



## IMPACT OF ICT IN OIL AND GAS EXPLORATION: A CASE STUDY

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### ABSTRACT

Information and Communication Technology (ICT) is of great importance to almost all aspects of oil and gas operations, from upstream to downstream operations. ICTs help to optimize oil and gas processes and thus improves the efficiency and viability of oil and gas operations. This paper presents the core areas of application of ICTs in the oil and gas industry using Nigeria's oil and gas industry as a case study.

### Indexing terms/Keywords

Downstream , Information and Communications Technology, Oil and Gas Operations, Oil and Gas Industry, Upstream

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## 1.0 INTRODUCTION

The Nigerian economy is currently supported by oil, which is the major non-renewable energy source. ICTs play an important role in increasing productivity and efficiency in many sectors of the economy. With the expectation of high oil prices, the question arises as to whether increased production and more equitable distribution of useful oil and gas energy resources are possible, through the use of modern ICTs. This applies mostly to developing countries like Nigeria. Oil exporting countries try to maximize the advantages of using ICTs, while oil importing countries are interested in using oil and gas more effectively. Thus, determining the impact of ICTs in the oil and gas sector can be used to better access the future economic development of developing countries. ICTs provide a means to improve both upstream operations (crude oil production and exploration) and downstream operations (transportation, refining of crude-oil and distribution of oil products).

Oil companies in particular adopt ICTs to improve the efficiency and effectiveness of their operations, as well as to aid management decision making. This helps to strengthen their competitive positions in rapidly changing environments. Environmental, organizational, and technological factors are creating a highly competitive business environment in which customers are the focal point [1]. Furthermore, these factors can change very quickly. Thus, the growth of any company is tied to retaining loyal customers, improving productivity, reducing costs, increasing market share, and providing timely organizational response [2]. ICT is a major tool for dealing with these issues. Due to the degree of uncertainty in today's competitive oil industry, oil companies in Nigeria are operating under increasing pressures to produce more with minimum resources. In order to succeed in this dynamic environment, oil companies must undertake innovative activities such as improving operational processes and continuously reviewing competitive strategies. ICT has a high impact in oil and gas operations. For example, in upstream operations ICTs and related technologies may provide possibilities for expanding proven crude oil reserves, improving the rate of crude-oil extraction from existing wells, and providing further means to discover new wells [3].

## 2.0 THE NIGERIAN OIL AND GAS INDUSTRY

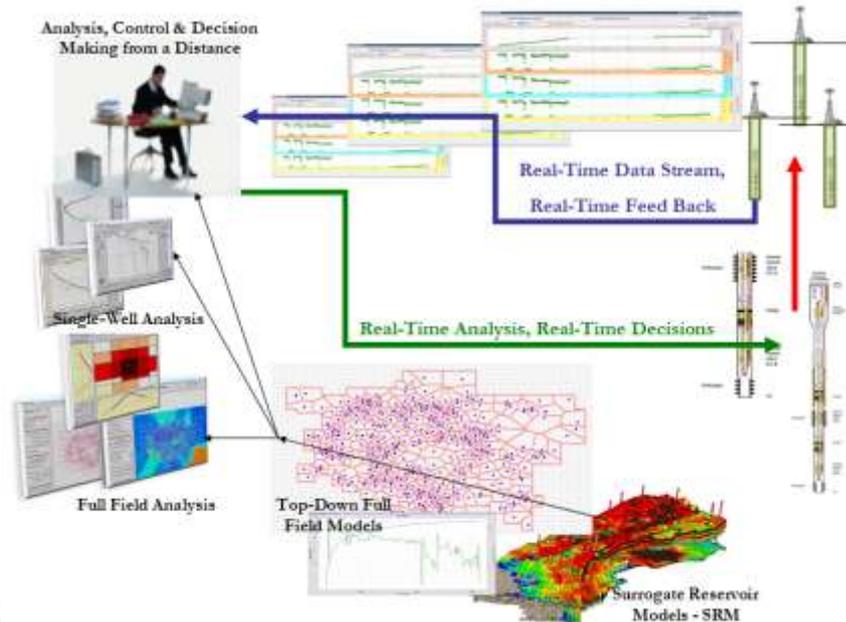
In Nigeria, oil and gas operations first began with the first commercially viable discovery at Oloibiri (Niger Delta) in 1956 by Shell. This period also marked the arrival of other oil multinational oil companies such as Gulf oil and Texaco (now Chevron), Elf Petroleum (now Total), Mobil (now Exxon Mobil), and Agip, in addition to Shell, which was already playing a dominant role in the industry. These other companies were also operating JOAs with NNPC, with varying percentages of stakes in their respective acreages. To date, the above companies constitute the major players in the industry, accounting for most of the total oil and gas production in Nigeria today [4]. The use of ICTs in the oil and gas industry in Nigeria is not only useful to the International Oil Companies (IOCs) in their quest to remain technologically relevant, but it is also useful to the National Oil Companies in Nigeria and other OPEC countries.

Nigeria produces only high value, low sulphur content, light crude oils - Antan Blend, Bonny Light, Bonny Medium, Brass Blend, Escravos Light, Forcados Blend, IMA, Odudu Blend, Pennington Light, Qua-Iboe Light and Ukpokiti. With a maximum crude oil production capacity of 2.5 million barrels per day, Nigeria ranks as Africa's largest producer of oil and the sixth largest oil producing country in the world. Nigeria appears to have a greater potential for gas than oil. Nigeria's gas production in the year 2000 was approximately 1,681.66 billion scf, 1.3715 billion scf was associated gas and the rest 310.16 billion was non-associated gas [5].

## 3.0 IMPACT OF ICT IN OIL AND GAS UPSTREAM OPERATIONS

Upstream operations include exploration and production of crude oil, and a major concern is how to extend the life of crude oil reserves in a bid to keep up with the increasing demand for oil, the upstream sector is facing the challenge of increasing oil production and improving the rate of oil recovery. This has led to Multinational Oil Companies (MNOCs) investing more in research and development, and as a result, improved drilling and extraction technologies have been developed. A key challenge is to get more oil out of existing oil fields through the use of advanced technologies that allow for real time visualisation of the oil wells and thus increase oil recovery. ICTs make it possible to collect huge amounts of data concerning oil fields, with manipulation of those data in models which support decision making with respect to optimal oil recovery methods.

Oil fields are becoming part of an ICT network, as all of them are increasingly connected through the internet and monitored in real time. All the components of oil fields, including the oil wells, pumps, pipelines, and oil rigs are interconnected, with each component having an IP address. The Nigerian Petroleum industry uses the computing capacity provided by major IT companies. These IT companies provide capacity to geoscience departments of MNOCs to manipulate data of oil wells using the 3D seismic technology which makes it possible to monitor changes in oil fields. Horizontal drilling of oil wells require accurate data manipulation. By using well logging devices while drilling, the data from the oil wells are transmitted to experts, who then judge and take action to ensure best practices. Formerly, logging was performed as the drilling tools were pulled out of the well. Now ICTs enable data to be read using sensors in the drill string, the data are normally digitally transmitted in real time to the monitoring offices. This is illustrated for an offshore oil platform in Figure 1 below.



**Fig. 1: Real Time Monitoring of Oil Exploration Activity [6]**

The oil exploration and production optimization department of oil companies are now increasingly responsible for running the Smart Fields. Shell developed the “Smart Field” program which is a holistic way of looking at production, reservoir management, and other technical processes. It aims to maximize the life cycle value of assets by integrated development and deployment of “Smart” capabilities. A smart field is one whose life cycle is continuously optimized [7]. Shell’s Smart Field philosophy is illustrated in Figure 2 below.



**Fig. 2: Shell’s Smart Field Philosophy (measure-model-decide-control loop) [7]**

A Smart Field implies remote control and operation of oil wells on a constant basis using the interpretation of near real time data captured by sensors that are installed within oil wells and obtaining information about various physical and chemical parameters of the oil well. Computer based models capture data not only from sensors but also from logging equipment and flow rate measuring equipment. All these different streams of data are integrated into a model that helps geologists, engineers and other experts to work as a team to find solutions to ensure the well’s optimal behaviour [8].

A smart collaborative environment is shown in Figure 3. The central part is the asset team, which is based in a central, mainly onshore location and receives data through servers in almost real time, thus enabling the situation in oil fields to be monitored. To take a decision, the team needs to collaborate with the remote desktops of geoscientists and call in experts. The so-called immersive collaboration centre reviews the process and gives feedback at a higher company-wide level [9].

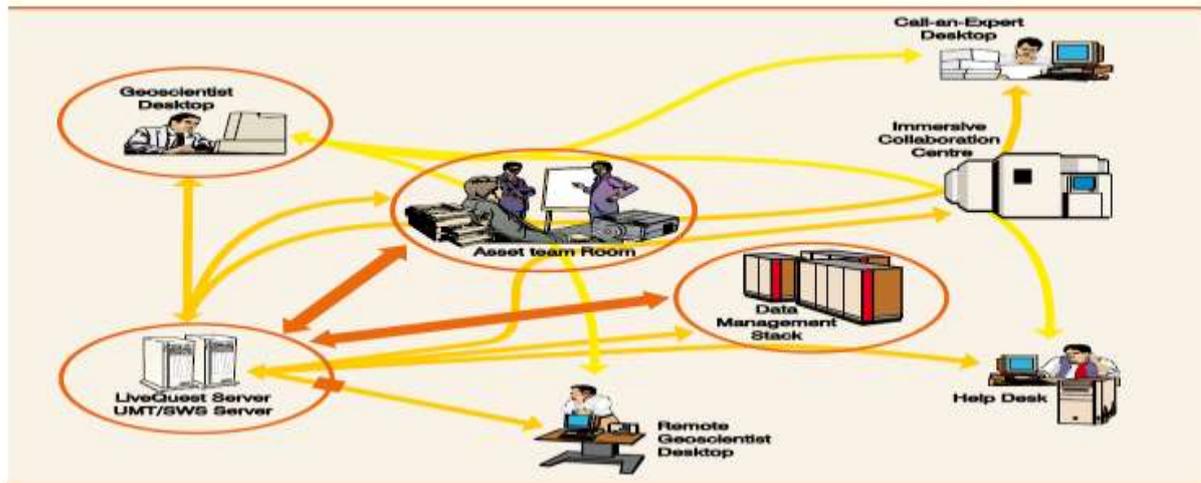


Fig. 3: An ICT-based Collaborative Environment in Oil Upstream [3]

### 3.1 Scada Technology For Upstream Oil Exploration

Scada is a type of industrial computer control system that can monitor and control large scale industrial processes that include multiple sites, and large distances. A SCADA system usually consists of the following subsystems:

- A human-machine interface (HMI) is device which presents process data to a human operator, and thus enabling the human operator monitors and controls the process.
- A supervisory computer system, acquiring data on the process and sending control commands to the process.
- Remote terminal units (RTUs) connecting to sensors in the process, converting sensor signals to digital data and sending digital data to the supervisory system.
- Programmable logic controller (PLCs) used as field devices because they are more flexible than special-purpose RTUs.
- Communication infrastructure connecting the supervisory system to the remote terminal units.

Most control actions are performed by RTUs or by PLCs. The feedback control loop passes through the RTU or PLC, while the SCADA system monitors and supervises the overall performance of the loop. Data acquisition begins at the RTU or PLC level and includes meter readings and equipment status reports that are communicated to the SCADA host as required. Data after compilation is formatted in such a way that a control room operator using the Human Machine Interface can make supervisory decisions to adjust or override normal RTU or PLC controls. A HMI is the device which presents process data to a human operator, and with which the human operator controls the process. HMI is normally linked to the SCADA system's databases and software system to provide data and management information. The HMI system normally presents the information to the operator graphically, in the form of a mimic diagram. Thus the operator can view a schematic representation of the plant being controlled.. Figure 4 below is a diagrammatic representation of a simple PLC/SCADA system that supervises and controls a pumps flow rate.

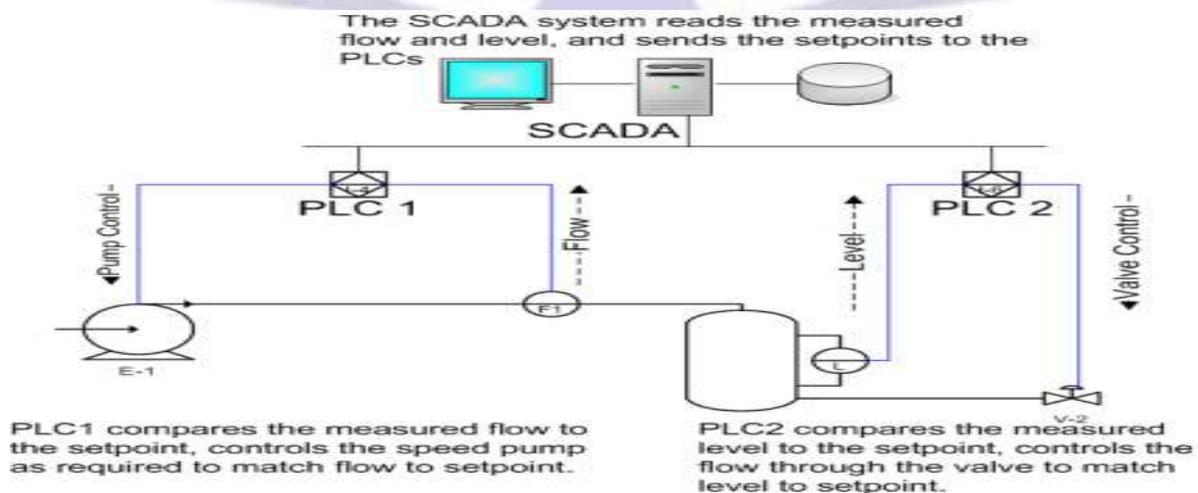


Fig. 4: PLC/SCADA System For Supervision and Control Of Pump Flow-rate [12].

Oil pipelines, rigs, pumps and platforms are monitored by ICTs and interact by relying on large amounts of high-technology inputs, such inputs are gotten from exploration, drilling and production operation using SCADA. SCADA makes it possible to monitor, compute, model, and take decisions on various levels of upstream oil operations. SCADA can be applied to various aspects of oil and gas operations. Applications can be found in upstream areas such as well monitoring, downstream in areas such as pipeline operations, in trade by managing the fiscal metering/custody transfer operations and logistics in application such as inventory management of tank storage facilities [11]. Telemetry is often used in combination with SCADA, being the process by which data is collected and actions are performed remotely via a suitable transmission medium. Due to the remote location of oil-fields outside the network coverage of main telecommunications networks, in order to have access to sufficient bandwidth, most oil companies rely on the services of satellite telecom providers to link all their oil-fields and manage them from a central location. A dedicated satellite communication network as shown in Figure 5, for the SCADA application environment offers greater security and reliability.

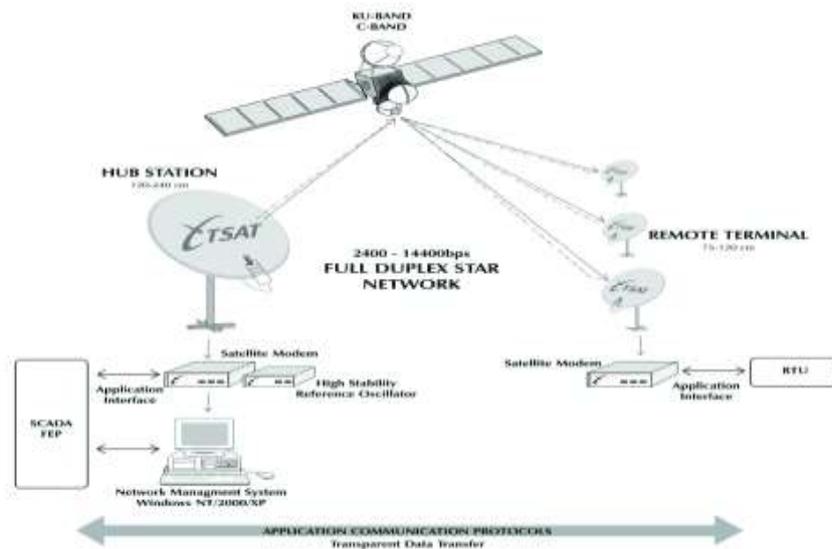


Fig. 5: A Satellite SCADA Network [11]

### 3.2 Impact Of Ict In Oil And Gas Downstream Operations

Downstream oil operations include transportation and refining of crude-oil as well as marketing and distribution of its end products. ICTs allows for the storage and manipulation of the different levels of data on purchasing and delivery of crude-oil, refining and distribution of end products. Those data include crude-oil prices, inventory, delivery costs, and so on. ICTs are used in refineries to aid technological processes and to increase the yield of oil products with minimization of harmful emissions. In transportation and distribution, ICTs prevent losses and helps to optimize the stocking and final delivery of oil products to end users.

### 3.3 Ict Use By Multinational Oil Companies In Nigeria

The Federal Republic of Nigeria is the largest oil producing country in Africa, and one of the largest oil producing country in the world. The Multinational Oil Companies (MNOCs) involved in oil exploration in Nigeria include Shell, Chevron, Exxon Mobil, Total, and Agip. These companies are using modern technologies to improve the flow rates of existing oil wells. By using traditional and modern well and reservoir management techniques such as artificial lift, hydro-fracturing and water flooding techniques these companies achieve higher recovery rates from existing oil wells. Integrated production management software based on geological simulation models using 2D and 3D seismic data of the key fields [12], enable the MNOCs to identify those wells with the greatest potential and to allocate drilling, hydro-fracturing and lifting resources to maximize the net present value of production in each field. These MNOCs use VSAT (very small aperture terminal) satellite communication technology to provide network coverage for mobile field operations and remote oil fields. The satellite communication technology helps to relay information from oil rigs and platforms and thus enable remote monitoring of drilling operations. The MNOCs continuously invests in developing and improving the information technology knowledge of their workforce so that they can better adapt to new technologies. Figure 6 gives a summary of the use of ICT by oil companies in Nigeria.

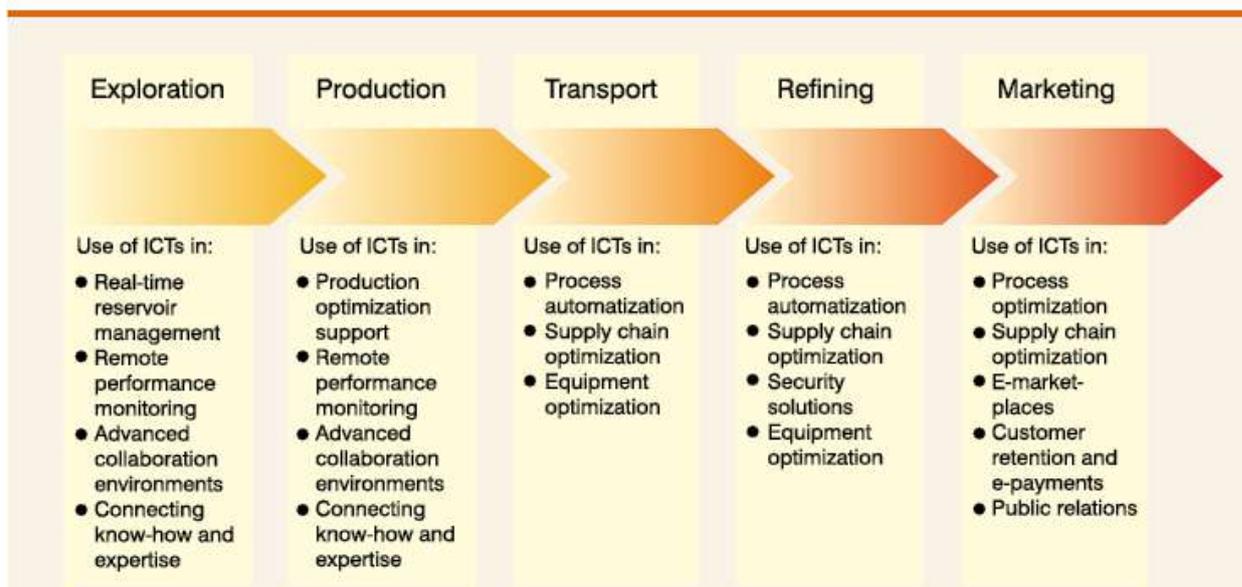


Fig. 6: ICTs use in the Oil Supply Chain [3]

## 4.0 CONCLUSION

Crude oil will continue to play an important role in the future world energy balance for decades to come. Improved use of ICTs and related technologies in the oil and gas sector can help to solve the current difficult situation regarding oil supply in the world energy market and thus achieve a more efficient use of existing oil resources. ICTs and related technologies can help to discover new oil reservoirs, with greater accuracy and also lead to more efficient oil extraction from existing fields. Consequently, oil and gas industry stakeholders should adopt a longer term strategic approach, including increased Research and Development efforts in the oil sector geared towards developing and implementing new and valuable ICT solutions for the oil and gas industry.

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