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Applying A3 problem resolution to new system design to improve performance and reduce rework

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Abstract

There is a need for constant improvement in today's projects/technology to stay competitive in the Oil and Gas market. This motivates actors in this domain to constantly anticipate the need for new products through innovation and development efforts that result in advanced subsea products. One such product is the Subsea Gas Compression module (SGC), the first installation of its kind. Aker Solutions has worked on standardizing Subsea Production Systems (SPS) and developed a quality system to fit these projects. When initiating new product development, Aker Solutions needs to adapt their quality system to define work processes suitable for an innovative project, which may demand other focus areas than for a traditional Major Subsea Project. At the time SGC project execution reached System Integration Testing (SIT) several errors were discovered. Some of these were attributed to late life design changes, multidisciplinary complexity and poor application of the Project Execution Model (PEM). This paper explores the SGC project from a retrospective viewpoint, investigating errors discovered during SIT by performing Root Cause Analysis, and recommends, based on the results, that the company updates the PEM with targeted activities for new product development to improve performance and reduce rework during later stages of development.

Introduction

Aker Subsea (AKS) is a company in the subsea market that focuses on standardizing Subsea Production Systems (SPS). The Project Execution Model (PEM) developed by AKS is used for guiding and monitoring complex SPS projects, with the intention to minimize project overruns that may lead to delayed or postponed delivery.

A standardized SPS project goes through a tender phase where AKS identifies the technological solution, establishes its price and delivery conditions, and makes an offer to the customer. When the client accepts the tender provided by AKS, the company proceeds with project development, following the SPS PEM, illustrated in Figure 1.

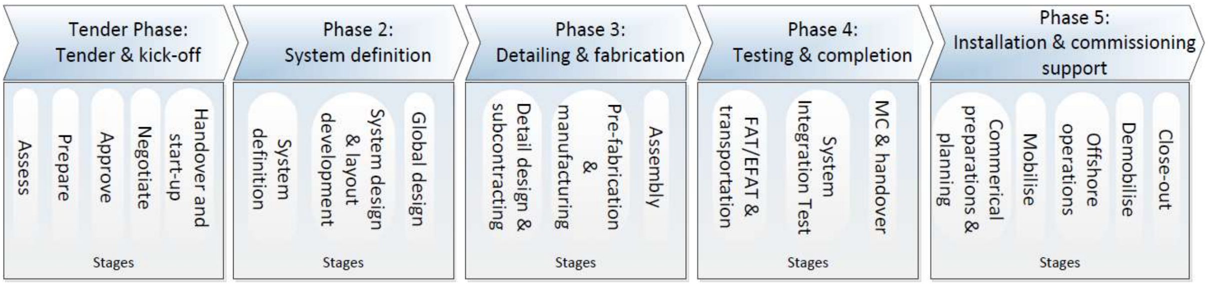

Figure 1 - PEM key stage objectives [9]

The PEM is a gate-based model, indicating a workflow and tasks that need to be set and closed out at each stage before entering into the next one, as well as helping management to evaluate project process and continually assess the need for improvement. The use of the PEM in AKS has been the topic of previous papers [20] [24].

When the project has been conducted from engineering through fabrication (phases 2 and 3) and into SIT (phase 4), it is possible to look on the project execution from a retrospective view. This enables analysis of the errors registered from testing, such as tolerance issues, fabrication not according to drawing, issues with remotely operated vehicles (ROV) operations, design changes, interface problems, etc. Such errors not only cause project overrun by extending fabrication and the project test scope, they also generate more work for the engineering department to revise all relevant documents and drawings. The issue with this is that in the final phases of the project the project management is trying to reduce the manpower projection plan, in accordance with the original schedule that shows a tapering level of activity, which in turn has a negative impact on the delivery schedule of the project. AKS has instituted a quality policy to ensure that all projects, services, and work processes used are meeting the business requirements as well as customer and other stakeholder requirements. The quality system is intended to continually improve the business strategy for staying competitive in the subsea market and building customer satisfaction. Using tools, such as Change Control System (CCS), Non-Conformance Request (NCR), and Plan, Do, Check, Act (PDCA), the idea is to improve execution processes continually to avoid "defects" in projects that can cause an extended cost or project delay.

Systems Engineering (SE) is an interdisciplinary approach and means to enable the realization of successful systems [16] [17]. SE considers both the business and the technical needs of all stakeholders with the goal of providing a quality product that meets the user needs. This paper provides suggestions for SE processes that can be used to facilitate quality assurance (QA) activities and continuous process improvement, as illustrated in the triple overlapping area in the Venn diagram in Figure 2 [1]. The original figure can be viewed at http://sebokwiki.org/wiki/Systems_Engineering_Overview.

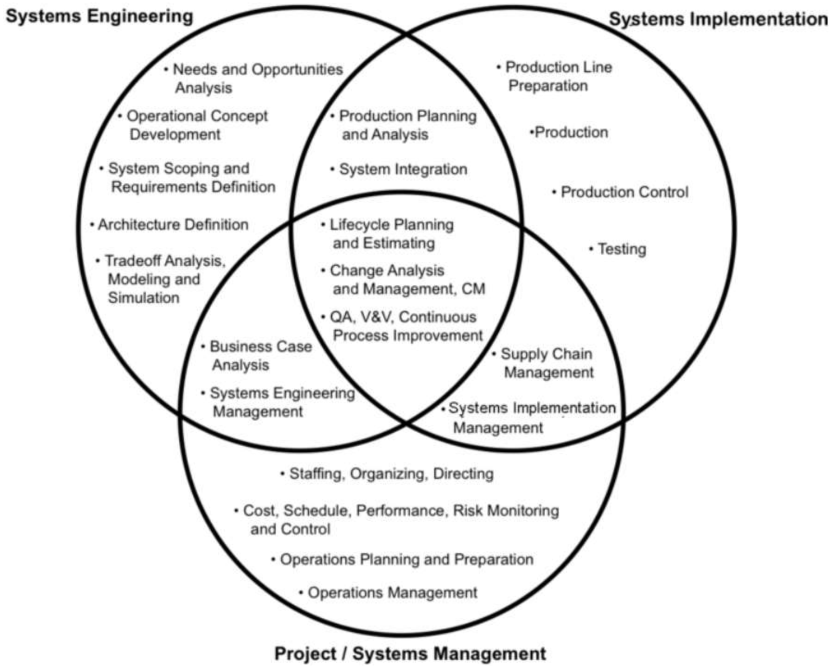

Figure 2 - Venn diagram SE boundaries [1]

This paper continues with background into the AKS project execution methods, followed by a presentation of the research methods and results, before a discussion and suggestions for future work.

Background

Aker Solutions. Two subsidiaries of Aker Solutions are mentioned in this paper: Aker Subsea AS earlier named (AKS) and Aker Engineering & Technology AS. AKS focuses on Major Subsea Projects (MSP), delivering SPS and service for the oil and gas market. There is a need for continuous research and development in the subsea branch to address new requirements for existing reservoirs. To meet this need, AKS established a new department that focuses on emerging subsea technologies (EST). The EST department is working on the Subsea Gas Compression module (SGC) in collaboration with their customer. When this development succeeds, it will satisfy the market for extended oil & gas recovery from existing reservoirs.

Previously, each subsidiary of Aker Solutions customized their own PEM based on the original PEM Capex [9]; Aker Subsea for SPS and Aker Engineering & Technologies for topside projects such as offshore facilities. When the new EST department was formed, it was understood by management that neither of the existing PEMs was appropriate for a new product development effort since both were too standardized for their own line of products/systems. And, since the SGC project is a first of its kind delivery project that places a topside process facility in a subsea environment, employees from both subsidiaries were brought together so the different fields of expertise could be maintained. Management combined the essential pieces from both PEMs and set deliverables for the different gate reviews without knowing the total project scope. This made it difficult to use the control level of the PEM effectively, and resulted in the deliverables for the gate reviews not being accurate. When this caused a lot of unnecessary and extra work, the management then decided to abandon the PEM, and instead focus more on experience and open communication logs between the engineering work-packages (WP), the external suppliers, and the customers. Using experienced employees in the project allowed AKS to maintain operational and support processes in the SGC project and still conform to the internal quality practices, which will be further elaborated in the next section.

The research questions for this paper focus how the PEM could be customized to the needs of EST to help the next projects to avoid some of the issues encountered during SIT in the SGC project. Root Cause Analysis (RCA) of the SIT reports and A3-problem solving approaches are applied to determine which SE processes can contribute to the PEM.

Research Methods

The focus for this research paper is to understand results from the SGC project execution by looking on it from a retrospective angle and determining if there were any errors discovered during SIT that could be discovered and fixed earlier? To get an understanding of this situation, the first task was to look on AKS's quality system by reading internal procedures (will be further elaborated under Business Practice) as well as reading literature and ISO standards on the same topic.

After relevant data was collected, the next step was to analyze employees' attitude towards the SGC project execution and understand their opinion about the PEM. A survey using questions constructed with the Likert Scale was applied using a series of questions with five response alternatives ranging from strongly agree to strongly disagree [12]. Additionally a RCA was conducted on the most critical errors discovered during SIT. The RCA helps to define what, how and why something happened, as an important step toward preventing recurrence [21]. The RCA was integrated with an A3 problem solving reporting approach to share the results with the organization. The next two sections report on findings from an internal documentation review to understand the AKS organizational guidelines.

Quality as an integrated part of the company

What is Quality? When quality/reliability engineers [14] observe daily compromises on quality in order to move products or services out the door they conclude that it is difficult for an organization to be successful from a quality perspective. Quality, as a subject, can create confusion because it has many operating parts, such as quality management, quality assurance (QA), quality control, statistical process control, and appraisal. It can be quite hard to look on the quality system and use it effectively. First, management must internalize quality as a corporate culture in order for the organization to be successful. Crosby determined that the price of non-conformance was around 30 % of the revenue of an organization, and actual quality was a critical factor in determining results [14]. When Crosby started to work with management, he realized that they were not intentionally malicious, they just did not have a workable definition of quality; it was just some sort of negotiable "goodness". After this discovery, Crosby wrote about the quality system in a way that was readable for engineers as well as management. The goal was to implement quality as a management job given that "systems" were an illusion. By doing so, quality would no longer be an "add on" or an irritating subject to be run by some committee. It was shown that after implementing the "absolutes of quality" management sets a clear policy; clear and doable requirements are established; employees and suppliers learn how to accomplish them correctly every time; productivity soars; and customers are successful.

The PDCA cycle. This Plan-Do-Check-Act cycle begins with the identification of a problem and is an internationally recognized process for implementing continuous improvement in an organization [5]. This process is also referred to as the Shewart or Deming circle [22]. In general, PDCA thinking is applied to all projects, typically for achieving specific goals within a specific time frame after which the project is terminated, as illustrated in Figure 3.

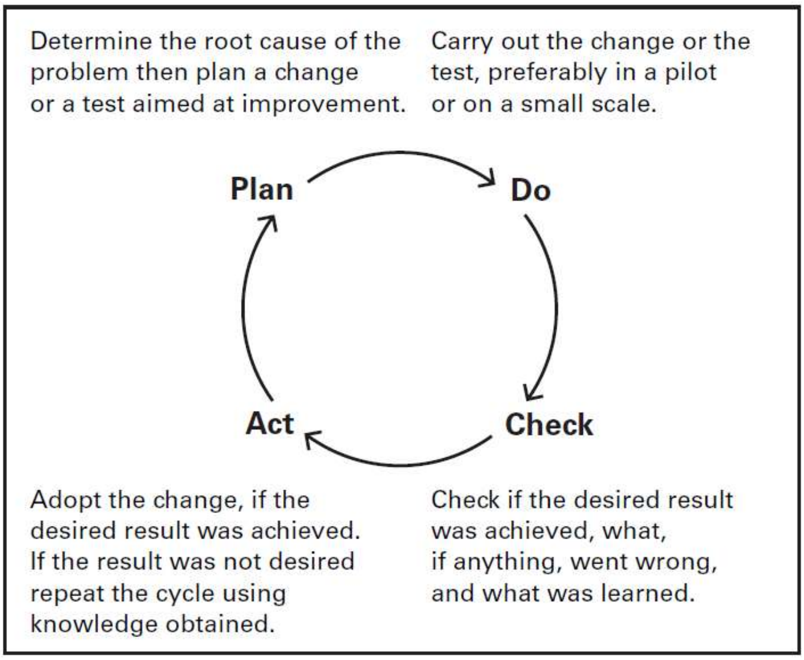

Figure 3 - PDCA cycle [15]

Business Practices

The purpose of the AKS Quality Manual [6] is to define and document the business operating systems and procedures used to meet the requirements of ISO 9001:2008 [18] and API Spec Q1, Fifth Edition, December 1994 [11]. The quality manual is valid for the whole business organization. It provides information for both management and employees to follow to meet the company's expectations reflected in AKS's quality policy that states the quality objectives and requirements given by the customer and/or other stakeholders. The goal is to become more competitive and encourage education and training for all employees. AKS aims to continually improve the effectiveness of the work processes and systems used by following the improvement cycle shown in Figure 4.

PEM. The main objective of the PEM is to improve the project execution performance and secure predictability of operations with a standard, transparent project execution methodology. The methods are based upon sound operational practices in combination with early identification and continuous monitoring of project risk exposures. The PEM is divided into three levels: First is the *Strategic Level* where all the phases are defined; followed by the *Control Level* that comprises a number of stages for each phase. Finally, the *Execution Level* defines the individual discipline work processes, which are focused on sequencing the work in accordance with the availability of information required to perform the activities in the respective phase. According to one of the authors of the PEM, the model provides generic guidance applicable to all technology projects in Aker Solutions [2].

Lessons Learnt. The lessons learnt "procedure" is a key element in the continuous improvement of the business's processes [3]. Recording these lessons helps to preserve valuable experience from projects/tenders, provide a common learning platform to facilitate knowledge sharing across regions and product areas, collect input for continuous improvement of the PEM modules, and avoid repeating mistakes. The lessons learnt database contributes to the process of preventing and correcting faulty actions/procedures supported by the NCR.

NCR. The main purpose of the Non-Conformance Request (NCR) process, pictured in Figure 5, is to secure proper registration, record the solutions, and follow-up all quality non-conformances in a product or deliverable [4]. NCRs provide input for trend analysis and lessons learnt, continuous improvement, and correct handling of concession/deviation request/permit and technical queries, and contribute to reduction of overall quality cost.

Results

SGC project analysis. Errors discovered in the SGC project during SIT are the basis for this investigation. After sorting all the errors, the next step was to associate the errors with a Work Package (WP) and determine to which discipline they belonged using a Work Breakdown Structure (WBS). Figure 6 illustrates the entire WBS with extensions for WP 2, which was the most significant work package activity. The shaded boxes are the ones selected for the RCA in this paper. The percentage given for the different WP in the second level of the WBS reports on the number of errors discovered during SIT distributed across all WP. On the third level the distribution of the total errors for WP 2 across the different disciplines is given. The final step was to determine common categories for the errors regardless of the WP. Due to the high complexity and short time frame for the research, the errors were aggregated into one of nine categories. As illustrated in Table 1, the categories are named on the top row and the WP with respective disciplines on the left side in the table. Here, the percentage shown in each category for all WP illustrates which discipline can be correlated to this sort of error. Presented in the end of the table, is the total percentage of errors distributed on the different categorizations. The set of errors that were the basis for the RCA appear in bold. These errors were selected because they were most interesting for the project. The values are reported as percentages of the whole to guard the confidentiality of the raw data.

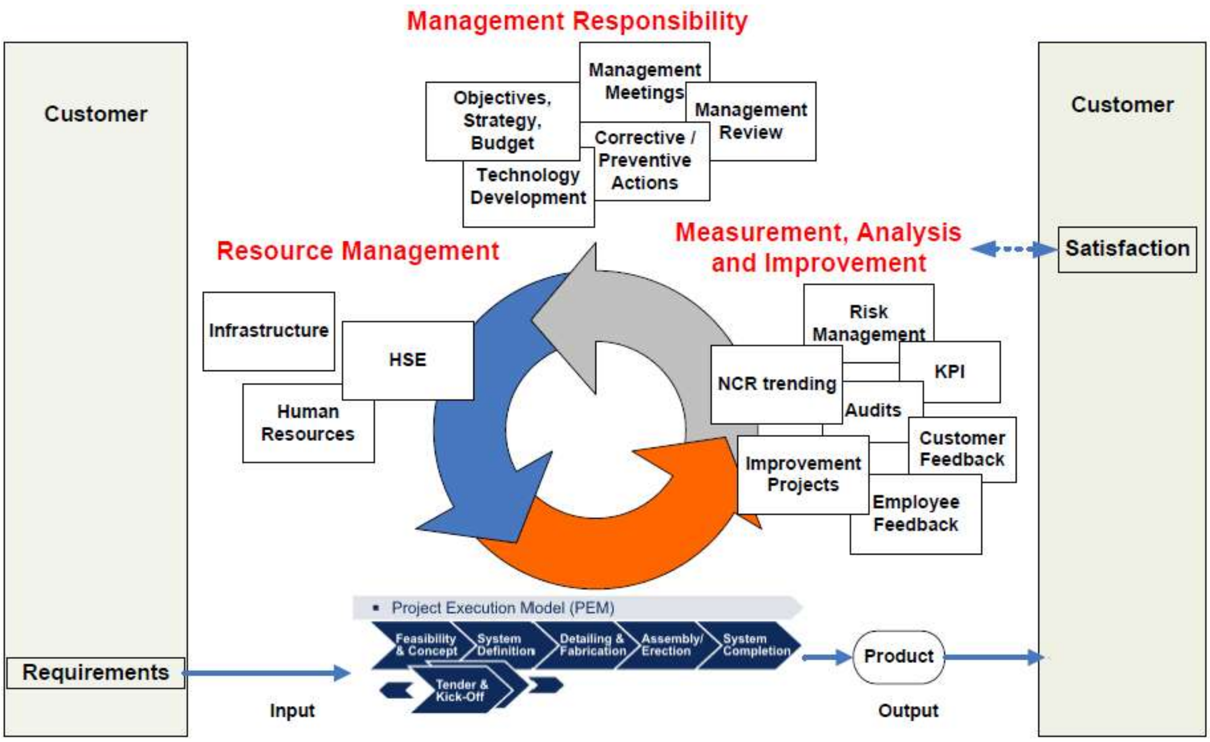

Figure 4 - Continual Improvement Procedure [8]

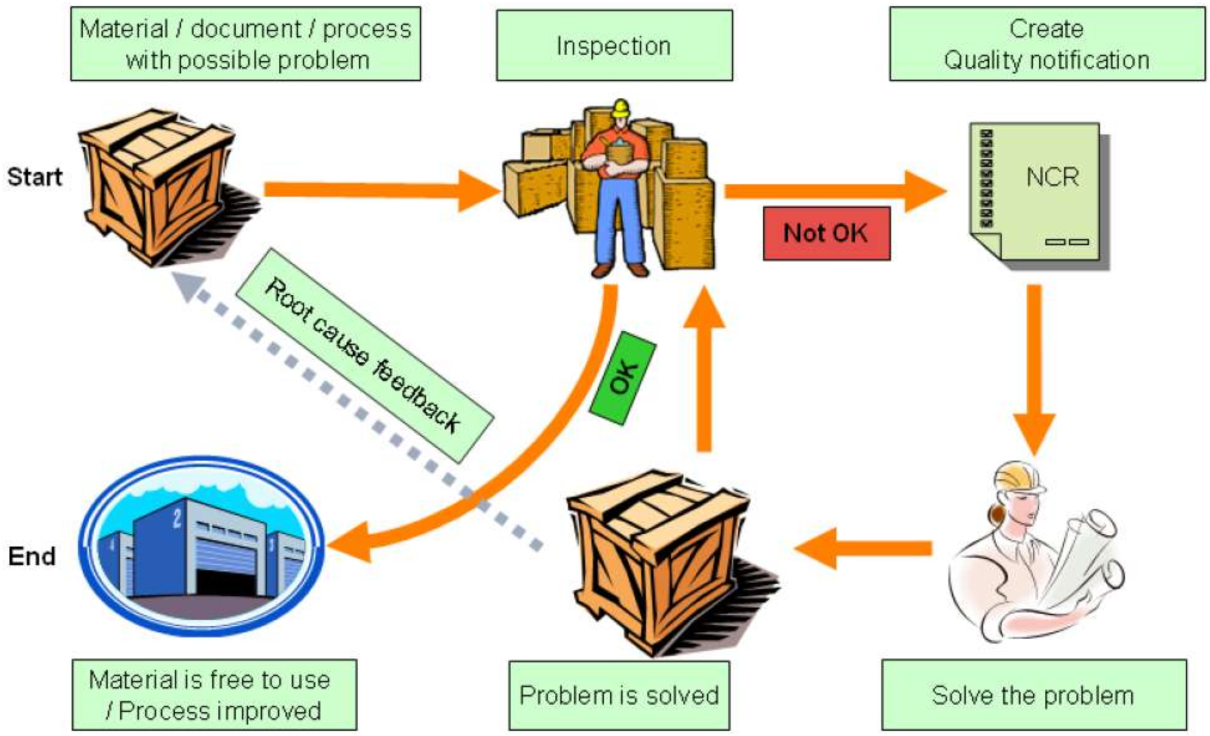

Figure 5 - NCR Process Flow [4]

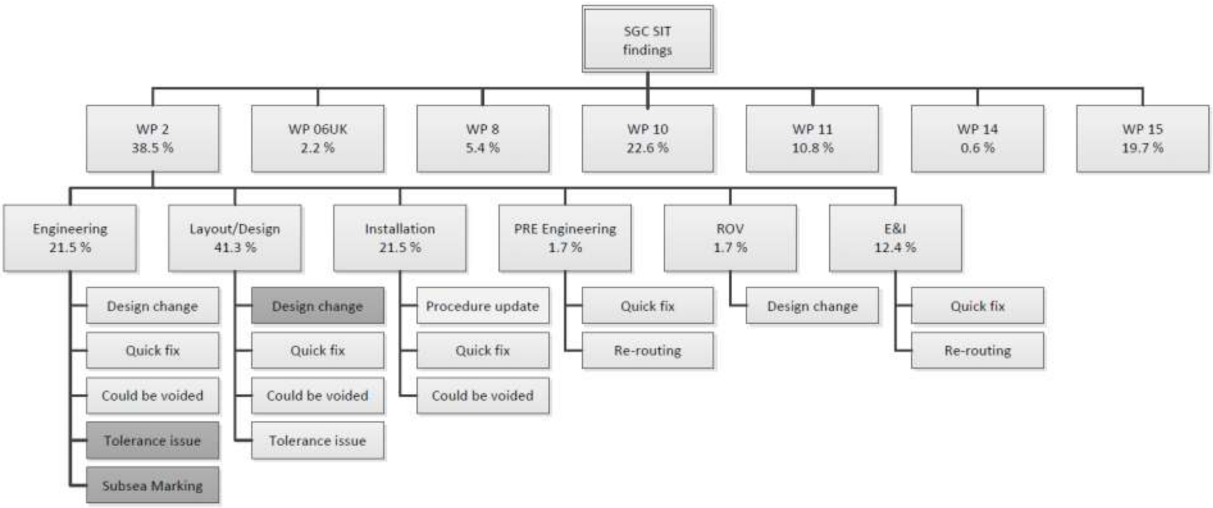

Figure 6 – WP 2 in the WBS tree for SGC showing SIT errors

Table 1 – list of errors categories by workpackage

WP	Role	Design Change	False Positive	Quick fix	Subsea Marking	Tolerance issue	Re-routing	Scratch on hub	Procedure update	Not according to drawing
WP 2	Engineering	3 %	15 %	4 %	**42 %**	**33 %**	0 %	0 %	0 %	0 %
	Layout/Design	**49 %**	5 %	9 %	0 %	**14 %**	0 %	0 %	0 %	0 %
	Installation	0 %	2 %	3 %	0 %	0 %	0 %	0 %	72 %	0 %
	PRE Eng.	0 %	0 %	2 %	0 %	0 %	7 %	0 %	0 %	0 %
	ROV	1 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
	E&I	0 %	0 %	1 %	0 %	0 %	**93 %**	0 %	0 %	0 %
WP 6	Engineering	0 %	0 %	0 %	**21 %**	0 %	0 %	0 %	0 %	**23 %**
	Design	0 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %	8 %
WP 8	Engineering	3 %	2 %	1 %	5 %	0 %	0 %	0 %	13 %	0 %
	Design	5 %	2 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
	PRE Eng.	0 %	0 %	3 %	0 %	0 %	0 %	0 %	0 %	0 %
WP 10	Engineering	10 %	15 %	26 %	32 %	0 %	0 %	0 %	15 %	0 %
	Design	**28 %**	0 %	0 %	0 %	**20 %**	0 %	0 %	0 %	0 %
WP 11	Test Engineer	0 %	52 %	1 %	0 %	0 %	0 %	0 %	0 %	0 %
WP 14	Engineering	1 %	2 %	0 %	0 %	0 %	0 %	0 %	0 %	0 %
WP 15	Structural Eng.	0 %	5 %	50 %	0 %	**33 %**	0 %	**100 %**	0 %	**69 %**
	Total changes per category	25 %	20 %	22 %	6 %	5 %	4 %	4 %	10 %	4 %

Two types of RCA were performed on the errors based on which approach yielded the most helpful conclusion. Toyota's "5 why's" method and the fishbone diagram [13] were both useful to focus the discussions with the respective employees in the WP to find out the cause of the error, and asses what could be done differently in the execution process to prevent the error from reoccurring. The other RCA technique that was used was to define the problem with *what, when* and *where*, as well as *what is the significance*? [21].

Employee Survey: The employee survey was constructed using a Likert scale. The project engineers in the SGC project were asked to examine their opinion and understanding of the PEM and to evaluate its usefulness. The survey was answered by 90% of 40 employees. The survey included 9 questions as follows:

1. *I am aware of PEM.*
2. *I have used the PEM through the SGC project.*
3. *My colleagues have used the PEM on the SGC project.*
4. *I have used the PEM to define my work on the SGC project.*
5. *The input to my work is clearly defined by the PEM.*
6. *I know the actual source of the inputs I used and they are not always defined in PEM.*
7. *I know which colleagues that will use the results of my work.*
8. *My work results are stated as an output in the PEM for my colleagues.*
9. *The PEM provides adequate directions for the activities of the SGC project.*

The final question also opened a communication link allowing respondents to add a comment to their answers on the questionnaire. Analyzing the trend of answers and comparing them to each other, there is good symmetry, suggesting that the employees answered honestly. For example, when the employees state they have used the PEM throughout the project (question 2), they should also know whether their colleagues used the PEM or not (question 3). It was determined that the internal consistency in the survey results is relatively high. Due to the sensitive nature of this data, the results cannot be shared at this time.

During the analysis of the survey, it was discovered that both the change control board (CCB) and the change control system (CCS) are very important. For the CCB the tool CCS had been used for a long time in Aker Engineering & Technology AS, and saw its first days in AKS when the SGC project started up. All requested changes in the project are evaluated through a change board where the requested participants usually are Project Manager, Procurement, Planning, Change Control Coordinator, and affected discipline WP lead [19].

CCS is a newly developed IT tool, with the purpose to control all changes needed in projects, minimize impact of changes on project execution and progress, control processes for evaluation, approve and close-out changes, ensure traceability and information availability across project phases and locations; please refer to Figure 7. The benefits of the CCS will be further discussed in the next section.

<u>Employee Interviews:</u> At the end of the research period, an interview session was held with the Engineering Manager, Mechanical Completion Manager and SE lead in WP 2 for the SGC project. During this meeting, they reviewed the RCA that had been prepared, and were able to explain the actions taken throughout the project; this provided the researcher an opportunity to compare the management's conclusions with the ones derived for this paper in the discussion that follows.

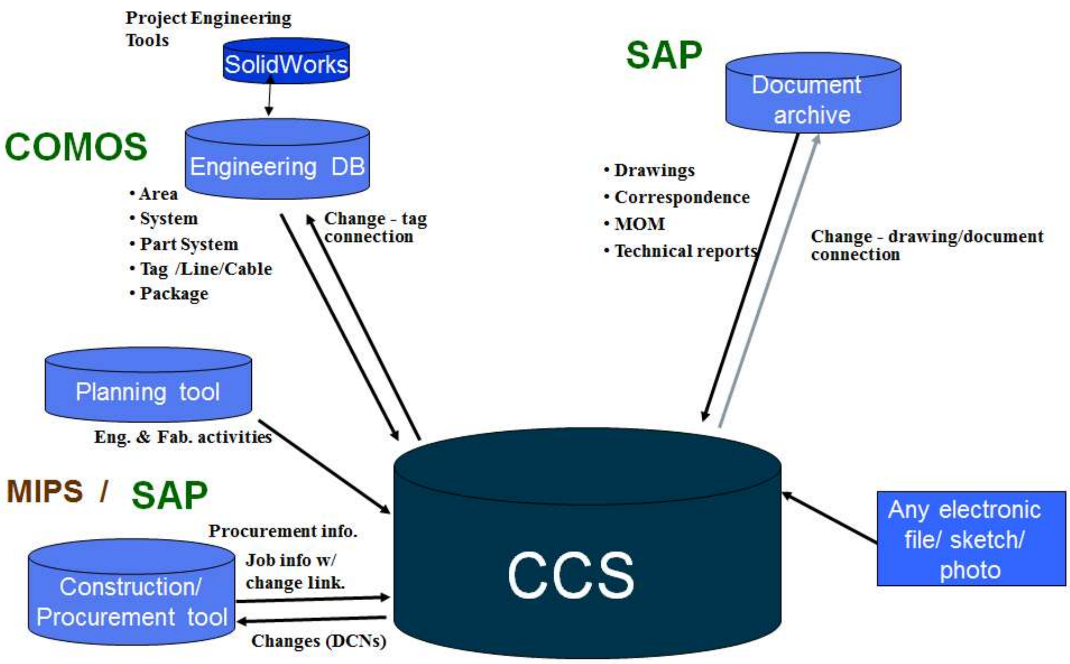

Figure 7 - CCS Interface towards other internal systems [7]

Discussion

This section evaluates the findings of the research and their implications for AKS.

Survey. The survey was completed early in the research to investigate the level of awareness of SGC engineers regarding the internal procedures and compare it with the stage level [23]. It seems that some employees only look at the PEM as an overall guideline for project control for management. As mentioned earlier the PEM is divided into three parts, where the control level is the second part of the PEM. However, the fact that there is an *Execution level* with relevant work tasks at each stage seems to be unknown to the majority of respondents, ref one of the respondents answer:

> *I have answered Agree to all points. PEM shall be the overall guideline for project control, be project pulse check. Unfortunately, we do not have a PEM suitable for a project like SGC, 3/4/2015.*

The purpose of the survey was to gather feedback for management about how project employees understand the PEM. While PEM is a powerful tool developed by employees with mature knowledge of the oil and gas industry, the tool can be quite difficult to understand fully for new employees (who also are put to work instantly and must learn while doing). The researcher recommends the usage of A3 reporting formats to map PEMs strategy for the different units would be advisable.

RCA errors. After Table 1 was created, it was easier to see which categories the errors were mapped into independent of WPs. This was provided to the SGC project SE lead (WP 2) who marked out the errors of the different categories the project would like to see further elaborated, (marked with bold percentage in Table 1). Performing RCA on the different errors highlighted by the WP 2 SE lead, made it possible to track down where each error could be discovered earlier in the project execution, as well as to develop a short plan on how to specifically prevent this error from reoccurring for a future project. When RCA was performed and a suggested root cause of the problem was decided, the researcher contacted employees in the investigated WP who dealt with the error at the time the error could have been prevented. This allowed the engineers to explain their opinion for the cause of error and allowed them to give their opinion for what that could be done differently in the execution process, which could help them to discover errors earlier in the project execution. Collecting all this information from RCA and supported by the internal discussions with project engineers, it was possible to map the different errors into the PEM key stage objectives. This allows the QA team to scrutinize the PEM and suggest updates or training to support the project engineers using it to provide solutions on process improvement.

Interview. During the interview session, the researcher provided a summary of the categorized errors discovered during SIT, with a proposed action for future implementation in form of a RCA that could be implemented in the project execution for preventing such errors from reoccurring. Showing the RCAs to the interviewed employees initiated a discussion about the processes used through the project. Focusing on the category with most errors (design changes) the management explained that in the start phase of the project several of the complex products of the system were outsourced to sub-suppliers for various reasons. The management explained these core products usually were followed up by AKS using a Test Qualification Program (TQP) to ensure that the products quality meet the requirements specified. The management also explained that several of the issues with design changes could be prevented if AKS had the same focus on the non-core products in the system. This focus would include how the part is integrated with the system and how it functions during operation, and not only the product description itself. Based upon the results of this interview it can be concluded that TQP also should be assessed for handling product interfaces and its operational function and not only the specification of the product itself, especially for newer projects.

A3 Report for process improvement. The work accomplished in this study showed that the usage of the A3 problem solving technique is a reliable tool, easy to learn and adapt. A3 problem reporting gives adequate information about an error and its context, how to implement a solution for the error, and the way forward for documenting errors into AKS's database for lessons learnt and NCR. It is highly recommended to take advantage of such a versatile tool that can be used on several layers of the organization.

Record Keeping. In practice, all errors discovered in a project should be implemented as a product or process NCR into internal database e.g. System Applications and Products (SAP) with a root cause of the error and the implemented solution through CCB [4]. For the SGC project, the CCB handled the errors discovered during SIT through CCS. In general, all errors discovered shall be handled by the change board manager together with project manager and affected WP manager. It was suggested in a prior research effort, that an error discovered during SIT also should generate a process change request to discover these errors earlier to prevent late life design changes [24]. With respect to lessons learnt, it is stated in the PEM key stage objectives tasks that it is the responsibility of project employees on the different WP to capture and record errors with suggested solutions in the database. In this way, the team for newer projects can at each stage open the log of lessons learnt from previous projects and use their experience to prevent issues from reoccurring.

As stated earlier, the SGC project was executed with employees from both topside and subsea experience. Considering its complexity, it was decided that the most profitable way for managing such a complex system (i.e. adding a subsea process facility) was to combine topside and subsea engineers (including the fabrication team). This meant combining both "documentation tools" and "engineering tools" to support both the fabrication yards' "handling system" as well as internal engineering support systems as SAP. With employees from two different backgrounds, both PEMs were used with their respective orientations; namely, the Subsea PEM was more modular based and the topside more "engineering discipline" base. In this case, the CCS tool was found to be the communication tool for transition of "document flow" using COMOS as the main layer database (see Figure 7). During SIT testing it was noted that the CCS was a great tool for passing concerns and issues discovered during SIT back to engineering. Registered errors could be brought up for evaluation by the change board, as the basis for proposing a design change to the customer for implementation. The change board manager is able to assign tasks to the involved parties through CCS, such as give orders to "impacted" parties where interfaces are involved.

SE Processes. In summary, as management moves forward to create a PEM customized to the needs of the EST, they will want to pay close attention to the processes that appear at the three-way intersection of the Venn diagram in Figure 2, especially configuration management and continuous process improvement.

Conclusion and future work

When the company seeks to be innovative and steps outside their comfort zone with new product development it can be difficult to maintain the quality system already in place since the "focus area" may change. The SGC project illustrated the challenges such a project encounters during execution phases by being a first of its kind development project.

As stated in the INCOSE Systems Engineering Handbook [16] quality is a daily focus, not an afterthought. Everyone in the organization should know about the quality policy. AKS has grown quickly the last couple of years due to high activity in the offshore industry. This leads to high activity in AKS for project development where the average age of engineers in the company has decreased compared to what it was several years ago [10]. With younger engineers working in the company, it is important to have a good training system to bring employees faster up to speed with project execution terminology, so the employees can be effective in projects, and thereby deliver results that will help to deliver a project within time and budget.

In retrospect, the EST organization had no PEM that was suited for a new product development project. Given that there was no time to develop a new EST PEM before project kick-off (which may also be because of the uncertainty of the project scope), the decision was to steer the SGC project with a combination of both PEMs, even if management knew this could be problematic for the control scope. On the one hand, it can be said that the organization put together a team well suited for a first time new product development project and at the same time keep control of the core parts that are the premises for the success of the advanced project. On the other hand, there is still room for improvement to continually reduce rework, maintaining the lessons learnt database and following-up on NCR. Following through on these activities before future projects begins is one of the conclusions to be drawn from this research.

Also, the research results suggest that the EST organization needs useful SE methods that can be applied to assess the SGC project and improve processes, such as the use of A3 problem solving reports, ref Appendix. Adoption of the A3 reporting within Aker Solutions and AKS has been very slow and is left for future work.

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Biography

Alexander Svendsen is a System Integration & Test Engineer working in Aker Solutions for the Subsea Gas Compression Project, currently positioned as PLOP lead on customer site handling project finalization and handover to customer. Holds a Master's degree in Systems Engineering on top of a Bachelor's degree in Mechanical Engineering with an education from Stevens Institute of Technology and Buskerud University College.

Cecilia Haskins is an industry Associate Professor of Systems Engineering at the Norwegian University of Science and Technology (NTNU) where she teaches courses in research methods, globalization, CSR and sustainable development, systems engineering and project management. Her research interests focus on improvements to manufacturing and construction projects in shipbuilding and the oil and gas industry.

Continuous improvement to reduce rework, control costs

Date: **Latest Draft**	Owner: **Alexander Svendsen**
Approval Date:	Manager Approval:

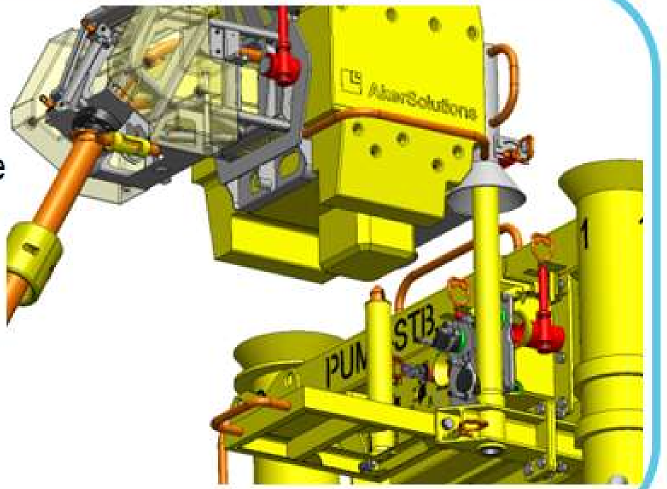
Background

- SIT of complex subsea products resulted in additional testing for complex interface
- Due to interchangeability the plan was to perform one test of each HVFL* towards one pump each. This test scope expands from 3 tests due to tolerance issues to 9 tests.

	Pump Module #1(Spare)	Pump Module #2	Pump Module #3
Pump trafo 2/HVFL #1 (Spare)	Re-test requested	16.04.2015	07.02.2015
Pump trafo 1/HVFL #2	15.04.2015	17.04.2015	22.01.2015
Pump trafo 3/HVFL #3	Re-test requested	Re-test requested	07.02.2015

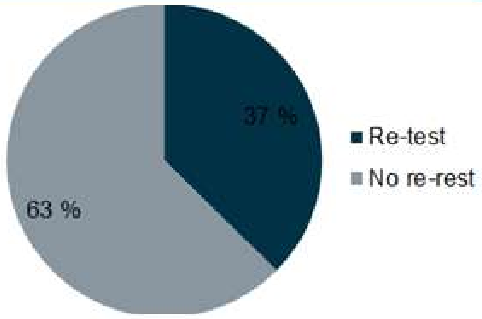
CURRENT CONDITIONS

- Error found during SIT of mating HVFL1 toward Pump 1 when jumpers snapped
- FAT was performed at sub-suppliers site with PRE Engineering to qualify the product and its interface mechanism.
- High voltage jumpers for the HVFL (male connector) were at an angle inconsistent with the Pump (female connector), and outside the variance established for the jumper sub-supplier.



GOAL

- Reduce the amount of re-test at SIT.
- Implement Lessons Learnt and NCR.
- Improve the work process model for the quality system using PDCA.



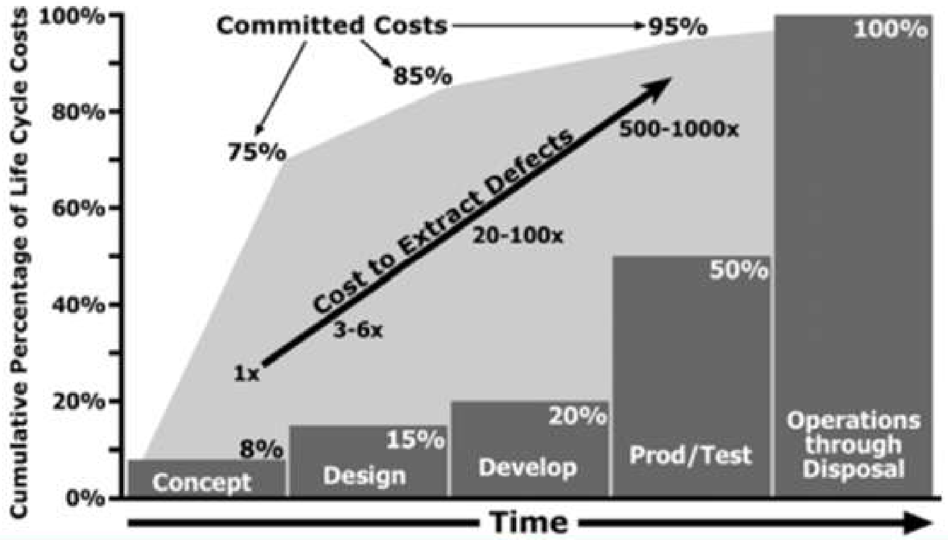
ROOT CAUSE ANALYSIS

- Unable to mate HVFL1 towards Pump1 successfully. ***Why?***
- The High Voltage jumpers in HVFL snapped early in the mating. ***Why?***
- The angle between male and female connector was outside acceptance criteria. ***Why?***
- The FAT conducted on the HVFL delivered by the sub-supplier did not detect the anomaly. **Why?**
- The PRE Engineering work process did not place enough attention on the critical interface. ***Why?***
- More focus needed in TQP on interfaces as well as core system parts.

* HVFL = High Voltage Flying Lead

PROPOSAL

- Reduce re-work by changing traditional design work practices. Not only run TQP on sub-parts being the *core* part of the system. TQP should also be brought on the interdisciplinary part of the system, the interface mechanism.
- Focus on issues like this during design can reduce the cost of extra defects discovered during testing.



PLAN

What?	Who?	When?	Where?
Notify QM regarding the issue. Improve the TQP for future projects, with focus on interdisciplinary with interfaces. Make a Lesson Learnt on the scenario to improve the work processes, allowing for the ability to reduce rework.	Project Manager shall define whom that will give a suggestion for improving the TQP and notify QM. Lessons Learnt shall be written by Test- and Design Engineer.	As soon as possible, or at least before they leave the project.	Aker Fornebu
Address early FAT on fabrication yard when sub-suppliers components are integrated to the system.	Engineering- and Mechanical Completion Manager need to coordinate for this to happen at fabrication site.	Extended FAT at fabrication site needs to take place early before SIT kicks off.	Aker Egersund

FOLLOW UP

- Verify that the PDCA loop is actively used in the company.
- Ensure Lessons Learned is updated.
- Verify NCR is made (if applicable).
- Ensure continuous improvement; reduce lead time before delivery by improving quality.