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**Faculty of Science and Technology**

# MASTER'S THESIS

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# Preface

The present thesis concludes my M.Sc. in Offshore Technology, with specialization in Industrial Asset Management, at the University of Stavanger. The study was conducted in cooperation with Kvaerner during the spring of 2016.

I am very grateful to my external supervisor, Odd Ingvar Ur, who offered me the opportunity to write this thesis under his supervision, despite rather gloomy times in the industry. I would like to thank him for all the hours he set aside for discussions and read-throughs, and for providing me with constructive feedback throughout the project.

I would also like to thank my faculty supervisor, Knut Erik Bang, who has provided prompt feedback and assistance whenever I have been in need of his services. I am especially grateful for the confidence he has shown me by letting me regulate the progress of my own work without frequently having to deliver time intensive status reports.

Lastly, I would like to give a special thanks to all members of Kvaerner's SCS function, who willingly shared thoughts and experiences right from the start, and who made me feel very welcome during my stay at Kvaerner.

Thomas Sætre

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# Abstract

In modern times, the increasing use of outsourcing and specialized suppliers have changed the fundamental basics of competition in the construction industry. Rivalry is no longer limited to the firm level, as the main arena for competition now exist between supply chains seeking to outperform each other. This new dimension of competition calls for careful management of suppliers, and have directed many researchers' attention towards the field of supply chain quality management (SCQM).

In order to strengthen the technical aspects of their supplier follow-up activities, Kvaerner have recently restructured their supply chain surveillance (SCS) function, making it a part of their Completion Department rather than their Procurement Department. This study aims to document the current structure and practices in the restructured function, and outline how altering these can enhance the supply chain's performance, something that will provide Kvaerner with a competitive edge in the modern arena for competition.

The present thesis concludes that there exist a substantial potential for Kvaerner to improve their competitiveness through broadening the scope of their SCS activities. They can do so by extending their continual improvement process, establishing routines for conducting structured supplier evaluations, and entering closer relationships with a handful of suppliers. Implementing these measures should enhance their supply chain's performance, and thereby reduce the life-cycle costs of future acquisitions. As Kvaerner's SCS functions are project-specific, and thereby dissolved between projects, it is also concluded that systems and routines for transferring knowledge is essential for establishing and maintaining efficient SCS functions in upcoming projects. Due to the current state of Kvaerner's systems and routines for transferring knowledge, the present study recommends that these are reviewed and improved to ensure that accumulated experience are carried forward in future projects. If carried out properly, this will allow Kvaerner's SCS function to reap remarkable benefits from repeating successful practices and decisions, while avoiding already discovered pitfalls.

# Sammendrag

I nyere tid har den økende bruken av spesialiserte leverandører og kontraktsfestede underleveranser endret de grunnleggende prinsippene for konkurranse i bygg- og anleggsbransjen. Hovedarenaen for rivalisering befinner seg ikke lengre mellom enkelt bedrifter, men mellom hele verdikjeder som forsøker å utkonkurrere hverandre. Denne nye dimensjonen av konkurranse krever omstendelig oppfølging av leverandører, og har fått mange forskere til å rette fokus mot kvalitetsledelse i forsyningskjeder.

Med mål om å styrke de tekniske aspektene rundt leverandøroppfølging, har Kværner nylig restrukturert sin funksjon for forsyningskjedeovervåkning, og gjort den til en del av deres ferdigstillingsavdeling fremfor innkjøpsavdeling. Følgende studie ønsker å dokumentere nåværende struktur og praksiser i den restrukturerte funksjonen, og samtidig se nærmere på hvordan disse kan endres for å forbedre forsyningskjedens ytelse, noe som vil sikre Kværner et fortrinn i konkurransen om fremtidige kontrakter.

Det konkluderes med at det eksisterer et betydelig potensiale for Kværner til å forbedre sin konkurransedyktighet gjennom å utvide omfanget av deres funksjon for forsyningskjedeovervåkning. Kværner kan realisere dette potensialet gjennom å utvide prosessen for kontinuerlig forbedring slik at den også omfatter leverandører, etablere rutiner for strukturert leverandørevaluering og ved å inngå tettere samarbeid med utvalgte leverandører. Dette bør kunne øke forsyningskjedens ytelse, og dermed redusere livssykluskostnader relatert til fremtidige anskaffelser. Ettersom Kværners funksjon for forsyningskjedeovervåkning er prosjektspesifikk, og dermed blir oppløst ved prosjektslutt, konkluderes det også med at gode systemer og rutiner for erfaringsoverføring er nødvendig for å etablere og opprettholde velfungerende funksjoner i fremtiden. Som følge av den nåværende tilstanden til Kværners eksisterende system og rutiner for erfaringsoverføring, anbefales det at disse gjennomgås og forbedres, slik at oppsamlede erfaringer blir dratt med videre i kommende prosjekter. Dersom dette blir gjort på en god måte, kan Kværners funksjon for forsyningskjedeovervåkning høste store verdier gjennom å gjenta suksessrike fremgangsmåter og beslutninger, samtidig som den unngår feil fra tidligere prosjekter.

# Table of Contents

## List of Figures



## List of Tables



## List of Appendices

# Acronyms

| | |
|---|---|
| AB | Appointed Brand |
| APO | Assigned Purchase Order |
| ARR | After Action Review |
| COF | Consequence of Failure |
| COWR | Carry Over Work Register |
| CPI | Company Provided Item |
| EPC | Engineer Procure Construct |
| EPMS | Engineering, Procurement and Manufacturing Schedule |
| FA | Frame Agreement |
| FAI | First article inspection |
| FAT | Factory Acceptance Test |
| ITP | Inspection and Test Plan |
| MC | Mechanical Completion |
| MCCR | Mechanical Completion Check Records |
| NCS | Norwegian Continental Shelf |
| PMP | Procurement Milestone Plan |
| PO | Purchase Order |
| POF | Probability of Failure |
| PPFP | Procurement Package Follow-up Plan |
| PRB | Package Responsible Buyer |
| PRL | Package responsible Lead |
| PSFA | Project Specific Frame Agreement |

| | |
|---|---|
| QM | Quality Management |
| QS | Quality Surveillance |
| SCS | Supply Chain Surveillance |
| SCQM | Supply Chain Quality Management |
| SQS | Supplier Quality Surveillance |
| TB | Travel Board |
| ULQ | Utility and Living Quarter |
| VOR | Variation Order Request |

# Chapter 1

# Introduction

## 1.1 Background

Larger construction projects require careful management of suppliers to ensure that they are completed within schedule, with the correct quality, and at an affordable price. From this, it appears evident that contractors who are good at managing their suppliers will also have an advantage when competing for future contracts.

Recently, Kvaerner restructured their supply chain surveillance (SCS) function, making it a part of their Completion Department rather than their Procurement Department, in order to strengthen the technical aspects of their supplier follow-up activities. In their pursuit of the ultimate SCS function, Kvaerner have requested a critical assessment, which should result in a set of potential improvements and optimizations.

The reader should note that Kvaerner's SCS functions are established on a project basis, and thereby frequently dismantled and reconstructed. Consequently, high quality systems and routines for transferring knowledge across projects are vital for establishing and maintaining successful SCS functions in the future.

## 1.2 Aim of Thesis

The present thesis aims to identify weaknesses and development opportunities related to Kvaerner's current SCS function, and provide Kvaerner with input on how adapting accordingly can render their organization more competitive in the future.

## 1.3 Methodology

To fulfill the aim stated above, relevant theory and information on how to establish and maintain a successful SCS function were gathered from a range of literary sources like academic journals, books, papers, etc. As Kvaerner's SCS functions are not permanent, the importance of preserving experience became evident at an early stage in the study, and literature on how to ensure efficient transfer of knowledge were therefore included.

The theoretical grounding were then compared to a case study developed through observational- and documentary analysis of Kvaerner's SCS function. Observations were made through daily interaction with function members, and attendance in function related meetings. Those practices that could not be observed during the author's stay at Kvaerner's facilities were made part of the case study through documentary analysis. The documentary analysis included review of Kvaerner's internal manuals, guidelines, procedures, strategies, etc.

From the comparison of theoretical practices and those actually performed, function related weaknesses and development opportunities were identified and used as a basis for the recommendations presented in the conclusion.

Shortly summarized, the following sub-objectives would have to be fulfilled for the study to be considered a success:

1. Perform a thorough literature review on state of the art practices for managing construction supply chains, and present theory relevant for establishing and maintaining a successful SCS function.
2. Conduct a case study on Kvaerner's current SCS function, and document its present structure and routines.
3. Compare the current practices with those discussed in the literature review, and elaborate on deviations that could hold the potential for future improvements and/or optimizations.

## 1.4 Limitations

As the execution period of the studied project was far more extensive than the one of the present thesis, the author was not able to follow the whole run of Kvaerner's current SCS function; parts of the case study therefore had to be based on descriptions of how this function should operate in theory. Further, no structured attempt were made on mapping the economic aspects of Kvaerner's systems and procedures, and any references made to cost reductions are based solely on assertions presented in the studied literature.

## 1.5 Thesis Structure

The present thesis consists of seven chapters, and the upcoming six chapters are structured as follows:

**Chapter 2:** provides a brief review of Kvaerner's history and ongoing activities, before it introduce the Johan Sverdrup project, which forms the basis for the case study presented in chapter five.

**Chapter 3:** presents state of the art theories on how to best manage construction supply chains.

**Chapter 4:** introduce vital principles for successfully capturing, storing, and retrieving organizational knowledge within project-based organizations.

**Chapter 5:** describes the current structure and practices of $K^2$JV's SCS function.

**Chapter 6:** outlines function related strengths and weaknesses revealed through the case study, and elaborate on how these hold the potential for future improvements and optimizations.

**Chapter 7:** summarize the thesis by linking objectives and conclusions, highlighting challenges encountered, and providing recommendations for further work.

# Chapter 2

# Kvaerner - Then and Now

## 2.1 History

This section is inspired by (Kvaerner, 2011, Bryhn, 2015).

In order to understand how the company known as Kvaerner today originated, one must first familiarize with individual histories of both Aker and Kvaerner, two companies that emerged in proximity of Christiania (now Oslo) during the mid-1800s. Aker established at the estuary of the Aker River in 1841, and specialized in building and installing steam engines on vessels originally designed as schooners. About a decade later, Kvaerner established on the riverbanks of the Alna River, and specialized in producing iron products for industrial and agricultural purposes.

The following 100 years, Aker expanded their facilities, partially with governmental support, and gradually grew into one of the largest shipyards in Norway. In the same period, Kvaerner kept expanding their original business, and became a leading supplier of tools and mechanical equipment for trains, railroads, bridges, and eventually buildings and other larger constructions. Kvaerner also broadened their business to incorporate production of cranes, pumps, and turbines for hydroelectric power plants, making them one of the largest industrial companies in Norway. At the end of this 100-year period, World War 2 (WW2) burst out, resulting in a sharp decline in both Aker and Kvaerner's business expansion.

Following the war, ship owners around the world were eager to get back into the shipping business that had once made them wealthy, and thereby desperate for replacing the ships they had recently lost. While Aker's shipbuilding business in Oslo were blooming, they eyed the opportunity for satisfying the market's cravings for oil-transport, and introduced the so-called super tankers. To fulfill this business idea, Aker had to acquire a site where they could establish a shipyard large enough to produce tankers of record-breaking size. Eventually, Aker discovered the perfect spot, and established a new yard at Stord.

Much like Aker, Kvaerner also exploited the vacuum of ships following WW2. They gradually entered the business of manufacturing gears, and building and installing ship engines. In 1962, Kvaerner decided to follow Aker's example, and became a full-scale shipbuilder. This was the start of an intense rivalry, which would remain at a high level for decades to follow.

New opportunities opened up for the two companies when the Ocean Viking struck oil on the Norwegian continental shelf (NCS) in late 1969. The companies' desire to enter the emerging oil and gas industry was amplified even further by the oil crisis in 1973, which had devastating impact on their order backlogs. Fueled by the oil crisis, both Aker and Kvaerner established themselves as subcontractors in the oil and gas industry, working their way from apprentices to masters in the decades to follow.

Over the years, several mergers had been proposed between the two firms, but none of these had followed through. However, in 2001, both parties agreed to merge Kvaerner with the publicly listed company responsible for Aker's oil and gas activities, Aker Maritime. Despite media speculations describing a climate between the two companies so poor that any attempt of merging them would be a complete act of foolishness, the merger later proved a success.

Following the merger, a substantial amount of restructuring were required. As part of this process, the former Kvaerner became a part of Aker Kvaerner, which was later renamed Aker Solutions. Not until 2011 would the Kvaerner brand reappear, this time as the company known as Kvaerner today. To satisfy customers' increasing demands for more specialized EPC contractors, the shareholders of Aker Solutions decided to list their EPC business for offshore platforms and onshore facilities in a separate company, under the name of Kvaerner.

## 2.2 Kvaerner's Current Position

Today Kvaerner is a well-established supplier who delivers complete offshore oil and gas platforms along with onshore processing plants and facilities. The company is recognized as (Haugan, 2015):

- A leading EPC contractor for projects on the NCS

- A leading Norwegian EPC contractor for onshore processing plants and facilities
- A leading European provider of steel jackets to the offshore oil and gas market
- A global leader in offshore concrete structures

Kvaerner has earned these hallmarks through their nearly 50 year's long tradition of serving customers with value-generating projects and predictable outcomes. These projects have resulted in more than 15 of the world's most recognized floaters, more than 20 large onshore plants and terminals, the delivery of 42 large steel jackets, and involvement in design and construction of 26 offshore concrete structures (Kvaerner, 2014a). A substantial portion of these projects are designed for use in Arctic and sub-Arctic environments, and Kvaerner have currently delivered more projects intended for such conditions than any other contractor ever have.

Despite their good reputation and impressive record, Kvaerner have not reached their goal yet. Their ultimate vision is to *«become a top league international EPC player»*, something they aim to achieve through dedication to their value compass, illustrated in Figure 1 (Kvaerner, 2015b).


*Figure 1: Kvaerner's Value Compass (Kvaerner, 2015b)*

The current downturn in the global oil and gas market has not made Kvaerner's road to becoming a top league international EPC player any easier. Norwegian companies are known for delivering high quality products and solutions, but often at a higher price compared to foreign contenders. As the market becomes tighter, the large oil companies tend to favor cost over quality when selecting their suppliers, an obvious disadvantage for Kvaerner and other Norwegian companies competing in the oilfield service market. However, despite the difficult market situation, Kvaerner recently received a confirmation that they are performing well when they won the «Gullkronen2016» (The NCS Performance Award for Business Success of the Year 2015), awarded by Rystad Energy. The jury gave the following statement when announcing Kvaerner as the award winner:

> *The winner has consistently proven a persistent capacity to survive and thrive in a particularly risky, volatile and competitive segment of the oilfield service market. In gloomy times, the winner has shown great ability to venture with complementary business partners, expand market coverage, and drive both technology and business model innovation. The value of this ability was clearly shown during the fall of 2015 when the winner bucked the trend in the oil service market, exhibiting an 80% share price rally since early October (Rystad Energy, 2016).*

By winning this award, Kvaerner states that they are capable of delivering both quality and predictability in challenging times, and proves themselves as a suitable contractor for future projects.

## 2.3 The Johan Sverdrup Project

Back in 2010, Lundin struck oil in their exploration block Avaldsnes. The year after, Statoil did the same in the neighboring license, Aldous (Norsk olje & gass, 2012). Both findings were initially deemed substantial, and when it was later discovered that the reservoirs were interconnected, the findings were categorized as an *«elephant field»* and put under the joint name of Johan Sverdrup. The field is located on the Utsira High, about 140 km west of Stavanger, and ranked as one of the five largest oil discoveries on the NCS with a resource estimate of between 1.7 and 3.0 billion barrels of oil equivalent (Statoil, 2015).

The Johan Sverdrup field is to be developed over several phases, where the first phase encompass the establishment of a field center comprising of four platforms; an accommodation platform, a process platform, a drilling platform, and a riser platform. Later development phases may include the deployment of yet another process platform along with several wellhead platforms situated in the field's more remote areas (Statoil, 2014). Figure 1 provides an illustration of the first phase field center.


*Figure 2: Johan Sverdrup Field Center: Phase 1 – Adapted from (Statoil ASA, 2015)*

### 2.3.1 Kvaerner's Role

In relation to the first phase of the Johan Sverdrup development, Kvaerner have been awarded contracts for building three out of the field center's four steel jackets. All three jackets are to be built under EPC contracts, where Kvaerner's offices in Oslo handles the engineering part while their yard in Verdal carries out procurement and construction. In addition to winning contracts for three steel jackets, Kvaerner also won the contract for delivering the deck for the utility and living quarter (ULQ) platform together with their joint venture partner KBR (former: Kellogg Brown & Root). KBR is a worldwide engineering, construction, and service company who operates in, the markets of energy, oil and gas, minerals and infrastructure.

#### The Joint Venture

In August 2014, Kvaerner and KBR announced that they would establish a joint venture under the name of «$K^2$JV» to improve their competitiveness when bidding for topsides contracts related to the Johan Sverdrup field development (Kvaerner, 2014b). As mentioned, this joint venture later signed a contract with Statoil for the complete delivery of the Johan Sverdrup ULQ platform's topsides.

The joint venture aims to execute the project in a 51/49 percent split between Kvaerner and KBR, where senior personnel from both companies works as one integrated management team (Kvaerner, 2015a). A joint team, situated at KBR's premises in Leatherhead, UK, performs all engineering activities, while procurement activities will take place in both Norway and in the UK. Most fabrication work will be conducted in Poland under the management of Kvaerner, while Kvaerner’s yard at Stord will assemble and equip the final product. If everything goes according to plan, the project will involve a total of close to 2000 employees, and be ready for delivery in the first quarter of 2019.

# Chapter 3

# Literature Review: Managing the Construction Supply Chain

## 3.1 General

A huge portion of researchers who writes on the topic of supplier management in the construction industry, limits their studies to the construction of permanent buildings and infrastructure. A limited few include the construction of large-scale objects like ships, offshore structures, and space shuttles in their literary works. Neither of these products are necessarily fixed in permanent locations, but they are still outcomes of construction projects. Even though authors like Ballard and Howell choose to distinguish between construction and *fixed position manufacturing* (Ballard and Howell, 1998), the similarity of projects within these categories still result in a potential for sharing ideas and practices between them. Due to the significant resemblance between construction and fixed position manufacturing, the present literature review will present theory from both practices, without any further discussion of the two terms.

Modern contractors tend focus on what they believe to be their core activities, while they leave other activities to professionals outside the organization. They do so to enhance their productivity and sustainability, and thereby improve their position in the market (Lin and Gibson, 2011, Mohiuddin and Su, 2013) The increasing use of outsourcing and specialized suppliers have changed the fundamental basics of competition in the construction industry. Rivalry is no longer limited to the firm level, as the main arena for competition now exist between supply chains seeking to outperform each other (Foster, 2008). This new dimension of competition calls for careful management of suppliers.

Managing supplier quality in the construction industry is a rather complex task given the one-off nature of projects, combined with their extensive scope of work and long execution periods. The supply chains required to support such projects are large, global networks of independent suppliers, filled with unique management challenges. Briefly summarized, these challenges are related to ensuring that the required equipment and materials arrives at the construction site on time and at an affordable price, without any outstanding work or need for rework (AlMaian et al., 2015).

Neuman defines construction supply chains as *«fixed position manufacturing, in which the product being manufactured eventually becomes too large to be moved through work stations, so the work stations (work crews) have to move through the product»* (Neuman, 2014). To add some meat to the bone, this definition can be viewed in combination with how Vrijhoef and Koskela view construction supply chains. They characterize construction supply chains as (Vrijhoef and Koskela, 2000):

- **Converging:** Construction supply chains directs all materials to one project-specific location, which then serves as an assembly site for the final product.
- **Temporary:** Construction supply chains are established by project organizations who go through frequent reconfigurations to match one-off construction projects. The resulting supply chains are therefore recognized as fragmented and unstable.
- **Unique:** Projects with the size of construction projects will always differ from each other in some way or another, reducing the amount of repetitive activities.

To cope with competition on the supply chain level, most companies have adopted new methods for cutting costs and improving quality. Nearly all of these methods are heavily dependent on inspections and ISO-certification of suppliers. For the time being, most companies use inspection as a tool for «adding» quality to a product, rather than ensuring quality in the process of producing that particular product (Sullivan, 2011). Harold S. Dodge once said that *«You cannot inspect quality into a product.»*, implying that the degree of quality is determined previous to the time of inspection (Deming, 1986). This highlights an obvious weakness in the construction supply chain's method for ensuring quality. The approach focus on detecting and fixing problems related to finished products, rather than preventing them from occurring in the first place (Sullivan, 2011). When it comes to ISO-certification of suppliers, this certification appears to be the contractors' main pillar for establishing trust in their suppliers. A study conducted by Romano, on Italian suppliers, indicates that this type of trust is eventually arbitrary as neither improved quality nor reduced cost can be related to ISO9000-certification alone (Romano, 2002). In other words, neither supplier inspections nor ISO9000-certifications are sufficient for ensuring market dominance on the supply chain level. This implies that a more extensive framework is required.

## 3.2 Supply Chain Quality Management

When competition went from being limited to the rivalry between firms, to comprising rivalry between entire supply chains, researches started to show interest for exploring quality management in a supply chain context (Kaynak and Hartley, 2008). Through studies on this area, subject matter experts have discovered opportunities for discarding some of the traditional focus on inspections and supplier certifications, replacing it with approaches more beneficial for saving costs and improving quality.

Several authors have argued that there is a need for integrating supply chain management (SCM) with quality management (QM) as organizations who pursue both quality and supply chain goals simultaneously, tend to achieve a competitive advantage that is not easily replicated by rivals (Flynn and Flynn, 2005, Robinson and Malhotra, 2005, Foster, 2008, Kaynak and Hartley, 2008). By integrating these management approaches, firms will enable themselves to move on from controlling quality in supplied products, and onto ensuring quality in the supply chain as a whole. Traditional supply chains, designed for transaction and delivery, can then be replaced by more sophisticated ones, designed for meeting market requirements in a safe and profitable manner (Kuei and Madu, 2001). The idea that sophisticated supply chains are better suited for delivering high quality products at low cost, forms the basis for what is often referred to as *supply chain quality management* (SCQM). The following sections looks closer into the basics of QM and SCM in order to define SCQM and outline its potential benefits.

### 3.2.1 Quality Management

According to ISO 9000, quality management can be considered as the sum of the following four components (ISO, 2015):

- **Quality planning:** aims to establish a set of specific quality objectives and develop the processes required to fulfill these objectives, followed by allocation of resources deemed necessary for developing required processes

- **Quality assurance:** aims to substantiate the organization's ability to fulfill its predetermined quality objectives *(process related)*
- **Quality control:** aims to fulfill the organization's predetermined quality objectives *(product related)*
- **Quality improvement:** aims to improve an organizations ability to fulfill its quality objectives

The aspects of quality planning and quality improvement are described quite straightforward in the ISO 9000, while the definitions of quality control and quality assurance appears a bit more diffuse. To make these expressions more comprehensible, Arditi and Gunaydin distinguish between *product quality* and *process quality*. They define product quality as quality directly related to a physical product, and process quality as the quality of the processes used for fabricating and evaluating that particular product (Arditi and Gunaydin, 1997). With this in mind, quality assurance can be defined as a systematic approach towards assuring that a given process is sufficient for producing a product that matches a set of predefined specifications and requirements. While quality control can be defined as verifying that the finished product actually confirms to these specifications and requirements (Rose, 2005).

### 3.2.2 Supply Chain Management

SCM has emerged as an approach that allows firms to conduct inter-organizational operations in a more efficient manner. The approach emphasize the importance of collaboration between all participants throughout the supply chain, when pursuing business superiority (Robinson and Malhotra, 2005). Briefly stated, supply chain management is a set of practices and principles aimed towards managing and coordinating supply chain members, starting with those who acquire raw materials upstream, and terminated by the customers who evaluates overall quality downstream (Lin and Gibson, 2011).

Many authors have attempted to define the concept of SCM, but few have succeeded in capturing all aspects of the term. Through their empirical research on SCM, Ho et al. analyze and compare existing definitions, before they eventually propose a more comprehensive one of their own:

> *SCM is a philosophy of management that involves the management and integration of a set of selected key business processes from end user through original suppliers, that provides products, services, and information that add value for customers and for other*

*stakeholders through the collaborative efforts of supply chain members (Ho et al., 2002).*

Even though the idea of supply chains had been around for a long time when SCM first emerged, most organizations limited their attention to in-house activities. Few organizations focused on how to manage the activities designed to deliver products and services from suppliers in one end of the supply chain, to customers on the other (Handfield, 2011).

### 3.2.3 Merging of QM and SCM

A number of authors have argued that there exist positive synergies between QM and SCM, and that by merging these management approaches, organizations can realize remarkable value potentials. A study conducted by Flynn and Flynn confirms the existence of such synergies, and concludes that organizations should pursue these, despite the possibility of losing short-term revenues (Flynn and Flynn, 2005). The former practice of establishing departmentalized quality functions are outdated, and modern contractors must integrate quality with their overall strategic business approach in order to be successful in the marketplace. In other words, traditional QM must adopt a supply chain perspective and utilize both quality improvements and supply chain coordination simultaneously to best serve the end customers (Robinson and Malhotra, 2005). Supply chain performance is dependent on the relationship between supply chain members, and thereby on activities like acquisition of materials, supervision, training, coordination, etc. (Kuei and Madu, 2001).

The sum of these thoughts has formed the basis for the management approach referred to as SCQM. Most of the central researchers who have proposed ways to define SCQM have based their definitions on the ideas of either Kuei and Madu, or Robinson and Malhotra. Kuei and Madu defines SCQM with the help of the three simple equations illustrated in Table 1.

*Table 1: Equations for Defining SCQM – based on (Kuei and Madu, 2001)*

| | | |
|---|---|---|
| **Supply chain** | **=** | ***A production-distribution network,*** |
| **Quality** | **=** | ***meeting market demands correctly, and achieving customer satisfaction rapidly, and profitably, and*** |
| **Management** | **=** | ***enabling conditions and enhancing trust for supply chain quality.*** |

The present author finds the equations proposed by Kuei and Madu more suitable for describing an ideal supply chain, than for defining the concept of SCQM. For this reason, the present thesis will rely on the following definition, purposed by Robinson and Malhotra, in any further discussions of SCQM:

> *SCQM is the formal coordination and integration of business processes involving all partner organizations in the supply channel to measure, analyze and continually improve products, services, and processes in order to create value and achieve satisfaction of intermediate and final customers in the marketplace (Robinson and Malhotra, 2005).*

The latter definition emphasize how coordination of inter-organizational QM practices upstream is essential for achieving customer satisfaction downstream. This is pretty much in line with the work of Lin et al. who recognize supplier selection, buyer-supplier relationships and QM activities as vital for achieving high performance downstream (Lin et al., 2005). Baban argues that suppliers needs to rest assure that they will obtain business continuity, at least for the near and middle term future, if such buyer-supplier relationships are to be fruitful (Baban, 2013). Suppliers will not bother to commit time and resources to a specific customer's quality requirements, unless the relationship with this customer will remain constant for some time. However, more permanent relationships are not likely to see the light of day as long as price continues to remain the main criteria for selecting suppliers. Lin and Gibson strongly advocate that this type of supplier selection practice is put away, as it is doomed to induce poor quality in projects (Lin and Gibson, 2011)

## 3.3 Origin of Supply Chain Surveillance

Supply chain surveillance (SCS), also known as supplier quality surveillance (SQS) or simply quality surveillance (QS), has emerged as a result of the increasing focus on rivalry between supply chains. However, different organizations, both inside and outside the construction industry, have conflicting views on what activities SCS should include (AlMaian et al., 2015). While most organizations limit their SCS practices to QC and/or QA activities at supplier sites, only a few use SCS for instilling quality along the entire supply chain through including activities like supplier selection, supplier assessments, continuous improvement, and transfer of knowledge to future projects (Neuman, 2014). It appears as if the fact that non-conformities discovered at suppliers' sites are less costly to correct than those discovered after equipment or materials have been released, remains the prevailing reason for contractors to practice SCS. In other words, most companies do not embrace SCQM along with the implementation of SCS activities, and SCS becomes just another set of inspections for detecting and correcting deviations, rather than a function that aims to prevent them from occurring in the first place. Apart from in a few cases, the discovery of non-conformities do not trigger any improvement efforts aimed at preventing similar deviations from occurring in the future, and the cycle of rework is allowed to continue (Alves et al., 2013).

One company, who appears to have succeeded in establishing a SCS function that serves the overall concept of SCQM, is Boeing. They have adopted SCS as a proactive approach towards quality, and focus on strengthening the relationship between themselves and their suppliers in the pursuit for mutual gains (Boeing, 2010b). Boeing have moved away from supplier inspections, and towards supplier consulting, using surveillance as a tool for identifying areas where their SCS function can support supplier development (Boeing, 2010a). Toyota and Honda haven taken a similar approach, and include their most important suppliers in what they refer to as the *extended lean enterprise*. Here, contractors and suppliers establish mutual goals for reducing costs and improving quality (Liker and Choi, 2004). By taking this approach, these manufacturers have managed to improve the competitiveness of their supply chains, without feeding on their suppliers' revenues. Despite the fact that these manufacturers are not part of the construction industry, their practices are still highly relevant for construction supply chains.

## 3.3 A Lean-Inspired Touch to SCS

The concept of *lean*, originally limited to manufacturing, emerged in Japan following the Second World War. Japan had suffered heavy bombing during the late stages of the war, and Japanese manufacturers quickly realized that the investments required to rebuild their factories were far out of reach (Bhamu and Singh, 2014). Without the option to rebuild, manufacturers were forced to *do more with less* through making their production *«leaner»*. This was the start of the lean-practitioners' never-ending hunt for activities that consumes resources without adding value, popularly referred to as *muda* (the Japanese word for waste) in lean environments. The present thesis will not preach the implementation of a full-scale lean system, but merely highlight how the basics of lean can be useful for enhancing the performance of companies who embrace the concept of SCQM when establishing SCS practices.

Even though lean thinking was applied successfully in the manufacturing industry, a lot of skepticism exist surrounding ideas of implementing lean practices in the construction industry. Much of this skepticism origin from the fact that, in the end, manufacturing and construction are two quite different things. One can argue that construction is a special type of manufacturing, combining fabrication and large scale assembly (Ballard and Howell, 1998), but extensive construction projects will continue to remain fundamentally different from the manufacturing conducted in shops. As mentioned earlier, construction projects are unique and temporary, something which prevents traditional lean practices from being implemented directly. Zimmer et al. makes an important statement when they argue that the reason why the construction industry do not show any significant improvements from implemented lean practices is because most implementation attempts this far, have focused on the field of operations, while lean thinking as a concept targets entire value streams. Further, they identify the supply chain as one of the main areas where waste resides in construction projects (Zimmer et al., 2008), implying that there exist a significant potential for implementing lean practices in construction supply chains.

The SCQM approach discussed earlier entails an extensive focus on obtaining quality throughout the supply chain. Without emphasizing it, the approach is already pretty much in line with the basics of lean. Both lean and SCQM aims to improve the bottom line result, by altering and/or removing poor practices upstream. Such practices, or waste, becomes evident in construction supply chains when quality costs are scrutinized. To achieve a better understanding of how quality costs occur, it can be useful to divide them into three sub-categories (Arditi and Gunaydin, 1997):

- **Prevention cost:** costs related to activities designed for preventing errors and deviations
- **Appraisal cost:** costs related to activities designed for determining whether products, processes, and services are in line with established requirements

- **Deviation cost:** costs occurring as a result of not meeting predefined specifications and/or requirements

Traditional lean thinking considers inspections and supplier surveillance as wasteful activities. Nevertheless, inspections cannot be dismissed as pure waste when lean thinking is applied in construction projects. This is because non-conformances in construction projects may induce extreme expenses and/or catastrophic accidents (Ahmad, 2014). From the quality cost categories defined above, it is evident that simply eliminating prevention- and appraisal costs will increase the probability of deviations, resulting in an overall increase in deviation costs. As prevention- and appraisal costs are most often negligible compared to the potential deviation costs, inspections become vital in construction projects, and will continue to remain so for all projects conducted in the foreseeable future. This statement is strengthened by McGeorge and Zou, who points out that deviation costs are not only the direct costs of not meeting predefined specifications and requirements, but also include loss of revenues resulting from fleeing customers and deteriorating business reputation (McGeorge and Zou, 2012). The following sections will look closer into a set of lean-inspired touches that are likely to improve the construction supply chain's competitiveness, through reducing the life-cycle costs of acquisitions.

### 3.3.1 Introduce Continual Improvement

*Continual improvement*, often referred to as *continuous improvement*, is the core foundation of lean practices. It aims to continually improve products, services, and processes by identifying and removing wasteful activities, while implementing quality enhancing measures (Wig, 2009). Even though lean-literature tend to favor the term *continuous* over *continual* when introducing improvement processes, the present thesis will cling to the latter. This is because of the relation between the words' linguistic differences, and the nature of construction projects. Continual improvement implies that improvements happens frequently, while continuous improvement implies that the improvement process never pause (Grammarist, N/A, Oxford Dictionaries, N/A). In relation to project-based operations, the present author finds it more correct to talk about continual improvement, as the improvement process will cease in-between projects, resulting in discontinuity.

The perhaps most famous approach to continual improvement is the PDSA Cycle illustrated in Figure 3. The cycle consists of four systematic steps that are supposed to drive a never-ending improvement process, by being repeated over and over (Wig, 2009, Deming Institute, 2016):

- **Plan:** Set a goal for an upcoming improvement initiative, and define how to identify whether the initiative was a success or not. Develop a plan that describes a set of measures that are believed to make the improvement initiative succeed.
- **Do:** Implement the measures described in the improvement plan developed in the previous step.
- **Study:** Observe how the recently implemented measures affects the product or process under study. Keep an eye out for signs of progress, success, potential problems, and areas with potential for further improvements.
- **Act:** Evaluate the results of the recent study, and determine whether the improvement initiative had the desired effects or not. If the results are satisfying, recent changes should be standardized. Regardless of whether the study showed success or not, the results should be integrated in the planning of upcoming improvement initiatives.


*Figure 3: The PDSA Cycle - (Butler, 2015)*

## Zero Punch

Maintaining a continual improvement process over time can be challenging, as it is difficult to motivate people to continue with a process that has no specific goal nor a predefined termination date. The challenge may seem even larger for companies who have recently adopted the SCQM perspective, as this involves the establishment of continual improvement efforts at supplier sites as well. To sustain commitment to the cause, contractors often adopt what is referred to as the *zero punch* approach. The basic idea of the zero punch approach is to eliminate all product deviations, or punch, before the product is released from its supplier.

By adopting a zero punch approach, contractors establish both a starting point and a vision for future improvement initiatives, two important factors for successfully maintaining a continual improvement process over time. Whether achieving zero punch is actually practicable or not is of less importance, as long as it serves as a mean for aligning contractors and their suppliers in the pursuit of improvements. The most successful zero punch approaches focus on creating products free of deviations rather than treating deviations after the fact (Roebuck cited in Clippinger, 2015).

### 3.3.2 Establish More Permanent Relationships with Suppliers

Conventional contractors use multi-sourcing strategies for leveraging their suppliers, resulting in lower prices on products and services. Obviously, such strategies emphasize price and availability in the supplier selection process (Lo et al., 2007). This strong focus on costs may cause ignorance of other important factors. A prime example is how suppliers who submit low bids often have let their cost mentality overrule the importance of quality, resulting in risky corner cutting during the bid preparation phase (Chen and Yang, 2002). By selecting suppliers who clearly down-prioritize quality, contractors are likely to increase the need for thorough follow-up activities later. From a lean perspective, this intensification of inspections are equivalent with increasing the amount of waste in the supply chain. For large construction projects, depending on a vast number of suppliers, only a minor increase in inspection intensity will result in a substantial increase in inspection related expenses. Ahmad concludes that choosing suppliers based on quality rather than cost will eventually outweigh the initial gain of choosing the cheapest supplier, as selecting suppliers who are capable of delivering quality products will eventually reduce the cost of supplier follow-up activities along with the need for correctional actions (Ahmad, 2014).

By altering their supplier selection processes so that it values quality over initial costs, contractors enable themselves to enter more permanent relationships with their suppliers. Existing literature use several terms when discussing such relationships, all with slightly different content. Among these expressions are (Chin et al., 2006, Flynn et al., 2010, Baban, 2013, AlMaian et al., 2015):

- **Strategic alliances**
- **Supply chain integration**

- **Centralization**
- **Partnering with suppliers**

Despite their differences, the main message in these terms appears to coincide with Arditi and Gunaydin's idea that contractors should enter closer relationships with their suppliers in order to ensure delivery of high quality products with low life cycle costs (Arditi and Gunaydin, 1997), something which is critical for the success of future projects. The present thesis will not go any further into the detailed differences between the terms listed above, and will simply consider the overall aspect of establishing closer relationships between contractors and suppliers.

By following in the footsteps of companies like Toyota, Honda, and Boeing, contractors in the construction industry may take their SCS functions one step further. As discussed earlier, these manufactures have embraced the essence of SCQM by letting their SCS functions evolve into something more than just an organ for detecting and correcting non-conformances. They have moved on from solely inspecting their suppliers, and now offer consulting services as well. By taking a similar approach, contractors in the construction industry may conduct continual improvement efforts at their suppliers' premises, increasing the quality of supplied products while decreasing the need for intense inspection routines. Thompson et al. argues that establishing closer relationships is especially advantageous when these have the potential to span over several consecutive projects (Thompson et al., 1996). This is because longer relationships will make it more fruitful for contractors to develop their suppliers' capabilities through continual improvement, while it becomes more beneficial for the suppliers to act accordingly.

### Training and Development of Suppliers

Even though it is widely accepted that contractors must foster and maintain relationships with their suppliers in order to extract maximum value from their supply chain, contractors are still reluctant to the idea of supplier development (Wagner, 2006). Krause defines supplier development as *«any effort by a buying firm to improve a supplier's performance and/or capabilities to meet the buying firm's short- and/or long-term supply needs»* (Krause, 1997). Based on the work of Krause, Wagner distinguish between direct- and indirect supplier development, and conclude that these are two closely interrelated aspects (Wagner, 2006). In a subsequent article, he provides a more precise description of the two terms (Wagner, 2010):

- **Indirect supplier development:** is when buyers commit no or limited resources to the development of their suppliers, and rely on the promise of future business opportunities and communication of evaluation results for motivating their suppliers to initiate improvement efforts on their own.
- **Direct supplier development:** is when buyers takes on a more active role towards developing their suppliers, and allocate relationship-specific resources to the development process. These resources are human and/or capital resources, aimed at transferring knowledge and practices from buyers to suppliers.

Krause concludes that the two development approaches should be integrated, as the indirect approach serves as a key enabler for achieving success in the direct development activities (Krause et al., 2000). Direct supplier development include activities like (Krause, 1997, Chen et al., 2016):

- Supplier visits and on-site consultation
- Supplier certification programs
- Temporary transfer of expertise
- Training and education of supplier personnel

If compared to the traditional philosophies practiced in most SCS functions, it should be fair to argue that these functions limit their practices to indirect supplier development. From a SCQM approach, this is not sufficient for achieving future success, and modern SCS functions must comply with Krause's ideas on integrating direct- and indirect supplier development. By carefully investing time and resources in the training and development of suppliers, contractors may reap future benefits that stretches far beyond the initial investments.

### First Article Inspections

Aviation, space and defense industry have successfully applied first article inspections (FAI) for improving safety and quality, while reducing costs related to non-conformances throughout the supply chain. FAI's are usually conducted as soon as the production of the first article or batch has been completed, and aims to ensure that a supplier is actually capable of producing the product in accordance with predefined specifications and requirements, before full-scale production takes place (ASD-STAN, 2015). Even though FAI's are most often practiced in relation to series production of simpler products, its benefits should apply for the production of more specialized equipment as well.

At first glance, it may appear harebrained to introduce an additional set of inspections, when the ultimate goal of lean thinking is to eliminate such «wasteful activities». However, if closer relationships are established between contractors and suppliers, these inspections may prove useful for verifying quality in the early stages of production, and thereby reduce the number of non-conformities developing over time. In other words, by making FAI's part of their SCS practices, contractors can reduce the intensity of inspections required later. As FAI's are conducted at an early point in production, where the suppliers have only made limited investments, they become something more than just routine control activities. Detecting deviations this early will be beneficial for both contractor and supplier, and is likely to mitigate future quarrels.

### 3.3.3 Conduct Supplier Evaluations

Performance measurement is a vital part of the continual improvement process. It identifies areas with improvement potentials in the early phases of the process, while it serves as a verification tool following implementation of improvement measures in the later phases. As James H. Harrington famously stated:

> *Measurement is the first step that leads to control and eventually to improvement. If you can't measure something, you can't understand it. If you can't understand it, you can't control it. If you can't control it, you can't improve it* (Harrington, 1999).

Along with SCQM and the establishment of closer and more permanent relationships between contractors and their suppliers, comes the need for a new approach towards performance measurement. Measurements that focus solely on contractor's internal performance are no longer a sufficient guiding pin for future improvement initiatives. Therefore, current performance measurement practices must be broadened and further developed, in order to ensure further optimization of the supply chain's competiveness (Haald and Ellergaard, 2011). In other words, modern SCS functions are dependent on supplier evaluation systems for fueling their continual improvement process.

The supplier evaluation process seeks to rate the performance of existing suppliers, based on how well they manage to fulfill their total obligations towards contracts and purchase orders (Emmett and Crocker, 2007). Supplier evaluation serves two purposes as it stimulates both the contractor's future supplier selection process, and the suppliers' ongoing improvement processes (Haald and Ellergaard, 2011). Even though much of the existing literature solely focus on benefits related to the selection of future suppliers, ref (Kannan and Tan, 2002, Chin et al., 2006, Songhori et al., 2011), the present thesis aims to include the additional benefits that can be harnessed when supplier evaluation is used as input in the continual improvement process. For the results of an evaluation process to be of any value, some sort of reference point must be present. Therefore, measured performance are usually compared to either a standard, the evaluated supplier's past performance, or the performance of a competing supplier (Giannakis, 2007).

Emmet and Crocker summarize the benefits of evaluating suppliers as follows (Emmett and Crocker, 2007):

- Makes it possible to identify supplier weaknesses that should be addressed, and which may have formed a basis for claiming compensation
- Results in ratings that can be used as benchmarks when evaluating other suppliers
- Serves as a basis for conducting and evaluating continual improvement initiatives
- Provides an overall rating of a supplier's performance that is less likely to be biased by personal relationships between buyer and supplier

### Development of Supplier Scorecards

Supplier scorecards are developed to ease the process of conducting structured supplier evaluations. For a long time such assessment schemes have been limited to financial measures, but the increasing knowledge of SCQM have gradually introduced the use of more quality- and supply chain oriented rating systems. In its simplest form, a supplier scorecard consists of a set of predefined areas where performance are to be evaluated, and a rating system that allows the assessor to indicate how well the supplier performs in these areas. More advanced scorecards also include the supplier's past performance, the contractor's future expectations, and some sort of weighting system that emphasize the more important evaluation criteria. Figure 4 illustrates a typical scorecard, with a qualitative rating system and weighted grading. Due to the inaccurate nature of the linguistic attributes related to qualitative rating systems, the total rating will usually vary depending on who the assessor is (Rajkumar and Kumar, 2004). For this reason, qualitative rating systems should be accompanied by a certain amount of quantitative criteria.

Company A–supplier evaluation
Supplier: XXX
Supplierno: XXX
Product: Electronics
Contact persons: Employee x and Employee y
Rated by: CM, PD, and OP

Rating:
1. Excellent
2. Good
3. Average
4. Not satisfactory
5. Not acceptable

| Rating | | Q2–200X | | |
|---|---|---|---|---|
| | | Grade | Weight (%) | Total |
| A | Product quality | 4 | 25 | 1.00 |
| B | On-time-delivery | 5 | 25 | 1.25 |
| C | Cooperation | 2 | 15 | 0.30 |
| D | Environment | 1 | 10 | 0.10 |
| E | Total cost development | 5 | 25 | 1.25 |
| Total | | | Grade | 3.9 |

*Figure 4: Example of Basic Evaluation Scheme (Haald and Ellergaard, 2011)*

Bourne distinguish between three approaches for developing supplier score cards (Bourne et al., 2003):

- **The *needs led* approach:** This is a top down approach, where customer- and stakeholder needs are identified and used for developing a set of evaluation criteria. Thus, the scorecard becomes a mean for monitoring the contractor's progress towards fulfilling these needs.
- **The *audit led* approach:** This is a bottom up approach, initiated by the audit of an existing scorecard. The results of the audit is then used for improving existing evaluation practices.
- **The *model led* approach:** Here a theoretical model of the organization forms the basis for developing a suitable rating system.

In relation to the present thesis, the audit led approach is out of the question as the use of supplier scorecards is currently untouched within Kvaerner's SCS function. Due to the SCS function's nature, and heavy focus on quality, the needs led approach seems like a natural starting point. As mentioned earlier, the execution period of the studied project is far more extensive than the one of the present thesis, and parts of the case study in chapter 4 is therefore based on a model of how the SCS function should operate under ideal conditions. To conclude, the needs led approach would be the most appropriate one for developing a supplier score card to be used by Kvaerner's SCS function, but the one to be developed in relation to the present study will have to be based on a hybrid between the needs led- and the model led approach.

# Chapter 4

# Literature Review: Transfer of Knowledge

## 4.1 Introduction

It is a well-known fact that EPC contractors are generally quite poor at harnessing knowledge and experience from ongoing projects. When confronted with the crippled knowledge sharing between their projects, contractors tend to blame their very nature. Existing literature commonly refer to projects as unique and temporary tasks, conducted to accomplish a set of predefined goals. Contractors claims that the uniqueness degrades the relevance of knowledge sharing, while the temporariness makes it impracticable as the project members who possess relevant knowledge and experience are scattered to the four winds as soon as the project hits the finish line.

Even though projects are unique per definition, there still exist a significant potential for transferring both knowledge and experience across them. Sir John Seely Brown (Prokesch, 1997) once said, «*Most activities or tasks are not one-time events. […] every time we do something again, we should do it better*». In the spirit of these words, it should be fair to argue that proper routines for transferring knowledge can enable future projects to make use of proven methods and solutions, and thereby avoid already discovered pitfalls. By repeating successful decisions and avoiding old mistakes and rework, contractors can greatly enhance their value creation. Moreover, the only way to safeguard this value creation is through effective knowledge management.

### 4.1.1 Knowledge Management

Knowledge management aims to conserve, develop, and distribute organizational knowledge in a way that allows the organization to utilize it in an efficient manner (Davenport, 1994). A widely cited definition of knowledge management is the one developed by the Gartner Group:

> *Knowledge management is a discipline that promotes an integrated approach to identifying, capturing, evaluating, retrieving, and sharing all of an enterprise's information assets. These assets may include databases, documents, policies, procedures, and previously un-captured expertise and experience in individual workers* (Gartner Group, 1999).

It is this expertise and experience residing in individual workers that organizations must be captured and transferred across projects in order for contractors to realize their true potential for value creation.

## 4.2 What is Knowledge?

In everyday life, we use the term «*knowledge*» quite casually, and very few of us walk around with clear distinctions between knowledge, and terms like data and information. However, when examining knowledge transfer, such distinctions must be present as there is no use in attempting to transfer knowledge if one do not know what knowledge really is. Consequently, many authors choose to introduce epistemology, the study of knowledge, into their literary works. By doing so, they are able to state and describe assumptions on how knowledge can be obtained, stored, and distributed.

### 4.2.1 Epistemology

Venzin et al. presents and compares three different epistemologies already introduced by other authors (Venzin et al., 1998):

- **Cognitivist Epistemology:** Here, organizations develop knowledge by formulating increasingly accurate descriptions of the pre-defined environment surrounding them. By gathering data and information on this environment, the organizations are able to describe it more precisely, and thereby generate more knowledge. The data and information harvested is considered universal, and neither influenced by the sender nor the receiver's characteristics. In other words, the cognitivist approach equates knowledge with data and information, implying that it is relatively easy to transfer across projects.

- **Connectionistic Epistemology:** The connectionistic perspective is quite similar to the cognitivist one when it comes to the attempt of describing a pre-defined environment surrounding the organization. However, connectionistic theorists have a slightly different view on how knowledge is transmitted from sources to receivers within an organization. They highlight the contextualized nature of knowledge and claim that knowledge is not only dependent on the stimuli that enters the system, but also on the processes that transfers stimuli from senders to receivers. Theorists do not separate senders from receivers, but focus on the connections between them, where knowledge is judged to reside.
- **Autopoietic Epistemology:** The autopoietic approach is fundamentally different from the two others, as it do not share their view on how organizational knowledge is equivalent with the data and information gathered on a surrounding environment. From this perspective, harnessed data (the lowest form of potential information) is not knowledge, but merely inputs to knowledge creation. Information on the other hand, is considered to be the process that allows the development of knowledge. In other words, data requires interpretation before it can become knowledge, indicating that knowledge cannot be transmitted directly from source to seeker. Koskinen illustrates this with an example of how two students listening to the same lecturer will build different knowledge (Koskinen, 2010).

According to Venzin et al., neither of these epistemologies are deemed superior to the others in general, but in relation to specific studies, one of them might prove more appropriate (Venzin et al., 1998).

When it comes to transfer of knowledge between complex projects where several disciplines are involved, it is obvious that harvested knowledge is not universal. What is considered best practice for one discipline may negatively influence the work rate of one or several others, inhibiting knowledge from being universal and thereby excluding the cognitivist approach from being suitable. At the same time, the temporary nature of projects hampers the connection between knowledge sources and recipients. This connection is crippled because the original source is likely to relocate before anyone attempts to extract the information he initially stored during a foregoing project. With practically no room for any further discussion between source and recipient, these should be viewed as separate entities as there is no guarantee the receiver will interpret the transferred information in the way the knowledge source initially intended him to.

From these arguments, it appears as if the autopoietic epistemology is the better fit for knowledge transfer across projects. The approach seems even more appropriate if one consider how the other epistemologies claims that gathering more data is equivalent with generating more knowledge. While in reality, too much data tends to cloud the mind of the receiver, making it harder to identify what is really important.

### 4.2.2 Data, Information and Knowledge

By adopting the autopoietic epistemology as a foundation for discussing knowledge transfer across projects, one acknowledge the inherent challenge in transferring knowledge from one person to another. Articulated experiences alone are not enough to ensure transfer of knowledge; some common ground between sender and receiver must be present. With this in mind, it becomes even more important to distinguish knowledge from data and information. As illustrated in Table 2, Davenport, Prusak, and Stenmark, all draw towards the autopoietic aspect in their attempt to distinguish between the three expressions, as neither of them consider knowledge as universal.

*Table 2: Views on Data, Information and Knowledge - based on (Davenport and Prusak, 1998, Stenmark, 2002)*

| | **Davenport & Prusak** | **Stenmark** |
|---|---|---|
| **Data** | A set of discrete, objective facts about events. | Information that is too decontextualised, i.e. too distant from the knowledge required to interpret it |
| **Information** | A message, usually in the form of a document or an audible or visible communication. | Knowledge that can be partially articulated and furnished with words. |
| **Knowledge** | A fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. | Personal experiences and cultural inheritance used for creating and interpreting information. |

Both of the literary works compared in Table 2 highlights the important aspect of how the borders between data, information, and knowledge shifts, depending on context and the amount of common ground between the involved parties. Davenport and Prusak argues that knowledge is neither data nor information, even though these terms are related and the difference between them is often a matter of degree. Further, they claim that information is more noble than data, and that one can transform data into information by making it (Davenport and Prusak, 1998):

- **Contextualized:** the purpose for gathering the data is known
- **Categorized:** the units of analysis and/or other key components of the data is known

- **Calculated:** the data is analyzed either statistically or mathematically
- **Corrected:** obvious errors are removed from the dataset
- **Condensed:** the data is summarized in a way that makes it easier to interpret

In a manner similar to the one used for deriving information from data, they further derive knowledge from information. They claim that people can transform information into knowledge through (Davenport and Prusak, 1998):

- **Comparison:** use previous experiences to form a clearer picture of what the received information is trying to tell them
- **Consequence assessment:** evaluate what significance the received information has with regards to future actions and decisions
- **Connection assessment:** how can this piece of information relate to other people/information
- **Conversation:** gather input from others when processing the information

Stenmark views the terms a bit differently, as he do not judge knowledge to be more valuable than information. He claims that information and data are two opposite ends of a continuum, and that whether something is perceived as data or information is dependent on the user's previous knowledge. To conclude, he argues that in order for a person to transfer knowledge, this person must first use his knowledge to derive transferable information (Stenmark, 2002). While Davenport and Prusak only consider how data can become information, and information become knowledge, Stenmark highlight that these processes also happens the other way around; an acknowledgement that will prove itself vital in relation to the challenge of transferring knowledge from one person to another. Despite Stenmark's thoughts on how knowledge is not necessarily more valuable than information, the present study will hold knowledge to be of greater value. This is because there exist no guarantee that the knowledge source will manage to transform his knowledge into information of sufficient quality for the receiver to recreate equivalent knowledge.

### 4.2.3 Taxonomies

The foregoing sections presents theory on how a number of authors choose to distinguish knowledge from data and information when discussing knowledge management and transfer of knowledge. This leads us to the famous, and still ongoing, discussion of knowledge taxonomies.

In the late 50's, Michal Polanyi formulated how people rely on previous experience to shape inputs in the pursuit of knowledge. He described this active shaping of inputs as a tacit, or silently applied, power that resides within human beings. Further, he defined knowledge acquired through this process as «*tacit knowle*dge», based on the idea that humans know more than they are able to express through words and letters (Polanyi, 1958/1962). As a counterpart to tacit knowledge, he also defined «*explicit knowledge*», which represents knowledge that can be articulated through documents or conversation without losing integrity (Nonaka, 1994).

Even though most authors who adopt the autopoietic epistemology also accept Polanyi's idea of a tacit knowledge dimension, there appears to be some dispute on how to treat explicit knowledge. Some authors argue that all tacit knowledge can be articulated, and thereby become explicit, while others argue that tacit knowledge only concern the knowledge that can never be articulated (Bartholomew, 2005). Bloodgood and Salisbury place themselves somewhere in between the two extremes by defining explicit knowledge as knowledge that are easily articulated, and thereby easier to transmit and imitate (Bloodgood and Salisbury, 2001). Then there is Stenmark, who claims that explicit knowledge do not even exist as all that can be articulated is simply information, and thereby have nothing to do with knowledge (Stenmark, 2002).

However, when tied back to the autopoietic epistemology, it should be fair to argue that what exact taxonomy and definitions one choose to support is not that important, as most of the literature in which they are found seems to have conclusions that more or less coincides with the ones provided by Alavi and Leidner. They argue that knowledge can be transferred from one person to another by extracting information from the knowledge source and using it as input to the recipient's knowledge creation process (Alavi and Leidner, 1999). Based on the connection this theory establishes between information and knowledge, Alavi and Leidner concludes that only people who share a requisite amount of common ground can truly exchange knowledge (Alavi and Leidner, 2001). Just imagine the challenge of explaining colors to a person who has never experienced the gift of sight.

## 4.3 Conservation and Retrieval

Levitt and March claims that unless the implications revealed through previous experiences are somehow conserved and transferred to those who did not experience them, important knowledge are destined to vanish along with personnel who retires, or for other reasons leave the organization (Levitt and March, 1988). This storage and retrieval of previous experience is often referred to as organizational memory, an important aspect of knowledge management. Stein and Zwass defines organizational memory as the means by which previously acquired knowledge influence the current practices in an organization (Stein and Zwass, 1995).

Organizational memory is a combination of knowledge and practices stored in routines, archives, and in the mind of individual members. Subject experts often refer to this knowledge contained in the mind of individuals as «tribal knowledge». This is because such knowledge stays with a limited part of the organization, and is likely to vanish unless its essence is extracted before the knowledge-owners take their leave. When extracted, this essence can be articulated and stored in archives, or become part of a continual improvement process and implemented into existing routines.

Knowledge accumulated and maintained within routines will remain in the organization's possession, despite passage of time and turnover of personnel (Levitt and March, 1988). Likewise, everything that is articulated and stored in archives will also remain part of the organizational knowledge. However, experience that is stored in archives may be forgotten, and practically removed from the organizational memory. Routine-based conceptions are more readily available; making it somehow superior to anything stored in archives. Nevertheless, archiving is better suited for situations that do not happen frequently enough to become routines.

### 4.3.1 Lessons Learned

Lessons learned (LL), formerly known as «best practices», is a knowledge management tool developed for maintaining and improving the organizational memory. The term «best practices» was discarded as it was too restrictive, misleading people to believe that there exist only one best practice for each given situation (Koenig, 2012). By returning to the example of how what is considered best practice for one discipline may negatively influence the work rate of one or several others, the flaws of this expression becomes evident.

LL is a further development of the after action review (ARR) introduced by the US Army in the 70's (Carrillo, 2005). The ARR's were based on the idea that following action, too many things required the soldiers' attention for them to focus on writing a report. Thereby, a system was developed to debrief the soldiers, capture the essence of the recent experiences, and store this in a report (Koenig, 2012). The system enabled involved individuals to harness experience from recent events by asking four leading questions (Carrillo, 2005):

- What was the goal of the mission?
- How did the mission actually turn out?
- Why did the mission turn out this way?
- How to improve similar missions in the future?

The original AAR's, used by the US Army, were designed to extract experience in a reactive and structured manner. The more developed LL-systems on the other hand, do not solely consider how to extract experience from past events, but also include how to verify, store, and reuse this experience in the future.  In general, the workflow of LL-systems follow the basic principles illustrated in Figure 5.

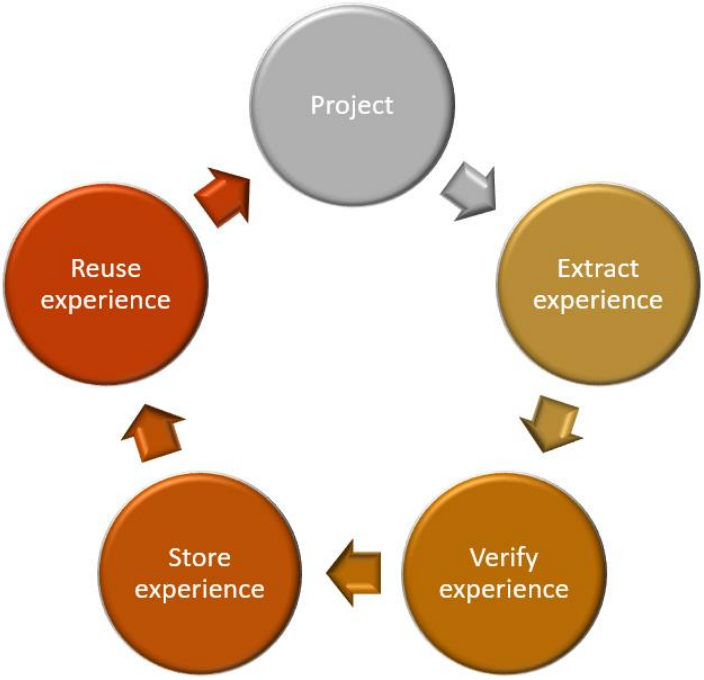


*Figure 5: Generic Workflow of a LL System - adapted from (Weber et al., 2000)*

### Project

The basic idea of a LL system is to capture the knowledge developed through an ongoing project, and use it as a basis for improving future projects. The first step in this process is to identify the areas on which one desire to obtain experience.

### Extraction

Organizations can extract experience from ongoing projects through structured and unstructured processes. It is desirable to capture both positive experiences related to achieving organizational goals, and negative experiences related to unfavorable outcomes. Based on the work of Weber et al., the following three methods for extracting experience from ongoing projects are considered in the present study (Weber et al., 2000):

- **Passive extraction:** Employees submit lessons they recognize as important for future projects through forms, online solutions, and different means of communication with designated personnel.
- **Reactive extraction:** Following a project, or some other significant event, interviews and/or standardized reports are used to ensure the extraction of relevant experience. The ARR's described earlier is considered the mother of reactive extraction.
- **Active extraction:** Whenever an organization identifies a remarkable achievement or a substantial problem, active extraction can be initiated. With either of these outcomes as a starting point, an assessment with the purpose of identifying and harnessing relevant experience is conducted.

### Verification

Experts are assigned to verify whether the extracted experience is applicable for future projects or not (White and Cohan, 2010). In addition to verifying applicability of accumulated experience, the experts are to prevent any redundancies from entering the system.

### Storage

Storing LL's is the last step in capturing the obtained experience. There exists several formats used for storing LL's, but all modern formats are exclusively stored in IT/ICT systems. As a result, modern databases for storing knowledge is usually searchable (White and Cohan, 2010). Moreover, the database could be designed to automatically suggest and distribute LL's based on upcoming activities, or similar trigger points.

### Reuse

To be of any value, the captured experience must at some point be either fed to, or retrieved by future knowledge seekers. Weber et al. refers to this process as «dissemination», and divide it into a set of distinct categories (Weber et al., 2000). With their work as a foundation, this study will distinguish between the following three methods for disseminating experience:

- **Passive retrieval:** Users search for relevant LL's in the experience database, and apply the ones they find useful.
- **Active dissemination:** The LL system is programmed to prompt users with relevant LL's whenever predefined milestones are fulfilled, or key activities initiated. Active dissemination also include the aspect of distributing recently submitted LL's to personnel involved in ongoing activities that may benefit from the experience obtained in these.
- **Reactive retrieval:** Whenever users are in need of additional knowledge, they can invoke a support system to obtain relevant LL's, rather than conducting a manual search within the database.

### 4.3.2 Foresight and Hindsight

Bartholomew introduce two workshops aimed at improving knowledge management, out of which one is used for retrieving knowledge and the other for conserving knowledge. He refers to these as *foresight* and *hindsight* respectively (Bartholomew, 2005).

- **Foresight:** is a workshop where previously acquired knowledge is identified and brought to bear on new projects. Such workshops brings together experienced and unexperienced personnel for discussing alarming aspects of upcoming activities. If conducted properly, foresight-workshops serve as a process where experienced personnel introduce less experienced personnel to upcoming challenges. At the same time, knowledge used for solving similar problems in the past can be located and retrieved from the experience database. From time to time, the less experienced personnel participating in such workshops will bring new solutions on how to treat recurring problems.
- **Hindsight:** is a workshop used for conserving experience at the end of projects. Conventional project reviews are often left to personnel in certain positions, who then have to conduct these singlehandedly. By making project reviews a group activity, reflection and learning happens naturally, and increase the value of the conservation activity. As more people are now involved in the knowledge sharing process, the final product will become more detailed and less biased.

## 4.4 Sharing and Learning

From the theory presented on knowledge transfer this far, it has become evident that the transfer process concerns both sharing and learning. From the choice of epistemology, the present thesis acknowledge the inherent challenge in transferring knowledge from source to receiver. Shortly summarized, the challenge origins from the idea that knowledge cannot be transferred directly from one individual to another, as it must first be converted into a storable format to become transferable. The storable format can then be obtained by the receiver, who will attempt to recreate the knowledge from which it was once deduced.

This brings us back to the discussion of knowledge taxonomies, where subject experts discuss the difference between tacit and explicit knowledge. For simplicity and practical reasons, this thesis will equate explicit knowledge with data and information, and the terms will be used interchangeably from here on out. Despite this simplification, the thesis is still in line with the mentioned work of Alavi and Leidner, which describe how knowledge can be transferred through extracting knowledge essence from a source and using it as input in a receiver's knowledge creation process.

Nonaka defines the transfer of knowledge as a process of externalization and internalization, where externalization refers to the conversion of tacit knowledge into explicit knowledge, and internalization refers to conversion of explicit knowledge into tacit knowledge (Nonaka, 1994). From this perspective, the existence of problems that may hinder people from sharing and learning from each other is easy to imagine. Subject matter experts often refer to these problems as *barriers*. Schilling and Kluge defines barriers as *«those factors either preventing organizational learning or, at least, impeding its predictability»* (Schilling and Kluge, 2009). To familiarize with the concept, the views of two central authors are compared in Table 3.

*Table 3: Views on Transfer Barriers - based on (Disterer, 2001, Szulanski, 2002)*

| Distere | Szulanski |
|---|---|
| **Individual barriers:** | **Motivational barriers:** |
| - Uncertainty | - Lack of confidence |
| - Motivation | - Lack of incentives |
| - Loss of power | - Jealousy |
| - Revelation | - Resistance to change |
| | - Turf protection |
| | - Organizational structure |
| | - etc. |
| **Social barriers:** | **Knowledge barriers:** |
| - Language | - Recipient's lack of prior knowledge |
| - Conflict avoidance | - Recipient's lack of ability to unlearn |
| - Bureaucracy and hierarchy | - Poor understanding of transfer practice |
| - Incoherent paradigms | - etc. |

Distere distinguish between two types of transfer barriers; those related to the individual's motives and agenda, and those related to how the individual acts in a social setting (Disterer, 2001). These categories appears quite interwoven, and it should be fair to argue that they can be seen as two sides of the same coin. Szulanski, who is known for criticizing authors sharing Disterer's view, compile these barriers into one category and refer to them as *motivational barriers.* He argues that motivational barriers are merely incentives for not transferring knowledge, while the real reason for not doing so resides within what he refers to as *knowledge barriers.* Knowledge barriers are qualitatively different from the motivational barriers as they consider an individual's ability, rather than willingness to share and absorb knowledge (Szulanski, 2002).

Schilling and Kluge adds yet another dimension to the aspect of barriers. Not only do they consider how barriers may hinder individuals from sharing and acquiring knowledge, they also describe how barriers may restrict knowledge from being absorbed on a group or organizational level. To show this connection between individuals, groups, and organization, they present what is referred to as the 4I model (Schilling and Kluge, 2009):

- **Intuiting:** individuals develop personal knowledge from personal experience
- **Interpreting:** individuals share their insights with others through words and actions
- **Integrating:** understanding of an experience reaches consensus on group level
- **Institutionalizing:** the shared understanding is implemented in systems, procedures and strategies, and thereby released from its origin with a group or individual

The barriers situated between individual, group, and organizational levels are not too different from those described by Distere and Szulanski, but acknowledging their existence is of great importance for developing a successful system for knowledge transfer. Barriers related to institutionalizing is especially important, as removal of these is critical for handling the problem of tribal knowledge.

Instead of adopting one of the views presented above, this thesis will combine all of them to acquire a broader view on barriers. Any barriers that impede the externalization process will be referred to as *barriers to sharing*, while any barriers that impede the internalization process will be referred to as *barriers to learning.* In addition, the term *technical barriers* will be used when referring to any barriers that are closely related to the knowledge database's design or attributes. Figure 6 illustrates how barriers may cripple the process of knowledge sharing.

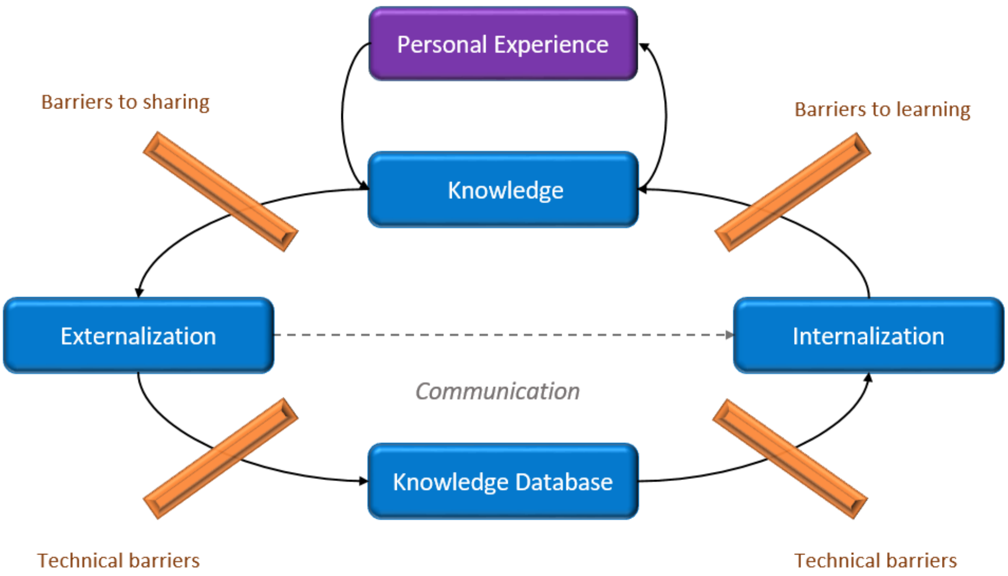


*Figure 6: Barriers in the Sharing and Learning Process – adapted from (Schilling and Kluge, 2009)*

# Chapter 5

# Case Study: Current Practices in $K^2$JV's SCS Function

## 5.1 Definitions

The following definitions are not official, and merely aim to explain how terms and expressions are used within this chapter.

*Bulk*

Identical and interchangeable devices, free of tag specifications.

*Commissioning*

Verification of equipment and bulk's functional requirements.

*Company*

An organization that have contracted another organization to perform a predefined scope of work.

*Contractor*

An organization that, by contract, is bound to execute a predefined scope of work.

*Equipment*

A unique device with an assigned tag, and thereby a predefined purpose in the overall construction.

*Mechanical Completion*

Verification of whether equipment and bulk is in accordance with specifications and ready for commissioning.

*Preservation*

Actions carried out to prevent degradation of equipment and bulk during storage periods.

*Punch List*

A list prepared near the end of a project, describing work and activities that are incomplete by the time they should have been completed. This includes completed work and activities that needs to be redone or modified.

*Tag*

Identification of a unique/individual item within a system.

## 5.2 Introduction

The results from this case study represents how the present author interprets the methods and processes practiced within $K^2$JV's SCS function. These results are based on observations, dialog, interviews, and information obtained from manuals, procedures and similar sources of documentation. Despite multiple external reviews, the methods and processes described here might deviate slightly from those actually performed.

### 5.2.1 Purpose of the SCS Function

The main purpose of the SCS function is to ensure that equipment- and bulk packages, supplied by external organizations, arrives at the construction site on time and with the correct quality. This is vital for ensuring safe and efficient implementation of these when they are to be integrated with the overall structure. $K^2$JV defines supply chain surveillance as:

> *The continuous monitoring and verification of the status of procedures, methods, conditions, processes, products and services, and analysis of records performed in relation to stated references to ensure that specified requirements for quality are being met ($K^2$JV, 2015b).*

From the definition above, it follows that the SCS Function fulfills its purpose through diligent inspection- and verification routines.

### 5.2.2 Procurement of Equipment and Bulk Packages

When acquiring equipment and bulk from suppliers, $K^2$JV assigns a team of two persons for each respective package, who are then responsible for the procurement process. Each team consists of one package responsible buyer (PRB) and one package responsible engineer (PRE). The PRB is responsible for the coordination and execution of all commercial procurement activities, while the PRE is responsible for the acquisition's technical aspects. In addition, one of them receives the title of package responsible lead (PRL), granting him or her the overall responsibility for the acquisition.

The fact that successful supervision of suppliers requires expertise within more disciplines than any single person can acquire, forms the foundation for $K^2$JV's SCS function. The function consists of a multidisciplinary team who have experience with following up suppliers and conducting mechanical completion (MC) activities. This forms a pool of expertise where PRE's can acquire both services and knowledge. The basic idea of the SCS function is for it to assist the PRE with package-related activities on request, but in the practice the function have a slightly more active role. For most acquisitions, the SCS team suggests a set of surveillance activities, which is then merely approved by the PRE.

## 5.3 Overview

The previous section described how the SCS function intend to support the PRE's in the process of following up procurement packages. This section aims to describe the SCS function's workflow from the PRE approves their suggested surveillance activities, and until the ordered equipment or bulk is ready for delivery. Figure 7 illustrates a simplification of this workflow, and is followed by a more detailed description of the different process steps.

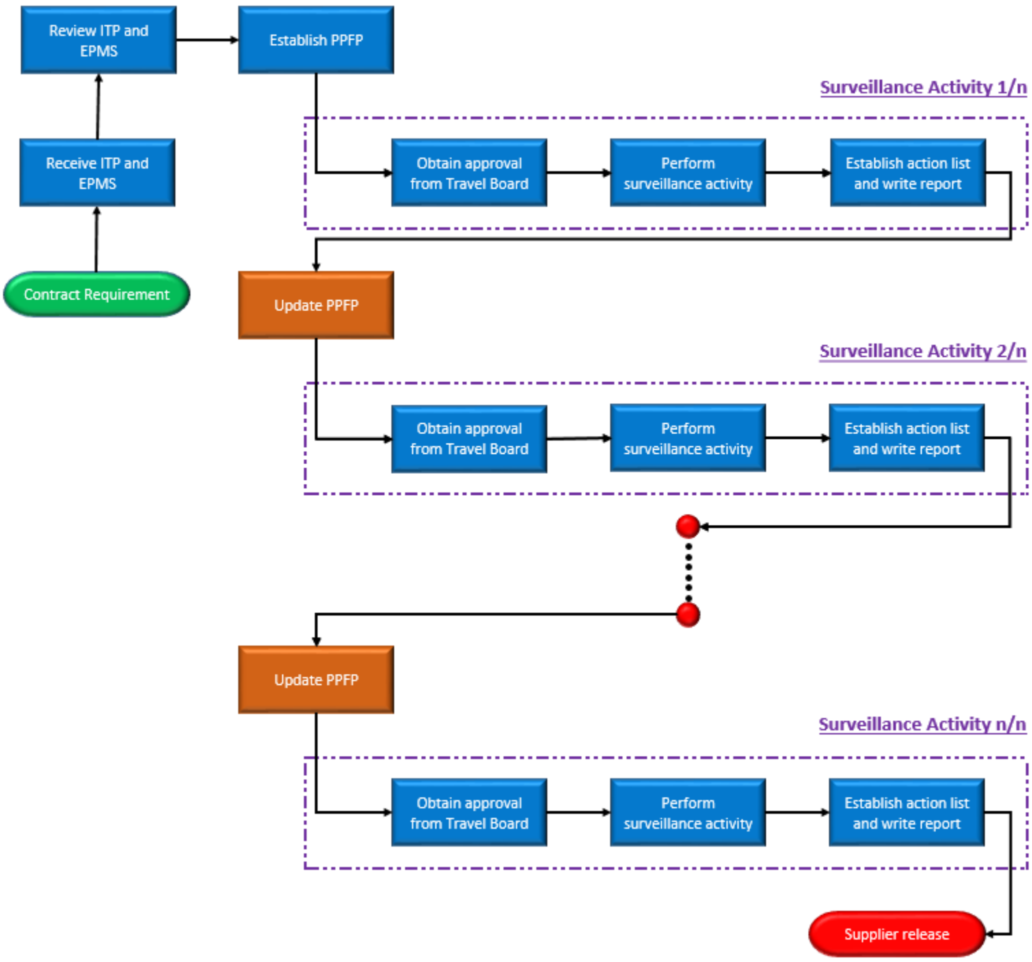


*Figure 7: Simplified Workflow*

### 5.3.1 ITP and EPMS

All of K$^2$JV's suppliers are by contract required to submit an inspection and test plan (ITP) along with an engineering, procurement and manufacturing schedule (EPMS). This must be done within four weeks after receiving the initial purchase order (PO).

The ITP is supposed to give an overview of the different inspection and test activities required during the supplier's fabrication process, and define the stakeholders' degree of involvement in each of these activities. The stakeholders accounted for will normally include the supplier himself, K$^2$JV, Statoil, and any critical sub-suppliers.

The EPMS, also referred to as the construction plan, is a schedule of all tasks to be handled by the supplier from the time he receives the PO and until he delivers the final product. In order to better illustrate start-up dates, durations and dependencies, the EPMS normally comes in the form of a Gant chart.

When viewed in combination, the ITP and the EPMS should provide $K^2$JV with information that allows them to identify the following ($K^2$JV, 2015h):

- Deadlines for when $K^2$JV must submit information and documentation required by the supplier's fabrication process
- Specific dates highlighting by when the final product and documentation must be delivered
- Dependencies between activities
- Duration of the different activities; including startup dates, intermediate milestones and completion dates
- All witness tests and hold points where $K^2$JV's presence is required (a more detailed description follows in section 5.4.6)
- Delivery dates and bonus/payment related milestones
- Main inspection and testing activities, accompanied by a description of the product or process to be tested
- Codes, standards and specifications applicable to activities, tests, and inspections
- All activities to be undertaken by supplier or sub-supplier
- All activities to be undertaken by $K^2$JV or a third party firm
- Main principles of the project specific quality plan
- Detailed manufacturing and delivery plans for all critical equipment and materials to be provided by sub-suppliers

### 5.3.2 Procurement Package Follow-Up Plan

All surveillance activities are carried out in accordance with an inspection and verification program, referred to as the procurement package follow-up plan (PPFP) ($K^2$JV, 2015b). The PPFP is a compilation of all verification and follow-up activities to be performed at the supplier's premises in relation to a specific purchase order ($K^2$JV, 2015a).

The overall objective of the PPFP is to ensure timely delivery of equipment and bulk, with a minimal amount of punch. Ideally, the number of punch equals zero, but this is virtually unobtainable in practice. In combination with a criticality rating assessment, which will be further described later, the supplier's ITP and EPMS indicates how extensive the PPFP's follow-up activities should be in order to achieve a practical minimum of punch.

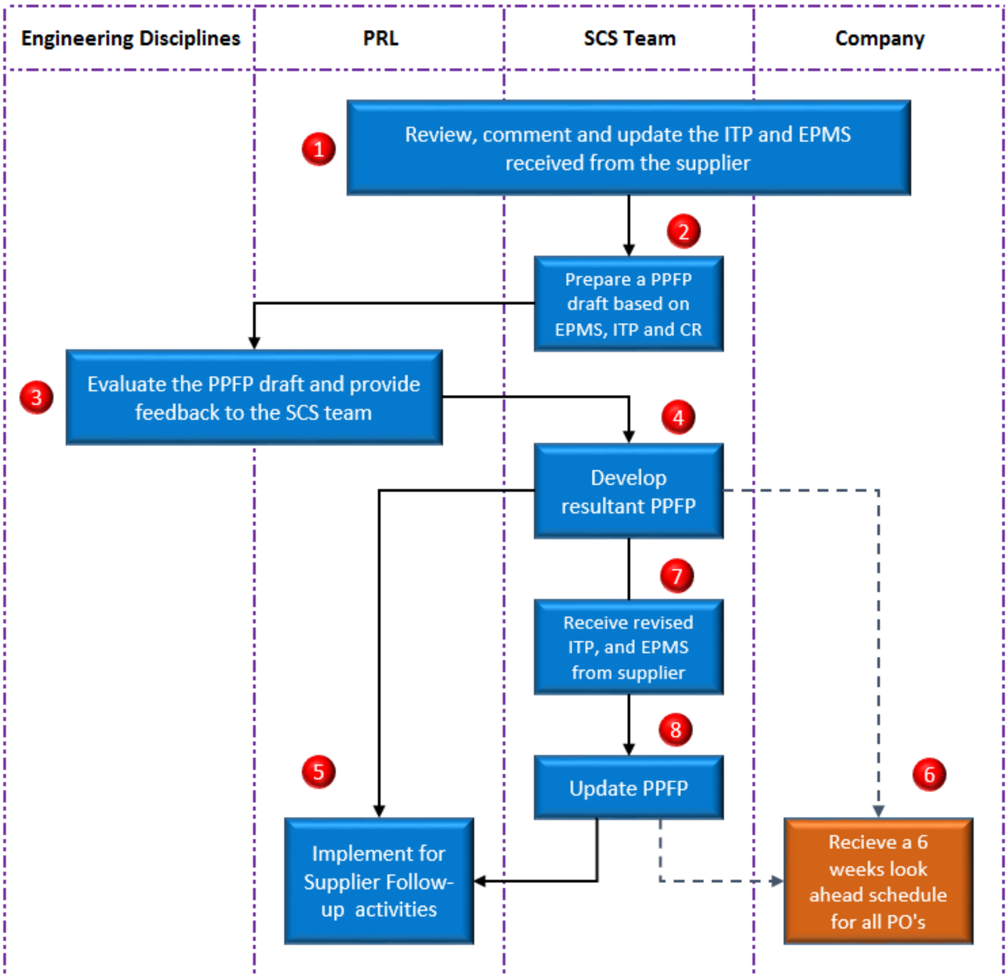


*Figure 8: PPFP Development Process – Adapted from: (Kvaerner, 2015c)*

Figure 8 illustrates the PPFP development process, and highlight who are responsible for the different steps in this process. Each respective step can be described as follows:

1. As mentioned earlier, the suppliers' ITP and EPMS forms the basis for establishing a PPFP. The first step in developing a PPFP is therefore reviewing and commenting the initially purposed ITP and EPMS. The SCS team, PRL and Statoil, all takes part in this process. After receiving input on the ITP and EPMS, suppliers have 15 working days to review the documents and issue an updated revision ($K^2$JV, 2015e).
2. Based on a criticality rating and the ITP and EPMS initially received from the supplier, the SCS team prepares the first draft of the PPFP. This draft includes an overview of all future inspection activities, along with an outline of the resources required to perform these activities.
3. The first draft of the PPFP are recommendations from the SCS team, and should incorporate the basic needs and requirements of all support disciplines. The PRL is responsible for verifying that the PPFP actually fulfill these needs and requirements

($K^2$JV, 2015e). Consequently, the SCS team forwards the draft with recommendations to the PRL, who then evaluates the draft in cooperation with relevant disciplines, and report any required changes.

4. As soon as the SCS team have incorporated any modifications required by the PRL, a revised version is issued.
5. The SCS team then forward the resultant PPFP to the PRL, who implements it as a basis for future supplier follow-up activities.
6. This resultant PPFP is also forwarded to Statoil, who use it in the creation of a six-week look ahead schedule, comprising all their PO's.
7. At some point in time, the supplier returns with the revised version of the ITP and EPMS, discussed in step 1.
8. The SCS team then implement any changes required by the supplier's revision, and distribute the latest PPFP to both PRL and Statoil.

### Criticality Rating Assessment

Despite the fact that conducting criticality rating assessments are usually outside the SCS function's scope of work, it is still useful to know how these are structured, as they are vital for the PPFP development process.

Kvaerner and KBR hold separate procedures for assessing the criticality of equipment- and bulk packages. As these procedures are based on quite similar principles, it has been decided that Kvaerner's procedure will be used for conducting criticality assessments in relation to the Johan Sverdrup project. In addition, any results obtained through Kvaerner's procedure will be compared to a set of standard criticality ratings provided by KBR. In cases where Kvaerner's procedure results in ratings that are lower than the standardized ones provided by KBR, a justification must accompany each respective rating ($K^2$JV, 2015c).

When determining the criticality of equipment- and bulk packages, two main elements are considered; probability of failure (POF) and consequence of failure (COF). These elements consist of 12 sub elements, which are all assigned a discrete rating in the interval 0-4 during, where 4 is recognized as the most critical. The elements are structured as follows ($K^2$JV, 2015c):

**POF depends on:**

- Design Complexity
- Design Maturity
- Manufacturing Complexity

- Maintainability
- Supplier's Acquaintance with Product
- Lead Time
- Past Experience with Supplier
- Complexity of Logistics

**COF may influence:**

- Health and Safety
- Environment and Ecology
- Construction Related Schedules
- Operational Expenditures

All sub-elements are then summarized and assigned an overall rating, ranging from the letter A to D, where A is recognized as the most critical. The overall ratings are distributed as follows ($K^2$JV, 2015c):

- 37-48 → Criticality A
- 25-36 → Criticality B
- 13-24 → Criticality C
- 12-0 → Criticality D

For each respective criticality level, there exists a standardized guide of recommended surveillance activities. The guides consists of one set of activities that are compulsory, and one set that is package sensitive and thereby considered on a case-by-case basis.

As mentioned, conducting criticality assessments is usually outside the SCS function's scope of work. This is because the assessment is conducted previous to the supplier selection, in order to allow the requirements that follow this rating to be included in all inquiries. Consequently, the POF sub-element "Past Experience with Supplier" is assigned an initial rating of 4, and revised as soon as a supplier has been designated ($K^2$JV, 2015c).

There are however examples of situations where suppliers are selected prior to the conductance of criticality rating assessments. This is most common for equipment and materials with substantial lead times, for which the project owner have assigned suppliers before the overall EPC contract has been awarded. The project owner do so to prevent long lead items from causing delays in the overall project. Whenever this is done, the criticality assessment becomes a part of the SCS function's scope of work. No matter whether the SCS function is responsible for the assessment or not, their representatives may act as consultants, and the resultant criticality rating is to be updated continuously during the procurement process.

### 5.3.3 Travel Board

Travel Board (TB) is a forum where the project discuss, approves, and comments upon the SCS activities suggested in the latest PPFP. Both $K^2$JV and Statoil have designated representatives situated in this forum, who evaluate and adjust the intensity of package follow-up activities aimed towards suppliers through bi-weekly TB meetings. Any adjustments made to the original plan during these meetings are reflected through a revised PPFP ($K^2$JV, 2015h).

One week before the next scheduled TB meeting, all members receives an updated version of the PPFP, including a six-week look ahead. The activities up for approval will be the ones scheduled for execution during the first four weeks following the upcoming meeting ($K^2$JV, 2015e).

The four-week PPFP agreed upon during the most recent travel board meeting will include the names of all SCS members who are authorized to fulfill their travel arrangements ($K^2$JV, 2015e). All supplier visits should be approved in the TB before they are executed, and individuals who choose to travel without formal authorization will have to cover their own travelling expenses, as unauthorized travels are covered neither by $K^2$JV nor by Statoil.

### 5.3.4 Surveillance activity

In accordance with the PPFP, the SCS function performs a wide array of surveillance activities during the procurement phase. Besides from obtaining the required approval from TB, all inspectors who are to conduct supplier inspections must establish a clear agenda with specific objectives to be executed during the visit. All suppliers are entitled to receive this agenda at least five days prior to the visit. Checks related to HSSE and preservation are natural parts of all inspection activities, and thereby not necessarily stated explicitly in the agenda ($K^2$JV, 2015f). The inspectors are also responsible for acquiring sufficient knowledge on relevant contractual agreements, supplier progress reports, and any outstanding work from earlier visits that may be relevant for the upcoming inspection.

Whenever nonconformities or deviations are revealed through surveillance activities, the supplier is immediately given one of the following instructions, based on the character of the discrepancy ($K^2$JV, 2015h):

- If the identified discrepancy is of a character that may be accepted, the supplier shall file a variation order request (VOR). The SCS representative will then clearly state this in the supplier visit report and log it in the SCS action register. A more detailed description of both supplier visit reports and the SCS action register follows in section 5.3.5.
- If the discrepancy identified is of a character that under no circumstances can be accepted, the supplier is immediately instructed to conduct necessary corrections. The inspector logs the required corrections into the SCS action register, and assigns a due date by when the corrections must be in place.

### 5.3.5 SCS Report and Action List

Whenever an inspector from the SCS function is part of an inspection or test at the supplier's premises, he is to write a supplier visit report and develop an action list. The report is to be written in a standardized format with references to the PPFP, and shall include the agenda developed previous to the visit ($K^2$JV, 2015h). In addition, the report is to identify all inspected items and the criteria used for passing/failing each of these.

Much like the report, the action list also follow a standardized format. It aims to highlight required actions, the individuals responsible for taking these actions, and by when the these actions are due ($K^2$JV, 2015g). All requirements that appear in action lists are stored in an action register, and followed up by the PRE. As a part of the HSSE controls mentioned earlier, all supplier visit reports shall include a standardized HSSE checklist that is filled out during the visit. Both inspector and supplier shall review, approve and sign the supplier visit report.

#### Minutes of Meeting

Some surveillance activities are exempted from supplier visit reports and action lists. These are activities that consist merely of meetings, and which do not involve tests or inspections. For such activities, so-called Minutes of Meetings are considered sufficient documentation. These are official records of the meeting conducted, and shall replace the otherwise compulsory supplier visit report.

## 5.4 Description of SCS Activities

This section aims to describe the activities for which the SCS function is either responsible, accountable or entitled to receive information about progress and/or status. These activities are supposed to ensure that suppliers are able to meet contractualized quality requirements, by verifying their methods, procedures, environments, products and services. A fair portion of these activities repeats themselves more than once during the lifetime of a project.

### 5.4.1 Kickoff Meeting

The first official interaction between the SCS function and the supplier is the kickoff meeting. This meeting aims to establish a common purpose for supplier and contractor by clarifying the acquisition's commercial aspects and quality requirements.

The general agenda for a kickoff meeting will, among other things, include:

- A review of the PO's commercial aspects, including:
    - price
    - lead times
    - invoice procedures
    - storage costs
    - incoterms
    - potential order growth
    - use of potential frame agreements
- A review of the PO's technical aspects and quality requirements, including:
    - design related challenges
    - deviations agreed upon subsequent to the PO award
    - preservation requirements and routines
    - upcoming quality inspections

### 5.4.2 Preproduction Meeting

The purpose of the pre-production meeting is to make sure that the supplier is ready to start production through evaluating the purposed progress review and clarifying the equipment/bulk-package's technical requirements and inspection requirements. The preproduction meeting must not be confused with the kickoff meeting, which merely aims to clarify on what inputs the supplier should base his production.

The general agenda for a preproduction meeting will, among other things, include:

- HSSE review
- Review of the supplier's quality plan, ITP and EPMS
- Review of scope of work for potential sub-suppliers
- Review of manufacturing procedures
- Review of preservation routines

### 5.4.3 Progress / Follow-up Meeting

Progress and follow-up meetings are meetings scheduled on the initiative of the PRB. Progress meetings aims to document the suppliers' progress towards predefined milestones, while follow-up meetings are used for intensifying supervision of activities lagging behind on either schedule or budget. The PRB may request members from the SCS function to join these meetings whenever he is in need of their technical capabilities for defining a supplier's current progress, or for scheduling future progress requirements.

### 5.4.4 Fabrication Inspection

Fabrication inspections are inspections carried out on a regular basis, which aims to verify that the production of ordered equipment and/or bulk is according to approved procedures and in compliance with the project's specifications. Such inspections also include verification of the suppliers' own procedures for quality control, and their commitment to these.

The general agenda for fabrication inspections will, among other things, include:

- Progress evaluation
- Checks of whether piping, instruments and electrical components are installed in compliance with drawings, specifications and procedures
- Surface treatment and preservation checks
- Comparison between conducted work and approved ITP
- Evaluation of operability and maintainability

### 5.4.5 Weighing

Unless managed properly, there is a possibility that the weight of equipment and bulk will cause the overall structure to become too heavy. This may cause problems in relation to load-out, transportation, offshore lifting, or mating phase. DONG's recent termination of the Herje platform's EPC contract is an example of how crucial weight control is. Herje's topsides had become too heavy for both the installed jacket to bear and for any crane to mount it offshore (DONG, 2016, Svendsen, 2016).

To avoid such problems, $K^2$JV have a designated «weight team» who are responsible for managing weight controls at supplier sites. The team makes a list of predefined weight controls for each supplier, and assign SCS members to those control points that may benefit from their technical expertise.

### 5.4.6 Attend Witness/Hold Points

Witness points are supplier activities defined in the PPFP, which should be witnessed or reviewed by a representative from the SCS function. In cases where no SCS representatives are present during the first occurrence of a test recognized as a witness point, the SCS function are to take one of the following actions ($K^2$JV, 2015h):

- Confirm that the test if repetitive, and schedule for one of their inspectors to attend a subsequent test at first opportunity.
- Determine if the supplier's documentation of the test is sufficient for accepting the witness point.
- Schedule for inspection of the tested product/procedure at first opportunity, and determine whether this inspection justifies acceptance of the witness point.

Hold points are much like witness points, with exception of the fact that suppliers may not continue with any activities beyond these until they have been witnessed by a representative from the SCS function, or a written authorization to do so has been provided by $K^2$JV.

### 5.4.7 MC Punch Out

As the PRE is responsible for all technical aspects of the procurement, from PO placement and until product hook-up, a part of his responsibility is to follow up all MC activities conducted by the supplier previous to product release. All MC activities that are to be carried out by the supplier are stated in the initial PO, and followed up with the use of mechanical completion check records (MCCR). MCCR's are discipline-based check records that forms the basis for upcoming MC activities. They are prepared for all tagged items, and enables the PRE to record results of MC related activities performed by the supplier.

Throughout the fabrication process, suppliers are required to conduct so called MC punch-outs in order reassure $K^2$JV of their progress. These are simply reviews of the MCCR's, where tests and checks described in these are conducted and assigned one of the following statuses (Kvaerner and Tveter, 2015):

- **NA:** The check/test is for the time being not applicable to the referenced tag, but it may become applicable in the future.
- **OK:** The check/test has been completed with satisfying results, and no further work is required for this particular tag.
- **PA:** The controlled item has defects that affect either safety or operability, and must be repaired before subsequent activities can commence.
- **PB:** The controlled item has defects, but these affect neither safety nor operability. Subsequent activities may commence, as long as corrective actions are scheduled and carried out prior to product release.

Following a MC punch out, the PRE is responsible for retrieving the resultant MCCR's and implementing these into $K^2$JV's systems. All incomplete/inadequate work is compiled in a punch list, which then forms the basis for further follow up activities.

### 5.4.8 Final MC Punch Out

By the time of the final MC punch out, all checks and inspections described in MCCR's and in the SCS action register should have been executed. Both $K^2$JV and Statoil are to assist the supplier during the final punch out, and the SCS function is responsible for ensuring that the team who conducts this punch out have sufficient multidiscipline competence for assessing all conducted checks and tests.

Any work described in the SCS action register, which is not completed by the final MC punch out, is transferred to the MC punch list, and assigned the status PA. The supplier is then responsible for clearing these punch before the package is released for delivery.

### 5.4.9 Factory Acceptance Test

Following the final MC punch out, a factory acceptance test (FAT) is scheduled and conducted. The execution of the FAT takes place at the supplier's premises and aims to verify that the ordered equipment/bulk meets the predefined criteria specified in the purchasing agreement. In addition, the FAT intends to verify that the equipment/bulk is fully functional, something that is usually proved through simulation or conventional function testing.

Any punch items discovered during the FAT is added directly to the MC punch list, as the SCS action register ceased to exist after the final MC punch out. If all preceding surveillance activities have been conducted properly, the punch items discovered during the FAT should not be too comprehensive, as the more extensive ones are likely to have been assessed already.

### 5.4.10 Inspection of Surface Treatment and Insulation

Following the FAT, a member from the SCS team is supposed to verify that surface treatment and insulation are conducted in accordance with relevant standards and procedures. The surface treatment inspection are to cover paints, metallic coatings, and fire protective coatings, and usually involve visual inspection combined with adhesion tests, cut tests, and/or other applicable tests. Insulation inspections are usually limited to visual inspections, but may include review of installation procedures and conditions.

### 5.4.11 Final Inspection

The final inspection seeks to clarify whether the supplier have managed to clear his punch list or not. If the list still contain punch that will remain after the estimated date of delivery, the PRE and PRB will prepare a joint recommendation, describing the corrective actions needed to clear these ($K^2$JV, 2015d). This recommendation is presented for the project management, who then decides whether to extend the lead time and provide the supplier with more time for clearing the remaining punch, or if the material will be released for shipping as scheduled and the remaining punch transferred to $K^2$JV's scope of work.

Any punch transferred from suppliers to $K^2$JV, are recorded in a carry over work register (COWR) and completed at a later stage. $K^2$JV is entitled to remuneration for all work recorded in the COWR, and a suitable compensation format is to be agreed upon before the package is approved for release. The COWR will serve as a basis for planning and scheduling the MC activities that must now be conducted at K2JV's premises.

### 5.4.12 Preservation and Packing Inspection

According to K$^2$JV's standard PO's, all suppliers are responsible for preserving their products prior to release. The initial preservation is based on what is required for the equipment to maintain its mint condition during a 24-month temporary storage (K$^2$JV, 2015f). The preservation applied shall satisfy the supplier's own preservation requirements along with any additional requirements imposed by K$^2$JV's preservation procedure.

K$^2$JV's SCS function is responsible for providing experts to verify and approve the applied preservation, prior to product shipment. The verification process includes inspection of external preservation such as covers, seals, and drainpipes, along with mediums and pressures used for internal preservation. If the product requires any preservation maintenance after leaving the supplier's site, SCS representatives are to obtain instructions on how to fulfill these requirements.

When applicable, the preservation inspection is to encompass packing inspection as well. Proper execution of packing and logistics are essential for securing the initial preservation applied by the supplier. The package inspection aims to verify that the product is packed in a way that do not interfere with any of the initial preservation, and assure that this preservation will remain intact during transportation.

### 5.4.13 Quality Assurance Visit and Audit

Over the course of a project, the PRE and PRB's are responsible for conducting QA visits and audits at supplier sites. The main reason for conducting these audits, are to ensure that suppliers have established the contractualized systems and procedures as required by K$^2$JV and/or the project owner (K$^2$JV, 2015h). As for any of the other inspection activities, the technical expertise of the SCS function is available on request.

## 5.5 Supplier Selection

Even though selecting suppliers is outside the SCS function's scope of work, some comments will be made on the current selection practices. As mentioned in relation to the criticality rating assessment, some suppliers are appointed by the project owner prior to project award. This is done to mitigate the risk of items with long lead times causing delays in the overall construction process, and is just one out of several scenarios where $K^2$JV are not eligible to freely assign equipment suppliers. In total, $K^2$JV distinguish between six different types of contracts that may alter their basis for selecting suppliers:

- **Frame Agreement (FA):** There exist a frame agreement between the project owner and a particular supplier who provides a certain type of equipment. Whenever $K^2$JV are to acquire this type of equipment, they are to honor the project owner's frame agreement.
- **Project Specific Frame Agreement (PSFA):** This contract is very similar to the regular frame agreement, except from the fact that this one is limited to acquisitions made in relation to a specific project.
- **Assigned Purchase Order (APO):** The project owner have assigned purchase orders for items with long lead times, prior to official award of a contract. When $K^2$JV are later awarded the overall contract, they inherit these purchase orders.
- **Company Provided Item (CPI):** These items are to be provided by the project owner, and $K^2$JV are thereby excluded from the acquisition phase.
- **Appointed Brand (AB):** In this case, $K^2$JV are free to choose any supplier of their liking, as long as it provides the brand specified by the project owner.
- **Engineer Procure Construct (EPC):** No restrictions are imposed by the project owner, and $K^2$JV may browse the supplier market without accounting for any external constraints.

From the contracts described above, it is evident that $K^2$JV are bound by certain restrictions in the process of establishing their supply chain. Apart from in relation to the equipment- and bulk packages classified as EPC or AB, $K^2$JV have no say in the supplier selection process. Packages classified as EPC are the only packages where $K^2$JV are fully free to choose their suppliers, while packages defined as AB provides them with a certain degree of freedom. These are important observations with regards to the establishment of more permanent relationships between $K^2$JV and key-suppliers, as they say something about the potential for doing so. Table 4 provides an overview of the number of packages bound by each type of contract, and thereby quantifies $K^2$JV's potential for establishing such relationships.

*Table 4: Acquisitions and Contracts – based on numbers extracted from ($K^2$JV, 2016)*

| Contract type | Number of packages | Share |
|---|---|---|
| FA | 7 | 6 % |
| PSFA | 46 | 36 % |
| APO | 10 | 8 % |
| CPI | 16 | 13 % |
| AB | 12 | 9 % |
| EPC | 32 | 25 % |
| N/A | 4 | 3 % |
| Total | 127 | 100 % |

According to the data presented in Table 4, $K^2$JV may freely assign suppliers for approximately 25% out of all equipment and bulk acquisitions. When viewed in combination with the packages where they are simply restricted to a preassigned brand, $K^2$JV are able to influence the supplier selection process in approximately 34% out of all equipment and bulk acquisitions. In other words, there exists a potential for $K^2$JV to get closer with some of their suppliers.

## 5.6 Routines for Transfer of Knowledge

For the time being, no function-specific routines exists for transferring knowledge between projects where Kvaerner have established SCS functions. There do however exist routines for knowledge transfer on an overall level within the organization. Conversation with members of the SCS function, along with other Kvaerner employees, reveals quite strained relations to Kvaerner's system for transferring knowledge. The present author's overall impression is that employees at Kvaerner, or at least a portion of them, sees participating in Kvaerner's knowledge transfer process as a waste of time. The strange thing is that there is not a single one of those involved in these conversations, who claims that transferring knowledge is not important, they simply do not value Kvaerner's existing system and routines for doing so. Reoccurring statements resembles those listed below:

- Writing the reports are too time-consuming
- The experience captured in existing reports are of little value
- Retrieving knowledge from the database is impracticable as it takes too much time to locate relevant reports

- Retrieved reports often lack detail, showing signs of being conducted in a hurry
- Reports tend to be biased towards the owner’s position and interests

In order to scrutinize the negative attitudes towards Kvaerner’s knowledge sharing system, a meeting was scheduled with a representative from the department of *Quality Management & Continuous Improvement*, which recently acquired ownership of Kvaerner’s existing experience database. The consulted representative immediately acknowledge the challenges related to Kvaerner’s current system and routines for transferring knowledge, and reassured the author that the task of improving these were already situated on his desktop. The meeting resulted in a list of positive attributes related to the existing system and routines, which could remain useful even in a more developed process for transferring knowledge.

### Positive Attributes

- As a part of Kvaerner’s continual improvement process, a multi-disciplinary team verifies reports before they are stored in the existing database.
- Stored reports are sorted with respect to milestones, process owners, relevant keywords, and so on.
- The database is searchable.
- All lessons learned are accompanied by their author’s contact information, enabling future knowledge seekers to get in touch with the original knowledge source.
- Changes made to any of the stored reports are traced and verified.

# Chapter 6

# Findings and Discussion of Potential Improvements

## 6.1 Discoveries

The case study conducted in chapter 5 has revealed both strengths and weaknesses related to $K^2$JV's SCS function. These discoveries are presented below, and lays a foundation for the improvements suggested in section 6.2.

### 6.1.1 Strengths

There is no doubt that the current SCS function consists of a highly skilled workforce with remarkable amounts of experience. Several of the function's members have more than 30 years of experience from relevant industries, and some of them have even remained part of Kvaerner's organization their whole career. As far as the present author has seen during his stay at Kvaerner's facilities, the SCS function's tasks are performed in a manner very close to the practices described in relevant guidelines and procedures. This close relation between actual practices and those articulated, ensures a remarkable potential for transferring routines from the current SCS function, and on to those established for future projects.

Kvaerner's recent decision to restructure, and establish the SCS function as a part of their Completion Department rather than their Procurement Department, can be judged a wise decision. This is because personnel who are familiar with problems culminating at the end of projects now are included in the stages where these problems originate. The new structure allows Kvaerner to work consciously towards mitigating these problems, preventing them from growing out of scale.

Another strength is how Kvaerner, in accordance with their zero-punch philosophy, involves suppliers in the process of planning future follow-up activities. As described in the case study, suppliers contributes to the planning process by submitting an ITP and an EPMS, which the SCS function later use as a basis for developing their PPFP. By involving suppliers like this, $K^2$JV practice what can be seen as *front-end quality planning,* an approach that aims to align the suppliers' view on quality with the one of the contractor, ensuring that all involved parties pulls towards the same goal.

### 6.1.2 Weaknesses

The number of quality inspections, or non-value-creating activities, conducted during the acquisition of a standard equipment package, is significant. Huge expenses incur when inspectors travel back and forth between Kvaerner's premises and supplier sites. Not only is there a lot of travelling within the overall function; but each inspector is subjected to quite intensive traveling schedules as well, especially in certain periods. It is also worth noting that the project owner only compensate $K^2$JV for the services of one inspector per supplier visit, even in cases where a multidisciplinary team would be beneficial. Long story short, measures should be implemented for reducing cost and/or the amount of required travelling; preferably both.

For the time being, $K^2$JV's SCS function have no structured methods for conducting supplier evaluations. Except from in cases where $K^2$JV intervene to treat more extensive abnormalities, the supplier do not receive any feedback on their performance apart from the size of issued punch lists. Such practices eliminates the potential for maintaining a continual improvement process, and sustains a culture of conducting relatively expensive quick fixes on demand.

Prevailing theory suggest that the life-cycle cost of acquisitions can be reduced through giving quality a more dominant role in the supplier selection process. As highlighted in the case study, there is a potential for Kvaerner to enter more permanent relationships with a handful of suppliers, something that would enable them to emphasize quality when setting up their supplier base. The present author were not able to identify any endeavors to utilize this potential for reducing costs, at least none targeting the benefits that could be realized by the SCS function. Consequently, the potential values that could have been realized through education and development of suppliers, remains untouched.

From the case study, it becomes evident that the existing system for transferring knowledge within Kvaerner is far from qualified for capturing, storing, and disseminating experience available in ongoing projects. The amount of system distrust present in the user group shows that the system is in need of a substantial overhaul before it can become a valuable asset. There is reason to believe that the discontent with the system has been present for a long time, something that could make it challenging to convince Kvaerner-employees to devote to the knowledge sharing process, even if both system and routines are improved radically.

The perhaps largest weakness in Kvaerner's SCS function is that it is project specific, and thereby dismantled between projects. There is no guarantee that any of the current function members will be part of SCS functions established in relation to new projects in the future. Combined with the lack of systems and routines for transferring knowledge across projects, the loss of valuable experience and practices becomes inevitable with time. Unless other countermeasures are implemented, time and resources will be allocated to overcome the same recurring challenges over and over. As the predicted spread in upcoming projects prevents Kvaerner from making the SCS function permanent, knowledge transfer must be given top priority to avoid loss of valuable experience.

## 6.2 Suggested Modifications

When the strengths and weaknesses discussed in section 6.1 are viewed in combination with the literature presented in chapter 3 and 4, a need for improvements starts to surface. The present thesis recommends that the following modifications are applied to any SCS functions established by Kvaerner in the future, in order to accommodate this need.

### 6.2.1 Embrace SCQM

From the discoveries made in this report, it appears as if Kvaerner have implemented their SCS practices without fully embracing the concept of SCQM. As a result, the function remains a quality management tool for verifying quality, rather than an approach for achieving business success through instilling quality along the supply chain. Based on the theory presented on how to manage construction supply chains, the present author suggests that Kvaerner strive to integrate the set of lean-inspired touches discussed earlier, in order to adopt more of a SCQM approach when setting up future SCS functions. In short, Kvaerner should extend their continual improvement initiatives, establish closer relationships with a handful of suppliers, and develop routines for evaluating their supplier base. As these measures are rather interwoven, it is recommended that they are all implemented simultaneously to fully utilize the synergies that exists between them. The following sections presents a more detailed view on each respective measure.

### Broadening the Continual Improvement Process

For the time being, Kvaerner's practices for enhancing supplier performance are limited to the use of indirect supplier development. Kvaerner rely on incentives like bonuses, penalties, and the promise of future business for motivating their suppliers to initiate internal improvement efforts. The present thesis suggests that Kvaerner engage in a more active role towards supplier development, and commit both human- and capital resources to the cause of transferring value generating knowledge and practices onto their suppliers. By taking this approach, Kvaerner can more or less customize suppliers to match their exact requirements, minimizing the efforts and resources required for smoothening the product-handover process.

Kvaerner have practiced continual improvement internally for some time now, but they have yet to establish a structured approach for including their suppliers in the process. Nevertheless, a zero-punch philosophy is already in place, ensuring both a starting point and a vision for a broader approach to build on. In fact, the SCS team who are currently limited to verifying quality in products, have the experience required for identifying development opportunities at supplier sites. Not only are they capable of highlighting areas with potential for improvements, they should also be capable of consulting suppliers on how to release these potentials. By including their suppliers in the continual improvement process, Kvaerner will be able to enhance the quality of their supply chain, and thereby increase the competitiveness of their business. However, the reader should acknowledge that a given supplier might have other, larger customers, something that may reduce their willingness to devote to improvement initiatives encouraged by Kvaerner.

### Keeping Key-Suppliers Closer

By entering more permanent relationships with some of their suppliers, Kvaerner may enhance the effect of any improvement initiatives aimed towards these. If contracts involving key-suppliers are allowed to span over several consecutive projects, the concerned suppliers should become more motivated for participating in Kvaerner's improvement initiatives as the resulting modifications would now apply for a longer period of time. For the exact same reason, it would also become more beneficial for Kvaerner to commit time and resources to the development of future improvement initiatives.

It should be reasonable to assume that by entering closer relationships with a handful of their suppliers, Kvaerner would obtain a set of suppliers that are more trusted than the rest; this is especially true if these relationships are structured in a way that opens for sharing losses and revenues. Such trust gives rise to a potential for reducing the vast number of inspections usually carried out by Kvaerner's SCS functions, as an ideal relationship between contractor and supplier would remove the supplier's incentives for cutting corners in the production process. Even though relationships like this probably never occur in practice, the present thesis assumes that it is at least possible to establish one that reduce the supplier's incentives for doing so.

By assuming that a given partnership have such integrity that the supplier will not deliberately attempt to cheat the contractor, the occurrence of any non-conformances can be traced back to the suppliers ability rather than intention. As a result, one can say that a supplier, who at some point is capable of delivering a product in accordance with the contractor's desires, will also be able to deliver a product of equal quality in the near future. With this simplification in mind, the present thesis suggest that Kvaerner should introduce FAI's, inspections that aims to verify that the first article or batch satisfies quality requirements, for key-suppliers. By doing so, Kvaerner can verify that the supplier is able to deliver the desired product, and reduce the intensity of subsequent inspections accordingly.

The reader should acknowledge that even though the case study revealed a potential for Kvaerner to influence supplier selection in approximately 36% out of all acquisitions made in relation to the Johan Sverdrup project, this is not necessarily the case for future projects. Even more important, the fact that Kvaerner may freely acquire certain types of equipment in one project, do not guarantee that the same type of equipment can be acquired without restrictions in the next. Obviously, this is something that complicates the process of Kvaerner getting closer with a set of designated suppliers.

### Developing Routines for Evaluating Suppliers

Conducting structured supplier evaluations is a vital part of extending the continual improvement process into the supply chain. Among other things, the result of a supplier evaluation can be used for:

- Providing input on areas where the supplier should improve, and thereby on where there might exist a potential for initiating continual improvement efforts.
- Strengthening the process of selecting suppliers in the future by providing information on how those used in the past have performed on previous projects.

- Identifying supplier specific incentives that could be embedded in future contracts to ensure that suppliers emphasize areas in which they tend to underperform.
- Optimizing future inspection programs by increasing the inspection intensity in areas where the supplier are proven weak, and reduce the intensity in areas where the supplier appears more consistent.

As the SCS function have pole position for evaluating supplier performance, Kvaerner should develop a structured method for their inspectors to take part in the evaluation process. The present thesis suggest the implementation of a supplier scorecard that covers areas relevant for smoothening the product-handover process. An illustration of how the author envisions a supplier scorecard developed for the studied SCS function can be found in Appendix A. The scorecard consists of eight columns, structured as follows:

1. **Area:** lists all areas to be assessed (ref Appendix A for full overview)
2. **Past rating:** displays the rating obtained by the supplier in the previous rating session
3. **Targeted rating:** highlights the rating set as «future target» in the last assessment
4. **Actual rating:** the rating resulting from the ongoing assessment
5. **Weighting:** shows the predetermined importance of each evaluation area
6. **Weighted rating:** displays the actual rating after weighting has been accounted for (actual rating multiplied by assigned weighting)
7. **Improvement initiative:** highlights areas where improvement initiatives have been implemented or agreed upon, and should state some sort of reference to the relevant improvement plan
8. **Future rating target:** indicates what rating the supplier should be able to obtain by the time the next evaluation is to be conducted

Due to the present author's lacking knowledge on quantitative criteria relevant for the evaluation process, the scorecard is limited to a qualitative assessment. If Kvaerner should decide on implementing the scorecard, it would be wise to add some quantitative rating criteria as well, in order to prevent the evaluation scheme from becoming too biased by the assessors' interpretation of the qualitative criteria.

### 6.2.2 Establish Systems and Routines for Transferring Knowledge

The case study revealed that there exist no function specific routines for transferring knowledge from the existing SCS function and onto future ones. It was also discovered that Kvaerner's overall system for transferring knowledge between projects is of rather poor quality. As Kvaerner's SCS functions are established on a project basis, and thereby not permanent, the lack of knowledge transfer results in frequent loss of tribal knowledge and practices. For this reason, it is recommended that Kvaerner review and improve both system and routines for transferring knowledge. The present study do not aim to develop neither, but merely focus on establishing a sound basis for doing so. Whether Kvaerner choose to establish new systems and routines specific for the SCS function, or if they choose to further develop the existing ones, the theoretical grounding presented here will apply.

From the theory presented on transfer of knowledge we have that knowledge source and knowledge seeker are two separate entities, implying that knowledge is contextualized. It was concluded that knowledge cannot be transferred directly, and must therefore be transformed into transferrable formats such as data or information, before it can be disseminated. This data and information can then be used as input in the knowledge seeker's knowledge creation process. By recalling what was illustrated in Figure 6 (page 39), we know that for knowledge transfer to run smoothly, three different types of barriers must be torn down, or at least kept adequately low. These are; barriers to sharing, barriers to learning, and technical barriers. With this in mind, the present author suggest that Kvaerner extends their efforts towards mitigating barrier development, and add to the existing measures for lowering barriers.

Even though the existing database is currently not able to fulfill its duties, the case study revealed a set of attributes that contributes to the cause of lowering barriers. These attributes should therefore be included as a part of the future databases as well, and can be summarized as follows:

- Reports are verified by a multidisciplinary team to ensure that the content is factual
- The database is searchable, making it easier to locate relevant knowledge
- Stored reports are sorted with respect to milestones, process owners, key-words, etc. providing users with the ability to arrange reports according to a criteria of their liking
- Any changes made to stored reports are traced so that the reports can be reverified
- All stored reports contain the author's contact information, enabling future knowledge seekers to get in touch with the original knowledge source

From the nature of these attributes, it should be fair to argue that their main focus is on lowering barriers towards learning. However, the latter attribute must be implemented with care, as it may end up as a barrier towards sharing. This is because some people may fear that what they store in the database will give rise to questions towards their work, and thereby choose to withhold information to avoid potential confrontations.

In addition to those barriers already addressed by Kvaerner's existing system and routines for transferring knowledge, the present study has identified six more that cripples the existing connection between knowledge sources and knowledge seekers. Table 5 lists these barriers and highlights their impact zones.

*Table 5: Additional Barriers to Transfer of Knowledge*

| Barrier | Sharing | Learning | Technical |
|---|---|---|---|
| There exist no routines for when and how lessons learned are to be collected. | X | | |
| There exist no standard/guideline indicating how reports should be structured. | X | | |
| Lack clear definitions of who are responsible for storing and retrieving reports. | X | X | |
| There exist no routines for when and how lessons are to be retrieved and reused. | | X | |
| The database lack automated dissemination of reports that are relevant for upcoming key-activities. | | | X |
| The system lack some sort of expiry date on reports that will notify owners/experts on when these need to be reverified. | | | X |

The barriers themselves are rather self-explanatory with regards to how they can be treated, and should therefore be relatively easy to overcome. However, the reader should acknowledge that the attributes required for overcoming the system's technical barriers might be difficult to implement, or of little value compared to the expenses related to their development. The reader should also note that barriers such as fear of losing power, lack of time, tense social relationships, etc. are considered too intricate for the present study, and therefore excluded. Anyhow, such barriers seldom originate from the knowledge transfer system itself, and must therefore be solved elsewhere.

In order to enhance their knowledge transfer routines even further, Kvaerner can make use of so called foresight- and hindsight workshops. By introducing foresight workshops, veterans and newcomers may share thoughts and experiences, while locating lessons learned relevant for upcoming activities. At the same time, implementing hindsight workshops will ensure that the reports developed for capturing experiences from key-activities becomes less biased, as they are developed on a group level. This group activity will also increase the probability that data and information stored in the system is sufficient for future receivers to recreate the knowledge it was once derived from. Both workshops contribute to the process of lifting knowledge from the individual level, making it group knowledge, which eventually becomes an integral part of systems and procedures. This reduces the risk related to loss of tribal knowledge and practices. Prevailing theory also emphasize that the process of reconstructing knowledge runs smoother the more common ground that exists between the source and seeker. Storing and retrieving lessons learned through group sessions will increase the amount of such common ground, and should thereby enhance the knowledge transfer process.

# Chapter 7

# Summary and Recommendations for Further Studies

## 7.1 Objectives

The aim of the present thesis was to identify weaknesses and development opportunities related to Kvaerner's current SCS function, and provide Kvaerner with inputs on how adapting accordingly could render their organization more competitive in the future. For the assessment to be considered a success, the following sub-objectives had to be fulfilled:

1. Perform a thorough literature review on state of the art practices for managing the construction supply chain, and present theory relevant for establishing and maintaining a successful SCS function.
2. Conduct a case study on Kvaerner's current SCS function, and document its present structure and routines.
3. Compare the current practices with those discussed in the literature review, and elaborate on deviations that could hold the potential for future improvements and/or optimizations.

## 7.2 Challenges

There is no doubt that the largest challenge encountered in relation to the present thesis emerged during the literature study. The number of books and articles directly related to the subject of SCS/QS were more scarce than anticipated, and the author had to scout the outskirts of literature to obtain ideas and practices for improving Kvaerner's SCS function. In addition, the literature discovered here lacked consensus on key-terms and practices, complicating the task of developing a sound theoretical grounding even further.

Another challenge emerged from the fact that Kvaerner had recently adopted the SCS function as a part of their in-house activities, after outsourcing it for years. Familiarizing with routines and procedures in and newly established function was sometimes difficult, as some of these had yet to be carved in stone, and were therefore frequently subjected to changes.

In the aftermath of writing the present thesis, the author realize that he was perhaps a bit too ambiguous with regards to the scope of work. The subjects of managing construction supply chains and transferring knowledge proved so extensive, that they could easily have formed the basis for two separate studies.

## 7.3 Conclusions

The present study concludes that Kvaerner have not embraced the concept of SCQM when establishing their SCS practices, something which provides them with a rather narrow perspective on how to manage their construction supply chain. Consequently, Kvaerner's SCS function remains a tool for verifying quality, rather than a starting point for ensuring a competitive supply chain. By adopting more of a SCQM approach when managing their supply chain, Kvaerner could reduce the amount of SCS-related costs through eliminating some of their current inspection activities, along with the need for correctional actions. The present author argues that Kvaerner can achieve this through implementing the following set of lean-inspired practices:

- **Broadening the Continual Improvement Process:** By extending their continual improvement process into the supply chain, Kvaerner will be able to enhance their supply chain's performance through developing their suppliers' methods and processes; a must for succeeding in modern competition. In relation to the SCS function, this involves extending the role of the function's members, promoting them from inspectors to consultants.
- **Conducting Supplier Evaluations:** The continual improvement process cannot sustain unless it receives inputs on improvement requirements. As broadening this process would involve Kvaerner's suppliers, routines for discovering in-house improvement potentials are no longer sufficient for fueling the improvement process. Kvaerner should therefore establish routines for conducting structured supplier evaluations in order to

ensure that the improvement process receives the required inputs. Furthermore, a structured method for conducting supplier evaluations could be used for:

    - *Selecting future suppliers*
    - *Drafting contracts containing supplier-specific incentives*
    - *Optimizing the intensity of existing inspection programs*

- **Keeping key-suppliers closer:** By entering more permanent relationships with a handful of suppliers, Kvaerner may enhance the involved suppliers' commitment to upcoming improvement initiatives. These extended relationships will also prolong the period where Kvaerner are able to reap benefits from implemented improvements, and thereby strengthen their incentives for developing improvement initiatives in the future.

Further, the temporary nature of Kvaerner's SCS functions calls for high quality systems and routines for transferring knowledge, in order to avoid the loss of valuable experience whenever one of these is terminated. By carrying forward accumulated experience, Kvaerner may repeat successful practices and decisions, while avoiding already discovered pitfalls, something that will allow them to both generate value and reduce expenses. Unfortunately, Kvaerner's existing system and routines for transferring knowledge is far from sufficient for obtaining these benefits. The present thesis therefore recommends that existing systems and routines for transferring knowledge are reviewed and improved, and that the resulting system and routines possess the following:

- Routines for extracting experience from ongoing activities
- A search engine that simplifies the process of locating relevant reports
- Clearly defined roles stating who is responsible for storing and retrieving reports
- A standardized format for how lessons learned should be structured
- Routines for when and how lessons learned are to be retrieved and reused
- Automated dissemination of reports relevant for upcoming key-activities
- A multidisciplinary team that verifies the content of stored reports
- Some sort of expiry date on reports, triggering reverification by owners and/or experts
- A system for arranging the stored reports according to key-words
- Active tracing of changes made to stored reports
- The option for knowledge seekers to get in contact with the knowledge source

## 7.4 Further Studies

As mentioned, there exist a potential for Kvaerner to enter closer relationships with some of their suppliers, even though certain restrictions are present. The reader was warned that determining the size of this potential were actually quite complex, and that the potential described in the present thesis is a simplified estimate only. Further studies could be devoted to exploring how extensive this potential really is, and to identify those suppliers who would be most appropriate such a relationship.

Based on observations made during a supplier visit where the present author were allowed to follow one of Kvaerner's inspectors, it is suggested that a future study could look into the possibility of introducing the use of video-transfer, something that could remove the need for having inspectors present at some of the witness points specified in the PPFP. The current practice for treating witness points is to provide suppliers with details on which witness points inspectors from the SCS function will attend, and then discard the rest. By implementing the use of video-transfer, suppliers could be requested to stream all witness points, and SCS inspectors could attend random ones unannounced. If practicable, this would reduce travelling costs drastically, increase the number of tests actually witnessed by personnel from $K^2$JV, and free up time in the SCS inspectors' otherwise busy schedule.

The present study also looked into the need for upgrading existing systems and routines for transferring knowledge, but did not account for the investments required to fulfill this need. It would be useful for further studies to look into the actual cost of developing system and routines that holds the recommended characteristics, and it is therefore recommended that an investment analysis is carried out to cover this area.

Lastly, some comments were made on how the presented scorecard only contain qualitative ratings, while there is no doubt that it would benefit from the implementation of a set of quantitative criteria as well. Further development of the purposed scorecard thereby appears natural in relation to future studies.

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# Appendix A

# Supplier Scorecard

# Supplier Scorecard

| Supplier: | Assessor: |
|---|---|
| Package: | Date: |

| Area: | Past: (1-5) | Targeted: (1-5) | Actual: (1-5) | Weighting: (0-100%) | Weighted: | Improvement Initiative? (x) | Future target: (1-5) |
|---|---|---|---|---|---|---|---|
| HSSE | | | | | | | |
| ITP/EPMS | | | | | | | |
| Schedule accuracy | | | | | | | |
| Product quality | | | | | | | |
| Weight control | | | | | | | |
| Surface treatment | | | | | | | |
| Insulation | | | | | | | |
| Preservation | | | | | | | |
| Packing | | | | | | | |
| On-time delivery | | | | | | | |
| Overall communication | | | | | | | |
| Total | | | | | | | |

## Rating Guide

| | | |
|---|---|---|
| 1 | Excellent | The supplier have exceeded the requirements set by $K^2$JV |
| 2 | Good | The supplier have fulfilled all of $K^2$JV's requirements |
| 3 | Satisfying | The supplier have fulfilled most of $K^2$JV's requirements |
| 4 | Poor | The supplier have shown inconsistency with regards to $K^2$JV's requirements |
| 5 | Not acceptable | Product and/or procedures are out of control, and cannot be accepted by $K^2$JV |