Wilbert Ramos

Adoption of new technology in the subsea oil and gas industry

Master's thesis in Technology Management
Supervisor: Dr. Arve Pettersen
February 2021

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Norwegian University of Science and Technology
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Abstract

The subsea oil and gas industry is a reluctant industry which tends to avoid the introduction of new technologies which do not have a field proven history. Laying the groundwork to benefit from new developed products, systems can be costly, challenging and potentially could end up in failure as it is very difficult to get customers onboard. Therefore there is a need to context a strategy to increase the success rate of new technologies being used in subsea fields. How to ensure that new technologies are shaped according to clients expectations (internal technical standards) and/or ensure that clients' expectations are shaped according to new technologies therefore minimizing the risk of not having customers who are eager in using new technologies in existing fields or new development fields.

Conventional strategies require product marketing i.e. once the product is available or at least in an acceptable TRL then the journey to introduce, educate, convince and sell to potential customers is started which is challenging, time and resource consuming. On the other side, for oil and gas operators to implement new technologies it is also time and resource consuming for them to be able to digest new ideas and technologies. Therefore it may take some time before new technologies can be implemented even if they are cost efficient.

Established worldwide subsea oil and gas operators like Total, Shell, Exxon, Equinor, Aker BP, etc, have a set of specific internal standards that suppliers need to comply with. The last presents a challenge to the conventional strategy for marketing new products, i.e the new product shall comply with each of the internal standards that each operator owns. It derives, best case, in specific products per operator and worst case being unable to introduce the new product to specific operators.

For a supplier like Akersolution, NOV and TechnipFMC which have broad spectrum of competence within subsea production system, the possibilities to increase the rate of innovative products is quiet huge and having a strategy on how to get onboard customers *a priori* thereby assuring the path is prepared for new technologies to be sold, will maximize the rate of new technology success.

Keywords:
Technology, innovation, buy-Grid model, buying center, group culture, group and organization culture, risk, pattern of diffusion, adoption, industrial buying behavior, disruptive technology, adoption of new technologies, technological innovation.

Acknowledgment

After two years of study combined with work and one year combined with Coronavirus (COVID-19), with a lot of challenges at work and in private life, it feels really rewarding to complete the present thesis. I ought to admire and thank my wife Katerine for her support, comprehension and positive energy, to my two children Johannes and Casper for their smiles and patience. To my parents Isabel and Edgar, I would not be writing the present thesis without you, rest in peace my beloved father you are in my heart. Finally to my brother, Ronald, I have the outstanding luck to have your unconditional support THANKS!.

I would also like to thank all the excellent lectures at NHH, NTNU and Chalmers, it has been a pleasure to participate in all the sessions, such broad knowledge in different areas which allowed me to develop my career.

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Abbreviations

ASME	American Society of Mechanical Engineers
API	American petroleum institute
BoD	Basis of design
B2B	Business to business
CAPEX	Capital expenditure
DCFO	Subsea control systems incorporating high-bandwidth communications and electrical power supply for offshore Oil and Gas production facilities
DNV	Det norske veritas
EMA	European medicines agency
EPC	Engineering, procurement, and construction
eSCM	Electrical control module
EU	European Union
FEDEM	Front-end development manager
FMCA	Failure mode, effects, and criticality analysis
GS	General specification
HSE	Health, safety and the environment
IEEE	Institute of Electrical and Electronics Engineers
IP	Intellectual property.
IRL	Integration readiness level
ISO	International standardization organization
ISA	International Society of Automation
ITT	Invitation to tender
IRIS	In-service Riser Inspection System
NORSOK	Norwegian shelf’s competitive position, standards developed by the Norwegian petroleum industry
NIH	National Institutes of Health
NPD	Norwegian Petroleum Directorate
OECD	Organization of Economic Cooperation and Development

OPEX	Operational expenditure
PO	Purchase Order
PR	Pig receiver
R&D	Research and development
SAPL	Subsea Automated Pig Launcher
SCM	Subsea control module
SPL	Subsea Pig Launcher
SRL	System Readiness Level
TR	Technical Requirement
TRL	Technology readiness levels
TQP	Technical Qualification Program
USA	United States of America

1 Introduction

Subsea oil and gas industry is very conservative, in comparison to other industries, as oil and gas operators have been focusing more and more in minimizing economical risks, improving safety and reducing damage to the environment due to external forces like government regulations and society expectations (social construction). As a result oil and gas operators have established and set their specific standards to protect themselves for any eventual failure, however as every major operator has developed its own standard, they have become a barrier and key technical challenge when new technologies or innovative solutions are tried to be introduced in this industry.

Suppliers who try to introduce new technologies-solutions, face the challenge first when oil and gas operators start a front end engineering; at this stage usually technical solutions are not fixed however new technologies-solution are not discussed in detail therefore they are taken as options to the next step; tender. During tender the need for graving into details arises and discussions between specialists starts however due to the time constraint and strategies to win projects, most of the new technologies solutions remain as options. At the end, in project execution there is very limited time for additional discussions as milestones need to be achieved according to contractual terms. As a result new technologies-solutions are left as options which tend to be out of a project in a normal project model.

Seen from the operator side, oil and gas operators engage front end engineering companies (suppliers) having as technical safeguard their specific standard package requirements. Every deviation to the standard requirements requires a formal deviation request starting as informal discussions with several rounds ending with a formal submission of a specific point making the process very time consuming and heavy to be implemented when limited time is given.

In parallel to the challenge described above, changes in the energy market toward more environmentally friendly technologies, pushes oil and gas operators to improve and/or add new technologies into their production chain. Oil and gas operators are becoming hybrid-energy companies adjusting their portfolio from previously entirely based on fossil fuel to hybrid models, that is fossil source based together with other environmentally friendly technologies like wind turbines to power up oil and gas production systems thus reducing the overall carbon footprint. In general new low-carbon technologies are of interest, technologies like solar panels, biotech and genetic engineering are clear substitutes as defined in Lasse B. Lien, Eirik Sjåholm Knudsen and Tor Øyvind Baardsen (2016) however these technologies could also be used in hybrid-energy companies.

According to the international energy outlook (2019) published by US Energy Information, petroleum and other liquids total consumption seems to increase the next 30 years, being relatively stable in OECD countries while increasing in non-OECD countries, refer figure 01.

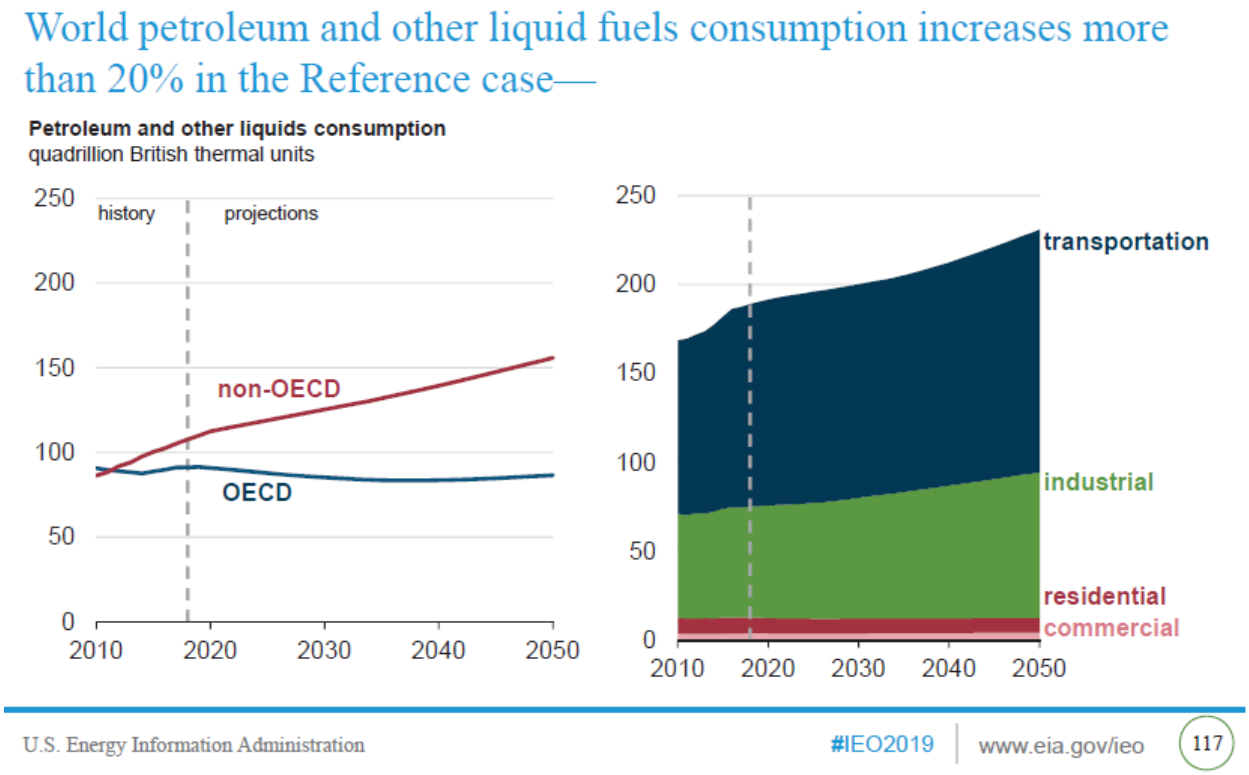


Figure 01, petroleum and other liquids consumption - US Energy Information

The last provides business opportunities as well as risks for suppliers of technology and knowledge. Oil and gas operators shall require suitable technologies for them to implement innovative systems through innovative technologies and knowledge to process more energy at lower cost while being environmentally friendly.

Finally to harvest the opportunities created in this conjuncture, knowledge and technology suppliers need to be innovative, focus in improving technology shall be reinforced with innovation programs.

1.1 Oil and gas supplier interest

Oil and gas suppliers like NOV, TechnipFMC, Aker Solution and others have extensive product portfolios with a lot of knowledge in different areas from subsea production to oil and gas downstream processes. As innovation is a key source of competitive advantage Oil and gas suppliers have being redesigning its cutting-edge product portfolio in different areas, some examples include:

- Subsea 2.0 "where The products are smaller, lighter and use fewer parts than previous generations. The product platform is built using standardized components configured in a modular architecture" (https://www.technipfmc.com/WelcomeChange#page-1).
- Electrical actuators eliminate the need for hydraulic control fluids and reliably withstand high-pressure and high-temperature. (https://www.akersolutions.com/news/news-archive/2016/subsea-electric-actuator-ready-for-market/)
- Electrically Trace Heated Pipe-in-Pipe which optimize production subsea flowline via controlling the fluid temperature and avoiding hydrate or wax formation thus reducing risks of subsea flowline blockage. (https://www.technipfmc.com/en/what-we-do/subsea/subsea-systems/Subsea-infrastructure/Rigid-pipelines)
- erT&D™ real-time torque and drag data system, it is able to provide real-time data on downhole friction and hole issues during deviated drilling operations. The information and data help the operators to make necessary adjustments to reduce the chance of getting stuck, lower the risk of damaged equipment, and improve wellbore quality. https://www.nov.com/products/certd-torque-and-drag-system

Sales teams struggle to commercialize new developed products/technologies due to the conservative behavior that the oil and gas industry endorses. Internal and international technical standards & regulations restraints and slow down the introduction of new technologies. As found by Thomas Steenburgh and Michael Ahearne (2018) who talked with companies about the biggest challenges they face in growing revenues, they heard a consistent complaint: Senior leaders have great confidence in their ability to develop innovations but not in their ability to commercialize them. It's a big problem, because it limits the return companies reap from their R&D spending. Therefore there is a need to improve the rate of sales of new products/technology when they are available or at least in an acceptable TRL.

There is a strong competition in the subsea production equipment market, the market has an small amount of system suppliers like TechnipFMC, OneSubsea (Schlumberger), GE Oil and Gas, Aker Solutions, NOV with countable number of customers (oil and gas operators) setting a lot of pressure in reducing costs and lead times thus also limiting the ecosystem of new products /technologies. According to the US international energy outlook (2019), petroleum and

other liquids total consumption seems to increase the next 30 years and the Norwegian Petroleum Directorate (2019) reports that "More than half of the estimated remaining resources on the Norwegian shelf have already been discovered. 85 per cent are located in the fields and 15 per cent are located in discoveries that are being considered for development." meaning that brownfield projects are more likely to increase in order to maximize the efficiency of operators existing assets. Finally as society and governments are pushing for technology to be more environmentally friendly, a trend that is gaining its momentum, oil and gas suppliers have the opportunity to introduce new technology however a successful introduction requires a different strategy in comparison to traditional approach for selling existing product lines.

1.2 Problem formulation and research question

The present thesis investigates how the oil and gas operators assess and reflect new technologies with respect to the feasibility in implementing them in production systems as established technologies and how they are organized to ensure new technology is passed on from innovation arena downstream to project execution.
Thereafter the information will be used to analyze how a supplier should approach Operators to ensure that new technologies are commercialized in a smooth manner.

From this standpoint, it will be investigated how industrial buying behavior, group and organization culture and technological innovation will be for transfering new technologies to commercialization.

The problem formulation is:

How can an oil and gas supplier increase the ability to commercialize new technologies? ensuring a smooth transition between new technology development to commercialization.

The problem formulation can be broken down to the following research questions:

1. How is the decision making process within the oil and gas operators with respect to introduction of new technologies?

2. What is the degree of openness for new approaches in the development department and EPC project department?

3. What is the characteristic of the oil and gas operators in terms of established adopter categories, that will help or hinder adoption of innovation.

The research questions formulated here will be referred to as the “Level 1 research questions” in the rest of the thesis.

1.3 Limitations of the thesis

The central point to be addressed in this thesis is to investigate how industrial buying behavior, group and organization culture and technological innovation will be for transfering new technologies to commercialization. The justification for these central points is that multidisciplinary knowledge is needed to be able to understand the complex relation between new technology (innovation) and commercialization. The topics converge at some point and will provide a deep understanding of the challenges that suppliers are facing when trying to transfer new technology development to established product lines.

Within industrial buying behaviour there is a good amount of theories and models due to the large number of variables and complicated relationships among the different factors. The focus in this thesis will be limited to the Buy-Grid Model as it represents in a clear manner where customers focus when the novelty of the purchase is new, modified or straight. The other models are deemed complex multidisciplinary models which cover a lot of factors which could disturb the main focus for this thesis, furthermore they also lack to make reference to group, culture and innovation relationships over time.

In addition group and organization culture is a wide topic, it is important to understand group behaviour to be able to co-work and influence in the best possible manner within an organization and also, maybe more challenging and important, in an interorganizational environment. The focus in this thesis will be set to group culture which impacts the understanding of what is important, what is correct for different groups as it varies from group to group. The latter will provide key information for short term and long term relationships.

Finally technological innovation, as described by Melissa A. Schilling (2017), is the act of introducing a new device, method, or material for application to commercial or practical objectives. This description emphasizes the diverse and variety of perspectives that innovation involves. According to Wolfe (1994), in his review of innovation literature, there are three main research perspectives. One view explores the pattern of diffusion, the mechanism and processes of the adoption of new ideas, behaviors or products. The second view explores the assets inside organization or interorganizational structures that are correlated with innovativeness. The third view covers a process-phase perspective on innovation activities and examines the different stages, periods through which an innovation is performed. This thesis will focus on the first perspective as adoption of new technologies means that Operators do something different than what they had done previously. The degree of adoption willingness will differ from operator to operator and thus help a supplier to put the right focus on a determined sector.

1.4 Thesis Structure

Chapter 1: Introduction. Background for the thesis, problem formulation and research questions are presented. Additionally it presents limitations of the study and provides an overview of the thesis structure.

Chapter 2: Theoretical framework. It provides the theory needed to analyze the research questions. The theory will be linked to each research question to justify its relevance and to show how it can provide insight into the research question. Finally, it will be considered if the theory triggers further need for information.

Chapter 3: Methodology. The research questions and the theoretical context for the research strategies are assessed. A research strategy is selected and arguments for this strategy are provided. Design and plan for the research program is presented.

Chapter 4: Empirical results. The results from the empirical research will be presented in this chapter. Empirical data will be presented for each research question.

Chapter 5: Analysis and discussion of results. Empirical data is analyzed and discussed in relation to each research question and towards the overall problem formulation. The relevance of the selected theories is analyzed. Suggestions for further work is discussed. Finally, it will contain critics and reflections of the research process and a discussion about validity.

Chapter 6: Conclusion

Chapter 7: References

Appendixes

2 Theoretical framework

2.1 Buy-Grid Model

2.1.1 Theoretical Framework

The buy-grid model is the result of an analysis performed to the purchasing process, it maps the purchasing process into a logical sequence of phases. Robinson, Faris and Wind (1967) introduced the framework, see figure 02, which notes three “buy-classes” and correlates each class with eight “buy-phases”. The framework provides a background for dividing the different decision levels, simplifying the process into segments which are useful for getting an overview over the critical stage gate decision. The last is also viewed as an oversimplified description that lacks a lot of phases, as Dominic Wilson (1999) states it will always be possible to identify further phases which also make reference to Webster and Wind (1972) which describes that this framework lacks any predictive power or causative explanation of buying decisions.

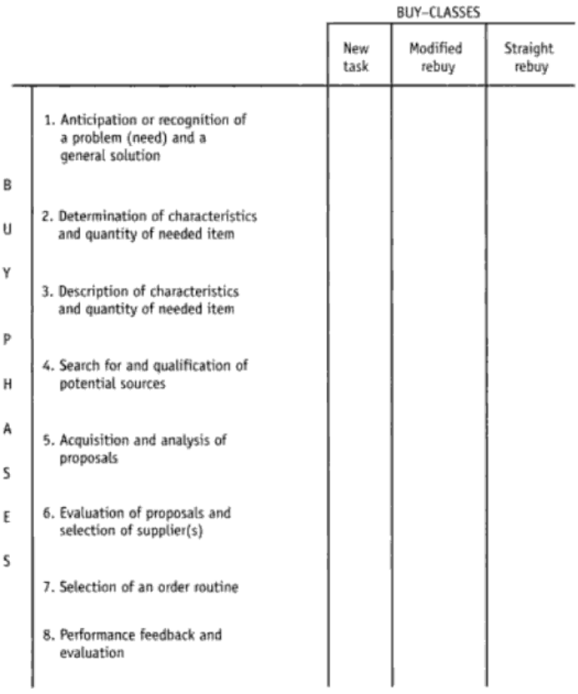


Figure 02, The buy-grid analytic framework for industrial buying situations. Robinson, Faris and Wind (1967)

It is a fact that every customer or business branch will have a specific set of phases and the dynamic will be specific for every customer or group of customers, therefore the buy-grid model

provides the basis to understand an specific purchase process according to whether the purchase is new, modified rebuy or straight rebuy, in a simplified manner.

The buy classes, as shown in figure 02, are divided in 3 sceneries. New task, modified rebuy and straight rebuy.

New task scenario means a purchaser wants a product and/or service that has not emerged before. Therefore a lot of information is needed as there is little or no previous experience, the purchaser will explore alternative solutions and consider other suppliers outside the “known supplier list”. This kind of task represents a huge opportunity for suppliers to get in the market and introduce new products. In this environment all buy phases are covered. Anticipation or recognition of the problem can come within or outside the company, therefore suppliers could shape/influence the opportunities, scouting for problems and or improvements. Determination and description of characteristics and quantity of needed items, involves in many cases a multidisciplinary team within or outside the company who determine how the problem/product/service be resolved. The search for and qualification of potential suppliers begins and is boundless, suppliers have the opportunity to become bidders once they are qualified. Acquisition and analysis of proposals, requests for proposals are made and a lot of details are needed, buyers analyse proposals, services and costs. Evaluation of proposals and selection of suppliers, proposals are weighted and compared, negotiations may continue with selected suppliers. Selection of an order routine is the time the orders are placed, follow-up activities are performed and ordered Items are received and accepted. Performance feedback and evaluation, an assessment of supplier performance is made together with the product / service assessment, did the product/service solve the need/issue?.

The modified rebuy scenario deals with replacement, modification, improvements of products or services thus the buyer company can run a simplified purchase process requiring
fewer suppliers and mostly known suppliers to allow a quick decision process. Qualified suppliers have an advantage and they can influence requirements to get an advantage in the purchase process.

In the straight rebuy scenario the products or services are already specified additionally there are suppliers already qualified. In this class falls the so-called “reuse as is” products or services. The buyer keeps the supplier as long as key parameters as quality, price and schedule are maintained. Acquisition and evaluation of proposals are performed with high focus on price and delivery. Selection is less complex than in a new task or rebuy class and performance feedback and evaluation is important so that suppliers are mapped and updated with the level of quality, delivery and price.

As a reflection it is seen that the model describes the interaction between a purchasing process and supplier activities providing convergent tasks/areas where both sides client and supplier could be able to influence each other.

2.1.2 Buy-Grid model and new technology development

The background described in the previous chapter suggests that the process and therefore people go through sequential tasks, broken down in steps to make a final decision. The Buy-Grid model represents the different buyer's modus which change according to whether the purchase is new, a modified rebuy or a straight rebuy.

The start is the problem recognition, which can be triggered and realized internally within the operator organization or triggered externally and pushed to be realized and accepted internally by the operator, the last implies that suppliers have a potential to influence the problem recognition, to what extent can it be influenced? Will most likely differ from operator to operator. When companies search for alternatives for new products, they will tend to be as broad as possible hence creating a lot of competition within suppliers -in order to to reduce costs -. Suppliers will try to get onboard based on operators requirements, however if a supplier or group of suppliers were involved in the problem recognition phase, they could also have an advantage in shaping operators requirements therefore getting an advantage over other suppliers when search for alternatives phase is started. Additionally it can be assessed that since oil and gas companies also compete with each other in the same market, a supplier or suppliers could influence so much that a specific operator decides to go ”solo” as an strategic move. Meaning that the next steps in the model are avoided and suppliers who did engage at the problem recognition phase get the purchase order, this could be a gradual decision or violent one. The last could be limited or not feasible due to internal policies that operators may have or by country laws, some countries push operators to call for open tenders to avoid monopoly.

Evaluating alternatives and potential suppliers and their offerings is an important job in the purchase process and especially when new technology is about to be ordered the scrutiny from the operator side increases. As stated in the previous chapter, operators will request a huge amount of information in order to understand the new technology and to qualify suppliers if necessary, therefore suppliers need be able to feed operators with the requested information and also find a balance to challenge the requirements and made all the necessary clarification so that client “feels” security and trust on the new technology. Furthermore in an ideal situation, suppliers shall remove any uncertainty during this phase so that after producing the product and delivering it, the client still feels security and trust on the supplier. Suppliers ought to understand the process, it is like understanding the rules of any game, *if you don't know how to score, you are unlikely to win.*

As the next stage, selecting a solution, comes into the picture, the reluctance of customers to consider new suppliers will increase. Operators usually have 2 main inputs: the technical solution and the commercial offer, to make the decision. At this point suppliers could make some adjustments however it is assessed that for new technologies to be introduced the

supplier work shall have been performed in previous phases. If unwanted technical/commercial solutions are adjusted then the risks for suffering during the implementation phase shall be expected.

New technology often miss proven records, even though it could have a high TRL rating, therefore in the implementation and evaluation phases best practice method for implementing and evaluating can not be applied however key parameters like low cost, improving quality, performance and safety still are applicable. Suppliers need to put effort on these parameters and make sure operators understand the different characteristics for the product so that benchmarking is performed in a fair manner.

Additionally oil and gas companies, like other companies in different market sectors, develop also informal organizations which influence the buy decision, the latter is described in the buying center concept outlined in a practical manner by Bonama, Thomas V. (2006). All the phases discussed above are more complex due to the fact that every phase has its informal organization, basically performed by several individuals and their relation to each other. In some cases the individuals will have a role or some roles, like initiator, decider, influencer, gatekeeper, purchaser, and/or user in one specific phase or several phases. Therefore identifying all these members will increase the supplier's probabilities to successfully introduce new technologies, however there is no guarantee that, even when all the individuals are identified, the result will be as per suppliers expectations due to human relations and unpredictable interaction between the individuals.

The buying center concept implies that a group of people have a say before a purchase is decided. The oil and gas industry is not an exception therefore it is expected to have a similar structure when purchasing decisions are needed, i.e. a group of people is involved a priori. They most likely have different titles, belong to different departments, business units. Involving different individuals with different backgrounds is also a way to manage risks. In this case the risk will appear when new technology is about to be introduced so the buyer or agent who actually issues the PO will need to get the feedback from different persons.

There will be for sure the users of the technology to be bought, are they involved? More likely there will be a different department being the user or may be a project within the oil and gas organization. Who are the influencers for new technologies to be ordered, oil and gas operators are huge organizations which tend to centralize information/technical requirements in order to impose a standard over organization, projects, operations. Influencers are expected to have experience in the product or field.

As for the gatekeepers, it is a well established process within big oil and gas organizations as they have approved supplier lists for different applications, suppliers are allowed to interact with the given oil and company if they are included in the list however for new products this list does not apply. What are then the barriers/gatekeepers?.

As stated in the buying center concept the purchasers are responsible for following the purchase routines, processes however and they most likely do not decide large purchase decisions, expensive products, risky products (like new technologies) as they will have huge impact in the company. New technologies have inherently high risk, as they have not been applied in similar applications and therefore safeguards need to be applied. In the subsea world the term field proven is a synonym of low risk as it means that the product has a positive record in a similar application.

Interpersonal and personal dynamics are described by Babu 2017, as factors which have a major impact in the buying decision. Individuals who hold power most likely will influence more than others, even if the advice does not meet the organization's need. Personal relationship is seen absolutely as a non-rational influence, all individuals involved in the buying process are at the very ground human beings which are subject to feelings. The latter could make a difference specially when multiple suppliers offer similar products with slightly different features, benefits, shapes, data, etc. However in most of the cases new technology is offered by a single supplier and the interpersonal relations could help the introduction of the technology based on trust, the more an organization or individual trusts another organization or individuals the easier it will be to, at least, present the new technology. Trust is not gain overnight it takes time, individuals need to show a behaviour which is consequent, with positive result and positive experiences, the latter does not mean a problemless record but a record of problem solver i.e. client is comfortable even when major issues arises, as they know that the specific supplier have the capacity, knowledge, resources and the experience of solving the problem.

It is also noted that depending on the new technology the number of individuals involved in the decision making can not be assessed from the buy-grid model, i.e. if the new technology is limited to a product which can be added in a system without modifying the system itself, then it can be assumed that the buying center will be conformed by fewer individuals than when the new technology actually modifies a system. If the system is about to be impacted then the decision making gets more complex implying that the informal organization to make the decision gets larger.

Since different individuals are added to the buying process, they will have different backgrounds, experience, behaviour, personalities therefore it could be of interest in knowing what will satisfy and remove their doubts about a new coming technology. Technical individuals like to go into the details and understand every single item, managers have a more holistic approach while comercial individuals will be more interested in economical results, the latter is a simplified assessment based on positions however each individual has a set of personal experience which also form their professional personalities. All the complexities introduced by human behaviour are not taken into account by the buy-grid model.

2.1.3 Research questions from the Buy-Grid Model

As discussed in the previous chapter there are several tasks/phases where suppliers could influence client's decisions. It is also understood that the more the purchase process advances in the phase coordinate the less likelihood of clients to welcome new incommers, therefore suppliers shall start to co-work with clients as early as possible when it comes to introduction of new technologies. However the last could open to the flow of a lot of information which may impact the novelty of the product hence it shall be balanced so that supplier is able to win Client's trust and at the same time it protects the novelty of the product in the market. Therefore the question will be: when it comes to new technologies Does the client have a review meeting with external suppliers to review possible improvements and share issues to be resolved? If not is the client willing to perform such reviews?

To address the correct team and timing is crucial in order to get an advantage as a supplier, it helps sales department to deliver the correct message at the right time. Are there different purchasing departments to deal with innovation projects (new products) and EPC projects? If more than one team then: Has client an established process for knowledge transferring between these teams?

Client's processes and internal standards govern introduction of new technologies and EPC projects, are these processes and routines for evaluation, qualification the same for both types? If they are different, does the client have a routing to transfer new technology into EPC projects?

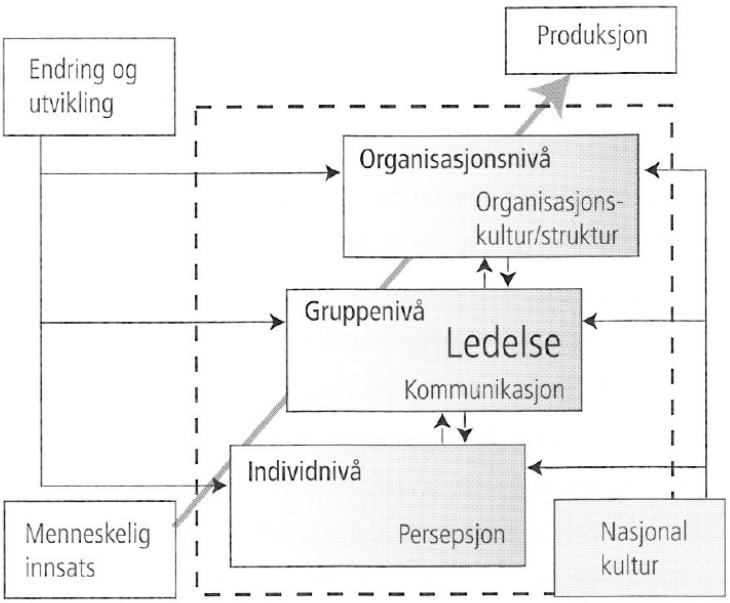
Performance feedback and evaluation phase is assessed to be a key parameter which provides access to additional projects specially after a brand new product has been delivered hence modified rebuy or straight rebuy classes are potential orders. Good cooperation shall be maintained throughout the purchase process to increase trust and increase rebuy possibilities, therefore different ways to improve cooperation shall be addressed. In a normal project there are weekly or monthly technical and commercial meetings, the latter ought to be improved. Is the operator interested in joining/establishing a digital cooperation platform not only for the project but in general for the relation client/supplier?.

2.2 Group culture

2.2.1 Theoretical Framework

A definition for a group that covers key variables is: "an entity comprised of individual who come together for a common purpose and whose behaviours in the group are guided by a set of

shared values and norms", (Haynes, 2012). Shared values and shared norms are seen as key elements since it means that the group emcompasses common core beliefs within it and each member also agrees on principles that rules the members behaviour when interacting internally and externally with other members/groups.



Figur I.1: Nøkkelelementer i endringsarbeidet.

Figure 03, Key elements for process change. (Endre Sjøvold, 2014)

Figure 03 shows the interrelationship between individual, group and organization level. External forces like national culture, needed changes or new development, social constructions, etc also affect the 3 levels. The link between organization and group level is performed by management and the link between group and individual level is executed through the manner communication between members within the group takes place. Finally it is also seen how production is a function of group values and norms.

The norms are a set of rules which regulate how individuals in a group shall behave between each other, towards external individuals, what they shall say, do, feel, propose, and react in specific situations. It defines what is normal and what shall absolutely be avoided, (Sorrels and Kelley, 1984). The norms secures the internal organization within a group both in relation to status hierarchy and functions.

Additionally cohesion is the variable which "glue" a group, it keeps a specific group together. The cohesion variable is not easily readable from inside a group or from an external observer, it requires observation over time to understand the cohesion characteristics in a given group.

According to Endre Sjøvold (2014), it seems that a group cohesion is not the sum up of each member behaviour/emotion but the group has its own behaviour/emotion (cohesion) and the latter influence members in a stronger manner than each individual is able to influence a group.

The group cohesion is consistent with the group values which in turn validates, endorses the group norms, all these patterns of connections between elements that regulate the group's emotions and its spectrum for action are called culture. The group culture regulates concrete actions and the feelling of the member around external and internal interactions.

Culture has the ability to influence individuals, shape individual behaviour, opinions, actions, this is why members from different group cultures understand the same situation in a very different manner. Big organizations will consist of several group cultures i.e. engineering department will have different focuses than marketing department, however it is possible to identify common attributes across groups within the same organization.

Endre Sjøvold (2014) provides the following culture classification:

Synergy culture, the members experience an open community where communication through the group feels comfortable as learning is achieved by contributing and being challenged by peers. Equality is an important characteristic, and influence is linked to mutual respect rather than formal status. As the group is in learning and challenging status identifying new possibilities and therefore creating new strategies and adjustment to new technologies is somehow easier in this kind of culture.

Care culture, the main purpose is the members satisfaction, where interpersonal relationships are the only ones of interest. The members are listeners, warmth and safeguarding. In this culture there is a lack of achievement of objectives.

Control culture, in this culture discussions are not allowed, the goals have been set and there is only one course to be followed. Acceptance of new ideas is pretty suppressed as analytical, technical and logical thinking is reinforced to achieve the goals while creativity is naturally suppressed. There is no learning from mistakes as errors are not allowed, everything shall work as expected.

Opposition culture, this culture can be needed for adjustments in balanced groups however if a group gets trapped in this culture then it will experience low cooperation and trust. Interestingly the leader assumes to defend its group against other groups in the organization, if the leader tries to avoid this “defend” position then its group will ignore her/him.

Addiction culture, the group members are passive and submissive, they rely on the system, processes or ideology. Acceptance of hierarchy and obey authorities outside the group is given.

It is the leader who has the responsibility for reaching the group goals and members wellbeing. Finally the members will follow the leader without questioning her/him.

Withdrawal culture, since there is no cohesion in this kind of group then it lacks culture. The members are perceived as highly independent with no desire or incapable to co-work with others. Fear for failing and the feeling for being too small is common in this group. Level of withdrawal is increased every time the leaders try to reach performance and achievement goals, as the members perceived them as hostile acts

To create a good relation toward a specific group it is an advantage to map and understand its culture. As Endre Sjøvold (2014) states: “For the cave-dweller, it was vital to be able to separate a friend from the enemy in a fraction of a second, for today's business leader it is just as essential to understand the patterns that develop in a negotiating situation”, in summary understanding the group culture is a powerful tool.

2.2.2 Group culture and new technology development

It is often experienced that different clients handle issues in dissimilar manners, some react with anger pointing to the contract to safeguard their assets, others react with less stress requiring to follow the issue up tightly, others require an explanation plus requiring updates from time to time without stressing the project and others seem not being worried at all. The response to upcoming issues as suggested above is related to group culture, which cohesion is dominant in each group’s reaction? It could be inferred that a control culture will tend to react with anger and a lot of stress as there is “something” treating the goals due to mistakes or unforeseen additional tasks. Opposition culture could also be related to an extreme reaction since low trust and a defensive stand is foreseen in this kind of culture. Withdrawal culture can be linked also to high stress reaction as the fear for failing engaged hostile acts.

Addiction culture will tend to react with absolutely non-stress relying on the processes and leave any action to the leads or authorities with higher levels of responsibility, while care culture focuses on interpersonal relationships showing a lack of champion mind for reaching objectives it will most likely expect the issue be resolved and taken cared by others.

Finally mutual respect, trust and proactiveness are some of the pillars in a synergy culture which will tend to understand the issues and be supportive and proactive in the solution of any issue instead of “just” following them up, this culture is absolutely of a great help to achieve common success as do not stress the group nor leave “actions” to others.

Above it has been discussed the link between group cultures and some experienced behaviour when it comes to issues in a project. However it is additionally noted that the groups running EPC projects have different behavior from groups running new technology development or groups running tenders, one reasons could be because groups running EPC projects are usually physically located where the project is running while new technology development are

performed having the groups spread around the world with a lot of informal and formal communication while tender groups rarely meet furthermore communication is handled basically through formal channels ie emails and phone calls are not so popular.
As described in the theoretical framework each group within an organization will have its own culture, this matches with what it is described above, also having the different groups near each other or spread around the world will for sure impact at some degree the group cultures.

To co-work in an efficient manner within an interorganizational group for technology management is challenging, mastering how to co-work across cultures provides a huge advantages, as most of the big oil and gas operators have a global organization, their groups are usually composed from different nationalities thus affecting the cohesion of the groups. As described by Stella (2012) direct and indirect communication is also a variable when communicating across cultures for example: cultures who easily say “no” in some situations against cultures which do not say “no” but use expressions like “maybe”, “ it is difficult”, etc. However that latter is just the tip of the iceberg since national culture affects not only communication but also the group culture.

With reference to figure 03, the input “human effort” is shaped, through national culture, changes in the organization, individual perception, communication, group culture and organization culture to finally provide as an output “production” therefore it is seen important to understand the context in which technology development is being carried out.

The inter-relation between individuals and between groups -within the same company- and with external groups -outside the company- are an important outcome of culture, it shall not be underestimated. As discussed in a previous chapter several individuals, buying centers, are involved in the same or different phases of a buying process. In order to make a decision, they need to get involved and communicate with each other, some individuals provide influence, others act as barriers. All interrelation is governed by the culture, the decision is made by a human, not a company, which needs to interact with different stakeholders, the relation that this individual has with other individuals -inside or outside the organization- is also influenced by the culture.

By the other hand the supplier’s individuals and groups have their own cultures which shall communicate with client’s individuals and groups. An awareness of the client's culture will definitely facilitate the communication at the beginning, while undergoing discussions and clarifications, finally it shall also facilitate the decision making. It is also implied that if the supplier has not been in contact with an specific client and/or individuals previously, then there shall be a focus in trying to understand and learn clients culture at the group and individual level. It is not common to get into a working meeting with a human-side focus, however doing so will provide key information about the roles, group and individual culture which will increase effectiveness from the supplier side.

2.2.3 Research questions from group culture

Understanding customers' group culture shall provide an advantage when entering into new technology development discussions, it can be seen as a tool which provides an additional competitive advantage over other suppliers, also provides benefits for both parts supplier and Client as it improves the understanding therefore goals can be reached quickly. If cultural rules are not shared or understood by at least one of the parties then most likely there will be a lack of union between the organizations and groups.

When a conversation is being started, few common rules are in place to lead it. How could we make sure a good start is accomplished? The more understanding about the client's culture and specifically the group culture that will take part in the conversation shall help to engage the discussions in the correct angle. So the first question related to technical discussions will be How reluctant is the group to adopt new technologies with non TRL, medium TRL and high TRL?. Additionally a deeper question will be regarding the degree of attachment to the internal standard specification that each operator has. For example Total and Equinor calls them GS and TR respectively. The question will be: With relation to the first question how open is the group for using completely an international standard like for example NORSOK in each of the 3 levels, instead of the operator's specific standard?
Furthermore what is the view for the client's group with regards to lesson learned review discussions for technical and commercial mistakes and performance?.

Oil and Gas operator have different values and their groups will reinforce them or void some of them, and since it also influences the culture then the following question is valid: Which set of values does guide the group, in the following context: (1)how we wish to be perceived, (2)how we wish to operate.

These questions will provide a feeling for the group culture and shall be addressed to both teams: innovation and EPC. However to get a complete picture of the group culture then it is needed a relationship and awareness of the different signals that the specific group is irradiating to finally get a clear and more accurate understanding of the group culture that it is being faced.

2.3 Adoption of new technologies

2.3.1 Theoretical Framework

The Process of Creative Destruction was described by Joseph Schumpeter, which essentially conceptualized the need for constant product and process innovation mechanism by which new

production units replace outdated ones. Furthermore Joseph Schumpeter (1934) predicts the need for innovation though the following statement:

A system – any system, economic or other– that at every given point of time fully utilizes its possibilities to the best advantage may yet in the long run be inferior to a system that does so at no given point of time, because the latter's failure to do so may be a condition for the level or speed of long-run performance.

The implications have been and are pretty known by companies, for a long term survival and growth then innovation is required however implementing innovation in parallel to the core business has proven to be difficult to perform.

Firms which are embarked in innovation journeys share common patterns under their development, all stages are described by Andrew Van de Ven (2008). Figure 04 shows the key components, specifically the red circle "adoption" is the start of implementation/termination period which cope with all activities in order to apply and adopt an innovation.

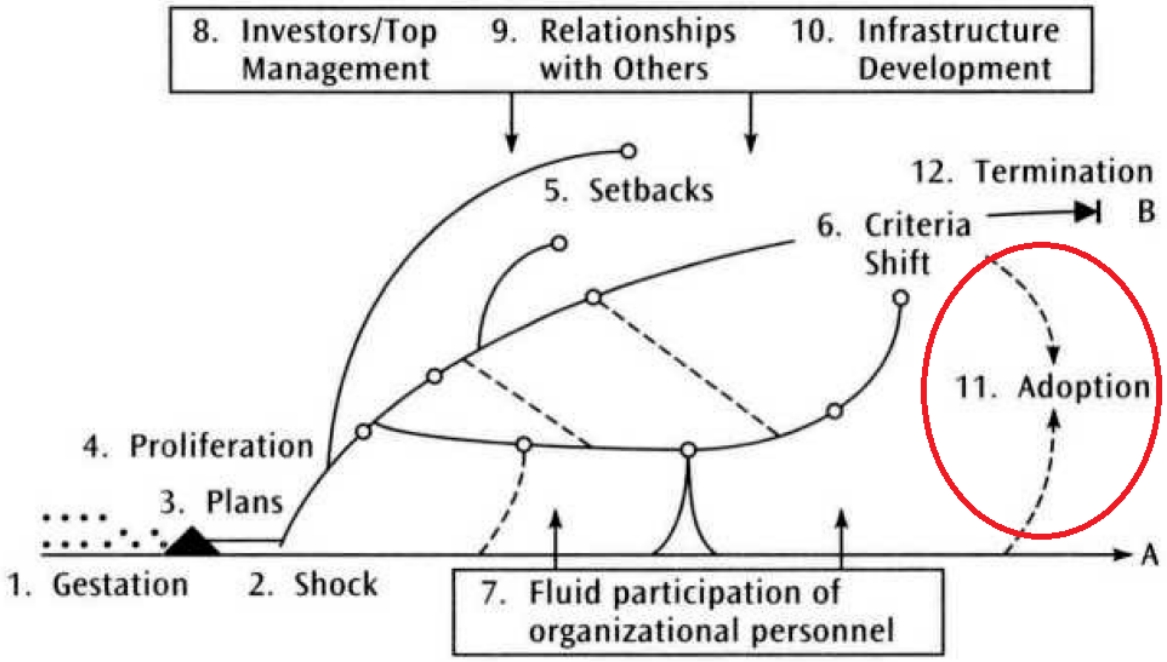


Figure 04. Key components of the innovation journey. Andrew Van de Ven (2008)

Andrew Van de Ven found that when the innovation is developed by a supplier or outside the firm, the implementation period focuses on the activities undertaken by a host company to introduce and adopt the innovation however it is also highlighted that reinvention occurs pretty often therefore development of an innovation is also performed under implementation / termination period. Reinvention has being studied by Everett M. Rogers (2003) finding that sometimes adoption does not change the innovation nevertheless in many cases adopters modify an innovation to fit their local application, the degree to which an innovation is changed

or modified by the user in the process of its adoption and implementation is, as per diffusion scholars, defined as re-invention. Diffusion is defined as the process in which an innovation is communicated through certain channels over time among the members of a social system, Everett M. Rogers (2003). Since diffusion is a function of innovation then it has a degree of uncertainty therefore superior technological innovations do not necessarily diffuse themselves, in fact as quoted by Moore Geoffrey A. (2013): “feature for feature, the less successful product is often arguably superior”.

The determination on when to start diffusing an innovation to potential adopters is described as one of the crucial choices in the whole innovation journey, external and internal forces apply pressure in different directions, for example the market (external) could required it as soon as possible due to high priority application, however internally due to quality and internal or external certification additional time is required. The latter is seen, with very strict certifications, within offshore industry innovation, ie gatekeeping being a control agency like DNV or rating of products in explosion proof zones regulated by EU.

According to Everett M. Rogers (2003), there is a decision-making unit which needs to acquire initial knowledge of an innovation, assess it and finally make a decision to adopt or reject the implementation, he has defined a model of five stages which highlights the innovation decision process, refer figure 05.

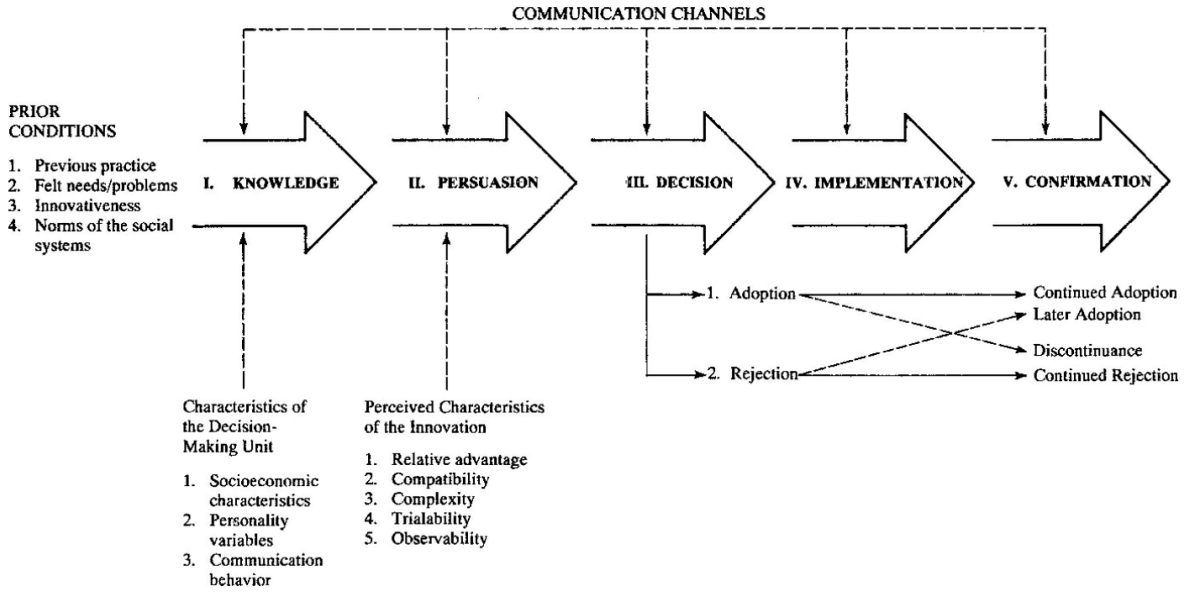


Figure 05. Model of five stages in the innovation decision process. Everett M. Rogers (2003)

According to this model, there are 3 types of **Knowledge** about innovation, awareness-knowledge which is the information that the innovation exists, “how-to” knowledge is required to be able to use an innovation properly and principles knowledge which consists of detailed information regarding the functioning principles. For complex innovation the amount of

how-to knowledge required for adoption is higher than in the case of less complex innovations. If how-to knowledge is not gained then rejection and termination are likely to happen**.**
Persuasion the result of this stage is the favorable or an unfavorable attitude that decision-making unit constructs towards the innovation. It is important to note that the meaning of persuasion is equivalent to attitude formation and change on the part of the unit, but not necessarily in the direction intended by some particular source, Everett M. Rogers (2003). The final attitude towards an innovation is not always in line to an adoption or rejection decision i.e., even if the decision-making unit has a positive attitude towards the adoption of the innovation it ends up not using it. The **Decision** stage unfolds the activities that are needed to make a choice to adopt or reject the innovation however rejection is an alive decision throughout the innovation-decision process as every stage is a potential rejection point. In order to reduce the uncertainty of an innovation, the decision-making unit in most cases engages a pilot trial or try out the innovation to determine its usefulness in their own environment, a positive result will support the decision to adopt the innovation. In the **Implementation** phase the decision-making unit begins to use the innovation. The innovator basically provides technical information to the client who is actively searching for information while the innovation is being implemented. When the innovation is part of the adopter's ongoing operations and the innovation is not any more distinctive as "new" then it is considered the end of the implementation stage. Re-invention of the innovation can occur in the process of its adoption and implementation. Finally when the decision-making unit seeks reinforcement of an innovation-decision already made then **Confirmation** is taken place, previous decision may be reversed, if conflicting information about the innovation is found.

As the innovation decision process has been established, categorizing the adopters will provide the full picture for technology adoption as individuals/organizations adopt an innovation at different periods in the time scale. Andrew Van de Ven, Everett M. Rogers and Moore Geoffrey A. use the same normal distribution, shown in figure 06, to describe adopter categorization.

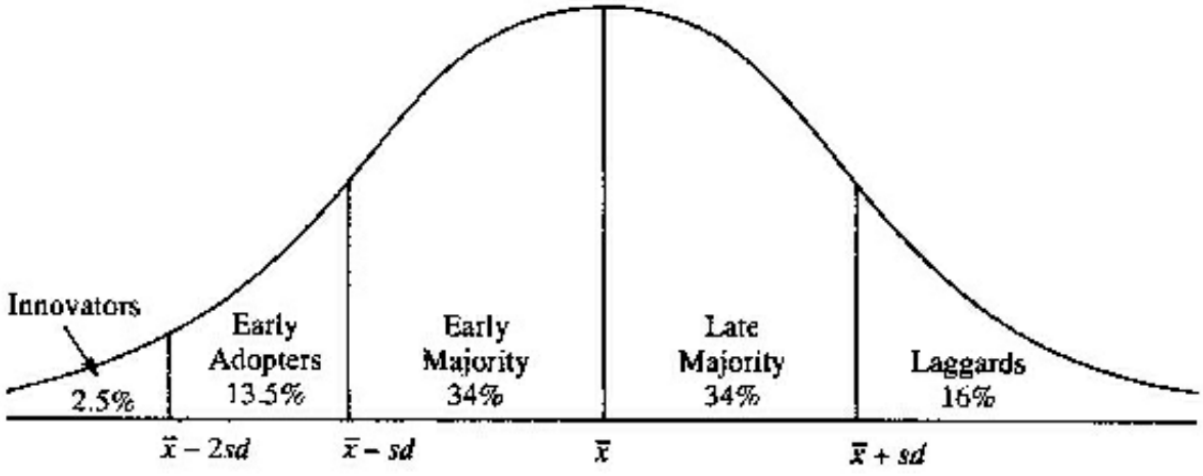


Figure 06. Adopter categorization on the basis of innovativeness Everett M. Rogers (2003)

Innovativeness is defined as a continuous variable by Rogers, Everett M., and it has been partitioned into 5 categories, to simplify the understanding of human behavior. Moore, Geoffrey A. (2013) challenge the “continuous variable” description of innovativeness since he adds a definition of a “chasm”,shown in picture 07. A description of the groups will be provided followed by the chasm finding.

Innovators: This group of adopters are keen to apply new products, always being proactive in scouting next technologies and have the ability to to understand and apply complex technical knowledge. However as innovation also has high risk of uncertainty, the innovators often have substantial financial resources to cover up for possible losses. They are willing to accept occasional setbacks and learn from them for the next opportunity. The innovator plays an important role in the diffusion process as it launches the innovation in a system by importing it from outside. They can be physically located far away.

Early Adopters: the group is seen as leadership opinion, therefore potential adaptors seek early adopters for advice with regards to an innovation. They are a more integrated part of the local social system than the innovators therefore they tend to speed the diffusion process. To keep the “leadership opinion” the early adopters are judicious in making innovation-decisions.

Early Majority: this group links the early adopters with the late adopters therefore it is a very important group in the diffusion process. As seen in figure 06 this group is one of the most numerous adapters therefore it is an key group for an innovation to be expanded.
They do not hold positions of opinion leadership therefore the decision making period is longer than the previous groups. “Be not the first by whom the new is tried, nor the last to lay the old aside” Alexander Pope, (1711) statement suits very well for this group.

Late Majority: This group is also a large group with regards to number of members, they are pushed to adopt an innovation due to economic context and the increasing pressure of the competitors, peers. They have limited resources therefore low risk investment are prefered and removal of most uncertainty about an innovation is endeavoured before the late majority feel that it is safe to adopt.

Laggards: It is the last group to adopt an innovation, they lack of opinion leadership. This group has a strong traditional background and past “what has been done” is important and used as a point of reference.
The innovation shall be proven with no chance to fail, as the precarious economic or other personal reason dont allow a test of the performance, qualities, or suitability of an innovation. Moore, Geoffrey A. (2013) highlights that from a market development perspective laggards are generally regarded as not worth pursuing on any other basis.

As stated previously figure 06 is represented to be continuously, meaning that if a company has an innovative product which reaches the innovators group then it shall reach the next group if it gets the right momentum however Moore, Geoffrey A. (2013) has found that is not the case, based on a study performed on several hightech companies in silicon valley. He has found that there is a “crack” in between every group, refer figure 07. The first crack between innovators and early adopters is described as the difference between the technology knowledge of the innovators and the difficulty of the technology for the early adopters to use it.

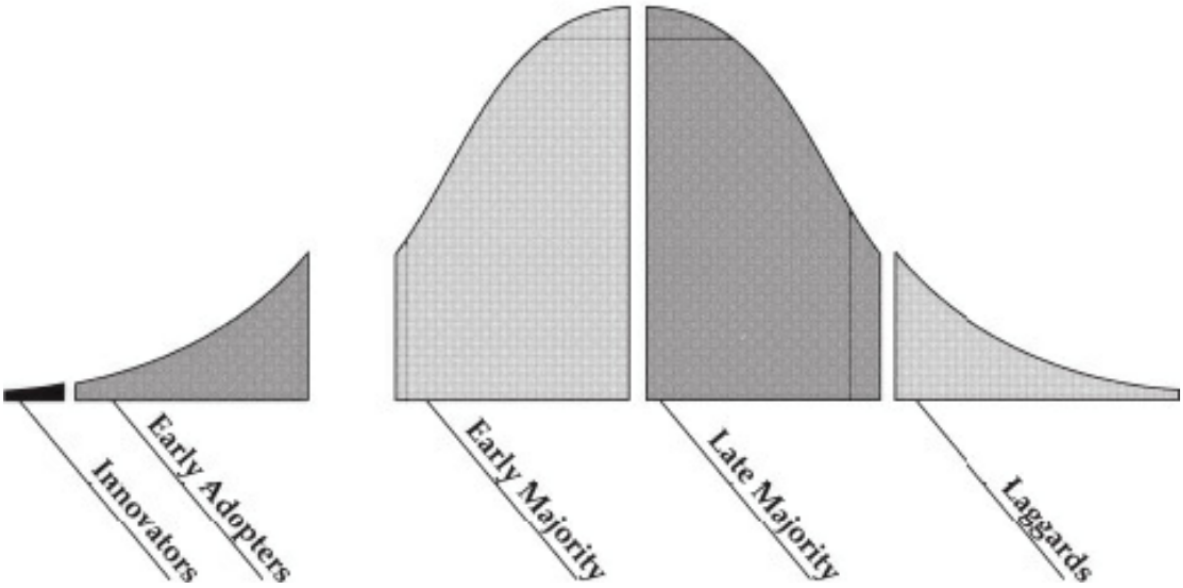


Figure 07. The revised technology adoption life cycle. Moore, Geoffrey A.(2013)

If the market stalls within the innovators group then the product falls into the first crack. Between the early majority and late majority there exists a similar crack, as the early majority adopts the innovation before the late majority due to the difference in the willingness to use an innovative product. Therefore Moore, Geoffrey A. (2013) concludes that the innovation shall be made even easier to be adopted by the late majority.

Finally the most dangerous transition is described as the chasm, so deep and wide separation between the early adopters and early majority. It is the more dangerous crack since it typically goes unnoticed, Moore, Geoffrey A. (2013) found that the early adopter expect to get a business advantage with respect to the competition when using the new product even knowing that they will need to manage bugs and glitches that comes together with new products. The early majority want to improve existing operations, discontinuity of products are to be avoided, they pursue evolution, not revolution. An important aspect is that early adopters are not accounted as references for the early majority. Field proven by an approved reference is a must for an early majority customer, and paradoxically “an approved reference” is another member of the early majority group.

2.3.2 Adoption and new technology development

As seen in the previous chapter adoption of new technology has a lot of traps, barriers, which the entrepreneurs need to overcome, entrepreneurs which are aware of the difficulties around adoption should be more successful or at least the odds for being successful shall increase. When a new development reaches adopters (from innovators to laggards) the adopters will be passive but also active therefore the latter most probably will try to re-invent, modify the innovation to best suit their usage, as described in the previous chapter, however companies should seek for standardization instead of having a lot of features dependant on clients. Of course a balance needs to be reached as clients like personalized product, services.

When to engage new technology diffusion is a tricky question, being the first does not mean success neither being the last. There needs to be an assessment depending on the market and clients standards. Large companies will most likely have more aversion to adopt new technology than small companies, also categorizing the clients adoption approach based on past data shall help to focus in the correct category group for example targeting at the beginning to clients which have an “innovator” behaviour rather than late majority behaviour. Therefore mapping client behaviour against adopter categorization bell should provide an advantage when diffusion is started.

Then, the buying center is also described as a barrier to adoption, in large companies there will be several departments and individuals dedicated to each communication channel or distributed to several channels furthermore each step in the communication channel could also be informally organized as described by the buying center concept i.e. having several individuals interacting each other being initiator, decision maker, buyer, controller, influencer , gatekeeper making the adoption even more complex as more network relations needs to be engaged so that innovation is adopted. Could be that some companies due to their culture involve more individuals than others in the decision making process, therefore to successfully influence the process the supplier should have an idea how the decision making process is executed in the client side.

The chasm is described as one of the main reasons why innovative companies, having sometimes the best technical product do not become successful but eventually competitors are able to jump the chasm and therefore adoption is a success. Even when an innovative product does well within an early adopter and has a lot of marketing and publicity, it fails to achieve the mainstream. The chasm appears due to the differences in adoption culture between early adopters and early majority therefore it seems like the innovation shall be re-invented to make more easier-accessible to the early majority and or the marketing effort needs to focus in decreasing the barrier to the early majority.

Finally is the chasm and the other cracks described in the normalized technology adoption life cycle bell curved repetitive? Is it valid for all new technology adoption?. Another answer to the seen results could be: unexpected events. Unexpected events could actually govern the success of an innovation, Taleb, Nassim Nicholas (2010) questions the fact that several processes do not follow a normalized curve, therefore it could be that unexpected events appearing quite often in the society and organizations actually decide which innovation success and which get stack in their way.

2.3.3 Research questions from adoption of new technology

Getting as much data as possible to map behavior and influence the decision making outcome is important for a supplier. Mapping the behaviour provides an understanding on how to engage adoption, who to engage and when to diffuse the innovation. As seen in the previous chapter adoption is a function of re-invention, which could range from no reinvention at all to worst case re-inventioned for every customer therefore it is important to understand which clients are open to accept standardized products and which are more interested in having a new technology as per their internal standards, as the result will provide value information on how to engage adoption with the specific client. Additionally how the clients are distributed in the adapter categorization bell curve shall provide enough data to be able to assess who to engage first and find out who are the influencers. Furthermore when to start diffusion has also an impact on adoption, depending on clients internal culture, willingness to share information, internal / external environment like market conditions shall help for timing for adoption.

Oil and gas operators have different organizations. It will be an advantage to get to know the different departments as well as individuals which might be involved in the decision making process as it will provide vital information to target the correct departments and individuals. The latter may be very difficult as some key players are not part of the official organization but are more informal structures within the organization.

When building up a market strategy for the new product or service the diffusion shall be assessed and adoption strategy shall be clear. To get a clear picture about diffusion, if the oil and gas operators are exceptical or not willing to discuss features which are outside their internal standards then most likely re-invention will be needed if the oil and gas company is about to adopt the technology by the other hand if they are open for not pursuing their internal standard and opened to international standard then re-invention will be limited and in best case no needed then the question will be: (1)from one to five, one being open for discussion and five absolute no open for discussions. Can the new technology only comply with international standards?, i.e. no customer specific standards apply to it.

The adoption strategy shall map the different stakeholders for the new product to be adopted as well as the mapping for the different oil and gas operators against the adopter categorization therefore the questions will be: (2) about the organization and individual with regards to decision maker and influencer. (3) how willing from 1 to 5 is your team into adopting new technology which is qualified according to international standard but not filed proven. 1 being open for discussion and 5 not willing to discuss.

2.4 Summary

In this chapter three specific theoretical frameworks have been presented and applied in a context where new technology is being introduced. At the beginning of the chapter it has been presented The Buy-Grid Model which discusses in which phases of the purchasing process the purchasing organization will put their effort dependent on three different types of purchase – new buy, modified re-buy and straight rebuy. As the buy-grid model lacks human impacts in the buying process, it has been discussed the buying center impact on the buying process. Both concepts consider different approaches with respect to the buying process since the Buy-Grid Model sees the company static while Buying Center sees it as an interaction between individuals with different informal roles. This provides a natural link to culture impact when introducing new technology as culture is innehently to humans. Following the latter discussion, Group Culture was introduced, given details about the different variables that influence group cultures and how cohesion in a group is an important parameter. Furthermore, Group Culture influences individual's behaviour towards members inside and outside the organization, this led to a discussion on group culture against individuals who are involved in the decision making process for adopting a new technology. Having these topics as a backbone, it was then introduced the concept of adoption of new technologies, where reinvention can be challenging while trying to standardize a product and at the same time as it is a natural feedback towards the end of an innovation process. Diffusion is also highlighted as a challenge when dealing with new technology which connects to the model of five stages in the decision process which was also presented. The buying center is seen also in this topic as an intrinsic feature of the model which again highlights the human impact in the adoption process. Additionally adapters were categorized in order to have a mapping over the market landscape, this is seen as a powerful tool which will allow us to understand the clients who are more flexible towards new technologies against clients which are somehow against new technologies and the spectrum of adopters that are between these 2 extremes. Finally it was discussed the chasm concept which describes an abstract wide and deep well where most companies fall, therefore failing in their attempt to reach the mainstream market (early and late majority). Success at the beginning within innovators and early adopters do not guarantee success with early and late majority as the expectation of the two sides are separated by the abstract well the chams, difference between visionaries adopting a new technology and mainstream market which are not keen on modifying their core business, services or processes unless right influencers start to support the new technology.

As a result, for being able to explore the main research questions, it has been developed level two questions for further research. The additional research questions described below are referred to as “Level 2 Research questions”. Since the “Level 1 research questions” from chapter 1.2. are the main research questions, they have been correlated with the “Level 2 Research questions”.

There are in total twelve level 2 research questions, each level 1 research question has been broken down into 4 level 2 research questions.

First research questions level one:

> 1. How is the decision making process within the oil and gas operators with respect to introduction of new technologies?
>
> Research questions level two:
>
> 1.1 How does the operator assess the use/deployment of a new technology which has been developed and qualified, for subsea use, by a supplier? Usually who is involved in this process?
>
> 1.2 With respect to new technology and responsibility, decision making authority, how is your unit organized?
>
> 1.3 Is there a formal or informal structural (organization) for adopting new technology? If informal, are all the members always engaged?
>
> 1.4 How many departments and individuals are commonly engaged when adopting new technology.

Second research questions level one:

> 2. What is the degree of openness for new approaches in the development department and EPC project department?
>
> Research questions level two:
>
> 2.1 What is the perception of the reason behind your company technical standards, for new product development and for EPC projects?
>
> 2.2 Are there differences when stimulating innovation or new ideas in the new product development organization VS EPC organization?, if yes what are the main perceived differences?

2.3 If you are part of the new product development department, how will you characterize the communication within your group and externally with the EPC group?
If you are part of the EPC project department, how will you characterize the communication within your group and externally with the new product development group?

2.4 When a supplier reaches you with new technology, how is the new information assessed?

Third research question level one:

3. What is the characteristic of the oil and gas operators in terms of established adopter categories, that will help or hinder adoption of innovation.

Research questions level two:

3.1 What is the view of your department with respect to adoption of new technology? (new technology being incremental vs radical)

3.2 In the context of adoption of new technology, what challenges are present within your department and company?

3.3 What do you regard as important factors in order to adopt new technology?

3.4 How, seen from an operators' perspective, can the biggest risks related to new technology be minimized

The research questions developed through this chapter, combined together with the previous discussions based on the theories described and detailed before will be the reference for empirical research. The results will be presented and discussed through the present thesis.

In the next chapter it will be developed the research methodology following the chapter where the results are presented thereafter the results will be analysed and discussed. Finally the conclusions and implications are presented.

3 Methodology

3.1 Introduction

Through this chapter, we explain how the study is designed and conducted. It is explained choice of method, selection, gathering and processing of data.
It shall also bring out an overall perspective in the selections that has been done, by assessing and discussing the validity and reliability of the data, finally concluding in a critical reflection.

The theoretical framework described in the previous chapter merged with the comprehensive problem formulation evolved in the set of second level of research questions. However to be able to correlate the latter with the real application within the oil and gas industry, it is then necessary to take contact with companies and individuals who are dealing with new technology in the real oil and gas market. Furthermore it is very important that the data that will be gathered needs to be as reliable as possible and at the same time it must be based on real interactions and experience, so that the results have an intrinsic value based on theoretical framework and real data from the field. Therefore the key will be to gather valid and trustworthy feedback to the research questions.

Selection of the method for empirical research can have a significant impact on the data collected and therefore the results and conclusions. The latter highlights the importance of selecting a suitable research methodology. Methods and approaches to the empirical investigation will be discussed with reference to the research questions in order to be able to find a suitable research method.

An ethical protocol will also be assessed as there shall be responsibility toward the individuals involved in the research for protecting their privacy, this is to minimize the chances that individuals will be somehow harmed when they choose to participate in the empirical research. Additionally the researcher's integrity and reputation shall also be protected, implementing an ethical protocol will also ensure that the empirical investigation will provide valid results and correct handling of sampled information.

Finally since the results are yet about to be found, the following quote made by Michael Faraday summarizes the exciting outcome ahead of us.
Although we know nothing of what an atom is, yet we cannot resist forming some idea of a small particle, which represents it to the mind ... there is an immensity of facts which justify us in believing that the atoms of matter are in some way endowed or associated with electrical powers, to which they owe their most striking qualities, and amongst them their mutual chemical affinity.

3.2 Selection of method: Qualitative

Understanding which research methodology is best suitable for providing answers to the given questions made in the previous chapter is vital, both qualitative and quantitative research have different research toolkits.

When a research makes use of measurements, which can be constituted of continuous or discrete data, which allow use of formal statistical methods then the research methodology is inside the quantitative research domein. A quantitative research engages a numerical analysis, collected by different means or using pre-existing data, that can be then processed to quantify the different features of the research participants. As it is a mathematical approach it is objective, repetitive and independent of the researcher background as she/he can be described as an observer with limited influence to the final results. The quality of the results has a direct relation with the quality of the data, how the data was constructed, time stamps for the data can also play a key role for the quality of the results. Also the mathematical tools used to process the data can in some context provide misleading results therefore the chosen model shall be well understood by the users.

In qualitative research the participants have the freedom for extensive answers thus allowing internal and external context to influence the reasoning behind the actions. In the same manner, when processing the data there could also be unknown influences which will special colour the results. An example of the latter is if the researcher has a red glass then the results will most likely be shaped within a “red spectrum” since she/he is seeing everything with a “red filter”. Another critique to qualitative research is that since the thoughts are specific to a given context, then a wider use of the result could provide a wrong interpretation. Therefore the context is key when processing qualitative data, referring to the context in which data was gathered and processed is an important aspect. Despite the critics, the qualitative research provides in depth-details since to questions about behaviour and the background of the action, “why” and “how” questions since it records attitudes and feelings. It also encourages openness as the participants are able to expand their responses therefore potentially could provide new perspectives which may be where not considered at the beginning. An important aspect about qualitative methods are the participants who are responding or providing the ideas, statements as they need to be of quality in order to get quality in the results.

For new technology adoption, where oil and gas suppliers do their best effort to increase the ability and therefore ensuring a transition between new technology development to commercialization of a given product, the relevant informations is to understand the background of the decision making mechanism and factors for why and how those stakeholders make the decision that they make. The relevance for quantitative information for new technology adoption is very dependant of time, new technology is developed quicker now than ten years ago, the oil and gas operators have more pressure to make quicker decisions now than 10 years ago, the methods, technical solution, internal and external context may impact the decision therefore

quantitative information will be of little use as all the why and how factors are not taken into account.
The circumstances which are present internally and externally to form all the features which influence a statement, idea is better taken care by quantitative research. The thesis formulation presented in previous chapter is specific to the current market landscape where oil a and gas operators are increasing their internal standard specifications, regulations from governments are in most of the countries well established, environmentally friendly / sustainable energy is getting more and more importance, within this context we want to know how the oil and gas operators make the decision for introduction of new technology which will provide key input to the question on how suppliers can increase the ability to commercialize new technology. The thesis formulation has been broken down into research questions which are related to: (1)purchasing human and organizational interrelationship, where we ask information about informal and formal organization and their composition, (2) group culture, where we ask questions related to group behaviour and interrelationship between groups, (3) new technology adopters, where we ask questions related to situations where new technology is prone to be rejected or adopted. In summary the research questions highlighted above, are searching for information with regards to individuals ideas and statements about adoption of new technologies, the latter together with the current market context will be better approached by the use of qualitative methods therefore qualitative research shall be used to answer the research questions formulated in this thesis.

3.3 Selection of qualitative research methods

The ideas, statements, non-numerical data that needs to be collected for the qualitative research is obtained by different methods. It can be used one or more methods, the following are some of the most relevant qualitative methods for our case:

Observation: this type of research records what the researcher has seen or heard, it cab typically, but not limited, happens in participant's home, workplace or any other natural environment. The researcher can be physically near the participant all the time, partially or with no presence at all. Both ends could face bias considerations as participants could be influenced by having someone very near or not having someone at all.

Interview: Qualitative interviews provide a medium for interaction between the researcher and the research subject, it could be informal, texted or conversational which provides a set of data for the researcher to analyze and collect relational data. The interview could have a wide range of participants from one to several, however the number of attendees needs to assure a close, intimate and free communication researcher-research subject to exploit and get as much as possible from each subject perspective.

Focus groups: During a focus group, a group of participants are gathered and requested to discuss a given topic, the participant needs to be related to the topic under study and shall be

interested in the participation. The group dynamic will influence the participants which in turn will reveal information which may not be revealed if the participants were not interacting with others. The group could be difficult to pull together.

Field research: It is a method that seeks to understand individuals, through observation and interaction, in their natural environment. Social researchers use this method to understand individuals behavior and reactions in a given social environment. Also research trying to understand wildlife in an specific environment then she/he could live amongst them therefore observing the interactions between the different components in their natural life environment. The latter highlights the difficulties in analysing such cause and effect behaviour as several variables in a natural environment will take place at the same time.

To find a suitable method it is important also to understand the ecosystem supplier - client, in the oil and gas industry there are not so many suppliers in contrast to other markets like utilities or communications, furthermore global suppliers are even fewer within the no more than 10 with someo them merging to get major market capitalization. Additionally the number of clients is also limited, the largest oil and gas operators are global meaning that they have presence around the world. There is also an increasing market, especially in the brown field sector, for local oil and gas operators which seeks to be efficient in fields where major companies are not so interested in developing a field. All above features make a tricky situation for the organization to open up information to each other, especially in the subject of this thesis, therefore it can not be expected that the oils and gas operator's personnel will be willing to gather in groups with other external organizations and transfer freely experiences and ideas without thinking in "secrets" not being shared. The latter will limit the freedom of individuals to express their own thoughts in the scenes. New ideas and relevant information could be suppressed for this reason which will definitely affect the research results. Even if the use of groups has a positive aspect to encourage discussing due to the different individuals being involved, in the present thesis it is not seen as positive as it will most likely suppress opinions due to secretive perspective. To have a "free" discussion it is imperative to build up trust in the group, and trust is not a parameter that can be turned on with a sentence or signal it requires a lot of time which in practical terms it is not possible in the current environment.

Also in the current situation, due to coronavirus covid-19, there is a challenge for having individual distancing to avoid virus spreading therefore it is an additional reason for participants being not willing to join group discussions or having a researcher nearby in their daily work environment. Additionally researchers will need to accommodate a special environment, according to regulations, if observation and field research methods are about to be established. Additionally having the researcher moved into the participant natural work space could potentially influence the dynamic and the researcher could become a part of the discussion and therefore limit the results.

From another perspective due to the workload, travel restrictions that most professionals are facing in the current time there will be limited available time for them to join the research, this

will also remove the possibilities to build up a group which has trust to each other to enable “free” discussions. Therefore once again focus group is not seen as an option.

To enable free dialog, thus participants are able to express their perspectives, beliefs, ideas in their natural environment, a one to one interview is seen as the prefered research method, it could be through video meeting, phone or physical presence. However physical presence is also seen as a challenge due to the coronavirus constraints detailed above. Having video meetings or phone interviews is seen as more realistic and practical in the current situation, additionally the participants will have a freedom to provide a time slot in their busy calendars.

3.4 Types of interviews

As a result of the discussion carried out above, a one to one interview is preferred however there are different types of one of one interviews: remote interviews (voice/video), face to face, computer supported, and also there is many other factors that contribute to the quality of analysis and one of the most important is the quality of the material that one is analysing, Corbin & Strauss (2008). Hence prior to discuss the type of interviews there shall be an assessment with regards to the interview research tool to be used ie.: structured, semi-structured or unstructured.

Structured interviews are described as those interviews where the questions are pre-determined and interviewees respond in the same order. Since structured interviews are rigid in nature, the participant could feel like they are inside a box with not so much room to explain or make examples therefore some information potentially could be missed, however the data analysis is easier to be performed as the differents answers can be compared in a practical manner as every participant has received the same questions.

Unstructured interviews are at the other extreme since no questions are prepared therefore it is not given that participants will be asked the same questions nor sequence. Data collection is collected in an informal manner and therefore less reliable however this method provides the most data density as it is not dictated by a predetermined set of questions. A negative aspect of unstructured interviews is the fact that responses are more difficult to be compared therefore more exposed to bias influence.

In the middle of the spectrum is found semi-structured interviews which features aspects from both structured and unstructured interviews. In this set up the researcher pre-defines the questions to be answered by all participants, however it is not given that additional questions or discussions may not appear suddenly as follow up or to clarify issues. In this manner semi -structured interviews take the best from both sides, the more straightforward comparison tool and the freedom to expand the interview to other domains giving more freedom to the

participant. The interviews for this thesis will follow the semi-structured interview tool as it provides a good amount of data which can be compared in a reasonable manner as well as the interview time frame will be limited due to participant's schedules.

Remote interviews voice, The use of remote interviews are used when difficulties in reaching the meeting location are a limitation factor, also availability of participants is usually an issue. Remote interviews via voice are practical as interviewees do not need to be in front of cameras, computers or other similar items, therefore there is a positive degree of freedom. Additionally it is a method which is "experience" as less intrusive than video based. If the participant requires access to illustrations then this method is not suitable.

Remote interviews video, this method requires access to the internet, the interviewer gets in addition to verbal information also a visual "face" information which could provide additional details about the situation i.e. if the interviewer is stressed, sad, relaxed, etc. In this method the human interaction is limited to voice and video which could limit the research in some cases.

Face to Face, since two individuals are about to meet and bias shall be avoided then the physical environment is of special importance, comfort, privacy and quietness specially are key factors. When addressing comfort it shall be managed both physical and more important psychological, If interviewees feel unsettled then it will most likely impact the research providing limited answers to the questions. Another factor is privacy, during the interview interruption shall be avoided, like making sure the meeting room is not open accidentally, switching off mobile phones. Finally quietness, in order to make the environment relaxing and decreasing the noise for audio recording the location shall be quiet.

Remote interview computer supported, it is an internet-based interview with several features which can be used during the sesion. One additional positive aspect with respect to voice and video is the fact that electronic whiteboard can be shared and notes be made "live" as the system provides online collaboration capabilities between participant and researcher. A risk in using this method is the potential interruption due to software issues outside the control of the researcher or participant as an example is a required software upgrade which could delay the interview.

Due to the geographical location of the participants and the current situation with the coronavirus face to face interview is regarded as not practical. Since nowadays there are different software platforms for remote interview computer supported, which also provides voice and video, then this method is selected.

Furthermore Kvale (2015) describes the different type of questions a researcher can angle an interview, in this thesis there are a combination of angles as there shall be a focus in the stories the interviewee is providing (narrative interview) which could lead to background findings which are not visible if the focus is only in factual data (factual interview). Therefore both narrative and factual focus shall be applied without influencing the participant bias.

3.5 Structure of interviews

In order to gather the needed data it has been concluded, refer to the previous chapter, to perform the interview in a one to one manner to make sure the interviewee is not influenced by others, remotely computer supported to have a high degree of freedom in case of needed tools for supporting ideas while been able to communicate via voice and video, making semi-structured interviews which provides pre-defines questions common to all participants and “live non prepared follow up questions” to extend the exploration and increase the understanding or freedom to interviewee to provide answers otherwise regarded as out of context. Observing the environment where the participants work is a challenge and will not be possible, therefore it will be a limitation of not being able to physically visit a workplace. However it will be endeavoured to establish a neutral environment where the participant feels like she/he is in its natural workplace therefore stimulating a fluent communication interviewer - interviewee. Both parties shall freely engage in the interview without feeling uncomfortable or stressed situations because of difficult questions or questions that might be perceived as “sharing secrets”. In order to avoid this situation an outline interview questionnaire will be shared, covering the questions presented in this thesis, with the participant a priori the interview. In this manner the participant will be able to challenge some questions or highlight any question that she/he understands is secret knowledge for the company.

The interview shall be as neutral as possible in order to get an accurate answer linked with the current context, how can an oil and gas supplier increase the ability to commercialize new technologies?, as in any other research the result can be influenced by participant bias, researcher bias and also interview bias. Interview bias is related to the set up of the interview, if the physical location of the participant or researcher is quite noisy, with a lot of interruptions then environment will tend to be negative and the experience will be coloured with this shades afterwards when researcher analysis the gathered data she/he could be influenced unconsciously about just this interview, the goes the other way around if one interview turn out to be very positive in comparison with the others then there will be a bias consciously or unconsciously therefore the physical location and environment shall be neutral, ie the same for the researcher in all the interviews and also requesting the participants to be in a location where they will comfortable, without interruptions while the interview is carried out. In this way the interview, and personal bias can be minimized as much as possible.

As the interview will gather a lot of information and to be able to have the capacity to analyse it in a detailed manner afterwards, participants will be asked if the interview can be recorded as audio format and kept it until analysis is finished. After the analysis is finished then the recording will be deleted. If a participant disagrees with it then the analysis will be performed with interviewers notes, handwritten or typed. Additionally recording the audio format of the interview allows the interviewer to concentrate on the specific interview rather than taking notes, which can also be a source of distraction in the interview. Furthermore recorded interviews allow

the interviewer and interviewee to develop a better communication which led to the interviewee disclosing more detailed and in-depth information, Mary (2008).

3.6 How many interviews and whom to interview?

The next step to be assessed is one of the most frequent questions which deals with sample size is how many samples (interviews) have to be done? How many are enough?. There is no straight answer to it as it will vary depending on the research topic. Most likely making the above questions are a wrong start. To be able to find evidence therefore firm conclusions when introducing new technologies it will be more practical to assess the number of reasonings, relationships between reasonings needed to have a clear foundation in the present thesis, too small sample data will just simply not provide information and too large data will be affected by law of diminishing. Additionally practical limitations due to available time for performing the research also have a say as large amounts of sample size will limit an exhaustive analysis of the data.

Global subsea oil and gas operators are not so many, below a list which have presence in Europe, America and Africa. From the list Chevron and Exxon mobil have been decreasing their activity in Europe in the last decade, therefore they won't be taken in the assessment. The rest of the global companies have a strong presence in Europe and therefore they use, in a proactive manner, norwegian suppliers for their subsea projects.

- Shell
- Chevron Corporation
- ConocoPhillips
- Equinor
- Exxon mobil
- BP PLC
- Total

The present thesis looks to understand the mechanism that governs a transfer of technology from being considered a novelty to be considered as well proven therefore enabling the path to commercialization in EPC projects. This mechanism are influenced by informal and formal structures, internal process which might be informal or formal, different individual stakeholder, cultural behaviour form personal to business culture formed by several group cultures with an organization, communication between groups, technology adoption in units where new technology is normal environment in a daily work (new development) and units where new product are avoided and in worst case banned due to risk, safety and uptime factors in a project. There are different aspects to be gathered in the interviews some of them could be seen by the participant as not “sharedable”, or answers could be covered with different wording and ideas however because of the use of open questions and non-stricts interviews there are opportunities to understand all these aspects. Gathering a lot of data will enter into the domain of “law of diminishing”, as the main questions are static and the pool of participants are within

oil and gas operators therefore somewhat homogeneous. and also require a lot of time to assess them.

There shall be data from two different departments from each oil and gas operator, one who deals with well established technologies i.e. in EPC projects where new technologies are seen as a source of risk, while the other shall work within innovation or R&D where new technologies, services are the daily subject and their primary goals. Therefore to be able to perform a comprehensive analysis and due time limitation it is decided to interview three operators out of 5 five which will provide a proper foundation for the analysis while also being practical in terms of time constraint.

All the above oil and gas operators have organizations which support both the core business with field proven technology as well as research and development which see the near future technologies to be used in order to improve the activities therefore remaining competitive in the market. Some of them are going even further seeing disruptive technologies which at some point could jeopardise their current core business. The plan is to interview participants for the following oil and gas operators.

Equinor, Main office is located in Norway and one of the world's largest offshore operators, the largest operator on the norwegian continental shelf, being responsible for 70 % of oil and gas production. It operates in more than 30 countries worldwide, having a strong position in Brazil. Equinor focuses on innovative solutions to be competitive in the oil and gas market, new technologies to transform the oil and gas industry to new energy sources as well as technologies to provide energy for low carbon future. Source www.equinor.no

Shell, Main office is located in the UK and Netherlands. In 2019 was ranked as the largest energy company by Forbes Global 200. It has operations in over 70 countries. Shell invests in research and development to improve the quality of their products and efficiency of their projects, they are also looking for a more sustainable mix of energy resources. Shell works actively to support open innovation as a manner to get new technologies in order to keep advantahce in the market. Source www.shell.com

Total, Main office is located in France. It is also a major energy player with a global presence and an integrated operator across the entire oil and gas value chain. It operates in around 50 countries and endeavour to leverage cutting-edge technologies for the oil and gas projects. They have also embarked in a journey to be prepared for the future energy renewing their portfolio by developing their exploration strategy. Total has also been actively engaged in developing deep offshore expertise having deep offshore projects in gulf of mexico and in angola. Source www.total.com

Engaging participants from Equinor, Shell and Total from both EPC projects where well established technologies are the preferred solution and R&D projects where new technologies

are developed and tested, will provide the required data and knowledge in order to be able to analyse the questions arose in the present thesis.

3.7 Quality of interviews

The interview shall produce knowledge, which is valid and applicable to this thesis so that reflections can be carried out with the best possible data. Therefore when conducting the interviews the researcher shall have an open mind and suppress any form of disagreements (visual, corporal or auditive) which the participant could perceive as negative bias. Additionally specific time and environment for the interviews to be carried out shall be fixed in a timely manner. Participants shall not be exposed to any type of pressure, the interview shall be conducted in a relaxed environment free of disturbances.

The interview environment shall be friendly, therefore the interviewer shall assure a neutral atmosphere for the interview to be performed. As in any good meeting, the interviewer shall provide a brief, a non-formal introduction to the study to improve a relaxed environment, it shall also highlight the importance of the participant in the study. As part of the introduction it shall also be clarified the anonymity and confidentiality, the fact that the participant's name won't be noted in the interview nor thesis and if the participant agreed to be recorded or not and when the recording will be destroyed.

The findings can potentially be corrupted by "interviewee bias" during the dataset collection stage hence compromising dangerously the validity of the findings. In order to avoid "interviewee bias" the interviewer shall not overreact to responses from the participant. Additionally carrying out the interview in a remote manner also helps to avoid interviewer bias as the participant is physically in another location, anyhow the interview shall also dress appropriately for the interview and perform the interview in a private setting.

3.8 Reliability and validity of results

Reliability is defined as a parameter which tells the researchers if the results of a study can be reproduced under a similar methodology. However the latest means that the object under research shall be stable since only an stable object can provide stable measurement given that similar instruments (methodology) are used. The developer's and adopter's groups will learn based on experiences, bad or good, toward new technology therefore this "object" shall be dynamic and not stable, i.e. it will change over time. There is no assurance that there will not be any change in internal or external influences. As a result, it will lead to a difference in the response provided by the participant.

Validity determines how truthful are the research results, therefore it implies the importance of the complete research process, from the theory which needs to be the backbone to support the assumptions and development of the study, to the report which provides a probed description of the findings. In between the theory and the report there are several steps like planning, interviewing, transcription, analysing and validation, Kvale (2015) which as a hole support and help to validate the research.

Due to reliability and validity issues in a dynamic model which governs new technology, it is important that the researcher inspects and makes “control” questions, critical questions through the complete research process. The participants will provide a lot of empirical data based on a day to day experience, then the researcher shall compare and check against the theory (which provides the backbone for the study) avoiding any bias internal or external. Additionally, it is important that a rigorous analysis of the empirical data obtained from the interview is performed in order to complete the loop and provide trustworthiness which is the main goal of validity and reliability.

3.9 Ethical considerations

As in other researches, the present research potentially can create tensions between the aims of the study to provide valid knowledge for people to use it and rights of participants to keep privacy and/or being anonymous. Therefore it is important ethics which prevent harm to participants while allowing the results being populated for others to use it. Since the protection of participants is seen as imperative, it is then necessary the application of appropriate ethical principles in order to prevent harm to them.
The present study will rely heavily on gathering data via interviews therefore it may appear some dilemmas like relationship between research and participants and subjective interpretation of the collected data made by the researcher. The participants most likely will be in contact with the researcher in the future due to work tasks (outside of the study) then the researcher would like to keep a good relationship with all participants, this could impose a bias however if the process itself is kept neutral and the same for all participants then this bias is removed. Another issue that may appear is the disclosures of secrets which could be seen as a negative impact to organizations that could harm the relation researcher/participant.

The dilemmas described above shall be prevented by the use of established ethical principles as follows:

Informing participants about the implications of their participation, meaning that the participant will be informed about the overall purposes of the research with both good and risks for the participants. The participants will be informed with aims of the research before the interview.

Access to the interview is only granted to the researcher and external mentor in order to protect the data for being used for other purposes.

Participants shall be informed how the data will be stored and used, the interview will be stored until a grade is awarded to the present thesis. The use of the data shall only be addressed for the present thesis.

Also privacy and confidentiality shall be clarified, as the participants will share data, in some cases anonymizing participants can ensure that participants can not be tracked back. In addition, in order to further protect the participants, names wont be recorded nor specific position titles. Finally the principle of justice shall be implemented, in this context it refers to equal share and fairness, all participants shall be treated in a neutral manner, during interview and analysis of data.
When participants are contacted, they will be provided with information described above with regards to the overall purpose of the research, practical information, how the data will be stored and used, and finally a confirmation about the participants privacy. The brief introduction is attached in appendix A.

4 Presentation of empirical Data

4.1 Foundation

All the participants were given a brief introduction prior to the interview and as part of the privacy context, they were requested to consent on voice interview recording. All participants agreed on it. All interviews were performed using a computer base format where Microsoft Teams software was the preferable platform tool. Microsoft Teams is a chat-based collaboration platform complete with online meetings and document sharing. In all interviews video meetings were used. The experience after the interviews is that good quality interviews can be performed by use of video online meeting platforms. There is no notable drawback as all interviews were fluent with good communication. Some participants were physically sitting in different countries and still the communication was clear without cuts.

An additional consideration was to protect the participant by having no records with regards to their names nor specific job titles, this was agreed with all participants. Even though some specific projects were mentioned during the interviews, they will not be mentioned in the present thesis in order to protect the participants. It was also agreed that using the operators' names was acceptable as it will make it easier for a reader to cross reference and search for more information. Presentation of the interview persons will be limited to broad descriptions about their roles and experiences.

In order to get the empirical data -participants- it was sent out a request to a broad group of persons working in different departments and countries. Total, Equinor and Shell were approached, Total was very responsive and four participants with different roles, both R&D and EPC, were interviewed. Equinor participation was limited to two, from both R&D and EPC. Shell participated with one from field development. Unfortunately, there were a lot of people who declined referring to too much workload. Additionally it was not possible to get participation from people working in purchasing, senior management roles, or non-technical roles.

Each interview took between 30 to 45 minutes, all the participants were very engaged in providing their perspectives, experience and having a positive approach when additional questions were provided. There were no interviews in which the participants got negative mood or asked to stop recording. The participants have different backgrounds with respect to nationalities and workplace (different countries), all of them were willing to be reached after the meeting in case of any follow up question.

All participants are representatives from the oil and gas operators with technical engineering, and technical management authority. Sadly It was not possible to agree on interviews with individuals working in other roles, a factor which could have influenced the negative response for participation from other roles, could be the Covid-19 situation, which it is experienced while writing the present thesis. Additionally it could be the fear or apprehension to share some details which could be understood as secret. However there has been a good participation from the EPC, pre-feed, concept and R&D organizations.

The following people participated in the interviews:

1.- Member and Lead within the research and technology development unit, interviewed 21.12.2020, Equinor. Provides research and expertise services to the equinor organization. Additionally it is involved in the concept phase in projects. It has several years of experience exploring and assessing new technologies to be used in projects.

2.- Field development specialist, interviewed 11.01.2021, Equinor. Leading consultant focusing mainly in early projects, maturity projects, tender EPC and field development phase. Also has experience working in EPC projects. Currently focuses on marginal projects where the use of new technologies are a focus as they may lead a project to be profitable.

3.-Technical leader within new technology development, interviewed 12.01.2021, Total. The main duty is to focus on research and development related to deep water technology, providing solutions and tools to other business areas or project units. Previously has had experience in exploration.

4.- Engineer within projects, interviewed 12.01.2021, Shell. The role focuses on pre-feed and support of projects in upstream production. It is involved in high level development projects, supporting teams to look at technologies that are proven or near to be proven so that the right maturity is achieved and therefore enabling projects to use the technology.

5.- Technical Manager within EPCi development and execution, interviewed 22.01.2021, Total. Identifies concepts for field layouts, involved in making the specification to be used in the tender phase, which ends up in a contract award. Additionally follows EPC projects from the beginning to installation. It is not directly involved in new product development however if the given project faces a challenge then his role is to solve it most of the time looking for technologies that suppliers can deliver .

6.- Project engineer within EPCi projects, interviewed 29.01.202, Total. Involved mainly in development of deepwater brownfields, which are mature fields as they have been in production in a given period. Therefore there is the possibility to bring new ideas and technologies while balancing the reuse of standard/existing products already in the field. Additionally, managing the obsolescence of the assets in the field as well as to achieve production targets are a focus. It is involved from the start of the project up to the startup of the field.

The interviews are not transcribed, they are presented in an abstract based on listening to the interviews in close attention in order to extract the core of the knowledge produced during the interviews.
The empirical data gathered during the interviews are presented operator by operator for each level two research question. Therefore each level one research question is presented as a subchapter in the following parts of this chapter containing the level two research questions.

4.2 Response to first research question - level one

The first level one research question is: *How is the decision making process within the oil and gas operators with respect to introduction of new technologies?*. Following the theoretical discussions, it resulted in four level two research questions as follows.

4.2.1 Research question one - level two.

The first question level two is: How does the operator assess the use/deployment of a new technology which has been developed and qualified, for subsea use, by a supplier? Usually who is involved in this process?

4.2.1.1 Response from Equinor

Even though a product is tested and qualified according to international standards by a supplier, it does not mean it will pass the internal standards from Equinor. The internal standards describe also how some specific products need to be made and followed up.

R&D department is responsible for following new technology from TLR 0 through TRL 4, ready for first use, and up to TRL7, broad use - field proven. A new technology needs to be qualified for subsea use even though the technology has been out in other markets for a while.

It is up to the projects if they will accept the use of new technology, as most of the TR standards are made from experience, new technology wont fit into the TRs. The project director is the one who signs but the decision making process is a bit unclear, it does not have an specific deadline. If the project director has been convinced to use a specific technology it means that it will be in the BoD as a base case or as an option, however they can be removed at any time. Nevertheless having it in the base case makes it a bit more difficult to be removed.

All required individuals are not always present during the decision making discussions. The project needs to have low cost for the project to be decided and then the project needs to have low risk, however new technology means a huge risk. That is the main reason for being difficult to find a project to be the first, as risk plays a major role. Project director relaxes if the technology is field proven however if the product is only qualified, (ready for first use) then they are usually exceptical.

When new technology is introduced in the project phase, then it needs to be introduced to a project management, presenting a business case and risk associated to it and how it will fit for purposes. Project management will then assess it, one of the important assessments is the fact that the new technology is only applicable to the specific project or if it can be standardized across the organization.

If the business case and risk are hand to hand then the organization welcomes it. Standardization is also becoming an important key because most projects have economic limitations then both internal standardization within Equinor and from the industry are positive signals. Equinior will like to use standard products because that will reduce the cost of the products. Equinor is developing more marginal projects therefore assuming more risks.

Equinor understands the benefits that a new technology brings to the market and if that suits the schedule, business case and risks then a process for the acceptance of the technology is executed.

4.2.1.2 Response from Total

New technology developed by a supplier can be known by the headquarter, projects, operations or R&D department, however to be able to make use of new technology, it is the expert (sitting in the head quarter organization) who needs to approve it technically. When the headquarter is aware of the new technology, then there is a structured approach, to use the technology in projects where the new technology provides an advantage (cost effective via OPEX, CAPEX, schedule, needed man hours, etc).

Normally there are system architects who define the concepts. There are well established processes when new technology is introduced at the beginning in a concept study phase, executed by others, like system architect responsible and/or operation unit, and then transferred to the projects.

However there is no established process when new technology is introduced in a project. Nevertheless there are in place routines called “project reviews” which are part of a standard procedure during the execution of a project, where introduction of new technology is highlighted and discussed.

Architecture role introduces the applicable technology depending on needs, therefore they are the ones being up to date with new products and technologies. Therefore there is a well structured system from architecture department (headquarter) to project but not the other way around. For information to flow from projects to the core specialist or system architects, it relies on informal knowledge: “everybody knows how it shall be done”. Still there is in place a “project review” safeguard which shall pick up between others, new technology introduced by a project.

A new technology for the company, it might not be for a supplier. While running the project phase, the team tries to customize the supplier's product for the specific application. Requesting a lot of documentation from the new technology to review it in several cycles. Company tries to shape the new technology to the specific application and field.

Furthermore, project units are not always engaged, Operation’s development department together with headquarters develop the needs and basic engineering, then when it is matured enough it is passed to the project units IF the project is big enough. For small modifications, Operation’s development department handles, manages the change directly without project units.

When R&D department is engaged with a new technology, it is then responsible for development and making sure the processes are followed. However the experts, headquarter, are following up the technical requirements and issues that may arise during a development. When the new technology is qualified as per the processes then, if applicable, a business unit, which could be a project, operation or other unit takes the technology onboard and uses it.

4.2.1.3 Response from Shell

In the project phase there are specific procedures called technology mapping, reaching out experts and going through databases looking for technologies that are relevant. If the relevant technology is new, then it is also considered to mature and qualify it. If it is seen that there is time for doing so in the project schedule. Since the projects can last for years then the maturation and qualification sometimes is done within the project execution.

Shell performs Technology replication meaning that they look into technologies which are out in the market. It can be technology which is just about to be born or technology which is being qualified or already qualified. Shell then tries to replicate it for the specific application and even they can mature and qualify the technology as per their internal requirements.

Also if the technology is already mature, qualified or deployed by others but not Shell, then there is a request raised to all the stakeholder and projects, asking them if the technology fits their purpose, if response is positive then a TRL is performed.

At the beginning projects enter into an opportunity funnel where they are filtered with regards to the projects that have commercial opportunities, then with the time, a front and development manager is assigned followed by a project manager when the project reaches feed. The technology or new technology will come as a part of an established process, feeding with information with regards to applicable technologies or new technologies. This information is fed by a team.

4.2.2 Research question two - level two.

The second question level two is: With respect to new technology and responsibility, decision making authority, how is your unit organized?

4.2.2.1 Response from Equinor

The R&D department makes research and also provides expertise services to the other organizations within Equinor, like projects or operational organizations. It includes early phase field development processes to actual qualification programs in projects. In the field development phase it is covered the feasibility assessment of new concepts with new technologies against a specific field.

In projects or studies where new technologies or philosophies are an option for the development, experts from R&D are engaged. Also the organization will lead any qualification of a new product / technology that a project or R&D development may need to be performed. The organization is a hybrid matrix type as it has its own qualification programs and in addition is allocated to other temporary organizations like projects while specialized resources are needed.

Early main tasks in the project department are related to maturity project development, setting up business cases, maturing the projects and finding correct technical solutions. They are also involved in the selection of the best offer and solution. Technology assessment is one of the tasks that is performed as part of the searching for correct technical solutions. The project gets a set of limitations and tools to work with from project management and other units, then there is the technology strategy provided by the technical advisor and operation units, and finally the R&D group which tries to sell new technologies, products into the projects.

The project management is the entity who assesses and enables the path for further investment, use of a new technology/product or rejects it. If the new technology is found to be suitable for the project then it is also assessed if an extensive usage across the complete organization is suitable. In case the latter is feasible then that information goes up beyond the project to another unit who will take the post and decide to implement or not the new technology/product across the complete organization.

4.2.2.2 Response from Total

In the development of new technology units (R&D), it is developed new technologies and once a certain maturity is reached, then the new technology can be delivered to other business units like projects or even directly to operations if the technology has been fully qualified and meets the expectations from Operation business units. Specific specialists outside the development of new technologies organization are involved to support the maturation, qualification of the new technology. The specific specialists are located in the business units where the final technology will be handed over to. Therefore there is a link between the business unit who needs the technology and the development of the new technology department. The management of these business units and their specialists are involved in a yearly workshop-basis where management has the power to stop the technology or approves the continuation of the technology.

EPC project units, it is not directly involved in new product/technology development however if the team identifies a supplier with new product / technology which enables the development of the field more efficiently then the project will approach the supplier and the supplier shall demonstrate the qualification for subsea use, in addition an approval from headquarter is needed. If it is a brownfield then the project needs to use the technology already installed in the field specified by Operations, if it is a green field then Operations with headquarter specifies the product, technologies to be used via the system architects.

4.2.2.3 Response from Shell

The participant is involved mainly in pre-feed development and also in projects. When it comes to pre-feed the main focus is not on details about the new technologies, but on technologies that allow the field to be developed. Details regarding the new technologies are added just before feed. Furthermore it is created a list of opportunities which later are filtered by assessing the relevance of the opportunity.

In projects, specific technology replication activities and technology mapping is performed. In order to get an overview over the available technologies, the experts are reached out since they are the ones aware of new technologies in their respective fields.

The technology replication team (R&D) is incharge of following the tests, maturation and qualification of a given technology.

There is no individual who owns a product, there are groups that manage different technologies or different products and they are assigned to support the different business units.

4.2.3 Research question three - level two.

The third question level two is: Is there a formal or informal structure (organization) for adopting new technology? If informal, are all the members always engaged?

4.2.3.1 Response from Equinor

There exist both a formal and informal structures, it depends where, which business unit, department, the new technology was introduced in the first place. It is very formal and clear that the new technology needs to be qualified as per Equinor standards. However the process for adopting new technology is different if the new technology is shown up in the project unit, R&D unit or operations unit. It is a formal structure from operation and R&D units to project units. It is a bit unclear or informal from project units to other units.

R&D department is responsible, in charge of qualifying the new technology according to the TRL level and internal standards.

In the project unit, the members who believe in a new technology, need to convince the project management for the use of the technology, balancing the business case, risk and schedule.

4.2.3.2 Response from Total

At Total it is also formal and informal structures. It depends which department, business unit engages the new technology. New technology development department (R&D) basically leads the qualification of a specific product or technology and their clients are other business units like project or operation units, therefore the structure is well established.

If the new technology is known by the headquarter or operations business units then they may introduce the technology based on the needs that they may have and eventually will engage the technology development group (R&D) for fully qualifying the new technology or the project group to handle the missing qualifications, it is regarded as formal structure.

If the new technology is introduced in the project phase (at project units) then there is no formal structure but rather an informal one where the project unit will need to consult headquarters for the approval for introducing new technology in the project.

The TRL assessment is performed and internal standards are followed for qualifying a new product / technology involving different experts sitting in different business units.

4.2.3.3 Response from Shell

The company has formal structures in the project phase where there are specific procedures for building up an overview over the available technologies, experts are also engaged and databases are checked looking for relevant technologies. There is also a formal structure to mature and qualify relevant technology within a project execution as projects can last for years therefore given time for maturation and qualification of new technologies.

Furthermore if the technology is already mature, qualified or deployed by others then Shell internally assesses it requesting stakeholders to check if the technology fits their purpose.

4.2.4 Research question four - level two.

The fourth question level two is: How many departments and individuals are commonly engaged when adopting new technology.

4.2.3.1 Response from Equinor

There can be different individuals engaged during the assessment for adopting new technology, depending on the department where the new technology has been engaged. Departments like operations, projects and R&D developments can initiate the adoption of new technology.

Operations have a small team to handle new technologies therefore they usually engage other departments like projects or R&D to support the adoption if required. Projects also may request resources from R&D developments to support new technology maturation, qualification. R&D units can carry on their own initiatives and also support other departments for new technology to be assessed, adopted.

4.2.3.2 Response from Total

There are basically 4 main departments or business units which are involved when adopting new technology.

Headquarters where the experts, specialist, system architects are sitting with key technology and product knowledge. Here is also performed the basic engineering or supports Operation units for doing so. Headquarters defines the concept study.

Operation units which are also called affiliates, end users or customers within the company, operations start the basic requirements with support from individuals from headquarters and also engage projects when the requirements and business case are mature enough. Operation units also engage R&D units, if a technology or product is needed to be matured and or qualified.

Project units could also introduce new technology, however this is rare as the “usual” flow for introducing and adopting new technology, comes from the system architects sitting at headquarter units. If the project team sees a technology which enables a commercial and technological improvement, benefits then they are able to “challenge” the initial basic design so that new technology can be discussed. Headquarters department plays a role of expertise in the technology and operation unit plays the role of end-user.

R&D department is also involved when adopting new technology, they make sure that all the processes for maturing and qualifying a technology / product are followed. R&D can be engaged from Operations, project or headquarter units. They do not have experts on every technology therefore they request specialists from the department who initiated the request for maturation, qualification of the specific technology.

4.2.3.3 Response from Shell

Within the project units it is initiated specific maturation tasks if there are technologies that have an impact in the given project. There are specific procedures to make technology mapping and to go through lists for checking which technologies are relevant for the project. The Project can additionally request experts from other units who can provide information about the relevant technologies. The projects that are commercially viable pass to the next phase where a technical lead “FEDEM” (front-end development manager) is assigned to oversee the technologies in that project. Later if the project survives a project manager replaces the FEDEM.

The technology replication teams (R&D) are responsible for getting the new technologies or new products through test programs, schedules to make the replication according to applicable processes and internal standards, meaning to mature them and fully qualify them.

New technologies are usually sponsored by the Technology replication teams if the technology can be applied over several assets, business units. Otherwise it is expected the project to be the sponsor of the new technology.

4.3 Response to second research question - level one

The second level one research question is: *What is the degree of openness for new approaches in the development department and EPC project department?*. Following the theoretical discussions, it resulted in four level two research questions as follows.

4.3.1 Research question one - level two.

The first question level two is: What is the perception of the reason behind your company technical standards, for new product development and for EPC projects?

4.3.1.1 Response from Equinor

New technology is always seen as carrying high risk, it is embedded in human beings, if someone sees a risk then automatically you want to avoid it. However technical people are being asked to become more business oriented then as a result the automate goal has become to improve the business case. How the business case can be improved, triggers the research for a technology that can improve the business case. When the business case is settled down then the risks are evaluated. Ideally the new technology shall improve the business case and lower down the risks, if these two variables are achieved then new technology is alway welcome. Equinor is keen on using technologies which are standard both internally because it is easier to manage it across the company, and external because then the technology will go down in costs. However Equinor's internal technical standards are too rigid to allow new technology therefore Equinor's philosophy, regarding internal technical standards, has a degree of openness to allow deviations if the new technology improves the business case and decreases the risk, an example is the DCFO technology which has many deviations from equinor's internal standards (TRs) but they have been approved it because it solves many project problems and improves many business cases.

DCFO is a solution, co-developed between Equinor and Alcatel submarine network, is based on DC power transport and Fiber Optic communication and addresses cost-efficiently tieback field architectures. It targets near-unlimited distances and deep-water operations, with superior reliability and resiliency and is considered as the base for "All electric" subsea control solutions allowing significant cost-savings. The solution is based on standard product whatever the project configuration, avoiding cost and delay required for new qualification of equipment.
Refer: https://web.asn.com/DCFO-subsea-control.html

Additionally external standards like for example the international standard for subsea control systems; API 17 F, has been developed by, between others, Equinor. However Equinor's internal standards (TRs) are more stringent than API 17F, and the company policy is to fulfill the TRs when qualifying a technology. Anyway the company is moving towards the use of

international standards, as there is pressure to cut costs then more incentive to work with international standards are seen in order to reduce costs. Furthermore it is up to the projects to use only industry standards nevertheless one shall keep in mind that there is a lot of learning in the internal standards as they are based on experience. Finally, there could be that the internal standards have too many restrictions, sometimes the requirements do not “see” what others have done and therefore tend to be too strict.

4.3.1.2 Response from Total

So for new technology there could be two cases with regards to internal standards, they do not cover it and if they cover it; they cover the subs-parts. For the case where they do not cover the new technology then there is no need for deviations, however a project will specify boundaries to make sure that the new technology is compatible with the needs and emphasis that the technology needs to be TRL7 - field proven.

Additionally if the new technology is completely new, not used at all, then the company will also engage universities, independent studies and join industry projects, cooperation with other operators to reach a level of technical specifications and/or establish new chapters in the external standards (international standards) like API. In this manner suppliers are allowed to deliver products with a common set of rules and that conform the basis for the requirements in a project. An example of this approach is the all electric initiative which is a disruptive technology.

By the other hand, the sub-parts of the new technology could be covered by the internal standards but maybe the application is new, in this case the information is transferred to the end user, typically operations, to ensure that Operation units understand the operational guidelines. As an example, it is referred to the SAPL technology, subsea automated pig launcher, where the application is new but all the components have been used in other applications like SPL subsea pig launcher, and PR pig receiver. So the internal specifications do not need to be updated even though it does not cover the SAPL, but it covers the individual parts. Therefore operation units will need to be teached with the application, as they are the end-user. They need to get used with it with regards to safety and HSE.

The internal technical standards are flexible, and deviation can be requested, but they govern existing and new technologies and the approver of any deviation is always headquarter unit. It is experienced that some time ago, the internal standards were added on the top of international standards (API, ISO) and project specifications which made it very difficult to pick up products from the shelf due to the quantity of requirements. This has been simplified since 2015, and still there is an ongoing process to simplify the use of internal standards.

4.3.1.3 Response from Shell

The company used to be very prescriptive, passing to the vendor a whole stack of requirements, expecting vendors to comply with all of them. In the recent year a process has started to decrease the number of documentation, so that the projects are now moving to functional specifications. For new technology, the approach is to go into the details to make it very clear for the suppliers so that they understand which internal standards the new technology needs to comply with. Also there will be a gap analysis, to simplify the process. The gap analysis maps the compliance of the new technology to Shell internal standards. The missing parts shall be qualified.

It also depends on the scope of the new technology, if it is just a small product (like an instrument) or if it is a whole system unit, the attention that the latter will get will be completely different.

4.3.2 Research question two - level two.

The second question level two is: Are there differences when stimulating innovation or new ideas in the new product development organization VS EPC organization?, if yes what are the main perceived differences?

4.3.2.1 Response from Equinor

In the R&D unit there is a trend to approach innovation together with external parties. At the same time there is a pressure to cut costs as the oil and gas sector has been suffering in the last years. Collaboration with external suppliers is seen as a strong model to develop new technologies. The Equinor open model to collaborate with suppliers has been a success for the norwegian market, specially within the norwegian supplier industry.

For the project units, it is required that the individuals think more and more from the business case perspective, technical people thinking like managers. Sometimes the focus is on technical risk, people move away from innovation because of the novelty and risks associated. However as the thinking is to improve the marginal fields, accepting new technology to reduce cost has a great potential. Pushing the solutions to be cost efficient, be open minded to find solutions to optimize the projects and its business model with low risks.

4.3.2.2 Response from Total

The project department does not stimulate too much new technology; it is not in its role itself, it can engage but it is not its primary focus. There are other units in the organization who are

supposed to focus on it. Generally there is no resistance to new technology in the organization as there is a lot of trust in the qualification program based on internal standards. The company is not afraid of being the first, it wants to be the leader therefore it is not afraid of being the first, it does not wait for others to test a new technology, if it sees that it is needed. It trusts its processes.

The R&D units, listen to the needs that other business units have and then engage with third parties, external companies to develop the needed technology. It also leads the process for qualifying the new technologies as per internal standards. There is good communication with other business units regarding new technology as they ensure that it covers their need and also the need of the R&D unit may have to further support new technologies.

4.3.2.3 Response from Shell

Shell is opening up due to the energy transition seen in the current energi market, embracing ideas that are coming externally. There are in place processes that make sure that the company looks also for new technologies outside the organization.

Project organization is always more conservative than other business units, it is always difficult to implement new technology which has high risk. No project wants to be the first to do it, because the risk is basically at the project level, if it were in a higher level, like in a portfolio level, then the risk could be spread around different projects or even to other business units

R&D units are scouting internal and external technologies, introducing and developing state-of-the-art technology, identifying, evaluating and unlocking new technologies to allow the recovery process to be cost efficient.

4.3.3 Research question three - level two.

The third question level two is: If you are part of the new product development department, how will you characterize the communication within your group and externally with the EPC group?
If you are part of the EPC project department, how will you characterize the communication within your group and externally with the new product development group?

4.3.3.1 Response from Equinor

When a project starts it receives inputs from product advisers, experts from several subject matter experts. Also they get feedback on previous projects from lesson learned activities. There are processes that run in parallel to provide the projects with the technologies they need to start with however it is also up to each stakeholder in each project to be involved and proactive. Even if there are processes, it is a fact that employes working several years in the company have more possibilities to influence new technology due to their network, as they will

know who to talk with, the different people that needs to be involved, while newcomers won't have that network therefore their influence to new technology will be limited at the beginning. Each project has its own requirement and set of stakeholders therefore it requires time for taking decisions, in that manner there is no structure that is perfectly in place.

R&D has focus in developing and introducing new technologies to the projects and other business units even to external organizations outside the company. But they don't have good processes to understand the requirements of each project. Team members from R&D provide information about the new technologies that a project can use to improve their business case or to enable a specific project, however most of those technologies are not field proven or even at TRL4 (ready for first use) which imposes a lot of risk for the projects. As a result there is always a fallback plan in case the new technology does work or takes too much time to be qualified. The project team and project directors assess all this information over time and allow to introduce some of the new technologies from time to time. As the projects belong to different business units, the projects aim to have low cost and then when decided they need to reduce risks, which means naturally going against the implementation of new technology. R&D units provide all the information about the new technologies to the projects, nevertheless It is up to the project directors to implement a new technology in a given project and experience says that a new technology which has TRL7 is more likely to be accepted than a technology which has TRL4 level.

4.3.3.2 Response from Total

From the project point of view there is a establish process and structured communication, project received the input from architecture responsible (headquarter) who are the ones responsible (according to the processes) to introduce new technologies, the project develop them through the internal phases until it gets into tender (ITT) and request supplier to make it. Then suppliers provide a lot of information to companies which can be partly relevant and parly irrelevant but the architecture responsible should already know what is in there. However it could also be that specialized teams will get first to know a new technology like for example an inspection tool for pipes, then there will be the inspection department who will first be exposed and then it will find its way into the system through different needs. However when a project is involved then all should be back to the architecture department which shall be aware of the different technologies.

Communication from projects to the architecture department is more informal; there is no real structure.

The R&D team communicates with projects but projects are not directly the end users of the new technology. An exception to the latter is when there is a direct business case between R&D to projects which is rare. The communication has an established process which at the end of a

technology development, it gathers a dossier that contains all the development which has been done to push, mature and qualify the technology. Then the business unit (projects, headquarter, operations) stamps the new technology ready for use. Therefore the technology can be incorporated, adopted in the business unit.

Additionally there are some specific groups who are formed to just look into new technologies like standardization, or subsea 2.0. Such groups are led by headquarters with members from different units like projects, operation or R&D. They are dedicated teams to bring proactively specific new technologies into brown or green fields.

4.3.3.3 Response from Shell

There are technology replication teams (R&D) embedded in the organization which will support or provide input to project units via formal communication channels. The communication channels are well established processes between these teams.

4.3.4 Research question four - level two.

The fourth question level two is: When a supplier reaches you with new technology, how is the new information assessed?

4.3.3.1 Response from Equinor

Once a study face is reached with a supplier then the supplier will tell the company how the business case can be improved, how the costs are saved and risk are lowered. If the improvements are related to the introduction of a new technology, then the first assessment is regarding the TRL that the technology has achieved. TRL assessment will provide some information about the overall risk but it does not specify the risks, in case the project decides to initiate it. Also assessments for costs and risks to run the needed TQP is performed, and compared with the benefits that the new technology brings with it. All this process and analysis is within the project unit. The projects are the ones evaluating the technologies, products from the suppliers.

If the technology is field proven (TRL7) but outside the company's fields then it starts at TRL3 at the company a continuation an assessment is performed to verify if TRL4 can be granted. So there is an established process for assessing the technology.

The assessment is a trade off between opportunity, risk and business case. As the TRL assessment is performed then TQP is valorated to make sure that they are according to the TRs. Then starts the discussions upwards to the TR owners. However the projects are able to run, implement the new technology without the support of the TR owners, therefore the projects

are able to take the full risk, nevertheless it is tough to go ahead without the support of the TR owners therefore very rare.

Sometimes the supplier is not able to sell its new technology just because the value of the technology is not understood, the supplier understands its technology/products but unless it can be integrated in the client's system then it is hard to utilize the technology. Therefore when company is presented with a new technology, it shall be understood by the client side.

IPs are also analysed as suppliers tend to have IPs in their new technologies, however the company aims to implement standard products to reduce costs and related risks when relying on only one supplier. Of course a supplier likes to protect its technology and it is understandable however too much protection is also assessed when a new technology is presented.

4.3.3.2 Response from Total

The process is well established and the assessment starts by reviewing the benefits of the cost saving and why the previous technology is obsolete.

A new technology for company might not be new for a supplier, however as company has not used it before then it needs to review it and understand its TRL. If it has been used in similar or equal applications, company will start to request a lot of documentation and information relevant to the new technology. It is always headquarters approving the new technology.

As the Headquarter team is notified, they also engage R&D department so that together they do TRL assessment. The project department will always engage the headquarter team. The mindset of the company is that new technology is needed to continue with success. The process is very strict and time consuming in order to fully understand the TRL score and provide a plan for further testing if needed. The organization in general incentives to use new technologies.

If it is a new technology which is already qualified the company will start a minor qualification or additional tests. The R&D unit will get in contact with headquarters or other business units to get the right specialist on board and they will go through all the records. If the TRL is assessed to be not sufficient (TRL 2 or 3) then it will go to R&D department which will first review if the technology provides an advantage over other technologies and then confirm with other business units the applicable business cases of the new technology. If there is a business case then step by step the technology will be reviewed more in detail using a minor budget, until consolidating the business case. If the TRL is assessed to be the highest then it could be in some cases that the new technology will go directly into the projects to be tested and implemented if applicable. Company will try to customize the new technology.

4.3.3.3 Response from Shell

The is a formal process and it would be performed by the following general stage gates:

- First to identify the technology
- Second relevancy of the technology.
- Third is to review if the technology has been used in the industry or other industry but never in Shell. Then the necessary qualification needs to be performed as per internal standards.
- Fourth will be ready for deployment.

The above stages may overlap depending on the ongoing assessment.

4.4 Response to third research question - level one

The second level one research question is: *What is the characteristic of the oil and gas operators in terms of established adopter categories that will help or hinder adoption of innovation.* Following the theoretical discussions, it resulted in four level two research questions as follows.

4.4.1 Research question one - level two.

The first question level two is: What is the view of your department with respect to adoption of new technology? (new technology being incremental vs radical)

4.4.1.1 Response from Equinor

The participant from projects sees Equinor as close to radical in comparison with other oil and gas operators in the market. Equinor is always upfront with respect to new technologies, it focuses on technology development. However there are some areas where the technology innovation has been incremental for a long period of time.

The participant from R&D considers that Equinor has an incremental approach, as the relevant technologies are evolving in a natural manner, for example the unmanned platforms are a natural step from manned platforms, however it is recognized that for others it could be described as radical. It is also highlighted that the business has to be conservative because one big error could mean being out of the market. Another example which can be classified as

radical is the Gas to X transformation where gas is transformed or used to get Hydrogen, ammonia or other types of fuels.

Equinor has a very open mindset for collaborating with suppliers, institutions and companies large and small that can help find solutions to business challenges.

4.4.1.2 Response from Total

From a project team perspective it is incremental as the subsea technologies are adopted from well established technologies used in other industries. The subsea oil and gas industry does not do anything outrageous. The technologies need to improve and adapt to the challenges of the new business cases and challenges that the old field faces. The new technologies need to support the old technology especially in the brown fields where old technology is used. An example are the SCMs which in the past and until now have been delivered with hydraulic and electrical interfaces and the new generation will support only electrical interfaces.

In R&D units there is an additional dimension which is the notion of time, to ensure the capture of all the aspects of the novelty, to understand the impact on new projects and operation therefore the time is needed. Radical innovation is seen as not suitable, maybe from the business perspective is justified however it is preferable to ongoing improvements.

One of the participants has worked in smaller oil and gas companies and he describes the smaller companies as having no interest at all in adopting new technology. Their policy was to use only field proven technology and did not want to qualify any new technology.

4.4.1.3 Response from Shell

There is a notion that it shall be both radical and incremental. Radical in the sense that there shall be a long term strategy and incremental to reach the long term strategy by developing the technologies in an incremental manner, step by step. The incremental steps shall be agile as agile as it can be in the oil and gas industry.

4.4.2 Research question two - level two.

The second question level two is: In the context of adoption of new technology, what challenges are present within your department and company?

4.4.2.1 Response from Equinor

Equinor is known for incentivizing new technology however when it comes to adoption, it adopts quite a few of them. The participant does not really know why the company adopts just some of them but it is something that has been acknowledged.

The adoption is also related with the available budget a project has to be able to run the qualification program and decrease the risks, huge projects with extensive budgets are able to qualify and adopt new technology like the Åsgard subsea gas compression, Åsgard became the first subsea gas compression in the world. If the budget is limited then the adoption will tend to decrease as qualification programs and risks associated with the new technology increases.
Technologies which cut costs are more likely to be adopted, as the market is more competitive and pressure in reducing cost has been increasing over the years.

4.4.2.2 Response from Total

Total does not have a resistance to new technology, as far as the new technology is qualified as per Total's processes then the adoption is up to each project and/or operational department. Operational departments have different teams around the world and they have different views with regards to a technology so they are free to use the technology they feel more applicable to their interests.

Adoption over time is an important parameter when running innovative technologies, new development takes time to develop, to be fully understood in order to secure correct functionality. It also needs to be fully tested so that risks are minimized. Additionally, timing varies in different business units and quite a lot. For example operations could use 20 years to develop basic engineering while a project needs to deliver in a very short time, usually around 2 years. Therefore adoption of new technology can be taken in a relaxed manner or in a stressful environment.

4.4.2.3 Response from Shell

In the new energy space where new sources of energy are being researched, Shell is becoming more open and proactively sees the different technologies, incentivizing new technologies to be researched. Adoption in this new energy space is still to be seen however in the oil and gas business Shell is not conservative anymore because of the size and speed of the projects. The processes and internal standards make sure that technologies are looked inside and outside the organization, in addition there are venture teams which are scouting continuously the market and if they see an opportunity they will support the company to progress in the market. However inside the project departments they will avoid to adopt new technology if no business case is found.

4.4.3 Research question three - level two.

The third question level two is: What do you regard as important factors in order to adopt new technology?

4.4.3.1 Response from Equinor

No technology will be successful if the end user does not understand it. Therefore in the company, the operation units are in most cases the end user as they will be using, operating and maintaining the new technology for a long period of time once the project unit has handed over it to them. Therefore it is important that the Operation units fully understand the new technology in order to adopt it, OPEX for them is a key measurement.

Standardization is also an important factor, every new technology shall become standard. For the company to adopt new technology, it is important that the technology can be used in several parts of the organization.

4.4.3.2 Response from Total

Time is needed when a new technology is presented and to be sure that it can be adopted. Confidence is built up over time, getting to know the technology, testing and qualifying it. A business case is the driver for executing all the qualification programs and for sure if the business is still applicable at the end of the qualification program then it will be adopted.

The TRL opens a pathway for adoption, in projects it is used to determine the technology readiness level of a new product. However for the technology to be adopted there needs to be a reason like lower cost than previous technologies, issues with the current technology or major benefits in comparison with existing technologies in the market.

4.4.3.3 Response from Shell

The company will only adopt technology which is fail safe and adequately tested. Adoption of technology is progresive, new technology is installed in assets where the economical or safety impact, in case of failure, will be limited.

At the end of the qualification process, the new technology is given the stamp “ready to be used” then all the business units are able to adopt the new technology if they find it applicable. There will be an assessment cost-benefit for CAPEX and OPEX before it is adopted.

4.4.4 Research question four - level two.

The fourth question level two is: How, seen from an operators' perspective, can the biggest risks related to new technology be minimized.

4.4.3.1 Response from Equinor

To reduce the risk there needs to be an understanding of the technology and how it implements the risks. Superficial knowledge about new technology like what it is supposed to do, is not sufficient. It is important to know how it works and how it can be implemented, how it impacts the project and the surrounding parts interfacing to it. Also why it is successful for operation units at the end.

Ensuring a multifunctional team from TRs responsibles, projects, R&D and operations, to review, investigate, and fully understand the new technology. All the gathered knowledge will then be used to decrease the risk of the new technology.

It is also important that the new technology follows international standards, as it lowers the risks of the technology by itself and also provides a less painful path to the company's internal standards.

Additionally risks are minimized by running FMECA. As an overall approach it is stated that the number of products and systems shall be reduced and equipment shall be the best. Therefore FMECA has been used quite early in the technology assessment. Based on experience, it has been seen that what fails are the areas where the company has not had focus on in the specific projects. The more a new technology is tested the more confidence it will have and the risk will be minimized as more verification is performed.

4.4.3.2 Response from Total

The technology needs to be qualified. Inside a project there is a qualification program and a backup plan that need to be assessed and performed if applicable. Depending on the risk and critically of it, there will be different approaches. If high risk is flagged and assessed to be critical for the project then before the project there will be initiated an upfront qualification work prior to contract award, examples to the latter are subsea separation systems and subsea pumps some years ago. If the risk is lower, and the company has experience with similar technologies then the qualification does not need to be initiated so early as eventually it will be qualified with some modifications. If the technology is not so critical and if the qualification fails then the identified back up plan becomes the base case and it is used.

The TRL is used to measure and assess the general risk of new technologies before a qualification program is started.

Minimize the risk by checking business cases with other business units and making sure that it is a needed technology. Also the initial budget is limited so that if it fails then the loose is minimal. Time is critical to minimize the risk as the more time the company has to verify the technology the better for all to get comfortable with the new technology.

4.4.3.3 Response from Shell

The new technology needs to be adequately tested in order to minimize the risk. Shell has processes and internal standards for testing and qualifying a new technology, the time frame will be different depending on the new technology usage. Replication is the process in which a team gets to know a technology and then is matured and qualified. At this point the risks are minimized from a technical point of view.

5 Analysis of Empirical data and discussion

In this chapter it is analyzed and discussed the empirical data presented and described in the previous chapters. First it is analyzed each level one research question together with its linked level two questions as a unity, having as background the empirical data. A continuation, it is discussed the relevance of the theories that were used as starting point. Afterwards it is brought the empirical data from the previous chapters back to the original research questions and analyzed the implications to the initial problem formulation.

At the end of the chapter suggestions for further work and reflections about the validity of the empirical data and the findings in the analysis are discussed.

5.1 Research Question One

With reference to the previous chapter, the level one research question one is: “How is the decision making process within the oil and gas operators with respect to introduction of new technologies?”. With reference to the theoretical discussion chapter, this provided in four level two research questions:

> 1 How does the operator assess the use/deployment of a new technology which has been developed and qualified, for subsea use, by a supplier? Usually who is involved in this process?
>
> 2 With respect to new technology and responsibility, decision making authority, how is your unit organized?
>
> 3 Is there a formal or informal structural (organization) for adopting new technology? If informal, are all the members always engaged?
>
> 4 How many departments and individuals are commonly engaged when adopting new technology.

It is clear that there are different business units within the oil and gas organizations. It is also understood that the business units have more or less common scopes in the oil and gas organizations that the participants belong to. It is also coherent between these organizations that there is a business unit which plays the end user/client role. This business unit is called “operations” and it is the one who receives the products/technology from project units and then they are in charge of operating, maintaining and improving it during the complete life cycle of the

system. They are also the initiators as they foresee a need for developing a field (green field) or improving an area of an existing field (brown field).

According to the buy-grid model the “operations” business unit will be at the beginning of the buy phases axes where stage one (anticipation or recognition of a problem/need and a general solution) suits the description given by the participants. At Equinor “operations” will define the general basis of design together with TR specialists and R&D specialists. At total “operations” will define them together with headquarters and system architects. Then (in both) it will be handed over to “project” business units for further development. It is a good assumption to state that a “project” business unit starts with the buy phase number 2 (determination of characteristics and quantity of needed Items) up to buy phase number 8 (performance feedback and evaluation).

It is very interesting to verify that one business unit like “project” can cover 7 buy phases, it does not mean that there are a lot of possibilities to introduce a new technology while a project is running because projects as stated by the participants usually do not introduce new technology (they can do it but is not frequent), the new technology is introduced before the basis of design is handed over to “project” units. Projects are in most of the cases also in charge of qualifying new technology (via R&D groups in all cases Equinor, Total and Shell) as they are very knowledgeable with the processes to be executed.

Additionally the buying center concept states that a group of people have a say before a purchase is decided and it is also corroborated that same figure is seen from the business units level, i.e. a group of business units have a say before a purchase is decided. The latter being linked to buy phase number 7 (selection of an order routine) in the buy-grid model. It is also noted that each business unit, for the specific field, will have its own group of people and therefore they will also interact within their own bubbles. Refer figure 08.

R&D business unit at Equinor provides expertise to other units in the organization, especially when new technologies are in the radar of field development and or projects. For example for unmanned platforms or next generation SCMs. Also this unit runs qualification programs for new technologies by their own or within projects depending on the budget and business case.

R&D for Total mainly focuses on leading maturation and qualification programs for technologies that have a business case within the organization. Once the technologies have been qualified then they are transferred to the business units that initiated the need. The specialists are not located at R&D but in the other business units.

It is reasonable to claim that R&D business unit is an influencer, according to the buying center concept, also other specialists like headquarter, or the owners of the internal standards are influencers. In Total the headquarters influencer have a lot of weight and they are even deciders as it is needed their approval before the project can go ahead with a new technology however it

is still in project responsibility to follow up, gather all the specialist, stakeholders before a decision is taken.

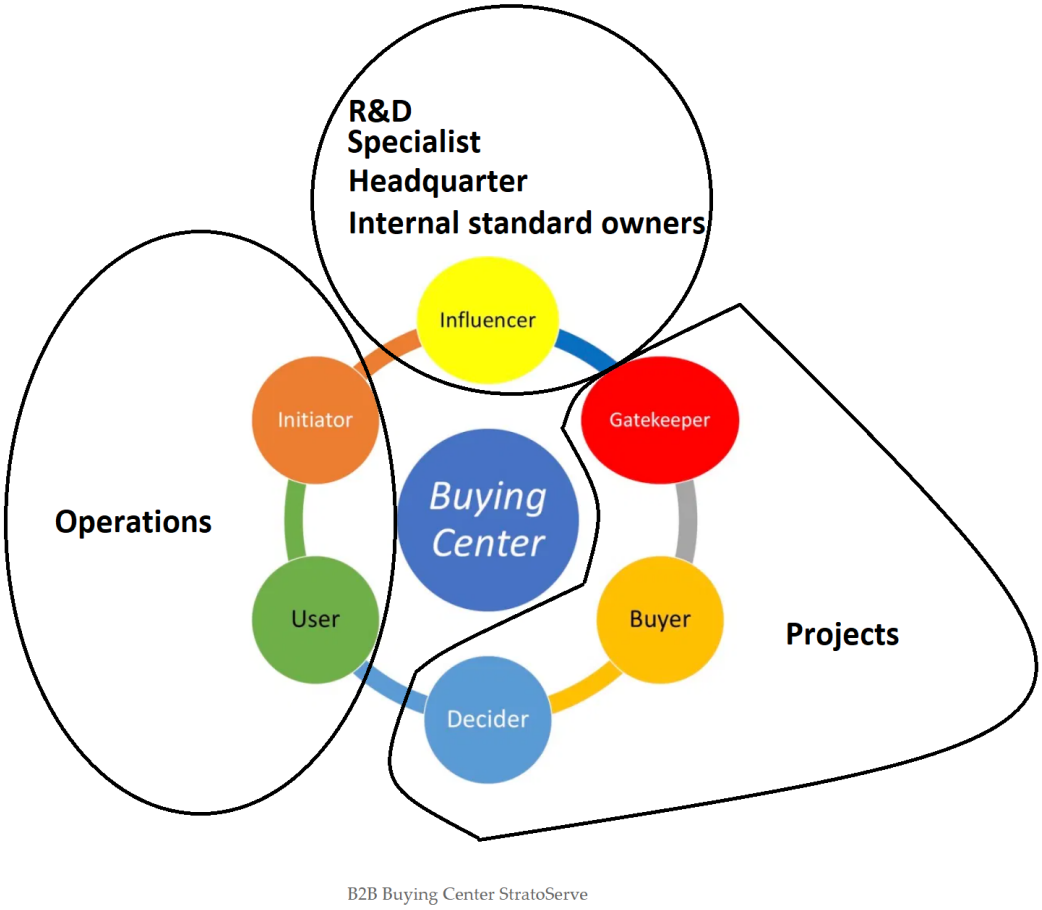


Figure 08. B2B buying center

Note: Figure has been modified from original. Original figure source: Stratoserve, Understanding the Buying Center can help B2B Marketers and Supply Chain for innovation.

In Equinor the projects do not need the approval of the so called TR owners (internal standard owners) although it is preferable to have their approval.

It is assessed that projects are the deciders as ultimately they are the ones who received the basis of design and develop it in detail, additionally they decide based on technology assessments, engage suppliers and finally are the ones placing the POs. The gatekeeper is a

bit unclear however if a supplier wants to introduce a new technology then the projects need to receive them and discuss it with influencers, initiator and user but if projects do not take that initiative then that technology will not arrive to the specialist therefore there is very low chances for the new technology to be introduced in the project phase. Total and Equinor do have informal processes for transferring knowledge of new technologies from project to other business units but both have structured processes from transferring knowledge from headquarters/ product specialist to projects. The lack of formal processes could be seen as a weak link however once the individuals have the right network then it is not an issue anymore.

The buying center concept links informal organizations that need to appear when a decision making is needed. It is absolutely clear how this informal organization also applies for new technologies to be adopted in the oil and gas organizations at least for Equinor and Total. For Shell it is a bit unclear as there is not enough data collected however based on the data the information is pointing towards the informal structure for the decision making. The input related to Shell aligns also with the fact that when the basis of design arrives to the project then it has already an input with regards to the technologies to be used, “When it comes to pre-feed the main focus is not on details about the new technologies, but on technologies that allow the field to be developed. Details regarding the new technologies are added just before feed. Furthermore it is created a list of opportunities which later are filtered by assessing the relevance of the opportunity.” Furthermore the projects at Shell also make qualification via replication activities which actually can be compared with R&D activities from Equinor and Total.

The timing for introducing a new technology to the oil and gas operators seems to be the earliest the best, applicable to all business units. The latter will allow the business units to be aware of it and introduce the new technology in case the technology is seen required to the given field. However the presentation of the new technology shall be prioritized to the operation units, as they are the initiator and final users at the same time. There is no guarantee that the technology will be adopted but at worst case at least the new technology will be considered in early concept designs and the more the company considers the use of a specific technology, the more chances the technology has to be adopted.

5.1.1 Enablers for new technology to be adopted

Technologies deployed in the oil and gas industry need to overcome several barriers, they need to be trusted before they can be adopted and deployed. A lot of these technologies come from other industries, where they have been designed, tested, placed in use for many years, however when they are introduced to the subsea oil and gas world then it seems like time becomes slower and sometimes suppliers give up before they manage to get their technology approved for adoption.

Equinor, Total and Shell, all of them have their own internal standards in addition to the international standards like ISO, API, ASME, IEEE, ISA and NORSOK. Even when a supplier has qualified a technology according to the international standards it is also needed to be qualified according to the specific internal standards. Even worse, some of the requirements in the internal standards point to different directions making it very difficult for a supplier to have one technology to suit all clients. In most of the cases the technology will end up being specific to each client resulting in the need of scaling up the amount of resources in the supplier side for maintaining the technology. The latter will increase cost for suppliers and for clients.

The responses to the interviews confirm the strong position that internal standards have in the oil and gas organizations the owners of those are influencers and very near to be deciders. The Equinor participants acknowledge that qualified technologies according to international standards does not mean that it will pass Equinor's internal standards as they cover much more.

To enable a technology to be adopted it needs first to be approved for use and the process for getting to that milestone can be arduous, tough, burdensome, time consuming and costly. Equinor, Total and Shell start assessing a new technology with their TRL approach, the TRL has several pros and cons, and both API (american petroleum institute) and DNV (Det norske veritas) recommend that the new technologies shall be assessed using the TRL scale. This is recognised in the subsea oil and gas industry and as the participants mentioned it is used to measure the maturity of all technologies, for qualification and readiness assurance.

Once it has been assessed and scaled from 0 to 7 (API) then the qualification program is built up. The assessment is done by the multidisciplinary team to review all the aspects of the technology. At the end of the qualification program the technology will be either ready for first use (TRL4), where the technology has been built as a production unit / full-scale prototype and tested under simulated environment or field proven (TRL7). The latter means that a production unit has been integrated into the operating system installed and operating in the same environment and operating conditions for more than 10%of its design life.

Once the technology is qualified, it is up to the project to adopt it or not. In equinor it is the project director who makes the decision based on feedback from the project team how this process is performed is a bit unclear however it is expected that the decision is not taken from one day to another but it is based on flow of information over time which at the end provides the required confidence to adopt the technology or not.

Additionally the technology needs to have a business case and low risk. A business case means cost effective in comparison with other technologies. Total, Equinor and Shell point to be cost effective in OPEX, CAPEX.

An additional enabler is the manner that the new technology has been introduced. It makes a difference if a technology has been introduced to the operation unit, R&D unit, project unit or to

other units. As the operation team is the one starting the basic requirements, it is preferable to introduce the new technology at this stage so that the chances in having the technology in the base case design increases. Also if specialists (in Equinor), headquarter (Total) and field developer (Shell) are aware of a suitable new technology, there are more prospects for having the technology also in the basic requirements, as they support “operations” at the very beginning. If the new technology is introduced in the project phase then there less chances to get it to the base case as the basic blocks are already in place. If the new technology really provides an advantage economically then the project could engage its review, however due to schedule limitations in most of the cases it will be a bit late.

Equinor, Total and Shell have formal structures when it comes to enable new technologies to reach a maturity state where projects, or other business units are able to adopt it, if required. The formal structure is very clear in a way that the new technology needs to be qualified as per their internal standards, this was pretty clear from all the participants. However when adopting new technology then seems like there is no formal structure, it is a more informal and diffuse process.

At Equinor and Total several individuals are put together to assess the adoption of new technology, the participant also explains that it depends which business units initiate the introduction (enabler). The latter can be understood as the different units have different specialists and the individuals have different roles. The individual roles are not the same in Equinor or Total. For example it seems like Equinor’s R&D business unit is an entity which has the ability to have experts or specialists, it is given technologies or products so that they are self-operating when it comes to qualification and providing specialist to other business units. While Total’s R&D takes a “manager role” i.e. it manages their qualification assessments to comply with Total’s processes and standards. However they do not have specialists in specific technologies or products, therefore they need to ask for such specialists to other business units. Projects at Equinor are also more independent than in Total. At Equinor the project is able to adopt a new technology even if the TR owners or subject matter experts are against it, the latter is of course not desirable however Project are allowed to proceed in that manner. Meanwhile at Total, the projects need to have a formal approval from headquarters when a new technology is about to be introduced. At Shell it appears that projects are also a bit more independent as they engage technology replication teams when a new technology needs to be qualified however it is not clear if they need to have a go ahead signal from a centralized team or not.

Finally it is the project who makes the purchase of the new technology after a long period of basic design, field development, discussion on applicable technologies, qualification plans, risk assessments, TRL assessments. All the business units and also the “project” units itself are enablers through all this global process. Depending on the implications of the new technology i.e. stand alone or system technology then the process will be quicker or complex respectively.

5.2 Research Question Two

With reference to the previous chapter, the level one research question one is: “What is the degree of openness for new approaches in the development department and EPC project department?”. With reference to the theoretical discussion chapter, this provided in four level two research questions:

1 What is the perception of the reason behind your company technical standards, for new product development and for EPC projects?

2 Are there differences when stimulating innovation or new ideas in the new product development organization VS EPC organization?, if yes what are the main perceived differences?

3 If you are part of the new product development department, how will you characterize the communication within your group and externally with the EPC group?
If you are part of the EPC project department, how will you characterize the communication within your group and externally with the new product development group?

4 When a supplier reaches you with new technology, how is the new information assessed?

Based on the information gathered in the interviews, it is noted that there are different degrees of openness, between the new development department (R&D business unit) and EPC project department (project business unit), towards new approaches. However the project department or business unit has more strict routines than the new development department. The latter is expected as projects need to deliver within a fixed period of time while R&D has more time to play with, furthermore they do not necessarily deliver a new technology to an end user, as the qualification process can be cancelled at any time. Additionally the R&D department nature makes it more flexible when it comes to new technology therefore it ought to be more open than projects, so that they can approach new technologies in a faster manner.

One of the technical pillars for the oil and gas operators is the internal standards, they defer from company to company and are seen as based on best practices for the company. As a core, the internal standards provide a basic principle to standardize requirements within each company. Furthermore they also rely on international standards which many of them have also been given inputs to, like API and ISO hence influencing them. Therefore understanding the culture of the oil and gas operators with regards to their internal standards and international

standard is important in order to have smart discussion, clarifications and cooperation suppliers - oil and gas operators.

Based on the interviews, the business units have different cultures with regards to new technology however it is also seen that there is a common set of rules, the norms, across the business units and that is their internal and international standards. These standards regulate the business units, groups and individuals behaviour towards new technology. International standards are valid for all the operators while internal standards are valid for each oil and gas operator. These standards function as glue and common language for communication between the different business units. As discussed in the theoretical chapters the group cohesion is not what each member or individual adds to the group behaviour/emotion but the group has its own behaviour/emotion (cohesion) and the latter influences the members in a stronger manner than each individual is able to influence a group. This is also valid to the complete organization which can be seen as a big group, where the individuals/members can be the business units. Then one cohesion for the complete organization is the manner internal and international standards are followed by the business units, which also shall shape the attitude, perspective, behaviours of each business unit towards internal and international standards.

Culture in the organizations is a powerful feature because it influences the individuals and group opinions, behaviour and actions. The data gathered from the interview shows that the internal and international standards are important for the business units, all the business units tend to have the same opinion, actions in relation to them. Therefore it is understood that one pillar for the oil and gas organization's culture are the importance of these standards at least from the new technology point of view. From the new technology perspective and with reference to Endre Sjøvold (2014) culture classification, it is recognized that all Equinor, Total and Shell can be classified as synergy culture when it comes to these standards. The individual and business units have open discussions, they are able to request deviations, able to challenge requirements, they look for business cases to proactively improve the field developments. As Total, Equinor and Shell participants explained that in the last years the internal standards are being simplified to allow the business units to be leaner. The energy market has a dynamic behaviour therefore it is important that the standards are adjusted over time.

Each business unit also has its own culture, the participants have been involved basically in project business units and R&D business units, therefore it is missing data from operations, headquarter, internal standard owners. It is analyzed that the project business unit from Equinor has a clear process when dealing with new technologies, if the new technology has a business case then it has potential to be introduced and adopted. They also need to assess with regards to risks brought together with the new technology, risks linked with the new technology together with the business case benefits are assessed and balanced. Projects at Equinor are pretty strong with regards to the internal technical standards and can, in some cases, go against them if they assess that the risks are low and the business case has great potential. It seems like they have a synergy culture as they cowork quite a lot but at the same time they are a bit rigid and leaning towards a control culture. The latter shall not be a surprise as they need to deliver in a

limited time with a limited budget therefore the goals are set, the course shall not be deviated unless there is a good reason for doing so. Total projects business unit has a similar culture (from new technology point of view) as a Equinors unit, however they have stronger guidelines with regards to introduction of new technology as the approval shall be done by headquarters. This does not mean that headquarters decides without hearing what the project says but it is valid to assume that depending on the ability of the project team to explain, illustrate the pros and cons, headquartered will allow or not the introduction of new technology, therefore the outcome will vary from individuals and projects. Shell project business unit is also conservative and its culture is similar to Equinor and Total as the participant said “Project organization is always more conservative than other business units, it is always difficult to implement new technology which has high risk. No project wants to be the first to do it, because the risk is basically at the project level”.

When it comes to R&D business units they are more flexible than projects towards new technologies. They also use internal standards, however the degree of openness to start with new technologies which have a low TRL is higher than in projects. The is seen in Equinor, Total and Shell.

Equinor’s R&D department has been engaging in technology development with external parties (suppliers) and this model is seen as a success, specially within the norwegian supplier industry. They do use the internal standards when qualifying a technology but they are open to technologies which do not comply with the internal standard at least at the beginning when engaging a new technology. Total R&D is in constant search for business cases, supporting needs that arise internally and also scouting for new technologies in the market. They also engage new suppliers for developing, maturing and qualifying a technology. It seems like Total R&D mainly promotes technologies that have business cases internally in the company i.e. technologies that are about to be adopted by other business units. R&D team at Shell is also scouting internal and external technologies, which may or not be qualified. They also need to qualify the technologies according to their internal standards.

Figure 09, is an attempt to describe how the Organizational culture related to new technology is understood, it is an illustrative graphic focused only on new technology. The internal standards which are included in the norms and rules are transmitted to the different business units. The roles are also set to the different business units and additionally, in parallel, the processes and unwritten rules are also communicated to them, they form part of the structure to shape the organization culture. Every business unit has its own culture as “group culture” therefore each one will have slightly different outcomes for identity, behaviour, values and finally actions. However as all these business units are influenced by the organizational culture then they shall share common norms, rules, roles, processes and unwritten rules thus synchronizing - supporting each other in a complementary manner - the outcomes of each business unit so that the organizational culture supports the goals of the organization.

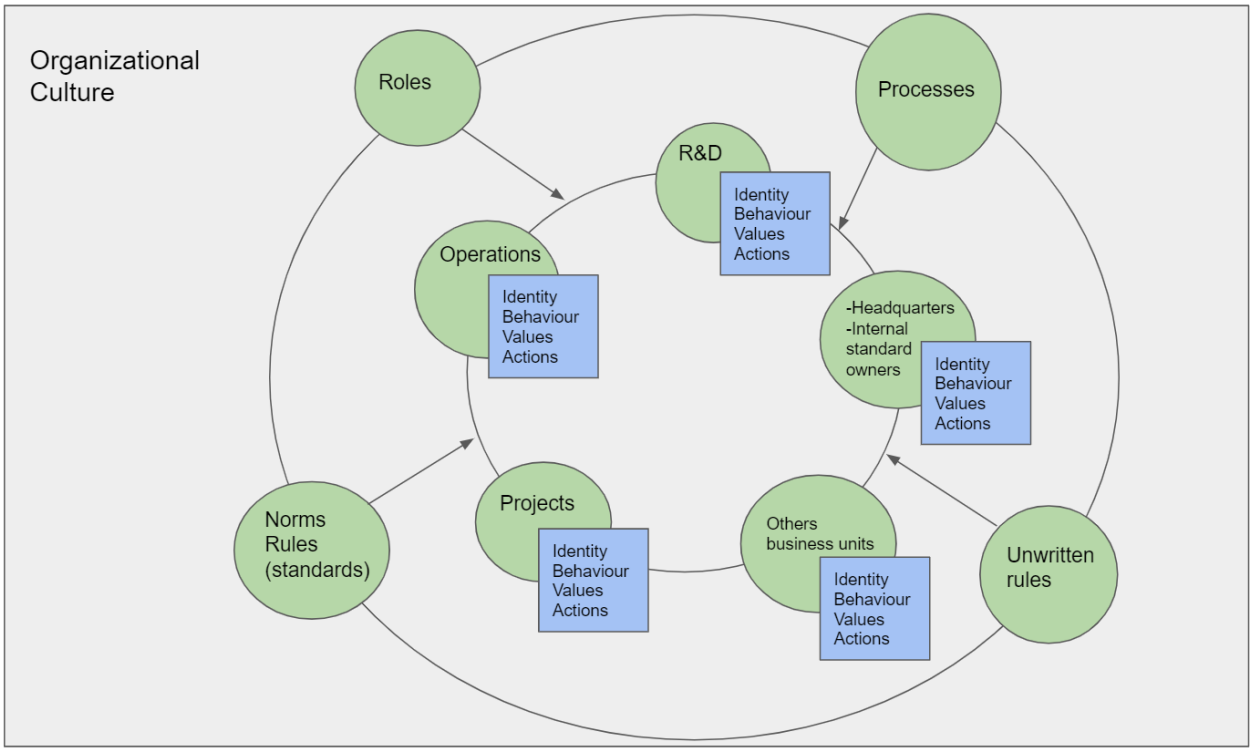


Figure 09, Organizational Culture - Technology

The norms, roles, processes and unwritten rules are a set of structured cores (the people or cognitive side is not shown in the figure as there is no data to support it) to build up the organizational culture. They are connected to each other to provide a meaningful input to the business units. The arrows linking the structured cores to the interrelation lines for business units, shows that they are linked to act as a backbone for the business units. Finally the blue rectangles are the outcomes from each business unit as each business unit has its own group culture.

Regarding the reluctance to adopt new technologies with non, medium or high TRL scale, it is very clear that Equinor, Total and Shell shall have the technology up to at least TRL4 and above depending on the scope of the technology, if it is a small product or if it is a technology which copes a system. The new technologies can be presented with a very low TRL scale however in order to adopt the technology the companies need to feel comfortable and trust it therefore the higher the TRL scale the better for the adoption decision. As one participant from Equinor said: “a new technology which has TRL7 is more likely to be accepted than a technology which has TRL4 level.”

5.3 Research Question Three

With reference to the previous chapter, the level one research question one is: “What is the characteristic of the oil and gas operators in terms of established adopter categories that will help or hinder adoption of innovation.” With reference to the theoretical discussion chapter, this provided in four level two research questions:

1 What is the view of your department with respect to adoption of new technology? (new technology being incremental vs radical)

2 In the context of adoption of new technology, what challenges are present within your department and company?

3 What do you regard as important factors in order to adopt new technology?

4 How, seen from an operators’ perspective, can the biggest risks related to new technology be minimized

The collected information shows that the three Companies, Equinor, Total, and Shell have similar adoption characteristics, they all trust in their internal standards and processes so that they do not wait and see what others do in order to adopt new technology, they do state positions and own leader opinions, they make their own conclusion about a new technology. On the other side, they do not adopt new technology only because it has a good business case, it is first in its kind or it is cool. They are not willing to accept setbacks, the setbacks and learnings are acceptable only in a controlled environment which are within the R&D business units. As one of the participants from Equinor said; “one failure could mean that the company is out of business”. These three companies take the necessary time that is needed so that internally they are confident about the new technology and they trust it because it has passed the qualifications set by their internal standards. Subsequently if the new technology still has a business case then they will adopt it. Therefore it is clear that Equinor, Total and Shell are inside the Early adopters group in the adopters categorization.

It is also seen that the early adopters group shall also have a spectrum of adoption as Equinor, Total and Shell have similarities but they are not 100% the same when it comes to adoption. They do proactively initiate new technologies, scout new technologies and have a goal to understand complex technical knowledge, therefore they all are a bit near to the innovators group however they do not adopt it quite easily. The Equinor’s participants see the company as

having an open mindset for collaboration with suppliers. They describe Equinor as both close to radical adoption and also having an incremental approach. Radical is seen especially in the energy transition market where new energy carriers are being investigated like hydrogen and methanol, however here again it is claimed by the participants that Equinor is good for incentivizing new technology however when the adoption comes into the picture, then it adopts only a few of them. The incremental approach seems to have more adoption cases as it is looked at as natural improvement of the technology. One parameter, an Equinor's participant highlighted, was the fact the when a project has an almost endless budget then the project is able to adopt new technologies like for example Åsgard subsea gas compression, delivered by AkerSolution in 2015, where compressor, pumps, scrubbers and coolers were placed on the seabed since the field uses subsea production systems, rather than on topside platforms (as typically installed). The adoption is related to business cases, qualifications and risks, additionally the more a new technology is tested and qualified - the less risks it will have nevertheless testing and qualification are time consuming and very expensive thus this could be a reason on why an endless budget tends to adopt new technology. Total is more cautious, the participants see the technology being adopted as incremental innovations as they understand that the subsea technologies are modified from well established technologies in other industries. They highlighted the need for new technology to support the old technology, the latter is an important feature to take into account, as backwards compatible (support of old technologies) technology will be more likely to be adopted than technologies which are not backwards compatible as the client will suffer from obsolescence issues after some time. Total advised also that time is an important parameter, time is needed because they need to understand the new technology, to make sure they capture all aspects of the novelty to then assess the impact on projects and operation. It is a bit difficult to know where Shell is, however it seems to be somewhere in the middle between Equinor and Total, the participant mentioned that there is a notion that it is both radical and incremental, radical to set the long term strategy and incremental to basically perform the steps needed to reach the long term strategy. As Equinor, Shell incentivizes new technologies and engaged in research looking at both inside and outside the organization.

Based on the data gathered from the interviews reinvention is also a fact at least in the present and near future. All the three companies strongly follow their internal standards therefore they put pressure on the new technologies to be customized to each company if they want to be qualified. A full qualification means that the technology is ready for adoption. In the far future it could be that internal standards are replaced by international standards allowing standardization of a technology to all the oil and gas companies therefore removing reinvention of new technologies, but it seems that it will take its time before that stage is achieved, if at all is achieved. In the present suppliers need to do reinvention if they want to be successful in the introduction and adoption of their technologies.

A factor that is important in order to adopt new technology is linked to diffusion and decision making, the prior conditions in the decision making stages described by Everett M. Rogers (2003) will be that the new technology is qualified as per the specific internal requirement for

each oil and gas company that is a key enabler in order to enter to the next phase which is “knowledge”. As described by the Total and Equinors participants understanding how the new technology works, how it can be incorporated in the system and how it is operated is very important in order to adopt a technology. The latter means that “operations” business unit, for instance, need to understand the new technology, it needs to know how it will operate it in order to decide if the new technology shall be introduced in the base case, then there will be persuasion phase where other specialist from headquarters and internal standards owners will discuss the new technology and make an assessment of it (if the technology is previously qualified, the discussion will be more easier for the new technology to be used as less risk will be in the air). When the persuasion phase has been terminated and the decision phase is initiated, then it means that the project unit has taken over the post. Once again if the new technology is already qualified then most likely it won't be rejected or avoided and most likely it will be ordered and implemented. However if the new technology is not qualified then it can be rejected almost in any stage of the decision making process. Therefore to increase odds of a new technology to be adopted it needs to be qualified and diffusion shall happen at the very beginning i.e. operation, headquarters and internal standards owners shall know about the new technology, given priority to operation units.

New technology risks are handled basically trusting the internal standard and processes that each oil and gas operator has. This is explained by all of the participants in different words. It is understood that their internal standards and processes are robust, they are based on experience, therefore there is a trust on those standards and processes. They can potentially hinder new technologies but they also allow companies like Equinor, Total, Shell to be early adopters and adopt new technologies without seeing each other.

Regarding the chasm which is located between the transition from early adopters to early majority, it appears to be not so problematic for the subsea oil and gas industry because the big companies like Equinor, Shell, Total are in the early adopters group therefore the other big players like Exxon, BP, Chevron, etc will most like be also in that group, hence supplier does not need to reach the early majority because the early adopters are the ones who invest more in subsea brown and green fields. They have more share in the market than the medium and small companies. The latter could change in the future however as per today reaching the market of early adopters is more than sufficient when it comes to the subsea oil and gas industry. Additionally It is interesting to verify that according to the theory “*the early majority want to improve existing operations, discontinuity of products are to be avoided, they pursue evolution, not revolution. An important aspect is that early adopters are not accounted as references for the early majority. Field proven by an approved reference is a must for an early majority customer, and paradoxically “an approved reference” is another member of the early majority group.”* This could mean that Equinor, Total and Shell are in the early majority and not early adopters but an important feature for discriminating these two groups is the principle that Early majority are “followers” however Equinor, Total and Shell are definitely not followers. Furthermore it is certain that the three companies prefer new technologies which are backwards compatible, which does not discontinue products and this feature will definitely help

the adoption of new technologies. They prefer to have a new technology which is incremental rather than radical because of the risks associated with the latter however they are opened for radical technologies which improve business cases then at the very end if the new technology provides a commercial value then it is of interest to the early adopters.

An interesting approach, which shall be said it lacks evidence, has been made by the information technology firm Gartner. It represents the maturity, adoption, and the perceived trend of a technology in a graphical manner with five phases, see Figure below on the right side.

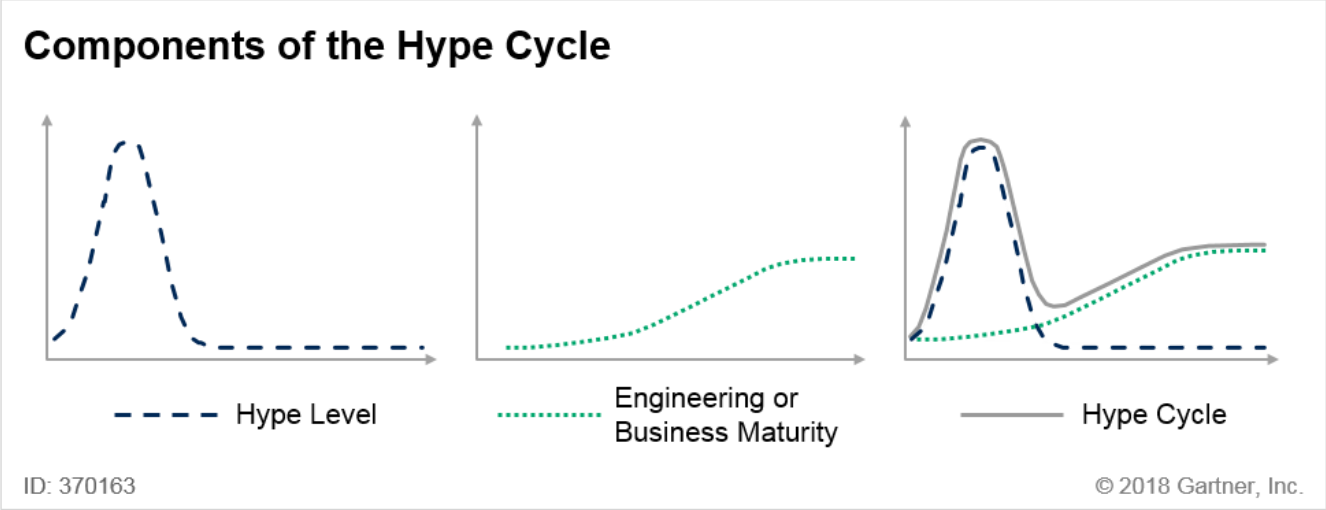


Figure 10, The hype cycle graphical presentation (Gartner)

Although Gartner has its own interpretation to the cycle, see their web page (refer chapter 7 references) for more information. For our discussions with regards to new technology for the oil and gas operators, it is interesting to find the following case; the hype level (left figure) shows the expectations provided by the new opportunities that the new technology generates, seen from the supplier side (the one which owns the new technology) however when it reaches the client side (figure in the middle) then the spectations, excitement drops because of how the oil and gas operators deal, assess new technologies, they need to take their time to assess it, first measure the TRL, assess risks and if they see a business case then it is initiated a qualification plan according to their internal standards, all this process take a lot time and effort to only enable a new technology to be adopted. Adoption is then represented when the green lines start to level up. Therefore there is a clear mismatch in expectations between supplier and oil and gas operators. For the hype level to be more realistic it is important to have a channel of communication with the oil and gas operators.

5.4 Relevance of Applied Theories

The present thesis began with a discussion about the resistance of the oil and gas operators in relation to the introduction of new technology. Suppliers struggle to get the new technologies adopted by the operators. Therefore there is the need to understand the client side on how they operate and how to approach them. Suppliers' investment in new technology is often time consuming and costly, they need to have a wide spectrum of specialists as new technologies require, in most of the cases, a multidisciplinary team in order to start, develop, test, qualify and maintain them. To keep a multidisciplinary team over a long period of time (several years) is becoming a challenge for suppliers therefore they need to get clients onboard in an early phase or get the technology adopted quite fast. It is also seen quite frequently that the clients want the new technology to be modified specifically for each one of them, hence putting the supplier in a costly position as they will need to have more resources associated with each specific solution, making the technology more expensive for both supplier and client. It also is highlighted the challenges with the internal standards that each operator has, therefore the need for a better understanding of the client behaviour. Being conscious about the manner oil and gas operators (clients) assess and reflect new technologies in early concept phases as well as adoption phases shall increase the rate of new technology adoption/commercialization.

Therefore it was selected three main theories to support the analysis; industrial buying behavior Buy-grid model and Buying center model, group and organization culture and technological innovation.

Buy -grid and buying center model are buying behaviour concepts which attempt to describe the buying process in different organizations. For the present thesis, they are suitable in order to understand the different buying phases and classes additionally the different roles in the decision making process for purchasing. It allowed, to understand in which phase and which groups are the ones that shall be notified or shall be prioritized with the new technology. These models provided relevant information related to the initial problem formulation. The participants for the interviews were technical staff therefore the gathered data is missing input from other individuals that have other non technical tasks like buyers, controllers, secretaries, line manager, legal in order to get the complete understanding for formal and informal structures around the purchasing behaviour. By the other hand there might be that the non-technical staff would have pointed to the technical departments as the discussions are around new technologies.

The group and organization culture is an important topic, it ”defines” the manner things are done in a company, it includes vision, values, norms, assumptions, belief and habits therefore

organizational culture directly influences the behaviour of individuals within the organization. In order to understand how the internal standards are handled inside the oil and gas operators it is important to understand their culture. Since all the participants have tasks related to technical roles, there was found a strong culture for use and application of internal standards which are directly linked with the company's approach to new technologies. Thus understanding and confirming this technical culture proved to be a relevant topic for the present thesis. Additionally involving participants from non-technical roles would have provided additional general cultural information however if that additional information was about to be relevant for new technology, is an unknown outcome for now.

The last theory that was selected in the technological innovation. It's relevancy is clear as it describes how innovation is developed, the journey is a long process with ups and downs going forwards and backwards, starting with one basic idea and ending with a completely different product is quite often in innovative projects. Then reinvention also was introduced, which is a process where adopters modify an innovation to fit their own necessities. It is seen in the interview that this also is the case for new technology in the oil and gas industry, the operators shape the new technology as per their internal requirements. After, it was named the concepts of diffusion and decision-making, both provide a foundation for understanding when and where a new technology shall be introduced or at least provide a priority. Finally adopters categorization and chams were introduced in order to categorize the adopter to trace their behavior and get to know their adoption trends in a better manner.

5.5 Considerations Related to the Initial Problem Formulation

The initial problem formulation stated in the present thesis was the following:

How can an oil and gas supplier increase the ability to commercialize new technologies? ensuring a smooth transition between new technology development to commercialization.

New technology, in the oil and gas industry, incremental or disruptive (radical) has a market potential and capture opportunities however it has challenges right from the initial idea, further development of the new technology and finally adopting it. Implementing a new technology has major challenges that can be disruptive for the company that is implementing it. The individuals and groups within the oil and gas organization need to understand the new technology, in order to recognize the benefits, implement and to operate it. It has been confirmed by the participants that the business units requiring the new technology (operation business units) shall understand the technology so that the business case is built up. At this point the journey has reached a milestone which can be described as an opportunity for the new technology. It has also been verified that if the new technology is not fully qualified as per the specific internal standards of the company (oil and gas operator) then the way ahead will be a steep curve as there will be several stakeholders against the new technology. If the new technology is fully qualified as per oil and gas operator's internal standards then the discussions will be more about finding a

suitable business case rather than discussions regarding TRLs, risks, qualification plans, test, schedules, cost which can kill the implementation of a new technology. For building up a business case there needs to be a demonstrated lower CAPEX and/or OPEX than the current technology. These benefits need to be demonstrated because implementing a new technology is expensive and time consuming.

New technologies which are incremental have more probabilities to be adopted than radical because they take care of the old system, old interfaces therefore there is no need to take down the complete old system. There will always be a resistance towards new technologies somewhere in the implementation process therefore in order to avoid resistance all business units at client side shall have an understanding of the new technology. Good communication and involvement, supplier-client, is crucial, giving priority to operation business units which are at the same time the initiators and clients internally in the oil and gas organizations. They initiate a need and co-work the basis of design with other business units like TR owners, headquarters then project business units are engaged to lead the project and deliver back the system to operation business units again. The latter indicates that if the new technology is known and understood by all business units, then it will be easier for the new technology to pass all the process.

Diffusion then shall be focused to the operation business unit however the other business units shall also be part of it at some point as it is beneficial to get everyone aware of the upcoming new technology. There were no participant who belongs to operation business unit but it is expected to see within this unit also an internal making decision process ie. getting everyone involved to understand why the new technology is an improvement or beneficial from the current technology. Suppliers shall also consider engaging key personnel in training in order to do trails and get feedback. The project units are not considered to be prioritized for diffusion as they are focused in delivering the project within a fixed timeline and budget, therefore new technologies are not in their focus. They can engage new technology but due to their limited time the new technology needs to be almost qualified or with field proven history. The R&D units can suggest a new technology but has a limited influence. R&D units play an important role as an enabler for a new technology as it will be part of the assessment and qualification program.

An important outcome from the gathered data is that all three oil and gas operators are trying to simplify their internal standard so that they become more flexible, additionally the participants from Equinor and Total mentioned that they see a major benefit to standardize the requirements at the international standards level like API or ISO therefore moving away from their internal standards. Overall standardization will clearly improve the subsea market as supplier's cost will decrease substantially therefore the investment by the oil and gas operators will be lower as cheaper subsea technologies will be available. The investment made by the supplier will also be lower as no client specific requirement will be needed. It is unclear if there is any deadline for such standardization, however the oil and gas operators are also engaging in joint industry projects where they collaborate with each other on subsea standardization therefore getting mutual benefits, improving a comprehensive specification for subsea applications, simplifying

risk assessments and boosting the re-use of already qualified technology. How much will this help the adoption of new technologies is a question that will remain open at least for radical or disruptive new technologies as they will most likely be outside of the international standards unless it is developed a standard that focuses specifically on new technologies. For incremental innovations it should help quite a lot as the technology will already be specified in the standards.

If the culture of the oil and gas organizations is about to change or if it is transforming with regards to; from internal to international standard is unclear but it is certain that the companies are trying to simplify the internal standards as they have experienced that they were becoming heavy drivers for increasing the costs of the products/technologies. For the moment suppliers shall try to qualify the new technologies as per the specific standards of each company as they will get an advantage on doing so. Suppliers shall meet the oil and gas companies with the awareness that per today they are trying to simplify their internal standards, that could enable better communication, but still they focus on those standards when new technology is on the table. The latter leads to a topic in B2B; Interrelation between groups from different organizations for the introduction and adoption of new technologies. From the interviews it is noted that from the technology point of view trust is important, what the oil and gas operators are doing when qualify a technology with their own internal standards is at the end to reach a trust level in the new technology therefore it is inferred that the more trust there is between two companies the easier is to discuss and reach agreements. Of course the complete picture will be an overall trust and not only from the technical point of view. Therefore if trust is built up from the technical point of view and from a trading point of view, then mutual cooperation, collaboration will definitely grow, helping the adoption of new technology.

As previously found, Equinor, Total and shell are in the group of early adopters and the main reason for it is because they trust in their own assessment, they are not afraid of adopting a new technology, if it has passed their norms and standards. They are not followers waiting to see what others do. It can be inferred that the other big oil and gas have the same behaviour so the supplier shall focus on this companies because they are more likely to adopt new technology and also because they have the biggest share in subsea market, they are the ones investing in major brown and green fields, so maybe there is no need to jump the chasm, as stated in a previous chapter, as the early majority do not have too much share in comparison to the early adopters. However there can be early adopters, early majority, late majority and even laggards within the same organization therefore for crossing the chasm suppliers shall educate and put more effort to train and teach the different business units in the oil and gas organizations that have adopted the new technology, as it will improve the knowledge and trust of the new technology and therefore pave the way to early majority.

Figure 11 below shows a summary of the above discussion, it does not show all the details but it is a good representacion. It shows the development of new technology and its adoption. It starts, from left to right, with the initial idea of the new technology in the supplier side. The supplier has its own organizational culture and the technical culture is given by the roles,

processes, unwritten rules, norms and standards that it may have. In most of the cases it will use international standards.

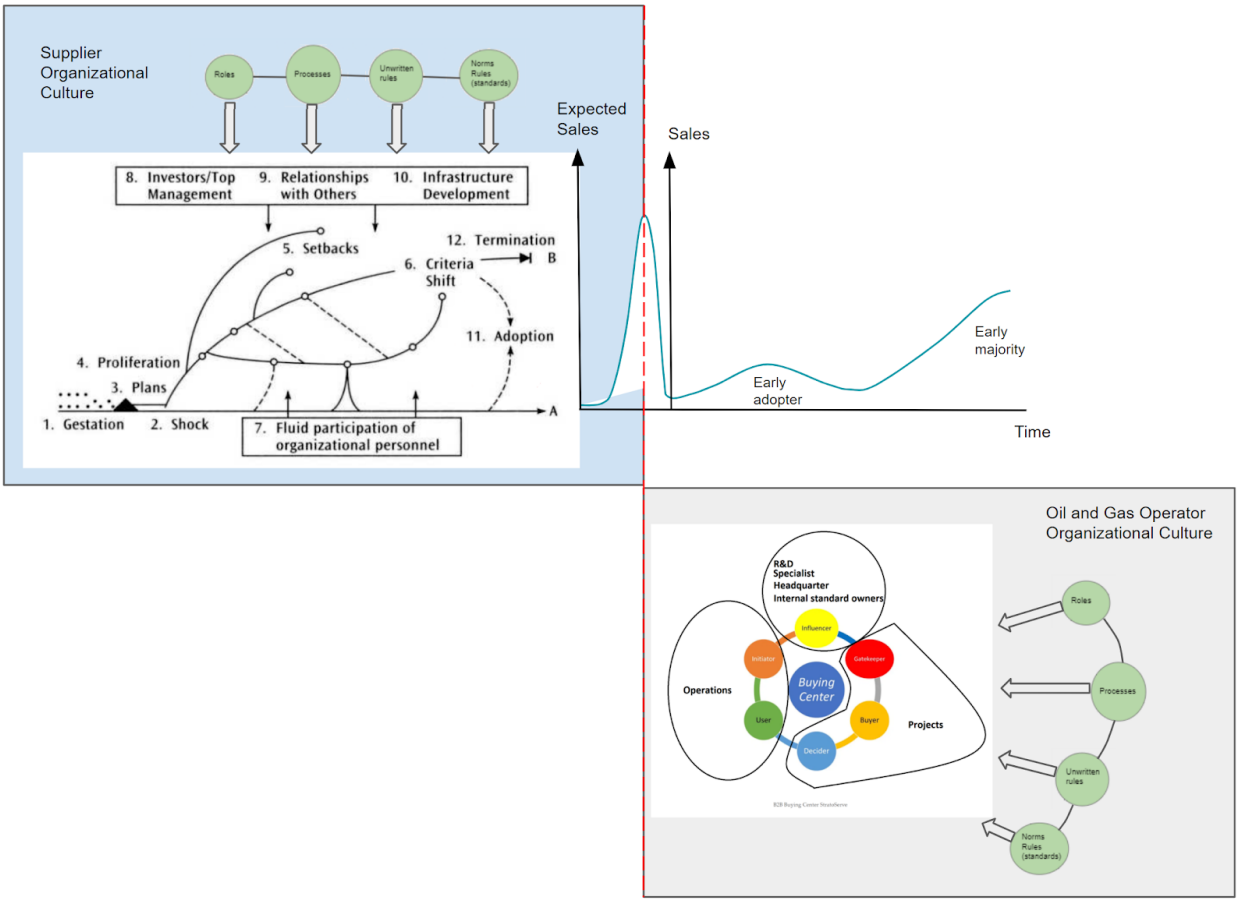


Figure 11 Summary adoption of new technology

The innovation process related to the new technology performed by the supplier is described by Andrew Van de Ven (2008), and while it is about to be completed, the supplier has major expectation as the opportunities are plenty, and the market seems to need the new technology (expected sales) however once it engages one of the oil and gas operators (vertical red dotted line) the expectations get smaller as the client starts to assess the new technology and do not adopt it until it is fully qualified as per client specific internal standards. At the client side there are several business units and depending who has received the introduction of the new technology then it will be handled in a different manner. If the client finds a business case for the new technology then the operation unit is involved in the introduction or it actually introduces it, therefore it is important that the operation unit has the required knowledge of the new technology, then it is passed or coworker with the other units until it reaches the project unit. The project unit then will place the order for the new technology if it is qualified as per company's internal standards. If not, then an assessment of schedule and cost will be done and possibly the fallback solution will be engaged. This process is part of the oil and gas

organization culture. It can pass several years before the early adopters adopt the technology as they need to find a suitable business case. Once the early adopters (within the organization) have adopted the new technology the sales will start to decrease as the other units will want to see how it goes with the new technology. The suppliers shall engage the client's business units to make sure they understand the technology and they operate it in the correct manner, installation shall also be supported and followed closely. This will provide more trust and if suppliers are able to cross the chasm then more and more operational units will start to introduce and adopt the new technology, reaching the early majority within the client's organization.

5.6 Suggestion for Further work

The gathered data is very technology oriented as the participants have technical roles, they understand and know how a new technology is handled in their departments and roles also provided information about other units how they understand they handle new technologies. Therefore in order to get a broader picture there shall be a further work to include individuals from commercial roles which will provide their perspectives and maybe new insights.

Also all the participants named the TRL scale as a guide to measure the maturity of new technologies. It is understood that the TRL is well established in the oil and industry therefore a standard method across them, however a TRL does not say anything about integration to other parts and system level readiness. These components are assessed separately by the oil and gas operators, therefore there could be beneficial for the supplier to have an standard systemic measurement for these variables so that it can be presented to clients in a standard format thus making the introduction/adoption process easier. There are attempts to implement this kind of approach, like the SRL and IRL, in other industries, therefore it will be interesting to study if the oil and gas operators are willing to endorse this kind of standardization.

With regards to adoption of new technology, it has been analysed that Equinor, Total and Shell have similar adoption characteristics in addition they are categorized as big oils and gas operators in the subsea market therefore it is of interest to also screen medium and small oil and gas operators in order to confirm their adoption characteristics and map them in the adopter categorization curve.

One of the things that shall be investigated in-depth is the contribution and or impact of Inter-Organizational trust in B2B. Understanding Inter-Organizational trust in the adoption of new technology may be a powerful tool. How important is the overall trust (from technology, commercial, legal, etc) to pave the way for communication, cooperation, collaboration and finally for adoption of new technologies.

Finally, the data gathered in the present thesis shows that the three companies (Equinor, Total and Shell) have started to simplify their internal standards so that they are more readable and flexible for the supplier to come up with solutions and/or new technologies. The latter is seen as a positive signal for the suppliers to be able to develop new technologies and standardize them across the subsea market however it could also be seen as a bad signal as a signal of oil and gas operator's organization decline because of "complacency". Therefore it shall be studied the background for simplifying their internal standards, is it because they are adjusting their norms according to the market? or is it because the organizations are losing their alignment; values-actions. The latter is described as complacency and could lead to a phase of chaos in the organizations.

5.7 Criticism and Validity of the Empirical Data

One limitation and probably the biggest one was the rejection of several people who were asked to participate in the interviews. It is not clear the reason for rejecting the participation however it could have a connection with the current time where covid-19 coronavirus has shut down or put on hold several projects within the oil and gas industry. In the specific case for Shell, the company was undergoing a major downsizing and restructuring at the time the request for participation was sent out, this definitely prevented people from accepting the participation as uncertainty in their jobs made them unavailable. Also fear about releasing informal "secrets" from their company is an explanation, especially for those working in non-technical positions as all people that were asked rejected the participation.

There is also the impression that the participants were really engaged in the topic and they took their time responding, explaining and describing the answers, giving some examples where necessary. There was also the feeling that at the end of the sessions some of the participants were a bit tired, that is understandable due to their workload. There is also the impression that the interview could have been sharpened with specific questions thus generating more specific knowledge. The participants were not confronted with several counter questions as the interviews could have become unpleasant experiences. All the participants seemed to be in their comfort zone while taking part in the interviews.

Lastly, the participants provided good data to better understand the oil and gas operators when they are dealing with new technology, providing details like the different business units across the organization, the manner they communicated each other and the roles they play when new technology is included in the basis of design and how each unit deals with new technology. Additionally they provided data with regards to the culture that the organization has from the technical perspective i.e. the norms and values that govern the units and how they take actions when facing new technologies to enable new technology to be adopted. The data allowed to categorize the organizations within the technology adoption life cycle framework to finally allow suppliers to focus on the right organizations and units.

6 Conclusion

Oil and gas companies with established internal standards, good processes are the early adopters, in the technology adoption life cycle framework, because of the confidence they have in their processes they do not follow others but trust in their internal assessments. It is most likely that medium and small oil and gas companies will wait and see before they adopt new technologies. Additional data to confirm the latter is needed.

The TRL is extensively used when dealing with new technology, oil and gas operators trust this tool to assess the maturity of a new technology. The higher TRL scale has the new technology the easier it will be for the supplier to introduce it at the client's business units, granted a business case is found. Therefore suppliers shall endeavour to get the new technology at least at TRL4, if not higher. As one participant mentioned, if a new technology has TRL4 then there will be some scepticism in the technology, however if it has TRL 7 then the system will be more relaxed for adopting the new technology.

Internal standards are the norms even when dealing with new technology in the oil and gas organization, this is valid for all the business units, it is deep in their culture. The operators are trying to simplify their internal standards however it is unclear at which stage they are, however they are aware that there is a need for simplifying them in order to allow suppliers to lower the cost of existing technologies and new technologies. Operators are also moving toward joint industry standards to pave the way for common industry standards similar to international standards.

The "operation" business unit plays two roles; initiator and end-user/client role. Therefore suppliers shall focus in this unit when introducing new technology to oils and gas operators. Operation units initiate the need as an initiator, and also operate and maintain the new technology as an end-user. R&D, headquarter and internal standards owners act as influencers therefore they shall also have knowledge about the new technology to secure a positive influence in the process of selecting the new technology. Finally project units act as buyers, deciders and gatekeepers, this unit places the actual PO to the new technology, it makes the decision based on information from the other units and suppliers, and act as gatekeepers as it may or not allow new technology to be introduced in a project phase.

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Appendix A

Brief introduction.

Purpose of the thesis :

The purpose of this note is to provide an overall overview of the thesis and request you to consider if you would like to participate in an interview.

The thesis is a final research as part of the NTNU's Master program in Technology Management, it aims to investigate how new technologies, which are part of R&D or innovation departments, can successfully be transferred to a commercialization phase. The theoretical framework used in the thesis establishes the backbone for the research and contains industrial/business buying models, group culture and adoption of new technology theories. The theoretical foundation together with empirical data, gathered from interviews, aims to answer a set of research questions which were derived from the theory. Finally there will be recommendations for commercializing new developed technology.

Practical information related to the interview:

Prior to the interview it will be distributed an interview guide which will list the questions for the participant to get familiarized with the interview. All participants will be provided with the same interview guide regardless of oil and gas operator or position in the organization.

The interview is expected to last between 30minutes to one hour, as the interview is semi structured.

Due to the difficulty in taking notes during the interview, participants are kindly requested to accept voice recording, voice recording can be paused at any time. Please let me know if voice recording is not accepted.

Privacy:

The interview will only be used for the present thesis. Participant's name and specific job title won't be recorded. If voice recording is approved then it will be deleted once a grade is granted to the thesis.

All data will be confidential and only disclosed to an external mentor at NTNU.

Best regards.

Wilbert Ramos.

Note:
External Mentor at NTNU: Dr. Arve Pettersen
email:arve.pettersen@ntnu.no

Appendix B

Interview guide questionnaire.

Introduction:

1.- Please tell us your role in the organisation and the unit you belong to. How is that unit related to EPC projects and to new product development?

2.- How is your unit organized? (with respect to responsibility, decision making authority for new technologies to be introduced)

Main topic:

3.- How do you think your unit approaches new technology, with respect to internal and external technical standards.

4.- How do you think your role, unit and organization shall approach new technology in the future.

5.- What is your view on innovation? (incremental vs radical?)

6.- Have you been part of a new development which has been introduced in an EPC project? If yes, how did it occur with regards to decision making. Is there a formal structure process or is it based on experience and informal discussions?

7.- Is there an established organisational structure to transfer new technologies into EPC projects? And vice versa?.

8.- Internally technical standards, how much does it dictate your role.

9.- Is there any process for assessing new technology being presented by a supplier? barriers?

10.- How do you adopt new technology and minimize risks related to it?

Wrap-up:

11.- Any additional comment that the interviewee shall have.

Wilbert Ramos

Adoption of new technology in the subsea oil and gas industry

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