

CPR-514 – Term Paper 2011#

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Submitted to : Dr. Bager Al Ramadan
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Abstract:

GIS is a fundamental tool for success in Oil and Gas exploration operations. It usually requires analysis of satellite imagery, aerial photomosaics, seismic data, regional surface geology studies, subsurface interpretation, well locations and existing infrastructure information. GIS systems can easily relate data elements to a map location, and allow to overly, view, and manipulate the data to analyze, understand, and draw conclusions. This paper will incorporate study cases from all over the globe, and emphasis how GIS has potentially enhanced operations efficiency, increase productivity, or reduce human/environmental risk. It will also shed the light on GIS application in Saudi Aramco and Venezuelan National Oil Company (Petroleos de Venezuela), and how it's utilized for surveying and exploration, engineering, logistics, planning, transportation, utilities /Assets Management, safety and emergency response, knowledge sharing, and land management.

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1. Introduction:

GIS (Geographic Information Systems) is a computer-based system providing advanced capabilities for handling spatial and descriptive data. It is an essential tool for decision making, by understanding geography and people's relation to location, we can make informed decisions. GIS Technology comprehends geography in a way to lead to making intelligent decisions. It display geographic data on way that a person reading a map can easily select data necessary for specific project or task, and display table of content for more detailed information.

Petroleum companies have, for years, used GIS to decide where to drill a well, route a pipeline, build a refinery, and reclaim a site. Today's GIS provides oil and gas industry solutions throughout the petroleum life cycle. All major oil companies in the world use GIS technology to manage their location-based information, from leases, wells, and pipelines to environmental sites, facilities, and retail outlets. GIS systems allow building a corporate database of different data types, and applying appropriate geographic analysis efficiently across the enterprise. It also allows managing the spatial components of everyday petroleum business objects such as wells, pipelines, environmental concerns, facilities, and distribution points. (ESRI Co., 2011)

On this paper, we will discuss GIS applications in Petroleum Energy and how GIS has potentially enhanced operations efficiency, increase productivity, or reduce human/environmental risk. We will incorporate study cases from all over the globe specifically Venezuelan National Oil Company (Petroleos de Venezuela) and Saudi Aramco.

3. Applications of GIS in Petroleum Energy Industry:

GIS is a wide spread technology in oil and petroleum industry; It is a powerful tool for analyzing and displaying data. GIS technology has served as a valuable tool for the efficient and effective management of assets in the industry for many years. Geographic information system (GIS) software can help petroleum companies see information in new and innovative ways, resulting in better management decisions. The benefits of geographic information system (GIS) technology in the oil and gas industry are well understood especially in Petroleum Exploration, Petroleum Production, Facilities Management, and Pipeline Management. (ESRI Press, 2007)

3.1 Petroleum Exploration and Production:

GIS is a fundamental tool as it offers the tools needed for extensive data analysis. Exploration operations employ craft of science to evaluate a region potential; it usually requires detailed analysis of satellite imagery, aerial photomosaic, seismic data, regional surface geology studies, subsurface interpretation, well locations and existing infrastructure information. GIS systems can easily relate data elements to a map location, allow to overly, view, and manipulate the data to analyze and understand its potential. It can calibrate Seismic methods, gravitational methods, and magnetic methods to assist on finding a new oil accumulations structures. Another powerful application of GIS is visualizing data as a digital terrain model of the surface and 3D models of the subsurface, which would allow further analysis of seismic surveys, subsurface and cross section interpretations, and profiling maps. (ESRI Co., 2011)

GIS is an effective technology that enables exploration and exploitation teams to share information, analyze data in new ways, and integrate the evaluation process. It is the best solution to overlay analysis of geographic, infrastructure, business conditions, and environmental factors for better reservoir engineering and decision-making. GIS allows for real time production data display on a well-by-well basis, which allow reservoir engineers access to a live data for future planning and daily production monitoring. Major applications of GIS in Oil and Gas Production operations are managing

surveillance data, production data, pipeline integrity, environmental monitoring, major incident management, logistics management, and well placement. (Ahmad I. A.-M., 2009)

Another Major application for GIS in development operation is well placement optimization; it helps to determine optimal location for conventional and multilateral wells in oil and gas reservoirs. Well planning is a complex process, as for each field there is a minimum required well spacing radius on the surface and same on subsurface to avoid well collision and any other implications on wells productivity. GIS allows petroleum engineers to more accurately plan and analyze complex well configurations in a single integrated application. (Ahmad I. K.-M., 2005)

3.2 Facilities and Pipeline Management:

Petroleum industry is one of the most vertically integrated industries. One company business workflow would include the whole process of oil production cycle such as, exploration, drilling, production, pipelines, GOSPs, refineries, shipping vessels, and sale outlets. Oil companies must keep track of every minute detail of all operating facilities; GIS can offer a solution for geographical and informational integration on real-time basis for such operation monitoring. Also, Geospatial information can be aptly used to map the gathering and transmission of products to and from a facility.

Petroleum energy companies utilize GIS to monitor the condition and flow of pipelines and determine the best pipeline locations to transport oil off the fields and to the refineries. Pipeline Management is a process by which you continually evaluate your active opportunities (from prospects to booked customer) for their balance of quantity and quality. (Ahmad I. A.-M., 2009)

4. Case Study: GIS applications in **Petróleos de Venezuela:**

4.1 Introduction:

Venezuelan National Oil Company (Petróleos de Venezuela) is an energy company owned by the Venezuelan state with worldwide spread commercial activities. It's a vertically integrated company, as almost all oil companies, its operations include exploration, drilling, refining, transport, and distribution. Petróleos de Venezuela uses GIS to visualize operational surface facilities online. They developed a geospatial satellite images web tool and the geospatial surface facilities web tool, which enables data visualization, spatial analysis, and integration with cartographic and other petroleum data. The Geospatial surface facilities web tool was developed to visualize the crude oil production facilities, gas recovery and distribution system, gas injection system, water injection system, and artificial gas lift system. (ESRI Press, 2007)

4.2 Implementation:

Integration of Geospatial Satellite Image web tool and Geospatial surface Facilities Web Tool requires main cooperate databases integration to store the geospatial data:

- ❖ Surface Database
 - where the spatial component of the data is stored on thematic layers:
 - A. Cartography with different scales of cities, rivers, roads, etc.
 - B. Wells, seismic 2D/3D navigation, leases, and surface facilities
- Exploration and Production Master Database
 - Where the attribute components of the geospatial, exploration, and production data is stored to support Petróleos de Venezuela activities. (ESRI Press, 2007)

4.3 Major features:

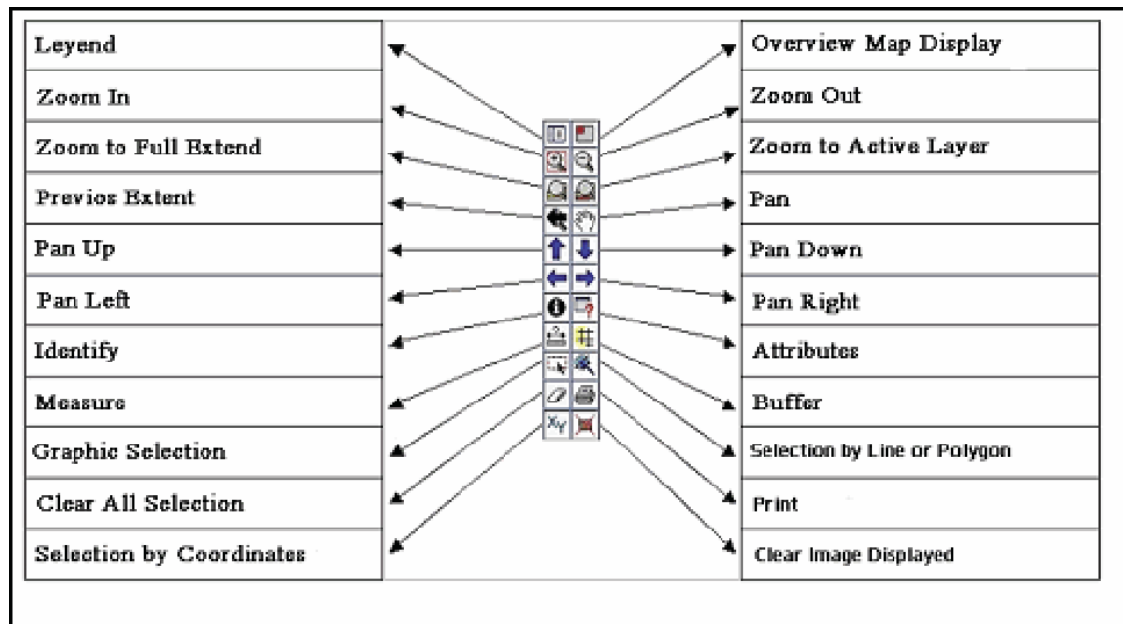


Figure 1: A brief description of tools available in *Petróleos de Venezuela GIS web tool*. (ESRI Press, 2007)

1. Satellite Image Catalog:

Corporate databases contain more than 200 satellite images (georeferenced and nongeoreferenced). The tool utilizes three geospatial indexes for visualization such as:

- A. SPOT—Multispectral and panchromatic
- B. Landsat—Multispectral and panchromatic
- C. Radarsat—Panchromatic

2. Integration of Satellite Images, Basic Cartography, Petroleum Data:

This tool allow for multilayers integration of different images, maps, and data from several databases. It can superimpose all *Petróleos de Venezuela*'s surface database layers on a geo-referenced satellite image, along with well locations and attributes, seismic 2D and 3D navigation, leasing, and operational agreements.

3. Dynamic Scale Adjustment:

Once a user zooms in or out layers of data and images auto adjusts scale accordingly. The function autos adjust layout to display the proper images and data scale based on the minimum and maximum scale factor display setting.

4. Image Request by E-Mail:

The tool offers a great service on term of request handling and delivery. User can select an image and the tool will send an email to remote sensing department with image and user identification in order to begin their processing and delivery.

5. Spatial Analysis:

The tool has additional functions for spatial analysis such as:

- Buffers,
- Query an area by coordinates
- Proximity,
- Measure distance

(ESRI Press, 2007)

4.2 Future Plans:

This GIS application has proved that complex corporate databases can be lined together in a relatively short time span, using existing facilities, without reengineering of data structure, or additional expensive infrastructure investment. It also allows for further integration with ArcSDE through migration of relevant portions. Plans forward are to extend data types within the systems to include recently acquired hyperspectral ikonos images to make use of the powerful visualization tools on the corporate intranet network. (ESRI Press, 2007)

5. Case Study: GIS applications in Saudi Aramco Oil Company

5.1 Introduction:

Saudi Aramco is the national oil company of Saudi Arabia. It ranked number one oil company in term of crude oil production and export. Saudi Arabia has the world largest liquid hydrocarbon deposit of 259 billion barrels in reserves. Saudi Aramco is fully integrated company with operation in exploration, production, refining, marketing, and international shipping. As part of its operations, the company manages network of world wide spread assets such as wells, pipelines, plants and buildings, roads, utility networks, jet aircraft, and supertankers along with joint ventures assets across the globe.



Figure 2: Saudi Aramco Hydrocarbon shipping vessels on GIS tracking application window. (Ahmad I. A.-M., 2009)

Saudi Aramco is one of first the Oil and Gas companies to recognize importance of GIS. Information Technology division in Saudi Aramco has been developing an innovative ESRI software-based GIS solutions for more than a decade now. GIS now is in use to manage Saudi Aramco wide spread network of operations and Assets, it used in wide aspect of Saudi Aramco operations such as Surveying and exploration, engineering, Well data integration, seismic lines/ shot-point mapping, geologic maps & satellite imagery, 3D GIS, Offshore data integration, Well cross-section, Saudi Aramco drilling knowledge

base, e-well information, E&P Data integration for Google earth, planning, transportation, utilities/Assets management, safety and emergency response, knowledge sharing, and land management. Saudi Aramco is even looking forward for a true enterprise GIS. Integrate GIS with SAP repository for better analysis and reporting. Integrate GIS with the company SCADA systems to provide a real-time view of the company operations-from well site production to refining and sales, Implement ArcPad and mobile GIS devices to gain efficiencies in the field and improve the GIS database, further consolidate and standardize the company's spatial data assets, and promote the benefits of GIS technology across the company. (Ahmad I. A.-M., 2009)

On this paper, we will discuss GIS application in Saudis Aramco wide spread network of operations and Assets especially Surveying and exploration, optimum well placement, well data integration, geologic maps & satellite imagery, offshore data integration, and data integration with Google earth.

5.2. Optimum Well Placement:

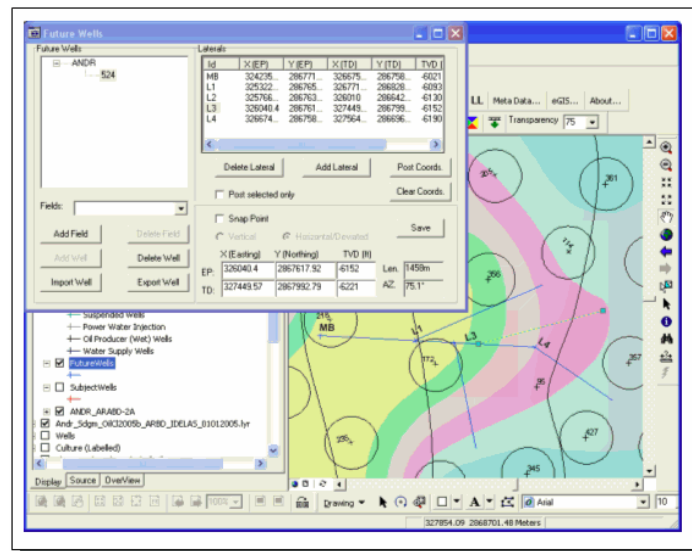


Figure 3: Saudi Aramco well planning application with a buffer zone around wells for minimum spacing. (Ahmad I. A.-M., 2009)

Saudi Aramco operations include drilling hundreds of wells; a planned well has to go through very detailed planning procedures. Determining an optimal location for vertical or multilateral wells is a complex process; Subsurface is not just simple homogenous geological rock body. There are many factors that play a role in well planning such subsurface geological environment, structure, and complexity, along with reservoir information, and surface land cover. GIS can integrate and represent these many data types in a single view. Saudi Aramco has developed a sophisticated tool to allow Petroleum Engineer to efficiently propose well location especially where the density of wells in field is high. Furthermore, this tool allows engineers to create and view complex operational maps such as fluid contact maps, formation pressure information, and well trajectory data. (Ahmad I. K.-M., 2005)

5.3. Well Data Integration:

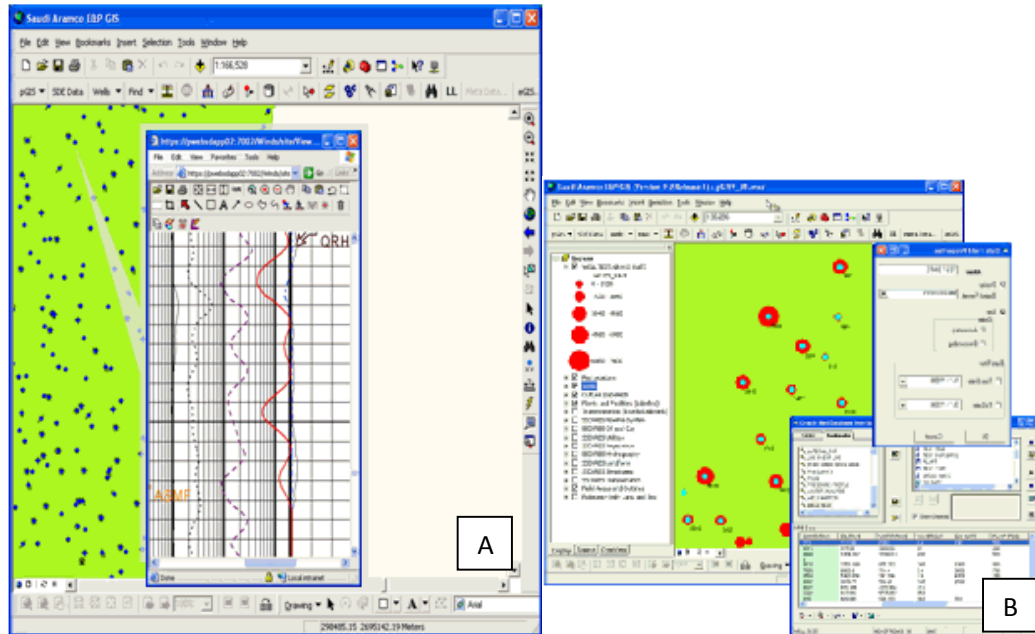


Figure 4: Saudi Aramco well data integration GIS application windows (a) showing well logs (b) showing a buffer zone around wells to reflect well productivity. (Ahmad I. A.-M., 2009)

Hydrocarbons wells are data rich and expensive boreholes. Integrating all data collection is a complex process. Saudi Aramco has developed a GIS solution to manage this process. It allow for 3D well view to provide a 3D perspective of the wellbore trajectories, casing, tubing, and perforation information. Wells data are stored in X3D (VRML) files, which are viewable through a browser plug-in for easy user friendly 3D sense. Well data collected are usually well reports and information, well logs, and core data. Well information is managed through an interactive, custom, intelligent interface which allows users to retrieve database tables for wells selected on the geographic map. Retrieved data can be displayed next to the well location or exported to excel or text files format for further study and analysis. Well logs and Core are different as they in an image format. Aramco GIS team had designed a special interface to display raw and processed logs in either TIFF or CGM format, and another interface for Core data to allow geologist and engineers to view and analyze them. Core viewer can display core

photographs, core description, core diameter, top-depth, bottom-depth, photo-date, etc. All non-imagery associated data are displayed as metadata information. (Ahmad I. A.-M., 2009)

5.4. Geologic Maps and Satellite Imagery:

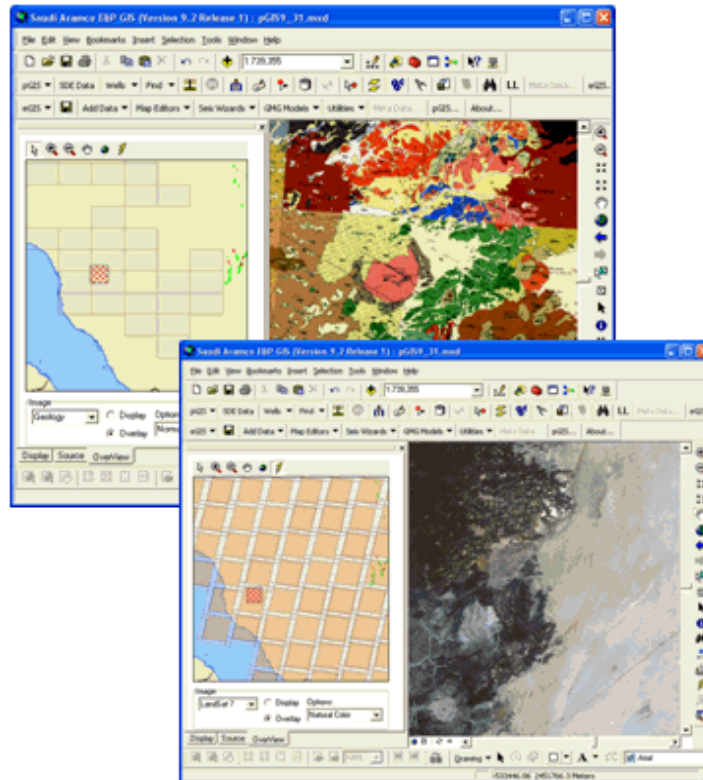


Figure 5: Saudi Aramco GIS application windows showing an overlay and integration of multiple disciplinary maps. (Ahmad I. A.-M., 2009)

Saudi Aramco as the world largest crude producer and Saudi Arabia national oil company has a massive collection of geological maps and satellite imagery. Aramco has designed a custom overview interface to display and overlay geological maps and satellite imagery residing in Aramco's GIS database for further analysis, providing geologists and engineers with an easy access to this massive collection. An index grid for the raster is utilized to show the footprints available for display and analysis. An interactive hot-link tool allows a user to select a particular footprint and display it in custom map viewer along with its Meta data. (Ahmad I. A.-M., 2009)

5.5. Offshore Data Integration:



Figure 6: A snapshot of Saudi Aramco GIS application for offshore data integration reflecting the complexity of offshore operations. (Ahmad I. A.-M., 2009)

Saudi Aramco manages Safanyaia, the world largest offshore field, along with many offshore oil and gas fields. Offshore operations are associated with a higher risk and challenges than onshore operations, which require a closer monitoring and quicker emergency response. Aramco utilize GIS application is used by drilling and workover department to monitor and response to emergency situation on oil platforms, rigs and Saudi Aramco vessels locations. All Saudi Aramco emergency teams are such as fighting vessels, security vessels, and oil pollution response vessels are tracked on the E&P GIS map display from the real time AIS (Automated Identification system) data transmitted by the vessels and stored in the corporate marine database. Detailed schematics, photos, lifting gear, pipeline connection, control valve, deck evacuation and additional infrastructure data are also available in Marine database. This information is vital for firefighting crew and logistic staff that must respond to the offshore emergency situation. (Ahmad I. A.-M., 2009)

5.6. Data integration with Google Earth:

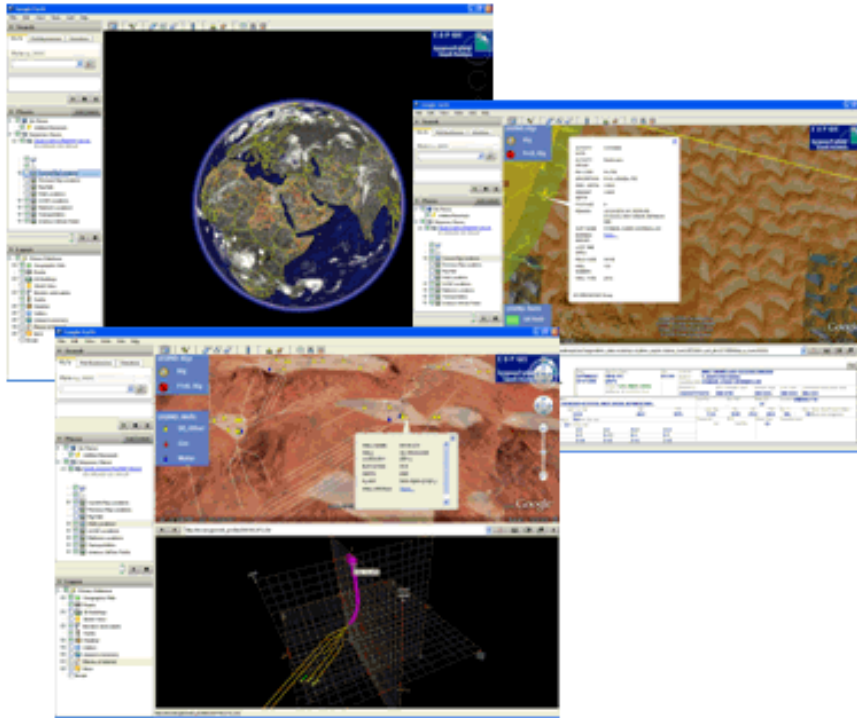


Figure 7: A snapshot of Saudi Aramco GIS application in integration with Google Earth. (Ahmad I. A.-M., 2009)

Google Saudi Aramco has developed an add-on downloads of data the paints layers of well, rig, plant and field information over the Google Earth globe. The add-ons allow access to latest hourly updated rig locations, another developed add-ons provide access to current well and associated plant locations on Google Earth. Layers are displayed with appropriate templates to reflect actual rig situation, and targeted hydrocarbon. Marked locations on Google Earth are linked to operation morning daily reports system and 3D based well trajectory information. (Ahmad I. A.-M., 2009)

6. Conclusion:

A geographic information system (GIS) is a technological tool for comprehending geography and making intelligent decisions. GIS technology has served as a valuable tool for efficient and effective operations management for many years. GIS represent a new concept of data integration that goes beyond IT systems. Integration of databases with maps, photographs, and documents and linking them would provide a synergy tool (GIS) that allows us to visualize, analyze, manage, and integrate data across systems and organizations. GIS application is the tool to make analysis and decision making processes much easier and more convenient. (ESRI Co., 2011)

The benefits of geographic information system (GIS) technology in the oil and gas industry are well understood, and fully recognized. Hydrocarbon Energy companies, for years, have used GIS to decide where to drill a well, route a pipeline, build a refinery, and reclaim a site. GIS provides solutions throughout the petroleum life cycle. Oil and Gas companies employ millions as workforce employees to perform a spectrum of jobs ranging from exploration geologist, and geophysicist to engineers, project managers, environmental scientists, and surveyors. All these industry related jobs rely on technical information that is geographically based.

Petroleos de Venezuela and Saudi Aramco were one of the early companies that have integrated GIS in their operational workflow. Petroleos de Venezuela utilized it successfully to monitor its operation facilities online through GIS system and satellite imagery through multi-databases data integration. On the other hand, Saudi Aramco utilizes GIS in all aspects of operations from exploration, well planning, drilling, production management, facilities management, pipeline management, and, risk and environmental management.

Works Cited

- Ahmad, I. A.-M. (2009). E&P GIS: Integrating E&P Data and Applications, Saudi Aramco. *4th Annual Saudi GIS*. Dammam, 2009:
http://www.saudigis.org/FCKFiles/File/SaudiGISArchive/4thGIS/Papers/3_AdilMarzooq_KSA.pdf.
- Ahmad, I. K.-M. (2005). Well Placement Optimization Using GIS, Saudi Aramco. *25th Annual ESRI International User Conference*, . San Diego 2005:
<http://proceedings.esri.com/library/userconf/proc05/papers/pap1253.pdf>.
- ESRI Co. (2011). *GIS for Petroleum*. Retrieved 12 25, 2011, from ESRI:
<http://www.esri.com/industries/petroleum/index.html>
- ESRI Press. (2007). *GIS Best Practices/GIS for Petroleum*. Retrieved Dec. 25, 2011, from ESRI:
<<http://www.aeroterra.com/PDF/petroleum.pdf>>

Appendices:

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