THE ROLE OF GIS IN OIL INDUSTRY MANAGEMENT

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ABSTRACT

The Oil industry growth and the rapid pace of urbanization in Sudan placed increasing pressures and urgent needs for GIS applications almost in all oil industry activities, including implementation of new tools for management and control of the environment and natural resources. The factors affecting the environment and the natural resources due to the oil industry development were highlighted. The GIS applications and functionalities enable efficient management of oil production processes and environmental assessments. GIS can help in investigating the factors of weakness and success of the oil industry and those influencing the environment and its management. GIS also provides sufficient spatial data and flexibility of work in the oil field with the possibility of incorporating environmental changes and influences in oil exploration plans, programs and projects.

This paper presents the role of GIS as a tool and illustrates its applications in the oil field management. The paper also outlined GIS experiences in Sudan and its capabilities for handling spatial data and remotely sensed materials, with reference to surface features management in the oil production fields of Greater Nile Petroleum Company (GNPOC) in Sudan.

Keywords: GIS, oil field management, environmental assessments, (GNPOC) Sudan.

1. INTRODUCTION

GIS in oil industry can be described as a system that can handle spatial data and spatial information of almost all objects in the industry, including the oil fields and their surroundings, and to be connected to specific location. In general the GIS cycle, starts from data collection, followed by data structure in a computer database, data management and analysis, decision making and data updating of spatial...
information. As natural resources are many and varied in the country like Sudan, GIS can account for the changes as oil development takes place. GIS can be implemented to manage and mitigate the exploitation of natural resources and their impact on the environment. This will require the use of GIS technical tools and methods of analysis, which can help in the process of spatial data collation, analysis, modeling and monitoring the impacts on our environment in a rapid and flexible manner. These tools will allow the decision and policy makers to communicate easily and promptly with their workforce in the oil industry.

The use of geography or spatial data in analyzing and making decisions is an old technique in the field of oil industry. A good understanding of geography is required in every step of a petroleum industry starting from topographic, geological and geophysical studies of the exploration site, and location of new wells, field development and drilling operations. Followed by crude oil production, gathering and processing, pipeline routing and alignment and primary distribution of oil using pipeline transportation, the storage system, refineries and the inventory management and truck dispatch. As well GIS can be used for marketing, demands forecast, price settling and customer service and demand fulfillment by managing all facilities through out the cycle of oil industry, i.e. in all stages of oil exploration, oil production and trading. In general it could be seen that the implementation of Geographic Information System (GIS) and Relational Database Management Systems (RDBMS) with the support of spatial information has opened a new era which will allow an efficient management of the spatial components of everyday oil industry work, such as leases, wells, pipelines, environmental impacts, facilities, and retail outlets, in the corporate database.

Nowadays oil producers are driven to bring oil production on line as quickly as possible and to operate at the lowest safe cost. This can only be achieved through accurate information, safe and reliable, efficient and environmentally sound operations. Here strict attention should be made to the GIS functionalities, standards (Wadidi and Abdalla 2005) and to regulations regarding operations and environmental safety. It is well known that safety, reliability and efficiency in oil industry are directly related to improved asset effectiveness in terms of availability, quality and operations, as well as decision-making and management.

2. Environmentally Sound Oil Field

In the oil industry, environmental services should be carried out based on both local and international experiences and standards. These services may include both onshore and offshore oil industry, such as environmental review, environmental auditing, and environmental impact and risk assessment. GIS implementation can help in the following main environmental assessment and management aspects:

♦ Environmental Auditing such as waste management of offshore oil production platforms and assessment of adherence to local and international environmental compliance standards.

♦ Assessment and evaluation of aquatic environmental effects of onshore oil developments and operations.

♦ Assessment and evaluation of the marine environmental effects offshore developments and operations.
Assessment and evaluation of marine environmental effects on seismic surveys on marine birds, whales, dolphins and fish etc.

Assessment and evaluation of environmental upgrade options for offshore oil production facilities, including risk analysis and priorities for implementation sequence.

Environmental assessment of platform and pipeline decommissioning.

Environmental input to oil spill contingency planning.

Marine inputs arising from platform operations including hydrocarbon contamination of sediments.

Environmental impact assessment of active electromagnetic sounding on marine life.

Environmental monitoring design, implementation and execution of programs.

For large oil spills as well as chronic exposure to frequent small spills and oily waste disposal necessitate proper oil pollution studies and contingency planning, comprising environmental assessments of specific situations or in a range of oil spill scenarios (David and Associates, 2006):

Assessment and evaluation of marine environmental effects of oil spills predicted from oil spill trajectory analysis.

Environmental effects of oil spill to inland receiving waters.

Environmental input to oil spill cleanup measures.

Environmental input to oil spill contingency planning: ecological resource baseline, coastal pelagic and demersal fisheries, benthic fauna and flora, and coastal mangrove resources.

Field environmental surveys and mapping of resource values potentially at risk.

GIS is very powerful technique for environmental review process, environmental auditing, Environmental Impact assessment (EIA) as well as environmental risk assessment. These can be outlined as follows:

The environmental review involves collating all available information from GIS database to identify the environmental hazards and assessment of their potential that cause significant environmental effects as well as the assessment of past environmental incidents and their resultant environmental effects. In particular- current data gathering activities are: number of sampling stations, frequency and method of sampling, sample processing, data reduction and analysis, statistical evaluation of data and data presentation.

The aim of environmental audit is to provide management with information that confirms that their environmental programs meet corporate goals, and assesses compliance with regulatory authorities, policies and standards. The environmental management audit is a systematic examination of the environmental management system (EMS) that checks whether the system is: being used as planned, actually works in practice, needs to be brought back on track to change with the regulatory landscape and corporate culture. In general, GIS should be implemented to:

- Improve overall environmental performance.
• Create economic benefits such as savings through waste and wastewater reduction.
• Improve the working environment.

Environmental Impact assessment (EIA) is a complex, multidisciplinary, systematic and predictive task, in which the appraisal and management of environmental implications is a continuing process throughout the life of the oil field. In EIA, the impact can be quantified and assessing its significance at spatial and temporal scales and establishing all necessary measures and presenting environmental safeguards. GIS can be used for environmental impact assessments, which are usually varied in nature, magnitude, extent and location, timing during construction, operations or decommissioning, degree of recoverability, risk, uncertainty or confidence in the prediction and significance at spatial (local, regional) and temporal scales.

GIS can be implemented for Environmental Risk assessment and risk management, which are being applied routinely in oil industry to evaluate the impact of potentiality hazardous substances. Risk management serve to provide risks to which a system is exposed, so that policies and practices can be put into place, such that risk can be measured and monitored, and reduced to acceptable levels, and considering reactive and preventive measures adopted to control and reduce the level of the risk.

3. GIS and Oil Field Management

GIS techniques provide search, visualization and analysis tools for the spatial data of interest in almost all phases of oil exploration and production. For many GIS functions for various organizations, data sets need to be captured only once and can be used for different purposes. For example, the GIS base map, concession boundaries and roads maps can be made available for many organizations for planning (Semlali et al 2005, Wally 1997) oil exploration and production, environmental assessments, housing, transportation, communications and insurance. The common use of framework data sets minimizes duplication of efforts and helps the oil teams to tackle multi disciplinary problems. With little GIS background users can be able to utilize GIS functionality for query, to display and produce maps and reports from the GIS data sets. In this way, almost all common oil field data, including environmental data, will be made available to a wide number of users in different fields. GIS functionality provides the oil field managers as well as environmental experts (Parker et. al. 1997) with a powerful set of tools for modelling spatial problems where several layers of graphical and tabular data may be involved. For example, well field protection usually taking account of potential hazards to the well field from flooding risk, septic tanks, storage tanks and industrial areas. GIS can be used for delineating buffer zones to protect wells fields from such hazards.

In general GIS provides new opportunity for reorganizing methods and approaches to consider all the spatial factors. At application level, GIS can be used in the oil industry for analyzing complex situations, visualizing problems, and creating geographic plans and solutions. GIS system increases the efficiency, reducing operation costs, and helping managers to make quick and better decisions by considering all available information and necessary geographic.
factors to create and plan for sustainable future.

Oil field management involves exploration process such as seismic operations; the process of wells specific identifications, managing the pipeline network to transfer crude sources to refining plant and facility management of various resources connected to such industry terminals. Here the following management activities may be handled by the GIS system:

a) Exploration phase: in this phase the national geodetic networks (Abdalla and Wadidi 2005) are generally considered as a basis for spatial data infrastructure and guide for the development of oil industry activities. The GPS is used extensively to ascertain the location of new wells or other facility features in order to continuously update the digital topographic database. GPS surveys provide geodetic coordinates on the World Geodetic System 1984 (WGS84) datum. The UTM map projection is used for all GNPOC spatial data production and GIS covering the concession area concentrated in zone 35 with central meridian of 27° East Longitude, as well as the pipeline (across zones 35, 36 and 37) and Bashyir port terminal in the red sea coast at zone 37.

Petroleum exploration is a very complicated process that dependent on a multitude of variables. For example, the seismic work and related processing needs spatial data for some selected areas. The coordinates of such locations for seismic studies and layout preparations are regularly being provided for analysis and implementation. Because of this, the analysis capabilities of GIS programs will definitely help in lowering the cost of petroleum exploration. Being explored GIS programs can also be used to monitor the condition and flow of pipelines and to determine the best locations for the pipelines used to transport the oil out of the exploration fields and to the refineries and storages at the main terminal. Exploration requires the analysis of a lot of different types of data such as satellite imagery, seismic surveys, surface geology studies, subsurface and cross section interpretations and images, well locations, and existing infrastructure information. Global positioning System (GPS) can be used to identify the required locations on the earth surface such as oil wells location to sub-centimeter level. So GIS can tie all types of structured data to well defined locations, this will allow users to overlay, visualize, and manipulate the data in the form of a map for thorough search, management and analysis.

b) Facilities Management: The infrastructure of oil industry is difficult to manage and maintained effectively because it requires keeping track of all activities such as drilling, pipeline network and refineries in real time. All types of attribute records in a form of text, tables, video and scanned documents, allow the true geographic placement of attributes entities in the GIS process. GIS
technology facilitates the organization and management personnel with spatial data with a geographic component.

c) **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 analysis and study of geographical locations, in this respect GIS can assist in management and utilization of resources in a way that can lead to optimal productions and transfer of crude and refined oil from well heads up to refineries as well as to storage units. GIS can be used in the site location process that may includes zoning and distances to point of interest, computation of areas, selection of right of way, slope of terrain, number of stream and road crossings, in addition to its use in design sketches for general use and supervision of oil activities.

4. Application of GIS in Sudan’s oil fields

Sudan has experienced great expansions in its spatial data infrastructure and information services built up through years of development. The slow progress of base maps productions and the negligence of national data infrastructure standards and specifications cause many difficulties in planning and management.

Sudan is divided into seventeen blocks laid for oil industry. It sets policies and instructions for different companies to participate in all process of exploration and production and general management. Currently each oil company in Sudan establishes its own GIS system. The use of GIS in various companies and in the Ministry of Energy by applying different systems of data base structures and many factors and parameters for the implementation of spatial data in such systems, created some lack of integrity and data sharing capabilities. Although the ministry of energy leads the production and arrangements of procedures of oil production, there are still many divergences in GIS applications and functionalities.

GNPOC can be considered as a pioneer company in Sudan oil industry. It established its GIS system to serve the company departments since 1998, followed by its Oil Field Information System (OFIS) in 2001. The system reduced the company staff efforts, such as the workload of engineers, analysts and field operators. The AutoDesk Map Guide product is used as GIS software, which facilitates the intranet to provide the service for all users and furnished GIS usage in the field for handling direct services, follow up of the users’ needs, update the system with current data, and training the users from different GNPOC departments.

The use of GIS technology is very relevant to the oil industry operations, offering unique, affordable, and comprehensive solutions that can support oil entities such as wells, pipelines, seismic locations, facilities, engineering drawings, wellheads, land ownership, roads, rivers, villages, and satellite images.

The stages involved in establishing the GNPOC database can be illustrated as follows (Figure 1)

a) Project expertise, collect and layout information of the site and set out plans of work and perform all required surveys and then perform professional
studies. The GNPOC concession area was divided into several internal grids for the wellheads and additional required oil exploration parameters.

b) The GNPOC survey team carried out the topographic and geophysical surveys, based on fieldwork operations and satellite imageries in 1997. The use of satellite images contributed in the earlier stages, in the delineation of planning zones, as at that time there is no existing suitable maps or spatial data.

c) The GNPOC collected information and the data from previous studies and the contributions and cooperation of many Government organizations is used for the establishment of oil exploration procedures.

d) The spatial data accuracy, completeness and formats were assessed and several GIS layers were assigned and created in different categories and specific GIS layers, such as wells, boundaries, facilities, roads and other geographic features.

e) In the year 2001 the GIS system is fully implemented and supported with the intranet that set with complete hardware and software.

In the near future GNPOC can manage to get other usage of the evolution of GIS, as being supported by powerful enabling technology that includes faster processors, inexpensive data storage, high-performance networks, standards for open protocols and wireless devices for accessing Web services. As well as the capabilities of GIS software, which evolve new capabilities and services-oriented architectures that will make GIS implementation more useful and productive. The modern integrity of the artificial intelligent, neural networks and GIS technology opens a new era for development and applications of GIS in oil industry. The intelligent analytical tools used for remote sensing techniques and Global positioning system, GIS/ GPS integration and the technologies of tracking, positioning and location intelligence can provide new applications of GIS in oil industry.

In general the GNPOC system of GIS can handle the following main activities:

- **Geodetic Database:** The GIS office is the custodian of geodetic network, which consists of number of horizontal, and vertical control survey monuments, distributed throughout the concession area. These monuments are used by various disciplines; in order to achieve a much higher level of positional accuracy in their surveys, maps and plans as well as their other spatial products.

- **Provide the GIS-OFIS personnel with spatial information through intranet platform to share geographic data and to produce their own spatial layers and to publish their thematic maps, and to get or produce informative reports.**

- **The GIS system uses spatial analysis functions to help in the establishment of field and site boundaries and management zones for further planning and management of activities.**

- **Provides better geographic awareness and improving decision making at all levels of oil industry human activities.** The system can provide daily sketches for the field operators at different levels and GNPOC departments (Figure 2).
Figure 1: GIS Users and Input/Out Data in GNPOC

Figure 2: GNPOC GIS Network Implementation diagram
Answer questions of spatial queries with respect to distances, areas and locations of physical objects.

Create reports for various activities such as road and facilities alignments and constructions.

The well established GNPOC GIS network (Fig. 2) right now provides for more than 300 persons with their required information, and the system is capable to add new users from different GNPOC departments.

The GIS system is used as a good storage for the collected, processed and structured spatial data, which can be used for oil management, analysis and decision-making. Now even airplanes pilots can be directed by GIS information to the right locations in the oil field site or to any location along the pipeline. Thus the use of the system led to increase the production and efficiency and quality of performing the GNPOC oil activities, as well as reduction in the execution costs, time and efforts.

Now the GIS system is used to facilitate and control most of the GNPOC oil operations and to identify physical locations, such as pipeline, over head power lines, pump stations, buried power lines, well locations, flow lines, field production facilities (FPFs), oil gathering manifolds (OGMs) and the central processing facility (CPF). industry. The application of GIS in the oil industry in Sudan is outlined with more emphasis in the GNPOC OFIS GIS implementation experience.

5. Conclusion

GIS technology offers very well advanced tools for spatial collection, management, analysis, and updating, as well as the production of different kinds of thematic maps in many applications including the field of oil industry. The paper highlighted the contribution and efficiency of GIS application in the improvement and management of spatial information in all stages of oil exploration, oil production and operation.

Oil industry of today requires efficient management and effective decision-making approaches based on GIS information with consideration of all the necessary factors. GIS provides the framework for such needs and help in management of all kind of natural resources and the environment. GIS enables better facilities management and development, which reflects an increasing efficiency and improvement in the human life and community development. In this paper the role of GIS as a tool for oil field management is illustrated with particular emphasis in handling environmental issues in oil

References


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