Applying A3AO to Facilitate Future Working Processes in the Oil and Gas Industry

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Abstract. Companies in the oil and gas industry strive to increase their performance in Engineering, Procurement, Construction, and Installation projects. New responsibilities of the Company within this research, encounter unforeseen surprises in an early project phase called As-Is Engineering. No prioritization for documenting and communicating working processes and key-personnel dependency are the symptoms related to the Company's challenges. To cope with the Company's challenges, this research investigates the development of a process architecting tool to facilitate future working processes. Given a known method of A3 Architectural Overviews from Systems Engineering for communicating architectural knowledge, we applied it together with process mapping to develop a process architecting tool for the Company. Through literature review and workshop testing with loops of feedbacks in the Company, a process architecting tool - Operational A3 is proposed. Results from surveys and interviews show the Operational A3 benefits the Company in terms of increased project performance.

Introduction

Due to rising global demand, volatile prices and new environmental regulations, reducing cost is one of the biggest challenges the Oil and Gas industry is facing (Veolia, 2016). Before 2014 the crude-oil price was exceeding $100 per barrel (Macrotrends, 2021). This led to big investments from oil and gas companies in new large-scale production facilities. Ever since 2014, the oil price has dropped significantly. In 2020 the oil price dropped below $50 per barrel (Stevens, 2020). As a result, the oil companies have cut back on investments in new production facilities, known as Greenfield. Now the focus has shifted towards maximizing the efficiency of their existing assets, which means the oil companies are investing in upgrades and maintenance of their existing production facilities, known as Brownfield (Richards, Sotomayor and Olsen, 2015). Due to the low oil price, oil companies try to

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keep the cost of Brownfield upgrade projects as low as possible. Therefore, companies with the responsibility for Engineering, Procurement, Construction, and Installation projects in this industry must keep the cost low by any means. Increased efficiency and quality are key attributes for keeping the cost low. This results in an increasing need for better working processes, which is facilitated in a way that makes engineers more effective with increased quality in their daily work.

The Company. The Company within the context of this research is a technology company located in Norway delivering products and engineering services for the maritime vessel- and offshore-industry. The Company has a long heritage of development and delivery of Safety- and Automation systems to both Greenfield- and Brownfield projects in the offshore industry. Projects in Greenfield are new projects executed from scratch with lacking constraints in terms of existing systems and solutions, while Brownfield are projects executed on a current state of a site with many constraints (Pan, 2021).

Challenge. The Company's current way of working in Brownfield upgrade projects are heavily dependent on engineers with many years of experience. Their dependency is visible within the first phase of a Brownfield upgrade project called As-Is Engineering. Their best practices and working processes are tacit knowledge, which is knowledge, skills and abilities an individual gains through experience (Oragui, 2020). The department in the Company that is responsible for these Brownfield upgrade projects, does neither like to prioritize documenting nor communicating how they are working. Consequently, engineers with less experience approach the As-Is Engineering phase different from the experienced engineers in terms of the usage of engineering-tools and best practices from previous projects. One resulting factor is that less experienced engineers have been neglecting the importance of this phase and therefore unforeseen surprises have occurred later that influenced the project performance. With the goal for increased project performance and being less key-personnel dependent, there exists a need of a tool for architecting the future working processes for As-Is Engineering. The architected processes shall be encouraging to read and use by other engineers, which in the end will lead to increased performance in future Brownfield upgrade projects.

Research question. To address the key challenge, the researcher aims to solve the following research question: *How to develop a process architecting tool to facilitate future As-Is Engineering working processes for increased performance in Brownfield upgrade projects?* The process architecting tool is to contribute to increased performance in terms of better efficiency and quality and being less key-personnel dependent in future Brownfield upgrade projects.

Literature review

Stakeholders and Stakeholder Management. Viewing the process architecting tool as the black-box, Systems Engineering approach has utility to help to manage the stakeholders to the system of interest. Understanding the stakeholder needs and requirements is key to develop the correct system. According to the ISO/IEC/IEEE 15288:2015, a stakeholder is an *"individual or organization having a right, share, claim, or interest in a system or in its possession of characteristics that meet their need and expectations."* As there might be thousands of stakeholders to a system of interest, the process architecting tool in this research concerns stakeholders from the Oil and Gas Brownfield upgrade project department within the Company.

A good stakeholder management help maintain good relationship among the people who have the most impact on your work (MindTools, 2021a).To develop the process architecting tool development, many of the stakeholder will be involved and thus their relationship need to be managed and analyzed properly. According to Brugha and Varvasovszky (2000) stakeholder analysis develops an understanding of the stakeholders in regards to interest, influence, position, networks, statements etc. The different stakeholders need to be managed and prioritized based on their characteristics. A

power/interest grid can be used to visualize whom to manage closely, keep satisfied, monitor and keep informed (MindTools, 2021b).

Processes and Process Mapping. Processes within an organization is seen as the important internal assets in terms of value creation. According to Muller (2009), a process is defined as *"an activity which takes place over time and which has a precise aim regarding the results to be achieved. The concept of a process is hierarchical which means that a process may consist of a partially ordered set of subprocesses. A process can be tailored and elaborated in one or more procedures that describe cookbook-like what needs to be done when and by whom. The why in a procedure has often disappeared, to be replaced by practical information for the execution."*

Processes refer to the core competency in an organization and plays a role for success relative to competitors. They can be considered a factor for business growth as they involve the majority of the organizations workforce and produce customer and stakeholder value. (Baldridge, 2009)

To display processes, many organizations use process mapping which is a graphical representation with illustrative descriptions of how things get done (Hessing, 2021). This is commonly used in LEAN manufacturing where organizations focus on minimizing waste within manufacturing systems while at the same time maximizing the productivity (Daniel, 2020). Process maps focuses on visualizations rather than communicating the process with texts. The purpose with process mapping is to provide effective visual communication of information and data, which is easily understood by team members and others. The key elements of a process map is actions, activity steps, decision points, functions, inputs/outputs, people involved, process measurements and time required.(Lucid Software Inc., 2021a). As the process maps provides insights in how a process is working, there are many different types of process maps, such as high-level process map, document map, value stream map, detailed process map, workflow diagram, swim lane map, etc. For instance, the high-level process map represents a process as a whole, whereas the detailed process map provides a detailed look at each step in the process (Lucid Software Inc., 2021b)

A3 Architecture Overview. A3 Architecture Overviews (A3AO) are known to be an effective tool for communication and capturing architectural knowledge in relevant aspects for a specific goal(Laar, 2021). It is based on a standard European sized A3 sheet (297*420mm) and originated from Toyota Motor Corporation's A3 reports where they used them for problem solving (Sobek and Jimmerson, 2006). The A3 format facilitates effective communication as it contains a combination of text, pictures, diagrams, and charts to describe a system of interest. Compared to a text document, the A3 format prevents "information overload". Chakravorty (2009) describes process improvement by using Toyota's A3 reports and the way this format establish a clear representation of a current problem. Since it is not a long text document, the A3 reports eliminates excess information not relevant to the problem at hand. Borches (2010) took the A3 reports from Toyota and further developed the A3AO tool. In the A3AO, architectural knowledge is represented in different viewpoints: functional, physical, constraints, key parameters, and visual aids. Borches (2009) proposed in his cookbook to use two A3 pages where one page represents textual information, while the second page contains visual architectural knowledge in the different viewpoints.

A3AO has been used during development of new products. Hooft (2020) made a tailored A3AO template to facilitate the application of Systems Engineering and systems thinking among systems architects in a new product development process. Having the A3AO template helped the team of system architects to develop new systems instead of just capturing existing system architecture. Thus, the A3AO format is known for its brevity and human-friendly way to communicate architecture knowledge. Pessele (2019) applied A3AO as a way to communicate architectural knowledge to assure common understanding and overview of a high-voltage charging system among stakeholders. The created A3AOs were found useful for training new employees, triggered discussions and helped

a team of system architects to get a better overview compared to other documentation. Sing and Müller (2013) even developed a Dynamic A3 Architecture with the intention to let the reader navigate through active links. They found out that their Dynamic A3 can facilitate knowledge capture and share a common understanding of a system of interest.

To develop a process architecting tool to facilitate future working processes, the A3AO as a method is considered as applicable tool. Extant literature on A3AO is mostly based on system architecture and how to communicate architectural knowledge during product development and conceptualization. However, the applications of A3AO towards working process architecture are limited. Johanssen and Zhao (2019) at the first place extended the usability of A3AO towards process architecting in software development. They pointed: "*If a company has a need to architect a process or simply unify their way of working, it is recommended to use A3AOs to communicate this architectural knowledge in the complex systems development process*". Their research looked at an existing system development process and captured past knowledge and best practices. However, the application on how to use A3AO to facilitate future working processes has not been researched yet. This led to an opportunity to contribute to process architecting literature using A3AO and process mapping.

Conceptual Solution

The literature review serves as basis for the conceptual solution of the process architecting tool to facilitate future working processes. In consideration with the importance to communicate an architected process in an easy and encouraging way for the end user, the conceptual solution represents key elements from process mapping together with the ideas from A3AO that is providing overview and communication.

We named the conceptual solution Operational A3 (OPA3). The word "operation" is defined as "performance of a practical work or of something involving the practical application of principles or processes."(Operation, 2021). The researcher used the term "operation" due to the environment the architected working processes are used. Activities within As-Is Engineering are highly practical in terms of "hands-on" activities such as different investigations, fieldwork, usage of engineering tools and checklists. With the practical aspect and communication of a working process in mind, the concept OPA3 consisting of two A3 sheets is made.

Process mapping focuses on visualizations rather than communicating a process with text (Daniel, 2020). Borches (2009) suggested using two sheets when making an A3AO, whereas one sheet has textual information and the other sheet consisting of figures and diagrams. As the OPA3 focuses on visualizations rather than text, the first sheet from Borches (2009)'s cookbook is replaced with high level diagrams and figures. The OPA3 is developed by Microsoft Visio, consisting of a Top-Level sheet and a Lower-Level sheet (see Figure 1 & 2). As Singh and Muller (2013) suggested, the two sheets and their active links in OPA3 can be tied together with the use of a linking functionality in Microsoft Visio for the purpose of easy navigation. As shown in Figure 2, the user can navigate to the related Lower-Level OPA3 by pressing "start" in the Operational Flow view in the Top Level OPA3 for the chosen process. Also, the same principle is applied in the Process View and the active process is called "Collect Scope Documentation" (see Figure 3). The user can navigate to "Analyze Scope Documentation" by clicking on the respective process box.
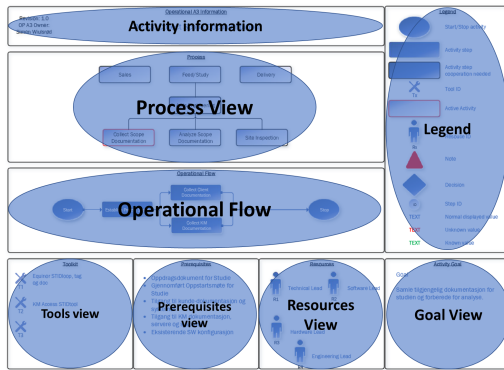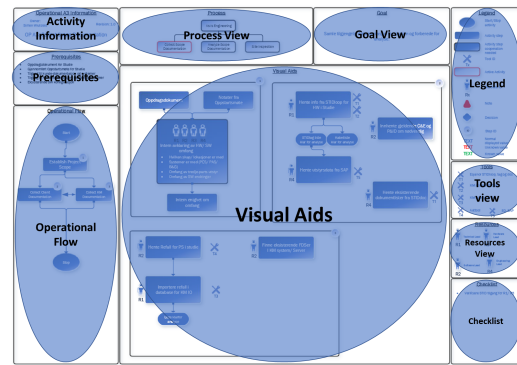
Figure 1. Top-Level OPA3

Figure 2. Lower-Level OPA3

Johanssen and Zhao (2019) found the useful views, e.g. operational flow, visual aids and goals, in process architecting, and used an Operator ID to well link those views. All those views are adopted to our OPA3 concept together with the use of an Operator ID. Furthermore, the same principle to Joannassen and Zhao (2019) is applied for mapping relevant resources and tools to be used in different stages of an activity or process. Figure 4 illustrates how our OPA3 concept utilized this principle. As a result, the OPA3 conceptual solution consists of the following views to architect a working process: Information, Process View, Operational flow view, Tools view, Prerequisites view, Resources view, Goal view, Checklist and Visual Aids view. It is to be used by experienced engineers to architect their working process knowledge. The intention is that the documentation (OPA3s) made then can be used by others in the future for increased project performance and for the project organization being less key-personnel dependent.
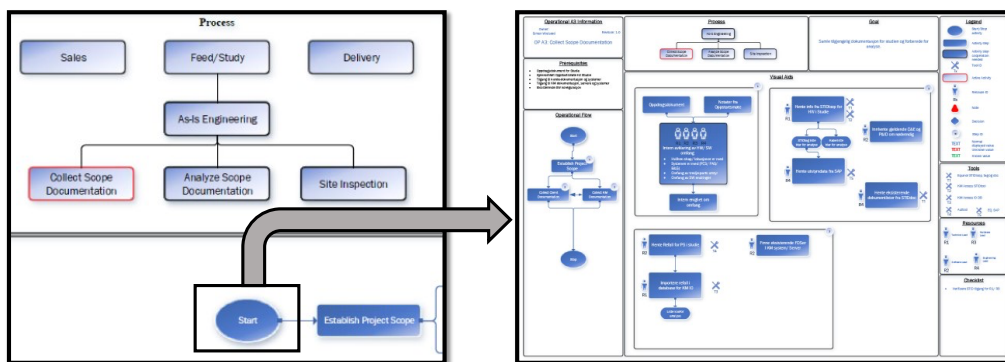

Figure 3. Linking top Level OPA3 to Lower Level OPA3 for activity "Collect Scope Documentation"
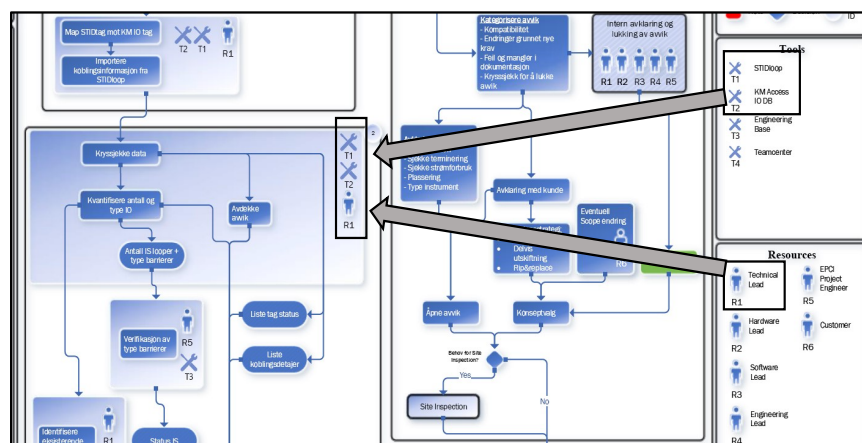

Figure 4. Mapping resources and tools to actions within a process on Lower-Level OPA3

Research Methodology

Case study. We employed a case study research method. According to Crowe (2011), a case study is an "approach to generate an in-depth, multi-faceted und understanding of a complex issue in its real-life context." In this case study, we aim to solve the challenges the Company are facing with the As-Is Engineering phase of Brownfield upgrade projects by developing a working process architecting tool to facilitate the future working processes.

Interviews. Interviews are a powerful research activity to collect data from other people (Muller, 2013). We used a combination of open interviews and semi-structured interviews in this study. Open interviews are a free format technique were there are no pre-defined set of questions beforehand, such as open-minded talk about a chosen topic with stakeholders. Comparing with open interviews, semi-structured interviews have the advantage by having predefined topics that could lead the conversation in the direction the researcher wants (Wiulsrød, 2020). Our semi-structured interviews started with an introduction to the process architecting tool OPA3 with a following set of predefined questions related to the stated themes. We used predefined questions that blend closed- and open-ended questions with follow-up questions like why and how (Adams, 2015). Specifically, our predefined questions are related to the following main themes: Text documentation versus OPA3, performance attributes in future projects, visual aspect of the OPA3 and key-personnel dependency.

A series of interviews are conducted to meet our research objectives. Four open interviews are performed for problem exploration, find relevant stakeholders, case study exploration, concept exploration, and concept feedback. Furthermore, five semi-structured interviews are conducted with relevant stakeholders. The interview participants are carefully chosen based on their relevance such as their positions, experience, and knowledge in the Company to the specific objectives of data collection at different stages of the research. All interviews are performed on Microsoft Teams meetings. The overview of interviews in this research are listed in table 1.

Table 1. Open- and Semi-structured Interviews with Stakeholders

No.	Type	Participant(s)	Experience	Objective	Phase
OI-1	Open Interview	1 Line Manager, 1 Installation Manager, 1 Engineering Manager	50+ years	Explore problem and relevant stakeholders for case study	Exploration
OI-2	Open Interview	2 Technical Leads, 2 Senior Engineers, 1 Project Engineer	80+ years	Case study exploration	Exploration
OI-3	Open Interview	1 Engineering Manager, 1 Line Manager	40+ years	Concept exploration	Exploration
OI-4	Open Interview	2 Directors	40+ years	Concept feedback	Exploration
SSI-1	Semi-Structured Interview	2 Directors, 1 Line Manager	40+ years	Concept feedback based on created OPA3s	Application
SSI-2	Semi-Structured Interview	1 Line Manager	30+ years	OPA3 concept feedback	Verification & Validation
SSI-3	Semi-Structured Interview	1 Project Manager	20+ years	OPA3 concept feedback	Verification & Validation
SSI-4	Semi-Structured Interview	1 Senior Engineer	10+ years	OPA3 concept feedback	Verification & Validation
SSI-5	Semi-Structured Interview	1 QHSE Manager	30+ years	OPA3 concept feedback	Verification & Validation

Research design. The research is processed through three phases as shown in Figure 5.
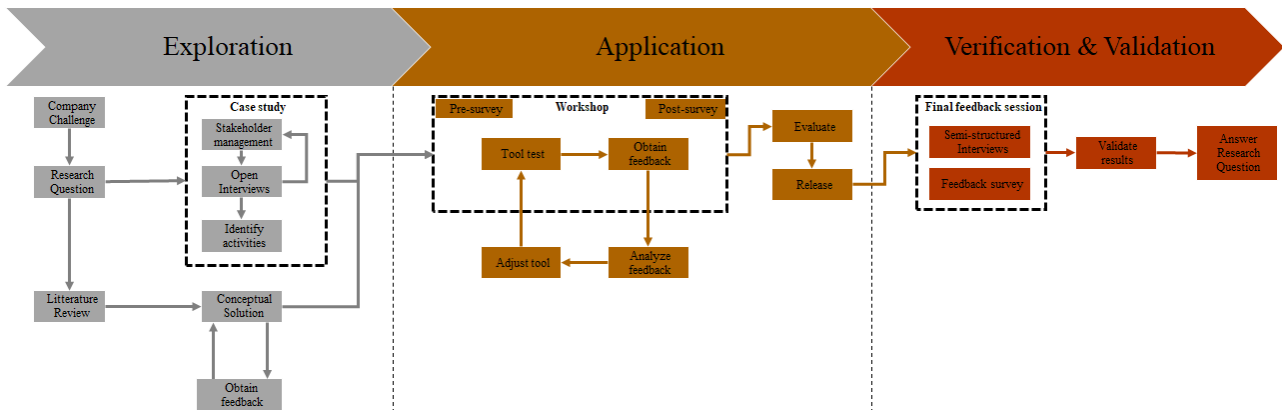
Figure 5. Research Design

During the *Exploration* phase, the main objective is to get an overview of challenges the case company are facing, identify a problem statement as a research question and identify a conceptual solution through literature review. A stakeholder management activity such as gathering and analyzing stakeholders are conducted to identify whom stakeholders to involve during different stages in the research. Open interviews with important stakeholders are done during this phase to get relevant information for the case. Based on the given information a set of As-Is Engineering activities are chosen to fit the scope of this research. Along with exploring the case, a literature review is conducted to find relevant literature towards the use of A3AO for a process architecting application. During the development of the conceptual solution, feedback is obtained with relevant stakeholders for the purpose of early verification of the process architecting tool.

Based on the conceptual solution and the chosen As-Is Engineering activities, testing during workshops are done with experts in the field of As-Is Engineering within the *Application* phase. Before the workshop, a pre-survey is introduced to the experts. The intention with the pre-survey is to measure the attitude before the architecting process and investigate the needed effort for using the tool. The process architecting tool is introduced to the experts. With the tool in hand, feedback during the workshop is collected for improvement and further adjustments of the process architecting tool. At the end of each workshop, a post-survey is given to the experts. Data from the post-survey are relevant data for evaluation of the process architecting tool in terms of attitude. Furthermore, an evaluation is done by open interviews to verify the created OPA3s for the chosen As-Is Engineering activities and determine the value of the process architecting tool in the Company.

In the *Verification & Validation* phase, the verified OPA3s are released among a different set of stakeholders in the department for Brownfield upgrade projects. The intention is to get feedback from a group of stakeholders with no prior knowledge to the process architecting tool. A feedback survey is introduced to the participants to verify and validate the process architecting tool in terms of increased project performance and less key-personnel dependency. Furthermore, semi-structured interviews are conducted with selected stakeholders based on their power and influence from the stakeholder analysis. The data collected from the semi-structured interviews are compared with results from the feedback survey with the purpose of validating the results towards answering the research question.

Surveys. Three surveys are conducted in this research: Pre-survey, Post-survey, and Feedback survey. In the surveys, the participants get a series of questions/statements where they answer with five response alternatives: Strongly Agree, Agree, Natural, Disagree and Strongly Disagree (Boone and Boone, 2012). This likert scale is used to measure attitudes or opinions directly (McLeod, 2008). The participants' attitudes or opinions are useful data for the implementation of a new process architecting

tool within the Company. All the participants to the surveys are with little or no prior knowledge to the OPA3 concept. Five participants answered the Pre-and Post-survey: Two Lead Engineers, one Installation Manager, one Project Engineer, and one Senior Engineer. The feedback survey is sent out to 44 stakeholders with different positions in the Company: Project Engineers, Senior Engineers, Lead Engineers, Line Managers, Projects Managers and Project support positions.

Case Study Findings

As-Is Engineering. Based on the interviews (OI-1 and OI-2), we asserted the As-Is Engineering phase is crucial for the upcoming Brownfield upgrade project. The customer for these types of projects states a project mission in a mission document. The EPCI-contractor conducts a Sale/Study where they analyze the customer need and stakeholder requirements stated in the mission document. This phase can be referred to as the As-Is Engineering phase as illustrated in Figure 6. Performing this phase well at the first place is crucial as this phase works as the foundation for future design decision and the rest of the EPCI-project phases.
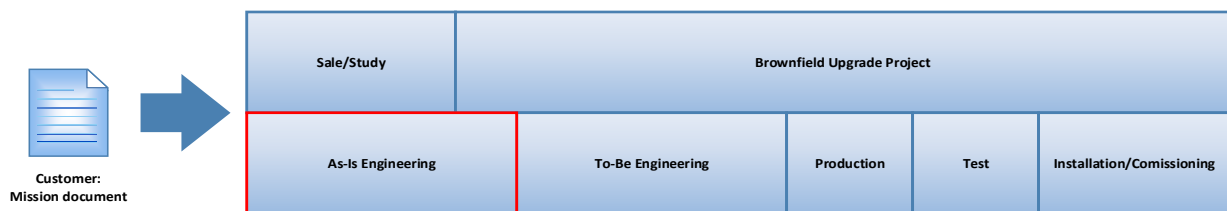

Figure 6. As-Is Engineering in the context of Brownfield upgrade project

In recent times, the customer has given the Company the total responsibility as the EPCI-contractor. The project organization consisting of Technical Lead engineers and Project Engineers who are responsible for finding the correct approach for the As-Is Engineering phase. As Brownfield upgrade projects are not the same each time, the Lead Engineers need to do reverse-engineering for an overview of the situation and the related systems. The essence in the As-Is Engineering is to find existing solutions, analyze and verify them in the light of existing documentation and the running system on board. Recent EPCI-projects conducted within the Company's Oil and Gas department posted challenges to be effective and consistent in the daily work. In the absence of working processes to follow for this type of engineering work, those engineers work differently while finding solutions, analyzing, and verifying system relationships in the Company. As a result, the quality for the end product (i.e. upgraded hardware and software) varies from project to project.

With a focus of developing a process architecting tool to facilitate the future As-Is Engineering working processes, we identify three key engineering activities within this phase (based on OI-2):

- **Collect Scope Documentation:** As the first activity of the As-Is Engineering phase, the goal is to gather all available documentation for the scope of work and prepare for analysis.

- **Analyze Scope Documentation:** The second is regarding where most of the working hours are spent. The goal is to verify correct existing documentation, list up deviations and propose conceptual solutions to fulfill customer need and requirements stated in the mission document.

- **Site Inspection:** The goal is to get a more detailed overview of the As-Is situation on board the vessel or platform being upgraded. Identifying typical and non-typical solutions, possible shostoppers and deviations leading to validation on findings from the Analyze Scope Documentation activity. The outcome of this activity is a survey-report where all findings are documented.

Stakeholder Management. In the exploration phase, we identified the key stakeholders to this research based on the OI-1. They include the personnel, who need to be managed closely, i.e. Technical

Lead Engineers, Senior Engineer, and Installation Manager. They have domain knowledge and can be referred to as experts in the field of As-Is Engineering. They are also part of the test workshops of the OPA3 concept. Moreover, we found Directors Oil and Gas, Project Managers and QHSE Mangers are to be kept satisfied as they great influence when it comes to introducing new tools and methods in the Company. Our semi-structured interviews mostly concentrate on those stakeholders within "Keep Satisfied" and "Manage Closely".

Concept Exploration. Before running test workshops with field experts, the utility of the OPA3 concept in the Company is initially explored with a Line Manager and a Engineering Manager in the OI-3. The importance regarding the level of abstraction to describe a process to be useful for engineers working with the As-Is Engineering in the future is clarified. The Engineering Manager pointed out the Company's Cost, Resource, Time (CTR) reports to be the lowest level of abstraction, whereby CTR as a document that describes each major element in the work breakdown structure, including a statement of work describing the work content, resource required, the time of the work element and a cost estimate (PMO, 2016). They are highly project specific as they are linked towards a project's Work Breakdown Structure. This level of detail within a CTR report is relevant to what level of abstraction we should architect the working processes in the OPA3 in the case study.

Through the OI-4 with two Directors within the Oil and Gas department, it is found the existing working process documentation in other parts of the Company is mostly text-based and thus is rarely used by others. The two Directors confirmed the visual aspect of the OPA3 could be beneficial in terms of the end user's interpretation of the working process being architected. In addition, one improvement to the OPA3 was identified regarding who should be responsible for the activity being architected - Technical Lead. This improvement is implemented in the process architecting tool on the Top-Level view (Figure 7). At this point, the OPA3 tool is ready for the workshop testing.
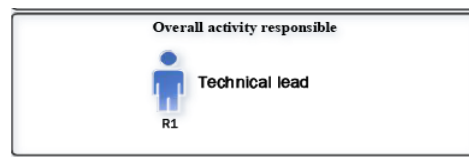

Figure 7. Implemented view for Top-Level OPA3: Overall activity responsible

Workshop Testing

The OPA3 conceptual solution is tested during workshops with experts within the As-Is Engineering field. With the tool in hand, the experts are told to architect the three identified As-Is Engineering activities: Analyze Scope Documentation, Collect Scope Documentation, and Site Inspection. The activities are split into three workshops with different experts for each activity. From each workshop, there are improvement points and feedback given to the researcher. Furthermore, a pre-survey (see Figure 9) is conducted after presenting the tool to the participant to obtain their attitude for architecting the given activity in the OPA3. Likewise, a post-survey (see Figure 10) is conducted for the same purpose. Highlights from each workshop are presented below.

Workshop 1. The OPA3 was first introduced to a Technical Lead to architect the **Analyze Scope Documentation** activity. The workshop ended up in a 2 ½ hours session, whereas the first 15 minutes were used for introduction and give guidance on how to use the tool. The participant started with architecting the process on the Top-Level OPA3. From start until the end of the workshop, it was identified that an Auto-connect function turned on in Microsoft Visio limited the participant in illustrating what he wanted. Unnecessary time was spent on rearranging boxes and arrows as they automatically connect to each other. Apart from that, the participant expressed it will go faster when you have used the tool a couple of times. He argued it ran faster than creating a text-based process docu-

-ment. He also stated it would have been easier to architect the process with a group of people, instead of one person being responsible for architecting the process. Furthermore, the participant gave feedback on the sizing on the Tools view, Resource View and Legend View. Both Tools- and Resource view on Lower-Level should be bigger as there might be even more tools and resources in more complex processes. To the contrary, the Legend View should be smaller as it takes up too much unnecessary space and rather increase focus on more vital views as shown in Figure 8. In general, the participant was positive using the tool to architect the given As-Is Engineering activity and would think the reuse value is bigger with this format than a text-process document.

Workshop 2. Based on the feedbacks from workshop 1, the tool was adjusted and given to the participants for architecting the activity **Analyze Scope Documentation**. This workshop was conducted with a group of experts as suggested by the Technical Lead in workshop 1. One Installation Manager, one Senior Engineer and one Technical Lead participated in this workshop with a duration of 4 hours split across two days. The researcher observed their use of the OPA3 to architect the given activity and then led the discussions among the participants. We found having one experienced Microsoft Visio user responsible for putting information into the OPA3 turned out to be efficient. Moreover, one of the participants pointed *"I like how the tool forces us to visualize how we work rather than describing it with text"*. No improvement feedbacks are noticed during this workshop.

Workshop 3. The activity **Site Inspection** was architected with OPA3 by a Project Engineer. In about 2 hours, the participant architected the given activity based on his knowledge. He found it easy to use the tool and the output of the tool is more encouraging to read for new engineers like him than text documents. No improvement feedbacks are given during this workshop. However, we found no participant used of the Normal/Unknown/Known value in all three workshops and it is removed for the final solution.
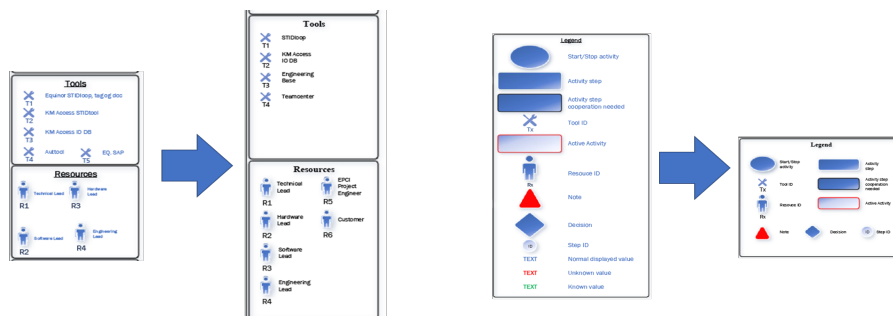
Figure 8. Lower-Level Tools- Resources View bigger & Legend Top-Level smaller

Workshop Pre-survey and Post-survey. All five experts in the test workshops participated in a pre- and post-survey. The survey results are shown in Figure 9 and 10. We found an overall positive attitude for architecting a process in use of the OPA3. It was easy to understand, and they saw the value of creating OPA3s both before and after using the tool. However, some would think it is a time-consuming process to create OPA3s and would have to be creative-minded.

Figure 9. Pre-Survey results workshops

Figure 10. Post-Survey results workshops

Final Solution and Evaluation

The learnings of the three test workshops help formed the final solution of the OPA3. Figure 11 shows the architected process for the **Analyze Scope Documentation** activity onto the two sheets in the OPA3: Top-Level and Lower-Level.

Figure 11. Analyze Scope Documentation in Final solution OPA3

The final solution was presented to the key stakeholders for validation and verification. The evaluation results from semi-structured interviews and feedback survey are elaborated below.

Semi-Structured Interviews

Text documentation versus Operational A3. Questions related to the theme Text documentation VS Operational A3 were the starting point in all the interviews. The directors (in the SSI-1) mentioned *"..it is easier to get people to look at this rather than reading a long document. Here you have two A3 pages giving the full overview. This activity you are showing here would easily be 20 pages of guideline documentation in comparison."* The Line Manager shared experienced (in the SSI 5) that the text-based process documentation is heavy to read and tends to be forgotten in the department. He could see this as more educational than text based: *"This is much more exciting to read and much more educational correct".* The senior engineer who started in the company a few years ago told (in the SSI-4) that he missed a document telling him how to do a certain activity or process step by step. He agreed on the value of the Operational A3 compared to text-based documents: *"With the ability to make the Operational A3 interactive with the use of links to other documentation, I believe this could be very useful in my daily work.".* Furthermore, the Project Manager (in the SSI-3) believed that this could replace text-based process documentation to full extent. However, the Quality Manager (in the SSI-5) hesitated to agree with the statement: *"We have a long way to go if you want to replace this with our existing text-based procedures. I like the visual aspect of the Operational A3,*

but I am not sure if this is the future for the company."

Performance attributes in future projects. The performance attributes for the project are determined as the efficiency and quality of the project work. The Project Manager (in the SSI-3) agreed on improved performance in future projects *"I believe we could reduce the amount of engineering hours if such OPA3s are made for different engineering activities. We can secure conformity in the projects, which will end up in better quality in the end."* The Senior Engineer and Quality Manger both agreed on that the potential quality improvement in future projects, yet found it difficult to say if the projects would reduce the amount of engineering hours by using this tool. However, The Senior Engineer pointed out an important aspect of improved efficiency *"I see the added value in terms of resource-allocation. If I get help from an engineer from another project, I could just point into the OPA3 and show him/her where we are and what to do next."* One Director (in the SSI-1) also responded regarding the increased efficiency: *"From Knowledge Management perspective there are a huge number of hours spent on finding the right information throughout a week. With the OPA3 people know where to look first before they ask other people".* The other Director (in the SSI-1) believed both quality and efficiency would increase and pointed out the possibility to improve based on learning: *"I believe this could add quality and improve the efficiency. I think it is easier to update the OPA3 than a text-based procedure when you find a better way to do an activity or process."*

The visual aspect of the Operational A3. Given the OPA3 is based on communicating processes visually, it is an highlight in the SSI-1 that *"We are developing towards a more graphical future with the newcomers use of social media, apps and others. I believe this could catch new engineers' attention and be a platform for architecting process documentation for the new generation."* The Line Manager (in the SSI-I) commented on the way resources and tools mapping onto the Lower-Level OPA3: *"I do like the way how the resources and tools are mapped on each step in the process flow. This is easy to read, and you know where to use each tool and who is responsible."* Furthermore, the Senior Engineer (in the SSI-4) would like to see how the OPA3 could evolve over time: *"It would be nice to see how this tool could have evolved if it was used over a period of a year or so".*

Key-personnel dependency. The interview participants were asked if they think OPA3 could reduce the key-personnel dependency in the Company. There needs to be a certain level of detail to reduce the need for a keyperson. Project Manager (in the SSI-3) answered: *"There will always be need for someone who has more knowledge than others, but documented processes in this tool will help you further before you ask for help."* The Line Manager (in the SSI-2) also commented that documented processes in this tool would be a great addition to the work but you will always be dependent on key-personnel. The Quality Manager (in the SSI-5) agreed with the Directors (in the SSI-1). on the level of detail: *"It depends on the level of detail and how you are using your keyperson. If you are using your keyperson for a step-by-step process the OPA3 will reduce the keyperson dependency. If you are using the keyperson for detailed knowledge, the OPA3 will not help."*

Feedback Survey

Figure 12 shows results from a feedback survey conducted in the department working with Brownfield upgrade projects. The overall response rate is 54% (24 out of 44 participants), whereas two participants answered with general comments to the process architecting tool itself. The majority (22 out of 24 participants) agrees or strongly agrees on the value of creating OPA3s. The consistency to the interview findings is yield. It is found the visual aspect of the OPA3 is mostly preferred rather than reading long text documents, in spite of some concerns OPA3 can be overwhelming or oversimplified. In addition, the adoption of OPA3 is believed to benefit the future projects in terms of efficiency and quality. Regarding the key-personnel dependency, the survey results shows that there is a significant number of people which is either neutral or not positive to the Company being less key-personnel dependent in the future by using this tool. The results also show that not everyone would utitlize the OPA3 to document how they are working in the future.

Discussion

In Sum, the results above show that the developed OPA3 can solve the current challenges. Most of the participants from semi-structured interviews agreed on increased performance in terms of efficiency and quality. As the Project Manager from SSI-3 was saying *"I believe we could reduce the amount of engineering hours if such Operational A3s are made for different engineering activities."* The feedback survey could verify this statement from statement 3 "Operational A3s could benefit the project organization in terms increased efficiency" with the following results: 6 Neutral, 11 Agree and 7 Strongly Agrees. In addition, the Directors pointed out that the use of this tool could benefit the organization in terms of increased efficiency and quality based on learning. However, the Senior Engineer and QHSE Manager did not fully agree with the statement as it is hard to say. The key reason is related to the fact the tool was not used over a longer period but only three As-Is Engineering activities in one-time workshops. If the tool had been used in the department over a period of a year or so documenting even more activities, it is believed answering the question would have been easier. On the other hand, people would believe by documenting future processes in this tool will help increase the quality in future Brownfield upgrade projects more than the efficiency. As the Project Manager pointed out "*We can secure conformity in the projects, which will end up in better quality in the end"*. The participants from feedback survey were overall positive to how the tool will benefit the Company in terms of quality and help standardizing the way people work in the future.

Results from feedback survey validate the importance of the visualization. People would rather read OPA3s than text-based documentation and the visualization aspect of the tool makes it encouraging to read. As the working processes is part of the core competency in an organization, it plays a role for success relative to competitors (Baldridge, 2009). If engineers would learn the process documents via OPA3s, the core competence in the organization is more likely to increase. Additionally, the Company see the value of creating OPA3s as they tend to be an arena for discussion. Pessele (2019) claimed using A3AO to communicate architectural knowledge triggered discussions and were useful for training new employees. Our Workshop 2 also confirms the use of the OPA3 tool triggers discussions in a room of experts. The visualization aspect could potentially contribute to the triggered discussions as the Technical Lead from workshop 1 said *"The visualization aspect makes me think"*.

The feedback survey shows mixed results regarding key-personnel dependency (with 5 strongly agree, 6 agree, 9 neutral, 3 disagree and 1 strongly disagree). The reason why has something to do with the level of details and how to manage the key personnel. As pointed by Quality Manger (in the SSI-5), *"If you are using your keyperson for a step-by-step process the OPA3 will reduce the keyperson dependency. If you are using the keyperson for detailed knowledge, the OPA3 will not help."* Even if the process documentation from OPA3 cannot replace a keyperson in a project, it could complement the keyperson's process knowledge as the Project Manager said "…*documented processes in this tool will help you further before you ask for help"*.
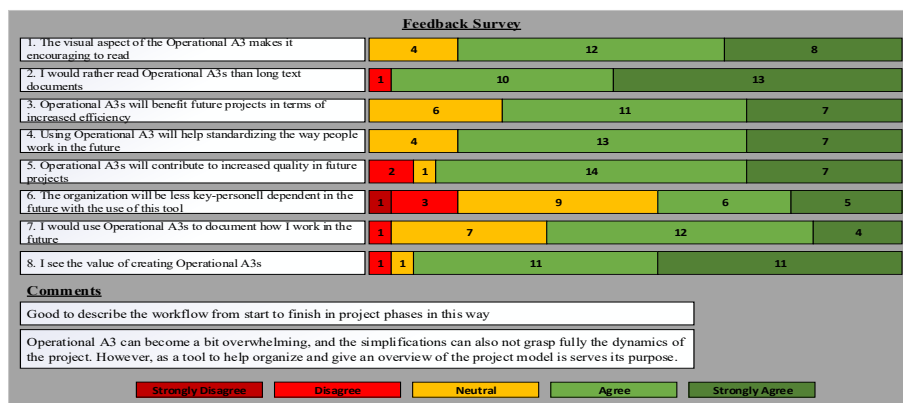
Figure 12. Results of feedback survey in Brownfield upgrade project department

Conclusion

This research applied the systems engineering problem-solving method to develop a process architecting tool that facilitates As-Is Engineering working processes for increased performance in future Brownfield upgrade projects. Through literature review and workshop testing with loops of feedbacks in the case Company, the tool was optimized. The optimized version of the process architecting tool - OPA3 is validated and verified in terms of efficiency and quality in future projects for the case Company. Among the case findings, the visualization aspect is found particular important when learning the As-Is Engineering working process. By adopting OPA3, experienced engineers can visualize how they work and communicate this knowledge to less experienced engineers. We also found that the OPA3 will not directly reduce the need for a keyperson in a project, however it should be a great addition to the work for less experienced engineers to improve their work performance based on learning visually.

This research contributes to the extended utility of A3AO and process mapping to help facilitate the process architecting in future projects beyond conventional past projects. The developed tool - OPA3 can be used on different type of projects where there is a need to communicate and architect a working process visually. The outcomes of this research open many research lines and future developments.

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