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# The Effect of Technology and Digitalization on the Quality Management System among Omani Oil and Gas Drilling Company

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## Abstract

This paper presents the mediate effect of technology and digitalization on the relationship between preventative maintenance (equipment related) and overall performance (Quality Management System) among an Omani oil and gas drilling company. Technology and digitalization is considered to be one of the key factors to improve and sustain the overall performance. The paper presents a comprehensive assessment in the overall performance of a drilling rig before and after introducing mechanization operated by one company. A case study will be considered to compare the existing conventional drilling rig performance before and after mechanization, operating at the same concession area, in terms of cost, well delivery, non-productive timing and HSE using a graph form. The overall trend between the two different types of rig design is determined.

**Keywords:** Quality Management System, technology, automated rigs, conventional rigs, performance and benchmarking.

## INTRODUCTION

Many authors from all over the world at different sectors and disciplines concluded that quality management system is obtained by organizations to enhance its overall performance (Archer, 2013). At the same time, many studies demonstrated the need to have fit for purpose quality management system which will be specific to the organization activities (API, 2013), (Ali, 2017).

Oil and Gas industry is considered to be one of the main pillars in the economy of many countries (IADC, 2017). Whereby, the need of having fit for purpose quality system will be crucial for the continuity of the business and capitalizing on the overall performance. Land drilling sector is considered to be one of the most dynamic and risky operations in this industry. Hence, recent studies point to the necessity of developing risk based approach quality management system to manage the overall performance for land drilling operations (Ali, 2017). The author will use one of the recent developed quality management system models specific to land drilling activities to study the mediate effect of technology and digitalization on the relationship between preventative maintenance (focusing on drilling rigs equipments) and overall performance as demonstrated in figure 1 below. The focus area had been highlighted in green.

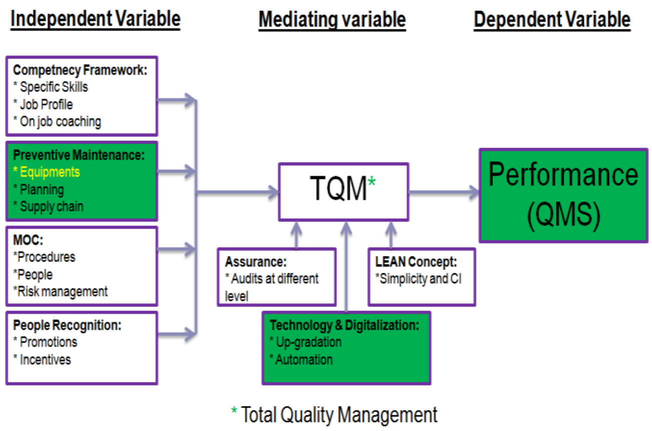


**Figure 1:** Land Drilling (QMS) Model (Ali, 2017)

## TECHNOLOGY AND DIGITALIZATION

Technology is changing the world including the way that different industries operate. The era of the 4th Industrial revolution which is characterized by a digital transformation that is changing the way that we operate in all areas including the oil and gas industry whereby it has been clearly seen by the rapidly growing importance of artificial intelligence, advanced analytics, robotics and machine learning (Company X-CEO ,2016).

Oil and gas industry is considered to be one of the industries that technology and digitalization has not reached its maturity level especially in the land drilling operations. Majority of the drilling companies who are operating in Oman are executing drilling activities with conventional type of drilling units (OPAL, 2015). The author has selected company X which is considered to be one of the major drilling companies in Oman and the intention is to review the current setup of a conventional drilling rig including it critical equipments, operating in Oman and identify area of improvement through technology and digitalization. The mechanized unit performance will be compared against the conventional one.

## RIG LAYOUT AND WELL PROFILE

As highlighted in above section, the technology and digitalization did not yet reach its maturity level in land drilling activities. As the majority of the drilling units which are operating in Oman concession area are classified as conventional drilling rigs (OPAL, 2015).

The author has selected one of the major oil and gas drilling companies in Oman Known as company X to conduct the study and detailed analysis. The intention is to review the current setup of a conventional drilling rig including it critical equipments, operating in Oman and identify area of improvement through technology and digitalization. The mechanized drilling unit performance will be compared against the conventional one. This company is operating in the south region of Oman whereby many wells profile exists.

However, one of the main reasons to select the south field to conducted the detailed assessment is related to the fact that many wells have been drilled by company X in this area compare to the north region using conventional drilling rigs whereby more than 500 wells have been drilled and the company has reached to the optimum well delivery (Company X, 2017).

Drilling rig is a large structure with equipment for drilling oil, water and gas well (IADC, 2015). These units are allocated in specific locations within concession areas. A typical rig layout location within Company X can be demonstrated in figure 2 below.

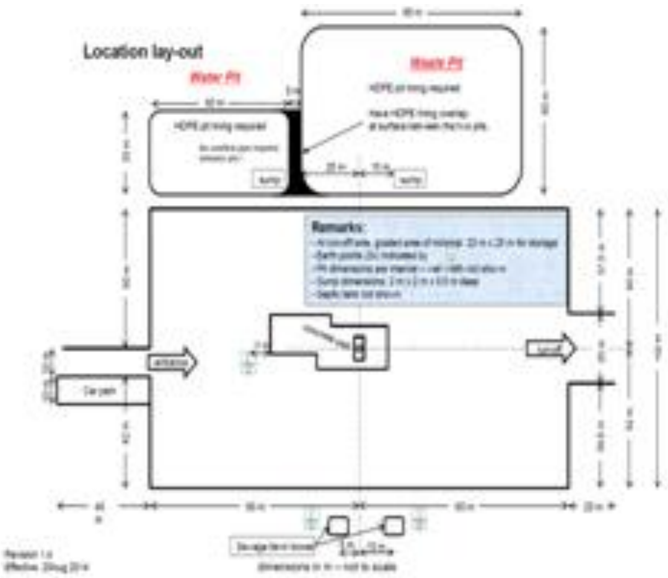


**Figure 2:** Rig Location (Company X, 2017)

Company X is drilling in overall 30 wells per year using one drilling unit. The wells are classified as shallow wells whereby the average total depth of the wells drilled is 1500m. These wells consist of 3 sections starting from top hole of 12.25" section, then 8.5" intermediate section all the way to 6.1/8" section (Company X, 2017) as demonstrated below in figure 3.

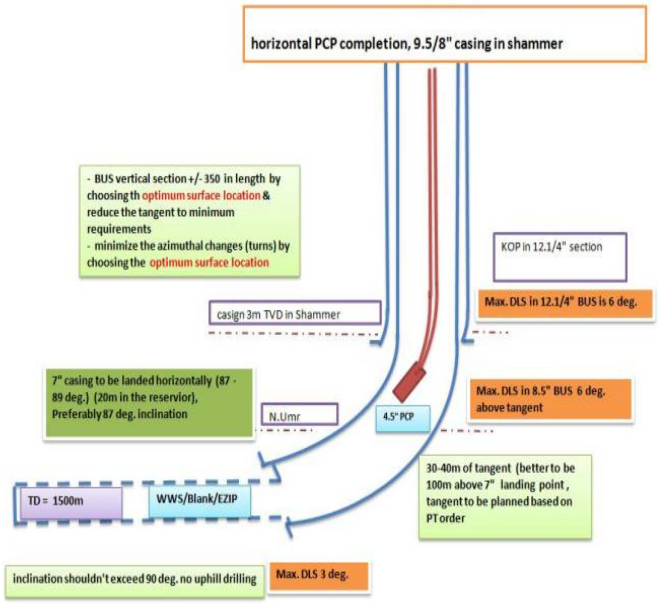


**Figure 3:** Well Profile (Company X, 2017)

This is the common well profile in the south field under company X concession area. Whereby, the company is able to deliver these wells in an average of 12 days, including moving the drilling unit from one location to the other (company X, 2017). The time breakdown of all the activities associated with drilling such well design is summarized in the table 1 below.

**Table 1:** Activity timing break down (Company X, 2017)

| Item number | Activity Description | Time Days |
|---|---|---|
| 1 | Rig Move & Rig Up. | 1 |
| 2 | Drill 12.25" hole section. | 2 |
| 3 | Run and cement 9.5/8" casing. | 0.4 |
| 4 | Nipple up wellhead & BOP stack. | 0.1 |
| 5 | Make up BHA & RIH to drill shoe track. | 0.4 |
| 6 | Drilling 8.5" BUS. | 2.75 |
| 7 | Run and cement 7" casing, N/U THS/BOP & test. | 0.8 |
| 8 | Drill 7" shoe track. | 0.5 |
| 9 | Drill 6.1/8" horizontal hole. | 1.7 |
| 10 | Run & set 4.5" WWS liner and stimulation. | 1.25 |
| 11 | POOH & L/D tubular. | 0.5 |
| 12 | RIH 4.5" BP completion. | 0.5 |
| 13 | N/U X-tree & Release rig. | 0.2 |
| 14 | Total Activity Time | 12.1 |

Based on above well design and its associated activities, the total cost is around $1,200,000 (Company X, 2017). This means that the company is expending more than $36,000,000 annually to drill the 30 wells.

Based on above activity breakdown timing, the author intention on this paper to answer the following question:

1. Will technology and digitalization support Company X to deliver same type of well design in a better timing and less cost?

The company is using light conventional drilling units with a capacity of 1000 Horse Power (HP) to drill such well type as demonstrated in figure 4.

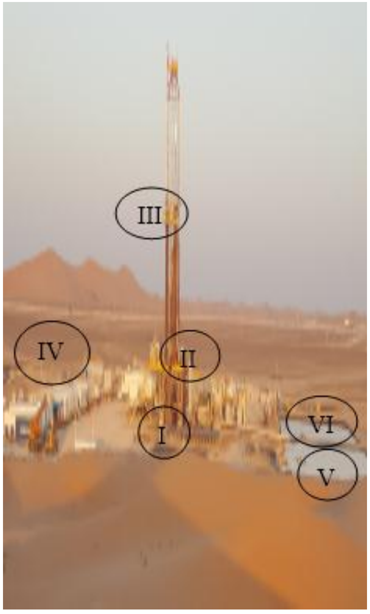


**Figure 4:** Rig Y (Company X, 2017)

The author defined the critical equipments and area of improvement that will be explored and the details are in the coming sections.

## METHOD AND RESULTS

The authors visited company X including the conventional rig Y as highlighted in figure 4 for total of five months whereby interviews took place with the technical experts. One of the main findings from the interview sessions and monitoring the drilling operation activities is that the overall completion of the well can be optimized in terms of timing if the flat time is reduced, (Company X, 2017).

Flat time definition in terms of drilling activities is the time which the rig is not utilized in drilling. Such as making and breaking tubular connections, running in hole, pull out of hole and other similar activities (Company X, 2017).

In the other hand, the overall cost of the entire well can further be optimized by injecting efficiency into the construction of the well location. Especially, the need of constructing the water pits to store water and waste pits which are used to store the waste generated from drilling activities.

Based on above facts, the author has selected 6 area of improvement whereby the current practice will be compared with the proposed automation to enhance the overall performance. The equipments are: 1. power catwalk, 2. iron rough neck, 3. iron derrick man, 4. sewage mobile treatment plant. 5. Water pillow system and 6. Pit less drilling as highlighted in figure 4 above.

## POWER CATWALK:

The current practice in drilling unit Y, is to depend of the conventional way of moving tubular from the ground to the center of well and versa visa. Whereby, human will be exposed and they will be physically on the line of fire to support the movement of tubular from point A (catwalk) to point B (rig floor) as demonstrated in figure 5 below.

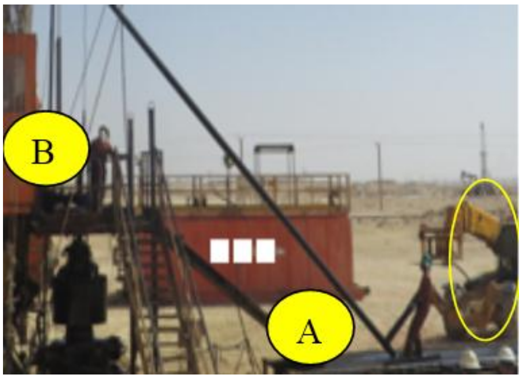


**Figure 5:** Conventional Catwalk, (Company X, 2017)

This is not only exposing people in terms of HSE, it also takes them more than 3 minutes to move one tubular from point A to B (Company X, 2017).

The author explored the market and approached different manufacturer with a vision of having the tubular moved from point A to B without the physical human intervention and less timing. After a detailed analysis, it was concluded that one of the optimum ways to run this activity more safely and efficiently is to replace the conventional catwalk with a power catwalk. Whereby the tubular will be moved up and lay downed in an optimum way as demonstrated in figure 6 below.

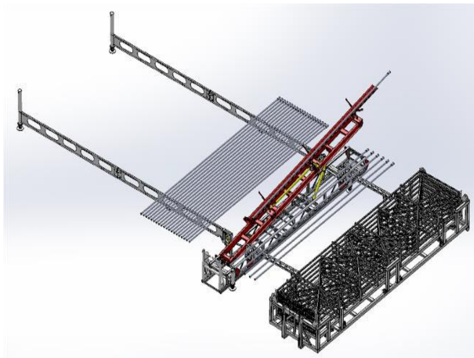

**Figure 6:** Power Catwalk, (Keuri, 2017)

The power catwalk will not only be able to move the tubular without human intervention, it also has the following features:

- Eliminate the need of having a forklift to shift the tubular from the tubular skips to the catwalk as seen in figure 5. Instead the tubular are stored in a hydraulic bin, whereby the tubular will be rolled to the catwalk (point A) and then to the rig floor (point B).
- The movement is completed within 45 second compare to 3 minutes. This has been proven by animation through a certain manufacturer (Keuri, 2017) and other operators using similar concepts.
- The entire operation of tubular movement will be handled by a remote control from a distance.

**IRON ROUGH NECK:**

The current practice in drilling unit Y, is to depend on three to four rough necks (people) working on the floor mainly for making and breaking tubular connection (company X, 2017). This is not only exposing people to line of fire. However, it also delays the entire process as demonstrated in figure 7 below.

**Figure 7:** Rig floor (Rig Y, 2017)

One of the best solutions which were explored by the author with different manufacturer is to have the iron rough neck at the rig floor to specifically handle the connection and dis-connection of tubular as demonstrated in figure 8 below.

**Figure 8:** Example of Iron rough neck, (NOV, 2017)

The iron rough neck will really be a value added to the overall drilling process by which it will eliminate the need of having human at the line of fire and it will expedite the process of the connections which will have a positive impact on the overall time required for running and pulling out of hole. The potential time saving will be around 1.2 minutes per connection.

**IRON DERRICK MAN:**

The current practice in drilling unit Y, is to have a dedicated person known as a derrick man who will be allocated on the derrick board which is around 25m high from the rig floor (Rig Y, 2017). Lots of fatality and injuries happened in the past with different companies where by the derrick man fall from the derrick or got crushed among the tubular. However, many companies including drilling unit Y is having the conventional derrick platform as demonstrated in figure 9 below.

**Figure 9:** Conventional Derrick, (Rig Y, 2017)

This was a real challenge. The author conducted lots of calculation to proof that the current drilling unit Y structure can accommodate the iron derrick man. Theoretically, unit Y can be upgraded to accommodate this improvement and at the same time manufacture technically support in proofing the concept as well as demonstrated if figure 10 below.

**Figure 10:** Iron derrick man, (Keuri, 2017)

One of the main advantages of the iron rough neck is the ability to operate from the driller cabin at the rig floor as demonstrated in figure 11 below.

**Figure 11:** Iron derrick man operating panel (Keuri, 2017)

**SWAGE MOBILE TREATMENT PLANT:**

One of the challenges that company X is facing in annual basis, is the need to construct septic tanks along with socka way pits in each and every location (Company X, 2017). This is not only expensive. It is un sufficient at the same time. As once unit Y moves from the current location to the new location, the old location septic tank will really cause threats to the stock live animals from one side and from the other side will expose the reputation company through civil and compensation claims as demonstrated in figure 12 below.

**Figure 12:** Example of Septic tank in Company X (Drilling Unit Y, 2017)

One of the optimum ways to overcome this challenge and to have a much cheaper and effective option is to replace the septic tanks with sewage mobile treatment plant whereby it will eliminate the need of constructing these pits from one location to the other. Also, by using the MSTP as demonstrated in figure 13 below, it will support the company to adhere into the country legislations and regulation. In the other hand, the byproduct of this system will be clean water where it can be used for different applications such as irrigation.

The author even approached chemical department writhing company X and jointly conducted a libratory analysis on the quality of water produced from the sewage mobile treatment plant.

**Figure 13:** Example of MSTP, (Keuri, 2017)

**WATER PILLOW SYSTEM:**

One of the requirements in each and every drilling location is to have the water pit to store the well site water for drilling activities. However, with the strict environmental regulations, constructing these pits are becoming even more expensive with the legal requirements of having the fence around them, installing the HDPE liner in these pits and restoring them after completing the well as demonstrated in figure 14 below.

**Figure 14:** Water pit in Drilling unit Y, 2017

Furthermore, it is really very difficult to manage such pits and at the same time, company X is losing lots of water due to the high temperature (evaporation effect).

The author was able to calculate the evaporation rate by using the Penman formula especially that the temperature data were available at company X stations. The Penman formula is as

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follow:

$$E_0 = \frac{700Tm/(100-A)+15(T-Td)}{(80-T)}(mm/day)$$

$$E_0 = \frac{[(700\times 30.2)/(100-22)]+[15\times 20.13]}{(80-29.5)}$$

$$= \frac{(21140/78)+301.95}{50.5}$$

$$= \frac{271.03+301.95}{50.5} = 11.35mm/day$$

$$Volume = Lenght \times Width \times hight$$

$$Volume = 50\times 30\times 0.01135 = 17m^3/day$$

T is the mean temperature, A is the latitude (degrees), $T_d$ is the mean dew point and $T_m$ which depends on the pits elevation height.

This means that company X is losing about 204 m3 of well site water is each well (assuming that the average days taken to drill one well is 12). More details are summarized in appendix 1.

Based on these facts, the author explored different options and the ultimate goal is to eliminate the need of constructing these pits by having water pillow system. Whereby, the well site water will be stored in tanks which can be fold and moved from one location to the other as demonstrated in figure 15 below.

**Figure 15:** Water Pillow system (CITAF, 2016)

**PIT LESS DRILLING:**

The other mandatory requirement in each and every well location is to construct the waste pits with an overall objective of storing the waste which is generated from drilling activities. The same environmental regulations which were stipulated for water pits are applied as well in the waste pits. Hence, it is another challenge which the company shall be dealing with in each location as demonstrated in figure 16 below.

**Figure 16:** Waste pit (Drilling Y, 2017)

One of the best practices which were explored by the author is the use of pit less drilling especially in the USA and European courtiers. The technical details were investigated to assess the practicality of implementing such a system in this part of the world. Theoretically, the system can be implemented in company X especially that the system is not sophisticated. As it is mainly depending on the centrifuge which company X is already using. However, the pit less drilling in addition, will have the grinder by which the drilling waste will be further grinded and then treated using specific type of polymers known as alkomer 101 whereby the initially the fluid will be separated from the cuttings and the final stage of separation will occur through the centrifuge as demonstrated in figure 17 below.

**Figure 17:** Pit less drilling (BOE, 2017)

As highlighted in figure 17 above, a libratory analysis was conducted to select the optimum type of polymer which will be able to degrade the drilling mud to water whereby the water can be used in different applications such as drilling the other wells. Other features of this system is the ability to recover oil from OBM sections and the excess cement will be utilized for other different application such as the manufacturing of solid blocks.

**RESULTS AND CONCLUSION**

Land drilling operations in Oman did not yet reached its maturity level in terms of technology and digitalization. However, with the current market challenges and the declination in overall oil process, all efforts are put together to identify areas of improvement whereby wells to be delivered in less cost. As mentioned in the previous sections, Company X is drilling 30 wells per year using one drilling unit with a total cost of more than $36,000,000 annually. In the other hand, the company is bleeding more hidden cost which is coming from HSE incidents and the challenges associated with the pits including the different kinds of claims.

**Well delivery Timing trend:**

Based on company X, the best well was delivered in 12.1 days. However, more than 5 days are considered to be flat time. The flat time is coming from tubular pick up/lay down and making/breaking connections.

A detailed analysis was conducted to compare the current set up timings and the timing that will result based on up gradation and injecting technology. The below graphs demonstrate the difference in timing before and after utilizing power catwalk, iron rough neck and iron derrick man as demonstrated in figure 18 below.

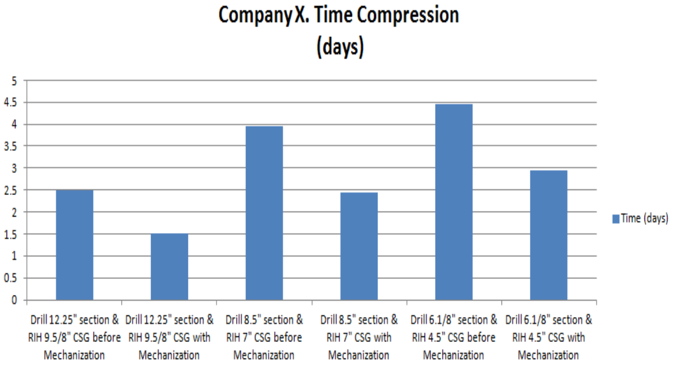


**Figure 18:** Time Compression between conventional Vs Mechanized

### Well location Construction timing trend:

Company X is currently constructing one well location in 7 days.

A detailed analysis was conducted to compare the readiness timing for one location and the timing that will result based on injecting technology. The below graphs demonstrate the difference in timing before and after utilizing sewage mobile treatment plant, water pillow system and pit less drilling, the total number of days required for constructing a well location has reduced from 7 days to 4 days.

### Well cost trend:

Company X will require making investment to purchase the mechanized equipment. However, once the company is fully operating with these equipments, the overall cost of the well will drop as demonstrated in figure 19 below.

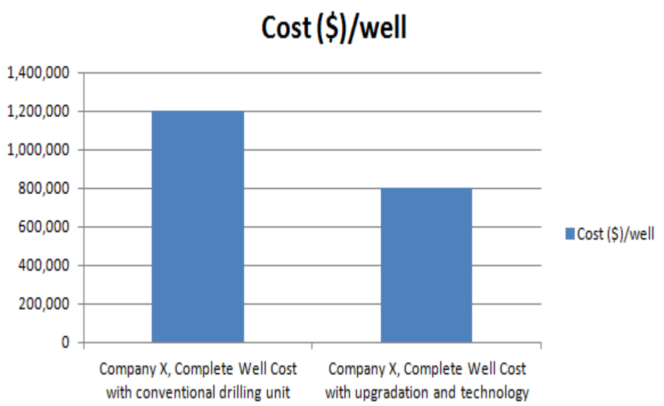


**Figure 19:** Cost Compression between conventional Vs Mechanized

## CONCLUSION

In summary, the author has concluded that technology and digitalization in rigs equipments will have a positive impact on the overall performance. This was proven through a case study of one of the omani's oil and gas drilling companies. Company X will be saving around $11,900,000 annually from one drilling unit if technology is considered on some of its drilling equipments. In the other hand, lots of savings will come from reducing the number of incidents, reducing the number of civil and compensation claim, utilizing cement excess in other applications, utilizing treated water and mud for drilling other sections and minimizing the evaporation rate from the pits. In overall, technology will promote a positive health and safety culture with the drilling operations.

Further studies are required to explore the option of introducing robotics in land drilling activities whereby the entire rig will be operated with only few numbers of people similar to the automobile industry.

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