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Enhancing Technology Transition from RDI to Applications

Case Study: Meyer Turku

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Master's thesis in Industrial Management

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ABSTRACT :

Innovation in the maritime industry is imperative in the strive towards the climate change goals set by the International Maritime Organization (IMO). Management of the innovation and technology development process in an organization is necessary for successful implementation of both incremental and radical innovations. Identifying and evaluating existing processes and problem areas in transitioning technologies from Research, Development, and Innovation (RDI) to the application stage is one way to improve efficiency and ensure that RDI and sustainability targets are accomplished. Technology development processes have been well researched and they are applicable with some modifications to the shipbuilding industry especially in an engineer to order environment.

This thesis is a case study on Meyer Turku which is a shipbuilding organization. The purpose of the study is to examine the organization's current sales and engineering change management processes and challenges in transitioning technologies from development to application within the technology development management process. Based on the assessment of the current processes, the study suggests methods to improve the efficiency of advancing the technologies from RDI to applications. The study begins with a literature review that comprises the different aspects of innovation and technology management process, understanding the engineer to order environment, the main components of engineering change management, and common strategies to advance RDI ideas to the application stage. The study utilizes an inductive approach and a qualitative method with semi-structured interviews. The themes for the interviews are gathered through literature.

The results of the study begin with the interview findings of the current state of the sales and engineering change management process and their respective challenges. They also indicate the current RDI efforts and challenges, state of knowledge management, resistance to change, and the ideal future process. The main result of the study is that the organization lacks a standardized process for advancing technologies from RDI to the application stage and it is best to focus on implementing new technologies in the sales phase rather than through change orders. The analysis provides suggestions for future RDI to application processes obtained from literature to best fit the organization and overcome the known challenges. It includes suggestions for the future sales process that incorporates the internal Technology Radar project. A modified stage-gate model is suggested for the technology development process with the Sustainable Process Industry through Resource and Energy Efficiency (SPIRE) project decision-making framework. The suggestions include the need for productization of technologies and change management.

KEYWORDS: Technology Development Process, Innovation Management, Engineer-to-order, Shipbuilding, Engineering Change Management

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Abbreviations

AOM	Agreement of Modification
EC	Engineering Change
ECM	Engineering Change Management
ETO	Engineer to Order
GA	General Agreement
GHG	Greenhouse Gas
IFR	Ideal Final Result
IMO	International Maritime Organization
MCDA	Multi-Criteria Decision Analysis
NPD	New Product Development
RDI	Research, Development, and Innovation
SPIRE	Sustainable Process Industry through Resource and Energy Efficiency
TDP	Technology Development Process
TRL	Technology Readiness Level

1 Introduction

One of the most significant global concerns today is the question of how to mitigate climate change. Agreements and regulations are increasingly being discussed and negotiated on a global, regional level, or industry specific to address this challenge. Similar to other industries, the maritime industry is under considerable pressure to improve its sustainability performance. In line with the Paris Agreement climate targets and United Nations Sustainable Development Goals, the present International Maritime Organization (IMO) target is to achieve net zero greenhouse gas (GHG) emissions by approximately or close to the year 2050 (International Maritime Organization (IMO), 2023). The industry comprises of a wide range of actors in shipbuilding, port operators, shipping companies, and partners that make up a wide business network (Aro & Haaja, 2023, pp. 4-5). Marine transportation or shipping covers approximately 90% of the global transportation of goods and trade volume (Wang et al., 2023, p.1). Passenger ships such as cruise ships is a distinct category in shipping which is also driven by the imperative requirement for sustainability (Kulkov et al., 2023, p.2).

As new policies emerge and the need for sustainability increases, companies need to strive to abide by the new rules and discover new solutions to reduce their carbon footprint. In the EU, there are incentives and funding available for companies to support their green transition research, development, and innovation (RDI) (Aro & Haaja, 2023, p.11). In Finland, one of the programs is offered by Business Finland to facilitate the green transition of Finnish maritime and ports, and provide solutions to the industry as a whole (Business Finland, n.a). The significance of the development of R&D is growing as the industry requires more radical innovations (Solesvik, 2016, p.1).

RDI is inevitable for reaching set targets, however an important aspect of the RDI is the management of the innovations and technology development as it determines if the new technology will be applicable and implemented on a ship. According to Rogers (1995), innovation encapsulates the whole cycle of new ideas and technologies from invention to diffusion, adoption, and finally application. Based on history, innovation is

extremely significant for production performance, competitive edge of the organization in the industry, and socio-economic development (Akintoye et al., 2012, p.97).

1.1 Research purpose, questions and objectives

There has been extensive research done on innovation and technology development management however there is little research on how to get new technologies from RDI to the application stage from an organization's perspective in the shipbuilding industry in the engineer to order environment (ETO). With the available funding, organizations have the necessary resources to gather new ideas, knowledge, and seek new technologies but there is a lack of relevant processes to successfully advance these technologies to the application and commercialization stage within a timely manner. The purpose of this thesis is to examine the current processes and challenges related advancing technologies from research, development, and innovation (RDI) to the application stage within the technology development management process of a shipbuilding company. It aims to provide strategies on how new technologies can successfully arrive at the application stage. Cruise ship is an engineer to order product and the duration of the project can be long therefore the study investigates the engineering change management process and the possibility for RDI technology application in the case company as well.

The research questions for the study are:

- 1) How does the current processes in Meyer Turku handle the transition of technologies from RDI to application?
- 2) What strategies can be implemented to improve the efficiency of advancing the technologies from RDI to application?

The research questions will be answered with the help of the following objectives defined in the study. 1) Analyze the existing sales processes and identify challenges for RDI technology applications. 2) Analyze the existing engineering change management process and identify challenges for RDI technology applications. 3) To propose strategies and

frameworks that can enhance the process of advancing RDI technologies to the application stage.

1.2 Limitations

This study is based on one shipbuilding organization, Meyer Turku. It is focused on the internal sales and engineering change management processes on new technology implementation, primarily in the basic design team. It also focuses on the innovation and technology development management from an organization's perspective to facilitate the internal Technology Radar project that is in its initial phases. The study excludes external stakeholder processes.

1.3 Structure of Thesis

The thesis has five main chapters. It begins with the introduction, literature review, research methodology, analysis and results, and conclusions. The first chapter provides a background of the study, research purpose, questions and objectives, and limitations.

The second chapter provides a literature review of new technology implementation which includes innovation and technology development management. It then proceeds to a review of the engineer to order environment and engineering change management. Lastly, it reviews the strategies to bring RDIs to the application stage.

The background of the case company is presented in the third chapter. It also provides the methods used for conducting the study and collection of data. The analysis of the data collected is then presented in relation to the research questions and objectives established in the study.

The fourth chapter provides the results and discussions to answer the research questions. The findings are connected to the theories presented in the theoretical framework.

The last chapter summarizes the results and provide conclusions. It also provides managerial implications and discusses the limitations of the study for future research.

2 Theoretical Framework

This chapter discusses the theoretical framework for the study. It begins by presenting the theories on innovation and technology management. Followed by an overview of the engineer to order environment. The third section will cover theories on engineering change management. Lastly, strategies on advancing new technologies to the application stage is presented. The theories selected are based on the applicability in this case study.

2.1 Innovation and Technology Management

The European Commission (Aristodemou et al., 2019, p.2) considers innovation management responsible for gathering knowledge and identifying opportunities that is in line with the strategic goals of the organization as a discipline. Organization investments in innovation are made to accumulate knowledge as it is seen as an economic driver. An economy that is derived by the 'production, distribution, and use of knowledge' is known as a knowledge-based economy and it is the essence of the technological era. It enhances economic growth and sustainability efforts which directly influences the innovation process hence innovation management is key to determining the competitive edge in the industry (Aristodemou et al., 2019, p.2).

2.1.1 Types of Innovation

There have been many theories to define and describe innovation. Schumpeter (Tao et al., 2010, p.20) defined innovation as the commercialization of a mixture of the following:

- (i) new materials and components,
- (ii) the introduction of new processes,
- (iii) the opening of new markets,
- (iv) the introduction of new organizational forms. (pp. 20)

Based on this definition, it can be deduced that innovations consist of both the business world and the technical world. According to Schumpeter, if there is only a change in the technology, it is called an invention however it becomes an innovation when the business world is concerned (Tao et al, 2010, p.20). The OECD (2005) determined four fundamental innovation types which are product, process, marketing, and organizational innovation based on Schumpeter's classifications of innovation types (Karlsson & Tavassoli, 2016, p.1485).

Literature has shown the importance of identifying different innovation types such as distinguishing the incremental and radical innovations or technological and administrative innovations (Karlsson & Tavassoli, 2016, p.1485). Although Akintoye et.al (2012, p.46) agrees with the importance of distinguishing them, they argue that these distinctions are rarely obvious in practice therefore the innovations should not be looked at as separate types. Innovation leads to either product or process innovation. However, the view of innovation has evolved to merge both product and process in a more systemic view as they complement each other (Akintoye et al., 2012, p.46).

Product innovation is an introduction or development of a new or improved product which can be a good or service (Akintoye et al., 2012, p.46). A complex process of evolving technologies, shifting customer expectations, reducing time-to-market, and increasing market competition results in product innovation. The success of product innovation requires a strong coalition between the organization, suppliers and customers. Product innovation can be further classified into radical or incremental innovation (Karlsson & Tavassoli, 2016). Radical or breakthrough innovation is related to uncharted approaches and unconventional uses of available technology. Incremental innovation is often utilized to further develop a product with new features that can be integrated with ease which increases competitiveness within industries or markets (Şimşit et al, 2014, pp.691-692). Lastly, there are new technology systems which is a collection of radical innovations that are linked with new developed organizational structures (Wiśnicki et al., 2021, p.584).

Process innovation can be defined as the utilization of a new or enhanced delivery method or production that incorporates improved techniques, software, or equipment. It can be steered to optimize production or delivery costs and advance quality. There may often be some overlap between process innovations and organizational innovations and it may be difficult to distinguish those (Karlsson & Tavassoli, 2016, p.1485).

Organizational innovation is the adoption of new approaches in the organization's business operations, organization structure or external partnerships. Organizational innovation has the potential to augment performance by optimizing processes to reduce transaction and administration costs, improve productivity, elevate work satisfaction and increase accessibility to non-tradeable assets. This entails codifying tacit knowledge and forming best practices, knowledge databases and lessons learnt, skill development programs, and onboarding trainings. This indicates that organization innovation and efforts to renew and improve procedures, systems, and routines to enable better teamwork, coordination and collaboration, knowledge sharing, level of innovation, and learning are strongly correlated (Karlsson & Tavassoli, 2016, p.1486). According to Hannan and Freeman (1984), the complexity of an organization causes a greater change resistance which reduces the likelihood of establishing organizational innovation (Karlsson & Tavassoli, 2016, p.1486).

Extrapolating from the innovation types, there are two types of innovations in complex, one off products according to Katila et.al, (2018, p.307). Cruise ships are an example of one-off complex products. Complexity in this context refers to a large amount of components that forms a product and interact with each other in complicated ways such as through design rules or intricate product architectures. Based on Teece (1996), the two types of innovations are autonomous and systemic. Autonomous component innovations can be referred as a 'stand-alone' innovative component. It can be integrated to an established system without any change to the other components. For example, incandescent light bulbs and high efficiency lightbulbs that have the same sockets or design

and installation for infrared actuated or touchless toilets are the same for traditional manually controlled toilets (Katila et al., 2018, p.307).

Systemic component innovation however, requires considerable modification to different aspects of the system upon introduction. For instance, radiant floor heating systems, smart energy or building management systems. These require significant alteration to standards in the industry and institutional memory on how things are usually done. To illustrate, regular floor construction process is not applicable for radiant floor heating systems as it requires a considerable network of pipes below floors. This would then have an effect on adjacent components in the design process on the flooring choice. For example, carpeting may not be ideal, if wood is chosen then it has to be laminated, or ceramic tile that is the most practical selection. The sequence of construction activities is also altered (Katila et al., 2018, p.307). Recognizing these two different types of innovation in complex one-off products such as cruise ships is important as the process of development and implementation of the innovations may differ.

2.1.2 Innovation Management Approaches: Linear and Non-linear Approach

Joseph Schumpeter (1934) was the first to establish the concept of innovation in terms of the socio-economic system. It began with the term 'supply push' or 'technology push' where new ideas or new approach to doing things lead to a supply and a demand of its own will be created. The concept then developed linearly from idea to innovation through the process of basic science, technological development, manufacturing, marketing, and sales. This forms the first-generation innovation models. However, this concept does not take into account the possibility of incremental innovation that could be derived from customer or market-driven feedback. It also reduces the importance of the learning process and knowledge gathering that reduces the dynamism which is the focal point of the innovation process. The next linear approach and second-generation models is the 'demand pull' which accounts for the majority of incremental innovations. It starts with understanding market needs and expressing them in terms of ideas, followed by

development, manufacturing, and sales or diffusion. This model still does not take into account feedback loops and intricacies of institutional innovation which is seen as an incomplete understanding of the innovation system (Akintoye et al., 2012, pp.21-23).

This leads to non-linear concepts of innovation also known as innovation system. The third-generation models called the Coupling Model of Innovation incorporates feedback loops in the innovation process but it is still sequential. It highlights the integration of marketing and R&D and a well-known model is Cooper's Stage-Gate model. The model defines points or gates that separate the innovation process. The gates function as decision points and phase reviews at the end of each stage is done to assess the previous stage which established better quality in the process (du Preez & Louw, 2018, p.548). However, the third-generation models still have some weaknesses as it does not have a place for external knowledge resources generated from supply chain and network. Organizational learning, knowledge sharing, and external networking are dependent on the alignment of activities within the organization (Akintoye et al., 2012, pp.23-24).

The fourth-generation models supplement the third model with early supplier cooperation in the design and development stages of a new product and integrate parallel activities that are done by different departments within the organization. The parallel rather than sequential integration enables an increase in knowledge and information sharing across the departments. The fifth-generation models also known as the 'Network' model further builds on the fourth model by adding the dynamic aspect, importance of improvement, and continuous change. It focusses on innovation on the organization level by knowledge accumulation through networking with players and integrating systemic processes (Akintoye et al., 2012, p.25). It is considered a closed innovation system as ideas are still developed within an organization. The sixth-generation models are the latest model and they are open innovation models where new technologies are developed through internal and external ideas and avenues to market. The core idea of the ap-

proach is openness and collaboration (du Preez & Louw, 2018, p.551). The later innovation models address important gaps of the previous models and understanding the changes enable a more holistic view of innovation management process.

The definition of technology is often in terms of production processes where it is a system of interconnected skills, know-how, and knowledge encapsulated in product and processes. In reference to this, the linear approach to innovation does not offer sufficient insights to the innovation process or the possibility of innovation differences that exist in the organization, industries, or countries (Akintoye;Goulding;& Zawdie, 2012).

2.1.3 Technology Development Process (TDP)

Technology development may at times be referred to as front-end innovation or fuzzy front-end is a core aspect of innovation and gaining competitive advantage. The technology development process is an outlined process in cultivating new knowledge, skills and artefacts which aids platform development and guides development of products and processes. This process results in the production of technologies that are new, out of the norm and difficult to predict. This is typically in the beginning phase of the innovation management funnel or also known as the front-end innovation. Figure 1 displays the position of the technology development process. Unfortunately, only selected innovations can be actualized and in order to select the best innovations and next course of action, an organized technology development process is required (Aristodemou et al., 2019, p.4).

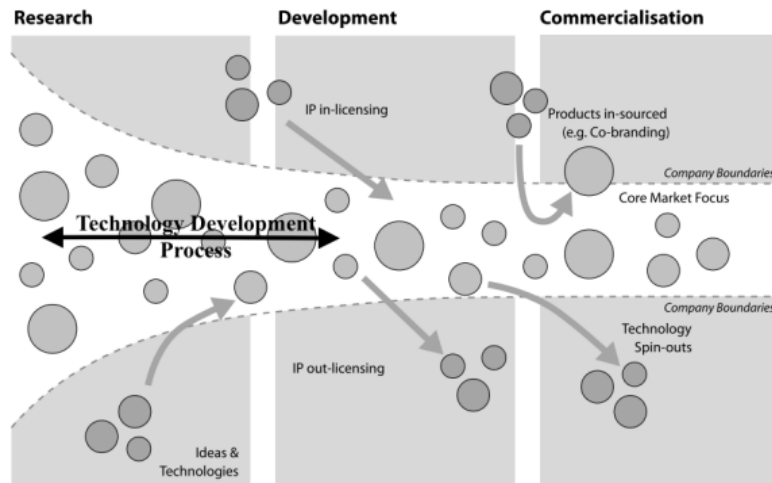


Figure 1. TDP and Innovation Management Funnel (Mortara, 2009b).

It has been argued that the technology development process is the intermediary between the transition from science to technology and from technology to application. The project is seen to have past the research stage and is in the embryonic phase where it is technology focused. The front-end innovation process begins when an opportunity is presented and is thought to have potential for ideation, exploration and assessment. It contains the stages from creation of ideas to the approval of said ideas for development and application stage (Aristodemou et al., 2019, p.4).

2.1.4 TDP Models

Literature over the years seem to be skewed toward new process development. Literature on technology development process models and their usages are limited. The models found in literature have a similar purpose which is to manage the technology development process and assist in the decision-making process in analyzing technology projects. Below are three examples of the technology development process models (Aristodemou et al., 2019, p.7).

Holistic Front-End model

This model organizes and controls activities that occurs before the new product development phase at the front end. The main purpose of the model is to grasp and link product, organizational, informational and operational strategy during the first phase of the development process. Similar to the previously mentioned processes, this model begins with concept development, market evaluation, opportunity discovery, technology assessment, and feasibility (Aristodemou et al., 2019, p.9).

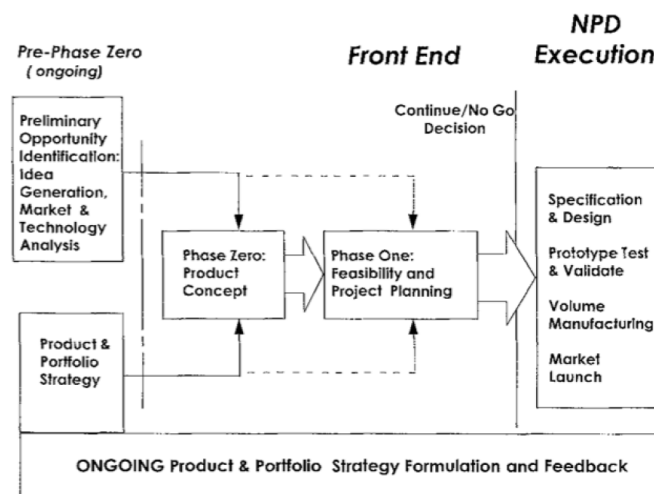


Figure 2. Front end model (Khurana & Rosenthal, 1998, p.59).

Technology Stage Gate (TechSG) model

This specific model is focused on the front end and controls technology development activities where risk and uncertainty are high. It depicts a comprehensive system which differs to the other models that only describes processes. The TechSG model aims to incorporate scientific and business accuracy in the technology discovery phase. It has six essential features which are 'project charter, technology state gate, technology development team, technology process owner, technology review committee, and technology structure planning' that are interlinked for a common goal. This model improves the decision making process with the help of the structured process but it can inhibit and slow down the idea generation process (Aristodemou et al., 2019).

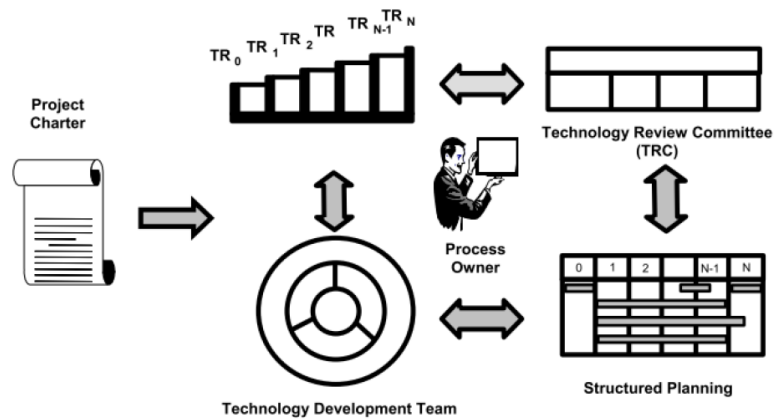


Figure 3. Technology Stage Gate (TechSG) model (Ajamian & Koen, 2002).

Technology Stage Gate (TSG) model

Cooper (2006b) points out that a separate process is needed for technology development project management as they are the basis for new prospects which he identifies as the technology development process. He suggested the technology state gate model to ensure that knowledge-build projects are properly managed. This TSG model contributes to the front end of the new product development process with three stages (project definition, technical evaluation, and in-depth analysis) as well as four gates (preliminary screening, technical review, in-depth analysis, and application process). The application gate (gate 4) is the most vital gate as the competitive leverage and the possible commercialization strategy of the technology application is established. It is also important as the gate merges the technology development process and the new product development process. Cooper adds that project strategic decisions should be done using customized selection criteria at the decision gates. Gatekeepers are to guard these and ensure that information is gathered at each stage via a range of qualitative methods and a comprehensive analysis is performed. This becomes a gate input. At the go/kill decision point, the project is accessed to be terminated or more investment should be allocated (Aristodemou et al., 2019, p.16).

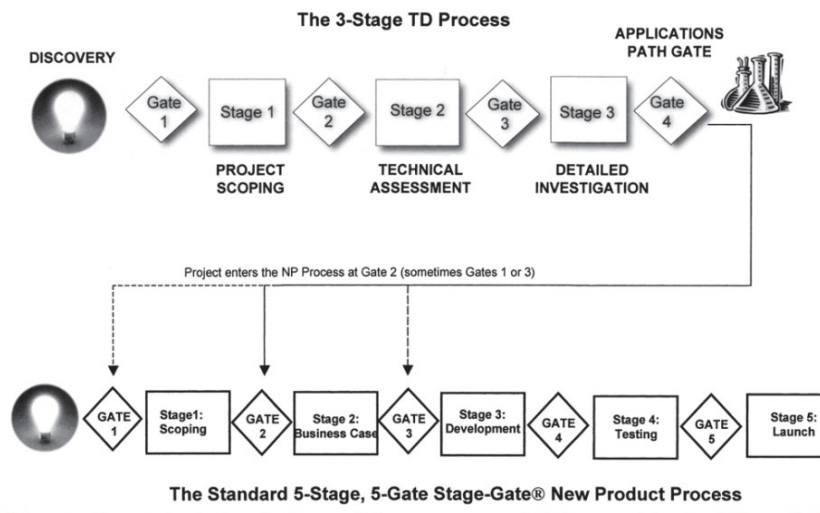


Figure 4. Technology stage gate process supplying the NPD process (Cooper, 2006, p.26).

2.1.5 New product development (NPD)

According to Burgelman et al. (2009), there is rarely a difference between product development and technology development processes. However, it has been argued that there are distinctive differences between the two, and literature to support this argument has grown. The conventional product development processes typically aim for the development of incremental projects which are usually low risk and decisions are made according to market analysis and financial return. Technology projects differ in this sense as it is usually has high uncertainty and high risk therefore the same criteria cannot be directly applied. Additionally, a separation is needed as the two processes have distinctive characteristics and they should be identified (Aristodemou et al., 2019, p.6).

According to Khurana & Rosenthal (1998, p.58), organizations that are categorized as successful have the following practices. A holistic front-end view is established with core teams and senior management. A systematic process-oriented working style is implemented to evaluate and match a broad spectrum of technical and organizational needs which includes business strategy, product selection, followed by product development. The formal processes together with the core team ensures that the product strategy fall

in line with the business strategy and resource allocation. A less formal alternative approach is through organizational culture where the core individuals are highly attuned to the business and product strategy. The degree of formality in the front-end process depends on how discontinuous or radical is the innovation, market dynamics, and the communication and interaction practice between the core team and senior management (Khurana & Rosenthal, 1998, p.58).

In a typical product development process, a concept is considered based on market and customer needs. If it is positively evaluated, concept is further developed while the technical feasibility is assessed, then the design process starts. However, minor changes may be required for this process to be applied to discontinuous products which is safely assumed to be technology push products. In such cases, a suitable market is pursued once there is a new technology to find a fit of the technology and a market potential. Once the match is successful, the process continuous as per normal. Since discontinuous products may be new to the world, determining product opportunities in the marketplace may require more effort (Veryzer, 1998, p.308).

2.1.6 Knowledge Management

Knowledge and know-how are essential elements to successful implementation of new technologies. Thus, processes of knowledge transfer and learning are essential in the technology development potential. Learning, knowledge and skills flow can take place through various ways. There is learning by doing, formalized R&D activities categorized as searching, replication, adoption, reverse engineering. Then there is collaboration and interaction with suppliers, customers, or other companies to obtain knowledge through upstream or downstream sources. Additionally, information on new technology and science discoveries or advancement is learning by absorption. Lastly, there is learning by inquiry from competitors or companies in the industry (Akintoye et al., 2012, p.102).

Learning is the process of incorporating knowledge in people whereas application and integration is the process of incorporating knowledge in products and processes. These processes are typically resource intensive and time consuming mainly because knowledge is to a certain extent, implicit. According to Stiglitz (1999), the way in which tacit knowledge is managed contributes significantly to the competitive performance of a company. However, codifying and fully converting tacit to explicit knowledge is not feasible as certain behavioral patterns and procedures are difficult to explicitly codify. He adds the importance of having a large extent of contextual knowledge for accurate gathering and merging of knowledge and technologies. The specific reservoir of tacit knowledge is difficult to acquire or transfer from a company to another. There is a learning period for any new technology to be accurately applied. This means that simply acquiring technologies and knowledge is not sufficient to gain competitive advantage, but the actual source is in the experience and knowledge especially investments in gaining a range of knowledge on the when, why, where and how to apply technologies. The different knowledge and skills set enables creation of new avenues and opportunities (Akintoye et al., 2012, p.103).

Technological regime or framework of innovation systems is a concept shaped by social factors that is distinct based on the industry. It is a system that consists of knowledge, experience, regulation, expectations, and assumptions shared with stakeholders that provides direction for innovation design and development. New and improved technologies are considered successful when they coincide with the predominant technology regime. The technology regime is also referred to in economic, political, and legal settings and is seen as a crucial framework to guide an appropriate innovation climate (Akintoye et al., 2012, p.103).

2.2 Engineer to Order Environment (ETO)

The ETO environment typically deals with products on a project basis that are designed, engineered and produced once the order from a customer is placed. The products are

inherently unique, highly complex, custom built and requires significant engineering expertise however the extent of the build can range between being based on existing solutions or designs that entirely original. The specification, product mix, volumes are determined by the customer which makes it challenging to forecast therefore the degree of unpredictability is higher in the ETO production environment (Iakymenko et al., 2020, p.4507). The complex production involves a number of actors, partners, suppliers, architectures that have high interdependencies (Arica et al., 2020). Customer requirements are often precise and regulatory standards as well as design codes can be stringent and must be followed (Abd. Rahman & Mohd. Shariff, 2003, p.184).

Time frames are usually long and specifications can be uncertain. In order to reduce delivery time, processes in design, engineering, purchasing and production are often overlapping. Therefore, engineering changes (EC) are managed differently in ETO environment compared to mass production and make-to-stock environment where ECs are batched and carried out before the next production is started unless it is safety concern which is then implemented immediately (Iakymenko et al., 2022, p.958). The production in ETO environment is discontinuous hence ECs cannot be deferred to the next production cycle. ECs need to be implemented promptly, and ECs implemented later in the stage can be more disruptive (Iakymenko et al., 2022).

2.3 Engineering change management (ECM)

Engineering change (EC) are iterations or change of a technical artefact that has been issued during the design phase. This includes, released structure, behavior, function, or the relation between these (Hamraz et al., 2013, p.475). According to Bucciarelli (1994), the design process hardly ever begins from square one instead, it is often an adaptation and refinement of existing designs. An original, novel, or creative design refers to the design of a product that begins with a clean slate which often requires extensive research, skill, creativity, and knowledge. An evolutionary design refers to a product design that is modified and stemmed from design that exists and this is usually prompted by ECs. That

being said, original designs could also be initiated by ECs in the product development stage as well as the product life cycle to modify and fit to developing requirements. Product development can be considered as an extended change management process therefore it is vital to analyze and fully comprehend changes (Hamraz et al, 2013, p.474).

2.3.1 Engineering Change Orders

EC's takes place due to the desire and at times necessity to develop and improve a product, meet new regulations or requirements, or rectify previous mistakes. EC's can be raised by several parties such as the company, customers, suppliers, market drivers: government regulations, and technological and market needs (Iakymenko et.al, 2022, p.958). However, primarily there are two kinds of ECs that occur. One is a fault or mistakes directly in the product, and the other is requested externally such as the customer. Often times, a change would cause a chain of events that would affect different departments in an organization that affect schedules and cost. ECM is the "organization, control, and execution of ECs". The main idea of ECM is to anticipate situations and reduce the amount of EC requests, efficiently implement ECs when they occur, and learn from them (Iakymenko et al., 2020, p.1).

According to Fricke et al. (2000), there are five goals related to ECM which are "less, earlier, more effective, more efficient, and better (Iakymenko at al., 2022, p.958). These goals often times are referred to as strategies as well. 'Less' refers minimizing the number of ECs. 'Earlier' refers to identifying and implementing changes early to reduce cost of implementation which is usually higher if a change is done later. 'Effective' refers to the accuracy in evaluating the necessity and possible benefits of ECs and changes are filtered if they are insignificant or not economical. 'Efficient' refers to utilizing resources as best as possible when implementing ECs. Lastly, 'Better' refers to learning through implemented ECs by reviewing and analyzing the accuracy of the impact estimation, investigating mistakes at every stage in the ECM process, and steps to circumvent errors of similar nature in the future (Iakymenko et al., 2020, p.4507).

There has been a couple proposed models for EC processing. The IDEF model is a five-step process which begins with “filter proposal, design investigation, appraise design, authorize change, and execute change” (Maull et al., 1992). Then a proposed model by Riviere et al. (2002) has three stages with specific steps within each stage. The stages are “EC proposal, EC investigation, and EC embodiment”. Lee et al. (2006) introduced a formal EC process with a four-stage model starting with raising an EC request, assess the request, disseminate the change order, and archive and examine for management needs (Hamraz et al., 2013, 476).

2.3.2 ECM Practices

Based on EC processing models in literature, the general consensus is that organizations should have a transparent and straightforward EC process including recommended steps to carry out ECs. The process should start with raising or requesting an EC with all relevant information. Followed by assessing all potential solutions and evaluating the cost and time impact of said solutions. The optimal solution for the situation can then be chosen and approved (Iakymenko et al., 2020, p.4508).

There are a few suggested strategies for implementing ECs. Change categorization often in monetary terms can be useful for decision making however there are two main strategies for effective EC implementation which are implementation based on urgency and based on batching. Regardless of which strategy is used, the last step in the EC process should be to evaluate and analyze the accuracy of initial estimations and lessons learnt should be documented and stored for future reference. Documentation and storage of EC information and its availability to all concerned is vital as a significant challenge in ensuring only the latest and most updated EC implementation document is available to all relevant departments has been noted in literature (Iakymenko et al., 2020, p.4508).

Integration and coordination between the different teams and having a representative from different fields such as sales, design, engineering, planning, production, as well as suppliers is imperative to efficient implementation of ECs. It has been indicated in literature that proper integration is more effective in reducing changes. The teams should have dedicated meetings to address and work on ECs (Iakymenko et al., 2020, p.4508).

However, the ideal EC implementation process is often not reflected in reality. Based on a study done by Iakymenko et al. (2020, p.4513), they found that the ECM process in ETO companies usually began with the project manager being notified of a change request and the project manager organizes the EC activities within the process. Once the EC is raised, an estimate is provided by the EC coordinator individually or with the help of a project team which may have representatives from different departments. The EC coordinator then sends an official change order request to the customer for approval which includes cost and delivery time changes that are estimated based on the project team's experience rather than a formal assessment. The assessment of all potential solutions are typically not done due to time constraint and straightforward solutions.

It was found that the companies do not hold separate meetings regarding ECs and often do not discuss ECs in status meetings at all but rather discussed informally via emails or one to one meetings. Once the change request has been approved by the customer, it is recorded and stored in the IT systems and the departments are notified. The study also found that the structured EC process was only applied to large ECs requested by customers. Internal errors in engineering or production that resulted in ECs were rectified directly by the relevant departments and were not recorded as a change order. This prevents the company from learning and preventing same mistakes in future. Improper documentations of ECs and locally stored files restricts accessibility. A few of the companies had utilized cloud solutions to archive EC assessments at the final phase once implemented but this prevents tracking and status updates (Iakymenko et al., 2020, p.4513).

2.3.3 ECM Tools

There are four different types of tools that support ECM: “computer-based support tools, change reduction and front-loading tools, design tools, and change propagation and impact assessment tools” (Iakymenko et al., 2020, p.4508). Computer-based tools are typically used to monitor and record modifications in all respects of the product life cycle, facilitate workflows, knowledge management on ECs to record and reuse, promote communication and collaboration within the company and externally, and virtually evaluate changes on products. These tools can be specifically built to support ECM systems, configuration management systems, Product Lifecycle Management (PLM), and Product Data Management (PDM) systems (Iakymenko et al., 2020, pp.4508).

Companies also utilize tools to reduce EC and front loading such as Quality Function Deployment (QFD) which helps interpret customer desires in engineering attributes or design specifications of a product and Failure Mode and Effect Analysis (FMEA) can reduce the amount of internal ECs by determining, prioritizing, and decreasing potential issues in a product if it is implemented early in the design process. The number of ECs can be reduced by product design tools such as Design for Manufacturing and Assembly (DfMA), design freeze, and Design for Changeability (DfC). DfMA can help to prevent design related changes that could occur later in the product lifecycle stages (Iakymenko et al., 2020, pp.4508-4509).

There are three fundamentals to changeability according to Fricke and Shultz (2005) which are independence, simplicity and modularity. The most common practice is modular design that has a web of modules with certain standard rules and there is freedom to customize or change designs within the module as long as the rules are followed and interface remains the same. The goals of DfC is to provide easy of changeability and implementation agility. Similarly, platform design enables changeability and can reduce the number of EC request from customers by adding specialized features once the platform is designed at the point the order is known (Iakymenko et al., 2020, pp.4509).

Design freeze is also a beneficial tool to reduce the number of ECs that are raised. A design freeze is a formal stop that is implemented in the design development where further changes are no longer allowed passed this point. The design freeze point may differ based on parts and system that require long lead times.

Referring to the study done by Iakymenko et al. (2020, p.4522) on ETO companies, DfMA was utilized by the case companies however they were unstructured and inconsistent. It was also found that none of the companies in the sample had utilized QFD, FMEA, or CPM. However, the companies utilized design freeze internally to decide on design drawings and proceed without further changes. Although change requests by the customer were still agreed upon in spite of the freeze point.

2.3.4 Factors Affecting Engineering Change Performance and Cost

Research has indicated that ECs in the ETO environment can often impact negatively on schedules and project cost. According to Love et al. (2017), once a construction contract has been agreed upon, changes can increase the project cost by approximately 24%. Not all ECs may be recorded therefore hidden losses may occur (Iakymenko et al., 2022, p.957).

There are several factors that affect EC performance. Based on a study done by Iakymenko et al. (2022, p.967), the most prominent factor that increases cost of EC is the time or phase when the EC takes place. The cost of EC rapidly increases as it goes through each stage of the product lifecycle as it requires more coordination between different people and functions to implement changes. The general consensus in ECM literature advises to front load ECs to earlier phases to prevent the high cost of implementing change. However this may be difficult to apply when it comes to customer initiated changes which are usually paid by the customer hence accurate assessment of EC cost is crucial. Unexpected costs that arises after the price has been agreed and paid by the customer is covered by the company that potentially reduces their profit margins (Iakymenko et al., 2022, p.967).

The next factor is maturity level of design or technology that may cause additional changes. Products and technologies designs that have low maturity with the combination of lack of skills, competence with the given design and EC implementation causes rework and added tasks. The lack of experience can negatively impact cost and time in ETO projects therefore learning from past mistakes in projects is essential. The study indicated that the cost of EC implementation was higher due to insufficient expertise, experience and autonomy in intricate ETO environment such as shipyards (Iakymenko et al., 2022, p.964).

The level of vertical integration in an ETO environment's supply chain is also a factor that can impact the cost of EC. Integration and coordination is easier and has lower cost when there is a strong alignment and coordination between engineering, design, and production functions. Changes are more difficult to implement when there are a large number of interfaces and handovers between actors. Additionally, EC implementation cost is higher when there is organizational structures and cultural differences between actors within a project where autonomy to implement and resolve ECs may differ. The hierarchical structures and power distance can increase the length and cost of the EC implementation process (Iakymenko et al., 2022, p.967).

The next factor that could increase the implementation cost of EC is the level of intersection between the phases in a project. The cost of implementation increases if an EC is raised when there are simultaneous activities occurring between design, engineering and production as there may be high data ambiguity. This may result in EC assessment according to individual knowledge and experience of those involved rather than basing it on concrete design and engineering data (Iakymenko et al., 2022, p.968).

The last factor mentioned in the study by Iakymenko et al. (2022, p.968) is the contractual specifications. The cost of ECs can differ significantly due to long negotiation processes on changes that have been initiated by customers as it usually involves legal advisors and may result in less than ideal solutions.

2.4 Strategies for new technology application

Based on Cooper's (2000) estimate, 46% of companies' resource investment in designing, developing and implementing new products are allocated to projects that may never be launched to market or experience market failure. According to Barczak et al., (2009) only 14% of initial concepts achieve commercial success. Therefore, strategies to advance RDIs from development to application and commercialization are essential (Leber et al., 2014, p.382).

2.4.1 Technology Roadmapping

The understanding and acknowledgement of technology evolution is vital when it comes to ensuring the sustainability of investments in the development of new products. Organizations that have a focus on long term potential rather than short term profitability is able to better allocate valuable R&D resources and the choices on the new product development holds greater significance for the organization's future growth. S-curve models associated with the technology life cycle is used to monitor the progress of technology over time based on the R&D investments. Since R&D investments are lower in the beginning phases, the performance of the technology is naturally slower. As time progresses and more effort is invested, performance accelerates significantly, but eventually the additional gains per unit of effort reaches a maximum point and start to decrease (Petrick & Echols, 2004, p.83).

Information on timing of developments, the necessary resources, and potential use of the technology in current and future product portfolio is vital to capitalize on technology developments. This can be achieved through technology roadmapping which have been adopted by several large international organizations. The roadmapping tool provides a structured approach to visually align market trend progressions, product development, and technology advancements. According to Phaal et al. (2005), the roadmap typically begins before the defining the project portfolio and serves as a crucial step in executing the strategic planning for the project portfolio (Alcantara & Martens, 2019, p.128). Information is collected through various sources to develop a versatile and adaptable short, medium, and long term product and process developments as well as R&D investments in an organization. The structure aligns information from all levels and upholds strategic plans and actionable steps (Petrick & Echols, 2004, p.89).

There can be many different roadmap formats according to a study done by Phaal et al. but there are commonalities between them. Typically, technology roadmapping has two interconnected cycles. One is focused on technology and the other is focused on market trends. Both cycles are influenced by the competitive forces within the industry. There are a few aspects that make up a roadmap. First is to determine the technologies that are fundamental to current and projected products. Next is to draw attention to anticipated technology developments that have been recognized and the resources required which includes underlying R&D investments to bring the new product to fruition (Petrick & Echols, 2004, p.90).

Launching a new product based on architectural innovations means that the newcomer must integrate both current technical expertise and fresh market insights. Based on the organization's accumulated knowledge over time, it is expected that the organization will follow a certain S-curve pattern. The technology development evolution follows forecasted lines and the course of the S-curve acts as a frame of reference. With an organization's IT capabilities, the knowledge base can be broadened by exploring new markets

and integrating new systems based on technical expertise. This results in knowledge expansion and creation of additional value. Cross organizational communication is key here (Petrick & Echols, 2004, p.91).

According to Petrick & Echols (2004, p.91), organizations that have an outward approach can build new supplier/buyer relationships which then forms synergy opportunities that has mutual benefits and potential technology disruptions. Additionally, it can put the organization's vision into action. This approach can significantly improve the time to market for the general supply chain. When there is high technology and market ambiguity, agile supply chains are vital as it reduces the need for a single organization to have all the knowledge and absorb all risks with the new technology. The supply chain network contributes to the knowledge pool and provides the opportunity to share risk among the members (Petrick & Echols, 2004, p.91).

When it comes to radical innovations, it creates new products with new technology progressions. In line with the discussion that all organizations are following the S-curve trajectory of a product, organizations that did not create the radical innovation would be stuck with at least one product that falls under the S-curve that is no longer in use or out-of-date. Some organizations may not be motivated to pursue innovations and some might even have incentives to prevent radical innovations from taking place especially when radical innovations are usually not initiated by mature organizations. Radical innovators are usually flying under the radar therefore technology roadmapping throughout the supply network is crucial especially for established organizations (Petrick & Echols, 2004, p.85).

There have been several different methods to approach the supply chain management but there is one strategy that has been widely adopted which is outsourcing. It connects the resource strength and competence within the network which increases the capacity of a single organization. Naturally, the suppliers would be a new resource for emerging

technologies and the development of said technologies would increasingly be conducted by the supplier instead of the assembler or integrator (Petrick & Echols, 2004, p.91).

2.4.2 Productization

ETO companies offer customization or customer-specific products to cater to customer needs which increases customer value. For certain markets, it is a competitive advantage however for others, it is a crucial element for sustaining operations and remaining in business. Customization to meet customer demands could lead to a large amount of individual product designs which affects production and delivery projections which typically should be determined at the contract negotiation stage. It essentially causes unreliable product delivery. With a wide range of product variety, profitability may differ from one product variety to another and as the product variety keeps growing, the general product portfolio profitability decreases, or it may even make some losses. Cost reductions are needed as a result of price competition therefore standardization and reuse of designs could be a good option. A reliable view of available products in the company is needed and this can be achieved through productization. Productization is a process that involves activities that transforms offerings from abstract to more concrete to increase understanding of products for both employees and customers. It includes the product's technical and commercial aspects which increases efficiency to produce (Mustonen & Harkonen, 2024, p.1271).

In the ETO environment, products and the delivery of the order are typically considered as separate NPD projects that have their own teams which causes an issue with productization. Hence, a customized product can be deemed as a 'prototype'. That being said, ETO companies can benefit from standardization and automatization of certain processes. One aspect of the order-delivery process that can be standardized is product design. To facilitate design reuse, an exhaustive understanding of the product offerings is required and this can be achieved through the productizing of said offerings with dependable and standardized product structure (Mustonen & Harkonen, 2024, p.1273).

A general product structure would contain all variations and configurations of the product in a specific structure. In simple words, a general framework of all the possible variations of a product should be established for each product. The product features should be treated as commercial sales offerings. This creates a basic version of a product that would be used as the starting point for sales and engineering. The structure also prevents the need to create individual structures for every product variation thus preventing a multitude of product variants. The systematic product structure promotes better unity between different function in terms of product realization as they may have different views and usages of product structures (Mustonen & Harkonen, 2024, p.1273).

The master structure is derived from product design which provides a foundation for product structure creation for different functions. There are two parts of the product structure, the upper (commercial structure) and lower (technical structure) part. The commercial structure covers the essentials needed for product customization based on the customer order and this is considered by the sales function. Whereas, the manufacturing function takes into regard the technical structure that contains the necessary elements for product manufacturing (Mustonen & Harkonen, 2024, p.1273).

It is necessary to have a clear link and alignment between the two parts, sales and technical viewpoints. Each feature or product for sale should have a corresponding version within the technical structure. This allows any add on feature to be evaluated separately which would facilitate the product feature development and production. It also enables cost calculations and price setting for the various features. Through this framework, a consistent understanding among different business functions and stakeholders on offered products can be established and maintained. Naturally, a standardized product structure could supply valuable data through the company's IT and business tools such as Enterprise Resource Planning (ERP) and Customer Relationship Management (CRM). However, in situations where new design is required, the general product structure may

not be suitable as it presumes that all feasible customizable features have been determined (Mustonen & Harkonen, 2024, p.1277).

Brière-Côté et al., (2010) suggests a framework for design reuse where it begins with selecting a product's shared features and reusing modified features which is then followed by customer requested features that are newly designed and supplied to the structure. This framework aims to improve cost and lead time estimations of new products as it is based on cost and lead time on existing products from previous deliveries. However, the proposed framework has limitations. It does not take into consideration the complexity, risk or different types of changes in product design. An appropriate and systematic process can be implemented to address these change requests prior to product development. It is important to consider and determine if the new product or design is solely for the single customer or aimed to be added to the company's product portfolio (Mustonen & Harkonen, 2024, p.1273).

One of the main challenges of customization is that it leads to a wide number of variants of a product. Previous designs may not be useable which reduces overall efficiency. Ideally when new orders are received, similar previous order designs are reviewed to implement it to the new order. But this leads to an increase in single variant structures which are difficult to manage separately, and it is also a data management issue. Typically, the designer's expertise and know-how on the previous designs determines the success of the design reuse. Additionally, there is challenge is translating customer needs into specifications during the sales phase and effectively communicating to other functions within the company. The lack of standardization and clear rules on parts that can and cannot be modified creates a knowledge gap between customer and designer interactions which causes inefficient use of time (Mustonen & Harkonen, 2024, p.1272).

According to Mustonen & Harkonen (2024, p.1277), the ETO business goal should shift from pure project thinking to recognizing the significance of maintaining control over

products. Productization is one option to exercise this control. They proposed that product development can be organized by establishing clear process definitions for the various product design modifications. Upon receiving a customer request, a preliminary analysis and decision-making needs to be done to determine if the new design ought to be added to the product portfolio as a standard offering or it will just be a customer specific design. In this analysis, considerations for the technical and strategic possibilities, market and financial aspects of the new design should be done. The product portfolio should be in line with the company's long-term strategic fit as well (Mustonen & Harkonen, 2024, p.1278).

In the case companies that were studied by Mustonen & Harkonen (2024, p.1278), the evaluations of new requests were done using scorecards with a range of evaluation criteria that varies depending on the request which includes customer categories, technical risk, net present value, market growth, strategic advantage, and employee skillset. The analysis should indicate if the standard offering or previous designs can satisfy the customer request or if a new design is needed (Mustonen & Harkonen, 2024, p.1278).

If new technology development or important changes are needed, it has been suggested that a large-scale NPD process can be implemented. In practice, this creates new products in the commercial portfolio and new product architecture and framework in the technical portfolio. In these situations where a new technical design is developed due to a customer order, the design should have a corresponding sales item. Once delivery is completed, actual costs are determined and evaluations on whether the design is added to the standard or customer specific offering is conducted which is beneficial for future requests. Taking into account productized offerings both commercially and technically may increase the product development efficiency, cost and lead time estimations, and profitability calculations which overall optimizes the offering process (Mustonen & Harkonen, 2024, p.1279).

2.4.3 New Technology Assessment

Based on Cooper (1984) NPD process, management should conduct a market and technical evaluation and assess existing technologies using a few criteria. NPD managers have the responsibility to select which NPD projects and when it would be best to invest based on the allocated budget (Cho & Lee, 2013, p.5325-5326). The goal of a project in innovation literature is referred to as the Ideal Final Result (IFR) where the outcome is delivered in the best way under certain limitations. When a technology is at an early TRL level, it is often difficult to foresee the IFR options that exist and expected to succeed which makes the development process complex. Therefore, a demonstrative instrument is required to aid in the identification process of the most viable solutions for proper resource allocation to achieve the IFR (Kralisch et al., 2018, p.2376).

In reality, there is often a need to halt projects that are in development and realign development and redistribute resources. Especially R&D in industrial environments typically have a higher priority on concrete results and readiness to redistribute resources and mitigate risks. The state-and-gate method is an approach that is often used to control the progress of projects to reach its targets. The well-known stage-and-gate method has shown to be useful for evaluating a few criteria as it was designed. However, a wider range of criteria requirements is needed to be incorporated in the gate decisions such as environmental, social, and life-cycle impacts. The decision-making process has become more complex and there is uncertainty and lack of understanding in the general process (Kralisch et al., 2018, p.2376).

Multi-criteria decision analysis (MCDA) contains multiple criteria and multiple choices of possible solutions to help with complex decision making where a complex decision is dissected into a number of straightforward and understandable decisions displayed in a clear and orderly sequence. Subjectivity is important in decision making and MCDA provides a means to make subjectivity explicit and record them for future audits and reevaluation of mistakes that may occur in the process. This makes it a beneficial tool in the stage gate process especially for group decision making as it increases the transparency

and understanding on the decision reasons to proceed or terminate ideas (Kralisch et al., 2018, p.2376).

The optimal solution is determined by comparing against the IFR in the stage-and-gate process. The IFT in this case would be a hypothetical alternative that is created based on the criteria set in each stage. If the idea measures up well compared to the alternative then the idea proceeds to the next stage and the ideas that do not meet the minimum benchmark would be terminated which frees up resources to be redistributed (Kralisch et al., 2018, p.2376).

A similar criteria approach can be used to assess sustainability. Sustainability assessment during the design phase is often a challenge due to limited data and inadequate compatibility between experimental data and on an industrial level. They are difficult to quantify. A repetitive approach, wide range of green metrics, and filling in the missing data regarding energy demand later in the process with the assistance of simulation tools can be used to overcome this challenge. There are several MCDA methods but the most common are Analytic Hierarchy Process (AHP) and PROMETHEE to help in sustainability assessments. At times, scorecards are utilized as well though it is not directly categorized as a MCDA technique (Kralisch et al., 2018, p.2376).

AHP is one of the more popular approaches due to its simplicity. According to Saaty (1986), AHP is a systematic method used to assess and break down complex decisions through pairwise comparisons of various projects and factors or criteria. The main advantage of this method is the ability to structure complex problem hierarchically whether it involves more than one person, various attributes, and over a different periods of time. Therefore, it is a widely used method for various fields that require allocating resources, prioritization, and decision making when there are alternatives. This method provides an objective estimation on the consistency of the decisions made (Cho & Lee, 2013). However, Kralisch et al. (2018, p.2376) argues that AHP has its weaknesses espe-

cially in maintaining consistency due to the considerable amount of pairwise comparisons that reduces the efficacy when simpler problems are concerned. Though the assessment criteria cannot be generalized and is project dependent, a range of criteria that includes technology performance in terms ‘functionality, economic sustainability, social and environmental impacts’ should be implemented (Kralisch et al., 2018, p.2377).

Kralisch et al. (2018, p.2382) proposed an ‘updated Funnel Theory’, a systemic approach to guide innovation projects to the IFT which may be commercial viability or some measure of successful outcomes. The framework was developed through a collaboration of scientific expertise by the authors and consultation of a wide variety of companies from different sectors, regulators, NGOs, and academia. The framework consists of “defining a goal and scope, stages, gates, criteria, indicators, measure via MCDA, and visual management methods” (Kralisch et al., 2018, p.2382).

The framework provides a constant and practical approach by an expansion of stage-and-gate through the introduction of Life Cycle Thinking (LCT) and Sustainability Assessment. In the development process, distinct criteria that includes all elements operational efficiency, and sustainability (economic, social and environmental) should be established at the respective gates. Life Cycle Assessment (LCA) and Social Life Cycle Assessment (S-LCA) should also be included in the selection process (Kralisch et al., 2018, p.2382).

2.4.4 Change management

Innovation can be considered as a comprehensive effect of processes that involve the interaction between players, impact on the change trajectory, and the rate of realization. The fundamentals at the core of the innovation process is the continuous development of organization and management frameworks that influences decision making on both small and large scales. To ensure the sustainability of innovation, change is imperative as system transform in an orchestrated and structured way. Change management and ‘reengineering business processes’ can be synonymous (Akintoye et al., 2012, pp.19-32).

According to Van de Ven (1986), given free rein, people and organizations would typically gravitate towards existing practices compared to undertaking tasks that are seemingly risk such as cultivating new ideas. It is a challenge to activate people to take action and focus on new ideas, opportunities, and requirements especially when it is in a well-established organization that has been operating with little or no issues. Changes rarely occur when there are no incentives to change and this is where management plays a role to create incentives that encourages people to foster and accept changes. Winch (1998) stresses the importance of managing the relationship between individual parts and the whole in the innovation process. Dividing efforts into isolated tasks without connecting them can be harmful to innovation. For an innovation to be successful, different functions, resources and skills need to come together in a coordinated way to create synergy (Akintoye et al., 2012, p.32).

Reengineering of processes and organizational structures may need to be redesigned for innovation culture to be successfully implemented. The organizational structure should be flexible which would increase the interaction across the organization irrespective of hierarchy or departments and enable knowledge sharing, increased transparency and collaborative decision making, and promote constructive discussions on shifting to the culture of change. Responsive management towards change would help individuals to transition and be involved in the change process with the right support from the organization in terms of training and education that would enable them to be more responsive to change (Akintoye et al., 2012, p.33).

Kettinger and Grover (1995) states that the efficacy of change implementation within an organization would increase when aspects such as strategic action, cultural readiness, learning and knowledge sharing ability, IT flexibility, and a balanced network relationship are focused on in a structured system. This would improve the process efficiency, product quality, work-life quality, and ultimately enhance business performance. This creates

a change-responsive management system that can be agile through organizational learning via performance feedback and when encountering new ideas and challenges (Akintoye et al., 2012, pp.33-34).

Strategic initiatives is the starting point for change and it is vital for top management to form visions, missions and strategic plans to support the transition and culture change. However, the realization of the change and efficacy of the implementation depends highly on the unification of interest across the organization. To create this unification, the management has to cultivate a culture of transparency and clear communication for the change to be implemented as little resistance as possible. Change agents play an important role here to ensure that there is awareness and understanding of the change and that the change is successfully implemented across the organization (Akintoye et al., 2012, p.34).

The organization culture includes the organization's ability of knowledge sharing which is vital for organizational learning. An organization that has a high hierarchical and fragmented structure limits the exchange of knowledge. Knowledge sharing occurs most under a change-responsive and forward-thinking management that combines different perspectives, resources, and methods in problem solving as well as promoting transparency and trust for collaboration (Akintoye et al., 2012, p.34).

According to Cranny et al. (1992), the realm of change management includes the process management with the goal of improving the quality and efficiency of the process simultaneously enhancing work-life quality. This would naturally boost the customer interest in the products and services. Process improvements frequently result from change that are incremental and radical. Incremental improvements usually provide an opportunity to learn from experiences that results in a better product with minimal changes to the processes. Radical changes are typically discontinuous and results to brand new products and processes which involves a shift in perspective. It is vital for an organization to de-

termine the change management strategy taking into consideration the impact of customer-driven pull and innovation-driven push as well as radical and incremental changes. This has significance to learning and the expansion of learning ability which has an influence on innovation (Akintoye et al., 2012, pp.35-36).

To summarize, a holistic understanding of the different types of innovation, TDP models, and NPD enables effective management of the innovation process and enables the implementation of the most suitable TDP model based on the environment. The products produced in the ETO environment are typically complex, highly unpredictable, and the duration of the productions are long (Iakymenko et al., 2020). Since the projects are long, ECs are inevitable. Therefore, understanding the goals of ECM and the factors that affect the performance of ECs are essential. With this in mind, technology roadmapping, new technology assessment, productization, and change management are relevant strategies to advance RDI technologies to application.

3 Methods

This chapter describes the methods used to answer the research questions and objectives defined in the study. The research approach, methods for data collection and data analysis are indicated.

3.1 Research Approach

The study's aim is to investigate the what, how, and why of a specific problem. To achieve this, a case study research method was utilized. Bill Gillham (2000, p.1) defines a case study as a method that investigates a case which can be an individual, group, institution, community to address defined research questions through a range of evidence seeking to best answer the research questions (Gillham, 2000, p.1). According to Yin (2003), there are three types of case study which are explanatory, exploratory, and descriptive (Ogden-Barnes et al., 2015, p.71). This study describes the current practices in the organization, explores reasons for decisions, and provide theories and approaches that could be useful.

The idea for the thesis was formed after taking part in workshops, multiple discussions with different people in the organization and accessing existing documents in the organization. After which, an extensive review of literature was done to gather ideas and identify theories. Hence the study took more of an inductive approach where theories are developed on the basis of the data intended to be explored which is then compared to literature (Saunders, 2007, p.57). The research questions and objectives were then formed. The company needed research on a specific problem therefore a case study was most suitable.

Considering the specifics of the study, a qualitative method was selected to be used as it enables exploration in situations where knowledge is scarce. It allows exploration of the informal reality of what really happens which was important as the research questions

were focused on understanding the processes within the organization (Gillham, 2000). Since there were many uncertainties with the structures in the organization, industry specific practices and terminologies, a semi structured interview approach was utilized to allow for any tangents and clarification.

3.2 Data Collection and Analysis

Through the preliminary discussions with the company representative, the target group which is the Basic Design was selected. Head of groups, key decision makers and individuals with knowledge expertise on the subject matter were selected and interviewed. During the interviews, individuals who may have more knowledge were recommended therefore additional interviews were organized. There were nine interviews conducted. Two project managers, one head of department, one head of group, one sales manager, two project engineers, one human resource specialist, and one energy efficiency specialist.

Table 1. Interview overview: participants, role, interview mode and duration.

Employee	Role	Interview Mode	Duration (min) of interview
1	Head of Department	Microsoft Teams	53:52
2	Sales Manager	In-person	46:34
3	Project Manager	In-person	29:19
4	Project Manager	Microsoft Teams	39:42
5	Project Engineer	Microsoft Teams	32:06
6	Project Engineer	In-person	31:58
7	Head of Group	Microsoft Teams	27:11
8	Energy Efficiency Specialist	Microsoft Teams	29:12
9	Human Resource Specialist	Microsoft Teams	35:26

The interview questions consist of open-ended questions that were derived from various literature that related to the key themes of the research questions. The interviews were conducted individually via Microsoft Teams and in person, and it lasted between 30 minutes to 1 hour. The sessions were recorded using the Microsoft Teams application for the online interviews and a voice recorder for the in-person interviews. The interviews were then transcribed using the Microsoft Word web transcription tool.

Through the preliminary analysis, it was found that a formal process for RDI implementation in the organization either through sales or ECM had not yet been established. Additionally, documentation of the general sales and ECM process for a new idea appeared to be limited. The interview transcriptions were analyzed and organized into themes. The general sales and ECM process were then charted, and core issues were identified. Based on this, the possible future processes were recommended and strategies to address the core issues according to literature were suggested.

3.3 Trustworthiness of Study

The validity and reliability in qualitative research refer to the generalizability of the study's outcome. The study is a qualitative case study on one company therefore the generalizability of the result may be limited. However, Patton (2001) states that the use of triangulation can be a strategy in qualitative research to improve the validity and reliability and increase trustworthiness. Triangulation can enhance the study by combining various data sources to address constructivism which perceives that circumstances changes the view of reality and there may be many versions of reality therefore multiple sources to collect data should be applied (Golafshani, 2003, p.603). This measure was applied in the study. The data collected were from various individuals in different positions with different levels of experience. The interview questions were mostly open-ended questions that allowed the individuals to provide perspectives that could enhance the study. Additionally, the interviews were recorded. The study also utilizes different

data sources such as the interviews and documentations on the Technology Radar project.

3.4 Case Company

The case study is centered on Meyer Turku Oy, a Finnish shipbuilding company based at the Turku shipyard, which is world renowned and has a 15% market share in the global cruise ship construction. Meyer Turku is a pioneer in modern shipbuilding, and it is recognized for constructing cruise ships, special vessels, and passenger ferries that are complex with innovative and technologically advanced solutions. The shipyard joined Meyer Group that includes Meyer Werft in Papenburg, Germany, and Rostock shipyard, Neptun Werft (Meyer Turku Oy, 2024).

Meyer Turku is renowned for sustainable shipbuilding and was one of the first shipyard in the world to certify quality, safety and environmental systems. In every new ship that is ordered and delivered, it helps accelerate the technological development and sustainability of the Finnish maritime industry. With the aim of developing sustainability in shipbuilding and maritime industries, the organization is involved in both national and international projects with various research and educational institutes as well as partners in the Finnish maritime cluster. On a more economic level, the shipbuilding projects are extremely significant for Finland that can significantly impact employment and the economy (Meyer Turku Oy, 2024). A single delivery of a ship can have a value of approximately two percent of Finland's yearly export (United States Securities and Exchange Commission, 2023; The Observatory of Economic Complexity (OEC), 2022).

Necoleap is Meyer Turku's research and development green transition project that gathers industry leaders, universities and research institutes that creates an ecosystem with the aim to develop sustainable technology solutions on a global level to build a climate-neutral cruise ship. The project partly funded by Business Finland. One of the main goals is to move the shipyard business toward green transition and respond to climate change

demands together with the ecosystem partners. The new solutions and ways of operating is vital for Meyer Turku to stay competitive in the maritime cluster and start receiving climate neutral ship orders in the near future (Necoleap, na). Meyer Group has recently presented the Avatar cruise ship concept with the goal of developing a climate-neutral cruise ship by 2025 and building the ship by 2030 (Smith, 2024).

There are over 30 research and development projects under Necoleap that are focused on four key areas that are the ship itself, shipbuilding, smart technologies, and future drivers. With Meyer Turku's position in the maritime industry and the partnership network, this program would allow Meyer Turku to address the energy, climate and digitalization challenges in the sector. The desired result of the project would be a direction of the long-term environmental responsibility actions in the industry (Necoleap, na).

This thesis is funded by Necoleap and falls under the Avatar project. More specifically, the thesis is directly related to the Technology Radar project which is a comprehensive RDI technology strategy for the future. The technology development is separated into three different streams which are hotel, machinery, and shipbuilding but they intersect and collaborate to form the product which the ship. The goal of the project is to actively scan and forecast emerging technologies that could be related to the industry, access when the technologies could be applicable, and identify new developments that could be implemented.

The study is focused on two decision windows in a ship project. One is the pre-contract and contract stage where new RDI technology applications are discussed between sales and the customer. The duration of the project depending on the size and complexity from order to delivery can be between 36 to 48 months after the contract is signed. The other window that the study investigates is the basic and detail design and beginning phases of the production and commissioning stage. New RDI technology applications in this window are done through engineering change orders.

4 Results

This chapter presents the results and discussion on suggested strategies in line with both research questions in the study: *'How does the current processes in Meyer Turku handle the transition of technologies from RDI to application?'* and *'What strategies can be implemented to improve the efficiency of advancing the technologies from RDI to application?'* First the key themes from the analysis are presented in the following order: sales process, challenges in sales processes, ECM process, challenges in ECM process, RDI efforts, change readiness and resistance, knowledge management, and ideal future process. Followed by the current processes in the organization and suggested strategies for RDI implementation.

4.1 Key Themes

In the preliminary analysis, it was discovered that a process for transitioning RDI technologies from development to application had not been established yet in the organization. The documentation for the general sales and ECM process that could be used as a basis for RDI implementation appeared to be limited as well. Therefore, the general sales and ECM practices and challenges were investigated. The interview transcriptions were analyzed and organized into themes as seen in this section. It is presented in a manner that ensures anonymity of the people interviewed. Based on these present-day themes, the current sales and ECM process were charted and suggestions for RDI implementation were provided in section 4.2.

The organization refers to ECM as the agreement of modification (AOM). Thus, ECM will be referred to as AOM when describing the organization's processes. Additionally, the customer is the ship owner and can be referred to as the 'owner' in the processes.

4.1.1 Sales Process

The sales process can be considered as a project that covers all the activities before the ship contract is signed. When there is a new idea whether from the company or from the customer, it is under the sales responsibility to implement the specification in the general agreement (GA) and make the cost calculations and comparisons. They try to offer the best and newest technology as much as possible but since the sales phase is several years before the actual building phase, the new technologies that may not be available at that specific point in time but may be available in the near future need to be taken into consideration when defining the specification document for the ship projects.

The majority of the sales process usually begins with the owner contacting the company representative when they have some ideas. Some customers have a more reformed idea of what they want and what they are targeting for their future vessels, but the details may not be clear. There are others who have a clear picture of what they want and have the specifications written. In the latter case, it is difficult to suggest a new technology to the customer. According to interviewee B, it is much easier to suggest new technologies to customers who have a general idea of what they want, and it is usually a joint project with the customer if it is a new type of technology. Interviewee G mentioned that there is some reluctance at times on the organization's end to take on the whole risk of a new equipment if the technologies are developed by suppliers. Depending on the customer, the development of the technology is a joint effort. Cost and sustainability are usually the main factors. Since sustainability related technologies may increase cost, it is usually stipulated before contact is signed that there is a specified amount of funds reserved for development purposes.

On the customer's end, typically there is a new team which may have an R&D department who are searching for new solutions and ideas. Once a potential idea is identified, the customer reaches out to the company representative to consider. The representative consults the system responsible engineers in the company however, a few of the interviewees mentioned that this process is not very clear. The system responsible are

supposed to be up to date regarding their specific system and technologies that are under their ownership as they are in communication with suppliers. They evaluate the ideas to see if they are feasible and if there are technologies to support the ideas. The system engineers might be able to provide additional new ideas as well. Options on different technologies are discussed here as much as possible.

In principle, sales handles the majority of the development of the concept up to certain maturity with occasionally support from basic design. After which basic design gets more involved. However in reality, the concepts are developed without the input from basic design. Interviewee B mentioned that they are based on previous vessels statistics and ideas from designer or specification on them but without direct input from basic design. If they have more than one technology to offer or suggest to a customer, they are presented to the customer and investigations are done.

Big or significantly new technologies are usually implemented in the sales phase because once the contract is signed, the implementation becomes more complicated. Therefore, it is strongly encouraged to bring new ideas over to sales before the contract is signed. There is a contract for every vessel. Sister vessels depend on the customer, and they may contain minor changes therefore it usually falls under project management and any changes are executed through the change order which may also be referred to as the Agreement of Modification (AOM) process. Sales is not really involved in the contract signing in this case. This is because the documentation refers to the specifications of previous vessel and previous GA.

For a modified repeat of a vessel, there is more freedom to change, but a new contract is required. If new technologies are to be implemented, then there is a sales phase that needs to be worked on before the contract is signed especially when a series of vessels are concerned. Typically, contracts are usually done for one vessel but there might be option vessels so the company knows the customer's intention and can start to develop the next vessels. The individual vessels have their own ship contact and specification.

4.1.2 Sales Process Challenges

A few of the interviewees mentioned that there is a lack of formal process for bringing new or RDI technologies to ship projects. One of the challenges mentioned was that the company appears to rely on existing solutions and ways of working. When there is a new customer with a request of a product from scratch, existing designs and technologies are often used. Compared to other similar companies, new concepts are developed and ready to be offered when the opportunity presents itself. The system responsible is supposed to be up to date with the technologies under their ownership but the reality is that there is a lack of resources. The priority is focused on the current project in construction and existing technologies.

All interviewees mentioned that the company has not engaged in commercializing its offerings yet. According to interviewee B, they lack a catalog or list of new technologies and products to offer a new customer. The company usually has to wait for the customer to make a request and be reactive. The communication between sales, basic design and project management could be improved regarding new technologies. The teams have different priorities at times. The project management needs to deliver the vessel therefore they are more focused on things that are in the present time.

It was mentioned by interviewee A that it may not be the company's strong suit to be selling products and ideas that they are convinced of. The customer usually has too much freedom and power to decide. Without a proper process to get an idea to product, there may be revolutionary ideas that do not get implemented as it is often up to the system engineer to see the idea and get it implemented when selling and presenting may not be their strong suit.

4.1.3 ECM Process

The AOM starts as a change request from the customer with all the relevant information on the change. According to interviewee C, the modification manager identifies who is the main responsible within the company. A quick study is done to check the feasibility of it. A team is then formed depending on the change requested and the change is studied in more detail and cost calculations in terms of hours and materials are conducted. A new document with the updated ship specification is prepared with a deadline taking into consideration the schedule affect. Then, a go-or-no-go decision is made. Based on the practices, it is better for the customer to open the change request even if the change is regarding a joint development or the company is proposing the change.

Communication and sharing of information on change orders are done through an internal tool called Meyer Bridge. Interviewee E mentioned that changes done in the early phases have a lesser impact on cost and if it is done in the later stages, the cost will rise significantly and there are teams that are constantly negotiating on costs. Depending on the change, the company would have to check them with turnkey suppliers and area builder who will provide the offer.

4.1.4 ECM Process Challenges

Interviewee A, B, C, and E shared the same view that the process for change orders may seem convenient but in reality, it creates a lot of problems from a design point of view. Based on interviewee G, it is quite improbable that the company suggests new technologies through a change order after the contract is signed unless it can provide a significant benefit. The change requests are almost always coming from the owner.

Interviewee C mentioned that change requests to implement new technologies or features are often coming at a late stage which can be very expensive and increases the

investment costs. Therefore, the company should be more proactive and be early enough to propose new things.

Another main challenge mentioned by the majority of the interviewees is the high volume of change orders for a project which takes up a significant amount of time. In some cases, the modification request is vague and unclear which requires meetings between the customer and technical team to clarify the details which can cause delays. There may be mistranslations on what is desired on the business end and what might be feasible on the engineering end. Interviewee H mentioned that purely technical improvements are typically easier to implement as decisions are usually made based on what it is, cost estimate and return on investment.

At times, the customer may benefit from additional guidance to make the right choices to prevent additional work in identifying alternative solutions or materials. Discussions are occurring with turnkey suppliers about costs and materials. The company is the link between the owner, architect, and turnkey suppliers. Turnkey supplier resources can be a challenge as the company relies on them for calculations and offers.

4.1.5 RDI Efforts

Interviewee B mentioned that the RDI efforts have been missing for some years and they are lacking information. Although there are RDI efforts now which is good, it seems slightly late and it may still take some time for the results to be useable. Many of the technologies that are being discussed under RDI are not fit for the next 5 to 6 years as Necoleap for basic research and the technologies do not have a sufficient TRL for direct implementation.

A number of the interviewees mentioned that the visibility and communication of the status of the RDI technologies can be improved, and it is difficult to know what is being investigated and when the technology is ready for sales to use as part of the discussions

with customers. With better visibility, it allows sales to provide valuable feedback from the customer to help focus priorities and start relevant investigations. Interviewee A also mentioned that system responsible may be unaware that there are development efforts on tools that they could utilize.

Some mentioned that the Necoleap has great ideas and theoretically developing them however there seems to be a disconnect and lack of exchange between the system responsible who would need to take the technology under their ownership and onto a ship project. According to interviewee A, the research and development of new technologies is usually done by the system responsible. But the development of the system is more organic and incremental. Technology scanning in the market, development of the technology and proactively investigating if new products can be developed is lacking at the moment.

In the sister or series of vessels, feedback on needed developments is received after the first vessel has been operating. There is a list depending on the discipline and it helps guide which areas should be concentrated on for the next vessels in the series. Unrealized topics are re-evaluated as well. However, interviewees A, B, D, F, mentioned that the process of sharing the feedback with the relevant departments need clarification. Feedbacks are often indicated in the lesson learnt.

The energy efficiency development was mentioned by a few of the interviewees. There is usually an energy efficiency contact person or project responsible in the project team. There are weekly or biweekly meetings depending on the project phase between the customer's energy efficiency team and Meyer's energy efficiency team who are constantly working on different development topics.

The energy efficiency team or project management team is under the machinery design. According to interviewee H, they may be the only team that is involved in the project from beginning to end. They have a process that is slightly different, and it is a two-phase

process. The customer approaches with an idea and a feasibility study is done. The scope is defined, and suppliers are contacted. Once the relevant information is received from the supplier, a one pager slide that includes the benefits, saving, energy efficiency calculations, any possible improvements is drafted. The system responsible is then consulted to see where to place the idea on a ship. The cost and necessary infrastructure needed are defined. This information and payback time are included in the feasibility study which is presented to the owner to decide if it is a-go or no-go decision. If it is a-go decision, the AOM process begins if the project is ongoing.

The second phase is where the studies are continued to better define the placements, interface, and cost which then come to another go-or no-go decision point. In the later phases of a new building project, schedules would have to be considered as compared to sales projects where this would not be necessary. Interviewee H also mentioned that the internal communication regarding new technologies depends on who is working on them. There is a collaboration with the system responsible to exchange knowledge however it can sometimes depend on the individual. A newer person may be hesitant to adopt on the new technology if it results in more work. There needs to be a clear benefit before it progresses.

In the current projects, there is a new development process where there is a steering group with the project management working group and working teams which consists of the system responsible. It is a design loop which goes through the first working group then to the working teams, processing it with the working group when the material is ready then moving it to the evaluation of the steering group. If the steering group thinks it is a great idea, then it becomes an AOM. Otherwise, it may need some adjustments, or it goes to a feasibility study or archive. The working group is the most important and the working teams change depending on the subject. The working group is typically full of engineers. The steering group level may be more project management related and they are usually defining the business case. The business case includes the payback time of investment, sustainability, marketing, user related aspects and etc.

According to interviewee H, resources may be a challenge at time. When there is something to develop, the company needs to have a supplier. The company is most often only an integrator and does not develop anything on their own.

4.1.6 Knowledge management

Almost all interviewees were unsure if there were any documented general processes for sales and ECM. According to interviewee B, retaining knowledge in the company is an ongoing challenge. Interviewee A and H mentioned that there is a relatively new apprenticeship system in the company where newcomers have an experienced mentor to guide and show the ropes. It was also mentioned that most of the learning takes place through discussions. In design, they have a project portfolio status meeting every week to go through all projects from design perspective with line management and technical managers. This also provides a space for newcomers to ask questions.

There is currently a need for a more formal process for learning from past mistakes. All interviewees knew that they have a 'lessons learnt' after the delivery of the ship but they are unfamiliar with the document itself. It depends on the departments to go through them and take the lessons into consideration for the next projects. This is done in certain departments for the different groups. However, they can be uncoordinated and often have different formats saved in the M-drive. Follow ups are infrequent at times and the lessons may be overlooked.

4.1.7 Change Readiness and Resistance

Interviewee B shared that the shipbuilding industry is rather conservative and there is a tendency to keep things the same especially when there is an example of a successful concept. There is a tendency to copy paste which is a big limitation when striving for

change. According to interviewee H, the resistance may occur due to new processes and changes as people would have to relearn and get used to the new processes. It goes outside their comfort zone. There were some conflicting views here. Interviewee A and C mentioned that engineers are quite open to new solutions, developing their systems and their technology. However, the reluctance comes from the possibility of the new technology causing additional work and stress when they are already working at maximum capacity.

In terms of personal development programs, the interviewees were not aware of any personal development programs in the company except for interviewee A, who has attended the Leadership Excellence training program for managers. It was mentioned that there should be personal development and training offered for engineers regarding change and time management. It would also be beneficial for them to know how to communicate and negotiate with stakeholders.

4.1.8 Ideal future process

Interviewee B proposes that when an idea comes in from a customer through sales, Necoleap as part of the RDI should have the idea investigated in the past and have it ready for sales to provide immediate feedback. Necoleap should be in communication with Basic Design to check on the feasibility and have a communication loop on how to proceed with the ideas. Interviewee A mentioned that the engineers should feel that it is a collective effort, and it is part of their daily work to push an idea through and implement them. They should have the time and easy access to know where to locate the ideas, the status of them, how to contribute, and what tools are available.

All interviewees shared the same opinion that in the sales phase, the company should be able to forecast technologies and include them in the contract as much as possible. The new technology would of course have to be developed during the design and production phase but at least the biggest items should be known before basic design starts.

Understanding of the market and foreseeing upcoming changes on a global level especially for big items should be done before the company starts the basic design to ensure that the relevant technologies are planned and implemented at an early stage. Interviewee E mentioned that there should also be guidance provided to the customer on the more accurate choices for example materials and agree on the specifics with the customer beforehand.

In discussions regarding the series of vessels, sales should be involved, or the information should be public to sales for discussions of the following vessels according to interviewee B. For examples, discussion about technologies with project management on a certain vessel in a series should be available to sales for negotiations and discussions of the following vessels in the series. If certain technology is not feasible to be implemented in the current vessel or the next, then sales would be able to include in the contract for the following vessels.

Interviewee A shared that there is a tendency to include as much technologies as possible into the first vessel which may place added demand on the basic design. Some of the technologies may not be available yet in the market. Especially for customers who have a history of ordering option vessels, there should be a strategy in the beginning to plan out what would be included in the first, second, third vessel and so on. This would require the company to be active and propose technologies.

4.2 Current Processes and Strategies for RDI Implementation

In this section, the general sales and ECM process is charted based on section 4.1. Strategies for advancing RDI development to the application stage are suggested based on the challenges indicated. Both research questions are addressed in this section, and it is presented in the following order: sales process, ECM process, Technology Radar, decision making, productization, and change management.

One of the major commonalities that was brought up the most among the interviewees was the company's cautious approach when it comes to suggesting ideas. It is common for the customer to approach with the ideas however it was expressed that this should change. Adopting a cautious approach may allow the customer more flexibility which can be a benefit, but it can also potentially result in added workload in the basic design phase due to revisions through change orders. It was the general consensus that the company should be more proactive to suggest technologies in the early phases and better forecasting of technologies are needed. This would allow better planning for the current project as well as the rest of the series of vessels and increase agility.

The responses regarding RDI implementation process were similar among all the interviewees as well whereby there is a lack of standardized process. However, there are informal practices on how to get a new idea to the ship application. The reason for the lack of processes is partly due to the absence of active R&D in the organization until last year with the Necoleap project.

4.2.1 Sales Process

It was a shared viewpoint that new technologies should be included in the contract in the sales phase as best as possible rather than raising a change order. Of course, the change order option is always there but it is not encouraged to be used as it can cause disruptions. Therefore, the sales phase is vital in implementing new technologies especially radical innovations. Figure 6 indicates the current informal process flow of an idea to the implementation stage based on the interviews.

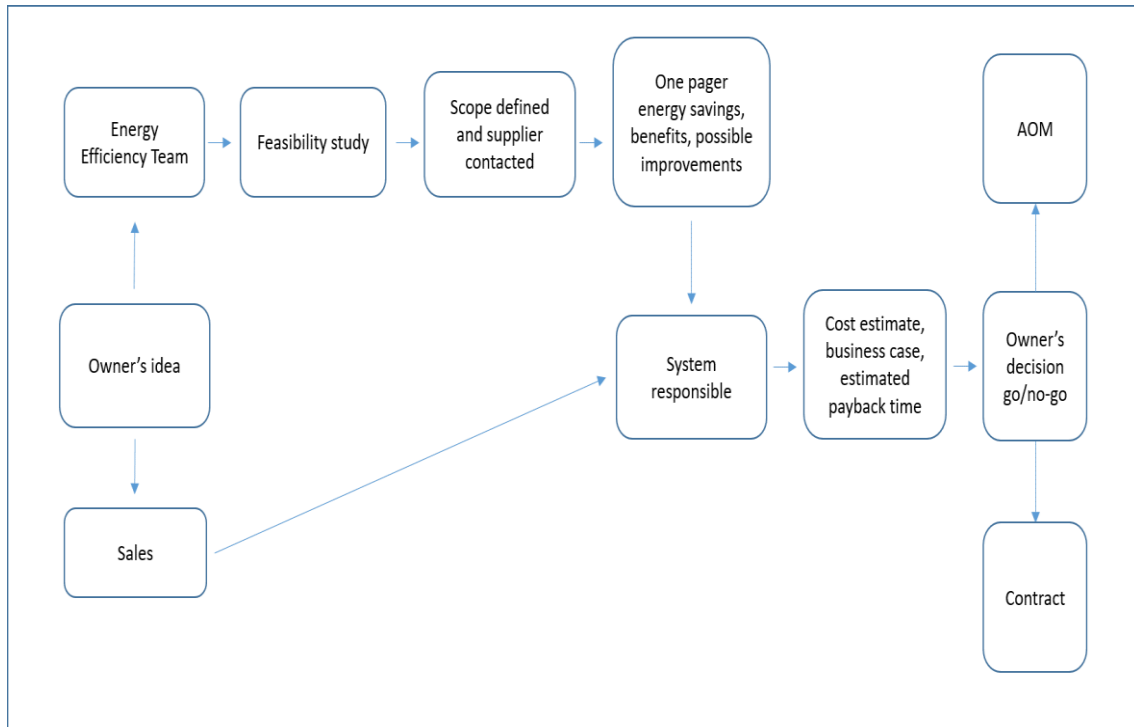


Figure 5. Current process of new idea implementation

The customer approaches the company with an idea through sales or the energy efficiency team. If it is through sales, the idea is passed to the system responsible for a feasibility study and they check with the suppliers on the technology availability and estimated cost. The cost, business case and estimated payback time is then provided to the owner for them to make the decision to go forward with the idea or not. If they decide to go forward with the idea, then it moves towards contract discussions.

If the idea comes from the energy efficiency team, the team conducts a feasibility study, define the scope and contact the suppliers. They provide a one pager with the necessary information to the system responsible who provides the cost, business case and estimated payback time and it moves to owner to make the decision. If the owner decides to go for the idea, the AOM process begins if the project is ongoing. If it needs to be included in the following projects, then it moves to the contract stage. A few people mentioned that the process on how the ideas are evaluated is not too clear when the

idea reaches the system responsible. It can be subjective and person dependent. At the end of the day, the system responsible is the one who needs to find a place in the system to implement the new technology. The process involving the energy efficiency team were positively mentioned by a few people. However, the team does not cover all innovations.

4.2.2 ECM Process

The AOM or engineering change management process in the company is straight forward and there were no issues mentioned regarding the process itself. It basically starts with an idea provided by the customer or by the company. It then goes through the investigation stage which involves an internal investigation and checks with turnkey suppliers. The cost is then calculated and documents for the owner is prepared. When the offer is ready, it goes to the owner for their decision. If it is a go, the owner will raise the change order through the internal IT tool.

The major concern that was raised regarding the change order is the amount of requests which discourages people from looking into non urgent matters such as development topics which are vital but not urgent. To overcome this challenge which is fairly common in the engineer to change environment, front loading to early design phases should be done as much as possible as suggested by Iakymenko et al., (2022). There may also be a need to review contractual agreements to reduce the amount of losses through changes (Iakymenko et al., 2022, pp. 969-970). A firm design freeze period should also be considered especially if there is a common understanding that there may be options vessels. Technologies or changes that passes a certain point should be planned to be implemented in the next vessel instead. Change is inevitable due to nature of the business and length of the project, but the amount of change requests can be reduced. Hence, the importance on accurate forecasting and being up to date on upcoming technologies and their maturity which the Technology Radar would be able to provide.

4.2.3 Technology Radar

It was unanimously agreed that Necoleap and the Technology Radar is a great step forward and definitely what the company needs. The Technology Radar project is a comprehensive technology strategy for the future. A ship consists of many different technologies that combines into one product. To manage the multitude of technologies, the technology ownership falls under groups. Ownership in this sense means technical expertise and knowhow, ensuring that innovation is the DNA of the group, have close contact with suppliers and the network, knowing the current state-of-art and planned developments under Technology Radar, driving development and taking project results into daily use, initiating and following new research in the respective fields, communicating to other disciplines about development, and maintaining suitable resources for innovation and technology development.

This would also include active tracking and forecasting of emerging technologies and their readiness level. The team should contact stakeholders directly to gain a deeper understanding of their work and assess when upcoming technologies would be available for the organization to utilize. Identifying needed development on the organization's end to bring the new solutions to fruition. Lastly, to track, document and communicate the topics and status in a suitable manner.

The Technology Radar project would be able to solve many of the challenges mentioned under the sales and ECM process. However, it is in the early phases, and it is still a work in progress. Therefore, suggestions are provided in this section to effectively bring RDI technologies to the application stage.

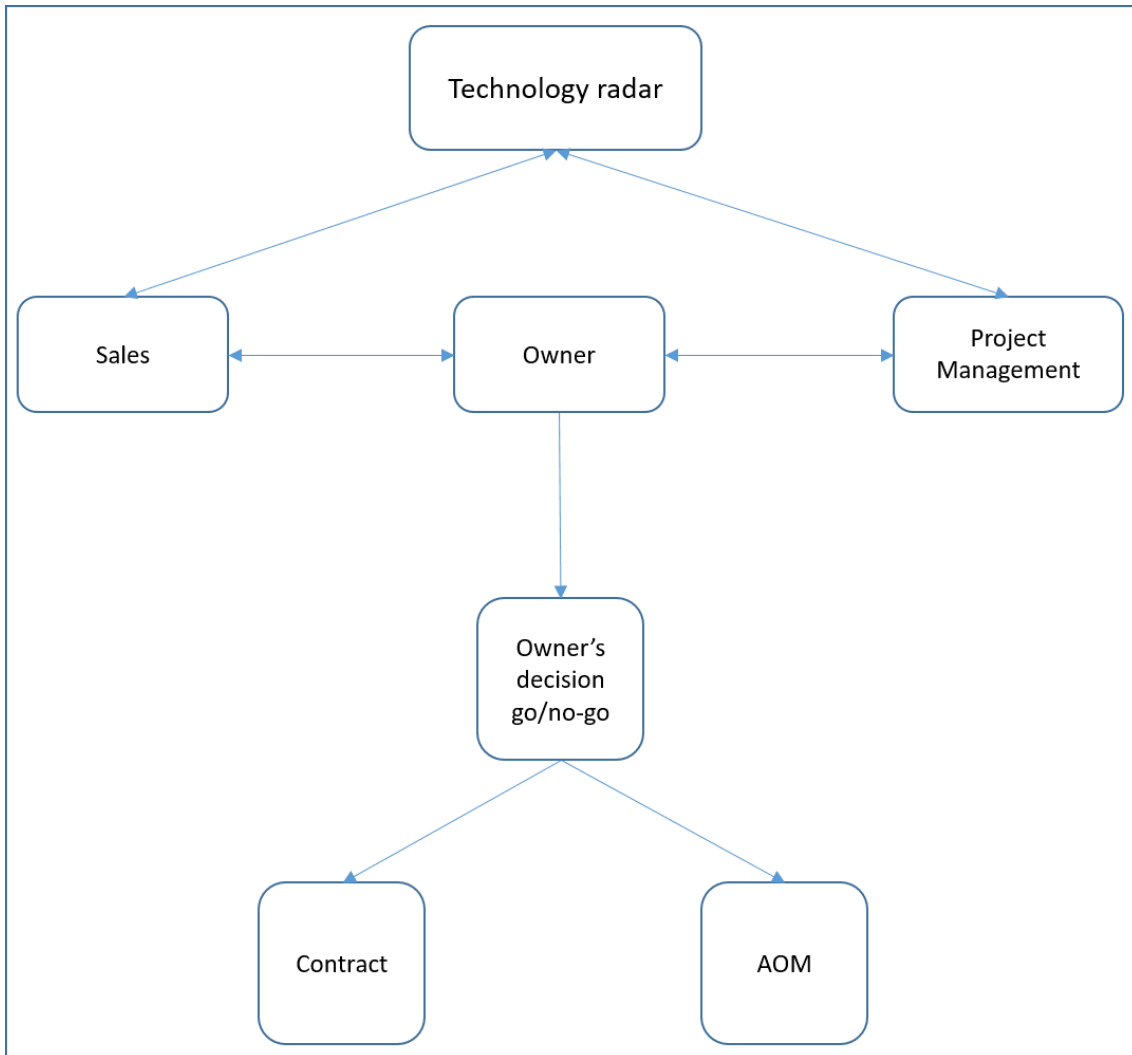


Figure 6 Future process of RDI implementation

The core Technology Radar team includes people in development from each stream among other experts in their respective fields. The possible future process of RDI implementation is visualized in Figure 7.

The Technology Radar is a technology development process from identification of technologies, managing them, and bringing them to ship applications. In this future process of RDI implementation, new ideas are passed through the Technology Radar through active scanning and monitoring of the development of technologies and their corresponding ship readiness level. The Technology Radar would provide input to sales and

the project management team. It is then offered to the customer for them to make their decision which leads to a contract or AOM depending on the status of the project.

The information flow would be a two-way street. Sales would be able to provide feedback and input to the Technology Radar based on their interactions with customers and indicate which technologies may need better prioritization. Likewise with the project management teams, they would provide input to the Technology Radar based on their interactions with the customer counterparts. This would also provide better transparency between sales and project management as they would be able to have complete information on technologies and ideas that the customer brings forward and what the company has to offer. This would address the challenge brought up during the interview whereby sales may not always have complete information if the customer is discussing new technologies or products with project management when the project is ongoing. This reduces the organization's negotiation capabilities for the next vessels in the series.

Looking into the Technology Radar in more detail, it combines both the technology development process and the new product development process. It covers the full process from idea to implementation. The technology roadmap is a beneficial technology management tool that provides a wide strategic view on how the new technologies and the long term goals of the organizations and market needs align. The important questions to be addressed here are 'where do we want to go, where are we now, and how can we get there?' (R. Phaal et al., 2005, p.99). Whereas Cooper's Technology Development Stage-Gate process that contributes to the new product process gives a good framework of how individual technology projects can be managed. Thus both tools act as a good guide for the management and progression of technologies in the Technology Radar.

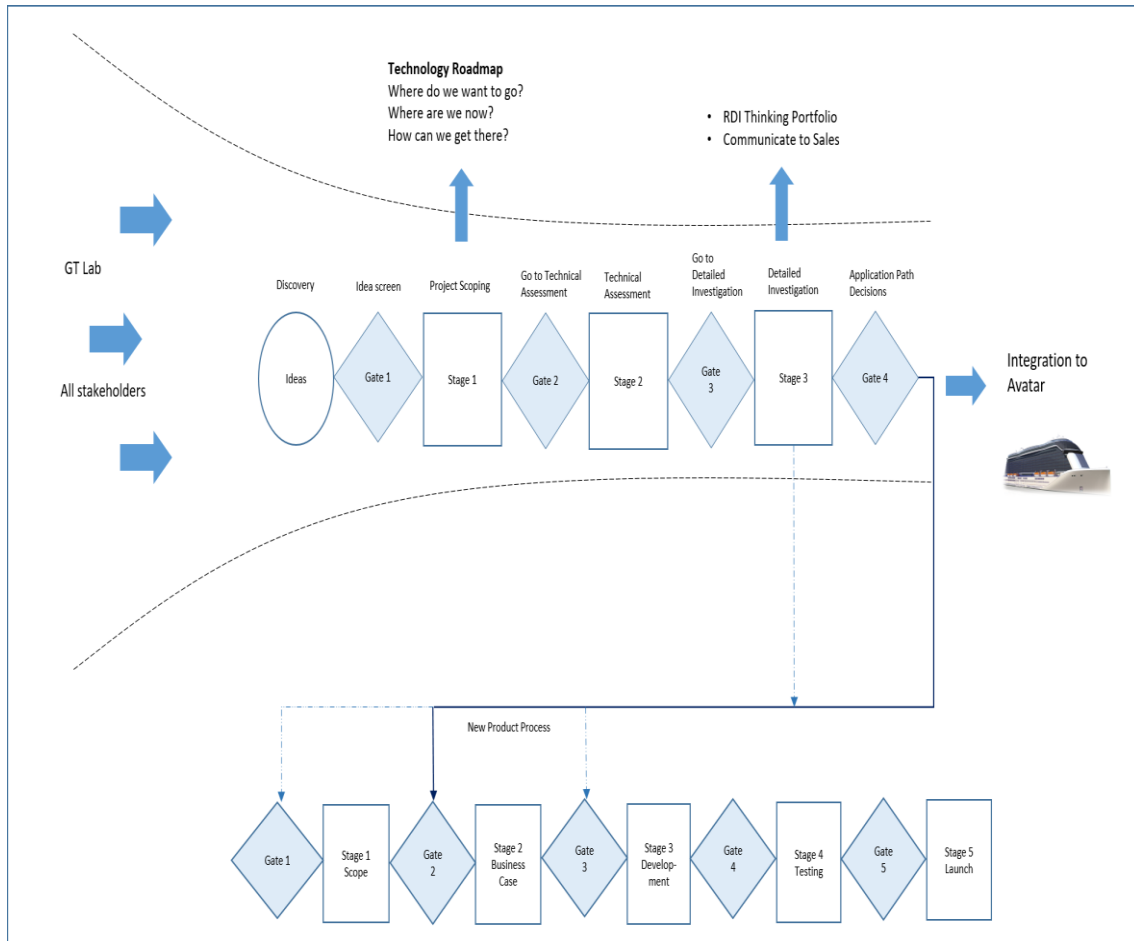


Figure 7 Overall Technology Radar idea implementation process including integration points. Modified from Cooper's technology development process (Cooper, 2006).

Figure 8 is a modified version of Cooper's model that integrates Meyer's processes for technology development and new product development. It indicates the possible overall process which include the technology roadmap, points to integrate to the internal portfolio tool, communication to sales, and integration to Avatar. It also indicates when the technology would move to the new product process which is discussed in more detail in the next figure. Figure 8 is also attached in the appendices for better visibility.

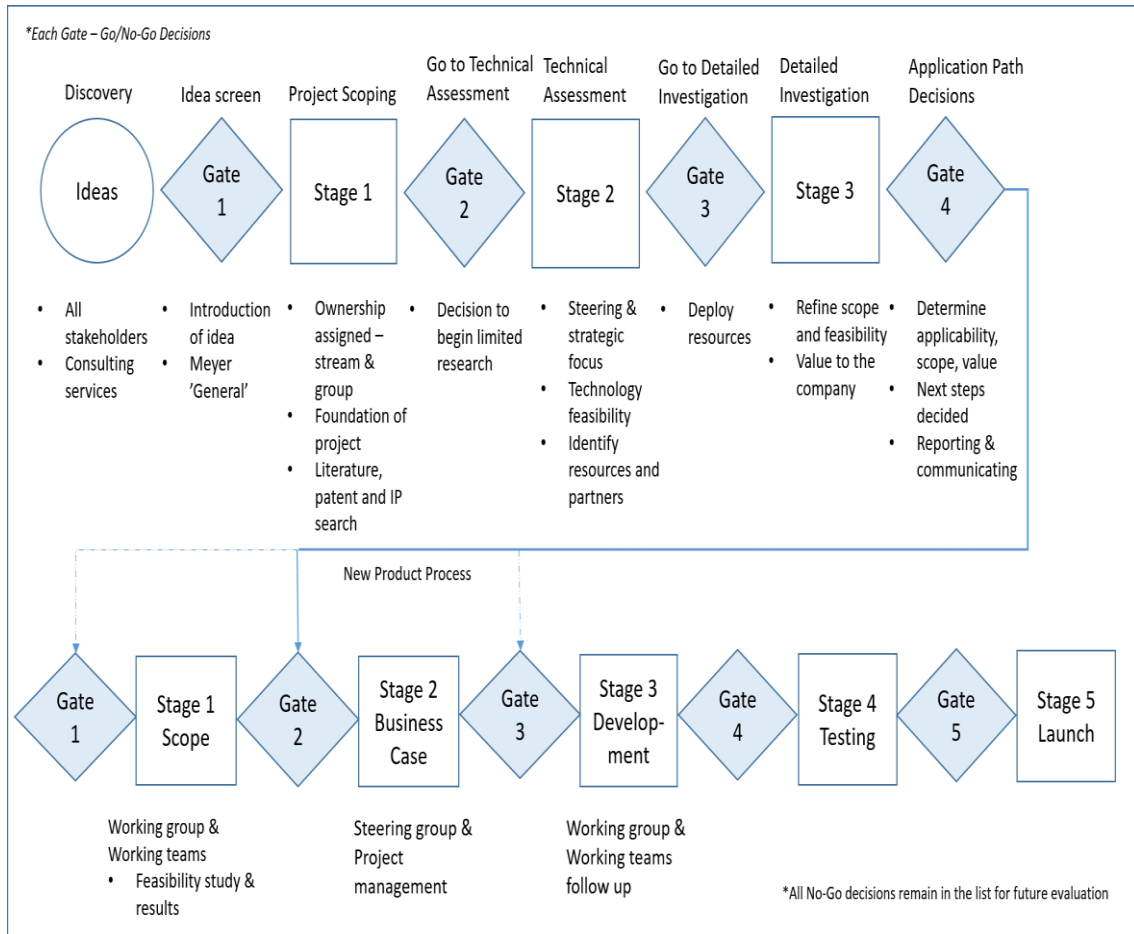


Figure 8 Technology Radar idea implementation process. Modified from Cooper's technology development process (Cooper, 2006).

Figure 9 takes a closer look at the model and what occurs at each stage and gate. It is important to note that go or no-go decisions are conducted at each gate. This modified version is using no-go instead of kill option as the no-go ideas and projects will be placed in an archive or remain in the list that may be revisited in the future.

It begins at the discovery phase where ideas are continuously scanned and there can be various sources of inputs from all stakeholders and the Green Transition Lab which is a collaborative workspace for the maritime industry where companies and universities can work together to strengthen sustainable development in the green transition.

The first gate is an initial screening of the ideas and largely qualitative to see if the ideas align with the company's strategic goals and potential influence, opportunities for strategic advantage, and probability of achieving commercial viability (Cooper, 2006, p.26). At this stage, the technologies are general and there is potential for the technology to be used by the certain streams however the extent of its potential is unknown yet. Go technologies fall under a 'General' category.

Stage 1 is where the technology ownership is assigned under the respective stream and group. The goal of this stage is to establish the groundwork for the research project, outline the scope, and develop a plan or roadmap for moving forward. This stage involves conceptual planning including literature, patent and intellectual property search, identify and evaluate competitive alternatives, resource gaps, and initial technical assessment (Cooper, 2006, p.26).

The second gate is where decision on whether to start preliminary experimental or technical activities in Stage 2. This gate is also qualitative and is still considered an initial review. The gate keepers for gates 1 and 2 are usually the same people. The technical assessment is done in Stage 2 and the goal is to do a feasibility study, technology assessment, building necessary partnerships, resource requirements, and evaluating the technology's potential significance within the steering and strategic focus (Cooper, 2006, p.27). In this stage the technology readiness level (TRL) and the ship readiness level (SRL) are determined by the respective streams and groups. Determining the TRL for each technology can be a time-consuming process especially when there is a long list of technologies. Since the TRL evaluation is a well-known assessment tool, AI tools can be utilized to accelerate the evaluation process to provide the relevant TRL rating for the technology based on their general development in the world. This would also be a good stage to check on the technology roadmap that has been established to determine the priority of the projects.

Ship readiness level

9. Commercialized – Actual system proven in an operational environment
8. Pre-production – System completed and qualified
7. Field test – System prototype demonstration in an operational environment
6. Prototype – Technology demonstrated in a relevant environment
5. Bench/Lab Testing – Technology validated in relevant environment
4. Detailed Design – Technology validated in lab
3. Preliminary Design – Experimental proof of concept
2. Conceptual design – Technology concept formulated
1. Basic concept – basic principles observed

The third gate is where decisions are made concerning resources. Since deploying resources requires funds, the evaluation at the gate is more stringent. It is the gate where there is significant commitment therefore the respective group that will assume responsibility for the implemented technology is the gatekeeper for Gate 3. It revisits the information in Stage 2 and commercial or implementation viability is gathered. The early involvement is essential for a seamless transition to the business unit during the commercial phase (Cooper, 2006, p.27). If the project is a go, then it should be added to the RDI thinking portfolio which is an internal portfolio management tool.

Stage 3 is the point where thorough investigations are done. The goal of this stage is to execute the complete experimental plan, demonstrate the feasibility of the study, and clarify the scope and importance to the company. This stage can involve significant expenditures and a longer period of work. Additionally, it includes activities that prepares for the business case implementation. To monitor and ensure that the progress continue as planned, project management methods are utilized and if there are any issues faced that prevents the project from completing this stage then it reverts back to gate 3 (Cooper, 2006, p.27). The RDI Thinking Portfolio would help in the management of the projects especially in terms of the milestone and status updates. It increases transparency and latest information on the projects would be in one place and employees would

be able to view all projects. This stage would also be an ideal time to communicate to sales regarding the new technologies for the necessary discussions with the customer. At that point, there would be enough information about the technology development and potential partners identified. It would also be beneficial to discuss with the customer regarding bigger technologies since it can be a joint venture with the customer to develop them and share the risks.

The last gate in the technology development process is Gate 4, the applications path gate. It acts as a gateway to a single or multiple new product or process development projects. The gatekeepers here are people in R&D, business development, and the group that has ownership of the resulting technology once it is commercially ready. The results of stage 3 and commercial prospects are reviewed, and the next steps are decided. The project could lead to potential joint ventures with suppliers or licensing opportunities. It sets the course for the potential commercialization of the technology moving forward. This gate can often be combined with the early phases of the new product development process. It usually takes place at Gate 2 however it can take place at Gate 1 or 3 as well as indicated in Figure 8 (Cooper, 2006, p.28). This phase would be a good point for Avatar integration however it could still depend on the ship readiness level of the technology. Ideally, the ship readiness level should be at least 5.

Using the example of the energy efficiency team, once the project reaches Gate 4, it goes to Gate 1, 2, or 3 of the new product process. If it requires more feasibility studies, then it goes through Gate 1 of the new product process. Feasibility studies are done in stage 1 by working teams along with estimated cost and energy efficiency NetZero calculation. It then moves to the working group who manages the working teams and does the pre-evaluation of the feasibility results. They then report the progress to the steering group and project management who determines the business case of the project. Go or no-go decisions are done at Gate 3 which determines if the AOM process begins. Stage 3 involves the development continuation and follow up by the working group and teams, followed by the necessary testing and launch. In the interviews, it was mentioned that

one improvement regarding the process of implementing energy efficiency ideas is to have some preliminary studies done prior to reaching the energy efficiency team. This model addresses this concern as preliminary and feasibility studies are done to a certain extent in the technology development process up to Gate 4, application path gate. It also addresses the concern that the responsibility to 'sell' the ideas fall under certain individuals and it increases transparency on the decisions made.

4.2.4 Decision Making

This model acts as a good guide but there may be challenges on narrowing down the ideas and identifying which technologies should be focused on and how they should be prioritized. Of course, there will be input from stakeholders at any point of the model which can help with the prioritization but there may be technologies that Meyer is the first to identify and would need to have a method to decide. The framework in conjunction with the Sustainable Process Industry through Resource and Energy Efficiency (SPIRE) project proposed by Kralisch et al. (2018, p.2382), aims to streamline and simplify the management of vast data across various knowledge areas to support the decision making in cross-disciplinary R&D to decrease the rate of innovation failures. The author points out that there is no one size fits all guideline for sustainable innovation therefore frameworks should be open and responsive to changes. The framework uses a combination of the state gate model with the addition of criteria, indicators, evaluation using MCDA, and visual management tools (Kralisch et al., 2018, p.2382).

The framework begins with identifying the goal and scope of the study which includes the aim, final delivery and baseline scenario. However, this definition should be flexible and responsive to change as it goes through the innovation process. To support decision making, the 'Ideal Final Result' (IFR) and minimum 'go' level definitions are vital at the start of the development process. It would also be stated at this stage if the technology is a modification of an existing product or process. An important decision in this phase is defining a baseline or standard for measuring project success. Sensitivity analysis is

also suggested by comparing the worst and best scenarios to grasp the full picture of key figures, limitations and uncertainties of the study to help with the decision making process (Kralisch et al., 2018, pp.2382-2383). In terms of Meyer, this phase should be done by the respective groups.

It then goes through the stages and gates that have been established based on the specific goals of the organization. The modified stage gate model in Figure 7 is applicable. The authors mention that the development teams should have their own targets (Kralisch et al., 2018, p. 2383). However, since Meyer would have to consider the European Council Climate Change goals, the following recommendations with some modifications are still applicable.

Gate 1: What is the potential result of the technology that supports the sustainability, operational and technical goals in comparison to the baseline?

Gate 2: Sustainability benchmarks need to be defined for comparisons to be made against the IFR and baseline. Is it possible for the technology to reach the necessary TRL within the project time frame? Is there a likelihood and prospect for industry adoption?

Gate 3: Will the technology achieve the environmental sustainability goals when scaled to full productions? Are there any expected economic advantages? Is there potential to have positive social impacts such as employment opportunities, resource conservation, etc. (Kralisch et al., 2018, p. 2383)?

Criteria at the gates will have to be established to assist with go/no-go decisions and these criteria are dependent on the project and goals of the organization. Common project management criteria that include the business process and learning can be included as well. The authors recommended the following criteria as an example: operational managerial elements to consider, financial management, environmental performance, and social performance. To effectively evaluate options based on the set criteria, there should be an agreement on performance indicators or specific indicators to measure impacts (Kralisch et al., 2018, p. 2383). Based on the interviews, the energy efficiency team

may have certain criteria and indicators in their studies. The Technology Radar team and the energy efficiency team should have a closer collaboration here to establish and align the performance indicators to ensure better transparency and communication.

The framework recommends using multi-criteria decision analysis (MCDA) such as Analytic Hierarchy Process for structured decision making. It is a fairly common tool which is used for standard product and process stage and gate and it can be beneficial in innovation projects as well although the criteria for decision making may differ slightly. The criteria encompass a broader range that includes technology readiness, environmental, social and economic effects. The values of the criteria are expected to be primarily quantitative as a result of sustainability evaluations, experimentation, and research. It is also expected to have a wide ranging and subjective scoring particularly at Gate 1. Consensus on subjective scores may be challenging to reach. The transparency and impact assessments that the MCDA provides greatly increases the understanding and acceptance of decisions in the state-and-gate process. Finally, the framework suggests a visual representation using a spider web diagram to indicate the various aspects of the criteria scores (Kralisch et al., 2018, pp. 2383-2384).

4.2.5 Productization

One of the challenges that was shared during the interviews was the lack of a list of technologies or products that could easily be offered to customer in the sales phase. It would help steer the sales discussions and promote a more proactive approach. Based on literature, this list of products and technologies is also known as a product portfolio or productization. Under the Necoleap umbrella, there is a project that is specifically working a comprehensive documentation of the product architecture. The project was not investigated in more detail for this thesis. However, it is important to note that there should be close collaboration between the Technology Radar and modularization team as new technologies that arrive at the new product process may require a new product

structure especially when it concerns a radical innovation and brings the possibility of design reuse.

There is still a need for a list of new technologies and a technology library in conjunction with the Technology Radar that should be established. The main aspects of productization according to Mustonen & Harkonen (2024) still apply whereby each technology, feature or product available for sale should have a corresponding technical structure and vice versa. This enables and maintains a consistent understanding between the different functions and stakeholders on the new technologies available for offer. This would overcome some of the challenges mentioned regarding the miscommunications that occur between business and technical teams.

4.2.6 Change Management

The study indicated that there are still efforts to be made for the organizational culture change to be fully adopted. It was mentioned by a few interviewees that people may still be sticking to the norm and there may be some reluctance to adopt new solutions as it would typically require more work. Top management have established strategic goals and timelines however the urgency and level of commitments towards these goals may not be entirely clear across the organization. There may be limited motivation for change especially when people are occupied with different tasks. The known pathway with least resistance is most often chosen unless there is a clear benefit visible. Change agents in this case would be managers who should spread awareness regarding the change needed and actively have open conversations about struggles that prevent them from adopting the change.

There is also a need for training and personal development. Only one of the interviewees have been invited to attend the Leader Excellence program organized by human resources. The criteria to be invited to the program needs some clarification. The rest of the interviewees were unaware of available programs for skill or personal development.

Trainings should be organized for different levels of the organization especially for individuals who are leading a team or have regular communications with the customers to ensure that they are equipped with the right tools for effective communication and negotiation skills.

4.2.7 Value in Processes

During the interviews, it was mentioned that having too many processes would discourage and hinder the motivation to find new ideas. Literature has indicated that having a strict structure for innovation can limit the number of new ideas. However, there are benefits to having processes in place especially if the focus is to bring value (Prastacos et al., 2002, p.65). Without a process, efforts may seem disorganized and scattered as it lacks standardization. Individuals may have different preferences and there would be different formats of documents which would naturally cause communication and transparency issues. Perhaps the apprehension to processes may be related to culture. It was briefly mentioned that the shipyards in Germany are slightly better at implementing new ideas and they are usually prepared with all the necessary information during presentations. They have well defined processes with a distinct hierarchy but there are pros and cons to it. In Meyer Turku, the organization is flat in terms of hierarchy and people are free to exchange ideas with all levels of the organization. It is a great breeding ground for innovation and having processes that bring value can only enhance it. There should be processes in place to organize and provide guidance to people.

According to literature, the word process can have different meanings to people. In general, a process can be defined as a chain of linked procedures that depend on each other and utilizes resources at each stage to transform inputs into outputs. The objective is key here and in respect to business process, it is connected to the organization's strategy. The organization's objectives would have to be known beforehand in order to create applicable processes to support these objectives. Processes that are not connected to business strategic planning still utilize resources, but it does not add value therefore it

has no basis to exist. This is crucial for effective management of processes (Akintoye;Goulding;& Zawdie, 2012) and it falls under the realm of change management.

4.2.8 Knowledge Management

A greater focus should be put on formulating a process that is suitable while keeping in mind that processes should be flexible and dynamic. Once a process is formed, it should be documented and easy to locate by those who need it. There is room to improve on the documentation of processes in the organization. To be a knowledge hub, documentation needs to be part of the organization culture. One suggestion would be to provide a simple template within basic design to standardize documents and ease the communication and learning process. There may be slightly different needs for different streams and the template can be customized accordingly. Individuals in leadership positions have to emphasize the importance of documentation to retain knowledge within the organization. This ensures that project histories and tacit knowledge is not lost when a personnel leaves.

Converting tacit knowledge to explicit knowledge helps the learning process within the organization and it can be a competitive advantage. It is expected that not all knowledge can be explicitly documented but it should be done as best as possible. This also helps in knowledge sharing which is vital for innovation and easing the onboarding process for newcomers. Some departments have adopted an apprenticeship system for newcomers which is a great step forward. Proper documentation of processes is able supplement the learning process.

Additionally, there seems to be a careful approach to knowledge sharing within the organization which may stem from the organization's history of long tenures. Individuals were often focused on their own tasks. There may not been a strong need to retain the knowledge explicitly as people used to stay in the organization for decades and they can

easily pass down the knowledge through discussions. However, trends indicate that tenures are shorter now and this means that knowledge is lost with the personnel, and it can be unfavorable to the organization and continuity of innovation. There are also collaborative efforts across departments now such as Technology Radar among others that require knowledge sharing. Therefore, documentation should be emphasized, and it should be stored in a designated place for easy reference and people should be informed about it.

4.2.9 RDI Communication

Among the interviewees, the need to enhance the visibility and awareness of the ongoing projects and statuses were highlighted. Communication improvements can be made. The organization has an internal portfolio tool that has been recently implemented. Communication of the project status and progress information should be available in the portfolio. Many had requested a one pager information of the project, and this can be easily obtained through the portfolio however the existence of the portfolio has to be shared more to the rest of the organization to increase awareness. There is also still a need to ensure that all project managers are updating the projects regularly. The project managers are ultimately responsible for the projects, but others involved in the project can provide updates as well. Options should be discussed if there are some challenges with providing regular updates.

As for Technology Radar, more awareness of the tool is needed in basic design. Perhaps, monthly or quarterly updates on the intranet or the Necoleap Teams channel is required to inform on the status of the Technology Radar and the Power Bi visualization of the summary of technologies. It should address the questions of 'what now'. For example, if referring to Figure 8, the list of technologies that passes Gate 3 are listed and informed via Teams channel and the progress of the individual projects can be tracked using the thinking portfolio if interested. There should be semi regular updates especially in the beginning to increase awareness and for them to get used to the radar. There should be

a standard process, and advocates should have one voice when directing people to the respective platforms.

5 Conclusion

This chapter provides a summary of the study and answers to the research questions. It concludes the study. Limitations of the thesis are mentioned, and the possible future research areas are suggested.

5.1 Summary and Conclusion

The aim of this thesis was to investigate processes and challenges related to advancing technologies from RDI to the application stage within the technology development management process in a shipbuilding organization and provide strategies on improving this process. The research questions to be answered were how does the current processes in Meyer Turku handle the transition of technologies from RDI to application?, and what strategies can be implemented to improve the efficiency of advancing the technologies from RDI to application? To be able to capture the full picture of the research problem, a theoretical framework was formed, and theories related to innovation, technology management, engineer to order environment, engineering change management, and strategies to advance new technologies to the application stage were reviewed. Through literature, the themes for the interview questions were created and semi structured interviews were conducted in the organization.

In reference to the first research question, it is broken into two parts. The first part was to analyze the existing sales processes and identify challenges for RDI technology application in the organization. The sales process covers all activities before the ship contract is signed. Through the interviews, it was found that there was a lack of formalized process for commercializing or getting new technologies to ship projects. The general sales practices were mapped out to document the process. The main challenges in the sales phase were the cautious approach, lack of forecasting, visibility of ongoing RDIs and the lack of clarity of when the technology is ready for sales to use in discussions with the

owner. Resources can be a challenge when keeping up to date with upcoming technologies while being focused on current projects.

Still referring to the first research question, the second part was to analyze the ECM processes and identify challenges for RDI technology application in the organization. The ECM process was standardized and straightforward however, there was a lack of documentation that was easily available. A change request is always raised by the owner and an internal tool is used for communication regarding the changes. The main challenges of the ECM process for RDI implementation is the high cost and amount of disruption it can cause to basic design. Another notable challenge is the amount of change orders that the different teams receive for a project. The teams are often depended on turnkey suppliers and area builders for quotes on the changes. There can be miscommunications between the different stakeholders that causes delays. New technologies are rarely suggested through a change order unless there is a large benefit.

The study also included challenges faced regarding RDI activities, the state of knowledge management and learning, change readiness and resistance in the organization and the ideal RDI implementation process. This provided a direction for the suggested strategies for RDI implementation which is the second research question. All interviewees mentioned that the organization should be more proactive in suggesting and forecasting technologies. The Technology Radar project would be able to address this issue. It is still in the early phases and the suggested process is reflected in Figure 6, 7, and 8.

A modified model of Cooper's Stage-and-Gate, which indicates both technology development and new product process. The suggestion includes why and when the technology roadmap would be ideal in the process, when the internal portfolio management tool comes into the picture, when it would be best to communicate to sales regarding new technologies, and when technologies should be integrated to Avatar. The model acts as a guide and not a strict rule. To help with the decision-making process of large amounts of new technologies, the framework proposed by Kralisch, ym. (2018) in

connection with the Sustainable Process Industry through Resource and Energy Efficiency (SPIRE) project was recommended as it also uses the stage-gate model.

An additional suggestion of productization was made to address the miscommunication challenge of products on offer and the lack of list of technologies to help in the sales phase. There should be closer collaboration with another project under Necoleap that is focusing on documenting product structures. Lastly, change management as a strategy was suggested. This includes deploying change agents to increase awareness, recognizing processes as value and effectively managing them, importance of documentation in knowledge sharing and the learning process. Suggestions for ways to increase visibility and awareness of Technology Radar and other Necoleap projects were provided.

Through the empirical study, the research questions and objectives that were defined in the study provided new insights into how to bring RDI technologies to the implementation stage within the organization. The results of the study may contribute to the understanding of RDI implementation in the green transition efforts of the shipbuilding industry although suggestions were focused on meeting the needs of the organization. If the organization decides to implement the strategies, a suggestion would be to prioritize the Technology Radar stage-gate model as it will be able to address most of the concerns mentioned and enhance competitive advantage while reaching its sustainability goals. If successfully implemented, it could serve as a model for future cruise shipbuilding in line with Meyer Turku's vision as a leader of the green transition efforts.

5.2 Limitations and Future Research

This research has a several limitations. Firstly, the study is based on one shipbuilding organization in the engineer to order environment in Finland therefore it may restrict the generalizability of the study. It was also focused on the Basic Design department and the sample size was limited due to time constraints. The results may not fully represent

other organizations in the industry. Additionally, the study did not take into consideration the innovation ecosystem and how it affects the rate of adoption of RDI technologies. Cost and risk management that is involved in the sales and ECM process were also not considered in this study which could definitely be looked at more closely.

Future research could expand this study by selecting a larger sample size or different regions. Further studies on the effects of the innovation ecosystem and the rate of RDI technology adoption may give useful insights to the technology development process. Additionally, studies on supplier relationships in terms of RDI applications in the industry would be beneficial as well.

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Appendices

Appendix 1. Interview Questions

Background Questions

1. What is your current role and responsibilities in the organization?
2. How long have you been in the organization?

Sales Process

1. What is the process/flow of information when we have a new technology to offer?
 - How are we communicating internally and to the customer about the technologies on offer?
 - How do we decide what technology is recommended?
 - o What does the process look like?
2. What are the challenges faced with commercializing new technologies?
3. What weaknesses and strengths have you noticed in the commercializing process?
4. How do you think it could be improved?

Engineering Change Management Process

1. Can you describe what is the process when a change order is raised?
2. How do we make decisions on a technology if there is more than one option?
3. How do we share data/progress/changes with stakeholders?
4. How do we decide at which point in the schedule can we still make changes?
 - Is there a design freeze period?
5. What are the challenges faced?
6. What weaknesses and strengths have you noticed in the implementation process of new products/technologies on to ships with change orders?
7. How do we learn from mistakes?
 - Could you provide some examples?
8. How do you think the process could be improved?

Future Process

9. How do you think the process of implementing future RDI technologies should be?

Change Management

10. Have you noticed any resistance to change? If so, in what aspect?
11. Have you participated in any skill development or leadership training within the company? If so, do you feel that the available training opportunities are sufficient.

Appendix 2. Overall Technology Radar idea implementation process including integration points. Modified from Cooper’s technology development process.

