Scholars Journal of Economics, Business and Management OPEN ACCESS
Abbreviated Key Title: Sch J Econ Bus Manag
ISSN 2348-8875 (Print) | ISSN 2348-5302 (Online)
Journal homepage: https://saspublishers.com

Implementation of Digital Transformation to Minimize the Risk of Incidents in the Upstream Oilfield Service Quality Performance

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DOI: 10.36347/sjebm.2021.v08i08.005 | **Received:** 02.07.2021 | **Accepted:** 05.08.2021 | **Published:** 12.08.2021

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Abstract **Original Research Article**

This study aims to determine the implementation of digital transformation to minimize the risk of incidents in the upstream oilfield service quality performance. This research is a literature study discussion from risks in upstream oilfield to the utilization of big data and digital transformation to increase incent prevention. The data in this research is collected based on journals, books, documents, etc that are related to the topic of this study. The result of this study is that the utilization of digital transformation toward oil and gas industry also enables the oil and gas chain, especially upstream field, utilizes "□-Frame" for the seismic exploration and "Field of the Future" intelligent outfield that can reduce the human's work that may cause the accidental risk and make the production more efficient, safe and friendly environment, traceable, and transparent.

Keywords: Digital Transformation Oilfield Service Quality Upstream.

INTRODUCTION

The development of the oilfield service industry has operational areas that are widespread in various countries. The leader of the global oilfield services market in North America (34 per cent) while Eastern Europe and the CIS (the Commonwealth of Independent States comprising post-Soviet nations throughout Eurasia) are one of the most dynamic oilfield services markets (16 per cent) (Usov, A., & Nesterenko, 2018). The drivers of the Russian oilfield services market are exploration segments and production drilling, characterized by stable annual growth of 10-12 per cent (Usov, A., & Nesterenko, 2018). Forecasts the global oilfield services market to growth from USD 106.4 billion in 2017 to USD 125.5 billion by 2023, at a Compound Annual Growth Rate (CAGR) of 3.35% during the forecast period. The major factors driving the oilfield services market include the global increase in oil and gas production and growing shale gas extraction. Another factor such as increase in demand for advanced technology, tools and equipment to increase efficiency of exploration and production activities in onshore and offshore areas is expected to drive the market for oilfield services. However, the volatile oil prices over the recent period, owing to the supply-demand gap, geopolitics and several other factors has been restraining the growth in the demand for oilfield services market.

Drilling Services are expected to lead the market for oilfields services, reasons being increase in exploration activities and massive development of shale plays in recent years. With wells being drilled going farther away from land and into the sea and being drilled deeper than before the market oilfield services is expected to grow in the forecast period. North America is the biggest market for oilfield services, owing to increased drilling and production activity in shale plays. The demand for oil and gas production has always been on an increase, which have led to increased exploration activities in offshore. This in turn is expected to act as opportunity for the market during the forecast period. Drilling services make up for the biggest share in oilfield services market, with drilling and completion services combined accounting for over 50% of the market. The oil and gas production have always been on an increase even when oil prices went down in 2014 because of the ever-increasing demand of oil and gas. This, in turn, requires for an increase in oilfield services for more production from existing and new wells, signifying an increase in oilfield services market. The active rig count has been on the rise in recent years, with around 920 active rigs in September 2016 to 1130 in September 2019, showing an increase in drilling activity and hence the oilfield services market.

LITERATURE REVIEW

Risks in Upstream Oilfield

Brief Review of Literature According to the U.S. National Institute for Occupational Safety and Health in International Oil and Gas producers (IOGP) Report (2016), a worker in the oil and gas industry is six times more likely to die on the job than the average American worker. The IOGP (2016) report notes that when workers are offshore, help is not close by, as a result of which an incident such as a mirror fire outbreak or another incident may quickly escalate into a tragedy with high fatality. For example, the Deepwater Horizon in the Gulf of Mexico in 2010 accident which claimed the lives of about 200 workers who perished in explosions and the Piper Alpha in the North Sea in 1988 in which 167 oil workers perished with only 61 survivals who jumped into the sea from the helicopter deck of the drilling rig gives an indication of the fatal and perilous nature of most ocean energy drilling accidents IOGP (2016). According IOGP (2016), most work-related injuries and fatalities are associated with working in an extremely high-pressure and physically demanding environment. Since upstream oil field jobs involves working on heights, heavy equipment, challenges getting to and from job sites and hazardous and dangerous materials, The probability of fatal accidents is usually very high.

The U.S. Center for Disease Control (USCDC) (2010) report indicates that oilfield work often appears on lists of the most dangerous professions. As the oil and gas industry boomed from an average of 800 active drilling rigs in the 1990s to approximately 1,300 in the time period from 2003 to 2006, the worker fatality rate increased, with over 400 workers losing their lives on the job. The U.S. Center for Disease Control (2010) found that the annual fatality rate climbed to 30.5 per 100,000 workers over those four years alone. The three states with the most oilfield deaths in the United States of America in 2008 were Texas, Oklahoma and Louisiana. From 2004 until 2008, the number of fatalities while working in the upstream oil and gas industry increased by 91 percent in Oklahoma, 21 percent in Texas and 30 percent in Louisiana (USCDC, 2010). IOGP (2016) notes that in addition to an alarming high worker death rate in the oil and gas industry, lifealtering injuries can also occur. In 2016 alone, at least 20 workers a month were hospitalized or lost a body part while on the job. Oilfield workers can also experience major burns and fractures, among other injuries. The Labor Department speculates that employers under report injuries by as much as 60 percent. The former head of the Occupational Health and Safety Administration (OSHA) pointed out that a culture of not reporting these incidents in the oil and gas industry is common, so even more workers are probably hurt or injured on the job (IOGP, 2016). Aryee (2012) in a study found that that the fatal explosion in the pump room on the Brazilian FPSO Cidade de São Mateus in February 2015, demonstrated the potential for major accidents on this type of unit (Aryee, 2012). It is therefore imperative that risk assessments of FPSOs address this type of event (Aryee, 2012).

Digitization of the Oil and Gas Upstream Chain

In 4.0 industrial era, digitization in the term of technological sector has significantly increased productivity, time saving, and other aspects that prosper enterprises among society, one of which is oil and gas industry. In this case, the application of 4.0 toward upstream chain has its own technique that covers the risk of tool traditional utilization (Koroteev and Tekic, 2021).

On the other hand, oil and gas industry is suffering from the skilled labor but they need to increase the oil and gas production, thus, the automation combined with the digitization is needed to maintain the productivity and simplify production, and gain higher achievement. Beside the digitization and automation, the modularization of the construction building is also required in term of oil and gas 4.0 especially in the upstream chain to reduce the prices of the construction and increase the quality of safety and quality. Besides, the Intelligentization is one of the science and technology development aspects that can increase the production up to 2%-8% and the recovery up to 2%-6% (Lu *et al*., 2019).

Therefore, according to Lu *et al*. (2019), the application of the oil and gas 4.0, especially in upstream chain, utilizing the above technological materials, is described as in seismic exploration and intelligent outfield. In the seismic exploration, the most important occurrence which is known as the process of obtaining geological information happens utilizing big data features. To precede the seismic exploration data assembling, one of the appropriate technologies utilized is "□-Frame" developed by Sinopec which can reduce the safety and interference and increase the quality of the data obtained since it utilizes wireless sensors which are lighter and easier to transport and install wired sensors rather than the utilization of cable. It is also supported by the research of Koroteev and Tekic (2021) that the data collection utilized in the seismic exploration data assembling by using wireless sensors which can produces the 3D images, the quality and detail of the data in seismic exploration step.

The second step of application scenario in the upstream element, according to Lu, *et al*. (2019), is intelligent oilfield. In intelligent outfield, it is also obtaining big data that is used as the basis for decision-making. The application of 4.0 Oil and Gas, beside replaces human in doing the repetitive work and human's analysis work, it can also be known as creating knowledge process which are awareness, analysis and warning, decision, execution, and optimization. One of the appropriate technologies utilized is called "Field of the Future" by BP. It is run by utilizing sensors and

automation to transfer real time data from the field to the remote center. The technology has three different frameworks of the "Field of the Future Program" which are (1) model-based decision making known as system optimization, (2) getting data to decision makers known as remote performance management, and (3) blueprint, system of control and instrumentation, architectural standards and also communication infrastructure known as digital infrastructure and IT architecture.

RESULT AND DISCUSSION

Digital Transformation on Execution of QMS Process and Oilfield Service Quality Performance

Digital technologies are helping almost every industry rewrite its operating landscape and the oil and gas (O&G) service industry can no longer remain behind. The potential benefits of going digital are clear—increased productivity, performance, safer operations, and cost savings. Further, for O&G players, who are already grappling with weak oil prices and moderating operational gains, one of the biggest advantages of adopting digital technology could be the resilience these technologies offer to weather the downturns that the industry is prone to *(Marshall et al.*, 2017) However, rapid changes in the digital world, a complex web of interdependencies between technologies, and even many names for the same technology often make it difficult for the industry to enable its digital transformation. For instance, out of the more than 200 technologies ever listed on Gartner's Hype Cycle from 2000 to 2016, over 50 individual technologies appeared for just a single year, while many took years longer to register mainstream success (Stanaway *et al*., 2016).

Typically, in the O&G domain, the digital thinking and narratives stop at data-driven insights. But to become a digital leader, a company should consider making a change in its physical world by modernizing its core assets (in this case, rigs, equipment, platforms, and facilities). In other words, it should complete the last three legs of the journey from bytes to barrels by closing out the physical-digital physical loop. Although digital maturity varies from company to company, the exploration segment of the industry in general is digitally ahead of development and production. While decades of earth science understanding and advanced imaging technology have helped exploration, a complex ecosystem and a legacy asset base have constrained the digital evolution of the drilling and production segments, respectively. However, not all sub segments within the exploration segment are ahead; similarly, there are a few sub segments within drilling and production that are adapting and getting ready for their digital leaps. Rather than detailing each sub segment, the following section talks about a prime sub segment within each segment—seismic imaging, development drilling, and production operations—where either the digital transformation is most needed or has the highest value creation potential (figure 3).

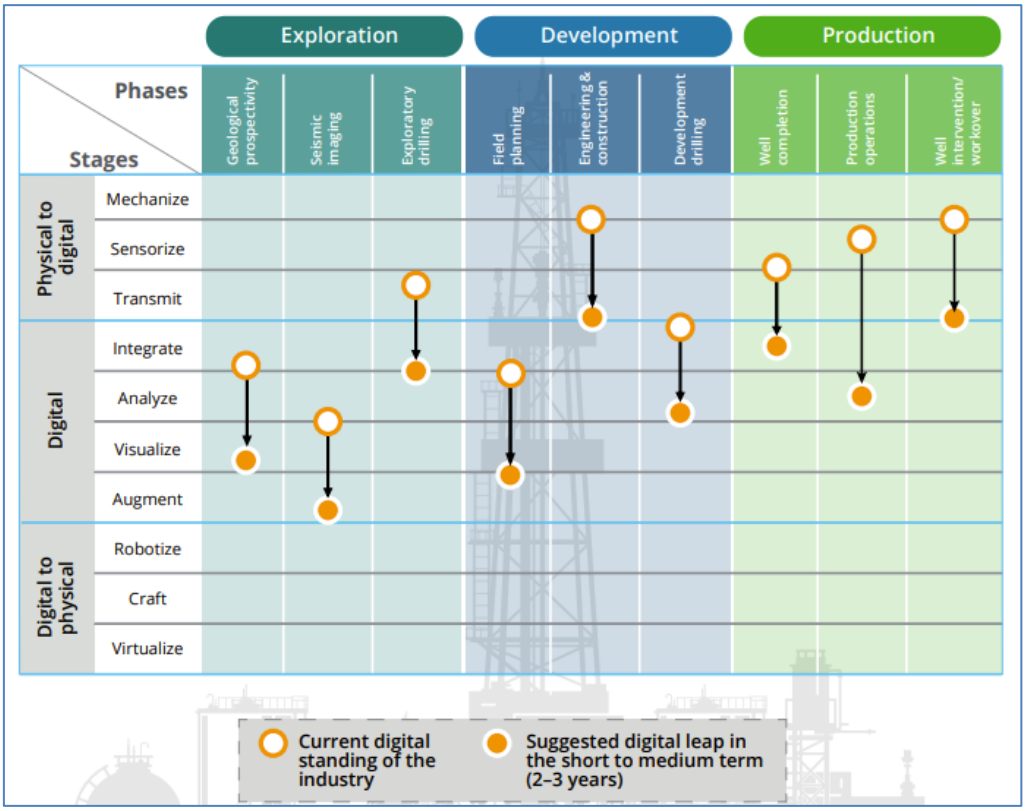

Fig-7: Current Digital Maturities and Near-Term Digital Goal Mapping For Upstream Operations

Research indicates that firms that make optimal use of information communication technology (ICT) can access new market opportunities, increased productivity, and improve operation more effectively (Elliott & Neirotti, 2008; Setia *et al*., 2013). In addition, through the convenience of accessing, communicating, and interacting within or among firms, information technology may contribute to organisational impacts (Bayo-Moriones & Lera-López, 2007; (Melville *et al.*, 2004). Implementation of digital transformation in the oil and gas service industry can provide benefits to improve the quality management system and firm performance. Several forms of digital transformation applications and their benefits include 1) Virtualizing the ecosystem; creating digital twins of offshore assets to increase structural integrity and prototype new and lean structural designs. Opportunity exists to optimize and extend life of fixed assets worth $3.4 trillion. 2) Enabling cross-functional workflows; Enabling cross-functional, cross-disciplinary workflows to connect traditionally siloes processes and provide an integrated view of an asset throughout its life cycle. 3) Integrating operations data; establishing data aggregation standards or developing secure drilling data integration platforms by collaborating with vendors. Companies expect drilling cost optimization of 9–12% through monitoring and analysis of aggregated drilling data. 4) Analysing at edge Using edge analytics to run linear as well as nonlinear performance analytics on systems and key operations at the platform. Upstream companies can potentially realize annualized well cost savings of $30 billion using advanced analytics in drilling. 5) Mechanizing and automating equipment Addressing safety and increasing productivity by mechanizing and automating tasks such as pipe handling, BOP handling, fluid system, etc., on rigs. 6) Robotizing platforms Developing unmanned wellhead platforms or designing key offshore operations for robot-only interventions. 7) Crafting complex parts Reducing downtime, optimizing supply chain, and enabling new thinking in material, design, and manufacturing. Using 3D printing, impellers in offshore pumps can be replaced in 10 days as compared to the three months required in traditional sourcing methods (Gerald, *et al.*, 2017).

Digital Transformation to Minimize Accident Risks in Upstream Oilfield Service Quality Performance

Risk as a concept is defined as the probability that an event may occur that will affect the outcome of an objective function. Relative of ocean energy drilling operations, it is the uncertainty that an offshore exploration or drilling project may face a sudden unexpected incident/accident that may affect adversely the achievement of the objectives of the project (IMO, 2008). This non achievement of the objective function may be termed failure depending on the extent of non-achievement. Thus risks are uncertainties which cause projects and programme to suffer failure. Accident risks may impose damages, injuries and death in which case they are categorized as either damage accident, injury accident and/or death accidents with each accident categories having differing methods and models of determining their economic and socio-environmental impacts (Chinonyerem *et al*., 2017). According to (Chinonyerem *et al*., 2017; Nwokedi *et al*., 2018) when accidents involve death of crew and/or personnel, it is termed fatal accidents while non-fatal accidents do not involve the dead of crew or personal but may involve injuries. The development of offshore safety policies and programmes and international maritime safety conventions relating to ocean energy exploration and drilling are all aimed at ensuring the safety of personnel, environment and equipment as capitals for realization of the ocean drilling objectives and the sustenance. But since the human capital remain the driving factor and reference force that propels and harnesses all the factor of production in the offshore energy sector, higher accident fatality rate and probability of fatal offshore drilling accident will without doubt obstruct the realization and success of ocean energy drilling operations. Considering the capital intensiveness of safety and specialized training needs for human operators in the ocean energy sector; the loss imposed by fatal offshore energy drilling operations is usually enormous. Where this is the case, cost offshore ocean energy insurance and risk management measures may equally go up inducing limitations of investment in the sector since the higher risk and may push up investment costs such that investors are discouraged (IMO, 2008). This will in turn affect limit job creation drives while increasing unemployment with series of other related social and environment challenges. As aforementioned, failure of oil drilling operations on platforms and Floating production, Storage and Offloading (FPSO) systems may lead to injury risks, economic risks, death, risk of environmental pollution among others; the failure of the drilling infrastructure itself is an occurrence that is a factor of risk as a result of exposure to various forms of hazards which represent casual agents of failures or failure modes (IMO, 2008; NAPIMS, 2014).

Though it is important to work to limit the occurrence of accident of any form whether fatal or non-fatal, but since offshore drilling operations are accident prone given the nature of the environment and it may not be possible to achieve a totally accident free operation, it is a better option to while working the limit accident occurrence generally, focus on determining the probabilities of fatal and non-fatal accident involving offshore drilling sector over a period with a view to putting higher concentration on reducing fatal accidents to the barest. Aryee (2012) posits that while accidents may not be possibly eliminated, fatal accident can be completely eliminated through proactive accident and safety management system, and when fatal accidents are completely eliminated; the objective function the offshore drilling operations will be achieved. The implication of this is the human capital loss induced on the company, industry, and economy by fatal accidents

will be eliminated too. The economic benefits of implementing fatal accident risk management and control methods when compared the cost imposed by fatal accident in the short run may prove favourable for fatal accident control measures coupled with the fact that human life itself unlike other forms of capital is irreplaceable there exists an infinite loss of output for every human capital accident induced death. When properties involved in damage accident can be overhauled, repaired and maintained and put back into productive, the same cannot be said of human capitals involved in fatal accidents, thus the need for the study to proactively determine the fatal accidents probabilities in FPSo's in use in ocean energy drilling operations in Nigeria in comparison to non-fatal accident probabilities in the drive to limit human capital losses induced by offshore energy drilling operations and the associated socioeconomic multiplier effects. The International Maritime Organization (IMO, 2008) developed the Formal safety Assessment (FSA) method in risk analysis in offshore drilling platforms and operations in the global ocean energy sector. Osuji (2004) and Olumide (2017) note that the offshore energy sector is the oil and gas sector, encompassing the oil and gas exploration and drilling operations using offshore oil and gas installations which in the simplest form consists of exploration vessels, seismic equipment, FPSO's, shuttle tankers, dynamic positioning (DP) vessels, and the associated deep water pipeline transport infrastructure for drilling, transfer and storage of petroleum and gas resources. Statistics from NAPIMS (2014) indicates that Nigeria has about 500 oil fields each employing various categories and capacities of drilling equipment for operation. Global project management and safety management practices require that the risk potentials and failures causing deaths and environmental pollution of each drilling platform/rig be identified, analysed and assessed to determine the level of fatality, injury and environment risks; and appropriate risk control strategies be applied to limit accidental failures and the unpleasant consequences.

Big Data and Digital Transformation to Increase Incident Prevention

The performance of an industry or enterprise depends on how they manage the process of the production which should minimize the risk happened toward their labors. In this paper, the oil and gas upstream are introduced a big data with the help of digital transformation. Big data is the data that contains any information from the quality maintaining to risk management. The important thing is not the data inside, but the treatment of how the enterprise toward the big data, if the data is utilized well, it may increase the quality of production and decrease the risk of the works (Kumar, 2014).

According to Behl (2020), the combination of the big data with the help of the digital transformation is considered to increase the performance of any startup (in which is in upstream industry for this case) because it can detect the problem and the deficiency of business model at the same time. Furthermore, the problems and deficiencies detected can give the information about the quality of the production and the risk management. From the data informed, the decision maker can have the basis which decision will be taken in order to increase the quality performance which can also be implemented in the gas and oil upstream.

The conceptual model of how the digital transformation and big data analysis can reduce the potential incidents is drawn into the chart below.

CONCLUSION

Digital thinking and narratives end at data-driven insights in O&G. To become a digital leader, a corporation should consider changing its physical reality by updating its fundamental assets. Thus, it should finish the remaining three legs of the journey from bytes to barrels by closing the physical-digital physical loop. While digital maturity differs from firm to company, overall industry exploratory segment is digitally ahead of development and production. Implementation of digital transformation in the oil and gas service industry can help improve the quality management system and firm performance, in the form of virtualizing and enabling easily and widely accessible working ecosystem.

Digital transformation involves the loss of human capital induced by catastrophic accidents on the organization, industry, and economy. The economic benefits of applying fatal accident risk management and control methods when contrasted to the short-term cost imposed by fatal accident may prove beneficial for fatal accident control measures coupled with the fact that human life itself, unlike other forms of capital, is irreplaceable there is an endless loss of productivity for each human capital accident induced death. When properties involving damage accidents can be overhauled, repaired, maintained and restored to production, the same cannot be said of human capital involved in deadly incidents.

The utilization of digital transformation toward oil and gas industry also enables the oil and gas chain, especially upstream field, utilizes "□-Frame" for the seismic exploration and "Field of the Future" intelligent outfield that can reduce the human's work that may cause the accidental risk and make the production more efficient, safe and friendly environment, traceable, and transparent.

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