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Digital Oil Field

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ABSTRACT

Digital oil field (DOF) system is mainly focused on wells, production, and operations; but now expanding into field decisions and management. The integration of the production systems' models with the reservoir models is growing in order to optimize production and recovery. Digital oil fields integrate technology, information, people, and processes to maximize asset performance and value across the oil and gas production life cycle. The purpose of digital or smart oilfields solutions is straightforward which are: to optimize production, improve operational efficiency and to increase productivity through integrated workforce. This paper represents an introduction to digital oil field.

KEYWORDS: *Real time system, artificial intelligence, upstream oil and gas, DOF system, deployment, engineer, IT, Information management system*

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INTRODUCTION

Some years ago, it was just the use of a machine for a particular exploration undertaking but has now widened to encompass automating and integrating a huge range of tasks across many aspects of the exploration and production cycle. The concept of digital oil field (DOF) is based on leveraging on the benefits of modern IT, automation, communication, operational efficiency, decision support, workflow automation, data integration, collaboration and production optimization. Benefits to be achieved include: empowering the workforce to be more productive, harnesses the data obtained to inform better operational decision etc.

HISTORY OF DIGITAL OILFIELD

According to some sources, the Azerbaijan capital of Baku was home to the world's first oil fields, which was established in the 9th century to produce petroleum naphtha, an intermediate hydrocarbon liquid, as shown in Figure 1. The local use of oil dates back to many centuries, with the modern petroleum industry along with its outputs and modern applications are of a recent origin. Petroleum is known to play a major role in politics, society and technology, taking roots in the coal and kerosene industry of the late 19th century. One of the earliest instances of this was the refining of paraffin from crude oil. Abraham Gesner, developed a process to refine a liquid fuel (which he later called kerosene) from coal, bitumen and oil shale, which burned more cleanly, and was cheaper than whale oil. The world's first refineries and modern oil wells were established in the mid-19th century, with the two giants petroleum industries were the United States and the Russian Empire, specifically that part of it that today forms the territory of independent Azerbaijan – producing 97% of the world's oil over the course of time in the 19th century. Azerbaijan drilled its first oil in Bibi-Heybat in 1846, more than a decade before the Americans discovery of oil in Pennyslvania by Edwin Drake in 1859. By the beginning of the 20th century, more than half of the world's supply of oil was produced by Azerbaijan [1, 2].

Digital oil field has seen the emergence of technologies that can increase the life of well, ensure extraction from previously unrecoverable wells, improve safety and provide so much real-time data –

this started about 30 years ago, as displayed in Figure 2.

Pre-1980s: 2D seismic testing-multi-lateral well drilling – Horizontal drilling and 3D seismic testing were the first big technologies of the digital oilfield, which dates back to the mid 20th century. It was in the 1930s that the first horizontal drilling was drilled while a multilateral well was drilled in 1950s. During this time 2D seismic testing was widespread but the technology behind 3D seismic testing was deployed in 1960s and was considered too expensive, and was carried out in the US according to the US Department of Energy (DOE).

Post !980s: 3D seismic testing takes off – The advances in Computer allowed 3D seismic testing to become standard, opening up many previously inaccessible oil wells for drilling. In the US during the mid 1990s about 200 to 300 3D seismic surveys were carried out per year, as shown in Figure 3. This made it possible to "see" below the salt layers, covering much of the continental shelf in the Gulf of Mexico. Horizontal drilling was widely known but largely too expensive in the 1980s, most especially for independent companies.

In 1984: First completely steerable bottom-hole assembly – This technology was a precursor to the "drilling with a mouse" technology that would be envisaged 20 years later.

Late 1990s: Horizontal drilling became more affordable – It was untill late 1990s that a typical independent company could routinely drill horizontally. By the mid 1990s, 2,500 horizontal wells were being drilled each year worldwide. Horizontal drilling was found to be responsible for the 10 billion barrels of US oil reserves according to a DOE 1995 study at the time. The first horizontal well drilled in multilateral wells becoming the norms at the time, with more than 700 multilateral wells planned around the world in 1997.

In 2003: BP's Valhall field-seismic on demand – In 1982, BP's (British Petroleum) field started production and was the first to use a life field seismic system, with a network of permanent buried cables to record 3D seismic data, as shown in Figure 4. In 2002, BP was one of the early adopters of 4D seismic data, which emerged around the year 2000, and invested about $45m on 'seismic-on-demand' technology, which provided unprecedented potential to acquire high quality seismic data for reserviour monitoring. BP called the project Life of Field Seismic. In 2006, BP later added the same technology to its Clair field project, west of Shetlands in the North Sea. Exxon Mobil, in 2003 released its Fast-Drill Process, increasing the drilling process by 80% by the use of a continuous real time display of mechanical specific energy as a tool to enable changes in drilling parameters, to minimize the amount of excess energy being used which enables increased efficiency.

In 2005: Advancements in wireless technology – Wireless capabilities now provide the backbone of many digital oil field technologies. Through this technology, multiple automated platforms can be controlled from a central location, leading to reduction of personnel needed to monitor the individual platforms. This as well allows small, unmanned single pile platforms to be operated and controlled from a manned platform, as well as data to be transmitted from sub-sea level to the platform. The Wireless Maritime Services, a joint venture between MTN and Cingular Wireless, developed a new generation of wireless that replaced the conventional satellite very-small-aperture terminal (VSAT) technology traditionally used. The technology enabled wireless transmission via bidirectional microwave radios. This has led to the improved effectiveness and freedom of ROVs, which by this time were used as standard [3].

In 2006: Shell's Smart Fields Technology – Shell's Smart Field Technology, was first used at the company's Champion West Field, offshore Brunnel in the South China Sea in 2006, used sensors with fibre-optic cables to relay digital information on temperature, pressure and other field conditions to control centres – this enables engineers to continuously monitor production, make quick decisions on how to best extract oil, spot any problems like blockages etc.

In 2011: Managing data overload – A major challenge facing the digital oil field is the effective use and integration of all the data that is collected. In 2011 GE Oil & Gas launched The Drilling iBox System to do this. The Drilling iBox is a hardware/software solution that allows operators to turn existing data into useful information, such as reports and status updates for event sequence, cycle counts and both condition-based and predictive maintenance. To make relevant data streams more digestable, a range of visualization software from companies like Cyviz and VSG have been released allowing complex information to be converted to clear graphics that make the decision-making process easier.

In 2013: Kongsberg and BP Collaboration – Kongsberg in collaboration with BP in September 2013, announced the delivery of a new real-time well-monitoring and early warning system to support well construction operations as part of its SiteCom Well

Advisor software suite. This is the first of several similar systems of BP for evaluating the potential development and deployment to monitor a range of well activities and equipment, from drilling and cementing to blowout preventers. The project's aim is to turn raw data feeds into information that can be used in real time. The technology, which consists of a series of dashboard-style consoles, is, according to BP, already deployed in more than 20 offshore operations worldwide.

In 2014: Present and future digital oilfields – As at today, hundreds of technologies have been developed to improve efficiency, assist deepwater drilling and provide better information for improved safety and disaster response, improved information sharing and remote operations. Despite this, some companies are still facing challenges in rolling out digital oil field concept to all its operations and also managing effectively the increased amount of data being recorded. Shell already has keyed into the fibre optic wells and Advanced Reservoir monitoring, and also ensured that all assets have the "appropriate level of smartness" applied to them. BP has similar goals to roll out its Field of the Future Technologies across its assets. If oil price remains low, optimizing all this technology and wealth of data it provides for enhanced oil recovery, increased safety and efficiency will remain paramount.

THE DIGITAL OILFIELD

The digital oil field is a real-time digital presentation of a field on a computer which replicates the behavior of the field. This virtual field gives the engineer all the information required to make quick, sound and rational field management decisions with models, workflows, and intelligently filtered data within a multi-disciplinary organization of diverse capabilities and engineering skill sets. The creation of DOF involves 4 major steps:

1. Data gathering – this is the most critical in engineering projects as it helps to set the limits of what the model can achieve and cut expectations.
2. Engineering model review, update and benchmarking – this largely involves engineering models review and update, real-time data historian deployment etc.
3. System configuration and deployment – this develops the DOF system architecture and the engineering workflow setup.
4. Post deployment review and update – this would be ongoing, would involve action reviews, updates and resolution of challenges of the DOF, capability development by the operator and optimizing the system for improved performance.

The DOF system is to help to integrate, automate and streamline the execution of field management tasks to significantly reduce the decision-making turnaround time. It is to also ensure that operational and field management decisions can be made within minutes rather than weeks or months. The gains and benefits cut across the entire production value chain from improved operational safety to operational efficiency and cost savings, real-time production surveillance, optimized production, early problem detection, improved safety, organizational/cross-discipline collaboration, data centralization and efficiency. There are however challenges with the DOF system which could be at the planning, execution and post evaluation stages, as well as the selection of an appropriate Data Gathering and acquisition system, Parts interchangeability and device integration with existing field devices, high data latency due to bandwith, signal strength etc., damage of sensors and transmitters on wellheads during operations such as stickline and WHM activities, short battery life, maintenance, and replacement frequency etc. These challenges will impact on the project schedule and cost, but however, lessons will be learnt which will improve the DOF learning curve for any oil and gas company.

The advent of the 5G technology with its influence on data transmission, latency and bandwith has the potential to cut down the cost of automated data transmission and improve the performance of data gathering to further increase the efficiency of the DOF system. The future of DOF will further be strengthened by improvements in digital integration technologies, computing power, cloud computing and sensing technologies, as shown in Figure 5. Required is synergy between the engineering team, IT, and instrumentation engineers to fully manage the system to prevent failures from interface management issues. Battery life status need be always monitored to ensure continuous streaming of real field data. New set of competencies which revolves around a marriage of traditional Petro-technical skills with data analytical skills is required to further maximize benefits from the DOF system [4].

THE BEST WAYS TO ACCELERATE DIGITAL TRANSFORMATION IN THE OIL AND GAS INDUSTRY

Digital Transformation (DT) is now a critical and crucial aspect of the oil and gas industry. Digitalization in the oil and gas industry requires holistic transformations that will allow companies to quickly adapt to changing market conditions and remain competitive. The report by Accenture, stated that 70% of leaders in the oil and gas industry were of the view that enterprise-wide transformation is key to remaining competitive. The major goals of oil and gas digitalization include cutting costs, boosting output, and increasing efficiency while empowering companies to become more sustainable. Some of the digital tools used to improve oil and gas processes are the application of data analytics to optimize production, leveraging drones for exploration and maintenance, and applying virtual reality for staff training.

The following are the ways to accelerate digital transformation in the oil and gas industry [5-7]:

1. Breaking down data silos. In large companies, data is often spread across different departments, leading to missed opportunities and lack of valuable insights. The breaking down of data silos help integrate data from multiple sources and make it accessible throughout the entire organization.
2. Fostering a culture of innovation. Every step in the value chain in the oil and gas companies is defined by rules and regulations, which generally poses a major obstacle to digitalization in the sector. Decision-makers need to create the culture of innovation that supports the adoption of digital technologies such as machine learning, data analytics, the IoT, and blockchain. Also company-wide training programs should be put in place to ensure that staff at all levels clearly understand how these tools could improve their performance.
3. Implementing advanced analytics. This helps to quickly analyze large amounts of data from disparate sources, identify patterns, spot trends, and make informed decisions. The implementation of advanced analytics is a challenging process which requires significant expertise to develop the necessary algorithms and infrastructure. It must be carefully planned in order to maximize benefits.
4. Establishing technology partnerships. There is the need for oil and gas companies to collaborate with partners specializing in advanced technologies, such as cloud computing and analytics. This will help bring specialized expertise to the organization and gain access to cutting-edge technologies and tools.
5. Utilizing digital twins. These are virtual models of 3D representation of an asset. Digital twins allow you to simulate and optimize different aspects of operations, from production to pipeline management. One can leverage digital twins to quickly identify leaks or blockages, optimize maintenance schedules, identify potential safety hazards, and improve employee training by allowing staff to practice in a virtual environment before working with actual equipment.

TECHNOLOGIES FOR ACCELERATING DIGITAL TRANSFORMATION IN THE OIL AND GAS INDUSTRY

Some of these technologies are described as follows:

1. **Artificial intelligence –** Both artificial intelligence (AI) and big data make data analysis more effective and help to increase operational efficiency. One can leverage this technology to identify operational patterns, spot shortcomings, and automate various functions across the organization. The use of AI models is particularly beneficial in areas as: predictive maintenance, supply chain management, and safety management. It should be noted that AI requires significant investment and good expertise to implement effectively. British Petroleum (BP) is a company that actively uses AI and ML, and with partnership with Microsoft.
2. **Manufacturing execution systems (MES) –** This helps to provide accurate operational data, such as production rates and equipment utilization i.e. to facilitate the coordination of workflows and improve efficiency. MES is also able to track inventory levels in real time, thus minimizing waste and ensuring that required materials are available at the right time. It is also used to ensure regulatory compliance by tracking data and documenting all processes and procedures.
3. **Blockchain –** In this case, each asset would have its unique identifier and would be tracked on a decentralized ledger, making businesses to have a more accurate and transparent view of their assets, and making it much easier to track and manage them. Blockchain coupled with the industrial internet of things (IoT) platforms can be used to track the history of devices and ensure enhanced security. For example, blockchaih and IoT can be used by companies to track the movements of goods and ensure their authenticity. Shell and BP use blockchain-based trading platform called VAKT to facilitate trading in crude oil. VAKT is a joint venture of major energy companies, including, but not limited to, BP, Shell, Total, Koch, Saudi Aramco, and Chevron.
4. **Augmented and Virtual Reality:** In the oil and gas industry, the major applications of aurgmented reality (AR) and virtual reality (VR) is staff training. Since the oil and gas sector

require experienced workers, training workers offshore is expensive and dangerous process. The use of VR helps to solve this problem, as the VR headsets can provide workers with practical training without the need to visit offshore plants. AR & VR tools is an excellent predictive maintenance application. AR headsets can significantly improve maintenance efficiency by providing graphical information and step by step instruction.

5. **Internet of Things (IoT):** Connecting field assets to an industrial IoT platform with smart sensors, oil and gas companies can ensure automated monitoring and diagnostics. IoT-enabled sensors enable remote access to maintenance data on heavy machines that are installed for offshore drilling. This is especially beneficial in remote areas with extreme conditions. It can also be used to monitor pipelines, a leak, or other damages caused during oil and gas extraction, that can result in huge financial and environmental damage. IoT technology ensures effective monitoring of pipes, pumps, and filters in the system and provides real-time data to avoid possible leaks. Woodside, which is an Australian oil and gas producer uses IoT sensors and data analytics to improve liquefied natural gas production operations. The company leverages sensors to monitor key parameters, including pressure, temperature, and flow rate.
6. **Data analytics –** In this case, the large volumes of data generated during production process gives valuable insights that would help organizations to quickly identify inefficiencies and areas for improvement. Data analytics can be applied in supply chain management, predictive maintenance, reservior modelling, and production optimization.

CONCLUSION

There is need to accelerate digital transformation (DT) in the oil and gas industry that will involve the quick learning to adapt to changing market conditions, through the use of best industry practices, such as breaking down data silos, implementing data analytics, and establishing technology partnerships. It should be noted that DT in the oil and gas industry is not possible without the effective use of Advanced Technology, such as the use of IoT and data analytics and monitoring and optimizing operations, to leveraging AR and VR, and conducting employee training. The incorporation of digital technologies will help companies gain a competitive edge over others.

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FIGURE 1. MAP OF BAKU, CAPITAL OF AZERBAIJAN.
Source: https://www.worldatlas.com/maps/azerbaijan

Figure 2. Digital oil well.
Source: https://en.wikipedia.org/wiki/Oil_well

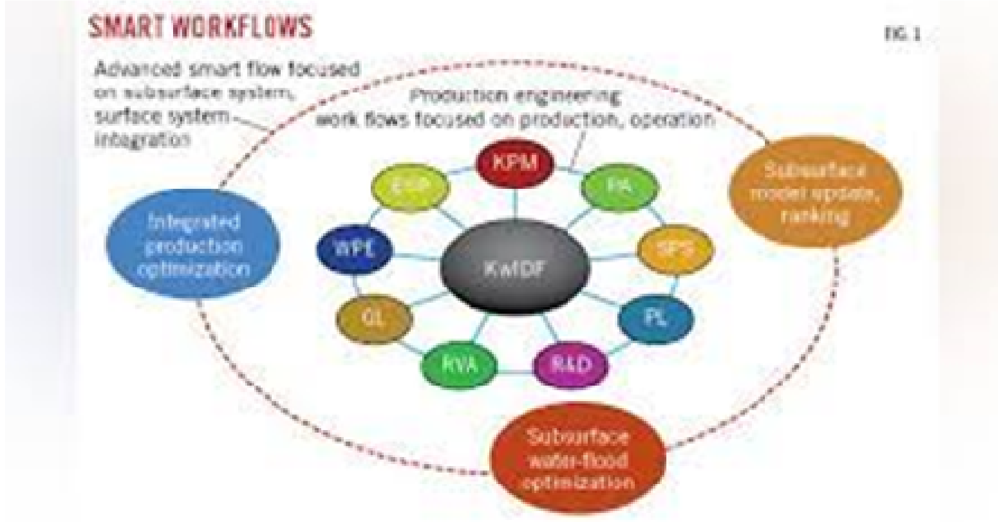

Figure 3. Digital Oilfield.
Source: https://www.ogj.com/pipeliness-transportation/pipelines/article/17232468/kocs-digital-oil-initiative-increases-north-kuwait-production

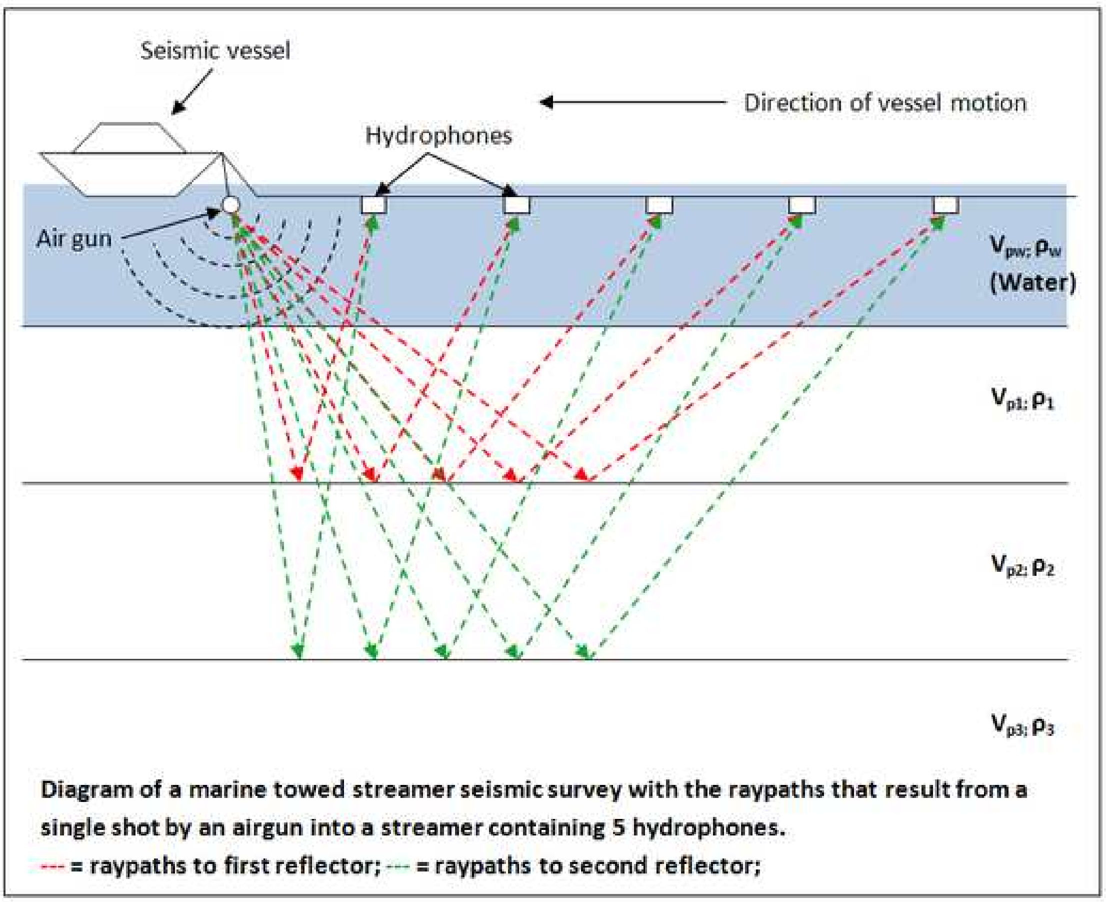

Figure 4. Seismic testing.
Source:https://upload.wikimedia.org/wikipedia/commons/0/01/Diagram_of_a_marine_seismic_survey.png

Figure 5. Oil drilling technology.
Source: https://en.wikipedia.org/wiki/Oil_platform