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# Digital Transformation in Energy Industry for Production Efficiency: A Review of Failure Analysis and Risk Mitigation

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**ABSTRACT:** *The oil and gas (O&G) industry has been evaluating several digital technologies to improve productivity, efficiency, and safety while lowering capital and operating costs, health and environmental concerns, and project life cycle unpredictable factors. The use of developing technology enables oil and gas companies to create digital twins (DT) of their assets. Before COVID-19, oil and gas firms had to overcome major challenges to their financial success, environmental responsibility, and efficiency. Prices have decreased so drastically because of the epidemic that there is now an extreme need for dealing with these problems right away. Extending digitization efforts is one of the most obvious and practical solutions to these systemic problems, as it may increase durability and continue to be appealing to investors. Many things must be done while the oil and gas sector work towards net zero carbon emissions, one of which is the widespread implementation of digital transformation. The adoption of digital transformation across businesses is one of many things that must be done as the oil and gas industry attempts to reach net zero carbon emissions. If the oil and gas industry is to continue operating, it must conduct its operations as safely as possible, which digitalization will help in doing. Companies need to focus their digitization efforts by linking them to the features that are most valuable. Businesses must develop fundamental abilities in data and analytics, technological architecture, civilization, and cybersecurity. By doing things effectively, downstream oil and gas industries will undergo a technology-driven change. This paper analyzes a review of failure analysis and risk mitigation.*

**KEYWORDS**: digital transformation, energy industry, production efficiency, failure analysis, risk mitigation

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## INTRODUCTION

The rapid development of technology, such as big data and analytics, instruments, and management systems, gives oil and gas companies the chance to digitize high-cost, lethal, or susceptible-to-error jobs. (Al Kaabi, A. M. 2017). Most oil and gas firms are starting to exploit these possibilities, and it would be beneficial to increase their efforts (Manning, J. 2017). Companies that utilize automation correctly can considerably increase their profits (Puumalainen, K. 2018). Given the significant rise in upstream capital investment in the oil and gas industry, improving production efficiency is critical (Wade, K. 2019).

Despite the location, most oil and gas firms encounter difficulties that make it difficult to achieve long-term production efficiency improvements (Naik, H. 2019). We believe that higher levels of automation can help to tackle the following global issues. Integrated production control, equipment tracking, and predicted shutdown systems are now essential for preventing or mitigating disastrous incidents in geographically distributed remote operations (G. S. 2019).

In the 2020s, upstream businesses can save up to $100 billion through automation and digitalization projects (Moellendick, T. E. 2020). More than 3,000 offshore firms invested $1 trillion in 2018 on operational expenses, wells, facilities, and subsea capital investments (Buzmakov, D. 2021). Digitalization can result in profitable and effective operations, saving 10%

of the amount spent last year, even though there are varying amounts of possible savings within off the coast, shale, and conventional activity budgets (J. J. 2021). Operators anticipate that digitization will lower facility and subsea costs by up to 30% and drilling costs by 10% to 20% (Warrian, P. J. 2023). By the end of the next decade, the actual efficiencies and economies will be closer to 10% because adoption across the full value chain of suppliers, from national oil corporations (NOCs) to majors to smaller E&Ps, will vary. New technologies are being introduced by upstream firms to stay up with the digitalization race (Springer, S. 2022). Additionally, the slump in the oil market has created a significant incentive for upstream operators and service providers to adopt efficient operations or risk being forced out of business (Boone, S. 2022, March). Digitalization initiatives can also boost production by boosting uptime, optimizing reservoir depletion tactics, enhancing worker health, safety, and environment, and reducing carbon emissions, all of which provide considerable value (Tukeva, H. 2023).

**The Automation Requirement**

Automation is not without its own set of difficulties (Vanschoren, J. 2019). Today's modern oil field is brimming with electronically interconnected structures, machinery, and equipment (Baltazar, A. 2018). A typical offshore production system may contain over 40,000 data markers, not all of which are linked or used (Zhang, Y. 2019). We anticipate that industry leaders will progressively use automation in upstream manufacturing operations, resulting in increased efficiency (D. C. 2020). In order to show how oil and gas companies might benefit from automation, we looked at production maintenance, a particularly enticing option (D. H. 2020).

**Using automation in preservation:**

Automating maintenance can increase production effectiveness in a variety of ways (Rathore, B. 2023). For instance, using various sensors and radio-frequency identification tags on equipment can help in activity monitoring. Applications that assist equipment condition monitoring, preventive maintenance, and automated shutdowns are made possible through tracking (Neghabhan, S. 2022). These applications increase dependable equipment and productive quality while minimizing the risk of catastrophic breakdowns and process disruptions. But having a lot of data isn't the only requirement for maximizing the benefit of automation in maintenance. Some firms find it difficult to maintain data quality throughout their IT networks. Others lack the necessary skills for compiling data and performing insightful assessments. Others have trouble converting analysis into action (Chen, Y. 2021).

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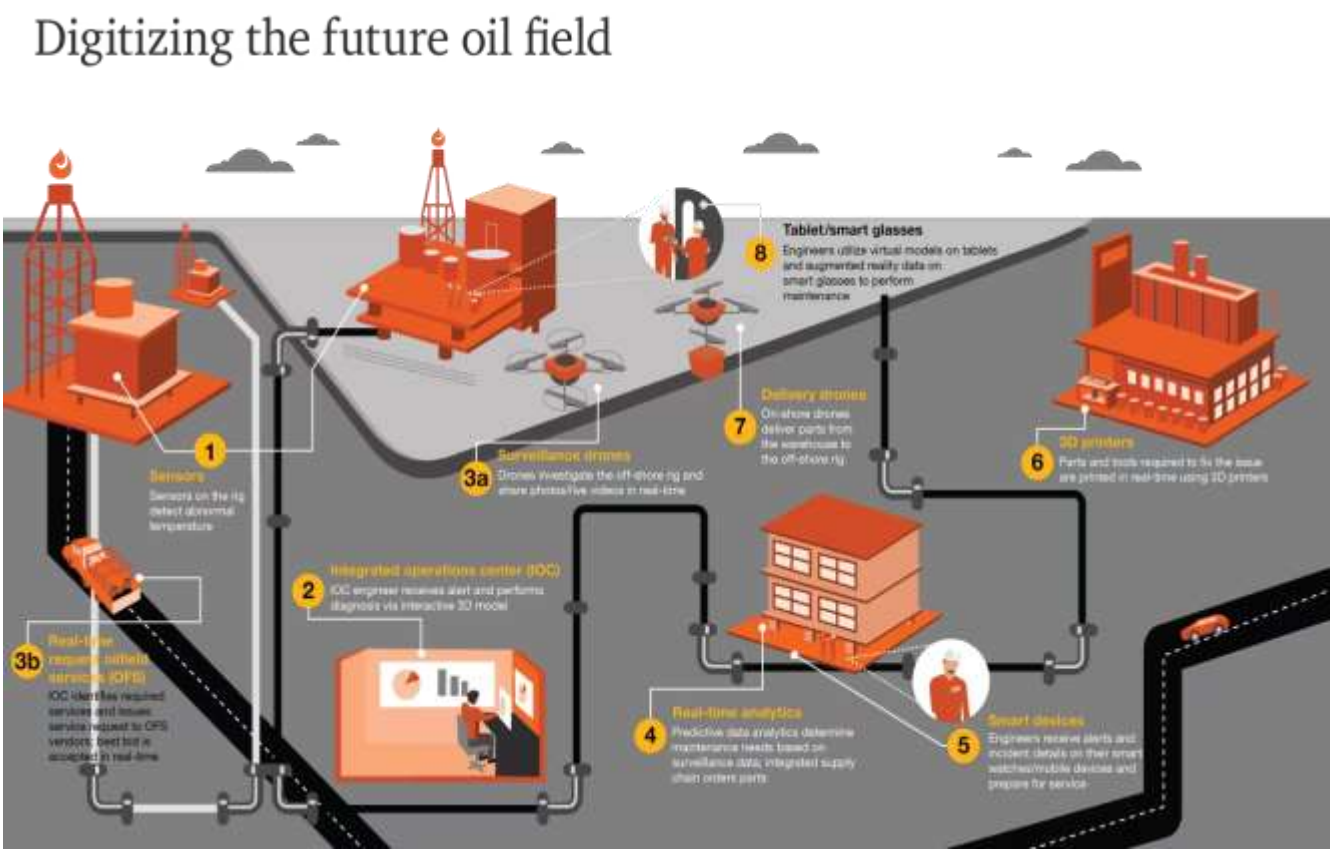
**Digitizing the future oil field**



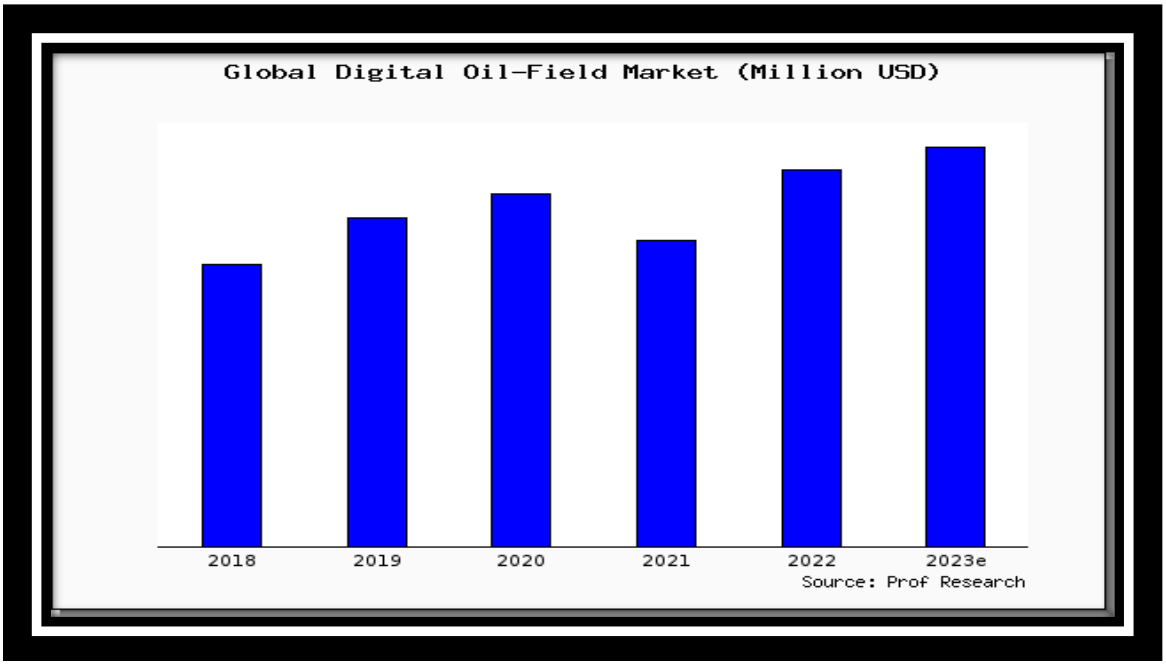

Even before the COVID-19 epidemic, the energy business experienced significant technological change (Alnaim, M. M. 2021). The "fracking revolution," the expansion of renewable energy, the development of battery storage, the vigorous promotion of a hydrogen economy, and the modernization of transportation represent transformative potential as well as a fundamental competitive threat (Chytiris, P. 2023). These new technologies, when paired with digitization, have the potential to offer new abilities and cost efficiencies to the energy, utilities before opening the door to new threat.

The digital oil field has developed rapidly over the last decade (Tekic, Z. 2021). This enabled better remote operations, more precise geophysical estimation, the deployment of new drilling techniques, increased safety, and so on (S. N. 2022). Many oil and gas firms have moved their research attention to digital oil field technology as a result of these breakthroughs in the exploration of this new concept(Ramaswamy, K. 2021). This is also evident from increased patent filing activity. Digital technologies for the oilfield, however, come with their own set of difficulties, just

like any other technology (R. E. 2022). There are a few stated below that every other firm in the oil and gas industry is still trying to figure out.

- Will the technological investment yield positive results?
- How do you persuade the management to agree?
- Are our rivals' oilfields already being digitalized?
- How can technology be seamlessly incorporated?
- Will the integration present new, unexpected difficulties? What are solutions if so?

According to forecasts, the worldwide digital oil field industry would grow from $24.60 billion in 2014 to $38.49 billion in 2024 (Polaszczyk, J. 2022). It will continue to grow at a CAGR of 4.6% during that time.




Yuen, K. F., Ong, K. W., Zhou, Y., & Wang, X. (2023). Social media engagement of stakeholders in the oil and gas sector: Social presence, triple bottom line and source credibility theory. *Journal of Cleaner Production*, *382*, 135375.

Based on its current growth and the growing interest in the field of digital oilfield, the tendency of patent filing will also continue to rise.

**Challenges for oil and gas (O&G) companies**

We identified two major challenges for oil and gas (O&G) companies: reduced oil prices in the immediate term and long-term decarbonization (Uratani, J. M. 2022). One effect of these challenges is a faster shift to cleaner energy sources, such as gas and electricity. A further ongoing effort is the search of more efficient, cost-effective operations. To this, we must now consider the anticipated medium to long-term effects of the COVID-19 pandemic, such as a dramatic contraction in the global travel industry and changes in human working patterns, such as remote working, which may further reduce demand for oil. The search for cost savings in the oil and gas (O&G) sector has never been more critical. While there is no silver bullet, digitization is a critical enabler in successful changes.

However, as our Digital Operations Study shows, oil and gas (O&G) firms have been hesitant to implement digital applications and operations. They must understand the full scope of what this means to further their digital transformation. Along with technology, it's important to improve workforce skills, alter workplace norms, and recognize how digital technologies may greatly increase business sustainability and efficiency. These are the key elements that will help oil and gas companies become more competitive, efficient, connected to suppliers, and responsive to client needs, leading to a wider revenue base and increased profitability.

Digital technologies are being used by the oil and gas industry to revolutionize its operational and business processes while creating new opportunities for profit and value creation (Roig-Tierno, N. 2021). The adoption of new digital technologies has prompted the oil and gas sector to start considering about how to incorporate DT technology. The adoption of digital technology in the oil and gas (O&G) sector now tends to be bottom-up and asymmetrical. Because of this, companies are not fully utilizing automation and digitization. It is essential to have an in-depth understanding of DT technology, the state of O&G-related DT research activities, and the opportunities and challenges associated with DT adoption in the O&G industry to fully realize the promise of DT and related technical adoption.

**Failure Analysis and Risk Mitigation**

The oil field must also digitalize other components, particularly the information technology architecture of the linked component (Rezgui, Y. 2020). The traditional communication method makes network analysis and optimization arrives at challenging to adopt in the digitalization of resources and infrastructure. It is difficult to move vast amounts of data across these disparate IT architectures (Kurien, A. M.2022). By fusing web services and connecting them to a cooperative and incorporated IT-based service structure, IBM makes it simple to use artificial intelligence concepts in the oil fields. The other difficulty with digitalizing oil fields is the potential hazards and deficiencies in cybersecurity. The market for digital oilfield technology is global, as opposed to the research efforts, which are only carried out in China and the United States.
The biggest risks the oil and gas companies faces are as follows:

**Environmental Risk**
Geological risk refers to extraction problems as well as the possibility that the readily available reserves in any deposit will be less than predicted. Researchers in the oil and gas industry work hard to mitigate geological risk by testing frequently, thus projections are rarely substantially "off." They use the phrases "proven," "probable," and "possible" before reserve estimates to illustrate their level of confidence in the findings.

**Risks of Supply and Demand**
Oil and gas companies face major risks from supply and demand disruptions. The uneven production pattern leads to the volatility of oil and gas prices. Other economic factors influence this as well, because, in addition to the standard price risks, financial crises, and macroeconomic factors may generate a capital shortfall or have other adverse impacts on the business.

**Economic Risk**
Besides from geological risk, the most critical factor in deciding whether an initial payment is commercially viable is the price of oil and gas. Essentially, the more geological hurdles to simple extraction, the higher the price risk for a particular project. This is since unconventional extraction is typically more expensive than vertical drilling down to a source. This is not to say that oil and gas companies will immediately cease operations on a project that has become unprofitable due to a price drop. These projects are frequently unable to be turned off and resumed instantly.

The Significant **failures** in the oil and gas sector are as follows:
Despite having a remarkable safety record over many years, failures do happen in the oil and gas business. The following are the most typical root reasons of these failures:

**Failure due to Corrosion**
Due to the nature of the operating environment in the oil and gas sector, corrosion is a frequent cause of failure. The degradation of a material because of a chemical reaction with the environment that worsens the substance's physical, mechanical, and metallurgical qualities is known as corrosion failure.

This may lead to breaking due to the creation of nonmetallic substances, fracture due to hydrogen embrittlement, or degradation of the components due to loss of cross-sectional area. Valve failure poses a substantial risk and is an expensive event in the oil and gas industry's offshore sector. It has severely negative consequences, including investment loss, decreased production from plant shutdown, health, safety, and environmental issues such as hydrocarbon (oil and gas) spills, environmental contamination, and, on rare occasions, human life loss. Numerous types of valve failures have occurred in the offshore industry due to a variety of factors, including poor material selection, corrosion, mechanical failure of valve components due to high strain and loads, lack of coating, and lack of inspection.

**The Factors Influencing Demand for Digital Oil Field Technologies**

Several factors are interacting to drive the Digital Oilfield Market forward. We try to highlight five main forces here:

**Growing Demand for Oil and Gas**: By 2019, the Digital Oilfield Market is predicted to grow by 40% to $3.18 billion.

**Developments in Network Technologies**: By managing and sending vast volumes of data from one plant to another, networking technology such as cloud computing will accelerate the digitization of the oilfield.

**Security Factors:** The risks related with safety issues will be reduced due to digital oilfield technology-based devices and systems. Insurance and security cost a lot of money for businesses.

**Oil Exploration in Isolated Locations:** Drilling operations have been carried out in new, distant, and geographically problematic locations (including undersea areas) in search of new oil reserves. Advanced automated systems can help with monitoring in these areas.

**Lack of Manual Labour:** Using automated technologies to mitigate the effects of a skilled labour shortage that is predicted to reach one million by 2020.

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