Introducing Knowledge Management Practices as an integrated part of Project execution

Tor Andreas Kaasa
Dresser-Rand
Kongsberg, Norway, 2017
+4745402968
Torandreaskaasa@outlook.com

Abstract. This research paper investigates the challenges of knowledge management (KM) practices in a supplier company in the oil and gas industry. During the study, the researcher concentrated his efforts on analyzing the KM practices conducted in the company's project execution effort. The researcher analyzed how the KM practices were conducted and documented in the past and how they can be performed in the future. The researcher utilized existing enabling systems to create a new KM practice to be utilized in the company. The research effort resulted in recommended changes to the current project execution model to enable effective KM practices. The recommended changes include: visual systems architecture, lessons learned practices and a new aspect in the utilization of non-conformities (NC) and corrective actions (CA) and finally a change-feedback process for the new project execution model.

Introduction

Background. The oil and gas industry has entered a new era, ever since the Brent crude oil price dropped over 75% in only 2 years from its peak in 2014 (NASDAQ, 2016). The sudden change in the market infected the industry with cost reductions symptoms that has affected everyone within its reach. The new oil price made projects that were budgeted according to the obsolete fiction-high oil price unprofitable, leaving the oil companies to hold on tight to their money in hope for an uprising. This sudden change in the market trends also affected the supplier industry. Furthermore, the ever-increasing wages, costs and focus on Health, Safety and Environment (HSE) in the oil and gas industry has created a path that is difficult to divert from, making the profitability and margins to decrease in line with industry trends. The resulting factor is that current market demands a turnaround from tailor made solutions to standardized new technologies at a lower cost without reducing the level of safety and efficiency. The latest cost-reduction trends within the oil and gas poses a great potential for the KM practices within the industry. Most companies in the oil and gas industry are project-based organizations where nowadays cost-reductions can be seen as equivalent to downsizing. In the Norwegian oil and gas industry alone over 40.000 work positions have been lost since 2014 (DN, 2016). Research on downsizing and restructuring in organizations over the past 20 years has indicated a number of common organizational and individual issues (Williams, 2004; Fisher and White, 2000). It is claimed that a large portion of these issues are related to loss of knowledge while downsizing and restructuring. Reports of replacement of individuals or change in roles by re-hiring, or engagement of consultants are examples of downsizing outcome which can indicate knowledge loss (Appelbaum et al.,1999, Cascio, 1993). Moreover, "reinventing the wheel" (Gregory, 1999), that can be seen as reintroduction of ideas and practices, appears often, the same

are reports of inability to locate vital information sources, both people and physical resources (Cascio, 1993). Reports of falling productivity levels, inefficiencies, increased errors and reduction of work quality (Cascio, 1993) also suggest loss of knowledge. Moreover, negative feedback from clients and employees are reported (Appelbaum, et al., 2003) and it may be similarly attributable in part to reduced access to vital knowledge.

Domain. The research is conducted at an engineering department in a supplier company that operates within the oil and gas industry where the researcher is employed in the duration of this study. The system of interest is a gas turbine package that drives a generator or a compressor that can be delivered to onshore and offshore facilities.

Company. The Dresser-Rand (D-R) business, part of Siemens Power and Gas, is a leading supplier of rotating equipment in the global oil and gas industry. D-R is present in more than 150 countries with over 70 sales offices and 12 manufacturing facilities. D-R Norway is located in Kongsberg and delivers engineering, assembling, testing, servicing and commissioning of gas turbine driven compressors or generator solutions in the rage of 1 – 66 MW. D-R has one of the largest installed bases of rotating equipment with over 230 units installed at onshore and offshore facilities in all around the world.

Problem statement. Organizations are increasingly valued for their intellectual capital (Beccerra-Fernandez and Sabherwal 2010) and in D-R, there is a significant potential within the human capital that has not been fully exploited. Experience from completed projects in D-R indicates that the knowledge generated during project execution is not captured properly. Most of the organizational knowledge in the company is tacit; it resides in the human capital that makes knowledge sharing challenging. A byproduct of unavailable explicit knowledge is that employees are often relying on others in the company to gain knowledge. A consequence of the lack of knowledge sharing, especially between projects, is that issues keep reoccurring in projects. There is a significant potential in finding solutions to capture tacit knowledge during project execution, making it explicit and sharing it to learn and reduce the possibility of reoccurring issues. To complicate matters, the merge with Siemens AG in 2014 introduced a complete new product portfolio. The main gas generator vendor was changed from General Electric to Rolls-Royce (RR). With this change, the company seized the chance to rebuild the design from scratch, merging elements and knowledge from both D-R and RR to create a new standard. Following the new standard is new vital knowledge generated by the individuals in the company that are in need to be captured, stored and shared.

Research Questions

-What are the barriers for implementing KM principles to a Supplier Company in the oil and gas industry?

-What measures can be taken to increase the efficiency of KM practices to Supplier Company in the oil and gas industry?

Rationale. Continuous knowledge sharing between projects is a rare phenomenon in D-R. More specifically, transferring knowledge and experiences from one project to another, from completed to ongoing and between ongoing projects is a challenge that has yet to be tackled. By enabling this knowledge flow to take place in time, we can reduce the likelihood of issues reoccurring and increase product quality.

Frame of references

Knowledge in general can be described as built on data and information, often reliant on context and created by individuals (Davenport & Prusak, 1998; Wiig, 1993). Achoff (1989) proclaims that the relation between data, information and knowledge is not interchangeable. However, there are dependencies between the categories in the hierarchy (Bergsjö et al. 2016). The hierarchy, called DIKW pyramid is often configured as seen in figure 1, ranging from data in the bottom followed by information, knowledge and sometimes also wisdom, experiences and intelligence (Rowley 2007).

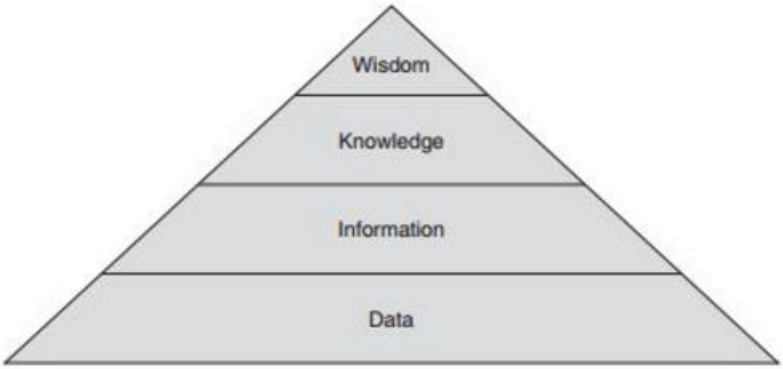

Figure 1. PIKW pyramid (Rowley 2007)

Organizational knowledge is the knowledge that resides within an enterprise that is required to facilitate production of the enterprise's products and services (Tyron 2012). It is the sum of knowledge within the organization, knowledge that resides in the employees, documents, processes, procedures and such like. A company's success can be in part determined in how well the organization utilizes its organizational knowledge.

Tacit knowledge can be described as knowledge that is difficult to articulate (Nonaka 1994). Tacit knowledge is often highly personal and resides within the individual. According to Tyron (2012) tacit knowledge can sometime be considered as intuition or judgment and is one of the most important organizational knowledge. It is often transferred trough demonstration and on-the-job training (Jarrar et al 2010)

On the contrary, **explicit knowledge** can be described as knowledge that is captured or recorded by the use of a formal physical mechanism (Tyron 2012). It can be in the shape of data, manuals, specifications processes and such like. It is relatively easy to store, share and transmit (Nonaka 1994).

Externalization is the process where tacit knowledge is articulated into explicit knowledge (Nonaka et al. 2000). It is known to be one of the most challenging processes within knowledge conversions seen in figure 3.

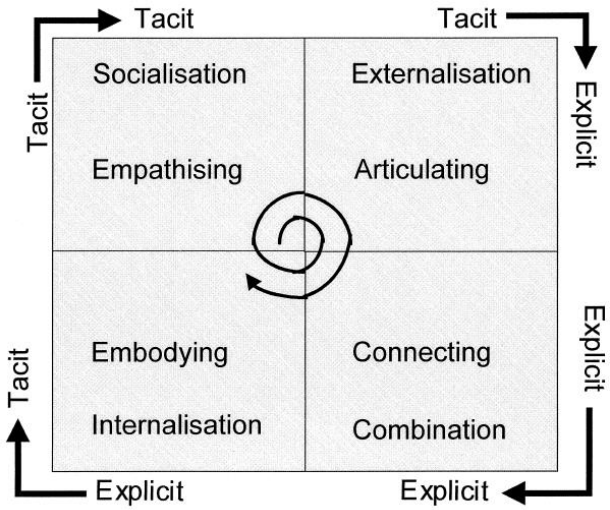

Figure 2. SECI process (Nonaka et al. 2000)

Knowledge management is in essence what you do to get the most out of knowledge resources (Beccerra-Fernandez and Sabherwal 2010). According to King (2009, p4) knowledge management is "the planning, organizing, motivating, and controlling of individuals, processes and systems in the organization, to ensure that its knowledge-related assets are improved and effectively employed". Lehaney (2004, p13) states, "KM requires a mix of business awareness, attitudes and practices, systems, tools, policies, and procedures".

For KM practices to be efficient requires a supportive structure often called **knowledge management infrastructure**. The KM infrastructure can be seen as the things that combine and facilitate the flow of knowledge (Lambe 2006) such as processes and tools that aid KM practices in succeeding (Bergsjö et al 2014).

Organizational learning can be seen as the process of learning within an organization.
To enable learning in a project-based organization, organizational members are required to create share and apply knowledge (Argyris and Schon, 1978; Huber, 1991). Members of an organization create new knowledge by being engaged in a learning experience (Kotnour, 2000).
Learning-by-doing is apparent when a problem solver compares actions and plans with results to develop procedures to accomplish positive results and avoid negative results (Anzai, 1987).

A **learning organization** is a company that facilitates an efficient learning environment and structure that aid employees to learn while working. Senge (1990, p. 14) state that a learning organization is "an organization continually expanding its capacity to create its future" According to Garvin (1993, p. 80) a learning organization is "an organization skilled at creating, acquiring, and transferring knowledge, and at modifying its behavior to reflect new knowledge and insights".
Project organizations are that are heavily dependent on its technical knowledge and the development of this knowledge (Kharbanda and Pinto, 1996), must continuously build their knowledge from experience (Kotnour 2000).

Research Methodology

The study is conducted as a participatory action research (Subramaniam and Youndt, 2005) of the current work processes in the engineering department in D-R. A combination of semi-structured interviews (Fylan, 2005), surveys, informal conversations, meetings and are used to map the current KM practices. The researcher conducted 10 semi-structured interviews with project managers and

engineers from all disciplines; Mechanical, Mechanical Systems, Electro and Quality Assurance. Moreover, the researcher conducted 3 different surveys, mapping the knowledge management practices in the engineering department. These surveys were configured in the Likert scale with five different response alternatives ranging from strongly agree to strongly disagree (Boone, 2012). In total of 13 engineers participated in the survey, representing every department. The participating engineers had from 3 to over 20 years of experience working in D-R and had an average project portfolio of 6 projects. The diversity of participants suggests that the observations of the current state can be seen as valid.

Current state of KM in the researched company

The researcher has analyzed the company's internal procedures in search for KM tools and practices. One of the most widely used KM tool in D-R is Lessons-Learned practices. Lessons-Learned or Post-Mortem meeting as the company name it, is a meeting that is performed after a project is completed. The meeting is intended to "summarize project experiences and inform each and every one in the departments so that corrections can be performed for future projects" (D-R, 2004, p.1). The meeting shall be documented in the form of a minutes-of meeting protocol. The protocol for the meeting includes two major activities:

1. Transfer relevant experiences from the meeting protocol and share them with their respective departments / projects.

2. Transfer relevant actions to the internal quality assurance system (Non-Conformity).

(D-R 2004, p.1).

The participants of the meeting shall be according to the procedure: the Project Manager, Principal Engineer, Project controller and project planner. Optional attendees are stated to be anyone from management.

To the researcher's knowledge there are no other stated KM tools or alike in the company's work procedures. According to the procedures, Post-Mortem meetings shall be sufficient to capture and share knowledge internally in D-R.

Besides the work procedures there are many subconscious knowledge transfer activities that conducted in the company. Hislop (2005) claim that within verbal communication, face-to-face is the most effective way to transferring tacit knowledge. From experience in the company, the researcher has noticed large quantities of key tacit knowledge are transferred verbally.

Probst, Raub, and Romhardt (2000) summarize: "Natural situations for sharing knowledge are those in which colleagues are physically present at the place of work. Where there are fewer opportunities for working together or meeting informally, efforts must be made to arrange social situations in which knowledge can be shared."

This statement supports the researcher's observation concerning knowledge sharing experiences in the company. The social situations found in the company are often very informal such as coffee brakes, lunch breaks, one-on-one conversations or stand-up discussions between colleagues. These informal meetings often include colleagues from different departments that drive cross-functional discussions that convey new aspects and tacit knowledge to be shared and interwoven. In these situations new personal and vital-for-business experiences and knowledge is frequently shared.

The company's quality system consists of potential knowledge generators and repositories. One of the most relevant is Non-Conformity (NC). NC is a java based case study tool that D-R use to log deviations during project execution and assigning actions to the respectable person or department. NCs are mainly created after inspection of an item or document if there is a deviation from the original specification on the deliverable. NC's are one of the few tools in company partakes in generating explicit knowledge with reasonable traceability.

Baseline Design Standard:

The company has taken a giant leap within project development during the last couple of years. After the merge between Siemens and D-R there has been a continuous effort to turn around the company to deliver products faster, cheaper while maintaining or even increasing quality. The overall goal was to reduce delivery time to half, from 12 months to 6 months and at the same time reduce overall cost by 40% (D-R 2016). This aggressive goal requires a completely new project execution model.

The company's old project execution model was based on the reuse of information and documents from completed projects. New projects began by comparing characteristics with projects that have been delivered. After finding the project that had the most similarities as the new project in terms of scope, location, structure, certification and so forth, the company copied the project of interest to be used as a basis for the new project. After the copy, the next step was to customize the copied project to be according to the new customer's requirements. This traditional approach enabled reuse of data and knowledge from previous projects. However, it demanded a lot of effort to reengineer the new project to comply with customer requirements. Last and not least, when copying old projects there was a high risk that the mistakes that were performed in the old projects most likely would occur in the new.

The new project execution model utilizes a new approach that converges towards a standardization platform. The new approach is based on a continuous improvement process. As seen in figure 1, the concept is to create a new Baseline Design Standard (BDS) where each new project derives its design from the latest design standard. The design standard consists of nearly every design deliverable such as 3D models, Piping and Instrument Diagrams (P&ID), Interconnecting and Wiring Diagram (I&WD) and Module Design Documents (MDD). The BDS consists of numerous configurations. The BDS configurations are dependent of the choice from various turbines, power turbines, generators, compressors and auxiliary systems. To administrate the configurations there is an automated configurator that interwove the configurations and extract complete documents according to customer input.

The new way of conducting customer projects require a stricter quality regime than before. As each document represent a standard for every new project to come, the necessity to keep it up to date is crucial. The contribution of the continuous improvement process is that each time new aspects or improvements that affects the BDS are detected in ongoing customer projects, they are first to be implemented in the project followed by implementation in the BDS. Changes or improvements that are applicable for the BDS is everything that deviates from the standard and is not project or customer specific such as:

- Dimension changes on tubing or piping (2" Gas inlet instead of 3")
- New supplier for components (New standard vendor for junction boxes with new interfaces requiring redesign)
- New functionalities added (Redesign of lube oil system to facilitate flushing)
- Physical relocation of components (Move junction box out of gas well to add more space for other components)

As we can see in figure 3, when these improvements found projects are applicable to be implemented in the BDS, there is a one-way knowledge flow from the ongoing projects and back to the BDS. This knowledge flow allows the BDS to be aligned with the latest improvements or changes found in the ongoing projects. Each knowledge flow incrementally improves the BDS by implementing solutions found in projects.

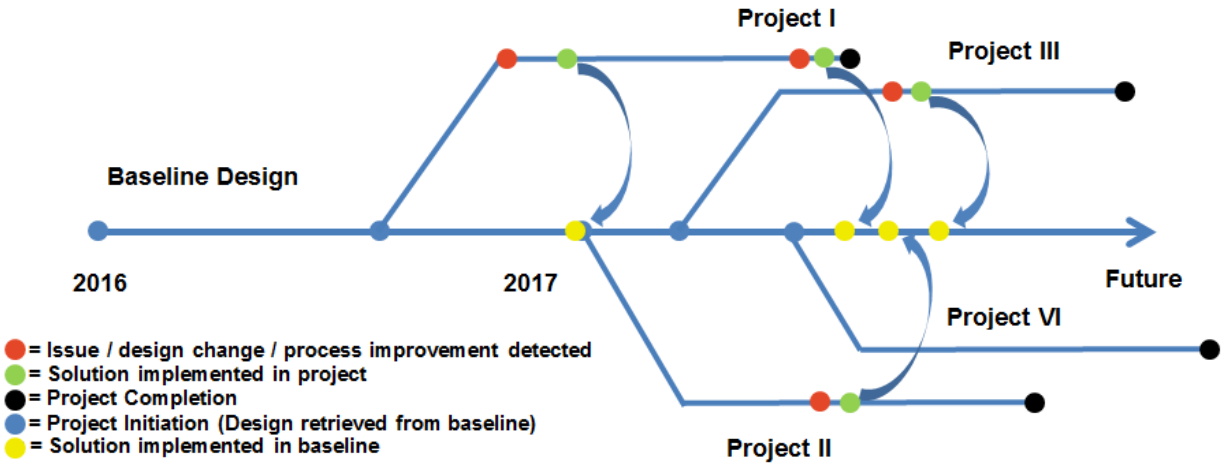

Figure 3. The Baseline Design Standard.

Analysis of the current KM practices in the researched company

Current KM practices in the case company are meager. The company has had a short-term perspective, focusing on months, potentially quarters, regarding project execution. The primary resources, in form of personnel and cash funding, in the company have primarily been allocated to the tasks directly related to project execution, i.e. to solve acute and around the corner problems. Projects are seldom initiated with focus on technical learning e.g. to implement new technical solutions that may be a part of the company's future offering. Moreover, there have been few resources focusing on long-term perspective especially concerning KM and OL i.e. there has been a lack of process improvements. Similarly, there are also tools and procedures missing to take full advantage of learning being done in the company. Some efforts have been conducted through the history of time, however few have been implemented and even fewer successfully. For example there has been created knowledge repositories in departments in form of excel sheets, to store vital knowledge generated within the department to be easy accessible. This specific initiative failed mainly due to not having sufficient resources allocated to maintaining the documents. The by-product of these meager KM practices has been reduced product quality and waste of resources especially related to repetitive errors occurring late in the project execution.

Lessons Learned

Lessons Learned is one of the few KM tools in use in the company that facilitates externalization. The content of the LL protocols in D-R is project based knowledge that possess both process and product knowledge. Interviews with project managers in D-R indicate that lessons learned practices are highly dependent on the project manager. As one citation of a project manager in D-R indicates:

"Each project manager have different ways of conducting projects, also with regards to lessons learned practices" – Project Manager 1 D-R

One survey conducted by the researcher indicates that around 20% of the engineers have never participated in lessons learned meetings. Those who had participated in lessons learned meetings

had been in far less meetings than projects. The average lessons learned meeting attended was 2,5 and the average projects conducted was 6,5. Research done in the project documentation reveals that lessons learned meetings have been conducted in only 8 of the last 16 projects. Of these 8 projects, only 1 project had a structured lessons learned setup and allocated actions for future work and improvements. The remaining had each its own distinctive format and setup. The average lessons learned protocol included few bullet points with no owner or actions for implementation or communication of the lessons learned. The content in the lessons learned found in D-R are informal sentences that are missing context. A lack of context may also be the result of too generic content in a lesson learned (Schindler and Eppler, 2003). According to interviews with project managers in the company, the lessons learned protocols are sent from the project manager to the line manager for implementation of the content. At this stage the ownership of the document change and the success of implementation are dependent on the line manager.

Nonconformity

NC is originally a tool used within quality assurance. As mentioned earlier NCs are used as a case study tool that is created due to a specification deviation on a deliverable. The process of conducting NCs is displayed in figure 4. The NC is used as an information collection platform where all case related information is collected. The result is information put in project and case context that can be seen as knowledge. The result of NCs is often actions that leads to improvements to mitigate the deviation or issue that is detected. Research on NCs conducted in the company indicates that the mitigation strategy for the deviations leads to improvements within the project where the deviation is detected. It is seldom that mitigation strategies are implemented outside the boundaries of the project i.e. process improvements. The risk of not implementing learnings from NCs to processes outside the project is that the deviation will occur in future projects when conditions are the same. Crosby (1980) determined that the price of non-conformance was around 30 % of the revenue of an organization. Findings from interviews suggest that NC is a time-sensitive operation where the person conducting the NC is often under pressure to complete the task as fast as possible. The outcome is that the quality of solving the problem decrease, often resulting in "quick fixes". The results are often primitive solutions that only addresses the issue at hand and does not facilitate a proactive mitigation strategy for future projects. The likelihood of finding the root cause of the issue increase in line with the time allocated to complete the NC.

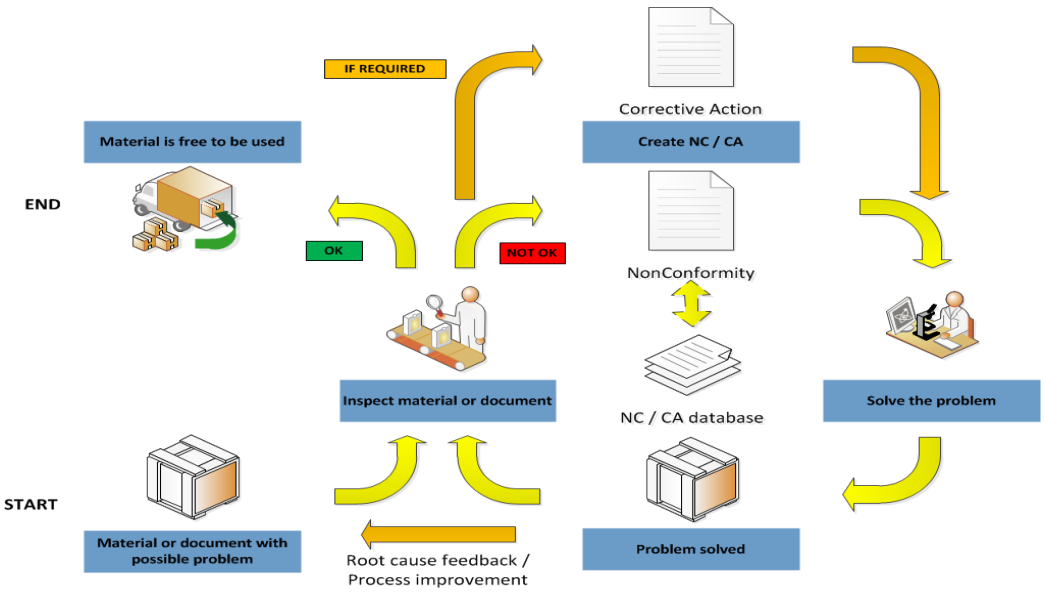

Figure 4. Illustrated NC process

Baseline Design Standard

The BDS approach can be seen as a continuous improvement effort that relay on incremental development to increase the technology readiness level (TRL) of the systems as projects are conducted. Seen as it is the first time the company is executing projects with the new system configuration, i.e. new turbine vendor, new design on all systems, retrieving verified project experiences and data from ongoing projects is vital for improvements. Without the knowledge flow from ongoing projects, the BDS will be at a standstill leaving out incremental improvements to the standard. However, there are other factors that can reduce the success of the new approach. First, the strategy does not account for knowledge feedback to projects. After projects retrieve the design from the BDS at project initiation, the BDS does not facilitate any feedback to the other ongoing projects, i.e. changes and improvements performed in the BDS that is applicable for projects. At the current state, each project has to constantly monitor activities that influence the BDS to be aligned with the latest updates of the design standard. This approach is not feasible, as it will generate many wasted hours monitoring. There is clearly a missing process concerning this knowledge flow. To illustrate, if we look to the BDS approach in figure 3, Project IV will not be informed of the improvements or changes performed in project I, II and III if there is no process of conveying these. To summarize, there is no process informing projects on the changes done in the design standard. Also supported in the statement below:

"Changes that are affecting the BLD should have a specific process to follow" - Engineer 1, D-R

Knowledge Management practices in general

Interviews, surveys and observations give a clear indication that knowledge in the company is shared through informal social settings. The practices of sharing knowledge are deeply rooted in the company and have become part of the culture. The result is that most of the knowledge in the organization is residing in the employees as tacit knowledge. The byproduct is making employees highly dependent on each other, especially on the once with the most experience. A survey conducted in the company by Singh (2013) also highlights that less experienced engineers are highly dependent on experienced engineers to understand system functionality.

The steps towards a learning organization

D-R strives to gain competitiveness in the industry. The customer base is following the market trends and demands that the supplier industry becomes cheaper and more effective. The immediate answer to the customers is the new project execution model, where D-R strives to reduce project delivery with 50% and cut 40% of overall cost. However, to achieve this goal in a long-term perspective development within knowledge management practices is essential. To learn from projects that are conducted in the company is fundamental to increase effectiveness and reduce costs.

Based on the analysis of current KM practices in the company, the researcher has identified areas applicable for improvements to improve organizational learning in the steps to become a learning organization.

Systems Architecture

An underlying aspect is that almost all systems are dependent on is the systems architecture of the deliverables in the company. Previously the company has had a visual architectural structure of the systems that made it easier for employees to understand. However, with the new BDS approach

there has not been created a new visual architecture. Not having a complete visual architecture are confusing employees and are limiting the capabilities of the supporting systems. Systems such as NC are dependent on an architectural structure to allow systemizing the actions according to the actual deliverable. A critical factor is that the employees will get a better understanding of the system by giving them a holistic view and this will aid employees to utilize the supporting systems correctly.

"The importance of having a complete architectural structure is crucial for success. The pace we have been working in lately does not allow for this structure to be complete in time"- Engineer 2 D-R

Lessons Learned

The researcher suggests integrating LL as a part of the project execution model. Given that the current LL practices success are highly dependent on the project manager, implementing LL as a standard will eliminate the project manager dependencies and increase the chance of execution. Moreover, LL should be a continuous project task that should be included in the project plan. The project manager and team should during the project note positive and negative experiences that they find relevant for future projects and process improvements. The document should be located in the same location in all projects folders allowing accessibility and traceability. The LL document should include knowledge owners and knowledge area according to the product architecture. Actions derived from the LL should be handled through the NC system to allow full traceability. The LL procedure must be updated to allow new changes to be implemented. Last and not least, line managers are responsible for allocating resources to implement process improvements and actions derived from the LL protocol. The importance of line manages prioritizing actions and improvements are vital for the success of the lessons learned practice.

Nonconformity and Corrective Action

The utilization of NCs has become frequently used as the new system in D-R has become integrated into a platform where many daily work tasks are performed. The NC has the capability of knowledge generation from a deviation. The people working with the NC will gather information about the specific NC and integrate it in a context and combine it with tacit knowledge from the problem solver that results in explicit knowledge via externalization. This knowledge can be seen as vital to solve the issue at hand and more importantly also to mitigate future NCs within the same problem area. The researcher propose to utilize new features of the NC system to allow knowledge sharing. The system has the functionality to communicate updates about NC status and content via e-mail. This feature is not utilized at the current state but can be implemented with minor alterations to work processes. Another feature in the company's quality system that has not yet been utilized is Corrective Action (CA). CA is an extension of the NC process that utilizes Root Cause Analysis (RCA) by the use of Toyota's five whys, to find the root cause of the detected NC.
CA can be initiated when:

- NC actions does not mitigate the issue
- Employees struggle to find the cause of NC
- Similar issues keep occurring
- Major Quality Incident (MQI) occurs (NC that have a potential cost impact of over 10000$)

Enabling the use of CA within the organization will coerce employees to investigate issues further and strive to find the root cause of the issues increasing the probability of mitigation. In figure 3, we can see how the CA are to integrated in the NC process

Baseline change-feedback process

As mentioned in earlier the BDS have some KM loopholes in the project execution model. The mitigation strategy is to make the latest knowledge in the BDS instantly available for relevant personnel. To achieve this knowledge feedback the researcher proposes to create a new process that concentrates solely on the steps where changes are to be implemented in the BDS and how this knowledge will be distributed to ongoing projects accordingly. The BDS is based on having knowledge owners for each system, called Subject Matter Experts (SME). The researcher suggests that the SME should be responsible for obtaining and distributing the knowledge concerning the changes. Distribution can be achieved by notifying the relevant system responsible in the ongoing projects via a standardized mail layout that facilitates the relevant information in an organized manner. To allow traceability the researcher suggests the updates shall be included in the MDDs (Module Design Document), a document that provides an overview about technical scope and definition of the subject package module.

Discussion

To measure a company's effectiveness based on all relevant parameters would seem like an almost impossible task. There are almost limitless amounts of factors that play the part in how organization effectiveness is achieved. One thing is certain; if you are able to identify, capture, store, share and reuse knowledge within the organization, you stand a better chance of increasing efficiency. D-R as many other supplier companies in the oil and gas industry are subjected to a fluctuating market with a high level of competitiveness. To succeed in this market one needs to stand out and appeal to the customers in an attractive manner. D-R's main competitive edge has always been flexibility in scope and delivering tailor made solution of high quality to the customers. Seen in context of the project management cost, time and quality triangle, the company has not been able to reduce either cost or time while increasing or maintaining quality. The prior market did not demand drastic changes within that area at that time. However, now that the oil price has dropped the customers are demanding changes, and it must happen fast if you want to stay competitive. This is as a fundamental reason for chasing efficient knowledge management practices.

Pre-study in D-R

The concept of using existing enabling systems for KM practices in this research was based on empirical data retrieved from a pre-study the researcher conducted in the company over a period of 4 months in the last quarter of 2016. The focus of the pre-study was to create a concept for system design reviews execution as a part of a new quality standard in the company. The researcher created a new design review checklist and tested it in 10 different official design reviews in the research company. The researcher was present as an observer in 6 of the 10 design reviews to see how employees react and utilize the new checklists. The meeting facilitators got an introduction of the format and how the list should be utilized prior to the meetings. The checklist was incrementally improved between the design reviews, implementing changes based on the researcher's observations and from a feedback session that was conducted in the end of the meeting.
The empirical data collected during the course of the pre-study were the following:

- Participants of the meeting tended drive the meeting towards how it used to be conducted
- Skip crucial parts of the checklist for the benefit of saving time
- Skepticism towards new way of conducting design reviews
- When challenges arise, go back to the known and familiar

Based on the empirical finding of the pre-study the researcher decided to find ways of integrating KM principals in the day-to-day routine of the engineers in the company. The researcher claims that the success of implementation of KM principals is highly dependent on the attitude and motivation of employees towards new practices. A pragmatic approach by integrating KM principals in an established routine of the engineers will increase the chances of success accordingly.

Impact of change management

The company has during the last couple of years been through many major organizational changes. Before the merge with Siemens AG the company was obligated to adapt to a Global Singular Process (GSP). In general, GSP was a program initiated to allow everyone in the organization to work in the same way, from the US to Norway. Following GSP were new unfamiliar systems where the employees have to perform most of the daily work. The integration of GSP was a complex process that was conducted parallel to customer projects on a limited timeframe that reduced the time for including the employees in the development as well as training. Post-integration observations indicates that the company is still working to familiarize itself with the new system to achieve efficient project execution. The byproduct has been untrained and uninformed employees that do not know how to utilize the new systems at its full potential. The implementation of BDS shows similarities to the GSP implementation. The new project execution model has not been communicated to the organization in a structured manner. The main reason for lack of communication was mainly due to confidentiality and security restrictions surrounding the BDS. It was initiated behind closed doors where limited personnel had access. When the implementation of the BDS was initiated commercially, no comprehensive training or information was communicated to the remaining of the company. The result has been further confusion amongst employees. Similarly, the new products portfolio including the new turbine supplier has not facilitated training for relevant employees. Working with new systems without proper training contributes in the confusion among employees.

Financial aspects

D-R main source of income is customer projects. The company survives on delivering new products and supporting them with services and spare parts during the operational life. The company's resources in are prioritized projects accordingly. As mentioned earlier, the company is focusing on project execution in short-term prospective. For example, when there are many tasks at the same time process improvements related tasks are abandoned to the benefit of customer project related tasks. This makes it difficult and sometimes almost impossible to implement process improvements and best practices found in during project execution. The risk of continuing in this approach is that the company will more likely redo mistakes and not evolve as a company based on the generated knowledge and experiences.

The current project execution model, the BDS, is dependent on internal financial investments to be capable of performing at its full potential. Previous projects in D-R have had substantial profit margins that minimized the impact of project and process development initiatives. However, new projects are now sold with significantly lower profit margin making project development and maintaining the BDS challenging. The risk of not having financial assets to allow the BDS to be operative and maintained is that the company will return to how it operated from before. This will imply that the changes and improvements found in projects will not be implemented in the standard and the risk of reoccurring issues will increase. More importantly, if the changes or improvements are not implemented in the BDS as soon as they become available will imply that the same work has to be performed in all the future projects to come. The result will be that the cost of implementing changes and improvements will increase linearly as project are conducted. Indications from ongoing projects imply that BDS changes and improvements have low priority due

to high level of project activity. The outcome is that BDS activities are often postponed for an indefinite time.

Conclusion

One of the biggest challenges in achieving efficient knowledge management practices in the company is that the company's priorities are directed towards short-term goals and less towards long-term benefits of implementing best practices. The current KM practices are limited due to lack of promotion and knowledge about potential benefits. The company has been influenced with multiple organizational changes and changes to systems that are limiting chances of efficient project executing. The company has over long time drifted towards a path that does not promote or facilitate KM. It has created a culture within the organization that sees process improvements and initiatives as challenging tasks to execute. Employees are often aware of the issues at hand but are struggling to see solutions when resources are limited. A top-down management driven change is needed to promote organizational learning and knowledge management initiatives to increase changes of success. The current trends in the market drive companies towards efficient utilization of the organizational knowledge in the companies, ISO9001 (2015) emphasized the importance of KM by introducing global requirements for efficient use of organizational knowledge. Management needs to see benefits of KM practices and strive to facilitate a culture that enhances learning. The pre-study for this thesis indicated that employees are relatively skeptical towards changing the way they work; integrating KM principals in their everyday work practice would limit the impact of change, hence increasing the chances of success. Verification of this research require a complete implementation. The researcher was not able to implement the proposals due to the limited timeframe of the research. However, feedback from experts within the company suggests that the proposed changes are feasible and will be beneficial for the company. The potential benefits from suggested changes are summarized in table 1.

Systems Architecture	Lessons Learned	NC sharing / CA	BDS process
• Increases system understanding • Becomes the infrastructure for enabling systems • Increases tractability of the system composition	• Facilitates externalization • Increases capturing and sharing of knowledge • Continuous project task to capture observations at the right time • Mitigates occurrence of identical issues • Increases organizational knowledge	• Facilitates externalization • Increases capturing and sharing of knowledge • Increases likelihood of finding root causes of deviations • Root cause feedback enabling process improvements • Mitigates occurrence of identical issues • Increases organizational knowledge	• Frontload projects with the latest updates in systems development • Clear knowledge ownership • Increases traceability of changes • Mitigates occurrence of identical issues

Table 1. KM improvement impact

Future Research

This study is based on qualitative feedback from semi-structured interviews, surveys and informal conversations. More data is needed to further strengthen the research. As this study includes multiple KM initiatives measuring the effect of each one would be best achieved by isolating and

implementing one by one and then measure. As an academic approach, this would be feasible. However, as the company is operating in a competitive environment a pragmatic approach is needed. The KM initiatives are all related to best practices and continuous improvement. The researcher suggests measuring the combined effect of the initiatives on a long-term basis. To get a better overview of the practices, the researcher suggest measuring the frequency of the utilization of the different KM initiatives. Furthermore, comparing the frequency with the measurements of the effects will give an indication of which one affects the most. Measurements that can indicate impacts of the KM initiatives can be:

- Reduction of repetitive errors
- Reduction of technical documentation revisions
- Reduction of hours spent in engineering
- Reduction of punch points on mechanical completion

As mentioned in the discussion, the organizational changes have had an impact on the company efficiency and will give noise to the measurements of the KM initiatives accordingly. Until the employees are able to use the systems effectively and trained properly in the relevant areas, it will give noise the measurements.

References

Ackoff, R. L. (1989). From data to wisdom. *Journal of Applied Systems Analysis*, *16*, pp. 3-9.

Alavi, M. and Leidner, D. E., (2001) "Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues", *MIS quarterly*, pp. 107-136.

Anzai, Y. (1987), "Doing, understanding, and learning in problem solving", in Klahr, D., Langley, P. and Neches, R (Eds), *Production System Models of Learning and Development*, MIT Press, Cambridge, MA, pp. 55-98.

Appelbaum, S. H., Everard, A. and Hung, L. T. S. (1999), "Strategic downsizing: critical success factors," *Management Decision*, Vol. 37 No. 7, pp 535-552.

Appelbaum, S. H., Patton, E. and Shapiro, B. (2003), "The early retirement incentive program: a downsizing strategy", *Journal of European Industrial Training*, Vol. 27 No. 1, pp. 22-35.

Argyris, C. and Schon, D.A. (1978), *Organizational Learning: A Theory of Action Perspective, Addison-Wesley*, Reading, MA.

Beccerra-Fernandez, I. and Sabherwal, R. (2010). *Knowledge management, Systems and processes.* M.E Sharpe, Inc. New York.

Bergsjö, D., Catic, A., Stenholm, D. (2016). *State of art in Knowledge Management and Lean Product Development*. CeLean White paper.

Boone, H. N., and Boone, D. A. (2012). Analyzing Likert scale data. *Journal of Extension*, 50 (2), pp. 1-5.

Cascio, W.F. (1993), "Downsizing: What do we know? What have we learned?" *Academy of Management Executive*, Vol. 7 No. 1, pp. 95-105.

Crosby. P. B (1980). *"Quality is free – if you understand it"* by Chairman and CEO, Philip Crosby Associates II, Inc.

D-R (2004) Dresser-Rand AS internal document. INS-PM-06 Post Mortem Meeting.

D-R (2016) Dresser-Rand AS internal document. Strategic Action Field.

Davenport, T.H. and Prusak, L. (1998). *Working knowledge: How organizations manage what they know*. Boston: Harvard Business School Press.

Fisher, S.R. and White, M.A. (2000), "Downsizing in a learning organization: Are there hidden costs*?", Academy of Management Review*, Vol. 25 No. 1, pp. 244-251.

Fylan, F. (2005*)"Semi-structured interviewing, in A handbook of research methods for clinical and health psychology"*, New York, Oxford University Press.

Garvin, D.A. (1993), "Building a learning organization", *Harvard Business Review*, July/August, pp. 78-91.

Hislop, D. (2005). *"Knowledge Management in Organizations. A Critical Introduction"*. Oxford University Press.

Huber, G.P. (1991), "Organizational learning: the contributing processes and the literatures", *Organization Science*, Vol. 2 No. 1, pp. 88-115.

ISO 9001 (2015) *"Quality management systems – Requirements (ISO 9001:2015)",* CEN - European Committee for standardization.

Jarrar, Y. Schiuma, G. and Zairi, M. (2010) Defining Organizational knowledge. A Best Practice Perspective. *European center for best practice management*. Research paper.

King, W. R. (2009) *Knowledge Management and Organizational Learning*, Katz Graduate School of Business, University of Pittsburgh, Springer Science+Business Media.

Kharbanda, O.P. and Pinto, J.K. (1996), *What Made Gertie Gallop? Lessons from Project Failures, Van Nostrand*, New York, NY.

Kotnour, T. (2000). "Organizational learning practices in the project management environment". *International Journal of Quality & Reliability Management, 17*(4/5), 393-406.

Lambe, P. (2006) *"Why KM is Hard To Do: Infrastructure, KM and Implementing Change"* Retrieved from: http://www.greenchameleon.com/uploads/Why_KM_is_hard_to_do.pdf

Lehaney, B (2004) *Beyond Knowledge Management*, IDEA Group Publishing.

NASDAQ (2016) http://www.nasdaq.com/markets/crude-oil-brent.aspx Accessed 01.01.2017

DN (2016) L. Kaspersen "Nå er 40.000 oljejobber borte", *Dagens Næringsliv*, 01.11.2016 https://www.dn.no/nyheter/energi/2016/11/01/1001/oljesmellen/na-er-40000-oljejobber-borte Accessed 01.02.2017

Probst, G., Raub, S., and Romhardt, K. (2000). *Managing Knowledge. Building Blocks for Success.* New York: John Wiley and Sons

Rowley, J. (2007). The wisdom hierarchy: representations of the DIKW hierarchy. *Journal of Information* Science, 33, pp. 163–180

Senge, P. M. (1990). *"*The art and practice of the learning organization". *The new paradigm in business: Emerging strategies for leadership and organizational change",* pp. 126-138

Schindler, M. and Eppler, M. J. (2003). "Harvesting project knowledge: A review of project learning methods and success factors." *International Journal of Project Management*, 21(3) pp. 219–228.

Singh, Vickram. (2013) "*Knowledge Capture, Cross Boundary Communication and Early Validation with Dynamic A3 Architectures",* INCOSE, Philadelphia.

Subramaniam, M. and Youndt, M.A. S (2005). "The influence of intellectual capital on the types of innovative capabilities". *Academy of Management Journal,* 48(3), pp 450–463.

Szulanski, G. (1996). "Exploring internal stickiness: impediments to the transfer of best practices within the firm". *Strategic Management Journal*, Vol. 17, pp. 27-44.

Tedmanson, D., & Banerjee S. B. (2012). "Encyclopedia of Case Study Research. Participatory action research". SAGE Publications Inc., pp. 656-658.

Tyron, C. A. (2012) Managing Organizational Knowledge. 3rd Generation Knowledge management and beyond. CRC press.

Wiig, K. M. (1993). Knowledge Management Foundations: thinking about-how people and organizations create, represent, and use knowledge. *Arlington, Texas: Schema*.

Wiig, K. M. (1997). "Integrating Intellectual Capital and Knowledge Management. Long Range Planning", *International Journal of Strategic Management* ,Vol. 30. No.3 pp. 399-405. *Elsevier Ltd.*

Williams, S.M. (2004), "Downsizing - intellectual capital performance anorexia or enhancement?", *The Learning Organization*. Vol. 11 No. 4/5, pp. 368-379.

Biography

Tor Andreas Kaasa received his Bachelor's degree in mechanical engineering from The University College of Southeast Norway in 2014. He has been working at Dresser-Rand's Mechanical System department in Kongsberg since 2014, and this report is the result of the master thesis research for his Master's degree in Systems Engineering.