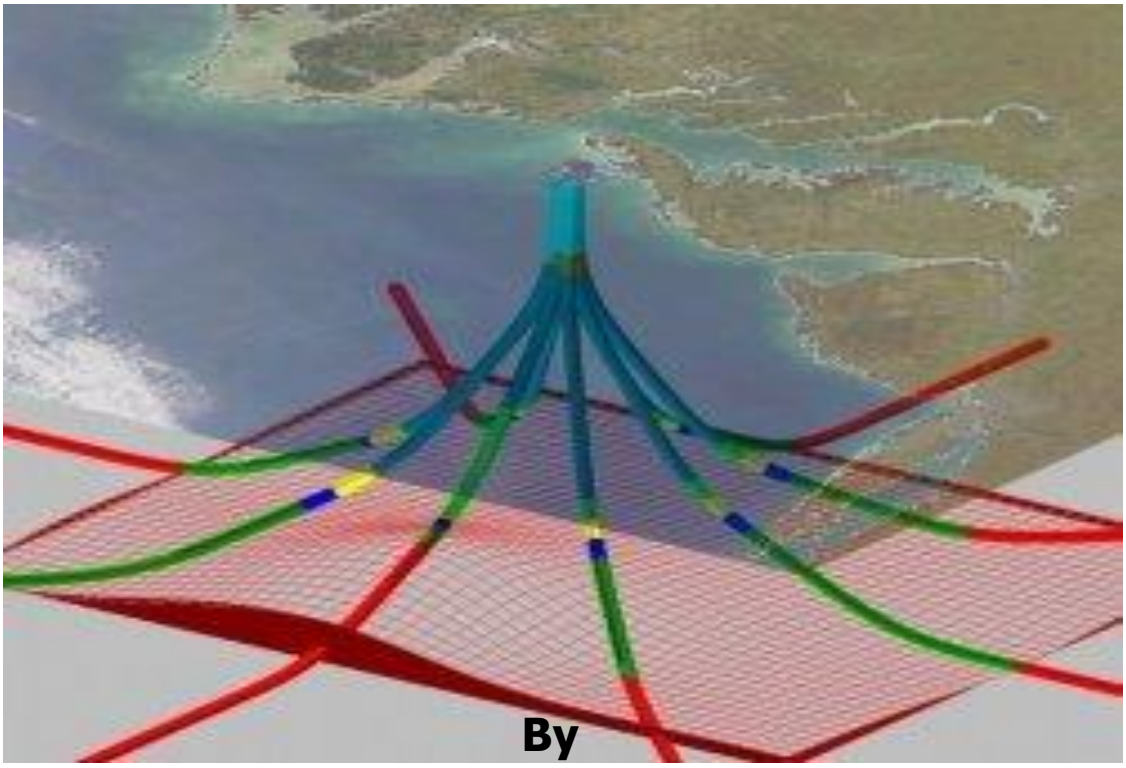
GIS for Petroleum



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GIS for Petroleum

1. ABSTRACT

Discovering new sources of petroleum ahead of the competition is one of the keys to staying successful in the petroleum industry. GIS can help to evaluate the potential for oil in promising locations.

Making decisions based on geography isn't new in the oil business. Where to drill a well, route a pipeline, or build a refinery are all questions that rely heavily on an understanding of geography to make the right business decisions.

Classical petroleum geology applications are basically based on making paper maps to find out geologic features of subject area. Mapping geological atlases are quite difficult and time-consuming work. Recently the data in the atlases are summarized and organized by Geographic Information Systems linking map graphics and tabular data in a digital environment.

Using GIS technology to manage all the spatial components of petroleum Exploration and production, well locations, pipelines, environmental concerns, facilities right through to the retail outlets. Apply the appropriate geographic analysis efficiently in a desktop-focused application which can be use effectively in the petroleum industries.

2. INTRODUCTION

The word “Geography” though not used often in our daily life, but it’s presence, reference and value has become an integral part of our activities in the way we do business, the way we communicate, the way we manage our resources and the way we live.

Our realization on the importance of Geography in our activities have led into the development of a full fledged Information system supported by cutting edge technology and research work undertaken by various organizations to bring in this power of "Where" to our life and business.

In the recent days technologies are converging in a rapid rate and the utilization of GIS technology by multiple disciplines across the organization is a common process to expand business and reach out to more customers providing quality service. We are into the age of Enterprise Wide GIS, which helps to solve:

- Business problems
- Automate Business processes and
- New ways to analyze business and spatial data

By incorporating the knowledge of "Where" into the existing business models of "Why", "What" and "When". (Anirban Acharya, 2002).

Petroleum Industry – Need of an Integrated Business-GIS. The use of geography in analyzing and making decisions is not a new thing in the oil and natural gas industry. A good

understanding of geography is required in every step of a petroleum industry starting from locating a place to drill a well, route a pipeline from the exploration site to the refinery plant, finding an ideal location for a refinery and lot more. And all these procedures t rely heavily on geography in order to make intelligent business decisions.

Using GIS to manage the different types of data required for exploration such as satellite imagery, digital aerial photography, seismic surveys, surface geology studies, subsurface and cross section interpretations and images, well locations, and existing infrastructure information. A GIS can tie these datasets together and allow you to overlay, view, and manipulate the data in the form of a map to thoroughly analyze the potential for finding new or extending play potential (Figure1 and 2). (Anirban Acharya, 2002).

Finally, the GIS environment offers the exploration geologist a wide variety of options for integrating regionalized geodata. The full power of the methodology of Characteristic Analysis introduced in the eighties can now be exploited by means of GIS support.

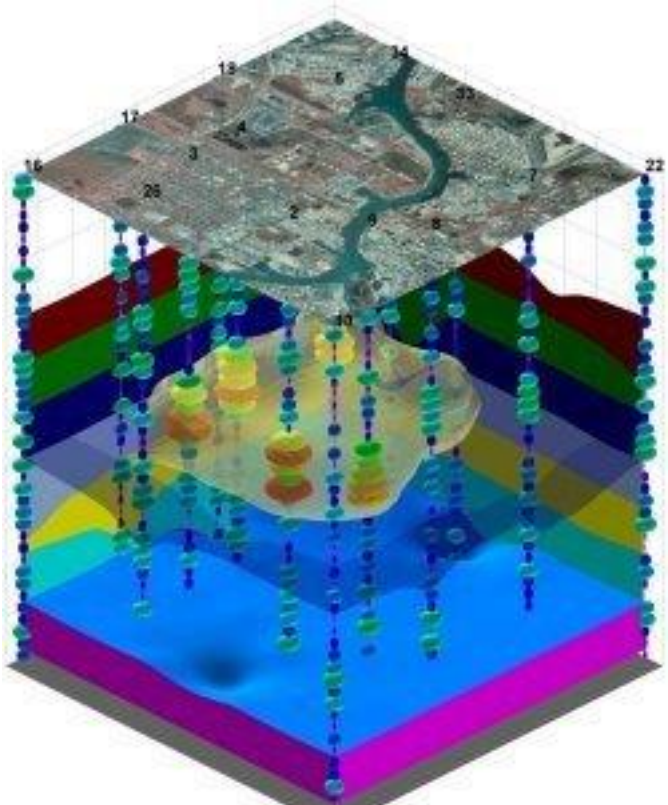


Figure 1. Exploded composite diagram
Source: www.groundwatermodels.com/software/SoftwareDe

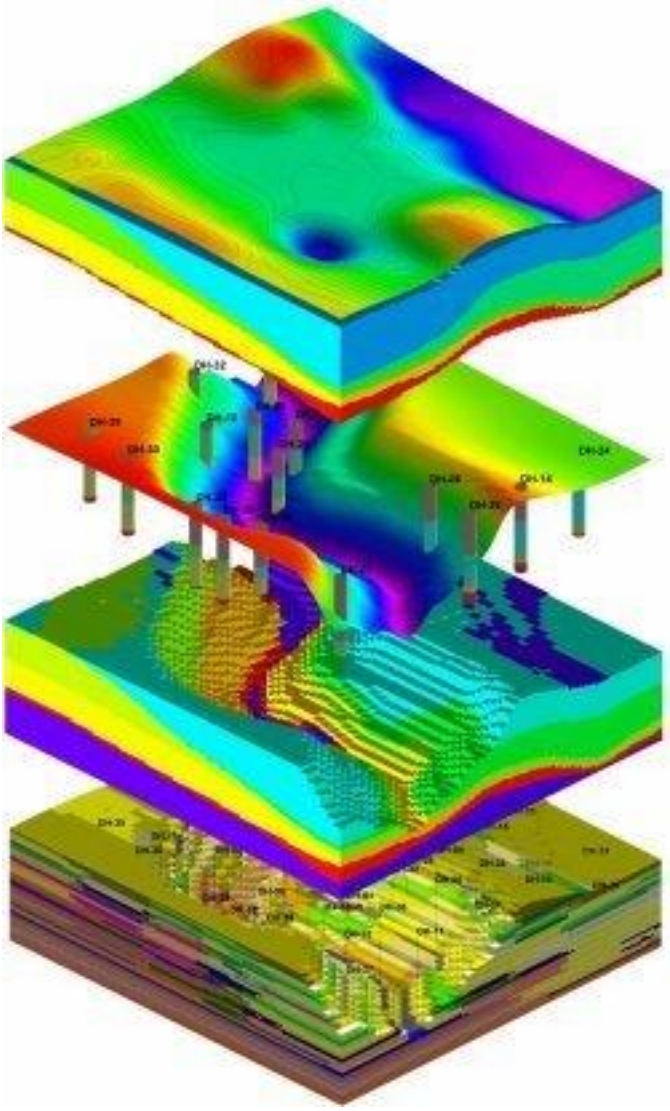


Figure 2. Geotechnical composite (from top): Stratigraphic block model, post-highway planned surface & stratigraphic boreholes, post-highway stratigraphic model, post-highway lithologic model

Source: www.groundwatermodels.com/software/SoftwareDe

3. Objectives

The main objective of this paper is to give an idea about the applications of the GIS technology in the Petroleum Industries. In addition to that, How the GIS technology can help to evaluate the potential for oil and gas in promising locations and taking the appropriate decisions.

4. Definitions

Tow things should be apparent: (1) we aren't clear about what GIS can do, and (2) we desperately need to be more clear. Joseph K Beny

GIS: Geographic Information System can be defined technically as a set of interrelated components that collect (or retrieve), process, store, and distribute information to support decision making and control in an organization. (Dean E. Gaddy, 2003).

In addition to supporting decision making, coordination, and control, information systems may also help managers and workers analyze problems, visualize complex subjects, and create new products.

The definition of the GIS is varying from source to source, depending on the user, technology system, business or professional use, and the branch of research or industry focus. This issue becomes increasingly complex as one tries to describe or interrelate the numerous sister GIS technologies. These technologies include computer cartography, photogrammetry, automated mapping and facilities management (AM/FM), and spatial decision support systems (SDSS). But for all practical purposes, we should simply focus on the abilities of GIS. Visualize what can be done with this technology, rather than try to work within the guidelines of some restrictive definition (Figure3). (Dean E. Gaddy, 2003).

The Association foe geographic Information (AGI) states that GIS is "a: Computer system for capturing, sorting, checking, integrating, analyzing and displaying data related to positions on the Earth's surface.

Figure3. Images produced by GIS technology and remote sensing.

Source : www.ornl.gov/.../v35_2_02/ infrastructure.shtml

5. GIS Technology

Think about it. The petroleum industry can and should be examined from a geographic perspective. It is inherently spatial. Each and every oil well, pipeline, tanker, refinery, and gasoline station can be pinned down to a precisely defined position or route that then can be modeled and visually portrayed. (P.B Goodwin, 1996).

To communicate the existence of these assets, we almost always turn to the geographer's best friend, the map. Without maps, a company would very likely lose track of its leases, drill more dry holes than it should, and fail to evaluate changing markets. For our industry, it is an irreplaceable medium, and few industries produce more maps than we do.

Unfortunately, paper maps serve only as a means to communicate a miniaturized, minimized, and myopic version of the world. Through the physically restrictive nature of this medium, a

great deal of spatial information has to be filtered, displaced, and removed to deliver a useable product. For example, if we tried to show a major oil company's distribution networks on a 36-in. by 36-in. piece of paper, we could do it. But the physical limitations of the paper would force to leave off many important details needed to describe these assets in full. Within a short period of time, moreover, construction activities, acquisitions, and divestments would make the map out-of-date, requiring time-consuming revisions (Figure 4).

GIS allows petroleum enterprises, or functional groups within, to communicate information and make spatial and temporal decisions about assets, activities, and natural resources. With GIS, however, it becomes possible to tie intrinsically all of the geographic coordinates for each asset to its descriptive "attributes". (Dean E. Gaddy, 2003).

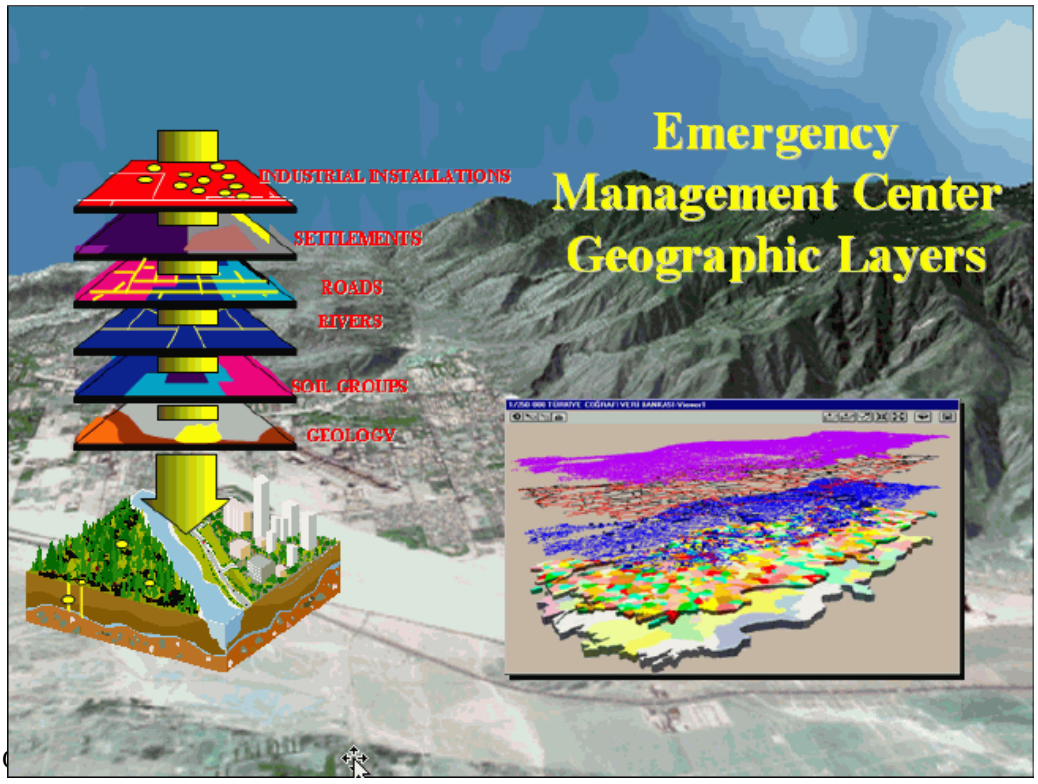


Figure4. GIS layers, more than one map.
Source: www.directionsmag.com

6. REVIEW OF LETETURE

6.1 GIS Use in the Petroleum Industry

Petroleum companies have traditionally invested quite readily in information technology (IT) over the years, throughout many portions of their business operations. In the past five years a significant proportion of that investment has been directed at the "spatial data component," such that at the present day some of the larger independent and National Oil Companies (NOC) are the leading exponents of "spatial data management" and the effective use of GIS. (Dean E. Gaddy, 2003).

This development is perhaps inevitable, due to the relatively high investment by these companies in their IT infrastructures and the very significant reliance that their business processes have on those spatial data. Virtually all petroleum business operations, from regional geologic exploration, through field appraisal and development, and from product distribution, facilities management and environmental modeling, to retailing or commercial and domestic supply, rely on fundamental spatial data components, mapped in the context of these employed systems, into "spatial business objects."

This is true for many other industries but the petroleum companies have been (comparatively) expeditious in the employment of appropriate GIS technologies to effectively manage these data and use them to better understand and plan their critical business processes.

As of today, most major petroleum organizations are involved in varying programs of data consolidation, compression and conversion, in order to more cost effectively and efficiently manage their integrated information archives.

6.2 GIS Companies and Solutions for Petroleum Industry

The integration of GIS into the current business model of petroleum industry is not an easy process, and requires through understanding of the detail requirements and practices of the Petroleum companies. Seeing a positive sign of growth and advancement of GIS in this sector major GIS companies and their partners have started to capitalize this multi billion dollar industry.

All major GIS companies have been instrumental in evolving new solutions for the petroleum industry for the last 3 decades. User Groups, GIS consultants, Oil service companies, Petroleum Engineers, GIS data providers, Hardware suppliers and Software suppliers all add up to growth and development enabling innovative solutions and analytical processes for the industry (Figure 5). (Dean E. Gaddy, 2003).

There is a sharp increase in offering a special petroleum application package and analysis component that can be added to the core GIS product. Especially partners of all the major GIS companies are offering customized solution on the base product.

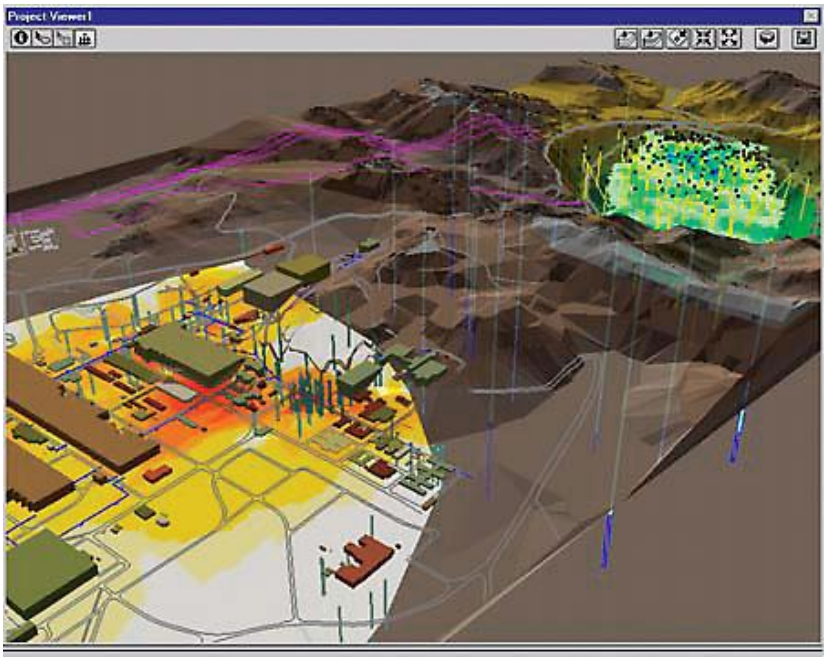


Figure 5. GIS solution for Petroleum industries, place wells

Source : www.gis.com/showcase/natresources.html

6.3 Drivers to use GIS technology in the Petroleum Industry

GIS technology has increased its relevance to the petroleum industry because of two driving forces: (William N. Wally, Chevron Petroleum1997).

1)- Technical

2)- Business

6.3.1 Technical drivers:

Hardware : Fast and relatively inexpensive desktop computers, with high-quality graphics monitors, connected to reliable networks, are becoming fairly common in our business. For a

few thousand dollars, one can now buy large-format color plotters that used to be an order of magnitude more expensive as well as slower.

Thus one of the primary information-bearing vehicles of our business is the map can now be created "on demand", easily, quickly, and accurately using GIS technology.

Software : GIS software like ArcView is much easier to use than ever before. The fact that it runs on PCs and Macs makes it available to everyone in the oil industry operation.

Data: Until recently, GIS technology was handicapped by high cost and long delays building geographic databases. In the past few years, there have been major improvements in the availability, accuracy, and cost of spatial data.

6.3.2 Business drivers to use GIS technology:

Multidisciplinary asset teams: It is now not unusual for asset teams consisting of disciplines such as geophysics, geology, petroleum engineering, facilities engineering, land/legal, and safety and environment, to all cooperate managing a reservoir. Such groups clearly benefit from shared databases, especially for map data showing locations of key features like wells, pipelines, population centers, environmentally sensitive regions, etc.

Although traditionally some of these groups knew next to nothing about each others' work, they all share one common data "key" the location of the asset. Thus GIS technology, which of course also uses geographic location as its primary means of associating data and attributes, is well-suited to support such requirements.

High-cost of internally developed, proprietary software: Until recently, most oil companies used specially-designed computer software, often developed internally, for most scientific and technical data processing. This was because it was usually not possible to buy already-written software that did the job. The cost of such an approach can be great. (William N. Wally1997).

6.4 GIS Applications in the Petroleum Industries

Exploration, Productions and Refining are involves the process of exploring new locations as petroleum reserves, managing the production of crude petroleum from earth strata, managing the pipeline network to transfer crude sources to refining plant and facility management of various resources connected to such a huge industry. (Dean E. Gaddy, 2003).

6.4.1 Petroleum Exploration

Discovering new sources of petroleum ahead of the competition is one of the keys to staying successful in the petroleum industry. While the application of GIS is relatively new to the world of petroleum exploration it will no doubt prove to be an invaluable tool. An efficient GIS can help to evaluate the potential for oil in promising locations. One of the biggest benefits of GIS programs is the ability of these programs to do analysis. Petroleum exploration is a very complicated field dependent on a multitude of variables, because of this the analysis capabilities of GIS programs will surly be able to lower the cost of petroleum exploration by analyzing the potential of petroleum being found at a potential location and also the potential yield of an oil field. GIS programs are also used to monitor the condition

and flow of pipelines and determine the best locations for the pipelines used to transport the oil out of the fields and to the refineries. (Dean E. Gaddy, 2003).

Exploration requires the analysis of a lot of different types of data such as satellite imagery, digital aerial photo mosaics, seismic surveys, surface geology studies, subsurface and cross section interpretations and images, well locations, and existing infrastructure information. A GIS can tie these data together to the location in question and allow you to overlay, view, and manipulate the data in the form of a map to thoroughly analyze the potential for finding new or extending play potential (Figure 6).

Geologists, geophysicists, engineers and petro-physicists usually perform exploration evaluation.

Following the analysis process, the individuals come together to integrate the independent evaluations into a final solution. The recent trend in the industry is to form multi-discipline teams and approach the analysis through integrated analyses.

The power of GIS can be applied here to help these individual disciplines to work in an integrated approach (Figure 7).

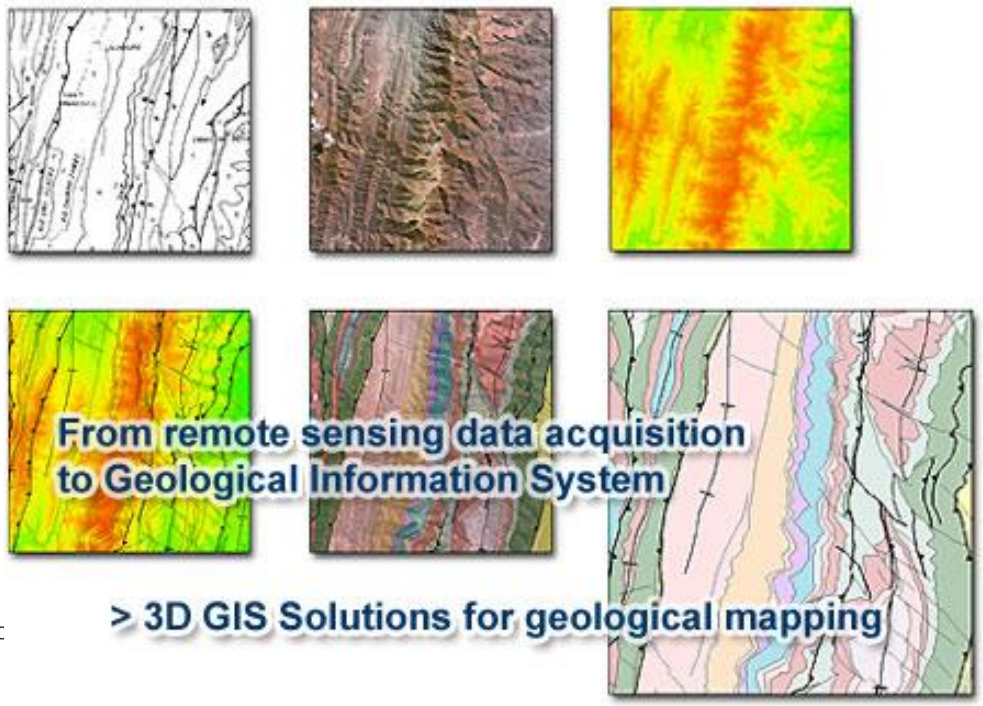
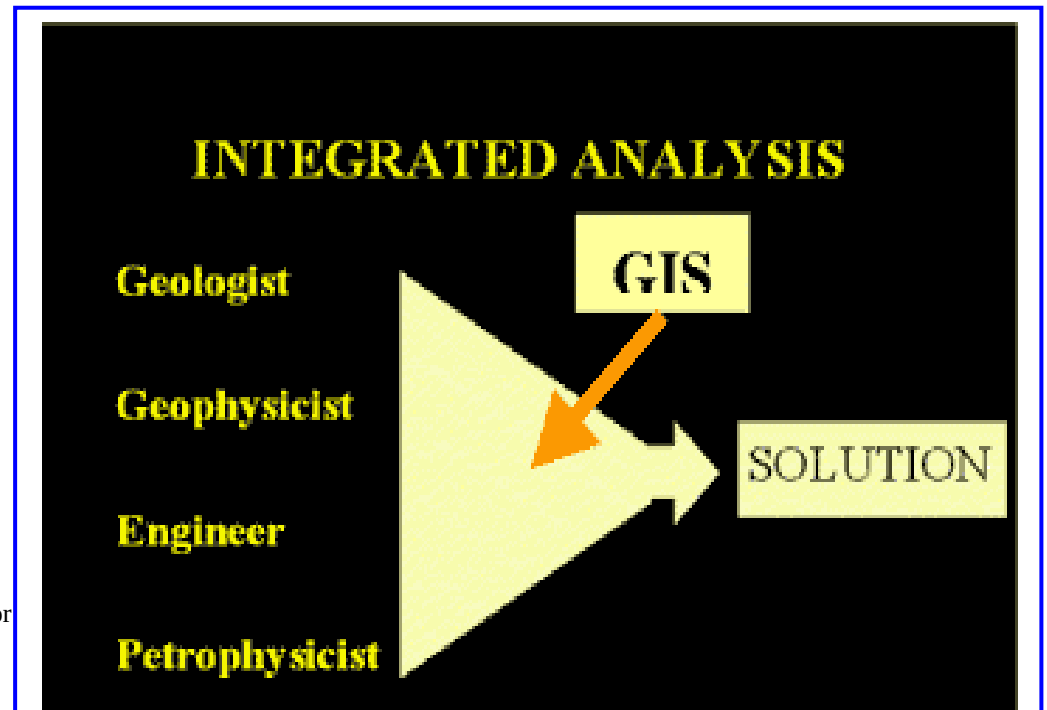


Figure.6 3-D GIS Solution for Geological Mapping
Source: www.tti.fr/en/article. php3?id_article=29

6.4.2 Production:

To produce found reserves, the company must first understand certain geographic, infrastructure, business conditions, and environmental factors about the area in question. GIS technology is ideally suited to this kind of overlay analysis and can be integrated with other business risk or economic business planning engines to provide a focused business solution toolset.



6.4.3 Managing Facilities:

The global nature of the petroleum industry results in an infrastructure that is vast and difficult to manage. A large, integrated oil company must keep track of everything from drilling platforms to pipeline networks to refineries. The commercial, operational, and often harsh environmental conditions in which these facilities exist make it critical that they be planned, operated, and maintained effectively.

Often, finding an economic reserve is as much dependent on a practically and properly implemented facilities structure as it is on the exploration and production itself. Certainly the profitability of a commercial venture is often heavily dependent on the facility and pipeline infrastructure.

GIS can be used to map the gathering and transmission of products to a facility. Once there, integrating with more traditional "in plant" infrastructure management systems, such as CAD, attribute records, and scanned documents, allows the true geographic placement of CAD entities complementing the CAD architecture.

6.4.4 Pipeline Management:

The Pipeline network forms one of the most critical and intelligent components of the petroleum industry. The creation and management of a functional pipeline network requires in depth analysis and study of geographical locations, business requirements and managed utilization of resources leading into optimal productions and transfer of crude and refined oil from petroleum reserves to refinery and then to storage units respectively.

Competitive pressure and regulatory constraints are placing increasing demands on pipeline operators to operate in an efficient and responsible manner. Responding to these demands requires accessibility to information regarding geographically distributed assets and operations.

GIS can be used in the site location process to minimize impacts to the environment during construction and from accidental release, as well as to lessen the costs of permits and liability risks associated with accidental releases. Ecological variables developed from publicly available spatial data sets can be utilized in this process.

6.5 Oil field Examples

In the petroleum industry, an infinite number of decisions and operations may be supported through some sort of geographical assessment. Upstream, a land department may use GIS and computerized cartography to keep the company appraised of lease commitments. Midstream, a pipeline engineer may use GIS, GPS, and inertial navigation systems (INS) to map material anomalies along a pipeline. And downstream, a marketing manager may use GIS with network nodal analysis to choose optional transportation routes. (Dean E. Gaddy, 2003).

With these kinds of analytical tools, it is important to ascertain the most appropriate way in which to solve a problem. This in turn requires a different thought process that focuses on dimensional relationships rather than textual.

In all cases, a GIS analysis must begin in the form of a question: Where did we drill our best wells last year? Where should we construct a pipeline? If company A merges with company B, what ideal combination of assets will provide new synergies?

Depending on the user, once the question has been formulated, the means of acquiring the answer will depend on the quantity and quality of accessible data that must be gathered. It also will depend on the hardware and software systems needed to process the data and the GIS technique used to answer the inquiry.

For example, the chief operating officer may require a few digitized maps, an off-the-shelf GIS program, and a stand-alone computer to make a generalized map of the company's operations. On the other hand, the needs of an asset team will differ. Instead they may need access to company-wide engineering and geologic data, a relational database, a Unix-based workstation, and a proprietary GIS to develop a shared Earth model. Obviously, the quantity of information demanded by the asset team, and the technologies required to process and analyze the data, will be more complex. Yet both users have one thing in common-a need to spatially visualize and analyze data for improved decision making.

Other important considerations for GIS development include the scope and global activities of the business. If the company is a small upstream oil producer operating in Wyoming, for example, a basic GIS program installed on a few select computers may satisfy the company's needs. On the other hand, a vertically integrated company with international operations in Asia may utilize an Internet-based mapping system linked to an object-oriented database. Again, the data resolution and the complexity of technologies may differ. Yet the ultimate

goal of producing a faster, cheaper, and more accurate answer remains integral to the user's objective.

Generally speaking, GIS can be broken down into five major activities. In its simplest function, GIS can present data in map form to communicate information. Second, GIS can organize geographic information in map, chart, or table form to visualize spatial patterns in order to stimulate visual thinking.

Third, GIS can query geographic points of interest and associated attributes to answer the question, "What and where?" Fourth, it can provide new information by building geographic themes from older layers.

Finally, GIS can track patterns in space and time to aid in the function of analysis, decision making, and workflow. In the following examples of these elements are described.

6.6 Oil industry Examples

How does a business know the possible applications of GIS if it is not aware of its capabilities? David J. Grims

Geophysicists, for instance, commonly work with 3-D seismic surveys that contain more

than a terabyte of data. This volume data requires tremendous processing power and advanced software programs to filter out noise to produce discernible cross section in deepwater floating operation. Once can also visit U.S Gulf Coast refinery or Canadian heavy oil facility to AM/FM and supervisory control and data acquisition technologies at work. As such, it can be said that petroleum high technology applications do not lag other industrial

application despite many comments to the country. Rather, they take a leading in the role in the development of information and spatial technologies.

The problem then clearly is not related to the singular use of telecommunication technologies, remote-sensing techniques, computers, or software applications. Instead, the challenge arises in the proper mixing of these technologies to implement a new paradigm. Building an effective GIS should not be treated as an experiment where users try to "cobble" together software or intertwine telecommunication systems with databases. Instead, it is one of trying out new thought processes to solve a particular problem from a geographic point of view through system integration. The petroleum industry has the means to solve its technical goals. Thus it is only a matter of putting the technologies to work in a cohesive manner.

6.6.1 Wellsite Selection (New Mexico) *Dean E. Gaddy, 2003*

A routine problem for exploration and develop personal involves wellsite selection. This type of work involves regulatory, ecological, geological, engineering, and technical issues that traditionally have been solved by overlaying successive maps on a light table.
In the San Juan Basin of New Mexico, for example, operators deal with:

- Highly irregular terrain such as canyons and arroyos (see figure 6 Fresno Canyon Topo Map, Source iGage Inc.).
- Native American archaeological sites.
- Different spacing requirements dependent on production fluid type.
- State regulations that limit available drilling acreage.

- Infrastructure avoidance issues (i.e., pipelines, telephone lines, and utility lines).
- Infrastructure tie-in issues (i.e., pipelines, gathering stations, compressors, pumps, and separation facilities).

The topographic map (Figure 8) may appear to be a simple scan of a USGS survey. Additional layers such as well spots, GPS routes, and other features. However, additional layers can be superimposed on top of the map, providing a tool for GIS analysis. This can be accomplished in a special raster-to vector program.

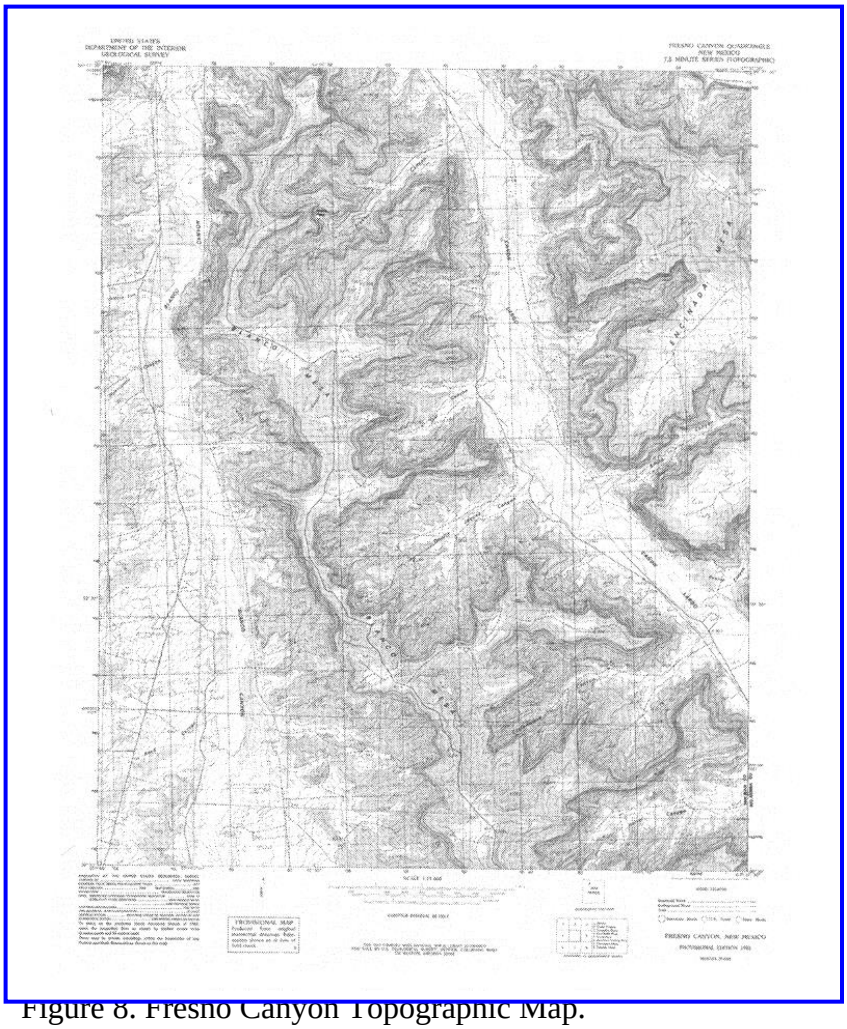


Figure 8. Fresno Canyon Topographic Map.
(Source: USGS and iGage (www.igage.com).

6.7 Advantages of Enterprise GIS (Saudi Arabian Oil Company, (Petroleum Eng.

Application Services Dept, Saudi Aramco, 2005)

Saudi Arabian Oil Company Explores the Advantages of Enterprise GIS The Saudi Arabian Oil Company (Saudi Aramco) is the state-owned oil company of the Kingdom of Saudi Arabia. It ranks first among oil companies worldwide in terms of crude oil production and exports and is among the leading producers of natural gas. Saudi Arabia is the holder of the world's largest oil reserves -one-quarter - at more than 259 billion barrels. Saudi Aramco is a fully integrated oil company with operations in exploration, production, refining, marketing, and international shipping. In conjunction with its operations the company manages a colossal network of assets that includes wells, pipelines, plants and buildings, roads, utility networks, jet aircraft, and supertankers (Figure 9). Saudi Aramco also runs joint venture refining and sales operations in North America, Europe, and Asia.

More than 50,000 employees perform a spectrum of jobs ranging from exploration geologists and geophysicists to engineers, project managers, environmental scientists, and deep desert surveyors. All of these jobs rely on technical information that is geographically based. Virtually all of Saudi Aramco's activities on land, air, and sea can be mapped to a physical location and analyzed in a GIS.

Recognizing this, the Information Technology Division of Saudi Aramco has been developing innovative ESRI software-based GIS solutions for more than a decade. These systems support the company's diverse mission and include

Figure 9. Saudi Aramco manages a colossal network of assets that includes wells, pipelines, plants and buildings, roads, utility networks, jet aircraft, and supertankers. (Source: Saudi Aramco, Public Relations Department)

6.7.1 Surveying and Exploration

ArcGIS Desktop (ArcEditor) is used extensively to plan seismic surveying missions, monitor the performance of contractor crews, and analyze geophysical data collected during the surveys.

6.7.2 Engineering

A custom Mapping Wizard lets staff access a wealth of spatial data from the Oracle–ArcSDE repository and quickly create publication-quality maps, without needing to know anything about GIS technology or cartography. Customized ArcGIS applications are used to support well site planning, wellhead maintenance, and other engineering functions. ArcPad software-based solutions are also being developed to support field-based navigation and data capture.

6.7.3 Logistics

The company's existing telecommunications infrastructure is being leveraged to dispatch and track the movement of company cars, heavy trucks, and ocean-going supertankers. Knowing the precise location of vehicles and vessels is essential for the timely delivery of goods and services. It also provides a lifeline for staff driving in remote desert locations.

6.7.4 Planning

ArcEditor is used to digitize the location of all new facilities, and the resultant information is reviewed online by planners and engineers using dynamic ArcIMS maps. ArcIMS has been integrated with a Web-based document management system to enhance decision making and reduce the project review time frame.

6.7.5 Transportation

ArcGIS Desktop has been integrated with a third party road and pavement maintenance system, enabling transport engineers to visually assess road conditions over a large geographic area and forecast road works based on local traffic volumes. Such spatial insights are impossible to gain without GIS.

Figure 10. An oil tanker. (Source: Saudi Aramco, Public Relations Department)

6.7.6 Utilities/Asset Management

Major projects are underway to convert the company's power, wastewater, and telecommunication networks from a legacy AM/FM system to the third party solutions ArcFM and Network Engineer from ESRI Business Partners Miner & Miner (Fort Collins, Colorado) and Telcordia (Morristown, New Jersey), respectively. This utility data is crucial for planning engineering works and will form an important pillar within the enterprise GIS. Interdepartmental data sharing agreements are helping to maximize the value of the company's spatial data holdings.

6.7.7 Safety and Emergency Response

Along with the vehicle and vessel tracking system, a Web-based gas leak emergency response system has been developed. This system reads live gas sensor readings and real-time weather information within the company's plants and graphically overlays this with important GIS layers such as digital aerial photos, buildings, roads, hospital locations,

airports, and rescue facilities. Using dynamic maps, emergency responders gain a clear, shared picture of the emergency and its potential impact on people and facilities (Figure 11).

6.7.8 Knowledge Sharing

An online mapping portal has been released on the company's Intranet. Developed in Java, the ArcIMS site enables staff to easily locate company facilities, dynamically generate routes and driving instructions, and share annotated maps with colleagues via e-mail.

Figure 11. The emergency response system predicts the track of a gas leak. (Source: Emergency Response System-Mapping System, Saudi Aramco).

6.7.9 Land Management

Saudi Aramco relies heavily on GIS to manage land use permitting processes, research land claims, and monitor illegal encroachment within the company's thousands of square kilometers of concession area. The feasibility of using satellite imagery to automatically detect and map land use changes over time is currently being investigated.

Saudi Aramco hardware infrastructure is configured to be fault tolerant with a load balancing option enabled solely to ensure 24/7 availability with optimal performance of these mission

critical applications. All corporate GIS data is stored in an Oracle9 database running ArcSDE 8.3 on a UNIX clustered server. ArcIMS is used to serve Web-based image maps across the company.

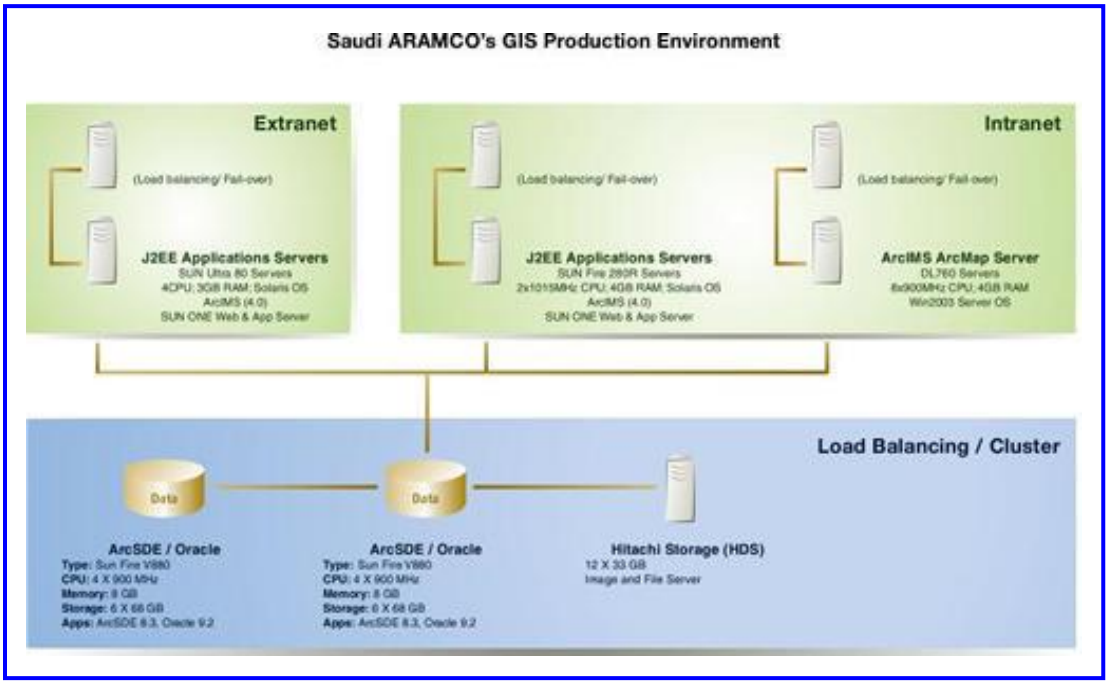


Figure 12. (Source: Saudi Aramco New Horizon, 2003)

7. GIS Solutions for Exploration & Producing

Exploration requires the analysis of many different types of data. GIS can tie these datasets together and allow you to overlay, view, and manipulate the data in the form of a map to thoroughly analyze the potential for petroleum at a location (Figure 13-14). (Charles C. Fried, 1990).

To begin production at a selected location it is essential to examine a wide variety of geography, infrastructure, business, and environmental factors about the area. GIS technology is ideally suited to this kind of overlay analysis and can be integrated with other

business risk or economic business planning engines to provide a focused business solution toolset.

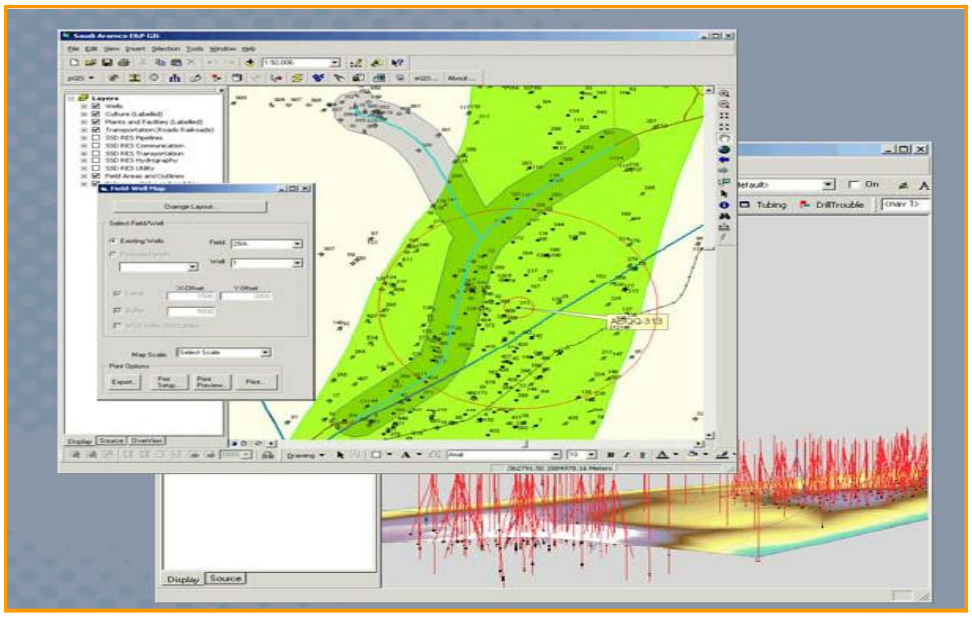


Figure 13. Desktop Mapping & Analysis (2D/3D),
(Source Petroleum Eng. Application Services Dept, Saudi Aramco).

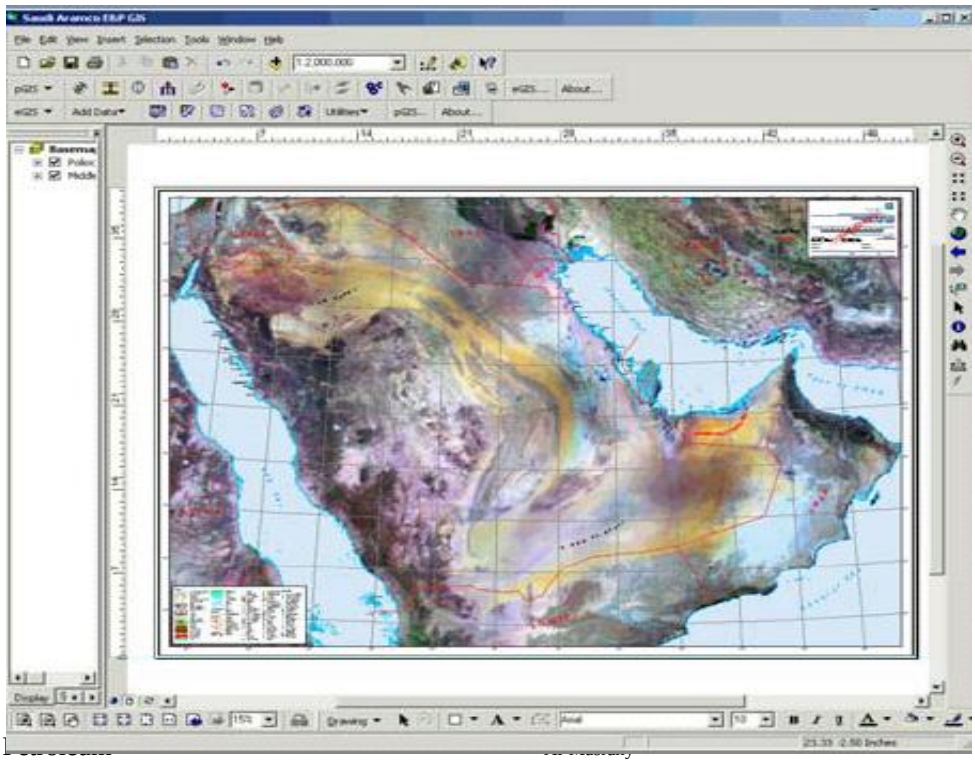


Figure 14. Automated Cartographic Mapping.

(Source: Petroleum Eng. Application Services Dept, Saudi Aramco).

8. Future Expectations

Although GIS technology brings lots of benefits to the oil industry already, it can still be made better. Where requested improvements can be stated and implemented in a generic way, they can benefit all users of GIS. Some things on "oil industry wish list" include:

- Geologic Evaluation
- Reservoir Analysis
- Seismic Acquisition (access of seismic data and well logs)
- Land / Lease Management
- Drilling Activity Analysis
- Competitor Analysis
- Mergers and Acquisitions
- Gas Marketing
- Improved integration with our relational databases.
- A truly global paradigm, where locations on the earth include "metadata" like Geodetic datum, Cartesian projection/spheroid parameters, etc.
- Improved "Conflation" tools. "Conflation" is the process of merging two or more GIS datasets, so that the output has the highest-accuracy data from all the inputs. As surveying tools and GIS data from satellite and ortho-photo images continues to

improve, existing maps and GIS datasets must be "high-graded", i.e. adjusted to remain consistent with the newer data. Managing this process may well be the biggest challenge.

- 3-dimensional GIS: Right now, use of GIS stops at the Earth's surface. To visualize subsurface reservoirs, we must change to completely different systems, which rarely present a "seamless" interface to the GIS.
- Advanced analytical tools for Retail outlet management.
- Integration of Mobile GIS services helping in optimized business solutions etc.

9. SUMMARY

GIS technology and related hardware and software have advanced to the stage where they offer tangible technical and economic benefits to the petroleum industry. Not only do they improve current business processes by furthering better data sharing and more accurate mapping, they also support efforts at "business process re-engineering", where technical professionals redefine their activities as they are able to access critical data in new ways.

Several GIS initiatives are well on the way to becoming production systems integrated into the business processes, with support groups and an increasing number of end-users who continue to discover new ways of benefiting from this technology.

The road ahead promises tough competition, technical advancements in software and

hardware utilization and integration, adapting to multi discipline requirements, improving the system architecture from discrete model to a universal model, advanced data acquisition methods and so on. The component of “Where” can make a real good impact in the Petroleum Industry in the way they do business and serve the customers.

10. CONCLUSION AND DISCUSION

Classical petroleum geology applications banded on producing paper maps to research geologic interest area. Mapping petroleum geology related maps is quite difficult and time consuming. Recently Geographic Information Systems (GIS) provides a better way of viewing and exploring data by linking both graphic and tabular data into a graphically "intelligent" map with supportive tabular information.

The GIS environment offers the exploration geologist a wide variety of options for integrating regionalized geodata. The full power of the methodology of Characteristic Analysis introduced in the eighties can now be exploited by means of GIS support.

GIS technology has increased its relevance to the petroleum industry because of two driving forces: technical and business forces.

"GIS is revolutionizing the way geologists work and think," *said Richard Bishop, exploration geologist with ExxonMobil in Houston and past AAPG president.*

GIS not only improves the speed, efficiency and accuracy of our maps but also provides the ability to make analyses that were never before possible. Such computational power will lead all disciplines within the business to learn different things much more rapidly, leading to greater insights.

"GIS allows the integration of technologies and interpretations - a whole range of ideas, data and analyses can be brought to problem solving that we have not seen before."

Everyone can input their data into the system and people will see things they never had the opportunity to see before and make calculations that they never made before, simply because it was too difficult.

Even though major oil companies have been moving data into GIS systems for several years, scientific and professional organizations have been slower to build GIS systems because of the expense.

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