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Towards the Development of Sudapet Geospatial Information System

Nadir Elyass[1], Kamal Sami[2]
[1]GIS Team Leader and GIS Developer at Sudapet – Sudan
[2]Department of Surveying Engineering, University of Khartoum
nadir.elyass@gmail.com[1], dr.Kamal.sami@gmail.com[2]

Abstract— *Sudapet is Sudan's national petroleum company with a vision of being a pioneer in the petroleum industry. Sudapet acts as the commercial and technical arm of the Ministry of Petroleum in Sudan. It has several subsidiaries that perform contractual and technical activities and is a partner in all petroleum operating companies in Sudan. The main aim of the article is to outline the general approach for the development of the Sudapet geospatial information system and to oversee the GIS and geospatial data available within the oil industry community of Sudan, as well as related government departments, and how it will be integrated with the Sudan basemap. The authors stated the necessity that the Sudapet geospatial team has to work with a clear understanding to collect the oil industry information, develop spatial and GIS standards and specifications, make awareness to the oil industry sector staff about the importance of having a unified reference frame, unified standards, symbology, and data models, which are vital for data sharing, data exchange, and data integration. Then, Sudapet has to focus on and prioritize, the development of its geospatial system and to be organized into the five tracks and 29 working packages. The five main tracks are Sector Policy & Governance, Organizational, Data, Information Technology, and Awareness & Capacity. The purpose of this article is to outline the way forward and provide spatial data and information on the establishment of a Sudanese oil production spatial information system to be included in the national geospatial database of Sudan and the exchange of development space between the Ministry of Energy. and gas, Sudapt, and oil companies in Sudan. This paper also emphasizes that the implementation and integration of geospatial data can change oil industry investments by providing valuable insights to investors and the decision-making process.*

Keywords— *CAD-Computer Aided Design. ESRI-Environmental Systems Research Institute, GBGigabyte, GIS, GPS, IT Information Technology, SQL: Standard Query Language, UPS: Uninterrupted Power Supply, WGS84: World Geodetic System1984*.

I. INTRODUCTION

The Sudapet Company was established as the Sudanese national petroleum company with a vision to pioneer the petroleum industry. Sudapet acts as the commercial and technical arm of the Ministry of Petroleum in Sudan. It has several subsidiaries that perform contractual and technical activities and is a partner in all petroleum operating companies in Sudan. The positioning and status of Sudapet necessitate the exchange of various types of data (technical, operational, and financial) with many entities including the Ministry of Petroleum and the operating companies. However, current efforts in information infrastructure are spread across several departments, data management and exchange standards are insufficient, adoption of GIS systems is generally low, and there is a need to leverage the organization's investment in data and systems through increased integration and coordination. The development of GIS standards is considered essential to resolve many of these problems. A consultant has been commissioned to execute a rapid assessment to pave the way for the detailed activities to develop a complete GIS Roadmap for Sudapet. The scope of work includes conducting a high-level assessment of the current conditions, identifying and discussing outstanding issues, and providing recommendations on how to address the most critical items, while also focusing on related standards issues. After consultations with leading GIS companies, Sudapet has identified key departments within the company, as well as key subsidiaries and external stakeholders. The article also identifies the issues, how the different standards may apply, and recommendations for addressing each issue. These are grouped into five areas: Sector Policy & Governance, Organizational, Data, IT, and Awareness & Capacity.

The Sudapet on behalf of the Ministry of Oil and Gas should activate Geospatial Information for Sudan's Sustainable oil production and Investment with the participation of its stakeholders for the preparation and implementation of the geospatial information, based on the directives and objectives of the government of Sudan and the Ministry of Investment and International Corporation (MIIC). The Sudan Survey Authority (SSA) has maintained the Sudan base map covering the entire country and developed systems related to geospatial data and information [1, 2].

This paper comes within the framework of activating the efforts of the Ministry of the Ministry of Oil and Gas to develop investment services through the application of approved geospatial technologies and applications adopted by the United Nations Global Geospatial Information Management (UNGGIM) Initiative [14]. The SSA will provide Sudapet and the Ministry of Oil and Gas with basic information and the Sudan National digital base map to be used as a base for all its geospatial information.

Today's geospatial systems require the use of accurate geodetic references and integrated geospatial information frameworks [11, 13] in Sudan. These frames are essential for geospatial data sharing, integration, and data exchange. This will help every Institution in Sudan, including the Ministry of Oil and Gas and Sudapet, to expand its capabilities to enhance data collection and management, raise the level of support for geospatial data activities, and provide solutions that enable the effective implementation of oil production operations.

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1. Sudapet National Company

Sudapet, a Sudanese company, was established in 1997 to become a leading national company and a strong technical and commercial arm for the government, Figure 1. Its main focus is on developing the oil industry, providing training for capable technical personnel, and transferring technical know-how to Sudan. Currently, Sudapet is reviewing its long-term strategy, which may have, a significant, impact on its future operations. To achieve its objectives the company, has set up several main subsidiaries, as shown in Figure 2, each with specific roles.

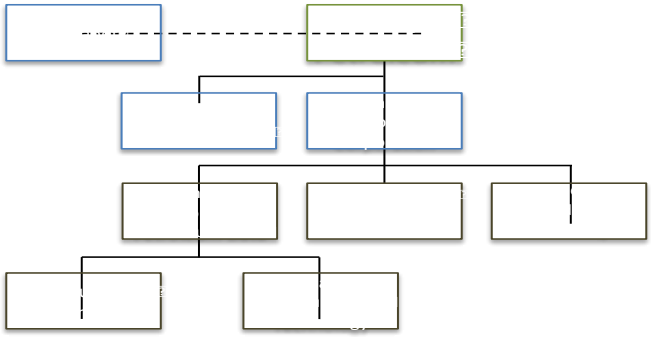

Figure 1: Main government stakeholders

Blue Nile Geophysical Company (BGC): is a joint venture company between the Bureau of Geophysical Prospecting (BGP) & Sudapet, is tasked to carry out specialized geophysical research and surveys, mainly 2D and 3D seismic and gravity data acquisition.

Blue Nile Processing Company (BPC): Its role is to process raw geophysical survey data, mostly 2D and 3D seismic data. A strategic objective is to transfer the necessary technology know-how to Sudan and train Sudanese staff.

Centroid: to provide engineering, project management, and operations & maintenance (O&M) services for the petroleum industry in Sudan. Essentially, it provides design consultancy services.

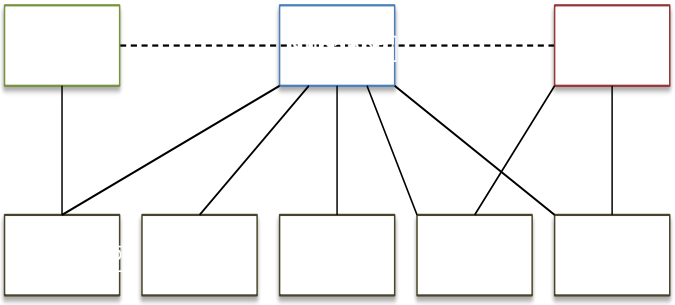

Figure 2: Sudapet & Subsidiaries

Asawer Oil & Gas: is a wholly-owned subsidiary of Sudapet, acting as a contracting company, covering the engineering, construction, procurement, and commissioning services to the oil industry in Sudan.

Petroleum Training Center (PTC): was established by Sudapet to provide high-standard training in the oil and gas industry.

Oil Exploration & Production Authority (OEPA): The role of the ministry is to generate new data, and to collect all data from the operating companies. WNPOC, among the operating companies, had progressed in the usage of GIS to the extent that it was integrating the specialized oil sector software suite (Schlumberger) with GIS, along with GNPOC who are also using GIS. OEPA faced difficulties with the national level basemap, and for this previously obtained assistance from the Sudan Survey Authority using the base maps at a scale of 1:250,000 dating from the late 1950s which were digitized (176 A0 sheets size) and then established as seamless datasets.

Operating companies submit proposals at various stages of their operations to the Ministry for approval. Where there is a need to re-conduct analysis using underlying spatial data, this technical assessment may be conducted at OEPA or Sudapet, on a case-by-case basis.

Petroleum Data Centre (PDC): The PDC was originally a department of the OEPA before being separated into a separate unit under the SPC. As such, PDC is an informative body, while OEPA is an audit and regulatory body. PDC's original mission was to provide integrated archiving and management of exploration and production data. As such, PDC is mandated to be the custodian of the nation's oil exploration and production data. Its specific scope is to plan, acquire, receive, register or inventory, prepare, load/store, publish, deliver, archive and dispose of the exploration and production data. In terms of its repositories, these should cover the full spectrum, including raw/original data, processed data, and final interpreted data.

In 1993, the Centre began collecting data from different companies. While data was previously collected on paper, more and more digital data is being collected. As the quantities of collected data increased, the lack of data standards began to appear. Until early in 2012, the bulk of the data collected by the Centre was geological and geophysical data, but since then PDC started collecting above-surface facilities, including pipelines and distribution companies.

PDC listed several examples of analysis or other operations that require data that are outlined below:

- Petrol station siting requires approval from Ministry of Housing and Ministry of Petroleum, and PDC wishes to use GIS to ensure an appropriate location;
- Need to calculate crude oil reserves, in terminals, refineries, in reservoirs;
- When deciding to do a new seismic line, they might find that it crosses an active agricultural area, which will entail compensation, and so if they had GIS data this allocation could be improved.

Organizationally, the Centre has different units responsible for different activities such as collection and verification of subsurface data; collection and verification of above surface data; GIS for analysis, Publish and dissemination of data. The Centre is expected to manage the following types of data: Seismic (digital, tapes, and hardcopies), Well Log (digital, tapes, and hardcopies), Unstructured (digital technical support and final reports), Geosample (physical), Production, Distribution companies, Pipelines, Refineries, Storage, and Facilities. Increasingly, the Centre requires data from other stakeholders. Such data varies from province to province, and from sector to sector, in terms of whether the data is available, is in hard or soft copy, is spatially defined or not, is complete,

and so forth. PDC collects such data directly from the different data custodians, as it is not available from any centralized body. Currently, the Sudan Survey Authority (SSA) offers effective solutions for basemap collecting, editing, storing, and delivering geospatial data and information. The Sudan National Base Map System (SNBS) will ensure the delivery of the geospatial information management system at an acceptable level of confidentiality, availability, and performance.

Figure 3: Base map interactions between the Sudan Survey Authority and the Clients

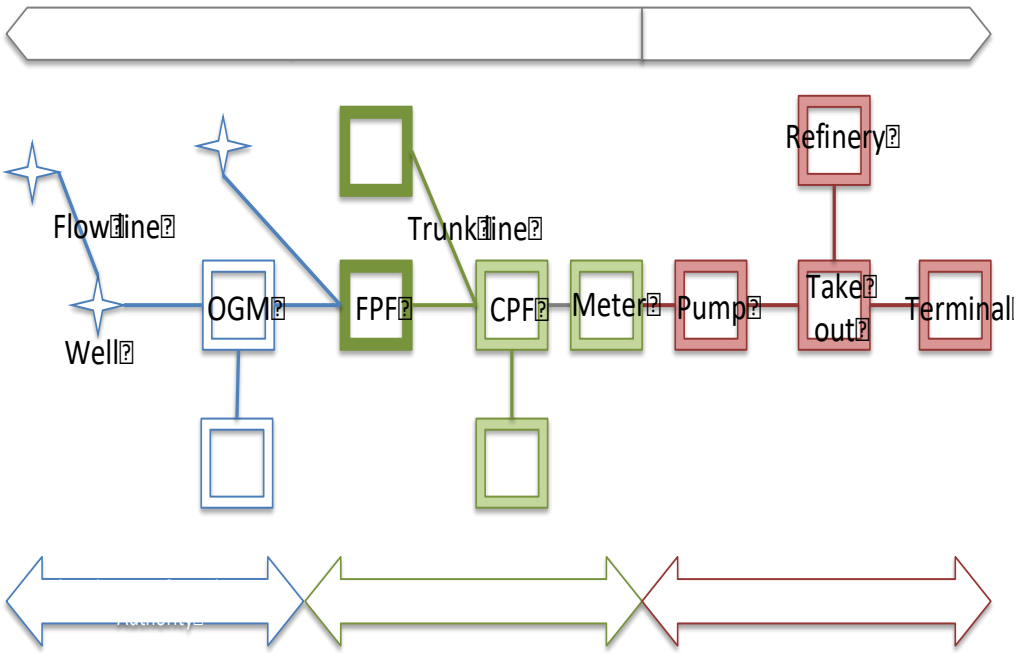

Figure 4: Division of Responsibilities

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Situation Assessment

The geospatial information management situation at Sudapet has been evaluated based on its structure, main functions, data, information technology, and staff skills. The review also includes aspects of other stakeholders in the oil sector.

The oil sector in Sudan is regulated by the Ministry of Petroleum (previously the Ministry of Energy and Mining). The ministry oversees the Sudanese Petroleum Corporation (SPC), which is responsible, for the day-to-day control of the oil industry. Sudapet, the main state-owned company, has been established to handle technical and commercial operations in this crucial sector. Regarding oil sector data, three entities within SPC need to be considered: the Petroleum Data Centre (PDC), Oil Exploration & Production Authority (OEPA), and the General Directorate for Petroleum Facilities, in addition to the Petroleum Pipeline Company.

Figure 3 illustrates the division of responsibilities of the Ministry's bodies across the various components of the oil sector, both upstream and downstream.

There are a number of concession areas, that have been licensed to operating companies, Figure 4 with the government holding shares in all of them through Sudapet. Figure 4 below identifies the concessions. Currently, there are nine concessions remaining in Sudan (awarded to APCO, Block E, CPOC, GNPOC, GSPOC, PDOC, PetroEnergy, STAROil, and SUDAPAK), although some may change and other new ones may be awarded.

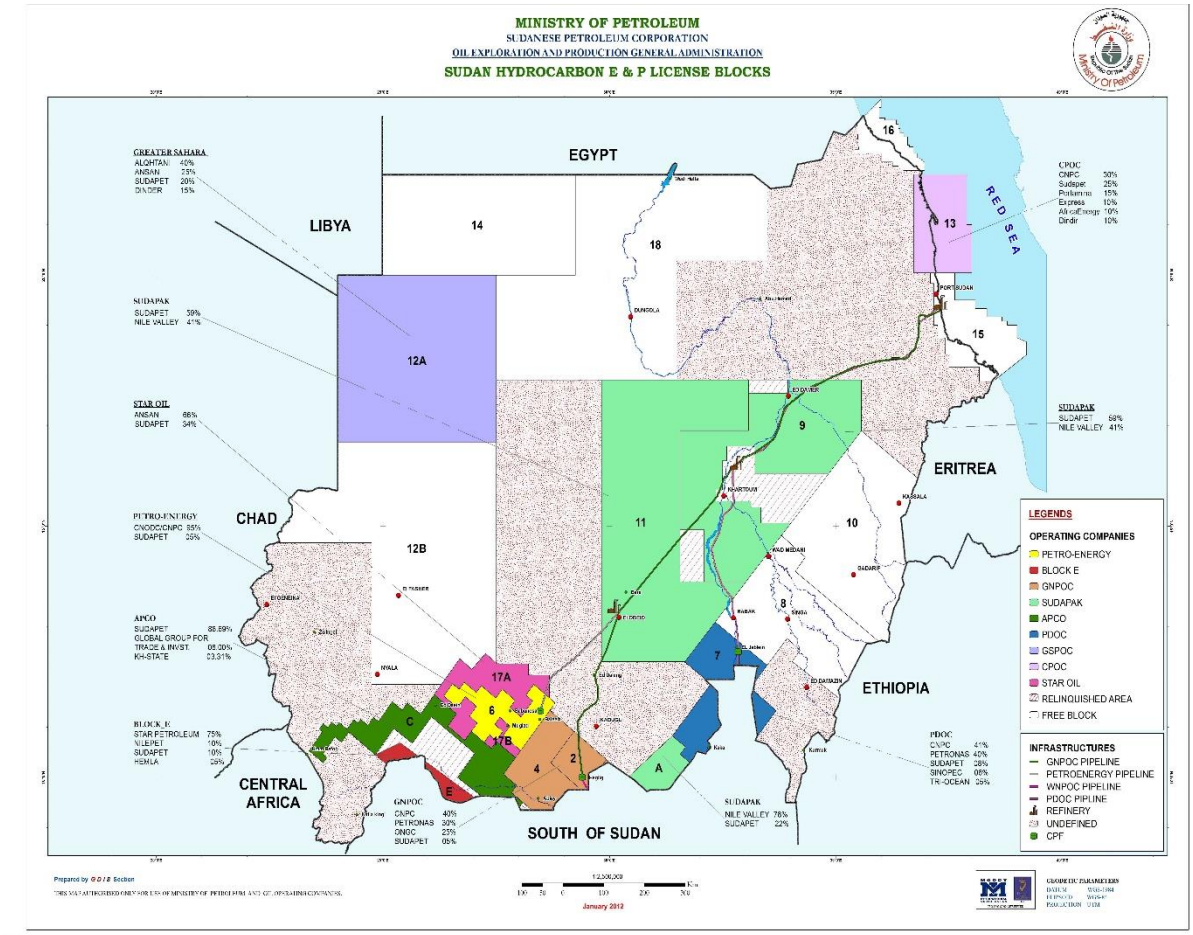

Figure 5: Concessions in Sudan

The Exploration & Production Sharing Agreements (EPSA) governs the relationship between the Sudanese government, represented by the Ministry of Petroleum, and the contractor, which is usually a group of companies including Sudapet, that are assigned a specific concession block. The agreement governs the relationship between the different parties, mainly the government, and contractor.

Any requests for data are formally processed on a case-by-case basis and usually proceed from the head of the requesting entity to the head of the supplying entity. The Unified Business Information System (UBIS) reflects a model of governance that ensures that all the different entities operating in the petroleum industry use a unified back office system that covers a wide range of services of which the most critical is the financial system. All companies, Sudapet and Sudapet subsidiaries, and operating companies are obliged to use the system according to the different agreements signed with the government.

The governance model also ensures fair cost distribution between the different system users based on the services used by each. Also, as some companies may need more services,

(that may need additional software modules), a committee representing the different members reviews the request and decides if others may also benefit from the service and distributes the costs accordingly.

Main Functional Areas

In this subsection, the main relevant functional areas at Sudapet, its subsidiaries, selected operating companies, and other state entities are discussed. This article reviewed the two core functional areas of Sudapet, along with certain support services of relevance, as:

(a) Exploration Department: The Exploration department conducts in-house studies and monitors and follows up with the activities of the operating companies. For a new area, geospatial data will be collected (airborne or ground measured) to execute a gravity and magnetic map to develop a configuration of the basin. The basin configuration is then used to determine where the 2D gravity readings should be taken and the parameters to be used for such readings [8,13]. Once the 2D readings are provided they are analyzed to define the structure, and then if a discovery or a prospect is made, 3D readings are taken, typically for a smaller area than the area that was surveyed in 2D. Geologists will then use the structure maps in order to assess the volumes. The economists use the calculated volumes and develop a feasibility model considering the various costs. Exploration wells will then be established, and based on hydrocarbons being proven; then the overall information will be handed over to the Petroleum Engineering department. The department uses or generates the following data sets: Block Boundaries, Gravity, Magnetic, and Reservoir boundaries, 2D seismic, 3D seismic, Exploration wells, Faults, Horizons, and Structure maps.

(b) Petroleum Engineering Department

The Petroleum Engineering Department is responsible for designing the best way to extract resources and is currently performing the work of the Production. The Production Department monitors the assets, both in terms of exploration and production companies. The main functions are:

Reservoir characterization and modeling. Ground modeling data and reservoir engineering data are collected, along with surface geochemistry and gravity data. These are mainly in the form of depth maps. This can also be helped with 3D seismic models. Wells data and their characteristics also assist in the modeling and interpretation. This output is then used by the reservoir engineers, who also look at the historical data to develop trends, allowing them to create production plans.

Reservoir management. Starting with the volume model produced by the reservoir characterization and modeling, along with data relating to fluid quality and type that comes from the wells, plus production history data and test data, analysis and interpretation are performed in order to understand the static and dynamic behavior of the reservoir. One of the functions is to determine the layout of the wells, a production allocation plan, and finally a reservoir strategy management plan (when to pump, how much, water injection, etc.). The main persons involved in this function are the reservoir engineers, petroleum technologists, and simulation engineers. It was noted that the well locations are generally based on subsurface conditions; however, GIS could be used to determine the ideal location of each well based on surface conditions.

Drilling and operations. Once each well has been determined, detailed engineering and operation plans are prepared, based on the different parameters such as the depth, whether the well will be vertical or not, etc. The engineering will address well casing, cementing, and other matters.

Service facilities. Sudapet facilities team is involved in both the engineering phase (design) to ensure that operations and maintenance requirements are addressed and included in the model. The objective of the facilities team is to ensure the reliability and availability of services. The team is also part of the hazardous operations to ensure that safety procedures are also addressed.

Economic modeling. Economic modeling is carried out by the economists. The calculated volumes of the reservoir and the drilling costs are used to study the economic feasibility of the prospect.

Asset management. Monitor the performance of the operating companies, which submit a plan at the beginning of the year that undergoes review by Sudapet before authorization, and progress reports every six months. The performance review may lead to a Full Field Review, which is a process to compare actual performance to expected performance that was obtained through modelling, based on which it may be decided to add more wells. The FFR is used to optimize the production from the field after production has started as the conditions may change during production.

A typical example of the workflow: Raw data is received from the Data Management for field development (i.e. not for new virgin areas). However, sometimes the seismic data is received directly from the operating companies and is first quality-checked before being passed to the Data Management subsection. When receiving the data, the data standard is checked (three standards commonly used in Sudan: (Schlumberger, CNLC, Chevron [8]). Next, the data is checked for its parameters (e.g. sometimes the measurement metrics need to change such as miles to kilometres) or for corruption, using a Windows-based program. In some cases files are converted into a text or LAS format. After the analysis, two types of data can be created at the vertical level (fault and horizon) while at the horizontal level a fault boundary is defined. All of these layers can then be used to create a structure map, which is typically sent to the GIS Section. The following datasets are used or generated: Block Boundaries, Reservoir boundaries, 3D seismic, Exploration wells, Faults, Horizons, Structure maps, Surface geochemistry, appraisal wells, Development wells, Master log, Core data and Reservoir Properties

(c) GIS & Data Management Section

The Section, part of the Technical Services Department, was established in 2009, as a standalone service provider. In the past, all the data requested by the different departments were provided by the subsidiaries and companies but after the section was created, it began to play the role of data channeling. The GIS & Data Management section is responsible to provide all IT related support for the geology and geophysical domains, covering hardware, software, networking, and data. The GIS & Data Management section is supposed to have 3 sub-sections:

GIS; Data management; and Asset data management.

The responsibilities of this Section are to provide services to all departments within Sudapet company, focusing on spatial data, including the acquisition of any data from outside parties for the Sudapet company, but not for subsidiaries or operating companies. The Section will identify human resource needs in terms of training. The following main Sudapet sections are outlined as follows:

a. GIS: Sudapet has been using GIS for a long period and has established a web-based GIS application to allow Sudapet staff to browse a wide variety of datasets and perform a limited number of analyses, such as profiling. This Intranet solution uses the ESRI ArcGIS Server platform. The fundamental oil sector data it displays come from the various stakeholders, in addition to some other data sets specific to Sudan's oil sector, as well as general reference layers that have been obtained from public sources. The GIS section assists other departments on a case-by-case basis, through the collection of supporting data, exporting of datasets that are specific to a project area, various types of analysis, and the preparation of maps and other visualization outputs.

b. Asset Data Management: The Asset Data Management collects and stores various information assets including Seismic data (geophysical data), Wells data (geological data), and non-spatial assets such as project reports, contracts, and studies. Currently, an in-house developed Microsoft Access application is used to catalogue all the different assets concerning the storage location of each asset (hard and soft copies). The system is believed to hold over 95% of the well's data and about 60% of the seismic data. The older seismic data, mainly for the past Chevron activities, were not properly maintained by the Ministry of Petroleum. At the time of development of the inventory, it includes approximately 2370 wells (out of an estimated total of 2500).

All the assets will be migrated to the e-Search system (a specialized Schlumberger system). The e-Search system will be accessed by different users across the company using a portal. The users will be able to locate and download the required data directly. If the digital data is not available or has not been loaded into the system the requester will submit a request to the asset data management team to access the data. The system tracks the users that "borrow" assets. The information, and soft data, are stored in a central location using a SAN storage device.

Upon arrival at Sudapet, the seismic data is distributed to the workstation team to perform the quality control checks. If the data structure is correct it is forwarded to the Asset data management team for documenting and archiving. If there are issues with the data the workstation team contacts the E&P team to correct the data. It was noted that there is no control procedure in place to ensure that the workstation team forwards the seismic data to the asset management team.

The asset data management team periodically issues a report on all seismic and well data that was collected during a certain period to cross-check with the Sudapet inventory. This is not a standard procedure and is dependent on individual initiatives.

(c) Data Management: The data management sub-section is concerned with using the e-Finder system, another Schlumberger system, where the administrators create the project workspace for any project team. The administrator also imports and adds the required core data in that workspace. The specific project team members then access the prepared data. The administrator privileges are only for the data management sub-section.

(d) Workstation Section: The Workstation Section, part of the Technical Services Department, is responsible for providing all IT-related support for the Workstation lab, covering hardware, software, networking, and data. Three departments use this lab: Exploration, Petroleum Engineering, and Production. The section is supposed to have nine persons, occupying four positions other than the team leader. The application engineers have a geology background but have received extensive training in the use of the specialized software, and assist the geology scientists to conduct their work. The hardware engineers are responsible for system setup and maintenance, while database administrators maintain the databases. The software data management tools at Sudapet include OFM, JASON, PIPESIM, TIMIS, ACCESS DB, E-Search, MERAK as well as others.

(e) Projects Department: The Projects Department is responsible for oversight of the tendering and construction of Field Surface Facilities (FSF) and other types of structures. The FSF comprises the well heads, trunk lines, flow lines or Oil Gathering Manifold, trunk lines (to field processing facilities - FPF), lines to the Central Processing Facilities, export pipeline networks, refineries, terminals, and all other surface facilities. As is the case with the Engineering Department, the department plays an advisory role, making recommendations, for works up until the construction is completed.

The department will use a wide variety of engineering design and construction drawings and documents at various scales, covering all FSF elements. In addition, the department relies on survey data, covering topography and geotechnical.

(f) Facilities Management Department: The Facilities Management department team; however 40-50% of their time is spent on supporting other departments in their activities. The team is composed of mechanical engineers, process engineers, electrical engineers, and instruments and control engineers. The department is concerned with overseeing operation and maintenance activities at the operating companies to ensure the integrity and availability of systems required for production.

The department monitors and tracks all above-surface facilities from the "Christmas tree" to the marine terminals. The upstream sections are from the entry point to the pumping station and the downstream sections are from the pumping station to the marine terminal, as illustrated in Figure 2. The Facilities Management department oversees the production and maintenance strategy where a production performance of 96% and above is acceptable. Some facilities require redundancy of 100% and the spare parts stocking policy is for two years. The normal practice is to stock spare parts for one year but due to the sensitivities in Sudan, a two-year spare parts policy is required. The operations part also involves monitoring the contractor selection strategy. Contractors may also be used for minor construction and maintenance activities.

The facility management team is involved in the DTR annual exercise with the operating companies where the detailed

operating company operational plans and budgets are reviewed. The review addresses what is to be done, for what reason, and the commercial benefits. Sudapet receives monthly performance reports that are reviewed against the submitted plans. The monthly reports are typically high level and the facilities team uses direct contact with the operating company for clarifications and follow-up, in addition to formal correspondence.

When the Projects team handover to Production the maintenance plans have to be available and in place. The handover includes as-built drawings, manufacturer reports, operations and maintenance philosophy and hazardous operations plans (which a focus on safety). The facilities team is involved in engineering (design) and projects (execution) activities in Sudapet. The team is also involved in cost savings proposals in the different operational phases.

The facilities department has embarked on a project to collect all facilities data from the operating companies working in Sudan. Much of the data has been collected and is yet to be loaded onto the e-Search system to provide Sudapet with a complete inventory of all facilities. There is no clear definition or specification of the data collected. Also, no maintenance or update policy has been put in place as of yet.

(g) Training and Development Department: The department undertakes three main functions:

- Contribute to the recruitment process
- Prepare a training and development program, which includes succession planning
- Implement a training and development program

Sudapet relies on two main training service providers. These are the Sudapet Petroleum Training Center, which provides the technical or 'hard' skills, and the Ministry Petroleum Training Center, which provides the 'soft' skills.

Generally speaking, the department does not utilize or generate any spatial data. However, the department expects that when developing a training program, it will want to first identify the staff that require a specific type of training, then establish where they are located, based on which they can then identify where the training is best delivered.

(h) Information & Communications Technology Department: The ICT department operates with a hybrid model. It provides certain services for the company as a whole, such as the network and communications infrastructure, and certain services like email. It also manages and maintains the servers and storage devices (SAN storage), although in the case of the Workstation Lab, the Workstation Section manages its infrastructure. Furthermore, the GIS & DM Section also manages its partitions on the servers, while the UBIS contractor manages the server partitions that are reserved for UBIS.

The ICT department is involved in certain aspects of the UBIS system. Most of the support for this system is outsourced to a company, and is paid for by all the entities that utilize the system, including all Sudapet subsidiaries and the operating companies.

(h) Quality Health Safety and Environment Department (QHSE)

Building on the role of Sudpet as the financial and technical arm of the Ministry of Energy and Gas, the QHSE department's role is to monitor and track all activities across the subsidiary companies that may have any environmental impact.

Sudan has issued environmental laws and regulations and all entities, including those in the oil and gas sector, should comply with them. The Ministry of Energy and Gas has the General Directorate of Environment and Safety as the regulatory body within the oil and gas sector. Although through the different agreements (including EPSA), the different companies are obliged to comply with local and international laws, that include the environmental laws, there has been a lack in enforcement mainly due to the many fast-track projects requested by the Sudan government. Very recently Sudapet has initiated projects that aim at addressing environmental compliance issues. QHSE at Sudapet has the following activities:

i. Environmental Compliance & Sustainability Data Management System

This is a project that is still in the early stages and aimed at installing a system for monitoring all activities that may impact the environment, collecting and comparing various measures against international and local standards. This monitoring system is to ensure that there is no impact on the environment, by monitoring the environmental status within the concession areas covering all upstream and downstream activities. There is a Sudanese law (under the Ministry of Environment) that requires the preparation of Environmental Impact Assessment (EIA) studies, and the EPSA states that operating companies should abide by all international and Sudanese laws. However, in practice EIAs are not always done due to the critical and urgent nature of the oil business in Sudan although in some cases the study may be done after the works are completed. The HSE is looking for ways to enforce this on the subsidiaries and operating companies, which will be done through the Ministry. The system will cover many aspects, including interpretation and visualization.

This system will use Monitor Pro (MP5), a UK software from EHS data Ltd. that has been approved by the Sudan Ministry of Environment, and will include easy to use tools that include both an in-built mapping tool as well as an option to link to other GIS systems. A vendor will install the software, while a local consulting company (Kaush) will assist with developing the parameters, data collection and implementation. The system will be installed at Sudapet headquarters, and it was also noted that QHSE has only engaged the ICT department in the process of acquiring the MP5 software. The GIS section was not involved, although the QHSE and the GIS section have cooperated on specific environment related studies in the past. The QHSE team recognizes that there will be need for GIS data and services. The department has linkages to the Ministry of Oil and Gas, of General Directorate of Environment and Safety, but currently there is no heavy involvement of the Ministry of Environment.

The system, when operational, will enable the different companies to directly enter readings collected from the field and will automatically send alarms if and when certain thresholds are exceeded. The solution will also provide analytical tools for studying historical data, and can also

automatically collect data from sensors that may be installed in the future. The software uses digital maps to reflect the locations for the different measurements. At the time of developing this article, there was no clarity as to where those maps would come from, or what their scale or content would be.

ii. Vehicle Monitoring System

Sudapet is implementing an Internet based fleet management system that will allow the tracking of Sudapet's fleet and employee transport vehicles, in real time on a digital map such as Google or other default maps. This is a cloud-based service provided by an external company (FM Telematics), currently covering all the company vehicles. The solution tracks the location and various telemetry readings from the vehicle to monitor the driver behaviour on various trips/journeys. The system is used to control and improve performance and reduce risks. Each vehicle is equipped with a GPS system that has a SIM card that uploads readings directly, while the system also allows for downloading the data from the flash drive that must be inserted in each vehicle. The system does not currently use detailed road maps where speed limits can be allocated as detailed road maps are not available. Currently the spatial street data does not have any embedded speed limit information, which requires that the Sudapet staff assign a single speed limit to each vehicle based on its expected usage, rather than relying on having the system track each vehicle against spatially-defined speed limits.

iii. Incident Management System

The IMS is a Sudapet in-house developed integrated browser-based incident management and reporting system, developed in collaboration with the ICT department. The system is basically a web reporting tool that all employees in Sudapet and its subsidiaries can use to report any incident or any risky situation such as:

- Accidents or injuries
- Complaints
- Dangerous occurrences
- Environmental incidents or breaches
- Near misses
- Audit non conformances
- Road traffic accidents

The system is currently in use by all Sudapet employees. The incidents are classified as Accident, Near miss, or Unsafe act. Any employee may register an incident and assign it to a specific person in a specific department for corrective action. The person reporting the incident can define the department to take the corrective action and the person to do it. The system alerts that person via email and the incident will be tracked till closure. The system should be extended to service Sudpet subsidiaries in the future. The collected data will be maintained in a separate database. There are no apparent plans for integrating with other systems although MP5 does allow for data exchange.

(i) National Information Center (NIC)

The National Intelligence Center was established by a special provision in 1999, amended in 2010. NIC is a government IT advisory body. The center works in several sectors such as infrastructure, applications, standards, promotion the industry of information, coordination between partners in ministries, governmental units, as well as institutions, and bodies in both private and public sectors, in addition to civil society organization.

Sudapet has received a set of documents (3 volumes) from the NIC on Spatial Data Transfer Standards (SDTS) developed by NIC.

This Spatial Data Transfer Standard (SDTS) provides a solution to the problem of transferring spatial data (ie geography and maps) from the conceptual level to the encoded details of physical files. Spatial data transfer involves modeling spatial data concepts, data structures, and logical and physical file structures. In order to be effective, the data exchanged must also be meaningful in terms of data content and data quality. SDTS addresses all of these aspects for both vector and raster data structures.

The base standard is in three parts. Part-1 addresses the logical specifications in terms of conformance requirements, a conceptual model, quality specifications, the data structure model, and the transfer format. Part 2 deals with data content by providing a standard list and definitions of spatial features and their properties. Part-3 specifies the implementation of SDTS in terms of the International Organization for Standardization for a Data descriptive File for Information Interchange.

The references listed in the SDTS documents indicates that a highly comprehensive research was conducted developing these documents and that international standards have been considered.

Volume 2 of the documents addresses the Utilities Geospatial Data Content Standards. The SDTS provides

a solution to the problem of spatial (i.e., geographic Utility systems currently lack a national geospatial data content standard for use in supporting engineering and life-cycle maintenance. This utility standard will benefit federal, state, and local governments, municipalities, and utilities that require standardized utility data content. This standard will provide new data sharing opportunities for the National geoSpatial Data Infrastructure (NSDI).

The purpose of this utility spatial data content standard is to standardize spatial information for utility systems. This standard specifies the names, definitions and locations for the parts of the hardware system that can be mapped geographically as feature types and their non-graphic properties. This Utilities standard is classified as a data content standard in the US Federal Geographic Data Committee (FGDC) Standard Reference Model.

This Utilities Standard is applicable for any system that captures or uses geospatial data about utility systems (i.e., compressed air, electrical distribution, electrical monitoring/control, fuel distribution, heating/cooling systems, industrial waste, natural gas distribution, desalination, stormwater collection, wastewater collection and water distribution) can be used to support life cycle management initiatives such as planning, design, construction and facility management (FM).

Although the SDTS does not explicitly discuss or define the petroleum industry specifics, (other from natural gas

distribution), it can be assumed that after a careful study of the Sudapet requirements, (Sudapet subsidiaries and even considering the field operations requirements), the SDTS models may be used and adapted to manage the different features such as all above ground facilities.

It may be noted that for oil pipelines there are three known data models. This may be beyond the scope of the Sudapet activities. However, as oil pipelines are critical assets, it is worth noting that out of the different models, (The Pipeline Open Data Standard (PODS, www.pods.org), the ArcGIS Pipeline Data Model (APDM, www.apdm.net) and PODS Spatial that differ from each other in both concept and execution), there is no "better" model. There is a need to understand the differences and select the most suitable for a particular organization.

The third volume of the SDTS is a Framework Data Content Standard Base Document.

The Geographic Information Framework Data Content Standard establishes common data requirements for the exchange of National geoSpatial Data Infrastructure (NSDI) framework data. The goal of this standard is to reduce the cost of obtaining, transferring and maintaining frame data for developers and users by creating a small set of data content elements and a common method for describing the data content.

The standard addresses eight core themes that are considered framework data of critical importance to the geospatial data infrastructure of the Nation, these are: 1. Cadastral Data, 2. Digital Ortho imagery, 3. Elevation Data, 4. Geodetic Control Data, 5. Governmental Unit Boundary Data, 6. Hydrographic Feature Data, 7. Transportation Network Data, 8. Remotely Sensed Data.

For each data object, it provides the data content with a high-level Unified Modeling Language (UML). The standard is divided into eight sections, one for each of the seven data subjects and a foundation document containing common information on two or more subjects.

For Sudapet operations almost all the addressed themes may be used, perhaps the cadastral data may be less critical as operations are commonly in rural and remote areas. The Framework Data Content Standard will improve and promote the efficient data exchange between Sudapet and other government entities that may be producing the data in addition to improving operational efficiencies.

The Geographic Information Framework Data Content Standard establishes important specification issues associated with geospatial data handling, processing, and management. These are:

1. Quality Conformance, Testing, and Evaluation.
2. Web Map Server Interface.
3. Data product specification.

(j) Greater Nile Petroleum Operating Company

The Greater Nile Petroleum Operating Company (GNPOC), one of the nine concessions in Sudan, is one of a few companies that is actually producing oil at present. As part of this rapid assessment, the focus at GNPOC was on data flow and management.

There are several units which are heavily involved in data. The first of these is the Technical Survey Department, which consists of five sections: Data Management Center, Geological Operation, E&P Planning, Geophysical Operation, and System Support.

The Data Management Center is responsible for geological and geophysical data. The Center is not responsible to store any interpreted data such as a reservoir boundary, fault, or horizon, although they do store a variety of reports.

The System Support unit receives data from the Data Management Center, and after quality checking it, it is stored in a master project file but in a lower resolution for seismic (usually 8 bit instead of 32 bit). After analysis and when a prospect is identified, this is provided in a SeeBase 3 file to the Ministry. These submittals will include reservoir basins, faults, horizons, structure maps, and other outputs, which will be the original format that they were prepared in (typically Geoframe and Petrel). GNPOC will send data directly to PDC, and Sudapet only receives processed seismic data but not original seismic readings.

The Exploration or Development groups will propose a new well, following which the Technical Support will first do a desk-based check to ensure that the location does not have any issues and if there are no obstacles, a field survey is conducted.

GNPOC operates an export pipeline, starting at their field Pipeline and proceeding to the sea terminals at Port Sudan. This pipeline is monitored and managed through a state-of-the-art SCADA control center, covering six pump stations, one terminal station, two takeoffs, and two other remote terminal units. The system runs on a Solaris 10 server. At the control center, data is stored both on the real time server and on a historic server using Sybase. SQL queries run queries on the historic data.

GNPOC has a number of tools to manage and/or view spatial data:

- GIS system
  - Well section. Users can filter and search for any well and then access the GIS to zoom into the AutoCAD viewer, or to access any reports related to that well
  - Seismic. Final navigation data, in other words the positioning of the shot points and the geophones, in SEG-P1 format, which comes from the seismic contractors
  - As built facility data. Over 11,000 DWG files
- From AutoCAD, one can identify a feature and then ask to see the report. This will then submit a query to the basic interface that will open having selected that feature in the database. From there one can pull up the reports or other available information.
- Production. Use a system called AVM (previously known as Avocet) to enter a large number of parameters, from the wells, OGM, FPF, and CPF. Here, SCADA systems are being used to capture the parameters instead of relying on human data entry.
- F2F is a tool used to push the AVM data to the Finder Production database, where it can be used in conjunction with other data to perform more detailed analysis
- Field view is a system that is used to update all well data, typically on a daily basis. The system can then be used to derive specific outputs or reports.

- A number of observations were made relating to data management practices and standards:
- GNPOC has its own well naming convention, which consists of two letters for the field, and then one or two additional letters (central, south, etc), and then a numeric digit
- The Data Management Center noted certain issues with data, such as integration, naming conventions, and formats. It was noted that the Ministry established a committee to look into such issues for around 4 to 5 years but no concrete outcomes were achieved
- GNPOC has some redundancy in data management, with different departments storing the same data
- GNPOC is starting to place standards on survey work and as built submissions
- Currently the construction contracts have no as built submission standards. Generally speaking, the PMC Project Management Consultant (e.g. Centroid) is expected to perform QC checks on as built drawings
- GNPOC data is provided to Sudapet upon request.
- There are situations where modifications to the facilities, including within the FPF and CPF are not documented in such a way that one can obtain an updated picture of the entire facility. In other words, each modification is documented by itself, especially if it required approval, but there is no updating of diagrams (for example) that might describe that particular facility. However, it is likely that any operations control software, such as DCS, would have their underlying data updated.

Geospatial Data

This section discusses various aspects related to spatial datasets used or generated at Sudapet, and to a certain extent at the other entities active in the oil sector in Sudan. Where the information was at hand during the interviews or available in a documented form, the rapid assessment attempted to identify the nature of the data (i.e. the metadata), what standards are applied, data management practices, and indexing.

Data Inventory

Given the non-availability of metadata for some of the dataset reviewed during this rapid assessment, only certain aspects are discussed. A lengthier and more comprehensive exercise would be expected to identify the following for each dataset:

- Method of compilation
- Level and method of updating
- Scale or resolution
- Source (in-house, other company, external, foreign)
- Projection and coordinate systems
- Geographic extent
- Accuracy (absolute, relative, vertical/horizontal)
- Soft/hard copy (vector, raster, simple scan)
- Problem areas.

Subsurface

Gravity. Created as point readings with x,y,z coordinates, taken either from aerial borne or ground based devices. Usually these are done for a whole block, but sometimes are done for part of a block. After a less dense scattered reading, another reading may be taken with a higher density. Raw data is processed by foreign specialized service providers. All this data is then provided to the Data Management unit. One of the problems is that the Data Management unit does not have all the data sets, and these may need to be requested from the operating companies. When the Exploration Department needs gravity data, they specify the block or field and the Data Management unit will supply it, along with a hard copy report. However, the reports are more available than the actual digital gravity data.

Magnetic. Same as gravity. There are places where magnetic panels will not be removed, but aggressive panels will remain.

Reservoir boundaries. These boundaries are interpreted using gravity and magnetic data.

2D and 3D seismic data. The Exploration department set the parameters for the data acquisition which is done by BGC, BGP, and ZBP. The data is then provided to BPC for processing based on specific parameters also established by the Exploration Department, and delivered in SEG-Y format. To date, there have been no problems with the SEG-Y formatted data received. There may be repeated readings for the same area, but this is mostly because older readings used less accurate technologies. Users that need seismic data will obtain it from the Workstation Section. 3D seismic data is the same as 2D seismic data except that it is collected as a grid.

Faults. Based on seismic data, the faults are interpreted both at a vertical level and at the horizontal level as a fault boundary.

Horizons. Based on seismic data, the horizons are interpreted.

Structure maps. A map of the subsurface where contours represent the elevation of a particular formation, reservoir or geologic marker in space, clearly displaying folds, faults and other geologic structures.

Exploration and appraisal well data. This raw data is either in ASCII or LAS format.

Master log. This consists of lithology, drilling data, and gas and oil data, delivered in a PDF format.

Core data. This is information interpreted in a lab about core samples taken while digging appraisal wells. This type of data helps derive the reservoir properties.

Reservoir properties. Water saturation and volume of clay, porosity, and permeability. Either in ASCII or LAS format.

Development well data. This raw data is either in ASCII or LAS format.

Above Surface

Block boundaries. These are administrative boundaries that represent the concession areas. Their boundaries are established by the Ministry of Petroleum, which is updated whenever there are changes to the blocks. Several versions of these dataset exist, both in terms of the different periods when such boundaries were established and subsequently modified, as well as official and non-official versions. Each block has attributes listing the partners and their respective share. This file was received without a projection but Sudapet added the Geographic WGS84 parameters.

Surface geochemistry. Surface samples are collected in the field and sent to the lab for analysis of their geochemistry.

Survey data. Survey data covers topography and geotechnical. There is no process in place to collect all survey data in one entity, and thus it is expected that such survey data is available

with the contractors that prepared the surveys and the operating companies that procured such surveys.

Design drawings. Drawings in different formats covering a wide variety of features, both for wells and above surface facilities.

As built drawings. Drawings in different formats covering a wide variety of features, both for wells and above surface facilities. It is believed that maybe more than half of as built drawings are actually design drawings and not as built drawings.

Sea Base

The data from the Sea Base project covers subsurface, above-surface, and non-oil data but is being listed here as a separate group as it was prepared through a single project. The Sea Base project (Structurally Enhanced View of Economic Basement) is one of four sub projects that were undertaken by the Exploration & Production Directorate and was conducted in 2009 in collaboration with external partners. The purpose of this project was to compile and provide a regional structural framework for oil exploration throughout Sudan, highlighting and analyzing the basement and basins evolution of the region. Through this project, a GIS database and associated metadata have been established comprising the following data, a few of which have been updated by the GIS subsection during the last two years:

Subsurface

The subsurface data contains the Basement composition, Basement terranes, Basement thickness, Basement beta factor, Basin depocenters, as well as the:

- Bathymetry. This is the ETOPO2 bathymetry dataset with a grid spacing of 2 minute resolution from the National Geophysical Data Center and is based on five sources, with the highest resolution taking precedence in any given area
- CRAP. Confidence, Reliability, Accuracy, and Precision map is an interpreted maximum confidence value at any x y location, using a number of inputs including mapped basement outcrop, basement well locations, seismic lines, cross sections, magnetic models, gravity models, magnetic coverage, and gravity coverage
- i-CRAP, Cross sections. Published cross sections were hyperlinked in the GIS, Crustal thickness, Earthquakes. Locations since 1973 recorded by the USGS, Fault density, Faults, Fields, Flow accumulation, Global heat flow. A compilation of global continental and oceanic heat flow measurements, Heat flow, Gravity. A combination of multiple gravity surveys stitched with satellite gravity data. Includes the Gravity_p, Gravity_r, Gravity models layers, high pass applied to Bouguer, low pass applied to Bouguer, 1VD of Bouguer, and Isostatic residual of Bouguer, Inferred heat flow, Magnetics. It is a stitch of multiple individual data sets, and includes Magnetics depth models, Magnetics_r, Compound anomaly of TMI, and First vertical derivative of TMI Modelling, Moho, Maturity, Sediment thickness, 2D Seismic, Crustal fracture zones, Volcanoes, and Wells. The compiled data from well and drill hole databases supplied by Sudapet. As the databases varied markedly in both database structure and the information they recorded, it was necessary to recompile each dataset to a common structure with a focus on the depth of the well and the formation, lithology and age at TD

Above surface

- Concession blocks
- Borders. Global data set
- Major cities. Global data set
- Pipelines. Global data set
- Railways. Global data set
- Rivers. Global data set
- Towns. Global data set
- States. Global data set
- DEM. From the SRTM30 global dataset with a 30 arc-second grid spacing (approximately 1 kilometer), flown in February 2000
- GRAS2004 surface geology. From the 2004 GRAS Geological Map of Sudan supplied in hardcopy and digital formats, and updated in block 14.
- Surface geology
- USGS surface geology
- Landsat. GeoCover Orthorectified Landsat Enhanced Thematic Mapper Compressed Mosaics, pansharpened, with a resolution of 14.25 meters and an absolute positional accuracy of 75 meters.

UBIS

The data that will be captured in UBIS covers subsurface and above surface assets. Although such data is being captured more for financial control purposes, it may however be possible to utilize the index keys of such data to relate it to spatially defined features and thus it is important to list this data here as it is expected to be a 'live' database that may prove to be very useful to the spatial informatics of Sudapet and other stakeholders. The rapid assessment did not provide any time to assess what type of data will be available or how it will be managed and updated.

Non-Oil

UN data. Around a dozen layers obtained from the Sudan office of the UN (freely downloaded from the Internet). These are mostly covering all of Sudan at a small scale. Some of the shape files have attributes, and these attributes may indicate the source at the feature level (roads, and settlements).

Digital Chart of the World. Very small-scale data covering boundaries, rivers, main roads, main cities, and other reference layers.

Environmental data. QHSE will be collecting certain types of information from operating companies, Sudan basemap, and at specified monitoring points, and the location of these points will be established. The information to be collected or shared will include Temperature, Soil, including its thermic conductivity, Topography, Road networks, Surface hydrology, Electric lines, Telecommunication lines, Settlement areas, and Vehicles.

Data Standards

Data content standards

Data content standards may cover several different topics. These are:

- Documentation about the actual content, such as a data model and data dictionary. No data models or data dictionaries were seen during the assessment. However, it is expected that the UBIS system will have such documents.
- The format of the data. There are no documented policies in place that define data content standards. However, in the subsurface domain, certain industry-standard formats have been essentially adopted as de facto standards and are commonly in use by all entities in Sudan's oil sector. These are:
- SEG-D for raw seismic data
- SEG-Y for processed seismic data
- ASCII or LAS for well data
- Acquisition, in other words the expected compilation methods, accuracy, etc. No set standards are in place that define acquisition, with the exception of specialized data such as gravity and seismic. However even in such cases, such standards appeared to be specifications that were issued by each client for each project, as opposed to a universal standard issued by the Ministry of Petroleum.
- Updating methods, frequency, etc. No set standards that define updating were identified.
- Data custodianship. According to the EPSA, all the oil sector assets are the property of the state. Presumably these assets include all types of data as well. However, the concept of data custodianship is different than custodianship in that custodianship includes responsibilities for the collection, maintenance, and disposition of data, and no documents were identified that defined custodianship in this manner.

Metadata standard

Metadata is data about a dataset, and metadata standards describe the manner by which each data set will be described in order to enhance its usability. Some of the subsurface data being used by Sudapet, as discussed above, adheres to an industry standard format and in certain cases these datasets have header (metadata) files. However, there are no metadata standards in place at Sudapet. Some of the datasets available at Sudapet's GIS subsection had feature-level metadata, in other words each record within the dataset would have one or more field identifying who created that record or when it was updated. Similarly, each record in the SDMP will have its own metadata file.

Spatial reference standard

There are no documented spatial reference standards in place at Sudapet. Such standards establish the projection and coordinate systems to be used.

Field data collection standard

Sudapet has recently completed its STSS initiative and one of the specifications is for conducting land/field photogrammetric surveys in order to compile topographic maps of property. It provides a number of specifications dealing with what to survey, benchmarks, record keeping, GPS notes, measurement accuracies, equipment calibration, methodology and monumentation. It also specifies that the results should be submitted in Intergraph Microstation version 5.0 format (in addition to hard copy). There is one detailed specification relating to GIS digital production (that contour lines should not touch or overlap), while also specifying digital file formats for 3D data, minimum text height when plotting labels, and mentions the need for symbols and patterns but without identifying any standard for them.

The specification document of one of Asawer's previous topographic survey contracts was sampled and found to be generally rigorous. It included a clear definition of the scope, a requirement for calibration of survey equipment and documentation thereof, measurement accuracies, survey procedures, some limited mapping requirements, and a requirement to submit the work in AutoCAD. However, there were no specifications as to how the data should be structured within AutoCAD, layer naming, attribution, symbology, or other possible specifications.

Data submittal standard

Data submittal standards define the structure, contents, and format of those datasets that are frequently submitted, especially as built drawings. The newly completed Sudapet Technical Specifications Standard includes one document, the "Guidelines For Preparation of As-Built Documents" standard.

The document discusses the AFC drawings, 3D model, and package contractor's AFC Drawings and 3D model. The guidelines discuss that site changes need to be marked on the AFC hardcopy and that these as-builts will be reviewed and stamped by Sudapet. The document also states that the contractor should also apply the changes on the digital documents. Although the submission of as-built documents does that hard and soft copies of the different drawings there no specific description on the formats or file data content or symbology.

Asawer's current as built drawing process is to indicate any changes on the Approved For Construction (AFC) drawing or to redline the change in AutoCAD and these drawings or files are then resubmitted to the client.

Map tiling standard

A map tiling standard is used to determine the optimum grid and index system to apply to raster files, which are very large, in order to ensure that network traffic is not overloaded and so that the user always views such raster files at a resolution that is appropriate to their viewing extent. Sudapet does not currently have large repositories of raster files that would benefit from a map tiling standard.

Symbology standards

Symbology or presentation standards define graphic symbols. They standardize the language for describing those symbols. There are no documented symbology standards in place at Sudapet. However, within the Exploration and Production domain there do appear to be common practices, such as color coding of prospects in the structure maps.

Other standards

The National Information Centre (Council of Ministers) has established some standards, as have the Town Planning (Ministry of Engineering Affairs). The following is a brief description of NIC and the developed Spatial Data Transfer Standards (SDTS).

Information Technology

This sub section discusses information technology, looking

at the software, infrastructure, and support systems in place to ensure a smooth functioning of operations.

Software

Sudapet and several of the stakeholders are using ArcGIS products (including Server), although the sanctions force the use of illegal cracked versions of these and other products. Also in use are MapGuide and Microstation, as well as AutoCAD. With illegal versions come certain challenges, such as not being able to use all extensions or modules.

However, the most significant use of geospatial tools are the specialized software packages for the oil industry. As for database management systems, Oracle and Microsoft Access are in use, while SAP is the underlying engine of the newly launched UBIS. The main operating system is Windows, although the specialized software packages are also used on Unix and Linux machines.

Geospatial data assessment

The assessment showed that, it became evident that the operating companies generate the bulk of the oil sector data and that there are also five public entities that need to access such data and which also produce limited amounts of data. These five entities are:

- Oil Exploration & Production Authority (OEPA), focusing on regulating the reserves, exploration and below surface activities;
- General Directorate for Petroleum Facilities (GDPF), focusing on regulating and/or managing above surface facilities, but not the export pipelines;
- Petroleum Pipeline Company (PPC), focusing on regulating the export pipelines;
- Petroleum Data Centre (PDC), tasked with archiving data;
- Sudapet, the technical and commercial arm of the government.

The EPSA and JOA provide the only legal and documented framework that could address responsibilities for data, but only in a very general way, and only as far as the responsibilities of the operating companies. The agreements focus more on maximizing the government's return on investment, without addressing the full role of data can play in increasing efficiency and protecting such investments.

However, the rapid assessment could not identify any clear or documented mandates as to the responsibilities of the five public entities, in terms of data. Some of the questions that require clarification are:

- Has the concept of data custodianship been established, and if so is it distinguished from ownership?
- Sudapet is taking a lead in seeking standards for oil sector data. What role if any will PDC have in this? Who will be responsible for enforcing such standards?
- PDC originally focused on archiving exploration and production data. This was recently revised to include "all data" but without any additional explanation. Is this to cover all above surface facilities, export pipelines, terminals, etc.?
- The entities that have regulatory powers need to access data in order to conduct their analysis and reach appropriate decisions, and in doing so they currently end up collecting and storing some data. Does their mandate require storing such data, or should that be left to PDC as long as data sharing tools and mechanisms can be put in place?
- With the exception of the operating companies, the other stakeholders typically require data and reports that relate to investments relating to exploration and production. The EPSA and JOA focus on subsurface data and reports but do not address above surface data, and more importantly do not address what are the responsibilities of operating companies for detailed operational data and records. The public entities are not expected to need detailed data for the operations and maintenance of all facilities, especially above surface networks. However, what are the detailed instructions that would govern what sort of records, data and related systems an operating company should hand over when their license expires or is terminated?
- If operating companies generate most of the oil sector data, who is responsible to ensure that it is in a format that satisfies the requirements of other stakeholders?
- Is the public entity responsible for archiving part or all of the sector data also responsible for providing access to other stakeholders to such data?
- If only part of the data generated is provided to the Ministry (whether to PDC or to others) for archiving, is there a retention policy for the other generated data that is not being provided to the Ministry?

One factor that may need to be taken into consideration is the fact that the five entities do not have the same chain of command, with three of them reporting to the Sudanese Petroleum Corporation, one reporting directly to the Ministry of Petroleum, and Sudapet being owned by the Ministry.

It is essential that all responsibilities that will shape well-functioning spatial informatics in Sudan's oil sector need to be identified, documented, agreed upon, and institutionalized.

TABLE 1: Outlines of the proposed Sudapet Geospatial Information working packages (WP)

WP No	Working Packages (WP) Details
WP 1	**Develop Sector Mandates:** The Sudan oil sector spatial informatics mandate must first be drafted. In collaboration with the stakeholders; Data Access Policy: While the mandates establish over-arching responsibilities, data access is an additional critical aspect that needs to be considered, especially when the oil sector represents such an important proportion of the country's economy and major foreign currency source. This is over and above the sensitive aspect of some of the data whether in terms of its commercial value or that it represents a critical infrastructure. **(Sudapet has to get use of reputed Oil companies experiences in this field and to make guide lines for the oil sector mandates)**
WP 2	**Develop Data Access Policy:** Once the Sudan oil sector spatial informatics mandate has been finalized, and once there is a stable sector-wide data model and the actual data sources have been identified, a process can be initiated with the custodians as well as the data consumers to develop a nominal assessment for each dataset (the feature geometry and its attribution) that may cover a number of factors. In consultation, a matrix would be developed listing all data sets and the factors that should be considered. The next step is to socialize this matrix with all internal and external stakeholders in order to complete the matrix.

	(The Ministry and Sudapet to work together to prepare a document related to this working package)
WP 3	**Identify Governance Structures:** There are a number of stakeholders, some foreign, operating in a competitive environment and in a market where the fluctuations in the price of crude oil require a constant focus on the bottom line. The following tasks are to be considered: A preliminary desk review which shall focus on the following aspects: The governance approach itself, in terms of hierarchy, jurisdiction, and authority; The types of bodies making up the structure; The stakeholders that are currently involved or expected to join; The envisaged arrangements for each type of body. **(The Ministry and Sudapet to work together to identify Governance structures by initiating overall Business Processing Re-engineering)**
WP 4	**Prepare Service Level Agreements:** It will be necessary to develop, adopt and disseminate a comprehensive framework for agreements with the stakeholders. The agreements shall consist of the instrument(s) to execute the mandates, policies, and governance that all stakeholders shall adopt. The main instrument is proposed to be a Service Level Agreement. Agreements are living documents that require management, both in terms of making modifications and monitoring their implementation. This will require the development of a Standard Operating Procedure (SOP) to ensure that the agreements remain relevant to any changing business requirements or circumstances, that any changes are disseminated and understood, and that their implementation is appropriate. **(Sudapet and each of its main stakeholders to work together to prepare SLAs that control their businesses.)**
WP 5	**Prepare Service Level Management:** A Standard Operating Procedure (SOP) is to be drafted that covers several areas: Executing an SLA by adding new stakeholders or adding/modifying/deleting datasets or services. **(Sudapet and each of its main stakeholders to work together to prepare SLAs that control their Mandates.)**
WP 6	**Refine Department Mandates:** An outline for the Sudapet spatial informatics mandate is to be developed in collaboration with representatives from relevant units. The mandate document can then be prepared, and then reviewed by all relevant stakeholders in one or more iterations until a final version is arrived at. **(Sudapet GIS department and the IT with participation of main stakeholders to form a working group to refine Department as well companies mandates.)**
WP 7	**Develop IT Strategy:** A core team from various departments at Sudapet possibly led by the ICT department would first agree on a broad outline of such a strategy, following which an initial draft would be prepared. The draft would then undergo review by a broad-based group within the company, and preferably some external individuals as well. If relevant, the Ministry's or SPC's IT group could also be included in this process. **(Sudapet IT department and its associated Partners to form a working group to develop IT strategy.)**
WP 8	*Workflows: Functions at Sudapet operate mainly on a project basis, with teams formed for specific projects with key focal points for each discrete area or domain. In parallel, departments operate separately (islands) even on initiatives/projects that may impact or be of interest to other departments. The rapid assessment did not identify any workflows that would indicate how work should proceed, along with roles and responsibilities. The following task is to Enhance General Work Procedures* **(Sudapet GIS department to lead Geospatial working groups and to make the detailed data inventory and to prepare all geospatial standards, working methodologies, quality control procedures.)**
WP 9	**Develop Detailed Data Inventory:** Samples of data generated or used by the various groups will be collected and compiled to an organized data sample archive. In this task, the information will be analyzed to evaluate the range of data required, and potential issues regarding data integration, automation and access. Characteristics of the data sources such as map accuracy and resolution, map scale and geographic extent, currency and quality, subject matter presented, and possible automation problems will be considered. Redundancy of data collection by different stakeholders, as well as inconsistencies between data sources of the same data theme will be evaluated. **(Sudapet top management to lead the development of data inventory in each Department as well as the main stakeholders)**
WP 10	*Data Model: A high-level data model in business or for any functional area is an abstract model that documents and organizes the business data for communication between functional and technical people. It is used to show the data needed and created by business processes.* ***(Sudapet top management to form a follow up entity with a power of giving instructions and time line to the Departments and working groups to finalizes their assigned working package's tasks.)***
WP 11	**Initiate a work group to evaluate and select a data model:** The work group will develop a set of criteria that must be satisfied by the data model. The work group will evaluate the data model most suitable for the Sudapet requirements. **(Sudapet GIS department to lead Geospatial working groups and to make develop oil industry data model taking consideration the adopted national GIS data model.)**
WP 12	**Task 12 – Develop Data Content Standards:** Each working group will be responsible for the development of a data content standard, following the agreed up on charter. Once a draft has been prepared, it will then be reviewed by all relevant stakeholders in one or more iterations until a final version is arrived at. Appendix 4 provides a template data content standard. **(Sudapet GIS department to lead Geospatial working groups and to make develop oil industry data content standards, taking consideration the international and the adopted SSA national standards.)**
WP 13	*Develop Metadata Standard: One working group will be responsible for the development of a metadata standard, following the agreed up on charter. The working group will first review different international metadata standards and develop a comparison of the differences between them, noting the areas where each of the standards is more relevant to Sudan's oil sector needs. The following standards and data models could be reviewed: ISO 19115, FGDC - STD-001-1998, PPDM, Energistics, SDTS, ESRI* **(Sudapet GIS department to lead Geospatial working groups and to make develop oil industry Metadata standards taking consideration the international and the adopted national standards.)**
WP 14	*Develop Spatial Reference Standard: A spatial reference system defines a specific map projection, as well as transformations between different spatial reference systems. Spatial reference systems are defined by the OGC's Simple feature access using well-known text, and support has been implemented by several standards-based geographic information systems (including ESRI software).* **(Sudapet GIS department to lead working group to adopt SSA geospatial Reference Standard (Datum) and to get or prepare the datum transformation methods and procedures to get use of the existing and future data in other Spatial Reference Systems.)**
WP 15	**Develop Field Data Collection Standard:** One working group will be responsible for the development of a field data collection standard, following the agreed up on charter. Once a draft has been prepared, it will then be reviewed by all relevant stakeholders in one or more iterations until a final version is arrived at. Appendix 6 provides a template for a field data collection standard. **(Sudapet GIS department to lead working group to *Develop Field Data Collection Standard*.)**
WP 16	**Develop Data Submittal Standard:** One working group will be responsible for the development of a data submittal standard, following the agreed up on charter. Once a draft has been prepared, it will then be reviewed by all relevant stakeholders in one or more iterations until a final version is arrived at. Appendix 7 provides a template for a data submittal standard. ***Task 16 – Develop Data Submittal Standard*** **(Sudapet GIS department in association with SSA to lead working group to *Develop Data Submittal Standard*.)**

WP 17	**Develop Symbology Standard:** One working group will be responsible for the development of a standard for different types of maps required by different sectors in Sudapet and subsidiaries, following the agreed up on charter. The working group could include representatives from the National Data Center, especially those persons that worked on the SDTS, as well as representatives from national entities responsible for survey and mapping. **(Sudapet GIS department in association with SSA to lead working group to *Develop symbology Standard*.)**
WP 18	**Develop Data Management Policy:** It is recommended that one of the working groups be formed specifically to develop and regularly update all data management policies and procedures throughout Sudapet. Once the policies and procedures are developed, this working group or a separate group will oversee any initiatives related to data management. The policy is expected to cover for each type of data that Sudapet receives or generates whether it needs to be updated or versioned, or is a one-off, and within that may also define how to handle time series. The policy will also include file naming conventions or guidelines, as one single convention may not be appropriate for a large organization covering a wide variety of data types, but maybe each major group of data types could have its convention. **(Sudapet Management, GIS and IT departments to form a working group to *Develop data management Policy*.)**
WP 19	**Create IT and Geospatial Group:** Create a group of information technology and geospatial technology professionals from Sudapet, PDC and OPEA (and others if required). This group would investigate and document the currently available infrastructure (hardware, software and communications) as well as planned changes in the future. **(Sudapet Management, GIS and IT departments to create Geospatial group.)**
WP 20	**Define Data Sharing Environment Requirements:** The group would define the data sharing environment requirements and assess the benefits and costs. This task should also identify the overall system operation responsibility and cost-sharing model if applicable. **(Sudapet Management, GIS and IT departments to define data sharing, data integration requirements.)**
WP 21	**Conduct Pilot Project:** A pilot project may be carried out involving Sudapet, PDC and OPEA to practically test the concept and applicability. The IT and geospatial group would assess, in collaboration with the different participants, the pilot project and recommend the final solution. ***(Sudapet to initiate a pilot project for the geospatial information implementation)***
WP 22	**Implement Solution:** The final stage would be to define the system specifications, secure the required budgets, go through the procurement cycle, and finally implement the solution. ***(Sudapet to initiate an implementation project with agreed applicable roadmap)***
WP 23	**Create IT work group:** Create an IT work group with members from the IT department and other IT persons providing support in the various departments. Other members will be required representing departments that use IT systems but do not have any IT personnel. The IT work group would work at identifying the information technology current and future requirements needed to support the business objectives, defining the appropriate set of standards that need to be adopted and implemented, and finally develop an IT strategy that would be approved by the top management. ***(Sudapet IT to initiate IT Working Group)***
WP 24	**Review current status and define IT SOP:** Create a work group with members from the IT department and other IT persons providing support in the various departments that would work at developing and defining IT related standard operating procedures that would recognize the business requirements, departmental working procedures and available IT resources.These procedures would include how the IT department would contribute in and be involved with defining and implementing a suitable petroleum data model. ***(Sudapet IT to review current status and to define IT Standard Operating Procedures (SOP))***
WP 25	**Develop capacity building plan:** Identify the IT skills required to support all IT operations, identify any gaps and develop an appropriate capacity building plan. **(Sudapet Management, to help GIS and IT departments to develop capacity building plans, Figure 6)**
WP 26	**Information Technology Awareness and Orientation:** This task will involve the design and deployment of an awareness and orientation program regarding the Sudapet spatial informatics strategic plan. It will be important that every level within Sudapet understand the basic purpose, objectives, and essential content of the strategic plan, at the level that will be most visible and the most impact to them. Such awareness will need to be developed at several levels in the organization and will need to address key components. **(Sudapet Management, to help GIS, Data Management and IT departments to initiate Spatial Information Plans and addressing the required awareness**
WP 27	**Institutional Performance Monitoring and Adaptive Management Orientation:** Once a detailed spatial informatics strategic plan is in place, monitoring its impacts and its various provisions will be important to gauge progress and make course changes in the future as the organization becomes more technology-oriented and new technological opportunities present themselves. To do so, Sudapet can benefit from adopting a systematic method for institutional performance monitoring and the adaptive management of the spatial informatics strategic plan and associated business areas over time. One of these that show promise is the "Balance Scorecard" approach. A program is conceived to introduce and test the application of this approach to support the monitoring and adaptive management over time. **(Sudapet Management, to handle the institutional performance Monitoring .)**
WP 28	**Executive Technology-Related Change Management:** This program provides a terms of reference for the development of an executive technology related change management program. This will be structured to address various levels of Sudapet managers, including unit managers, department managers, high-level executive management, as well as other external awareness building for managers among the stakeholder community. This is conceived as a yearly program to keep executives abreast of technology development in the organization, methods for leveraging these developments to further strengthen and optimize Sudapet business, and emerging technological innovations that may provide additional benefits in the coming years. **(Sudapet Management, to handle Technology-Related change management as per the requests from Sudapet Departments which will be based on working groups recommendations.)**
WP 29	**Spatial Informatics Training:** This task will address the need to develop internal capabilities at Sudapet to provide staff with selected training that has been customized specifically to address the issues and ways that professional staff think and work. This shall include providing training in the use of specific GIS, statistical, visualization and graphical techniques in support of specific activities. Including Basic usage; Advanced usage; Data management; Cartography; System administration. **(Sudapet Management, to approve geospatial Information Training as per the requests from Sudapet Departments which will be based on working groups recommendations, Figure 6).**

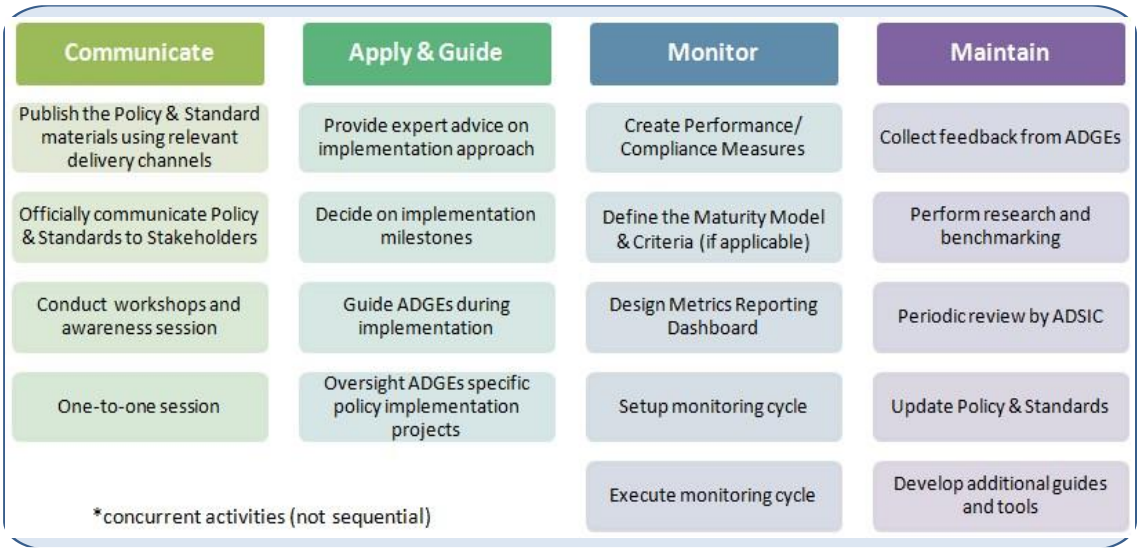

Figure 6: Implementation of governance consists of various activities

II. Conclusion

The main aim of the article is to outline the general approach for the development of Sudapet geospatial information system and to oversee the GIS and Geospatial data available within the oil industry community of Sudan as well as related government Departments. Sudapet illustrated that it follows a high-level GIS Road Map process and the available geospatial data will be grouped and classified.

Based on the previous studies and investigations, the authors recommend that, the Sudapet geospatial team has to be involved in the geospatial data collection, and to develop spatial and GIS standards and specification, to make an awareness to the oil industry sector staff about the importance of having a unified frame and standard, and look forward to data sharing and data integration applying international best practices. Here Sudapet has to focus and prioritize the developed outcomes of this study and to be organized into the five tracks and 29 working packages. The five tracks are: Sector Policy & Governance, Organizational, Geospatial Data, Information Technology, and Awareness & Capacity Building and knowledge transfer.

Sudapet and SSA are to standardize, and unify geospatial data within the Sudan Oil industry, getting use of the available data, to save resources, efforts, and time, without duplicating the geospatial data capturing, and to get use of the data through data sharing, data integration and data exchange, based on reliable strategic plan and road map for the future oil production.

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