DEVELOPMENT OF DESIGN REVIEW SYSTEM

Lappeenranta–Lahti University of Technology LUT

Electrical engineering, Master's thesis

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ABSTRACT

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Keywords: Design review, design management, process development, maritime industry

Quality is an essential aspect of modern market competition. This thesis describes the development and implementation of a new quality control system based on the pre-existing model and needs of the engineering team of the electrical solutions department of ABB (Asea Brown Boveri) Marine & Ports Oy. The engineering team had created a design review system and process to support it, and this thesis aimed to develop the system further and refine the process.

The new implementation of the design review was done on the Jira platform to fulfill all the requirements set by the organization. Those requirements included good usability, the ability to include more information linked to each review item, enabling task allocating, progress tracking, and continuous development of the design review data by all levels of the electrical solutions department.

As a result of this project, a new design review implementation was created. The new implementation fulfilled all the set requirements. In addition, the system was combined with lessons learned data, further increasing its relevance regarding improving the quality. Nevertheless, every system is flawed, and the need for further development was acknowledged during the process.

TIIVISTELMÄ

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Laatu on tärkeä kilpailutekijä nyisessä markkinakilpailussa. Tässä diplomityössä kehitetään laadunvarmistusprosessia ABB Marine & Ports Oy:n, electrical solutions -osaston suunnitteluosaston aikaisemman laadunvarmennusprosessin pohjalta. Suunnitteluosasto oli aikaisemmin luonut suunnittelunkatselmointijärjestelmän ja sitä tukevan prosessin. Tässä työssä oli tarkoitus kehittää suunnittelunlaadunvarmennusjärjestelmää suunnitteluosaston asettamien vaatimusten perusteella.

Uusi suunnittelunkatselmointijärjestelmä luotiin Jira-alustalle, joka mahdollisti asetettujen vaatimusten täyttämisen. Nämä vaatimukset sisälsivät helppokäyttöisyyden, mahdollisuuden lisätä uutta tietoa järjestelmän jo olemassa oleviin kysymyksiin, tehtävien jakamisen mahdollistaminen, edistymän seurannan ja jatkuvan kehittämisen mahdollistamisen koko suunnitteluosaston toimesta.

Tämän työn tuloksena syntyi uusi versio suunnittelunkatselmointijärjestelmästä. Uusi järjestelmäversio täytti sille asetetut vaatimukset ja lisäksi siihen sulautettiin rinnakkainen projekteissa havaituista virheistä koostettu tietokanta, joka entisestään lisäsi suunnittelukatselmointijärjestelmän tärkeyttä suunnitteluvirheiden estämisessä. Kehitysprosessin aikana järjestelmässä havaittiin uusia mahdollisuuksia, joiden johdosta järjestelmää tulisi kehittää lisää.

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I am also grateful for the high-quality education provided by LUT University, which has provided me with the necessary skills to produce this work.

Above all, I would like to thank my family and friends who have supported me throughout the process with various adversities and difficulties.

Abbreviations

ABB	**ASEA Brown Boveri**
AC	**Alternating Current**
AVR	**Automatic Voltage Regulator**
DC	**Direct Current**
ISO	**International Organization for Standardization**
LV	**Low Voltage**
MV	**Medium Voltage**
NPC	**Neutral Point Cubicle**
PCS	**Propulsion Control System**
PCU	**Propulsion Control Unit**
PEMS	**Power and Energy Management System**
RCS	**Remote Control System**
RDS	**Remote Diagnostic System**
SWBD	**Switchboard**

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1 Introduction

The maritime industry is a complex and requiring field in regards to electrical engineering as the vessels are required to fulfill batteries of requirements set by customers, classification societies, and government officials. Those requirements outline the quality expectations of onboard electrical system integration. In order to comply with the requirements and to ensure the quality of the integrations electrical solutions department of ABB Marine & Ports oy had developed a quality assurance platform, which concentrated on reviewing the system designs. This thesis aims to develop further and improve the design review system.

1.1 Background

Quality has become one of the critical elements in terms of competition in the business world. Therefore, a good quality assurance system is crucial to maintain and continuously improve the quality of products and services. The engineering team of ABB Marine & Ports oy had implemented a design review system and created a design review process to ensure and improve the design and to prevent the repeating of known issues in their designs.

ABB Marine & Ports operates in the maritime industry, and the focus of the engineering team to which this thesis was done is to design electrical system integrations for newly built vessels, mainly in the passenger vessel segment. In the vessel-building industry, the competition in large-scale projects has concentrated on a few companies, increasing the importance of quality and the reputation created by quality.

The purpose of this thesis was to further develop the system based on requirements set by the development team of the design review system in the team.

1.2 Objectives and delimitations

The main objective of this thesis was to develop a new, better implementation of pre-existing design review system and to improve the design review process. The developers of pre-existing systems set requirements for developing the new system. Briefly, the general requirements for the new implementation were increased usability, ability to share information regarding the questions, ability to allocate questions and tasks, ability to track progress within the design review, and lastly, to enable easy continuous development of the questions and related data by the engineering team.

This thesis was delimited only to implementing a new system and developing desired functionalities within the new system. The new system was supposed to be developed in a platform, which was to be selected based on a comparison of platforms during this thesis. The platform options were limited to existing platforms in the electrical solutions department. Furthermore, the creation of new questions and descriptions was excluded from the scope of this thesis, as the new system was intended to store imported questions from the previous version of the design review system, and new content was supposed to be created in the future by the engineers working within the organization.

1.3 Structure of the thesis

In order to obtain the reader's interest, this thesis has been structured in a way that the second chapter defines what quality is, why it matters, and how it can be improved. The focus of the chapter is to build motivation and understanding for the question, "Why should design be reviewed?". The third chapter briefly introduces the scope of supply in a vessel project and what an actual newly built vessel project could include in terms of electrical systems. The fourth chapter describes how the quality of the electrical system design for such a vessel was managed at the beginning of this project and what the development requirements were set for the new system. The fifth chapter describes the system's selection process for implementation and the system itself. The sixth chapter describes implementing the new design review system in the selected platform. The seventh chapter describes the development of the design review process. The last eighth chapter discusses the results and further development of the design review system.

2 Quality

As the main focus of this thesis is to implement a system to support quality improvement in electrical designs, it is crucial to outline what quality is. Therefore this chapter will go through the definition of quality, why it matters, and how it can be improved.

2.1 What is quality

Quality is difficult to be defined because the interpretation of quality depends on the context. One approach to defining quality is to divide quality into two different levels. Level one defines quality as the product meeting the given technical specifications, and level two means that the product satisfies the customer's needs. (Hoyer, 2001)

Due to the difficulty of defining quality, it can be hard to measure, and measures depend on the product or service at hand. Poor quality can also be measured, for example, based on the cost and how much money is needed to make the customer happy. (Juran, 2010)

As the perception of the quality and the quality metrics depend on the product or service being produced, it is good to present some examples. In the manufacturing industry, the quality, hence customer needs, might be just a set of desired attributes such as freedom of defects, product reliability, and consistency of the products. On the other hand, in integration project design, which is more of a process at its core, quality can be seen as an approach to fulfilling requirements set by the customer. (Erlhoff & Marshall, 2008)

Quality also cumulates in the supply chains, and the organization acting as an interface between the supply chain and the end customer carries most of the risks related to poor quality. (Oakland, 2014)

Although quality can be perceived in many ways, the common nominator is meeting customer needs. (Oakland, 2014)

In this master's thesis, the viewpoint from which the quality is perceived is the engineering team of the electrical solutions department of ABB Marine & Ports, which designs electrical system integrations for vessels. As the electrical solutions department does not manufacture any physical devices, the product of the design department is a service. However, as the design department is the main supplier, the quality of the products from sub-suppliers affects customer satisfaction. In this environment, the quality, briefly meeting the customer needs, can be determined by fulfilling the requirements set by the customer and classification society. As the projects are a combination of goods and services, requirements range from specific desired physical attributes to a well-functioning system where all the equipment serves its purpose and the operationality is flawless.

2.2 Why does quality matter

Quality matters for many reasons. Excellent quality improves the customer-supplier relationship, which usually leads to repeat sales. Poor quality, on the other hand, does not limit just repeat sales. It usually creates a reputation for poor quality, which also repels other potential customers. (Juran, 2010)

Due to the reputation that quality creates, quality can be seen as an advantage in modern market competition. Companies known for excellent quality prosper in the modern, ever more competitive business world (Oakland, 2014). Neglect of quality has already led to a situation where some market operators are losing market share to foreign operators and to high costs of poor quality (Stephens, 2004).

Quality also directly affects revenues. Quality reputation affects a customer base, which affects sales. On the other hand, defects in the quality usually lead to increased costs, which are needed to meet the customer's needs and requirements. (Juran, 2010)

Due to the nature of the maritime industry, the number of players in the market is relatively small, and the number of suppliers who can manage large-scale electrical integration design projects, such as designing cruise liner electrifications, is reduced to just a handful of companies. Therefore good quality is one of the main completion advantages. The design quality also directly affects the costs since not all design defects can be invoiced. On the other hand cost effects of changes in design can also be hard to invoice from the customer, especially if the requirement on hand has been clearly stated in the customer's requirements.

Furthermore, design flaws, which go unseen until the last phases of the project, may cause delays in delivering a vessel, which is extremely expensive. Usually, the party responsible for the delay is the one paying the fee.

2.3 How to ensure the quality

To ensure quality, an organization can create and enforce processes that verify that the customer's requirements and the promises made to the customer have been met.

There are multiple ways to ensure quality and to signal that quality has been considered within the organization. Some of the most popular quality management methods are described in Six Sigma and ISO 9000 standard series, which both have guidelines on how to achieve and maintain superior quality within an organization. (Juran, 2010)

Quality is usually achieved with quality tools such as quality control and quality assurance. Quality control is more of a reactive process, which concentrates on activities to maintain a certain achieved level of quality by inspecting the products or services and eliminating factors that have been found to cause defects in the quality. Quality assurance, on the other hand, is more of a proactive approach, which concentrates on preventing defects in quality with actions such as creating a quality management system and reviewing the processes. (Oakland, 2014)

One low-cost form of quality tool is the design review, where the product or service produced is examined by the whole production team in order to find errors and shortcomings. (Goodden, 2001).

The engineering department employed its approach to quality control in the form of a design review process. The design review was found to be an effective way to ensure that typical design flaws were avoided. The core of the design review process was to conduct reviews on the design at the end of each design phase. Reviews were done based on a list of questions, which were formed based on previously found flaws, which could have been avoided by ensuring that those things were considered during the design.

3 Typical delivery scope of a vessel electrification project

To assist in understanding the purpose of this work, this section introduces the scope of the design and the equipment and services that may be included in a vessel delivery project.

3.1 Overview

ABB Marine & Ports Electrical solutions department concentrates mainly on cruise vessel electrification. A project usually starts with creating a single-line diagram, which illustrates the required system topology, which equipment the vessel will have, and where the equipment will be connected to the electric grid. Figure 1 illustrates a partial single-line diagram of what a delivery project could include. The following sections will briefly describe the subsystems found in the single-line diagram.

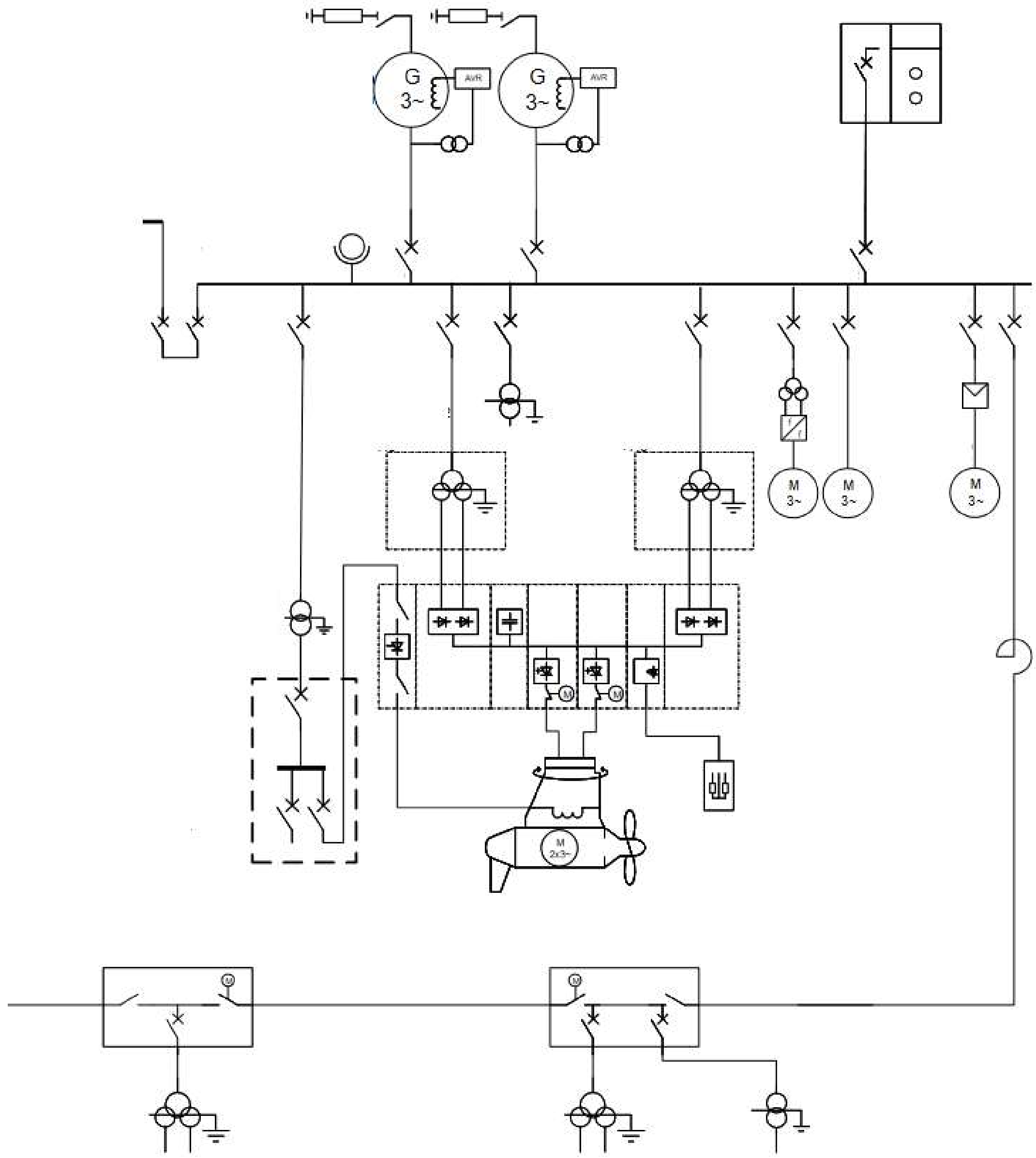

Figure 1: Example of single-line diagram (modified from source ABB Marine & Ports Oy, 2018)

3.2 Power plant

Power generation onboard a cruise vessel is usually done with a diesel-electric power plant, which consists of multiple, usually 4-6, generator sets to ensure redundancy during operation. Each generator set comprises a synchronous generator driven by a diesel engine. The automatic voltage regulator (AVR) controls the generator's output voltage by adjusting the magnetizing current. A neutral point resistor (NPR) grounds the generator's star point with a resistor, which limits the earth fault current in case of an earth fault in downstream systems. (ABB Oy, Marine, 2012)

In addition to the diesel-electric powerplant, modern vessels may have an energy storage system that enables a vessel to operate partially or fully without diesel engines. The main advantage of energy storage is reduced emissions as generators can be operated at the optimal point, and power consumption peaks can be covered with energy storage. (Pestana, 2014) (ABB Marine, 2021)

During docking, vessels are usually connected to a shore power grid via shore connection, enabling a vessel to shut down the diesel-electric powerplant, as the shore connection supplies the electric energy needed to run onboard electrical appliances. Furthermore, a shore connection is also used to charge onboard batteries in modern, fully electric vessels. (ABB Marine & Ports, 2019)

3.3 Power distribution

A cruise vessel usually has a medium voltage (MV) distribution system, which handles vessel power distribution. Typical cruise vessel onboard MV solutions usually utilize an 11kV voltage level. Some heavy consumers, such as propulsion converters, connect directly to the MV distribution network. On the other hand, the MV network also feeds smaller appliances, such as hotel loads, via transformer and low voltage (LV) switchboards or distribution boards.

The essential item in the MV distribution network is the switchboard, which is eventually a cabinet lineup made of switchgear. Typical vessels have multiple switchboards to maintain redundancy during operations, so switchgear can be run independently.

In some vessels, power distribution is done by utilizing a direct current (DC) system. DC solutions are useful, especially in vessels with an energy storage system. ABB's DC solution for DC distribution is the Onboard DC grid, a drive cabinet lineup where the voltage distribution between the drives is done using DC busbars. Power is distributed to other systems with inverter units, and inverter units are connected to DC busbar with isolating switch. Due to redundancy requirements, vessels have multiple DC lineups connected via DC bus tie. Power flow in bus tie is governed by a semiconductor feeder solution to protect each lineup in fault situations. (Hansen, Lindtjørn, & Vänskä, 2012)

3.4 Drives

Energy efficiency in modern vessels is achieved with frequency converters, known as drives. A vessel has multiple kinds of drives for different appliances ranging from main propulsion to hydraulic pumps.

If the vessel has an electrical propulsion system, one of the key elements of energy efficiency is propulsion drive. To reach the best performance and to prevent damage to the feeding network and/or drive, propulsion drives should always be controlled with a propulsion control system and/or power and energy management system. Usually, vessels have one propulsion drive unit for each propulsion motor. Propulsion drives can be categorized into two categories based on the operating voltage, low voltage (LV) drives and medium voltage (MV) drives. In addition to propulsion drives, modern vessels have multiple smaller drives meant for feeding smaller motors such as compressors and hydraulic pumps. (ABB Oy, Marine, 2012)

3.5 Control and automation systems

Typical modern vessels rely on multiple different automation and control systems during operation. Such automation systems include, for example, machinery automation, power management, emergency shutdown, and remote-control systems, but also more purpose-built systems like propulsion control systems, dynamic positioning systems, and remote diagnostics systems.

A machinery automation system is usually responsible for controlling various systems on board vessels, such as a hydraulic pump system and space heaters.

A propulsion control system (PCS) is an automation solution that enables control of the propulsion. ABB's approach to PCS consists of a controller unit and software solution. PCS controls propulsion drives, which enables the best possible operation within limitations set by the equipment. For example, diesel generators have limited power increase and decrease capability, which needs to be considered during design. A too-rapid increase in power demand may lead to a blackout or trip in the drive or even in the whole distribution system.

A power and energy management system (PEMS) is an automation system that specifies power and energy management. PEMS supervises onboard power sources and consumers and manages the power balance to prevent system blackouts. PEMS can be programmed to reduce non-essential loads, such as heating or cooling, during harsh operating conditions as a measure of protection.

A remote control system (RCS) provides means to control the vessel. RCS constructs from control stations located in the main bridge and wing stations. These control stations have means of controlling the vessel. RCS communicates with Propulsion Control Unit PCU and PEMS, as RCS is more of a human interface for the propulsion.

Remote diagnostic services (RDS) are ABB's innovative approach to doing maintenance. RDS system collects data on board a vessel and sends it to ABB offices for analysis, which enables planning of maintenance and real-time remote troubleshooting. Reducing faults during operation and planning maintenance in advance reduces downtime and costs significantly, increasing customer happiness and perceived quality. (ABB Marine & Ports, 2013)

3.6 Propulsion systems

The typical vessel has different kinds of propulsion motors for different purposes, which can be divided into two categories, main propulsion motors, and control motors. The main propulsion motor propels are typically located at the ship's rear and create thrust for a vessel, which enables a vessel to move. Control motors, on the other hand, are usually smaller and located in front on 90 decrees angle of the centerline. The main purpose of control motors is to create thrust to change the course of a vessel.

Main propulsion motors can be divided into two main types: shaft line motors and azimuth thrusters. Shaft line motors can be operated with a combustion engine or electric motor, and the angle of the thrust remains the same. However, the direction can usually be changed forwards and backward. Azimuth thruster units can rotate up to 360 degrees, increasing a vessel's maneuverability. Some azimuth thruster systems, such as ABB Azipod, have electrical motors inside the unit. (ABB Oy, Marine) Some other azimuth thrusters have the motor inside the vessel hull, and the torque is transmitted with a shaft solution.

3.7 General design

In addition to subsystems, which consider some functional properties of a vessel, the design needs to consider also more general items, such as cabling and network design.

In modern vessels, which rely on electricity from propulsion to cooking, it is essential to design cabling to electrify all the appliances in the best feasible way. In contrast to the inland cabling design, vessel cabling should be redundant so that, for example, a fire in one compartment of the vessel does not cause a blackout onboard the vessel.

As vessels nowadays rely heavily on digital control, network design is becoming a more critical aspect of vessel design. While designing the network, in addition to considering cable breaks and fire and flooding scenarios onboard the ship, the designer must also consider the cyber security of the network topology. For example, in a passenger vessel, any passenger may intentionally or unintentionally infect the network with a virus, which may, in the worst case, lead to loss of control of the vessel. Therefore, in some vessels, the need for multiple physical networks needs to be considered. Background of the quality system

The electrical design department has implemented a segment of a quality management system as a design review process. As the focus of this thesis was to further develop the pre-existing system, it is crucial to outline the pre-existing system and the requirements for its development.

4 Background of the quality system

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4.1 Design process

At the beginning of this project, the electrical solutions design department already had a review process in use as the team had found it to be an effective way to improve designs and prevent design flaws, as many of the solutions are implemented in multiple projects. Figure 2 illustrates the process of the design review. The process consisted of answering design-related questions and then reviewing those answers in a peer meeting. Found deficits were discussed, and corrective actions were planned during the peer review meeting. Most of the review process-related data was stored in an Excel file.

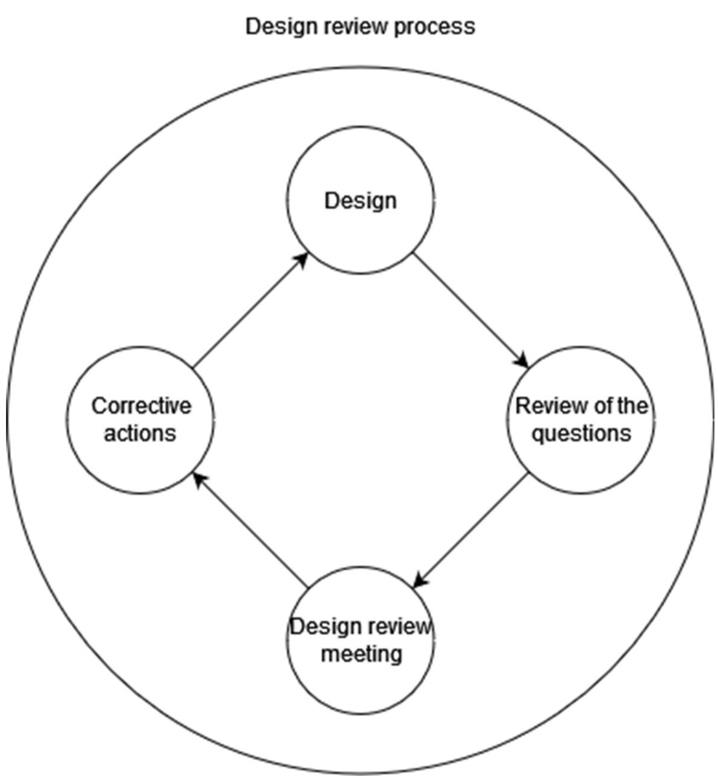

Figure 2: Illustration of the design review process

The Excel file had a template battery of questions for different subsystems, which may be included in a design project. These questions were organized in sheets based on subsystems, introduced in chapter 3. Sheets were further divided by design phases to concentrate on relevant questions during each phase of the design.

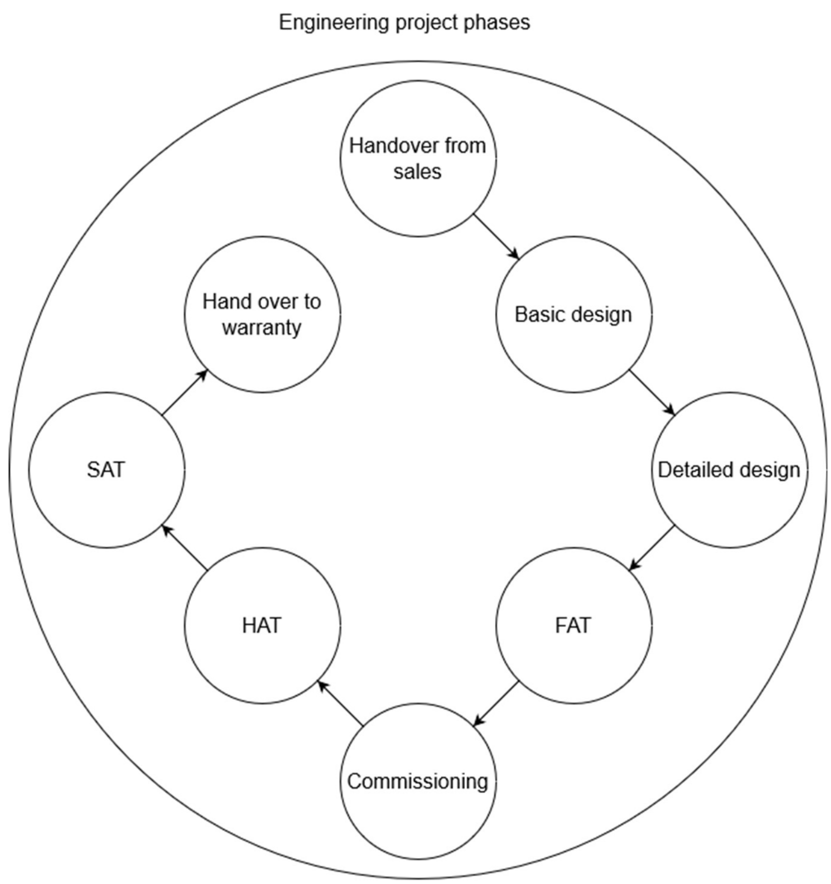

Figure 3: Engineering project phases

Design phases were divided into eight phases, as illustrated in Figure 3. From those phases, six were considered in the design review. Handover phases were not included in the design review as those were phases where the responsibility and information were handed from sales to engineering and, after the design was completed, from engineering to warranty. The basic design consists of creating final specifications for the different systems and devices before procuring the products. The detailed design included system integration design, such as interface design, which is mandatory to get the vessel to function as intended. In the design phase, issues were easiest to be avoided and cheapest to be fixed, as unnoticed design issues have been found to cause issues in later project phases frequently. Factory acceptance testing (FAT) is a project phase where the devices are tested to function as supposed. The focus of the FAT phase is to create good test programs to provide testing evidence of the system. These tests were supposed to prove the functionalities according to classification rules and customer requirements, as the functionalities are easier and cheaper to be fixed according to needs and requirements before the system is installed onboard a vessel. In the commissioning phase, devices are installed on board the vessel, and the main concern is to get everything correctly installed because the project schedule in later phases is tighter, and delays usually affect the customer's perception of quality. In addition, delays may cause a cost impact on the project as delays usually lead to contract fines. The harbor acceptance testing (HAT) phase includes testing of the system functionality at the harbor, followed by the sea acceptance trial (SAT) phase, where the entire system's functionality is verified in operational conditions on the sea. HAT and SAT phases are the last phases where the issues may be corrected without interrupting the normal operation of the vessel, which underlines the importance of creating good test programs which prove the vessel's functionality in normal operation and during system malfunctions.

4.2 Starting point

	A	B	C	D	E
1	**Question**	**Status**	**Comments**		
2					
3	**Basic design**				
4	Is colour according to specification?	Almost yes	Waiting for manufacturer confirmation.		
5	Is Premagnetization unit required?	No	Waiting for clarification.		
6	Lock type specified?	Yes	7mm triangle ordered.		
7	Vibrationdampers required?	N/A	Not in our scope.		
8					
9					
10	**Detailed design**				
11	Heater logics defined?				
12	Temperature measurements as required?				
13					
14					
15					
16	**FAT**				
17	Test documents available?				
18	Is there pictures of the units?				
19					
20					

Transformers | Shore connection | Cabling | Sheet7 | Drives | Main switchboard | DC grid | LV s ...

Figure 4: Format of the questionaries (Modified from source ABB Marine & Ports Oy, 2020)

Questions were formed in a way that did not ask any vessel-specific details of the design but instead raised a question if the item in question was considered during the design. An example question could be "Is color according to specification?" as shown in Figure 4.

Answer options for the question were predefined to yes, almost yes, no, and N/A, where yes means that the question has been considered and actions to fulfill the requirement have been done. Almost yes means that the question has been considered during the design but has not yet been done. No means that the question has not been considered in the design. N/A means that the question does not apply to the project. For the example question mentioned above, that would mean that the customer has not indicated any preference for a color. If the answer to the question was yes or N/A, the item was closed, and if the answer was almost yes or no, the item needed corrective actions. Corrective actions were described in the comments column with a few sentences, as shown in Figure 4.

The process of reviewing design in the pre-existing model was executed as illustrated in Figure 2: Illustration of the design review process. Reviews were done in each project phase after design. Executing the review proses was the responsibility of a projects lead engineer, and a preliminary review, defined in Figure 2 as "review of the questions", was done by the lead engineer. If the lead engineer did not have answers or knowledge of some of the questions in the Excel file, the system specialist responsible for the respective subsystem design was consulted. After questions in one project phase for subsystem were answered, the lead engineer arranged a peer review meeting, which is shown in Figure 2 as "design review meeting”. The purpose of the design review meeting was to review questions and answers to ensure quality and to share knowledge of known issues related to subsystems. A design review meeting was followed by correcting the findings of the design. This step is illustrated in Figure 2 as "corrective actions". Corrective actions were planned and written down on to excel sheet for each open question during the design review meeting.

The design review process had many problems, which the electrical solutions engineering department had recognized. A common nominator for these problems was the implementation in Excel. The Excel approach made it easy to forget the review list and corrective actions between the meetings, leading to a situation where corrective actions were dragging behind schedule. Questions were partially unclear because each question had just one cell to explain the item, and improvement of the questions was work intensive as the correction needed to be done to multiple Excel files.

4.3 Requirements

At the project's beginning, the people involved in designing and managing the pre-existing system defined their requirements for the development to maintain the integrity of the system. The main improvements requested were to improve usability, make the system more informative and implement solutions to enable progress tracking, task allocation, and continuous development.

The new design review system was required to be easy to use to attract more users and to make the design review to helpful tool rather than a mandatory procedure. As the system was supposed to become an information-sharing platform, usability was one of the critical factors in attracting users to use the system spontaneously, which would drive the development further.

Questions were in their original form, partially incomplete, and hard to understand. New implementation was required to find a solution that would make it easy to clarify questions in a way that would make the system more informative.

As described in 4.1, the original design review approach was based on an excel file filled with questions related to known issues from previous projects. In regards to remark management of design findings, the old system relied heavily on comments written in the excel sheet, which was found to be a poor solution as excels was usually opened only during preparation for the design review meeting and in the design review meetings, therefore one of the requirements was to have the ability to track the progress of questions and remarks and ability to assign questions and remarks, to share the workload.

The requirement of continuous development originated from the fact that the design review excel template was copied to all projects, and cross-checking and developing the questions was time-consuming and labor-intensive as each project had its own excel. That situation led to some improvements being lost or left undone.

5 Selection of platform

Although the general philosophy of the quality system within the engineering team was predefined, and requirements for the new implementation were set by the developers of the original approach, the platform was to be decided on the grounds of this thesis. This chapter will compare the platforms and introduce the selected platform.

5.1 platform selection

The organization did not select the platform for the new design review implementation. However, the pool of platforms was limited to systems already in use. In the selection process, desired properties for the implementation environment were high customizability, as the design review structure was to be maintained. On the other hand, it was required that the system could be easily further developed later on. Interaction between all project participants to allocate tasks and share knowledge within the system utilizing the questions. Ability to track the progress of the questions and corrective actions. Ability to create templates, which would be easy to maintain and copy for the delivery projects.

Due to requirements for the platform, the pool of possible platforms was reduced to Azure and Jira. These systems were very similar, and both fulfilled the requirements set for the platform. However, due to organizational barriers, Azure was not seen as fit for this project, as the development of the system was more strictly controlled. Therefore, the Jira platform was selected.

5.2 Introduction to Jira

Jira Software is an agile project management tool used for different applications across industries, from software development to financial services, due to its high adaptivity and easy customizability. (Atlassian, 2023)

Jira is based on projects, which consist of issues to be completed to reach the preferred outcome. People who are needed to complete listed issues and workflows, which helps to keep track of the progress. (Atlassian, 2023)

Issues in Jira can be considered as chunks of the project that need to be done to reach the desired results. These issues can be categorized by choosing different issue types for different chunks of a project. By default, Jira has issue types, such as epic, task, and subtask, but Jira admins can create and modify issue types to meet project needs. As a built-in feature, these issue types have a three-layer hierarchy, illustrated in Figure 5. The issue hierarchy can be modified as well. Each issue consists of fields, which are supposed to store all relevant data for the issue. (Atlassian, 2023) Issue fields are configured for each issue type in each project in issue screen schemas.

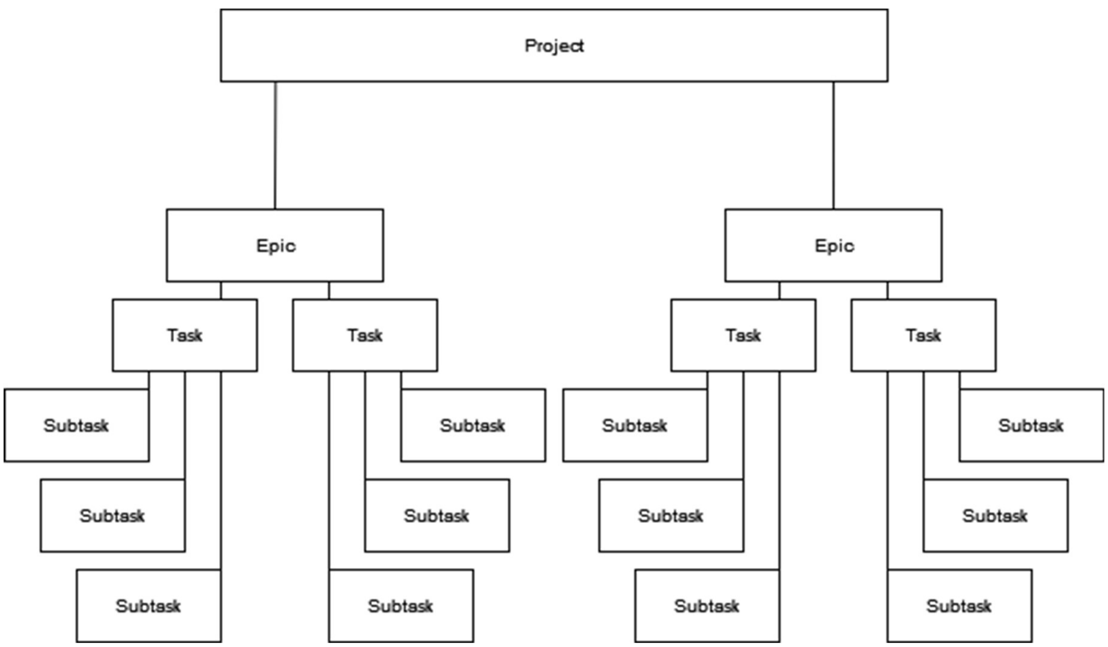

Figure 5: Issue hierarchy in Jira (modified from source Atlassian, 2023)

Workflows define the process of issue progress. Workflows consist of states, which indicate where the issue is in the process, and transitions, which represent actions that are done between stages. And resolutions, which are outcomes of the workflow. (Atlassian, 2023)

To simplify tracking of the issues, Jira has Kanban boards and dashboards. The Kanban board is a tool to visualize issues in a matrix, which helps resolve issues and track issue progress. (Atlassian, 2023) The dashboard is more of a project management tool, which comprises "gadgets," which are simply data filtered from projects and illustrated in a selected format. (Atlassian, 2023)

6 Jira implementation of design review

As the purpose of this work was to develop the pre-existing model, the first step of creating Jira implementation was to determine how the Excel template could be implemented in Jira as a template project.

Projects in Jira are collections of issues. The previous design review template had questions as its main tasks, which were connected to gather under an umbrella of a subsystem. In addition to the previous model of the template, the project requirements included better allocation of corrective actions. Therefore, in the constraints of the Jira system, it was logical to assign systems as epics, which collect issues related to one topic. These issues in the implementation were equivalent to questions in the excel template. To clarify the purpose of these issues, a new issue type, namely, design review questions, was created in the main task category. To enable better handling of corrective actions, a new issue type, design review task, was created at the subtask level, which was supposed to store data related to corrective actions instead of just listing those as a comment.

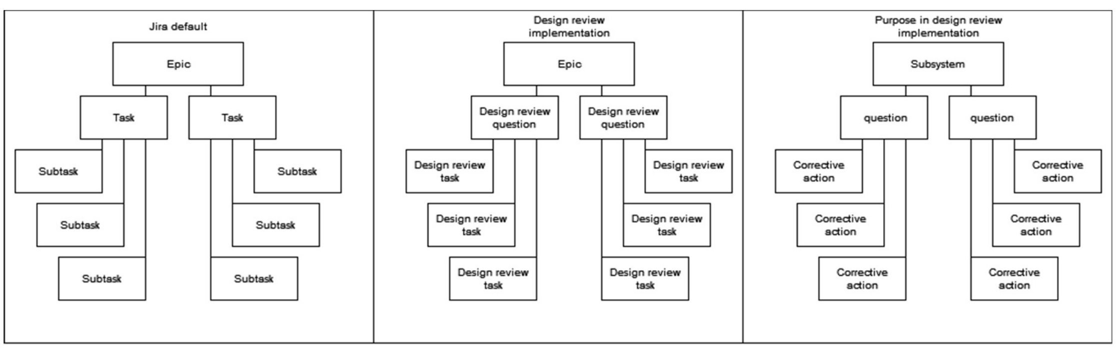

Figure 6: Design review issue structure implemented in Jira (modified from source Atlassian, 2023)

As the tasks are just placeholders in the Jira system database, the next step was to determine field schemes for each issue type. Field schemes are a set of fields assigned to an issue type within a project, and fields are just attributes for the issue. To keep the new implementation user-friendly, it was crucial to keep the number of fields to a minimum. As a base, the new implementation had to include data from the template excel. Therefore summary, stage, and comment fields were included. To make questions easier to be understood, description and attachment fields were added. The description field was supposed to include a brief explanation of the question on hand and some alternative solutions from the past.

As the new system was required to have features that would enable progress tracking, task allocation assignee, and start and due date fields were added.

A sequence number field was added to enable sorting a list of questions in a preferred order, as some template questions were follow-up questions for previous questions. The design review template link field was meant to contain a link to the template project, which made it easier to modify questions in the template if defects were found.

To obtain a desired structure in Jira, epic link, name, and progress fields were added. Epic name functions as an element in epic issue type where task-level issues can be linked. Epic link is a main issue level counterpart for epic name, which links the issue to epic, described in the epic name field. Epic progress was added for progress tracking purposes, and it holds the value of resolved tasks linked to a specific epic divided by unresolved tasks linked to the epic.

The rest of the fields in Table 1 were added for filtering purposes, as the Jira system was also used for purposes other than design review. Nevertheless, some of these fields hold essential information which may come in handy while assessing the questions. For example, each classification society has its own set of rules which must be followed

Field name/issue type	Epic	Design review question	Design review task
ABB system	x	x	x
Assignee	x	x	x
Attachment		x	x
Classification society	x	x	x
Customer company	x	x	x
Customer project number	x	x	
CVX number	x	x	x
Description	x	x	x
Design review template link	x	x	
Due date			x
Epic link		x	
Epic name	x		
Epic progress	x		
ES lead	x	x	x
IMO number	x	x	
Lesson learned		x	
Project name		x	x
Related to		x	
Repeat vessel		x	
sequency number	x	x	
Shipyard	x	x	x
Stage		x	x
Start date	x		
Summary	x	x	x

Table 1: Issue field schemas for different issue types

Fields were determined to be a poor solution for answering questions as Jira has a built-in workflow system. Therefore, the workflow's purpose was to hold answers to the design review questions as workflow statuses. Answer options remained as those were presented in the excel template. As developers of excel stated, it would be easier to continue with familiar answer options.

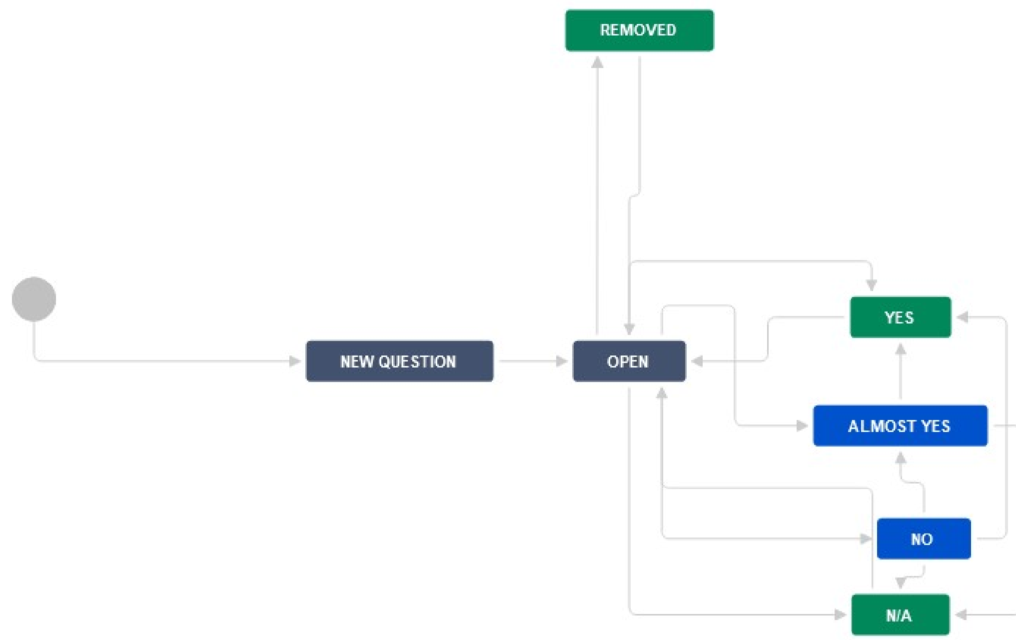

Figure 7: The primary purpose of workflow for design review questions was to indicate the answers to the questions

However, as seen in Figure 7, two new answer options were added to the system. The open state was included as a default answer to indicate that the question was not yet reviewed. Removed and new question states were added to help with question management. The removed state was added to enable the flagging of questions that needed to be removed, as regular Jira users do not have the right to delete issues. In addition, automation was added, which automatically removed all the issues in the removed state in design review projects. The new question state was added as a default state for user-created issues. The purpose of the state was to inform that the question needed to be checked and then added to production projects. The transition between states was available from each template option to each template option with open status included. Transition to the removed state was available only from the open state, and the only transition from the removed state was to the open state. From the new question state, the only available transition was to open state, and the reverse transition was not allowed.

Obtaining an overview of questions related to one subsystem in a particular project phase by filtering was hard. Therefore, it was found more straightforward to use Kanban boards during the review of the questions.

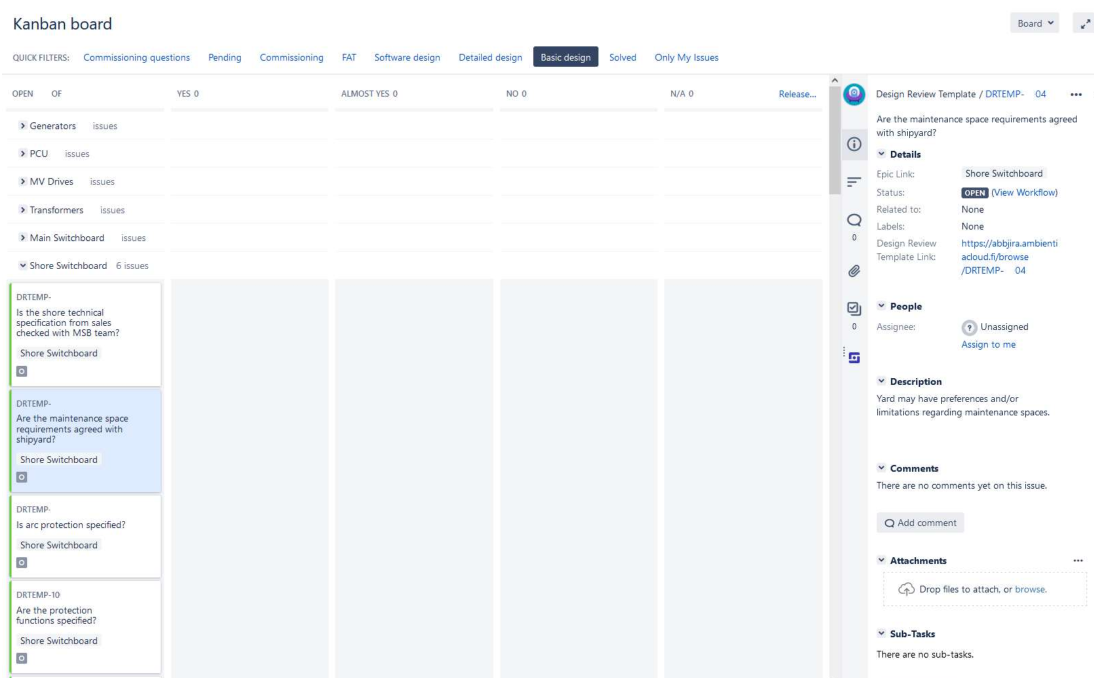

Figure 8: Design review Kanban board was meant for processing the questions

As shown in Figure 8 Kanban board was designed to have questions on the y-axis and answer options on the x-axis. Questions were grouped to the board using epics as a common nominator, as all the questions were supposed to be linked under one epic. Answer options were limited only to answers which were relevant during the design review. In addition, quick filters were added to filter only questions in the specific project phase. As the system enabled the simultaneous use of two quick filters, pending and solved, and only my issues were added to help filter only relevant questions. During the design review, questions were supposed to be dragged to the correct answer column.

Due to the high number of questions, overview and progress tracking of the questions was one of the critical improvements in the new design review implementation. To enable these functionalities template dashboard was created for the design review. The dashboard included different gadgets, which sorted questions into different formats from the design review project based on different issue filters. Selected gadget formats were two-dimensional filter statistics, the left side in Figure 9, a pie chart, which can be seen on the right side of Figure 9, and an activity stream, which displayed the ten latest changes in the project chronologically.

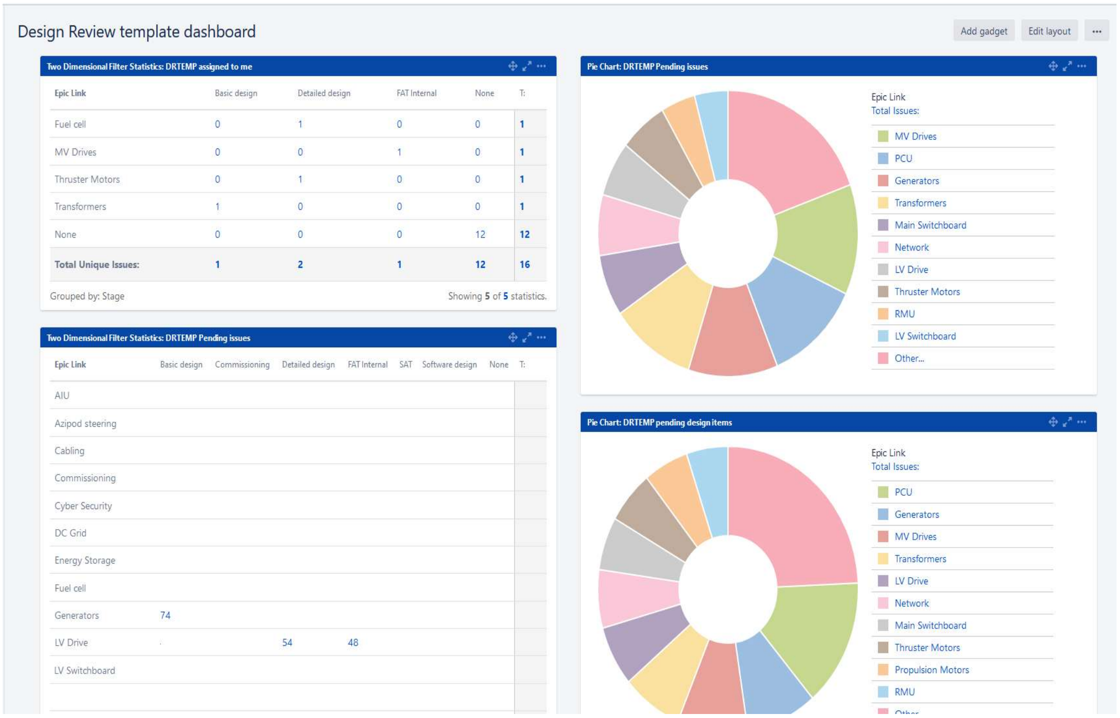

Figure 9: Some of the design review dashboard gadgets, which illustrate the filtered data from the template project

Issue filters for the two-dimensional filter gadgets were “assigned to me,” which filtered all the issues in the project, assigned to the current user, pending issues, which filtered all unresolved issues, and all issues filter, which filtered all the project-related issues. The Y-axis of all the two-dimensional filter gadgets was set to epic link, which eventually presented a subsystem, and X-axis was the project phase for "assigned to me" and "pending issues" filters, and the workflow stage for the “all issues” filter.

One of the pie charts had the same “pending issues” as the two-dimensional filter gadget and the other pie chart had “pending design items,” which is the same as pending issues but limited only to basic design and detailed design project phases. Slices of the pie chart represented epic links, and the size of the slice correlated to the number of issues linked to a specific epic.

7 Process development

The design review process had its foothold in the engineering department before this project, but some improvements were needed to obtain desired outcomes with the new platform. This chapter will describe what was changed and how it affected the process.

7.1 how reviews were done

The design review process mainly remained as it was at the beginning of the project. However, the ability to assign and track questions made it easier to review questions before the design review meeting, which enabled meetings to concentrate more on difficult questions rather than answering the bulk of questions.

The guideline in the new system is to set a question due date for the design review meeting, in which the subsystem or subsystems on hand will be peer-reviewed. The lead engineer reviews and answers questions prior to the design review meeting. If the lead engineer does not have answers to some of the questions, those questions should be assigned to a subsystem specialist for further clarification. The guideline in the new system is to set a question due date for a design review meeting.

The focus of the design review meeting has shifted from answering the bulk of the questions to discussing some of the more complex questions and comparing the overall system with similar vessels, for example, sister vessels from the same vessel series. If there are issues found in the meeting regarding the design, the lead engineer creates design review tasks in Jira and assigns them to the person who can solve them and sets a due date when the task should be resolved. Handling corrective actions is one of the main improvements to the prior process regarding the design review meetings, as issues were just added as a comment in the previous model.

Creating new questions in Jira was made to be as smooth as possible by limiting the fields that needed to be filled. As seen in Figure 10, the only mandatory fields were the project field, to which the question was to be added. Issue type, which stated the purpose of the issue, and summary, which in case of creating a design review question, was supposed to have the summarized question. Users are encouraged to create and update questions as they come across issues related to the design, which they deem important to be considered in the projects, or if they find incomplete descriptions or unclear questions in general.

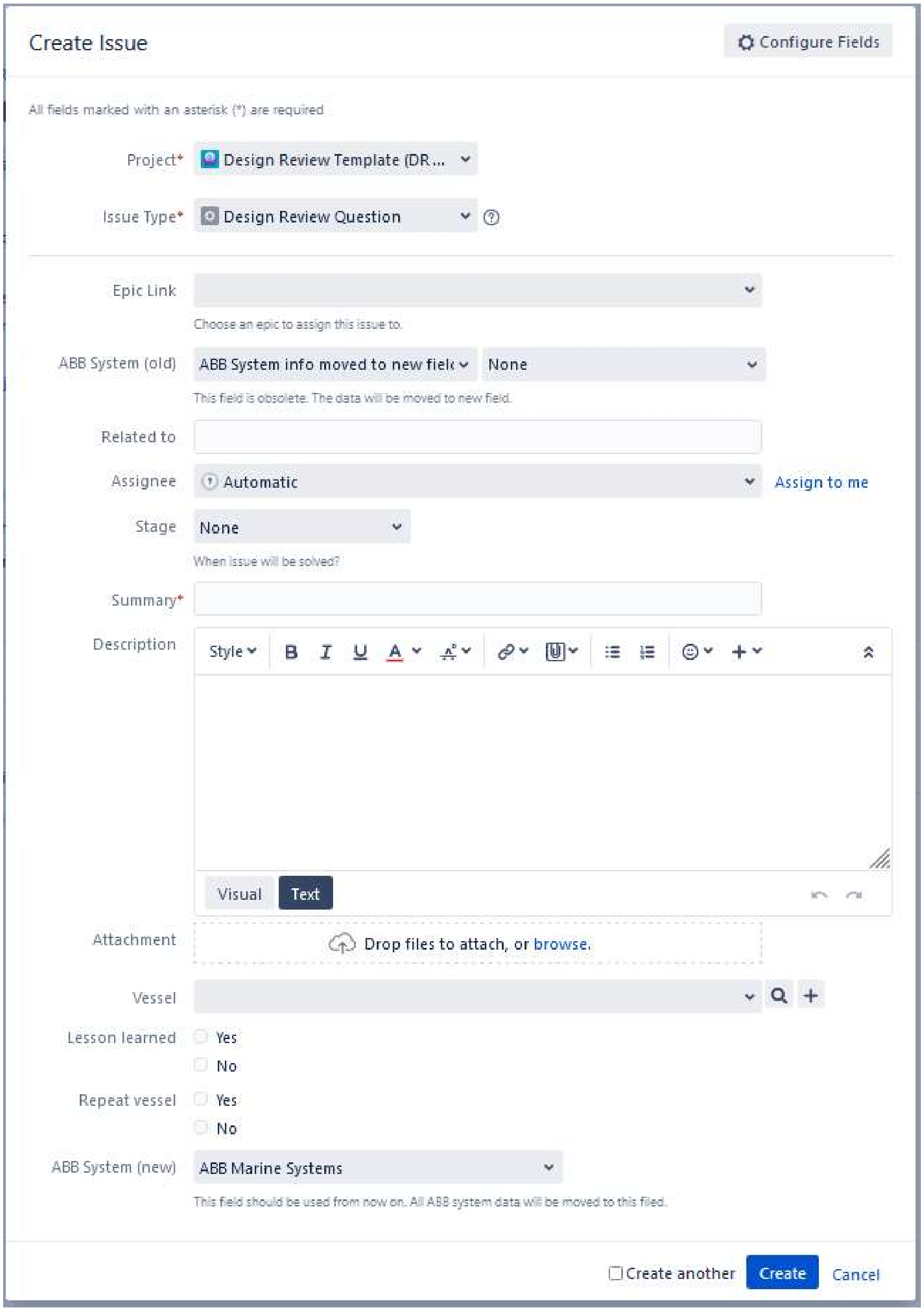

Figure 10: Issue creation popup screen, where input data for questions is defined

7.2 continuous development

Enabling continuous development of the system was one of the requirements for this thesis. Prior implementation was based on an excel sheet which was labor-intensive to develop and to keep updated on all the projects. Therefore development was done just on a small scale.

In regards to process, the new thing which supports continuous development is the ability to create new and correct old questions. In addition, a new improvement was adding lessons learned items to the design review system.

Creating and updating new questions in the new model was supposed to be done if the user recognizes that something has created issues regarding the design in the past and thinks it should be added as a question to the system. However, most of the new questions and corrections are done during design review meetings where descriptions are found to be incorrect, or discussion of a question leads to creating a new one.

The ability to create and edit questions also enabled cross-organization team collaboration as sales and warranty teams of the electrical solutions department can now create questions regarding issues, which they have found to cause problems in engineering team processes and designs. On the other hand, the engineering team now has a tool that enables task allocation to the sales and warranty teams. This helps to prevent misunderstandings with specifications from sales.

In addition to the ability to easily create and edit issues, lessons learned items were added to the Jira design review. Lessons learned items refer to documented design flaws and solutions made for those flaws. Lessons learned issues are raised internally or by a customer from delivery projects. As the engineering team aims continuously to improve their design solutions, lessons learned items were found to be crucial information to be added to the design review system. In the end, lessons learned items were issues that should have been found during the design review instead of finding those onboard during commissioning or after handover.

Lessons learned items added to the design review system were formed in a question format like all the other questions. However, the difference was that lessons learned items included better background of the issue on hand and a proposed solution to prevent the repeating of the issue, usually with reference documents from previous projects. To categorize lessons learned questions, the review system has a checkbox "lessons learned," which should be checked if the question is based on the lesson learned.

8 Conclusions

As a result of this thesis new design review system was created and commissioned to use in ABB Marine & Ports oy. This chapter discusses results in contrast to the requirements and how the system could be further developed.

8.1 Results

At the beginning of the project, a set of requirements was created for this thesis. Most important was to implement a new approach for the design review. Other requirements were to maintain the fundamental idea and the question database, improve usability, make the questions more informative, and add features for progress tracking, task allocation, and continuous development.

As excel was used as a base framework for the new system, the similarity to the previous system was maintained. The questions were imported to the new Jira system as a starting point for future development and refinement.

The implementation questions were more informative as each question in the new system has a set of fields containing essential information for each question. Especially description field and the ability to attach images and files to the questions greatly improved information sharing. However, the number of fields was designed to maintain usability, and creating and editing questions was easy.

Built-in Jira features also enabled delegating questions and corrective actions efficiently, which was one of the requirements for the implementation. Board features, Kanban board, and dashboard also enabled easy progress tracking of the questions and tasks, which was previously done by filtering open questions from an excel file.

Continuous development was made easy in the new implementation, and including the lessons learned reviews to the implementation further encourages the improvements on the system as the team has found it valuable to document and discuss the issues found in the design. However, the design review system's future and continuous improvement rely heavily on its users. User reception of the new design review was good as the team wanted to have a system that was available for each member of the team, and it was more informative than the previous excel implementation.

Based on this assessment, it can be concluded that the implementation produced on the grounds of this thesis fulfills the requirements set by the design review development team.

8.2 Further development

Though this project brought a lot of valuable improvements to the design review system, there is still room for further development. As the amount of questions is enormous and multiple questions are supposed to be handled simultaneously, the Jira system is a bit clumsy. Therefore, one of the further development focuses should be on exploring add-ons to improve the processing of the questions. One good add-on to investigate would be a checkbox add-on enabling answering the question by just checking the question checkboxes.

Another aspect that should be considered in further development should be enabling cross-project comparison, which would be beneficial, especially in sister vessel projects, where the vessels are usually expected to be copies of each other.

The last improvement which was raised during the project was the further integration of processes into Jira. Incorporating asset and design management into one tool would enable reviewing each subsystem regarding all the design requirements. On the other hand, combining customer requirements and design reviews could help to ensure the fulfillment of customer needs in the best possible way.

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