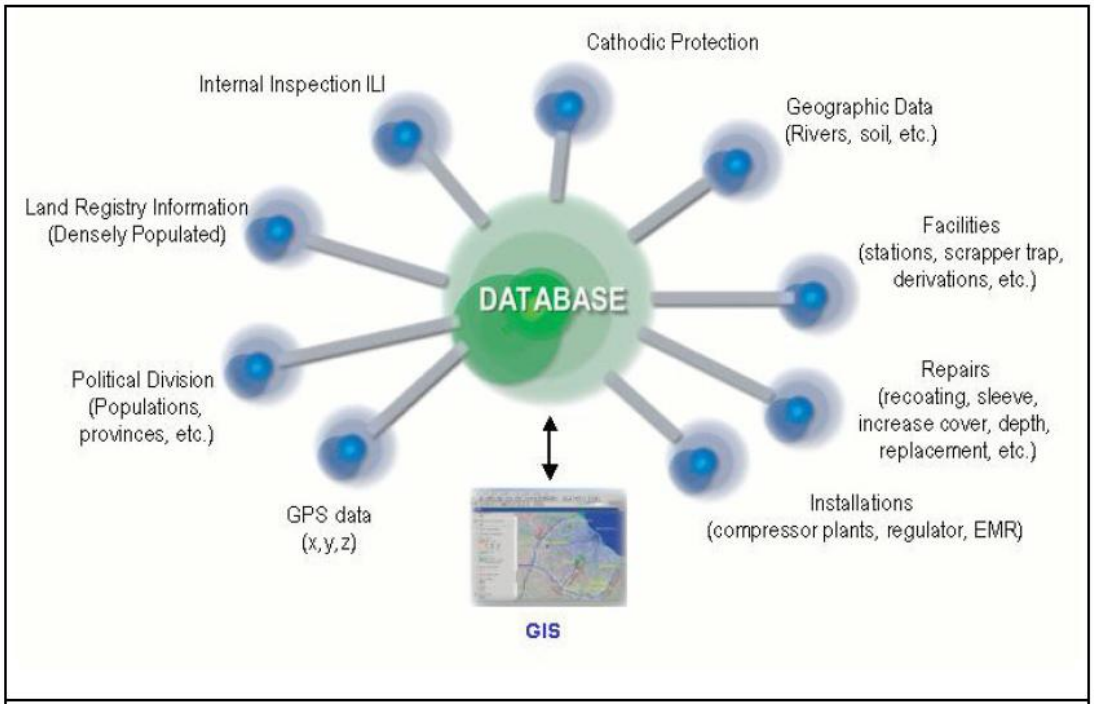

Figure 2: Data integration into GIS platform (source: Transportadora de Gas del Sur S.A.)

Due to GIS capability to combine different layers of information over a common location; it improves the understanding of each site and its characteristics. The following figure visualizes the combination of different layers.

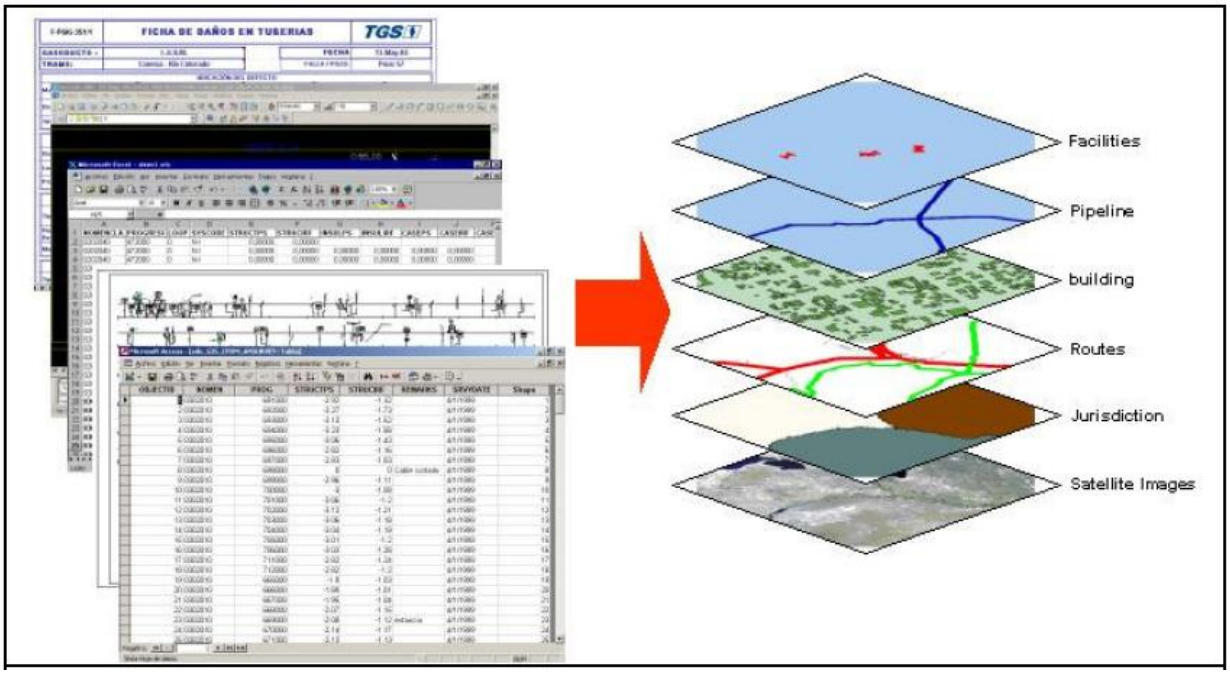

Figure 3: GIS visualization through the combination of different layers (Source: Transportadora de Gas del Sur S.A.)

Data Collection

In the pipelines business with Saudi Aramco, there are many things need to be considered before finalizing the route of any new pipeline. The following sub-sections will describe those factors.

General Rules

The following general roles shall be followed:

- A pipeline corridor constitutes an exclusive land use area for pipeline-related activities; no other uses are allowed.
- Non-Saudi Aramco communications cables are not allowed within the corridor except for crossings.
- All pipelines shall be placed in designated corridors, which are a minimum of 60 m wide.
- The minimum clear space between any pipeline and the corridor boundary shall be 30 m.
- In case of crossing and existing roads, thrust boring shall be considered.

Spacing of parallel Pipelines

Based on Aramco standards, the minimum centerline spacing of buried parallel pipelines, each built at different times, shall be 15 m to allow access for construction or maintenance equipment. The minimum clear distance between two parallel buried pipelines, built at the same time, shall be minimum 3 m, except where this clearance cannot be provided over a relatively short length (such as in a road crossing) not to exceed a maximum of 150 m. Vehicles and equipment access to each pipeline needs to be made from only one side.

The minimum centerline spacing of above-ground, restrained, parallel pipelines on individual supports shall be 3 m with 15 m access for maintenance equipment from one side.

Area classification

The first step before designing any pipeline the area classifications need to be identified. To be able to classify the area, a population density will be performed to find the PDI (Population Density Index). Based on the PDI, the area classification can be found.

Table 1: Location Class and Design Factors for Transportation Piping (Source: Engineering Encyclopedia, Saudi Aramco)

Location Class	Design Factor F	PDI	Commentary & Examples
1	0.72	10	Desert area non developed areas Water service lines.
2	0.60	11-29	Hydrocarbon service, in populated areas or parallel to highways
3	0.50	30 and above	Plant piping designed to B31.4 / B31.8
4	0.40	Special Cases	Highly populated complexes such as hospitals and malls.

Due the nature of pipelines, it may go through more than one area classification.

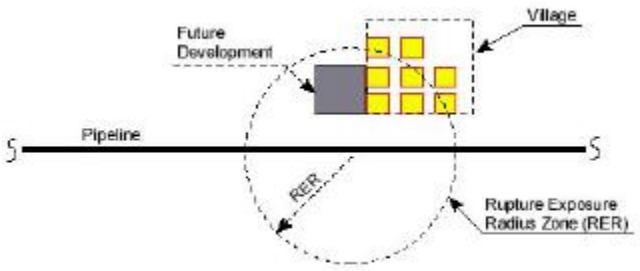

Figure 4: Schematic Diagram Explaining the concept of RER and PDI (Source: Engineering Encyclopedia, Saudi Aramco)

Spacing between pipelines & overhead power lines

Second factor which will affect the route of pipeline is overhead power lines. If any pipeline and overhead power line corridors cross, the minimum horizontal separation between any pipeline and the poles or support structures of overhead power lines shall be as follows:

a) 30 m for power lines operating in excess of 69 kV.
b) 15 m for power lines operating at 69 kV or less and having only one or two poles near a pipeline.
c) 4.5 m in producing areas for flow lines, trunk lines, test lines, gas lift lines, gas injection lines, water injection, supply lines, and disposal lines with pipe diameters of 24 inches and less.
d) The horizontal spacing between a pipeline and a parallel overhead power line shall not be less than shown in the following table.

Table 2: Minimum Horizontal Spacing between Pipeline and Parallel Overhead Power line (Source: SAES-B-064, Saudi Aramco)

Power Line Voltage	Minimum Horizontal Spacing from Pipeline
For any voltage less than 69 kV, parallel for more than 1.6 km (1 mile)	30m
For any voltage 69 kV and greater, parallel for more than 1.6 km (1 mile)	150m
Up to 230 kV, parallel for less than 1.6 km	30m
Up to 500 kV, parallel for less than 1.6 km	50m
Up to 1000 kV, parallel for less than 1.6 km	85m

Figure 5: A map shows pipeline corridor running near to a populated area. (Source: Google Earth)

Sectionalizing Valve Stations

Based on the product and area classification the location and the number of sectionalizing valve stations will be determined. The following table summarizes it.

Table 3: Sectionalizing Valve Spacing (Source: SAES-L-410, Saudi Aramco)

	Class 1	Class 2	Class 3	Class 4
Hydrocarbon and Flammable Pipelines				
Abs. vapor pres. >450 kPa (65 psia)	Note 1	Note 1	16km	8km
Abs. vapor pres. <450 kPa (65 psia)	Note 1	Note 1	16km	16km
Gas	32km	24km	16km	8km
Non-Hydrocarbon Pipelines				
Note 2	32km	24km	16km	16km
Other than Note 2	Note 3	Note 3	32km	32km

Note 1: Install valves upstream and downstream of environmentally sensitive areas as identified in the Environmental Assessment portion of the Project Proposal.
Note 2: Sour water, seawater, brine, and other contaminated or chemically treated water.
Note 3: Install valves only as required by the operating department.

Figure 6: A map shows a sectionalizing valve for couple of pipelines. (Source: Google Earth)

Figure 7: A map shows cemetery next to pipeline corridor. (Source: Google Earth)

Summary

In summary, to establish a database for GIS application to help in designing pipelines, the following layers need to be considered:

- Geographical layer
  - Elevation
  - Geographical features
  - Type of soil
  - Lakes and agriculture lands
- Area classification layer
- Existing roads
- Existing overhead power lines
- Existing pipelines
- Existing facilities
- Future approved facilities
- Lands ownership

By integrating all of that information into GIS, the designer shall have a proposed route for pipeline. This will save a lot of time in surveying the route in real.

Also, the following advantage will occurs by using GIS:

- Number of roads going is crossed. This information will help in estimation stage.
- Estimated length of pipeline.
- Identify crossing areas with other corridors not owned by Saudi Aramco. This information will help in early coordination with other parties.

Works Cited

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Abdul-Lateef Balogun, A.-N. M. (2012). Optimal Oil Pipeline Route Selection using GIS:CommunityParticipation in Weight derivation and Disaster Mitigation. *2012 International Conference on Future Environment and Energy* (pp. 100-104). Singapoore: IACSIT Press.

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