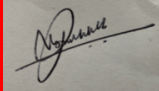




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**Technological Innovation Mapping of a digitalization concept in
maintenance and modification project portfolio for an oil and gas
enterprise**

By

Prasanna Hebbar

Thesis is submitted to the Faculty of Science and Technology
University of Stavanger
In Fulfillment of the Requirements for the degree of
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Abstract

The new trends in the current industry are emerging faster than expected. Companies are embracing technology like never before in order to increase productivity and efficiency along with working smarter. Digitalization is one amongst them which is gaining traction. “Research conducted by DNV GL has revealed that the oil and gas sector is looking to digital technology to provide the long-term efficiency and productivity gains needed to stay competitive” this has resulted in an acute focus on these concepts within the frame agreements in the oil and gas industry project portfolios.

With the help of this thesis, we will discuss how these concepts are developed to suit the stakeholder’s needs along with comparing them with their traditional counterparts. Digitalization concepts are generally very elaborate and heavy investments are made in this domain. This thesis will focus on a digitalization application conceptualized and developed in order to have an impact on the nature of the project and its deliverables. The major challenge with the introduction of the new technology is to streamline the existing work processes along with its practicalities in having to evolve with new digitalization concepts within its working environment, not only limited to technology rather its developers, end users, and also the mindset of the people. Moreover, there is this constant need to continuously refine these concepts such that this technology has its relevance maintained with the consistent need for change in the present industrial scenario.

Therefore, the purpose of this thesis is technology mapping of an innovation concept according to the big picture matrix as proposed by Stephen Fox. This framing identifies the technology dependencies, positive and negative effects over a short, medium and long term basis. This is studied on a live project portfolio viz. Johan Sverdrup. The key analysis areas are concept design and development, deployment/training of personnel, systems integration in lieu of traditional methods, people’s mindset, system challenges and benefits derived. With the help of these elements, the emerging application is analyzed to answer how does this strategy fit in the project premises and helps in achieving its desired goal.

The digitalization concept discussed and evaluated here is basically studied on the chosen organizations Maintenance and Modification also known as brownfield project portfolios as these are the projects which are more established in this part of the region in Norway. Focusing on innovation concepts based on the needs and the kind of the project portfolio gives the organization a unique advantage and gives them a competitive edge amongst its peers.

Our organization's digitalization strategy is focused on delivering results across two-time horizons. At present, it is all about driving cost reduction and increasing competitiveness. But in the long run, it is all about positioning the organization as a market leader in the new digital energy landscape with a unique value proposition to its customers.

The thesis is developed in steps of defining digitalization with the help of study material, literature. With the understanding of the concept, we place this derivative into the project in terms of Knowledge-based Engineering, Equipment which is the digitalization concept to be used on a control object, mechanical equipment. Having established this concept in lieu of the existing work process the observation is that, the information flow is radically transformed benefitting the project and its end users.

To keep it in tandem with the aim of the research that is to identify the potential for practical application of critical realism concerned with emerging digitalization concepts, a context analysis is done using the fishbone diagram. This illustrates the limitations when it comes to deployment of this concept in terms of project portfolio limitations, technological shortcomings, lack of systematic work processes, vendor information limitations and human mindset. We further proceed with the context analysis using the big picture framing. The big picture frames all the aspects of this innovation in one template wherein the potential positive and negative effects along with its efficiency and effectiveness dependencies are addressed.

The big picture framing shows the benefits derived out from this digitalization concept in short, medium and long term forecasts. This picture gives a clear mandate to develop and further implement this innovation concept throughout the different project portfolios in order to derive long term benefits.

In order to have access to these projected benefits, this technological innovation mapping process leads us to some of the areas that the enterprise should focus on, mainly: re-defining the work process and methods, to manage the work force in the new digital world by training the taskforce in new areas, integrating the KBe team in the organization's various project portfolios, imparting knowledge and benefits derived from this technology to the end-users in a multidiscipline environment and finally investing in continuously updating this technology to maintain its relevance in the future.

Acknowledgements

First and foremost, I would like to thank my family, my mom and dad who instilled a great work ethic and the quality to never quit in life, my wife for inspiring me consistently and supporting me unconditionally during this journey, my 4 year old daughter who in her own tiny little way contributed towards her Papa's dream.

Having spent some years working as an engineer in the oil and gas industry, my desire to learn new things and grow, got me back into academics. Pursuing my masters at UiS is that dream coming true. As I had a great curiosity in learning new technologies especially digitalization, served as a background in developing this topic. I was lucky to have my second innings signaled with temporarily working in implementing innovative digitalization concept for the organization without which it would have been very difficult to write this thesis. Hence, I would like to take this opportunity to thank Øystein Hoie, department manager in giving me an opportunity and Andre Fiskum, KBe equipment group lead whose experience and knowledge gave me a good insight in this domain.

Last but not the least I would like to thank my professor Idriss El-Thalji, who not only supported me with my idea but also provided invaluable input and research material in formulating the thesis topic and methodology in particular.

I am a believer in life is a continuous learning process. I am grateful to God that I have got this opportunity which will help in shaping my career path.

Prasanna Hebbbar
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List of abbreviations

PDMS	Plant Design and Management System
NCS	Norwegian continental shelf
CAD	Computer Aided Design
IoT	Internet of things
KBE	Knowledge based engineering
MMO	Maintenance, modifications and operations
2D	Two dimension
3D	Three dimension
LCI	Life cycle information
DNV GL	Det Norske Veritas Germanischer Lloyd

1. Introduction

This chapter highlights on how the research question is formulated as the existing literature only discuss briefly on the gaps in technology mapping hence my research aims to narrow down this gap with the help of digitalization tools, automated work processes, implementation philosophies of our case company. For this purpose, a brief introduction into the company in question is touched upon along with an insight into the structure of the thesis.

1.1. Organization

Our chosen organization is a very well-established multinational company which helps the world meet its energy needs, with engineering the products, systems and services required to unlock energy. The organization's goal is to maximize recovery and efficiency of oil and gas assets while using its long history of expertise to develop the sustainable solutions of the future (Anonymous, 2019). Spread over 52 locations it has an employee base of around 15000, along with this, its services are spread through the entire life of the field from exploration to development and production to decommissioning.

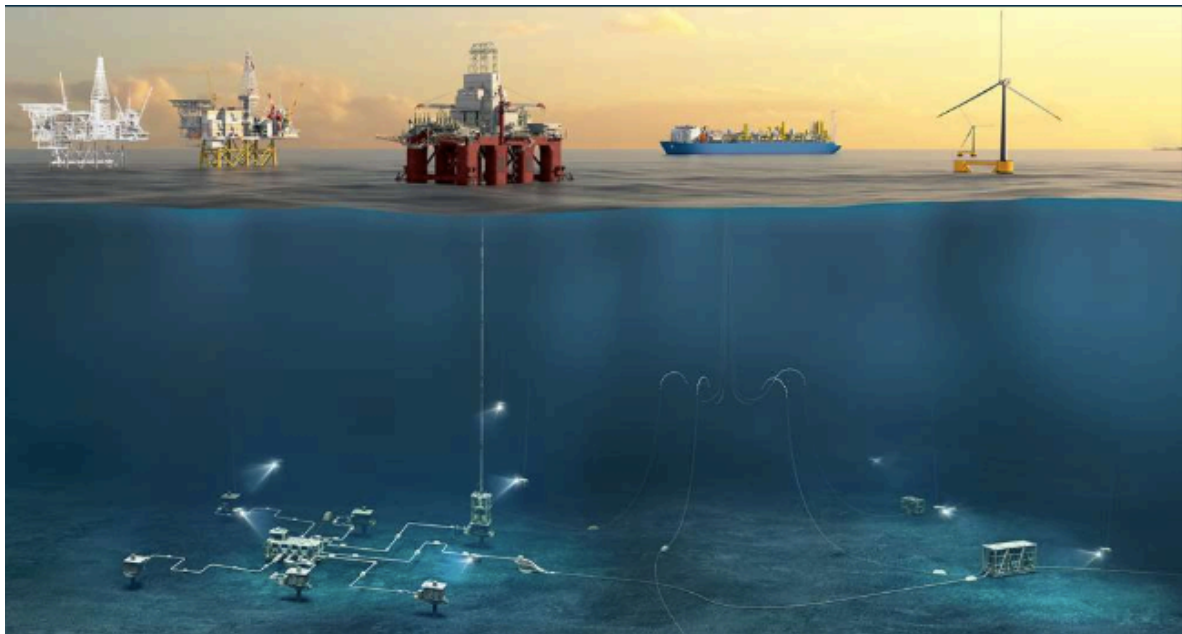


Figure 1: Offshore oil platform (Anonymous,2019)

1.2. Research objectives and relevance

A successful organization tries to reinvent themselves according to the market trends and necessities. New innovation technologies are introduced into their working methods which gives them an edge over its competitors. This new revolution in the industry which is 4.0 is basically connectivity, which includes smart technologies, big data, networked machines and processes. This makes the systems more efficient while reducing cost which is essential for the companies to survive while managing the change.

When we speak about innovation, we have twelve disruptive technology which we speak about viz., renewable energy, advanced oil and gas exploration and recovery, advanced materials, 3D printing, energy storage, next-generation genomics, mobile internet, automation of knowledge work, IoT, cloud technology, advanced robotics, autonomous and near-autonomous vehicles (Tay D. 2013). These disruptive technologies have an impact on the way we work and our thinking. When these emerging technologies are introduced into our everyday work process, we tend to mainly concentrate on the hype surrounding the new technology thus ignoring its other aspects. This short and medium range forecasts fails to provide the very necessary complete outlook.

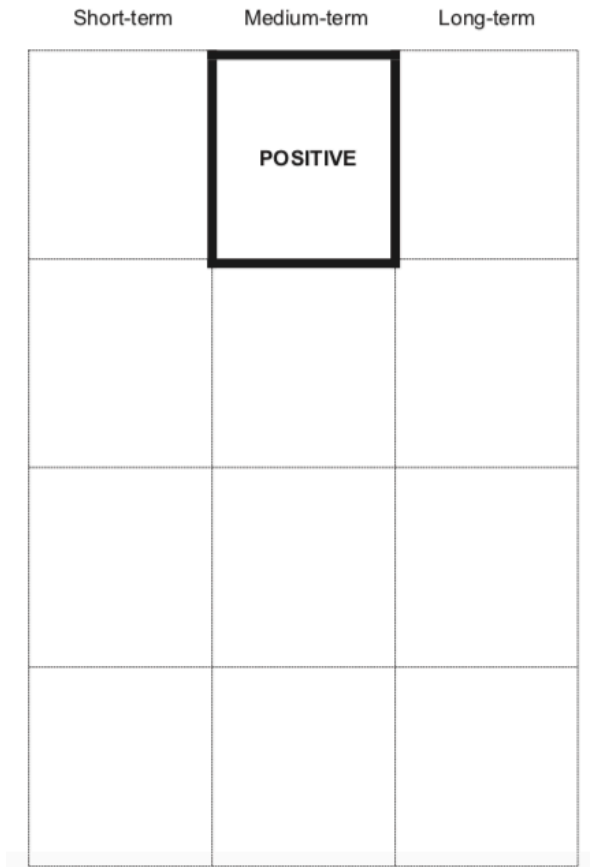


Figure 2: Hype framing (Stephen Fox, 2013)

For our case company, this digitalization application in the form of the automated work process is a blend of disruptive and incremental innovation. In the existing literature there is no mapping done for this new work processes on the company to my knowledge. The aim here is to narrow down this gap with the help of innovation mapping using the big picture framing.

1.3. Research question

The purpose of this thesis is technology mapping of an innovation concept according to the big picture matrix as proposed by Stephen Fox. This framing identifies the technology dependencies, positive and negative effects over a short, medium and long term basis. This is studied on a live project portfolio viz. Johan Sverdrup. The key analysis areas are concept design and development, deployment/training of personnel, systems integration in lieu of traditional methods, people's mindset, system challenges and benefits derived. With the help of these elements, the emerging application is analyzed to answer how does this strategy fit in the project premises and helps in achieving its desired goal.

Simultaneously when a new change is introduced into an existing work process, it is essential that these changes need to be systematically evaluated going further beyond the cloud of hype these changes bring along. Hence the formulation of the topic for the thesis is basically derived from the need by the organization to synchronize these digitalization concepts into their existing work methods for their various project portfolios and in different regions where their business exists. I have been involved in implementing these new work methods in this region for their MMO project portfolios. These new digitalization concepts are a product of Lean, Smart and Innovation derivatives which I am very passionate about.

Although digitalization concepts are not new to the industry, the oil and gas sector relied heavily on traditional work process and methods which worked when the oil price was high. However, things have changed drastically in the last couple of years with the downturn in the oil industry due to low oil prices. Organizations are under massive pressure to bring down cost and increase efficiency to survive, this has led to organizations tweaking their existing work methods and structure.

With the new trend a whole new meaning has been given to the way we work and execute things hence my quest has been primarily:

- To understand the need for innovation and its mapping into the project portfolio
- Interpretation of the new digital automation tools
- Benefits of digitalization and how it helps the project in lieu of existing work processes

- Challenges associated with implementing this new change

1.4. Objective

With new industry revolution 4.0, the main focus these days are on digitalization and implementing them into their products and services. But we know that each project portfolios are not the same and they have their own requirements.

The biggest challenge for the organization while introducing new technology in lieu of traditional work processes is adapting and educating the users. Moreover, establishing new work methods and processes are the need of the hour in order to embrace this influx of technologies. In this thesis, the first step will be understanding digitalization and how these concepts are customized in order to achieve the desired benefit which is to increase productivity and increase efficiency. This understanding is supported by the practical introduction of one of the digitalization concept called KBe equipment for our chosen organization. Now as this concept is the way forward, the research findings will be a measure of the effectiveness of this application and its associated challenges. During the course of the research, the findings may also be used to validate the improvement potential for any shortcomings of this application in the maintenance and modification project portfolios.

1.5. Structure of the thesis

The thesis is spread into chapters as follows:

Chapter 1: The first chapter lays the foundation for the thesis in terms of the general introduction of the subject, the organization and their product along with the method. Thesis structure is also discussed here.

Chapter 2: Touches upon the research method.

Chapter 3: This chapter highlights the theoretical background and the road map leading to digitalization.

Chapter 4: Addresses the data analysis.

Chapter 5: This chapter elaborates on the innovation concept as applicable for our organization and its project portfolio along with the comparison of new and existing work processes in the organization's value chain are established. Also, a detailed context analysis using critical realism and innovation big picture framing is formulated.

Chapter 6: This chapter pulls the curtain down by touching upon the improvement potential along with the conclusion.

1.6. Scope

What is digitalization and why is it important now more than ever in the current market situation?

Digitalization can be interpreted in many different ways. One of the definitions is “Converting information into digital formats which is processed and stored according to the organization’s requirements.” (Anonymous, 2019)

Why is it now given much importance to digitalization and what are the major contributing factors towards this approach?

In the modern era, the principle objective for an organization is to manage changes effectively, where changes can be in product and process technology, change in markets, methods of service or product delivery, outsourcing and financial or economical changes. These changes drive the organizations in reinventing themselves continuously.

2. Research Method

2.1. Research data collection:

The primary data collection method is my work experience in this organization. As an employee, I have been actively involved with MMO projects belonging to the piping and layout discipline. Along with it, I had the privilege to perform work on implementing digitalization application on a prestigious project in the NCS. A great deal of knowledge had to be processed during the course of my work experience in the new digital world which was to learn this innovation technology through an ad-hoc training basis with my counterpart, mapping it with the existing work processes and methods, communicating with the suppliers as well as the end users and the actual use of the application and deriving the results for the stakeholders. My engineering background experience combined with my keen interest in innovation strategies also helped me in this pursuit. Secondly, I utilized data collected from sources available in the companies portal as our chosen company is a forerunner in the oil and gas sector having very well established itself with a strong and successful history. My core background knowledge on service and strategy, management of innovation is also used as a basis in building up my analysis process.

2.2. Data Analysis:

Once we have established an innovation concept, comparisons are drawn between the existing/traditional work process against the new work process inclusive of the digital threads.

The outcome of this comparison is basically derived from the action research methodology. Our chosen organization has a dedicated team which puts forward lean and innovation concepts. Problems are identified and solutions are proposed. In our case, automating manual work process through the use of digital technologies. As the project portfolios are the key vehicles of the digital transformation, the underlying challenges identified while mapping this innovation technology on the company's MMO project portfolio here in Stavanger are mainly derivatives of the observations of my research during the course of the activity.

The main methods for collecting qualitative data for this research are:

- My actual work experiences as an engineer working in the oil and gas industry
- Training and knowledge transfer from my counterpart in the organization
- Actual work experience while implementing digitalization concept for a live MMO project
- Own observations
- Individual discussions with end-users, suppliers, management
- My previous research on Innovation and Strategy topics
- Literatures

Further to the data analysis, my approach is the application of critical realism based on Stephen Fox's method of implementation towards framing of this digital roadmap to keep it in line with the organizations motive of introducing digitalization initiatives and to measure its effects. Hence, a context analysis is done using the fishbone diagram to illustrate the limitations when it comes to deployment of this initiative. We further proceed with the context analysis using the big picture framing. The big picture frames all the aspects of this innovation in one template wherein the potential positive and negative effects along with its efficiency and effectiveness dependencies are addressed.

These observations and data analysis outcomes shall be further utilized by the organization to have an insight as to how this new digital influx disrupts traditional value chains in the MMO business areas and help them to develop and further implement business models in order to derive long term benefits.

3. Theoretical background

Organizations in the present-day market have to survive in a dynamic environment, where changes are introduced into its systems faster than ever before. A successful enterprise tries to reinvent themselves continuously by investing in technologies. Research and development programs are continuously on the go to help the projects to be more efficient and generate value to its customers.

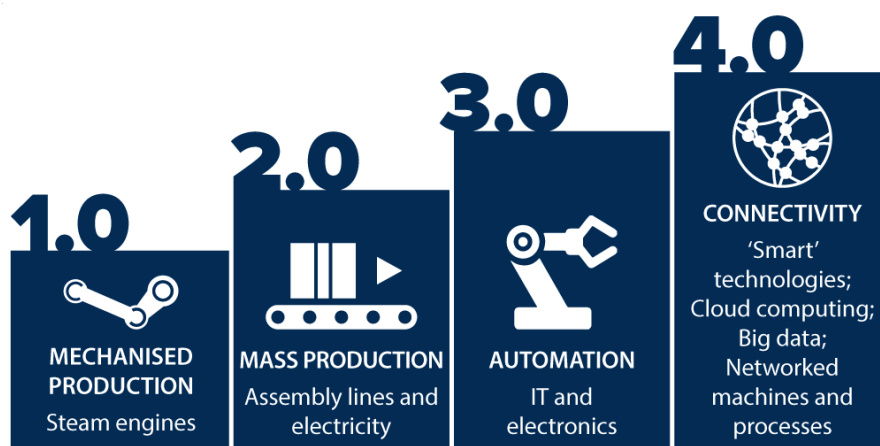
“Change is a dynamic phenomenon which needs continuous updating of short and medium ranges forecasts of technological developments, economics and market conditions, competitors state and capability, firms’ condition and capability, product and process competitiveness, firm’s resources, managing risks, political and environment dynamics etc.” (Frankel, 2008).

As a result, the organizations must frequently invest itself continuously in innovation to organize itself and learn to handle change more effectively.

The change that we are discussing here in this thesis is Digitalization which is a derivative of the current transformation of the industry.

3.1. Overview of digitalization

As we progress into the current transformation of industrial production to digitalized work often called fourth industrial revolution or Industry 4.0 (Iris Group, 2015) we notice the existing systems, work processes and methods are also being updated accordingly to accommodate this new set of changes.



The stages of industrial development
Source: Oxford Analytica

Figure 3: Stages of industrial development

Some key concepts of this digitalization are the digital twin, big data, cloud services, IoT etc.

Although we had the digitalization concepts at the micro level, the crude oil slump paved the way for organizations investing in these strategies now at a macro level. Not just the oil and gas, industry these internet of things (IoT) has also found its way into our households as well. Be it smart home where our regular house hold items interact with each other. Also gone are the days when a car needed to be taken for service to a workshop, now the health of the car at least with electric cars can be checked regularly using an application and simple updates sent via internet can fix basic functionalities of the car.

Digitalization can be shaped according to the organizations needs and requirements.

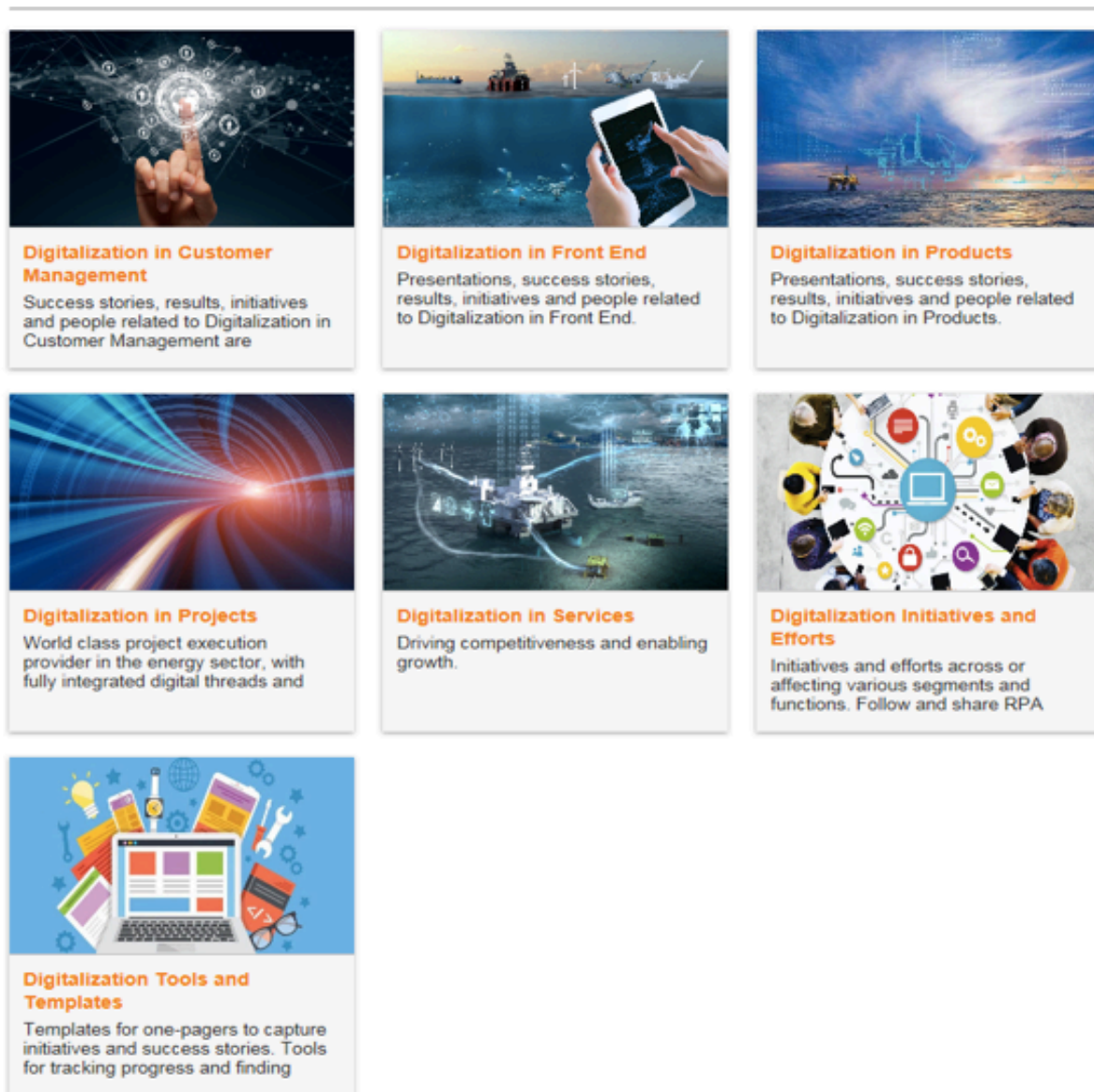


Figure 4: Digitalization per organization needs (Anonymous,2019)

With newfound digitalization tools and concepts, we intend to reshape our thinking in the environment we work in while implementing this vision in reality on the organization's project portfolio irrespective of its product and services.

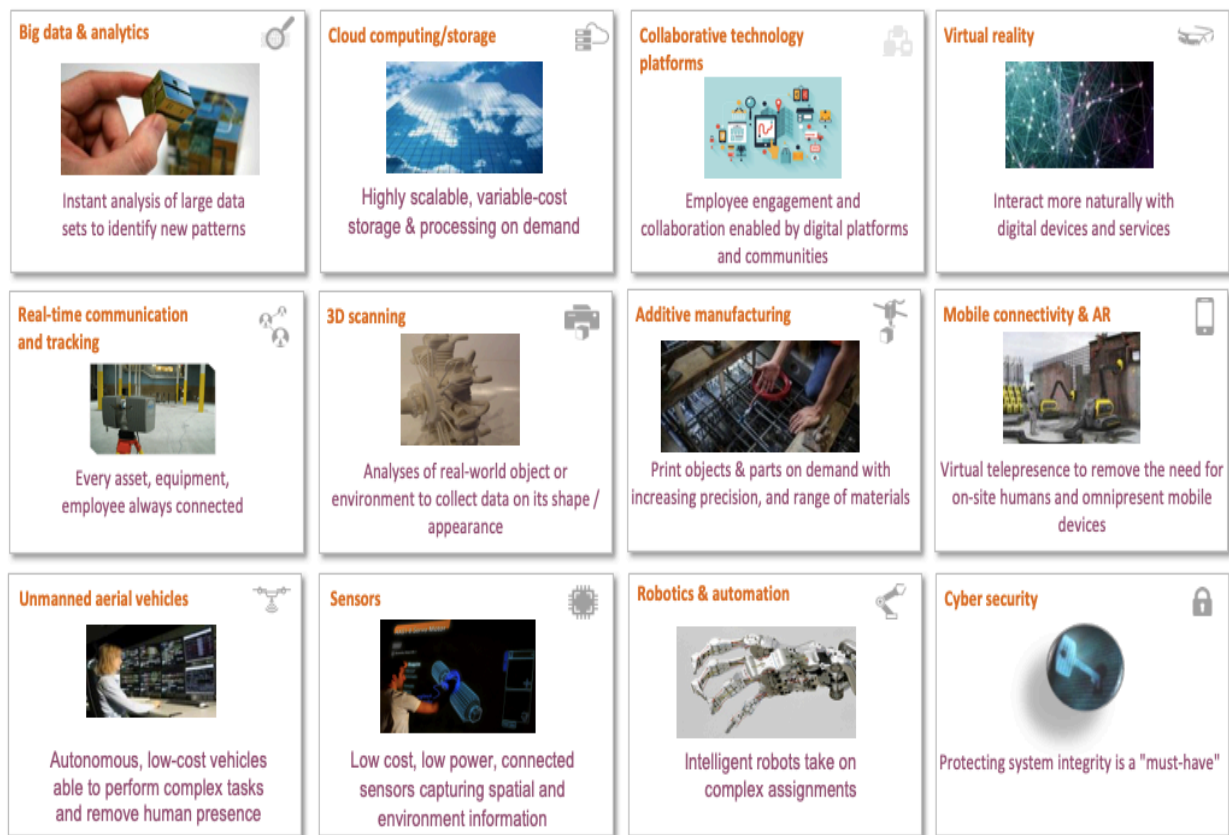


Figure 5: Innovations in digitalization in the oil industry (Anonymous,2019)

The above diagram depicts how the future looks like with new technology. With the collaboration of this new and emerging digital technology, the supply value chain is able to achieve new profound benefits. Technology from the earlier days where simple to understand and they were required to do simple specific tasks (Armstrong, 2017). The modern day technology is much more than that as they execute multiple tasks in a complex working environment which is possible due to systems connectivity. For that matter cloud computing, IoT etc., are the emerging trends. These technologies also help to realize the future state of the product.

3.2. Types of organization based on innovation

We now, know that the digitalization is here to stay and has a very huge potential to increase productivity and competitiveness. Hence effective integration of new digital technologies is very important in order to meet customers requirement and needs. With the need for organizations to introduce new business models inclusive of new technology there also exist few barriers.

However, these barriers are not common to all type of firms, based on this, organizations can be divided into three different groups (Iris Group, 2015):

Innovators: Organizations who develop the digital technologies of tomorrow. In the oil and gas business, they are predominantly the operators. The main elements that drive them into the digitalization path are to improve safety while increasing earnings. These organizations continuously invest heavily on innovative strategies thus streamlining their work processes and the systems they interact with. Moreover, they create business cases in these lines for their clients, some examples being the recent Johan Sverdrup oil and gas installation.

“Johan Sverdrup will be best in class on digitalisation and new technology. Digitalisation will reinforce the effect of several improved recovery technologies. Together, this has allowed us to increase the resource estimate for Johan Sverdrup, while simultaneously raising the ambitions for the field’s recovery rate to over 70 per cent. This will make Johan Sverdrup a world leader also in terms of the improved recovery. The sheer size and the field life of more than 50 years make Johan Sverdrup an exciting place to develop the solutions of the future. We are now working to mature technology for automatic production optimisation, a number of new pipe and seabed technology solutions, and a gradual development of a digital twin of Johan Sverdrup that will give us the opportunity to model and visualise key parts of the field even before we start production for Phase 2 in 2022,” (Equinor ASA, 2019)

Not just technologies related to oil and gas; smart homes, autonomous cars are already here more or less.

Early adopters: Organizations that synchronize themselves to the new emerging market trends. These organization of such kind, are primarily service oriented industries. I believe in my opinion the organization which we have referred to for the purpose of this thesis falls under this category. Service-oriented industries are majorly dependent on their client for projects which in turn generates revenue for the organization. Apart from staying ahead from its competitors and continuously reinventing themselves, they also need to prioritize the needs and demands of their customers as well. This helps the organization to stay ahead in the race while securing itself in this challenging market environment.

Followers: These kind of organizations typically follow the traditional work processes. They invest in new technologies only when these technologies become more mature. Some of the factors that influence this approach are lack of resources in terms of expertise, finance etc.

All the above players play a key role in contributing towards the development and deployment of new technologies. Even though the innovators initialize the digitalization process, the widespread implementing and talking the same language simply does not rest only on their shoulders.

Organizations who do business with them adapt these technologies fueling its further growth. Not just that, they even customize their own digitalization methods which act as a bridge for knowledge transfer and further development. Further implementation gives an opportunity to the followers who act as carriers of this technology and helping it to be implemented in a larger magnitude and for a widespread audience.

Having worked in the oil and gas industry along with my exposure in the digitalization work process, my conclusion is that the new technology, work processes and business case pertaining to digitalization are here to stay and help in value generation up against the existing systems and work methods.

3.3. Digitalization: Innovation in Oil and gas enterprise, a journey

In this theoretical approach, I have utilized some segments based on my initial research work where I had established innovation process and its strategies during the course of management of innovation subject.

The energy industry in particular has been quite reluctant to adopt any changes due to availability of tried and tested technologies, additional costs, risks involved with the change to name a few. Even though the oil and gas sector in Norway has come a long way from initial discovery in 1969 to production start in 1971, we are still conservative in bringing change. However, in the most recent times, we are making up for this lost time by implementing changes, for example, digital innovations at a much faster rate.

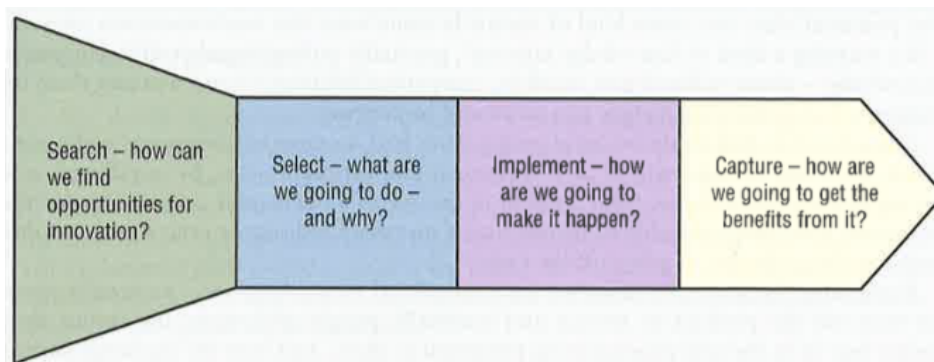


Figure 6: A model of the innovation process (Joe Tidd and John Bessant, 2014)

Our organizations quest in developing this unique innovative digital application is supported by the schematic representation of stages involved in the innovation process.

Innovation is all about survival and growth, established companies believe in continual investment in research and development which is critical to the development and sale of

innovative products and technologies while envisaging risks carefully. The adaptation to changes within the market and foreseeing the need for futuristic technology gives them the edge amongst other players. This, in turn, benefits the organization in maintaining their brand value along with the loyal customer support and maintaining the expectation of their shareholders while deriving profits through new endeavors (Hebbar P., 2018)

Innovation is creating value through change. But simply changing things in random directions can be very risky (Joe Tidd and John Bessant, 2014), hence a proper approach is essential to realize organization's goal. In today's world, organizations are competing in complex environments so that an accurate understanding of their goals and the methods for attaining those goals is vital. To achieve this the organizations need to have a clear set of strategy. An organizations strategy describes how it intends to create value for its shareholders, customers and citizens. Some describe this by their financial plans for revenue and growth, others with their product and services, some with their targeted customers and others from the quality and process orientation. Without a comprehensive description of the strategy, executives cannot easily communicate the strategy among themselves or to their employees. The innovation strategy involves three key steps:

Strategic analysis	<p>This segment begins with exploration of innovation space. The organization targets its product or service in the direction of innovation by analyzing the threats and opportunity, market trends, emerging customer needs, political climate-rules and regulations, competitors, key suppliers etc. This gives a good perspective for the organization to identify its strength and weakness, and how it can build and sustain a competitive advantage.</p>
Strategic selection	<p>Of all the things an organization can do prioritizing the ones which are important is necessary. To accomplish this, resources, finance, knowledge and market conditions plays a key note. With the use of KBe Equipment application, our organization will have an edge over its competitors this enables it to venture into different market sectors thus giving them an opportunity to have many project portfolios.</p>
Strategic implementation	<p>Once the foundation is laid with analysis and selection we then plan for its implementation. Key resources, partnerships, training, work methods and processes etc. play an important role in this step.</p>

Figure 7: Innovation strategy steps

Fig. 8 also represents this strategic process from a different perspective. This step by step process of defining the company’s strategy also helps to position themselves effectively to intercept the latest market trends, which allows them to be at tandem with the latest developments within the industry and modify their products and services incrementally thus paving the way to incremental innovation.

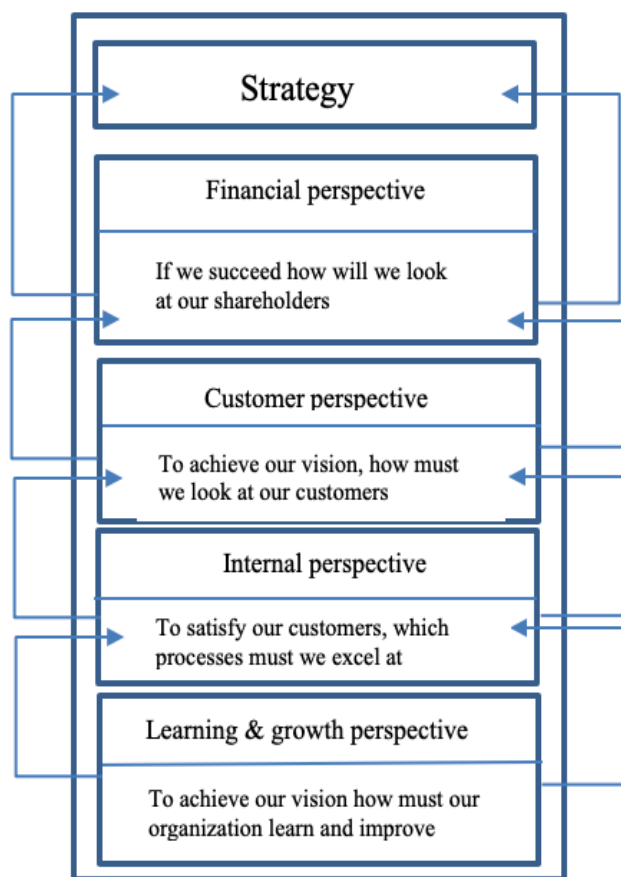


Figure 8: Strategy Map: The simple model of value creation (Kaplan and Norton, 2004)

In the modern global economy, growing organizations face hurdles with regards to changing the world economy, volatile political climate, ever changing technology and competition. Organizations sometimes do not pay heed to these changes which can result in damage to the organization losing its market value and share. The managers in the organization must emphasize on the strategic planning and management of their organization’s future. An effective integrated performance planning largely focuses on visioning process which is contemplating on organizations future with innovations and creative thinking (Hebbar P., 2018).

The dynamic capabilities refer to the organization's ability to perform specific activities or set of activities. Such capabilities tend to consist of a combination or configuration of resources. At the basic level, these can be the basic operational or functional activities of the organization, in case of our chosen company these activities are design and development concepts. At the higher level, dynamic capabilities include abilities to improve, adapt and to innovate which are discussed in the further chapters. The organization sets some rules and norms that define boundaries and success which are then challenged. If these rules or paradigms are not challenged, then the organization misses out on foreseeing the risk and opportunities and this will have a negative effect on its business. The core premise of integrated performance planning is that the company's future can be influenced and reshaped by the visioning process. To encounter this, organizations have to develop dynamic capabilities to tackle new challenges this is done by:

- sense and shape opportunities and threats
- seize opportunities
- maintain competitiveness through enhancing, combining, protecting, and when necessary, reconfiguring the business enterprise's intangible and tangible assets.

This is also done by the organization assessing its capabilities by identifying the key attributes of their most successful product and services. This is then followed by mapping these attributes to the resources or competencies of the organization and finally assessing the potential for the sustaining, protecting and exploiting these resources. For this, firms are increasingly looking for knowledge outside their organizational boundaries and are developing more outward-looking strategic approaches to research and development to source at least some knowledge of potential value from the broader environment in which they operate. With this, they must also tackle economic pressure when it comes to innovation due to the costs vs the revenues. Say in the current market scenario within oil and gas sector operators tend to save cost by investing less on exploration and maintenance. Lack of projects and new ventures combined with low oil prices has already squeezed the supplier industry and competition is quite stiff in this area. To sustain during these trying times, operators resort to cost cuttings while service providers execute jobs at very low margins which dampens their growth and future development. Competition can be sometimes so intense that established organizations file for bankruptcy. Service-oriented companies will have to consider other areas in business sectors where their services can be used best (Hebbar P., 2018).

Innovation incurs a certain cost on the organization basically due to the cost involved with research and development, market evaluation, human capital, innovation effectiveness etc. But in the current scenario of cost-cutting and downsizing it is better to smartly invest in innovations outside the boundary of the firm which help the organization in the longer run. (Hebbar P., 2018)

Innovations strategy can be identified by the organization based on its product and service. As per (Francis and Bessant, 2005) innovation can take many forms but the important ones are the 4 directions of change called the 4Ps model of innovation.

Product innovation	The service offering is modified by the organization based on its needs. For our case company it is delivering according to the customer needs such as contribution towards digital twin, optimizing efficiency thereby reducing cost through introduction of new digitalization concepts
Process innovation	The organization modifies the way it will deliver the service by changing existing work process and methods
Position innovation	The organizations utilizes its vast amount of data and experience that lies within its businesses areas to provide technology enabled solutions at speeds and accuracy levels that were not delivered before. This new found ability shall create an advantage in the market amongst its competitors
Paradigm innovation	This is something new which the organization creates and offers to its customers taking into consideration all the above three: a new model of implementing digitalization applications and optimizing the efficiency of its product and service by means of new ways of working

Figure 9: 4Ps model of innovation

4. Data analysis

In the preceding chapters, we have laid the foundation with theoretical understanding of what the digitalization is all about. Along with it, we have established that an enterprises success in the digital era is about its evolution and embracing technology by putting forward a business case that enables the project to take advantage of the new system.

In the following chapters, we will discuss on mapping this technology into a live MMO project portfolio. The KBe design team develops and supplies KBe software and methods across global business areas of the enterprise, in our case digital application called KBe equipment. This inclusion of new work process across different business cases are according to the global mandate for the business units to take part in digitalization initiatives.

- My first step in the analysis process is to place this technology into our existing work method. Using an actual project scenario, the comparisons between traditional and new work processes are drawn alongside learning the new technology, deriving the output for further project use in a multi-discipline environment.
- During this process shortcomings of this technology are continuously conveyed to the development team including actual communication with the suppliers so as to enable smooth processing of the raw data.

Having carried on with the actual implementation process, my observation is that the strong focus on introducing “change” camouflages the underlying problems these new technologies bring in. This is a great example of how the hype surrounding adopting a digital culture and embracing the benefits of digital tools the organization addresses the changes only on the periphery in the lines of optimizing its operations, improving quality, reducing lead times and subsequently reducing costs, meanwhile, making a weak ground level preparation.

For the organization in order to achieve greater benefits from this change, I have adopted the critical realism approach to address these issues. This approach looks further beyond the hype and gives a better perspective to decision making.

- The first step in this analysis is using the fishbone diagram. This analysis method takes into consideration all the key elements in one frame that causes any resistance.
- The second step is big picture analysis of this innovation, this framing of new digitalization technology demonstrates that the positive and the negative effects of this technology can be placed together as well as its effectiveness and the efficiency dependencies.

Finally, the analysis concludes with answering our quest with mapping the digitalization concept into the organization's roadmap towards a move into digital culture and providing a clear mandate into looking at the existing work process and transforms the business process at the core level.

5. Digitalization concept analysis

5.1. Work process analysis

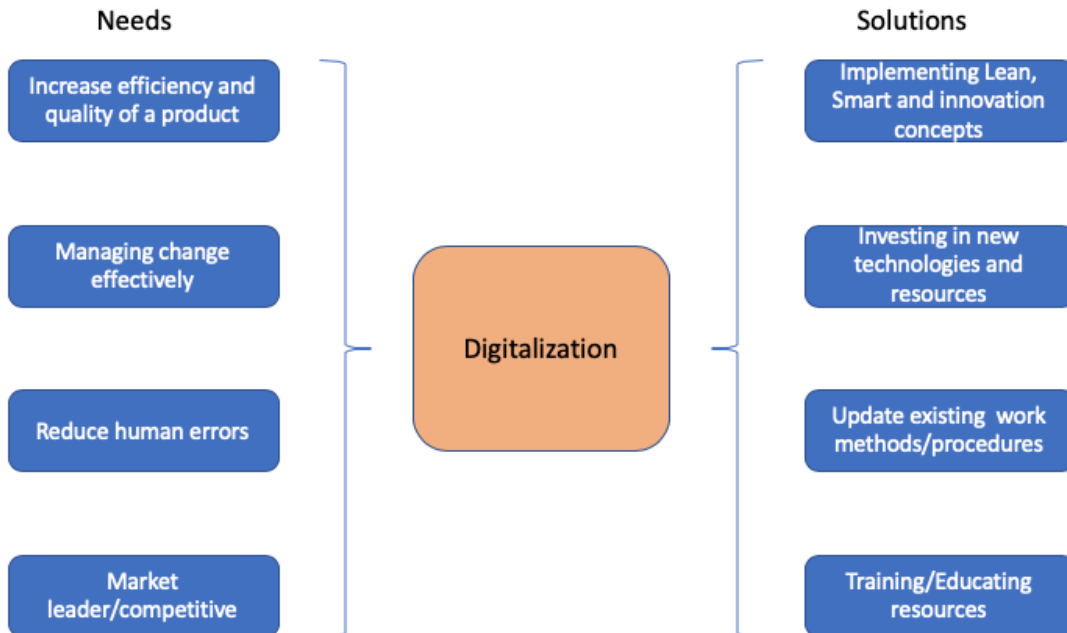


Figure 10: Digitalization mapping

With the massive transformation in the oil and gas sector things are changing rapidly. Organizations try to come up with concepts and ideas to satisfy this demand. Cutting costs and downsizing task force can reap short term benefits but the long-term benefits can be targeted by systematic investing in technology and continuous learning. A very structured approach towards problem solving is essential and adding bits and pieces into an existing problem won't solve the purpose. The company needs to:

- analyze the requirement
- focus on the underlying problem
- carry out detailed root cause analysis in the lines of lean/innovation philosophy
- rectify the problem using new concepts and strategies
- realize the future state

This road towards digitalization assists in transforming the organization in numerous ways:

- Digitalization helps in creating a virtual image of a product in advance with which the organization can visualize the products working in a very detailed environment thus optimizing use, maintenance and consumption of resources.
- Digitalization triggers improved communication. Organizations doing business together are forced to speak the same language this enables closer cooperation, hence there are more opportunities for innovation to succeed.
- Digitalization concepts such as automation, machine learning, artificial intelligence, Computer aided design (CAD) and other technologies have definitely increased productivity and improving multidiscipline reviews and decision making, this takes us away from compromise.
- Automation of tasks is definitely a big value addon as they reduce the possibility of mistakes due to human error and communication.

In the early 70s, when the oil industry decided to incorporate computer aided drawing, which was considered as disruptive technology as it was then opposed by engineers who were used to the traditional way of drafting on a drawing board. In spite of the protest, the industry realized the enormous benefit it provided, and they decided to invest in what they considered as “Expert system” which would make the decision on behalf of its users. These expert systems were the predecessors of what today we call as KBE.

Before we try to understand how the KBe equipment applications are developed and implemented into the project we shall understand what KBE is and how does it help to develop any application.

KBe stands for Knowledge Based engineering. It is a technology where design and engineering experience is captured, stored and reused in order to automate time consuming and non-value adding activities in the engineering workflow.

KBE is the amalgamation of 2D and 3D modeling and the engineering philosophies behind them, taking decisions in lieu of engineers. As a result, not only are capable of allowing flexibility in modeling but also speeds up the process.

KBE is a translating system for different analysis systems. It converts the analysis models to what we call as KBE models which are enriched PDMS models. These processed models are completely ready for the construction phase. Not only that the system has the ability to do the opposite too i.e., generate an analysis model from the KBE model thus speeding up the process.

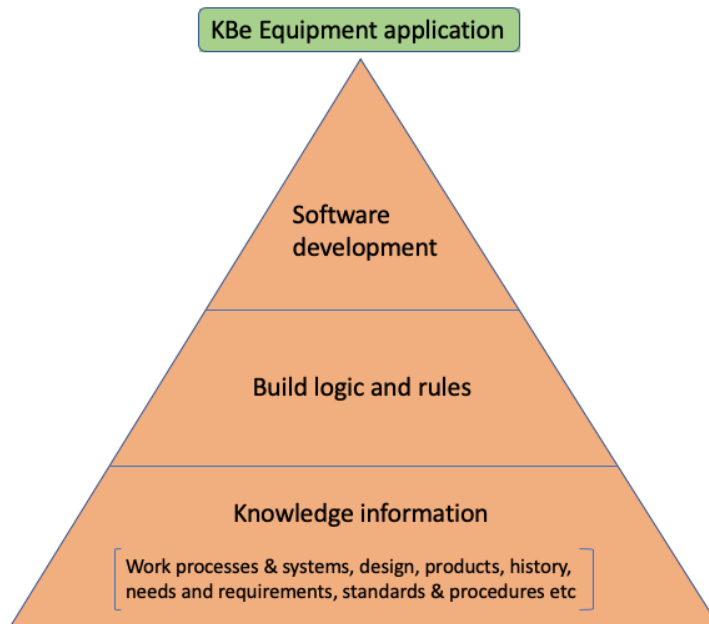


Figure 11: KBe equipment application development

The processes of utilizing this pool of knowledge information along with logic building blended with software solutions help generate KBe equipment application.

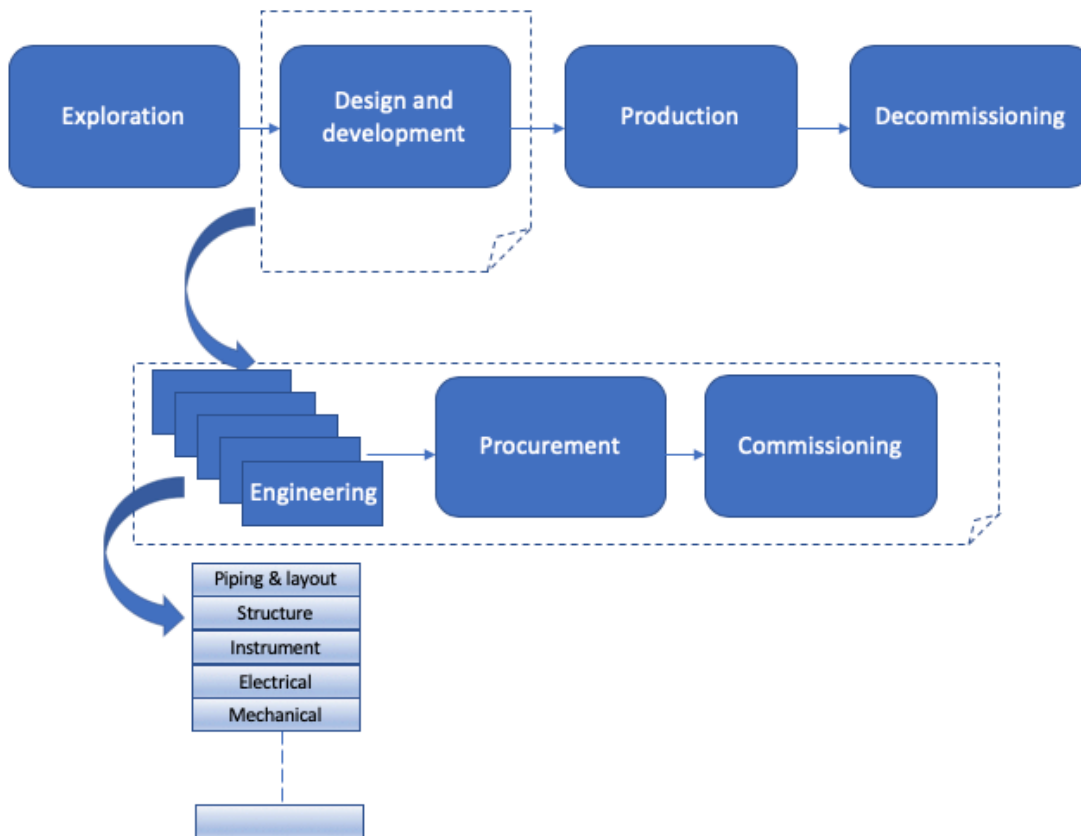


Figure 12: The life cycle of an oil and gas field

The above figure illustrates the life cycle of an oil and gas field in a multi discipline environment.

The journey begins with the discovery of a reserve. The field is then designed and developed into a reliable and efficient production facility which are typically known as green field projects.

This production facility is then maintained and modified throughout the life of the asset for it to be safely operated along with securing optimal depletion of the reservoir which is also known as brown field projects.

Our chosen organizations knowledge and experience covers every stage of the asset until decommissioning and removal of the asset.

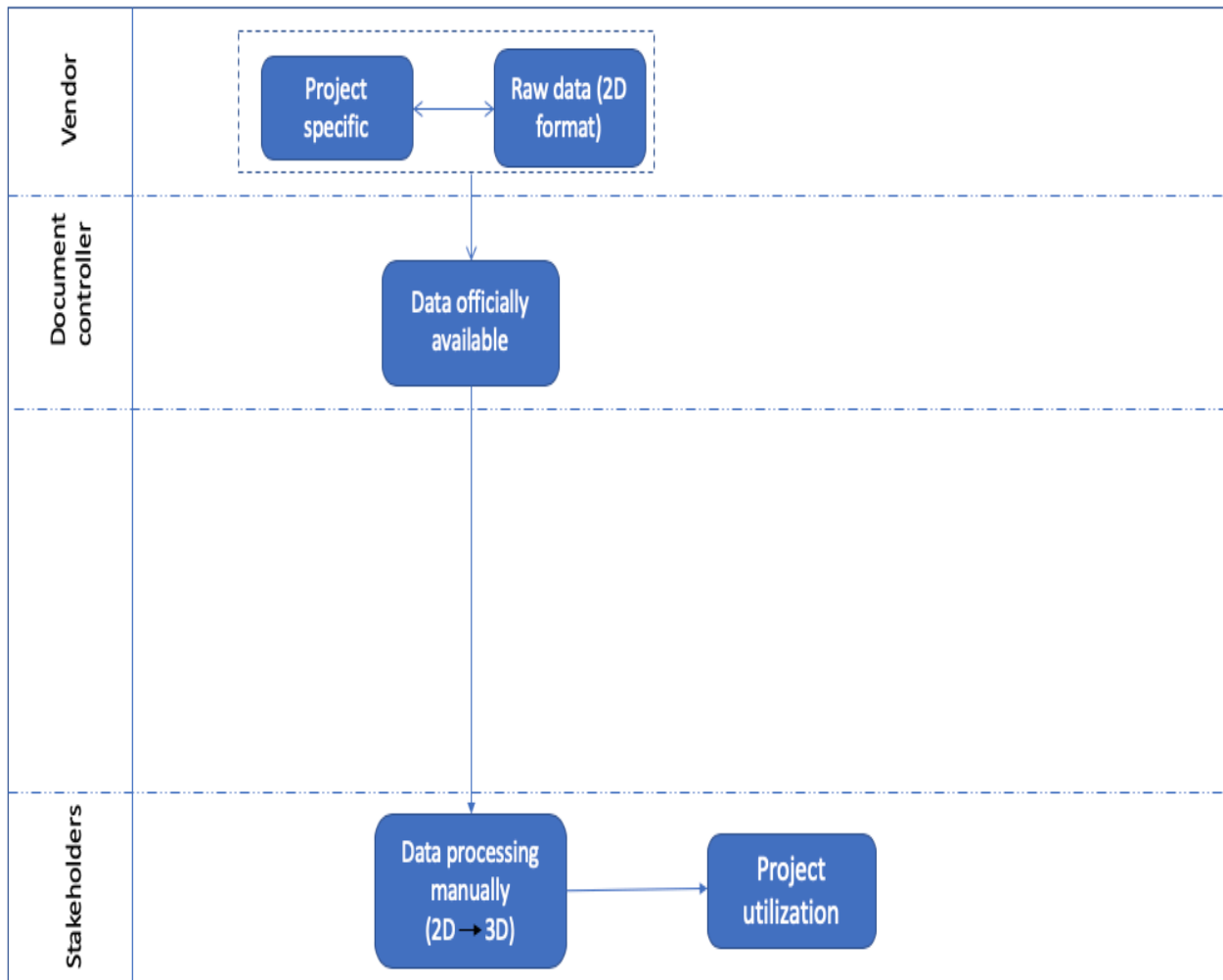


Figure 13: Existing(traditional) work process in an MMO project

The above illustration highlights the existing work process (traditional) without the involvement of the digitalization concepts or KBe.

Here the information flow is unidirectional, the project specific vendor information in a 2D format is facilitated by the document control center directly to the end users/stakeholders. This information in 2D format is then converted into 3D for further utilization by the projects end-users.

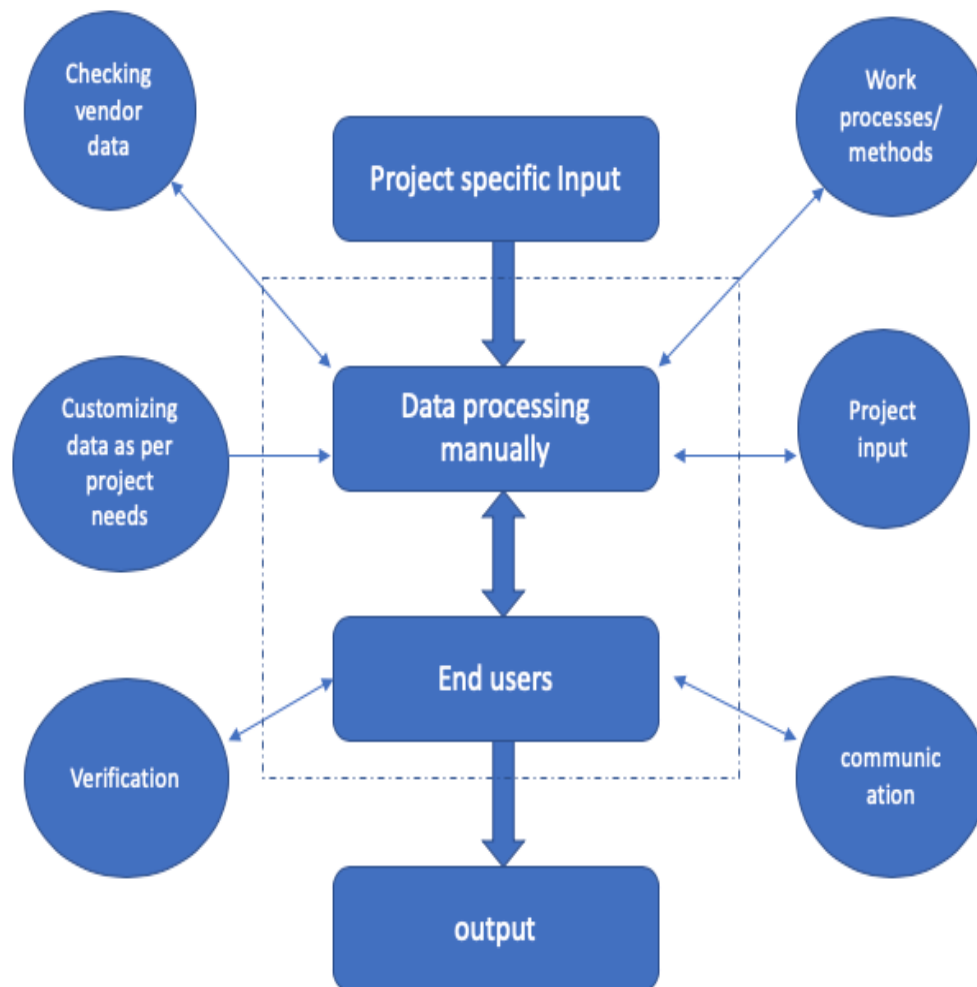


Figure 14: Data processing structure

In the above diagram, we can see how various elements influences the processing of the raw data. Although at first glance one might argue that the process flow chart is functional and quite interactive, we will have to look at this from a broader perspective. As the input is available in the format of 2D, the process of converting it manually is not unidirectional. The conversion of this data depends on the competence of the responsible designer and his ability in reading the raw data. Apart from that depending on the requirement from the various end users this data needs to

be customized to suit their individual needs, not only is this process time consuming rather the process is not devoid of human error resulting inefficiency and loss of productivity.

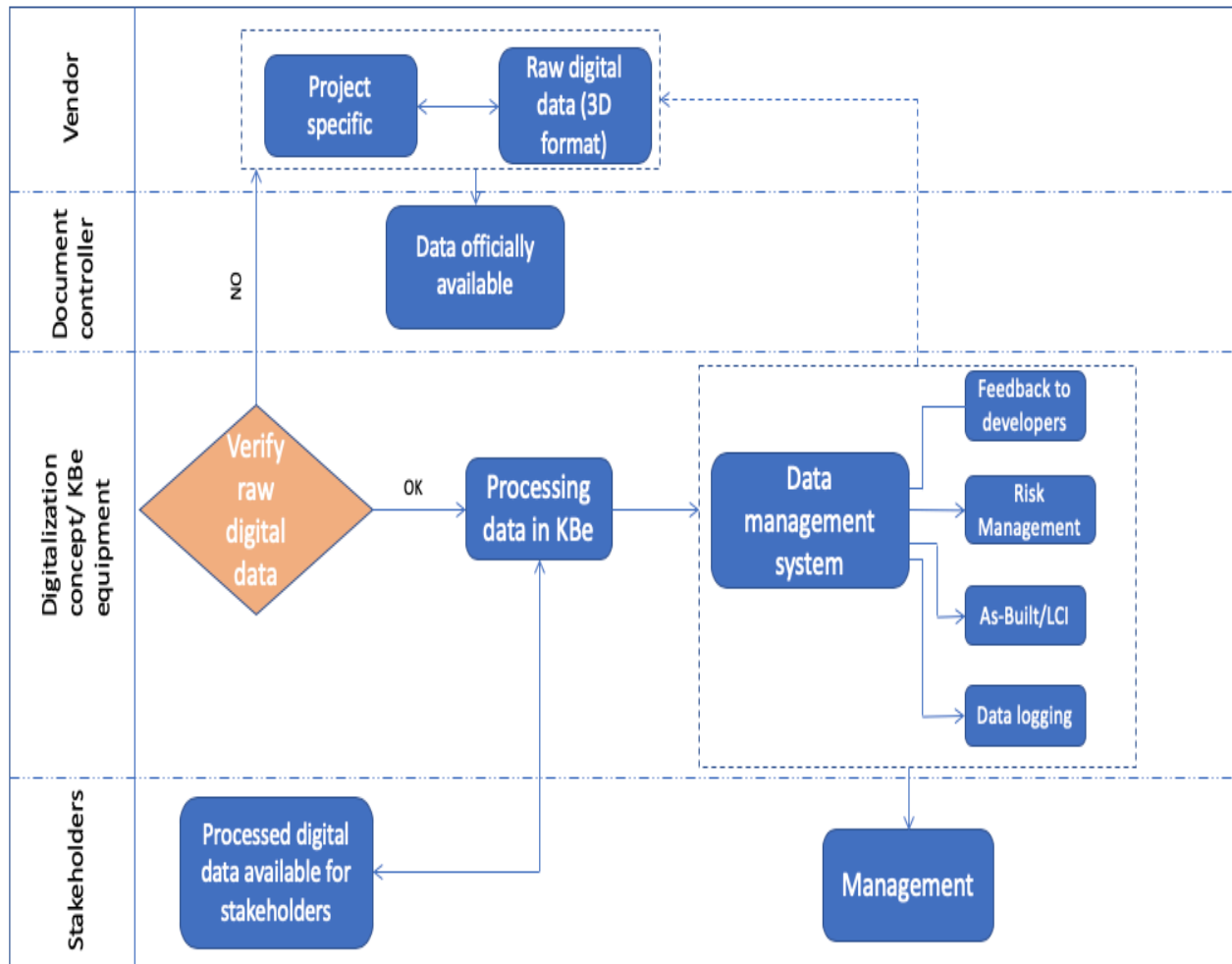


Figure 15: Process flow diagram including the digitalization concept

The above picture depicts the mapping of the KBe equipment into an MMO project portfolio work processes.

The initial step is the vendor providing the project specific raw equipment data in 3D file format. The document control center facilitates this data officially for further processing and controlling. Our digitalization concept in terms of KBe equipment is triggered at this stage of the workflow. The raw data received is read by this software to verify if the conditions as agreed with the supplier/vendor is achieved. This information is communicated back to the vendor, at times if the

data is not provided as per the requirement already established in supplier document list then new file as per the requirement is demanded.

The raw data is then read by the KBe equipment software which process this raw data and converts this information to a more readable standardized format by extracting necessary information while maintaining its integrity. The KBe equipment modeling enables the exchange of data between the supplier and the projects simultaneously enabling this optimized data for analysis, storing in the library for the purpose of future use.

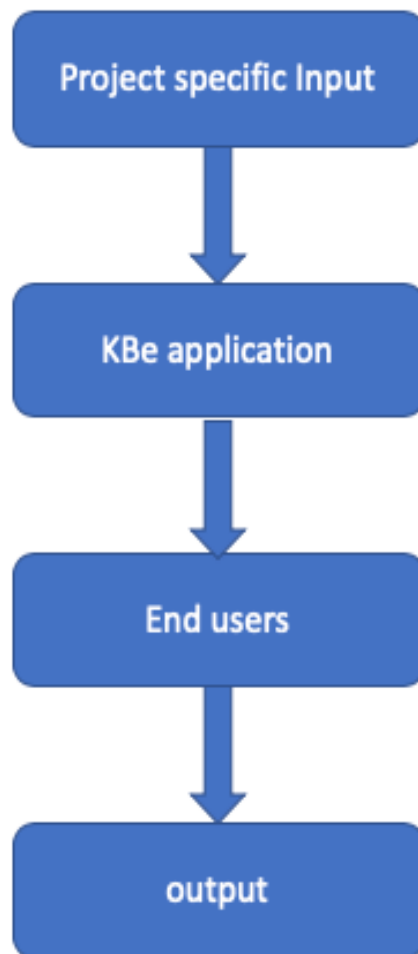


Figure 16: A streamlined structure of data processing

By introducing KBe equipment an innovative digitalization concept into the workflow we are able to implement technology which automates manual work saving time while increasing the productivity and efficiency. We use intelligent automation moving beyond traditional manual work which is repetitive and time consuming. This processed data is facilitated into the 3D CAD system on which various stakeholders have their claim to suit each discipline needs.

Moreover, the work processes are more streamlined, and the raw data is treated in a very structured manner. The corresponding information flow leads to data available at the early stage of the project increasing productivity, due to the reduced consequence for change and lead time while increasing efficiency.

5.2. Context analysis using a fishbone diagram

There are certain limitations when it comes to deployment of this digitalization concept into other business areas irrespective of the location.

Digitalization concepts developed using KBe enables information generation in a very short duration. It enables more questions to be asked, enables more information to be produced and enables more decision to be made more quickly about an evolving series of designs (Blount et al., 1995; Kochan, 1999). Due to this, these technologies are released with quite some amount of fanfare and hype although nobody dares to speak about the “elephant in the room”.

To address this, I have used Stephen Fox’s critical realistic approach theory. Critical realist research seeks to improve understanding of causal mechanisms, and corresponding causal contexts, which are needed in order to generate outcomes from actions (Carlsson, 2003; Radulescu and Vessey, 2009)

Debutant technologies have to face many hurdles before they start delivering. These hurdles come internally or externally to any organization, for example;

- new concepts are developed but project work order does not back the usage of this digital concept.
- new concepts are developed but in time it is difficult to maintain its relevance.

In order to elaborate on this phenomenon and further support my analysis in the big frame picture, we shall frame this using the concept of fishbone diagram. Fishbone diagram is also known as cause and effect diagram. This diagram helps in addressing the potential problem while identifying the root causes of the same.

Although we have discussed in our earlier chapters that digitalization will radically transform how we work in the oil and gas industry, I would like to emphasize the shortcomings this new transformation carries with it. The analysis is supported with the help of this diagram (Fig.17) and my personal experience combined such that this hype does not camouflage the underlying problems. Design and development is an important aspect in the life cycle process of an oil and gas platform and we use a lot of computer aided design tools in the initial phase of the designing

process, now when much sophisticated software solutions are used to compliment the CAD systems then team used to working in the traditional work process resist as they are not used to this kind of interference from external sources.

In my opinions some of the key root causes identified are:

- Project portfolio: They have a key role to play, without proper backup from the customer introducing digitalization concept can be expensive and unnecessary and it largely depends also on the size and type of the project. For example, green field, brown field, short term projects etc.
- Technology: If the purpose of this digitalization concept is not treated well it can be a curse rather than a boon. With time, the continuous update is essential to maintain the relevance of this digitalization concept. Not every organization can afford to have the IT infrastructure to implement and maintain this.
- Work processes: By far the most critical hurdle this one, unless and until if the traditional work processes are modified no cutting-edge technology will embark on a road to revolutionization.
- Vendor info: In our digitalization concept, vendor information is key input, if this itself is not in the required format it consumes a lot of time and resource to get this treated. Then, disapproval from within the organization's taskforce can be easily heard.
- Stakeholders: Are the consolidated group of people ranging from developers, end-users of this technology, management etc. These set of team players needs to synchronize their expectations. If discontentment from any one team player arises this can then jeopardize this fragile ecosystem. If the beneficial derivatives of this digitalization technology are not made clear, then resistance is inevitable.

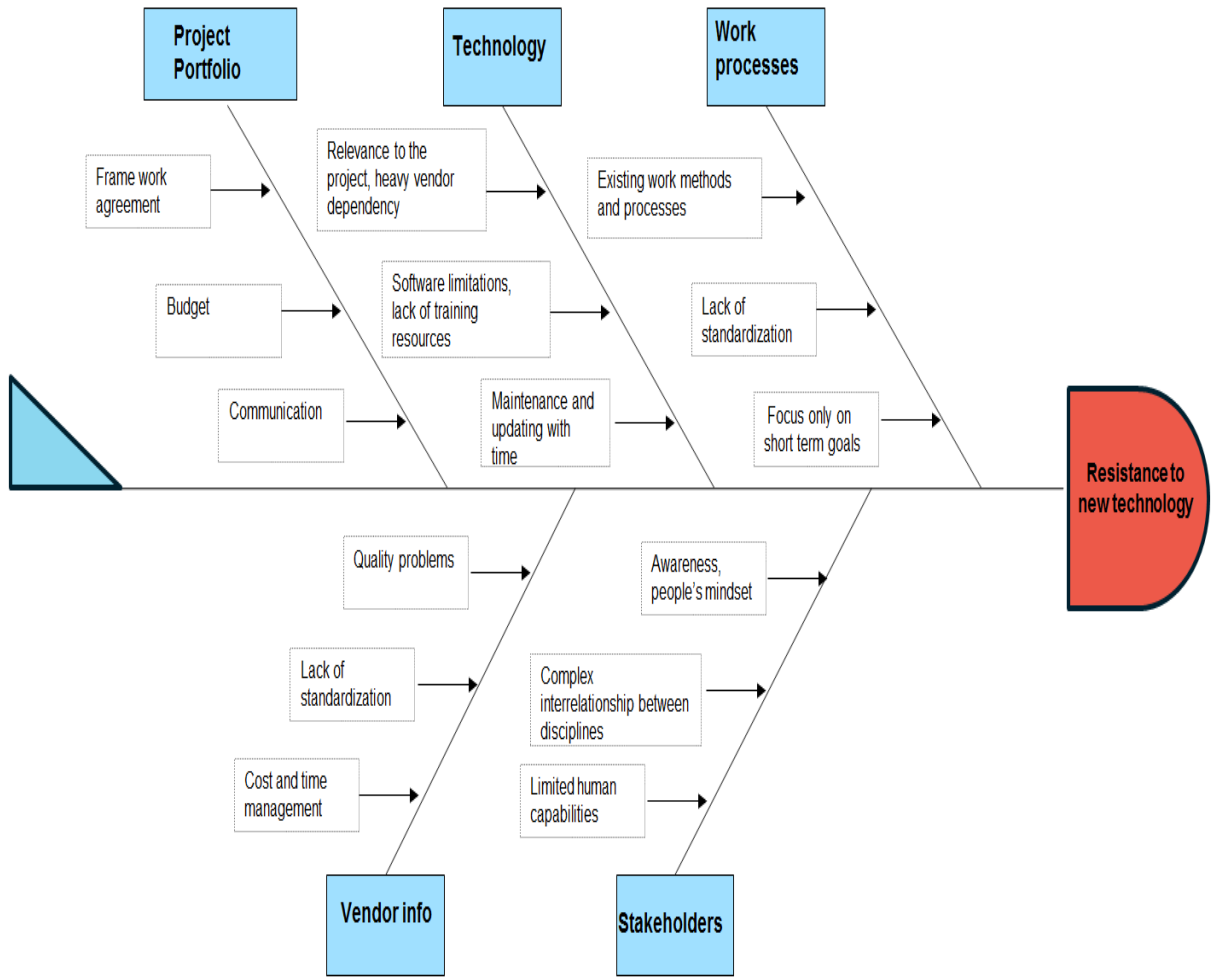


Figure 17: Fishbone diagram

5.3. Innovation Big Picture Framing

Under normal circumstances, the derivative of a vision is necessarily positive results. These technologies of the future must necessarily bare the fruits of its conceptualization and implementation.

This can be addressed using the big picture frame, which highlights the short-mid-long term benefits of the innovation concept according to the big picture matrix as proposed by Stephen Fox. (Stephen Fox, 2013).

Fig. 18 illustrates the big picture framing for our digitalization technology. Using this framing picture, we position the digitalization concept in a divergent frame. This helps in forecasting the potential positive and the negative effects along with their dependency factors. When an industry as old as the oil and gas sector intends to change its existing work procedures and bring in new technology revolution it is received with certain criticism and apprehensiveness in the minds of the task force. When existing work methods and procedures are made redundant to pave way for new technologies, it is essential to take into consideration all the aspects of its integration. The big frame gives a holistic approach in this regard while identifying the positive effects as well as the negative effects along with efficiency and effectiveness dependencies forecasted on a short, mid and long term range.

Potential positive effects: With our digitalization concept used by our chosen organization the data is made available at a very early stage of the project. In some cases, as early as in the bidding phase which helps the project to envisage quantity and increase quality which would have been difficult otherwise. The manual processing of the raw data with multiple revisions is greatly reduced due to the fact that uniform processing of raw data using digitalization tools helps the outcome in a structured and standardized format.

As we have discussed before in chapter 3.2, innovators set business cases for the organizations they are doing business with. Our digitalization concept contributes towards their digital twin concepts which is a replica of physical assets by digital copies. This effective utilization of digitalization concept helps the organization to position themselves better as manual and repetitive tasks are eliminated which adds to value generation. Data logging and storage can benefit further the projects wherein the know-how can be reused, which saves time and increases efficiency. Standardization helps the interested parties speak the common language. Suppliers, manufacturers, distributors, end users all share a common digital platform enabling the exchange of information automatically. This vital piece of information benefits all parties throughout the value chain. However, different stages in a massive project such as Johan Sverdrup are performed by more than one organization, these firms need to find a common platform to share the know-how who has the advantage over the other in order to meet the client's requirement for a

digitalized business case. This scenario acts as a revenue generator for the organization owning the digitalization concept by sharing knowledge to bring in uniformity throughout the life cycle of the project.

Effectiveness dependencies: In order to bring about a positive impact on the introduction of new technology many factors have a major role to play. In our digitalization scenario, we need to think in a broader perspective outside of this technology. The hype surrounding the new technology introduced usually dilutes the mandate required in the groundwork preparation needed. For example, the organization handling a particular type of projects and working in traditional organizational structure and work methods will yield very little benefits with the new change. Some contributing factors are people's attitude and mindset. When it is possible to derive results with the existing work process why bother change? Hence change has to be addressed to the right audience. Once we have the team on board then proper training and knowledge transfer are the key ingredients needed to deliver. When these two key contributing factors are worked upon at a macro level the effectiveness ranges from short to long term.

Efficiency dependencies: Oil and gas industry works in a very complex working environment (refer Fig.12). Given the volatile nature in itself, demands immediate results from any new change for it to sustain. However, the efficiency of the new technology is gauged by the virtue of its user interface and quality of the raw data it receives as the input. If this initial step is not laid out well then, this lag proves costly for the further stages in the process. With regards to our digitalization concept KBe equipment, the supplier does not have any access to how their raw data tends to behave in the digitalization working environment. This needs to be communicated well beforehand as early as the bidding stage of the project which can be quoted in the supplier document list. Also, proper communication between the equipment suppliers and the customer must be channelized. This effective communication along with data logging and knowledge-based engineering data centers help to reduce time wastage and increase productivity.

It is to be noted that today's technology might not be relevant for tomorrow. Any digitalization technology must integrate well into its ecosystem. Continuous investments in developing these digital technologies are essential to keep the technology relevant to the future. For example, Yahoo failed to join hand with Google which led to its downfall, similar case with Nokia failing to envisage the needs of the futuristic smart phones. Hence smooth functioning of the software, ease of user interface, user acceptance testing, error logging, the communication of the systems (systems talking) need to be continuously monitored and updated to maintain the efficiency in the long run.

Potential negative effects: Any new change introduced into an existing system brings in both potential as well as negative effects. This is like two sides of the same coin. Having had my fair share of experience implementing the digitalization concept into one of the maintenances and

modification project my observation is that digitalization is here to stay and for good reason, with this we now have to adequately gauge the potential negative effects and handle them effectively.

Organizations tend to get caught in their own web, as a lot of effort and resources is utilized in making this technology, but little is said and spoken about its implementation. For maintenance and modification kind of oil and gas project this technology might seem to be a little advanced in its kind, some factors affecting it are budget, time frame and resources. Moreover, it may seem excessive to implement digitalization concepts, if the nature of the project is small and restricted to a particular area of the platform. Even if this can be undertaken for older platforms getting this technology implementation made feasible might not be reasonable and cost-effective. As discussed above in the directive of the big picture framing, technologies influence us the way we think and execute ideas for the betterment of mankind.

	Short-term	Medium-term	Long-term
potential Positive effects	<ul style="list-style-type: none"> • Data available for projects use at very early phase • Reduce human error and manual work 	<ul style="list-style-type: none"> • supports Digital twin concept 	<ul style="list-style-type: none"> • Efficiency leads to market advantage • Automated digital data can be stored and reused • Standardization • Knowhow revenue generation
effectiveness dependencies	<ul style="list-style-type: none"> • Efficiency/enthusiasm of the end-user • right attitude/mindset • robustness of the technology • user interface 	<ul style="list-style-type: none"> • Efficiency/enthusiasm of the end-user • robustness of the technology • user interface 	<ul style="list-style-type: none"> • Project specific/frame agreement
efficiency dependencies	<ul style="list-style-type: none"> • Input data to be received in the right format 	<ul style="list-style-type: none"> • communication 	<ul style="list-style-type: none"> • Work procedures and methods • Continuous investment in technology
potential Negative effects	<ul style="list-style-type: none"> • Cost • Training • Resource allocation • Development • no immediate results (futuristic) 	<ul style="list-style-type: none"> • Managing data • Pilot project • Complex eco system 	<ul style="list-style-type: none"> • Maintaining the relevance of the system • licence • maintenance • support

Figure 18: Big picture framing

6. Discussion and Conclusion

Whether we like it or not, digitalization and its concepts are here to stay. However, during the last couple of years, the oil crisis which has largely impacted organizations and has affected its employees. Meanwhile, the uncertainty in the market is still lurking. At these times when the oil and gas market is finding its foothold, introducing new changes and work procedures are seldom appreciated. And to aggravate this, when we speak about digital concepts in lieu of human resources there is instant resistance.

An organization with a good history seldom accepts changes as their existing work methods and procedures have been deriving them the benefits they yearn, this trend is similar to believing that “a glass to be half empty” and no other way of phrasing it.

However, a successful organization which is ahead in its race have a different dimension of viewing, what they see is “glass as half full”.

When Apple.inc developed smartphone in 2006 nobody believed in the true potential of this technology, if Apple.inc had failed to have a vision and refrained itself from seeing the bigger picture then they would have gone the Nokia way. The same is the case with Tesla, what they have managed to achieve in a very short span in changing the dynamics of the automobile industry and the vision for the future is an achievement that the industry has to reckon with now.

When it comes to deploying KBe equipment, we know that the concept has taken off in couple of green field projects already namely Johan Sverdrup Phase 1 and Johan Castberg. Although, implementing it on the former has been more of a pilot project while implementing this technology on the later was on the lines of improvements/ lessons learned from the former. The goal now is to utilize this concept further in the MMO project portfolios. These concepts have the potential for growth meanwhile, the enterprise can prove its leadership in the market by managing the incremental innovation by adapting to the different needs over time and dynamic capabilities.

From the discussion and context analysis, we can conclude that our organization along with engineering this technology has the ability to adopt this strategy. However, for a smooth transition into the new digital world in the MMO project portfolios and to reap the desired benefits of this technology in a long run they need to focus on its interrelations and dynamics this technology might pose:

- The digitalization concept aims at creating value to the organization and its customer. Along with it this service must also be polished and fine-tuned regularly to add value during its implementation.

- An innovation disrupts an earlier working process and redefines the way we work with the introduction of a new digital concept. With our organization having an existing business model to execute a particular task (ref. Fig.13) it will still find ways of innovation opportunities. This new innovation opportunity (ref. Fig.15) reshapes the whole working process. This incremental reshaping of the work process paves the way for new methods of doing business with the organization's suppliers, customers etc. Hence with the introduction of the new change, the benefits from it also need to be made clear for it to resonate with the task force.
- Bigger organizations have many hierarchy levels, each member in this hierarchy level must be onboard in order to realize this new concept, this can be achieved by anchoring KBe department and its services in the organization chart and its service KBe Equipment in the project workflow.
- The organization must create a task force with the right skill set and impart training to its resources working in this environment. This will enforce a positive working environment as the skill set of the employees are continuously challenged and redeveloped. By this method, employee attrition is reduced, and the company manages to retain its skill set which benefits the organization in many numerous ways.
- In our earlier chapters we have discussed on friction these changes bring in within the task force. Experienced engineers programmed to execute in traditional work methods reject the idea of this disruptive department and its concepts as these digitalization concepts bring in automation. This is immediately interpreted as a threat to their jobs. Along with the benefits the changes bring in, they must also be made aware that these digitalization tools assist engineers to do their jobs quicker and utilize their time in other areas to optimize productivity.
- Compared to other areas of engineering within the organization, KBe department is comparatively a small team comprising of engineers and developers, as they bring in value generation to the entire value chain it is essential that continuous encouragement and marketing is necessary to characterize this department. If not, then chances of them overruled by traditional work processes are higher. Their ideas of bringing in necessary changes in our case introduction of digitalization concepts and various other in this regard must be encouraged and their proposals should be accepted and adopted such that they keep contributing and bring in a positive change in the years to come.

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