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A Critical Assessment of Digital Oilfield Implementations in the Middle-East

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Abstract

The digital era brings several enabling technologies such as the Internet of Things, mobile, and wireless technology networks. This, along with the low cost of oil and gas, is forcing Oil and Gas companies mainly, in the Middle-East, to invest in Digital Oil Fields. These Digital Oilfields fundamentally change the way oil companies operate and benefit by increasing operational efficiency and increasing production. The purpose of this paper is to investigate the technologies that make up a Digital Oilfield, look at the benefits and the challenges of implementing Digital Oilfields.

The research for this paper used a systematic review, where a methodical approach was used to collect secondary data from journal articles and conference proceedings.

Digital Oilfields use technology such as improved sensors, mobile and wireless networks, the internet of things, large storage capacity, and advanced analytical and modeling software. They integrate these technologies in a layered approach to increase operational excellence and production. Oil and Gas companies also benefit by improving organizational learning and breaking down silos, so information is easily accessed. This enables a creative and innovative culture and creates a competitive advantage that is not easily imitated.

Although Digital Oilfields Present Oil and Gas Companies with many benefits, they may face challenges during and after implementation. Due to Digital Oilfield's changing the way Oil and Gas operate, there may be changes in the organization structure. During the implementation, project management needs to be effective, and the governance of data and workflows must be enforced. Effective leadership is needed to ensure that there is a necessary change in the culture of the organization.

There should be further research to examine how the implementation of Digital Oilfields affects the lifestyles of employees and other benefits and challenges that might occur.

This paper looks at the introduction of digitalization in the Oil and Gas Industry through Digital Oilfields, which is not fully understood.

I. Introduction

A. Background

Digital Oil Fields includes real-time optimization and vast improvements in team integration and asset risk reduction through standard tools, domain experts, defined business processes, and appropriate facility or space (Udofia&Obong, 2018). The collaboration between all the discipline sectors in an operator company can alter how an Oil and Gas Company operates (Pickering &Sengupta, 2013) (Dickens et al., 2012).

Since 2016, the production of US Shale Oil has caused the global oil market to be a period of oversupply. This oversupply has caused a decline in oil prices and for many countries in the Middle-East and other OPEC member countries; this has led to lower earnings for their economies. There have also been significant capital expenditure cuts in exploration and production (OPEC, 2018). Due to these low prices, many companies seek to improve the efficiency of existing fields, upgrade aging infrastructure, and explore new areas (Modarress et al., 2016).

(Ajmi et al., 2014) believe that the countries in the Middle-East have economies that are sensitive to changes in the oil price. Kuwait, for example, where hydrocarbons account for almost half the GDP, has experienced a 3.5% economic contraction in 2017 due to OPEC related Oil production cuts as a result of low oil prices (Worldbank, 2018). Saudi Arabia also experienced a reduction in GDP in the 1st half of 2017 as the crude oil production was reduced due to an OPEC arrangement. (Worldbank, 2017). In 2017, Oman's economy was not helped back by low oil production and weak consumption, which caused a reduction in the GDP. (Worldbank, 2017).

Low oil prices are being considered the new normal (El Mahmah&Kandil, 2019). The available technology is allowing oil companies to invest in Digital Oilfields (DOF's) because of the automated approach to data management, routine tasks in obtaining oil field production, instrumentation, and equipment data. These new approaches lead to higher operational efficiencies, lower overheads, and improved production, which can lower OPEX and CAPEX for future investments (Gauder et al., 2017).

Research on the Digital Oilfield is noteworthy and relevant as the business model of Oil Companies change. Moreover, they have to overcome new challenges such as Major Skills Shortage in the Oil and Gas Industry; Oil and Gas discoveries in remote locations; Changing Technology Landscape; Reducing the HSE Risk; Improving Operational Efficiency and Fluctuation of Oil and Gas Prices (Udofia&Obong, 2018). Moon (2009) agrees that DOF's can help increase operational efficiency, operational cost

reduction, reduction in capital expenses, and increased reserves.

B. Rationale

Although the challenges are many, enablers have emerged that can be leveraged to ensure business objectives are met, such as Improved Sensors, Mobile Technology, and Internet of Things; High-speed internet; 'Big Data' and large storage capacity; Advanced Analytical Modelling Methods (Udofia&Obong, 2018).

As these enablers become more prevalent and cheaper to obtain, more companies will seek to implement digital techniques to optimize their operations. Understanding the benefits and challenges can aid these companies in the successful implementation of a digital oilfield. Kuusisto(2017) suggests that digitalization causes changes in the organizational structures, agility, learning, and enables different innovation processes.

This paper also uses the theories of Kuusisto (2017) to look at the organizational changes that may be affected by the implementation of digital technologies such as DOF's. It also analyses the organizational learning changes that may occur using the theories of Kuusisto (2017) and Peris-Ortiz, et al. (2018).

Using the framework described by Udofia&Obong(2018), as shown in figure (1), this paper describes DOF's in the context of People, Process, and Technology.

Figure 1: Showing the framework for the Digital Oilfield (Udofia&Obong, 2018)

Description of Each Chapter

This paper, which; critically assesses the DOF implementations in the Middle-East, is divided into sections. Chapter 1 introduces the topic and sub-topics covered in the research; it details the aim, objectives, and theories covered in the report. This will be followed by Chapter 2 provides a systematic review and uses a wide variety of quality articles, journals to describe a critically analyze the theories and concepts behind Digitalization, Digital Technologies, Digital Oil Fields and how it affects an organization. Chapter 3 shows the method of analysis used to research the topic's aims and objectives. It shows the search engines, websites, and journals used to obtain information on the topic. It clearly explains the evidence and findings. Chapter 4 is a discussion, which interprets the theories in the literature review and categorizes the findings in terms of benefits and challenges. It analyzes the data and theory and aims to fill some of the gaps that exist. The paper closes with a conclusion and recommendations. The aims and objectives are discussed, and the main arguments are highlighted to close the analysis. Suitable, Actionable, and Feasible Recommendations for successful implementations of a DOF are then listed; to aid in new projects.

II. Literature review

A. Digital Technologies Required for a Digital Oilfield

According to Hagberg et al. (2016), during their digitalization study of the retail structure, they defined digitalization as the integration of digital technologies into a business. It can involve the integration of internet-connected devices that can interface between the employees and data. Digitalization is the process of adopting and implementing digital technologies in an organization or society. These technologies have replaced paper with computers and are now using the internet as a global communication infrastructure (Legner et al., 2017). Parviainen et al. (2017) agree as digitalization or digital transformation changes the way an organization or business works on several levels, including process, where new tools are adopted and procedures streamlined; organizational level, where new services can be offered and obsolete practices discarded; and business domain level, where there can be changes in roles and value chains.

The previously introduced definitions all indicate that digitalization is the adoption or integration of digital technologies to a company or organization through internet-connected devices to use data to transform the way an organization operates through the streamlining and automation of processes, which can lead to organizational and business changes.

Digital technologies are key enablers to diversify and transform economies in the Middle-East, and many programs are on the way to deliver digitalization (Accenture, 2016). Many digital programs are now being implemented in the Middle-East, including digitizing oilfields, to make them smarter (McKinsey, 2016). (Deloite, 2017) indicates the many critical issues associated with implementing digital projects in the Middle-East.

B. What is a Digital Oilfield?

According to Pickering(2013), when an Oil or Gas operator company wants to implement a Digital Oilfield, they are interested in building collaboration and corporation throughout the disciplines and departments. Udofia&Obong (2018) states that a DOF is an Intelligent Energy concept; through standard tools, domain experts, defined business processes, and appropriate facilities, it optimizes the asset(s). It uses real-time production data and team integration to gain improvements in asset performance and risk reduction. Coffin et al.(2016) agree with Udofia&Obong (2018), stating that a DOF turns data acquired from the field into decisions that optimize the asset's or assets' value. These are achieved by fostering collaboration and corporation using tools and practices such as automation of tasks, data management, and integrating the data into models (Coffin et al., 2016).

DOF's are part of a comprehensive strategy to enhance oil and gas production using Digital concepts. It involves well instrumentation to provide enhanced real-time data; upgraded power and communications infrastructure to support the network of wells, well instrumentation, well equipment and streaming of data and the integration of collaborative decision hubs to enrich the asset team's integration and performance to shorten the observation to action cycle time (Jamal et al., 2013). As can be seen, a DOF is a significant consumer of information technology and requires the sourcing of reliable data, sorting and managing the data effectively and efficiently, and ensuring that it reaches the operational decision makers as quickly as possible (Pickering et al., 2015).

As can be seen, all writers indicate that a DOF is used to optimize the production of oil and gas assets the foster collaboration of domain experts through the use of standard tools and workflows. Implementing a DOF would require access to enhanced real-time data, power and communications, and workflows to use this data to make decisions. It uses a combination of People, Processes, and Tools to optimize the production profitability and lifespan of an oil and gas asset.

a) Digital Oilfields in the Middle-East

Petroleum Development Oman (PDO) is using a DOF connecting 2000 wells where real-time data is informing about Electric Submersible Pump Performance. They use diverse real-time data feeds into business rules to auto-generate Online Well Models. They have also developed Standard Operating Procedures (SOP's), which have been embedded into PDO's training for Production Operators and Engineers where rigorous scenarios are practiced in a classroom setting (Bimani et al., 2019).

In Saudi Arabia, Saudi Aramco has a DOF implemented to help manage their unconventional resource to achieve production excellence. The DOF provides cost-effectiveness acquiring data for accurate analysis, thus enabling production forecasting and collaboration among departments. The DOF collects real-time data, remote monitoring, and predictive analysis to help achieve production targets. It promotes decision support by relying on high input data, advanced analytics, and business processes. It also fosters better collaboration, data-driven decision-making, and accountability (Hamad et al., 2019).

In the Sabryah field in North Kuwait, a pilot project of 44 wells, representing 7% of the total well count, was tested using a DOF to explore the benefits. The project included implementing well instrumentation to provide enhanced well data, upgraded power, and communications infrastructure, creation of collaborative decision centers to automate work processes. This resulted in the improvement of the collection and accuracy of data, improvement of processes across different teams in varied locations, and improved effectiveness through automation to shorten the observation to action cycle time (Jamal et al., 2013).

C. Benefits of a Digital Oil Field

a. People

Organizational Learning

Martinez-Leon & Martinez-Garcia (2011) believe that for organizational learning to occur, knowledge generated from inside or outside of the organization has to be stored, exploited, and be involved in the performance. The knowledge includes information, interpretation of that information; it is a critical source of organizational belief and culture. Peris-Ortiz et al.(2018) agree, stating that organizational learning allows a company to improve its capabilities, behaviors by using its shared experiences and knowledge. Organizational Learning is strongly affected by leadership style and decision-making. According to Kuusisto(2017), digitalization affects the internal learning of a company by improving the access and analysis of knowledge, such as putting data in an easily searchable form. It can provide several technologies that can improve learning capabilities, data retrieval techniques, and search engines to identify and retrieve information from knowledge banks. According to Pickering (2013), the DOF fosters collaboration between all the operator company's technical departments. Udofia&Obong(2018) believe that for a DOF to be successful, the right organizational design and culture to nurture organizational learning must be in place.

Umans et al.(2018) highlight the improvement of life satisfaction of employees due to digitalization in the banking sector. Digitalization has a positive relationship with subjective well-being but with life balance and satisfaction. It shows that information management gives a positive relationship to life balance but not to job satisfaction. However, Larjovuori et al.(2016) believe that with the implementation of digital technology, there are expectations of mastering learning and mastering complicated technologies, which may increase workload and stress. There are also increased expectations of being available all of the time, and there is a blurred line between work and free time.

b. Process

Converting Data to Information and Knowledge

Dashti et al.(2012) believe that production reliability would be helped by instrumented wells that acquire well reservoir data, which would be fed into work routines that govern the processes. Coffin et al.(2016) believe that a DOF can streamline mundane processes by automating repetitive tasks and calculations; it can change how production engineers and technicians perform their duties. Using these automated workflows, data can be converted to information. It uses wireless sensors placed in the field, the Internet of Things, and broadband technology to enhance production surveillance from being a routine task to being exceptions.

Al-Jasmi et al.(2013) believe that DOF transfers, monitors, visualizes, analyzes, and interprets data in real-time, and therefore large quantities of data are converted into real-time information at the right time. The processes needed to do this include data integration, data federation, and software and workflow orchestration.

Coffin et al.(2016) believe that a DOF turns oilfield operation data into information and knowledge sharing, and this is done through the automation of tasks, integrating data into models, and fostering collaboration. The first method to foster collaboration is to share information and knowledge. To track information and create knowledge, data must be collected and managed via production surveillance. The status of the field must be known at all times, and if an incident occurs that affects the production, such as a shutdown or equipment failure, it will be known immediately a can be tracked until the situation is rectified. A database of occurrences and a ticketing system can be applied to help track the status of incidents (Coffin et al., 2016).

c. Tools and Applications

According to Jamal et al.(2013), implementing a DOF would allow an oil company to have improved instrumentation, upgraded power and communications infrastructure, and creative, collaborative decision centers. This allows the Oil and Gas Company to have the platform to increase the effectiveness through automating work processes and shorten the observation to action cycle. Udofia&Obong (2018) agrees that more modern technology can result in improvements such as advanced analytical models, revamped organizational models, and smarter supply chain process. As such Dickens, et al.(2012) believe the DOF can potentially alter the way an oil and gas field operates using technology to automate processes and aid in the decision-making process.

Challenges of Digital Oilfield Implementations

People

Organizational Structure Changes

Kuusisto (2017) believes that organizations' structure has been changed due to digitalization due to information being accessible and transparent, and available to all personnel. Kuusisto (2017) also believes that this allows the employee at lower levels to make more informed decisions. Foerster-Metz et al. (2018) agree that digitalization can give the management team many benefits and improve interaction with the employees. They also indicate that to reap these benefits, the organizational structure must be changed. However, Foerster-Metz et al.(2018) indicate that digitalization can affect the advancement of the careers of higher qualified resources. For engaged and not happy with the new collaboration and remote methods of DOF's and they feel threatened by the reliance on IT.

Leadership

Wiemers et al. (2014) indicate that leadership is critical for the effective deployment, uptake, and sustainability of digitalization projects. They also suggest that communication is another critical success factor. The culture of the organization also strongly affects individual learning, and sometimes the employees may feel threatened as their capabilities are challenged. DOF implementations also result in remote support, which reduces the need for a large field crew, although it increases team operational integration and situational awareness according to Udofia&Obong (2018).

According to Larjovuori et al. (2016), the leadership required for digital transformation success is transformational leadership, where members of the organization are involved in discussions about the development and competencies needed for the digitalization process. Top management and other departments must work collaboratively to define roles and responsibilities. The strategic leadership must construct a clear and significant vision for the digitalization implementation and execute the correct strategies. However, Sow (2018) believes that it takes more than one leadership style to implement digital technologies successfully and not significantly disrupt operations. Transformational leadership was essential and had a significant impact on employee motivation and creativity; however, it was not deemed the only leadership style necessary to implement a digital transformation successfully. Sow (2018) further states that leaders must enable a healthy organizational culture that promotes change and provides stability. Leaders must also show characteristics such as emotional intelligence, motivation, and empowerment to have buy-in from employees to implement digital technology.

D. Process

According to Martinez (2019), for digitalization to improve, there must be a willingness to improve the customer experience and process excellence in his study, where they examined case studies from varied industries. He believes that process excellence is a mandatory factor for the introduction of new technologies and that digitalization

can be implemented by using continuous improvement or by making radical changes, Business Process Re-engineering Martinez (2019). Hagberg et al. (2016) agree with Martinez (2019), stating that the integration of digital technology can mean the slight transformation of previously existing activities and processes and mean the introduction of new processes and services.

a) Governance

The first step to implementing a DOF is engaging the appropriate decision-makers and key stakeholders in the company. The domain experts are responsible for the establishment of standards, design, and governance process; they must align the BU's on the workflows and the development of the DOF (Bourgeois et al., 2015; Dashti et al., 2012) believes that to achieve the exploitation strategy, it is best to collaboration from an expert team where the data is controlled by rules input to an application engine that governs the automation at the well site.

Tools and Applications of a Digital Oilfield

The technology required for a DOF includes infrastructure, software that must be reliable and maintained. For a DOF to work, there is significant reliance on access to real-time data for all stakeholders to make critical decisions. The infrastructure required must be able to collect, transmit, convert data to information that must be visualized. It must allow the analyzed data and decisions to be delivered back to the field, and there must be an integration of application data and visualization tools. The software required must be able to deal with terabytes of data, allow collaboration between the disciplines, and have alarms and automated problem identification (Moon, 2009).

Udofia&Obong (2018) believe that improved sensors, the Internet of Things, communications, bandwidth, large storage capacity, and the ability to handle big data are now emerging as critical enablers used to ensure the success of a DOF. Although implementations and technologies can vary depending on various factors, the technology used for the implementation of a DOF are sensors, communications, complex algorithms connected to automated valves. Pande et al. (2010) suggest that a DOF is made up of sensors that send data to monitoring systems used to control the operations. The technology is made up of smart sensors, improved controls for the operating equipment, advanced communication, wireless technologies, connected information systems, software for collaboration. This technology allows the DOF to be managed from remote locations. These components of a DOF can be considered as enabling layers (Pande et al., 2010) as shown in figure (1). This is agreed to by Allen & Smith(2012), stating that there are four hierarchical architecture levels, which are made up of measuring devices, instrumentation; telemetry and automation; operations control, data management, and processing and business level. The measuring devices are surface and subsurface devices to provide data. The telemetry represents logic devices the can be used for data transfer and control. Software, visualization, data storage, algorithms, and automation programs are at the operations level. The business level is made up of higher-level visualization, reporting, decision support software, advanced analytics, and web-based applications.

In Kuwait Oil Company (KOC) Gas Development, group the DOF included components such as IT infrastructure, data management, business process and integration, visualization, security and system management software along with an architecture layer, which allowed scalability and interoperability (Dashti, et al., 2012).

III. Analysis

A. Systematic Analysis

The methodology used for this research was a systematic review where the literature was reviewed methodically, and the data collected was synthesized to retrieve the findings (Hanley & Winter, 2013). According to Hanley & Winter (2013), the systematic review will have the following characteristics: clearly stated objectives; detailed, reproducible methodology; a systematic search to find all studies that meet the criteria; an assessment of the validity of the findings; and a systematic presentation of synthesis and findings of the studies.

Three databases were used for searching for the relevant data, as shown in table 1. The following terms were used for the searches: 'digitalization' 'digital oilfield' 'digital oil field.' Table 1 also shows the number of records obtained from each database.

Database	Digitalization	Digital Oilfield	Digital Oil Field
Emerald	1901	19	2405
OnePetro	348	3098	11050
Google Scholar	20600	16900	276000

Table 1: Showing the search engines, journals and searches used to obtain articles for this paper

a) Inclusion Criteria

The inclusion criteria included all articles from 2009 to the present. The titles and abstracts were examined, and once they were accepted, the full text of the document was studied.

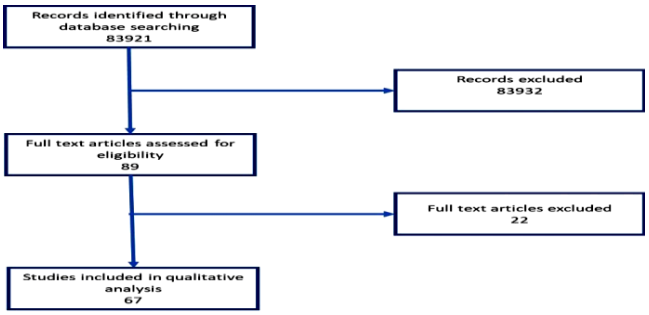

Fig 2

The selection process is shown in figure (2) and shows that the initial search resulted in 83921 articles from the various search engines. After the first inclusion criteria were passed, 89 titles and articles were studied, resulting in 67 articles and the full-text document studied. 22 studies were left out because they were not consistent with the objectives of the study.

Finally, data from the selected studies were extracted using the research objective and analyzed using a thematic analysis

B. Analysis of Findings

Topics		Literature
DOF Technology		(Udofia&Obong, 2018); (Jamal, et al., 2013); (Bimani, et al., 2019); (Feineman, 2014); (Desai, et al., 2017); (AbdulKarim, et al., 2010)
Benefits	People	(Foerster-Metz, et al., 2018); (Matzler, et al., 2018); (Wiemers, et al., 2014)
	Process	(Crockett, 2008); (Sankaran et al., 2009)
	Tools & Applications	(Jamal, et al., 2013); (Udofia&Obong, 2018)
Challenges	People	(Gilman &Nordtvedt, 2014); (Udofia&Obong, 2018); (Dickens, et al., 2012); (Cromton, 2015)
	Process	(Udofia&Obong, 2018); (Pickering &Sengupta, 2013); (Wiemers, etal., 2014)
	Tools & Applications	(Udofia&Obong, 2018); (Raban& Hauptman, 2018)

Table 2: Showing the summary of findings

a) Key Technology used in DOF's

Udofia&Obong (2018) consider that DOF uses the latest trends in digitalization and leverage these technologies as key enablers. Technologies such as smart sensors, mobile networks, improved bandwidth, connection backbone and quality video conferencing, Big Data and Large Storage Capacity, advanced analytical and modeling methods, and Internet on things can all be utilized in the implementation of a DOF. Jamal et al. (2013) indicate that the DOF is the collaborative environment where the technology allows the technical teams' integration. The system would include data management for real-time data, collaborative work environments for the automation of workflows that would allow features such as alarm systems, real-time visualization, daily surveillance, and action identification

Gyara et al. (2015) believe that for a DOF to be successful, the framework must be built on a scalable and flexible architecture that supports time management, integrated workflows, and business decisions. This means the DOF architecture must include integrating relevant information from different sources; it must deliver information to the right people at the right time and enable collaboration between disciplines and drive informed actionable decisions. Gyara et al. (2015) believe that a DOF must have the following framework, as shown in figure (3).

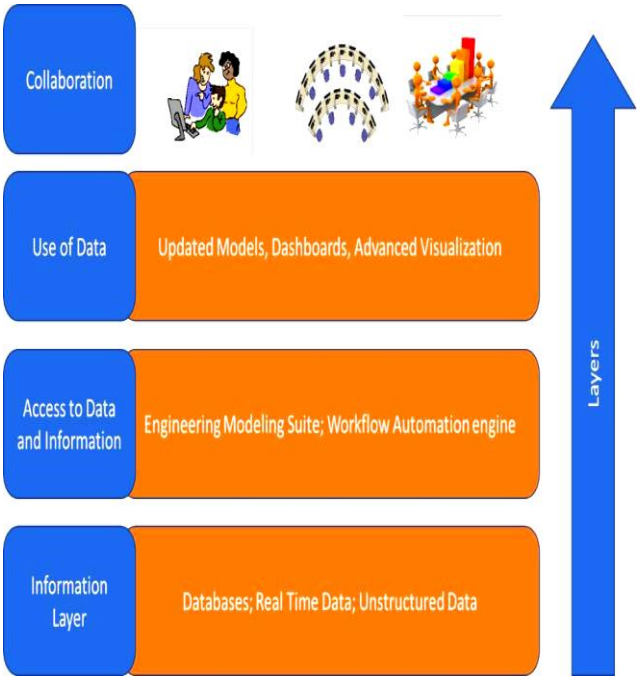

Figure 3: Showing the layered approach of the DOF, with the Information or data management Layer, a layer with engineering tools, advanced modeling and analytics and visualization, and collaborative environments. Source (Gyara et al., 2015)

This framework includes a comprehensive data management layer, an engineering modeling suite; a workflow automation engine; an analytics library and engine; and advanced visualization and collaborative environments. Pande et al.(2010) agree, considering that the smart sensors, improved controls for operating equipment, advanced communications, wireless technologies, connected information systems, and collaborative environments all have to come together in enabling layers to create a DOF that can be managed remotely.

A fully functional DOF would require several components of hardware, software, and processes that are integrated. These include hardware such as smart sensors, mobile, and communication equipment, and networks to improve the data transmission capabilities. The data transmitted would need to be managed using a robust data management framework customized for real-time data and allowing employees to work in a collaborative work environment where workflows can be automated.

Feineman (2014) believes that a DOF moves a company from having siloed workflows to having automated predicted workflows as shown in figure (A1) Appendix A and that the maturity of the DOF depends on where they are on this framework, which includes People, Process and Technology along with strategy and governance.

DOF's in the Middle-East

1) DOF Oman

PDO Oman is using a DOF to connect 2000 wells where real-time data is used to collect data to inform about the performance of the Electric Submersible Pumps (ESP) performance. They use diverse real-time, which feeds into business rules to auto-generate online well models. They also develop standard operating procedures (SOP's). These work procedures have also been embedded into PDO's training for Production and Operations Engineers where rigorous scenarios are practiced in a classroom setting (Bimani et al., 2019)

2) DOF Saudi Arabia

In Saudi Arabia, a DOF has been implemented to help manage unconventional resources to achieve production excellence. The DOF provided cost efficiencies by enabling production forecasting, collaboration, and data for accurate analysis. The DOF will collect real-time data that allow remote monitoring and predictive analysis to help achieve production targets. It will provide decision support by relying on the high fidelity of input data, advanced analytics, and business processes. It will also foster better collaboration, data-driven decision-making, and accountability (AbdulKarim et al., 2010).

3) DOF Kuwait

In the Sabryah field in Kuwait, a pilot project where 44 wells were tested using a DOF to explore its benefits. The project included implementing smart sensors to provide enhanced real-time data, upgraded power, and communications infrastructure; creation of collaborative decision centers and automated work processes, and this resulted in the improvement of the collection and accuracy of data, improvement of processes across different teams in different locations and the increase in effectiveness through automation and shorten the observation to action cycle (Jamal et al., 2013).

DOF benefits an oil company by addressing many issues, including people, safety, and processes. DOF's can address the significant skills shortage in the oil industry (Camps, 2015), operating in environmentally sensitive or dangerous areas such as deserts and areas affected by war. DOF's use of technology that connects the wells to the office regularly and data is streamed consistently, making it more accurate, which leads to more accurate models. Once abnormal readings occur, alarms can be raised, and there can be a faster response to problems. As a result, there can be improved reservoir or oil and gas production, improved team facilitation, and knowledge sharing.

Field	Country	Benefit	Source
Burgan	Kuwait	9 MBPOD (Thousand Barrels of Oil per Day)	(Desai et al., 2017)
Sabriyah	Kuwait	34% Increase in MBPOD	(Jamal et al., 2013)
	Oman	Increased runtime of equipment and performance, increased accuracy of readings and tests, pattern recognition and automation	(Bimani et al., 2019)
	Saudi Arabia	Optimized Drilling Operations and Well Placement, Increased Production, Reservoir Management, Production Operations, Real-time Integration, Higher Hydrocarbon Recoveries and lower Operating Costs	(Abdulkarim et al., 2010)

Table 3: Summary of the Benefits of Digital Oilfields in Kuwait, Oman, and Saudi Arabia

b) Benefits achieved through the use of DOF's

Udofia&Obong (2018) also believes that DOF's address the following challenges in the Oil and Gas sector, significant skills shortage,
discoveries in remote locations, changing technology landscape, and the reduction in risk and reduction in oil and gas prices. According to Udofia&Obong(2018), the benefits of successful DOF implementations result in production optimization; availability of remote support resulting in the reduction in risk exposure; extension of the life of the field; reduction of the field crew; reduced Non-Productive Time; reduction in risk exposure and increased operational integration.

People

DOF's can act as Digital learning platforms, where this can improve the company's internal education by hosting tailored training and development programs for employees and leaders, where they can attend the training in alignment with their work schedules, matched with their self-pacing and choice of topic (Foerster-Metz et al., 2018). This is agreed by Matzler et al. (2018), who states that

Organizational learning has become more comfortable as digitalization has vastly increased the amount of available information and ease of boundary-spanning activities. Wiemers et al. (2014) also indicates that building on institutional knowledge by quickly transforming data to knowledge is a crucial benefit of DOF's

Process

DOF's allow oil and gas companies to do work faster, cheaper, and better (Crockett, 2008). Crockett (2008) suggests that DOF's require real-time data, and with this data comes accuracy. Crockett (2008) believes that real-time data allows Oil & Gas companies to carry out daily hydrocarbon allocation in a more precise manner. With real-time data, Oil and Gas companies can create more accurate models and faster response to problems by using exception-based analysis of data. The data can be integrated to ensure that users have access to the same data.

With the implementation of a DOF Sankaran, et al. (2009) believes that processes can now be done using an integrated approach by linking technology with workflows and departments to form comprehensive business solutions and increase organizational capabilities.

Tools and Applications

Jamal et al.(2013) consider that the implementation of DOF's in Kuwait resulted in the refreshing of technology in the field. This has resulted in improved instrumentation, updated power, and communications and platforms, including software to increase the automation's effectiveness to shorten the observation to action. Udofia&Obong (2018) agree, indicating improved sensors and communications; upgraded power and communications infrastructure; collaborative decision centers to deal with big data. This can result in revamped organizational models and smarter supply chain processes.

c) Challenges of Successful Implementations of DOF's

Dickens et al.(2012) believe that the implementation of a DOF causes a technology-driven change and, as a result, will, therefore, cause several challenges such as resistance to change the industry practices, demands for proof of the product; and sustaining and tracking of the on-going value delivery. Udofia&Obong (2018) believes that there are technology, data, and people challenges with a DOF implementations. The main challenges with DOF implementations are based on technology, data, and people.

People

According to Gilman &Nordtvedt (2014), people are a severe challenge to DOF's or intelligent ways of working as it may disrupt their ways of doing things, and they may see DOF implementations as a threat. Udofia&Obong (2018) agrees that people's resistance to change is a critical barrier to DOF implementations along with having a flawed organizational structure and team alignment are also factors that can affect the implementation of a DOF. Dickens et al.(2012) also indicate that there may be practical challenges such as employees claiming that their asset or area of interest is unique, the project team has competing initiatives, and the staff lacks ownership of the project. Cromton (2015) describes another challenge with knowledge transfer, considering replacing the experienced workforce in the Oil and Gas Industry. The experienced workforce is leaving with a great deal of knowledge and experience acquired through physical learning, while the new workers are digital natives Cromton (2015). Based on the arguments of all writers' people are the biggest hurdles when dealing with DOF implementations, and for successful implementations, all aspects of people challenges must be addressed.

Process

Udofia&Obong (2018) believes that lack of project scope and weak project definitions are challenges for DOF's as this brings poor project alignment. Pickering &Sengupta (2013) believes many digital oilfield projects have not been delivered because expectations were poorly defined, and it is taking a long time to proliferate the uptake of industry standards. The significance of project management in DOF installations is also echoed by Sankaran et al. (2009), where strong leadership is essential to motivate and focus the project so benefits can be maximized. Both writers indicate that to ensure the successful implementation of a DOF, the project scope must be clearly defined, and the project must have strong leadership and ownership and buy-in from the employees.

During the implementation of a DOF, there must be a balance between the on-going business priorities and new technologies and work processes. A comprehensive Management of Change (MOC) plan must be implemented (Wiemers et al., 2014).

Tools and Applications

According to Udofia&Obong (2018), DOF's reliance on emerging technologies such as the internet, Internet of Things, and mobile networks makes them susceptible to cyber-attacks, and employees may see the added technology as an invasion of privacy. This is agreed by Raban& Hauptman (2018), who state that emerging technologies such as the Internet of Things harm the defensive resilience to cyber-attack. Both writers indicate that the reliance and confidence in the enabling technologies can cause issues and challenges as this puts the asset at risk of cyber-attack.

IV. Discussion

A. What Technology is required for DOF Implementation?

A DOF is a platform that leverages engineering workflows that can replace human work with more efficient, higher-quality automated work that can provide proactive

operational and optimization advice. This results from DOF's using high frequency and high volume data (Al-Jasmi et al., 2013).

The rudimentary outline of application components within the industrial systems environment includes data historian, data visualization, complex calculation engine, target setting, and alerting capability, and advanced optimization and control applications.

The architecture for DOF's in Saudi Arabia includes technology applied in 4 main layers, the surveillance layer, integration layer, the optimization layer, and the innovation layer. The surveillance layer monitors the field using real-time data; it includes data acquisition, delivery systems, data management, and alarming tools; data filtration; compression and aggregation. The integration layer provides tools where behavior patterns can be monitored continuously and inconsistencies detected. It includes data management and integration, process mapping and workflow development, monitoring detection systems, visualization and analysis systems, and collaboration environments. The optimization layer is a streamlined environment that allows integrating various tools in a plug and plays set. The innovation layer enables the subject matter experts to have dialogue and collaboration; it converts data to knowledge and can give the company a competitive advantage over its rivals (AbdulKarim et al., 2010).

In Kuwait, the implementation of the DOF included the installation of pressure sensors, temperature sensors, and other instrumentation, as well as data transmission infrastructure to measure the performance of wells. The surveillance eventually leads to a road map for effective good management, including candidate identification, action identification, implementation, and post job analysis (Jamal et al., 2013). According to (Bimani et al., 2019), in Oman, the enabling layers for establishing the DOF have been completed, and they are looking at innovation through analytical tools for predictive models on pumps and other equipment essential to the optimization of the oilfields.

The DOF's of Saudi Arabia and Kuwait are consistent with the model described by (Gyara et al., 2015) and (Pande et al., 2010), where both writers indicate that DOF's are implemented using enabling layers of data acquisition, access of information, information usage, and collaboration as shown in figure (3). Based on the model described by (Feineman, 2014) the maturity of DOF's shown in figure (Appendix A), the DOF's of Saudi Arabia and Oman are more mature than the DOF's of Kuwait in Saudi Arabia. The SME's are allowed to innovate and give the company competitive advantages (AbdulKarim et al., 2010). In Oman they are using analytical tools to develop models to predict the performance of equipment, giving more optimization and adding value to the organization.

B. What are the Benefits of Implementing a DOF?

In the Middle-East, there are several examples of DOF's in Kuwait, Oman, and Saudi Arabia. In Oman DOF, they have realized increases of 2% in production in 18 months and have identified oil gains of nearly 6% due to the automation of workflows. They have also gained 30% net oil gains by changing designs in some wells and reduce downtime because of intelligent alarms (Bimani et al., 2019). In Kuwait's Sabriyah field, there was full integration of the main components of the production system. Alarm systems were implemented, and online and real-time tools for surveillance of oil production and equipment was implemented. This resulted in oil gains of 37% during the period of evaluation.

a) People

Apart from the gains in efficiency and production, the implementation of DOF's has increased organizational learning opportunities in oil and gas companies in the Middle-East as Matzler et al.(2018) believes digitalization vastly increased the amount of available information and ease of boundary-spanning activities. This is extremely important in the Oil and Gas industry as, according to Udofia&Obong (2018), there is a crew change occurring in the industry, and there is a shortage of skills available. Increasing organizational learning can help younger engineers gain competencies faster.

The characteristics of a learning organization will help managers and employees meet these challenges by providing them tools to pursue a creative vision, learn and work together effectively, and adapt to change (Yadav&Agarwal, 2016). Mayo (2007) also agrees that in a learning organization, the processes allow the employees to participate in learnings at all levels. Although (Grieves 2008) believes that a learning organization is impractical and unobtainable, the implementation of a DOF can help in changing behaviors similar to a learning organization by breaking silos and making information readily available for engineers at all levels to make more informed decisions.

Although studies indicate that the implementation of digital technology has both positive and negative effects on lifestyle, there was no evidence to indicate that implementing a DOF positively or negatively affected the stakeholders or employees of the Oil and Gas firms in the Middle-East.

b) Process

The results show that the implementations of DOF's in Kuwait, Oman, and Saudi Arabia have resulted in considerable production gains, increased efficiency of wells and equipment. The implementation has resulted in faster processes, more up to date and accurate models, collaborative workflows, and better decision-making. The DOF's in the Middle-East are well on their way to having a positive return on investment.

This is consistent with the findings of Udofia&Obong (2018), where the implementation of DOF's has resulted in increased production optimization, availability of remote support, and reduced Non-Productive Time. (Feineman, 2010) agrees, arguing that the implementation of DOF's has improved reservoir management due to the effective use of surveillance data allowing more time for intervention and planning for problems, improved staff efficiency, and improved teamwork. Crockett (2008) also agrees, adding that it allows processes to be done faster and more accurately due to the collaborative decision-making, and there may be hidden benefits still not realized.

c) Tools and Applications

Enabling the technology associated with a DOF would help an Oil and Gas Company develop end to end business connectivity, and once information is available in the system, collaboration tools based on different applications can provide decision support for engineers. The technology allows the data and people to work in a collaborative and centralized structure, breaking down silos (Pande et al., 2010). According to Gyara, et al. (2015), implementing technology can provide oil and Gas Company with a competitive advantage as it can adjust operations while producing to optimize profitability.

The breaking down of the silos allows engineers and stakeholders to have more access to data and information where this can be converted to knowledge and allows them to update models faster and more accurately along with making better decisions.

C. What are the Challenges of Implementing a Digital Oilfield?

In the middle-east, there are many challenges to digitalization that may affect the implementation of a DOF. Many of these challenges affect digitalization projects on the whole and will have to be overcome by Oil and Gas companies to obtain the benefits.

According to Deloite (2017), the critical challenges to the implementation of digitalization projects in the Middle-East are that critical skills are not available internally; ownership of the projects are not clear; necessary infrastructure is not always in place; individuals and groups do not want share data; lack of infrastructure across teams inhibits agility and efficiency; and technology and software may not be customer-centric. Kuusisto (2017) believes that digitalization also causes organizational structures changes as the hierarchical organizations will be decreasing as organizations now will strive for flatness and agility. Kuusisto (2017) also believes that organizational learning will also become easier to achieve because of digitalization.

The literature review indicates many challenges to implementing DOF's; these challenges or barriers can be broken down into categories such as technology issues, project implementation issues, and people issues.

a) People

Kuusisto (2017) and Foerster-Metz, et al. (2018) both indicate that digitalization causes organizational structure changes as they cause organizational flattening as more employees have a voice and can make decisions. To support this digital transformation and the implementation of a DOF, oil and gas companies need to shift from their traditional, hierarchical structure to a flexible, decentralized organization with a team/project-oriented leadership to keep pace with the complex fast-changing environment (Foerster-Metz et al., 2018). Although this augers well for employees on the lower level, it can affect older employees and field personnel according to (Udofia&Obong, 2018) and (Pickering &Sengupta, 2013), where resistance to change is expected. In order to overcome this barrier, Pickering(2013) believes that there should be an alliance between oil companies to come up with the best practices for the DOF's and also projects should be clearly defined and the business objectives made known to the stakeholders (Udofia&Obong, 2018).

The successful implementation of a DOF requires effective leadership to communicate to the stakeholders, enforce and sustain the new processes, and alter the new culture of the organization. Sow (2018) believes that leadership culture and local management style variations from one asset to the next must be considered to plan and execute a practical approach for change behavior, process, and workflow transformation. Wiemers et al.(2014) agree that leaders must demonstrate a critical understanding of this process and be willing to embrace change, along with understanding that when they align their leadership characteristics with the change management strategy, it is likely to be more effective. A variety of leadership characteristics are necessary to ensure that the change can be accomplished, and these may not align with a specific leadership style (Wiemers et al., 2014). Larjovuori et al. (2016) believe transformational leadership seems to be the best leadership strategy for digitalization projects as it enhances employees' autonomy, self-actualization, involvement, and empowerment. This type of leadership is needed for DOF's as they not only require employee buy-in but also the ideas and know-how of employees can be critical to the success of implementations.

b) Process

Udofia&Obong (2018) believe that DOF projects suffer from many issues during implementation, such as poor project framing and weak definitions, insufficient resolution time to fix issues, and lack of feedback and post-implementation reviews. Sankaran et al. (2009) agree that project management is essential to the implementation of DOF projects as it can affect multiple departments and groups. Barth & Koch (2019) also considers that project management is a crucial success factor in ERP implementation such as DOF's. To ensure the success of a DOF implementation, there must be strong project

management where the project's scope is well detailed and the project team defined.

Implementation of a DOF can cause governance issues both in the implementation and after the project is delivered. Lappi&Aaltonen (2016) believes that problems can arise when the mediation between the business and the project team is not well defined, and the project's business case and decision-making authority causes tension. This agrees with Sankaran et al. (2009), who believes that the project management team must be clearly defined, planning must be done early, and the stakeholders must obtain support for the project.

c) Tools and Applications

DOF's require data to be transmitted via a computer network regularly, and this reliance on networks makes DOF's susceptible to cyber-attacks (Udofia&Obong, 2018). Bogdanoski&Petreski (2013) believe that critical infrastructure that relies on information technology and their dependence on the internet are targets of cyber terrorism. In the Middle-East, Al-RawI(2014) considers the Syrian Electronic Army has the sophistication to attack targets in cyberspace such as websites or social media channels. Proper governance and legal structures must be put in place to ensure the security of installations of DOF's as they are critical installations. This group or others like it can target installations such as DOF's which utilize information technology. The legal framework at the domestic and international level must be legally addressed to deal with cyber-attacks more effectively (Hathaway et al., 2011).

Sankaran et al. (2009) consider that building a justification for the technology change required for implementing a DOF is a challenge, especially in fields that have been operating for a long such as those in the Middle-East as the costs of the change can be relatively high. This is due to the changing legacy systems and the existing process and how is the return on investment measured. (Cropton& Gilman, 2011) agree.

V. Conclusion

This paper discusses the digital oilfields in the Middle-East, emphasizing Oman, Saudi Arabia, and Kuwait. The primary purpose of implementing the digital oilfield in this region was to improve operational efficiency and improve equipment longevity. As low oil prices are prevalent and the technology becomes more prevalent, Oil and Gas Companies have invested in DOF's to improve operational efficiency, lower overheads, and improve production.

DOF's have benefitted from the advancement of modern technology such as Improved Sensors, Mobile Technology, and Internet of Things; High-speed internet; 'Big Data' and large storage capacity; Advanced Analytical Modelling Methods. The primary purpose of the DOF is to integrate data from different sources to deliver this data to the different departments at the right time. The architecture for a DOF would include enabling layers of data collection tools, a data management layer, an integrated engineering modeling suite of software, and advanced visualization and collaborative layer.

There are many benefits to implementing a DOF, including improving organizational learning, faster updating of models leading to efficiency and production gains, and an end to end connectivity which breaks silos of information across departments. DOF's make data and information more readily available to staff. This openness of information can encourage creativity and innovation and can increase the capability of the Oil and Gas Company, giving them a competitive advantage that is difficult to copy.

There were also many challenges to the implementations of DOF's, such as changes in the organizational structure, leadership, project management, governance, and resistance to change. DOF is causing changes in the organization structure of a company as the structure becomes less hierarchal and decentralized. To facilitate this change, effective leadership is necessary to change the culture of the organization. Proper project design and communication must be put in place to ensure there is buy-in from all stakeholders and a proper governance procedure both before and after the DOF is implemented.

Further research is necessary to investigate how the implementation of a DOF affects the lifestyles of employees and what further benefits and challenges may arise when they are implemented.

VI. Recommendations

DOF's have proven to be beneficial to oil and gas companies in the Middle-East as they have optimized production, increased operational efficiency, and give the companies competitive advantages through analytical tools. Some challenges must be overcome to ensure the successful implementation of a DOF.

A. People

To ensure that there is buying by the employees and stakeholders, there must be effective leadership and communication. The leadership should practice transformational leadership as it enhances morale and the employees' performance by connecting the employees to the project. This challenges the employees to take broader ownership of the project (Odumeru&Ogbonna, 2013). The information of the project should also be communicated early to all stakeholders, including employees, partners, and regulatory bodies, as this can ensure buy-in and dispel rumors about the project (Sankaran et al., 2009).

B. Process

The successful implementation of the DOF will require significant project management and will need effective governance and change management to ensure the project is booming after the DOF has become operational. The project scope and project team should be well defined

and stakeholders engaged (Sankaran et al., 2009). The governance procedures for the project should be well defined and documented as with the implementation of a DOF, there would be many changes such as increased data volume; and faster, automated workflows (Lappi&Aaltonen, 2016). This can result in a lack of understanding by the staff. Governance and change management procedures must be in ensuring the smooth transition to the new working environment.

C. Tools and Applications

With the implementation of a DOF, there is a reliance on technology such as the Internet of Things and Communication Networks, and as a result, the DOF is at risk of cyber-attack. To ensure that this risk is mitigated, there should be a legal framework to deal with cyber-attack in the implementation jurisdiction (Hathaway et al., 2011).

Implementing a DOF is a costly venture as it embarks on changing technology such as sensors, infrastructure, and software. To ensure the project's success, the oil and gas company should build a comprehensive business justification and business case. This will justify costs to the shareholders and stakeholders of the project (Sankaran et al., 2009).

With the implementation of a DOF, there would be changes in infrastructure, software, and results. There would be resistance from the staff to embrace the new technology and processes. There should be a training program to ensure an uptake of the new technology and workflows (Pickering &Sengupta, 2013).

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Appendix

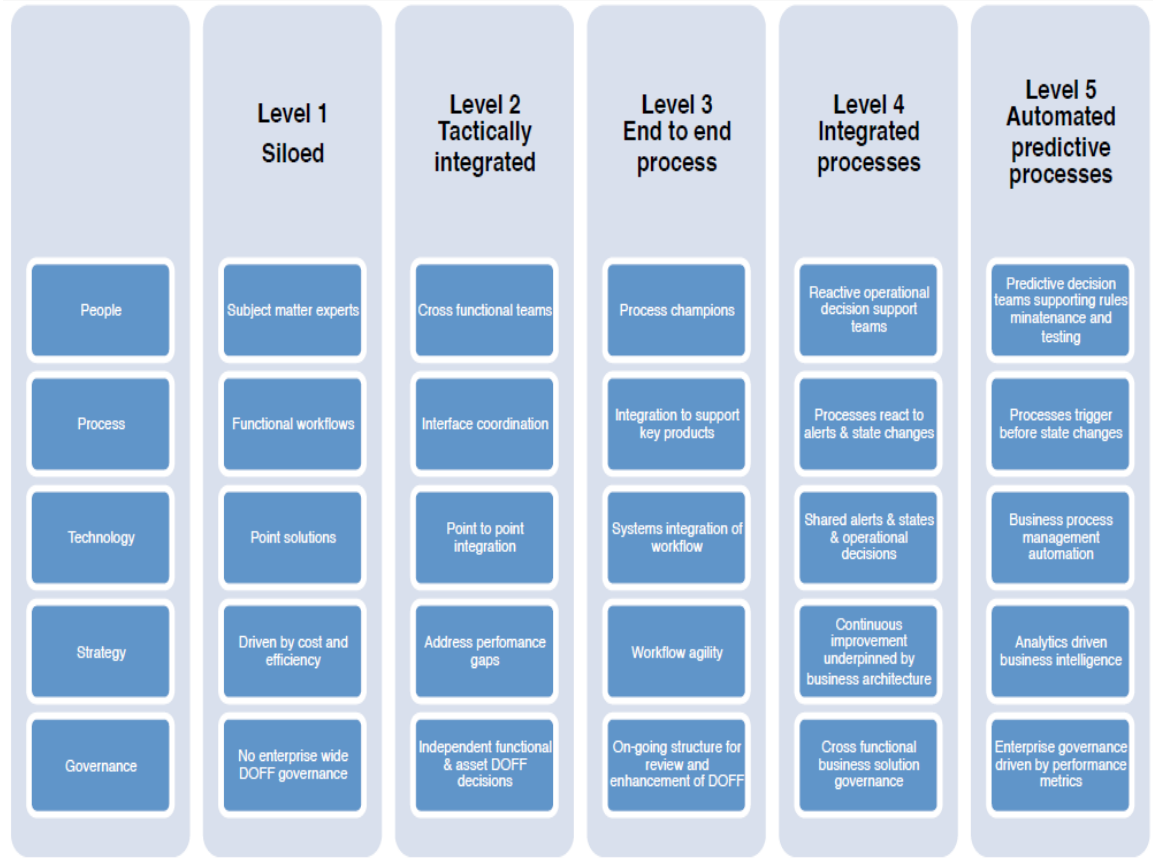

Figure A1: Proposed Digital Oilfield Maturity Concept (Feineman, 2014)