CHALMERS
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# Performance analysis of engineering, procurement and construction projects in modular construction

## A case study at Emtunga Solutions AB

Master's thesis at the department of Industrial and Materials Science

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Project process analysis of a modular execution within industry solutions
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# Abstract

The construction industry is well known for exceeding time plans and affectedly overrun budgets. Today over 50% of projects that are started will not be delivered at the planned deadline or not within the stated budget. More buildings projects are produced through modular construction, producing buildings in an off-site facility with a closed environment and equal conditions for every project. This enables easier transfers of methodologies and tools from the manufacturing industry towards construction usages. This research investigated the most critical performance measurements for Engineering, Procurement and Construction projects (EPC) and how concepts as continuous improvements and visual planning from Lean methodologies could be helpful for modular construction companies.

This research was performed together with a case company called Emtunga Solutions AB, which produces Living quarters for mainly off-shore oil rigs through modular construction. Ten semi-structured interviews with open questions to gather knowledge of the existing execution process at Emtunga was executed. Through the findings in the interviews, a survey was conducted to further confirm and determine these findings in a broader context. Several areas were found that seemed to have a significant impact on the project performance.

The main findings were the importance of continuous improvements, the possibilities with visual planning tool and the problematic interference in the process from change order by customer. These are three critical areas that severely influence organisations within modular construction that uses the EPC framework. If these are handled correctly, problems could be prevented, and it will enable an efficient project process.

Keywords: Modular construction, Engineering procurement and construction, Lean construction, Continuous improvement, Visual planning, Change orders.

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Gustav Axelsson & Oscar Elm, Gothenburg, May 2021

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# 1
# Introduction

The introduction of this Master thesis is firstly Background, Problem definition, Aim and Research questions presented. Furthermore are a few delimitation's is stated and the Case company's background is presented.

## 1.1 Background

The level of complexity in the construction industry is high, and the industry is often seen as fragmented, which indicates challenges from a management perspective. The processes, products and supply chains active within the industry are all contributors to this complicated situation (Kabirifar & Mojtahedi, 2019). This occurring complexity results in frequently inaccurate forecasts and the subsequent impacts are often shown in a transcended budget of cost and deadlines that are exceeded. In general, over 50% of construction projects are exposed to severe delay of time and significant exceeding budgets (Habibi et al., 2018). Thereby, there is an essential need to investigate and evaluate these issues and address the root causes. A solution to reduce these issues is the project method of Engineering, Procurement and Construction (EPC), were one organisation is responsible for all phases of engineering, procurement and construction. The EPC method is proven the increase efficiency throughout projects and solves some of the problems the construction industry is dealing with (Shen et al., 2017).

Today there are advanced methods to quickly construct buildings with off-site construction, from detached houses to skyscrapers and advanced technical facilities. The general name is *Prefabricated building construction system*, however names as *Preassembly* and *Modular constructions* are also well known for these type of method (Generalova et al., 2016). This type of construction enables the production of buildings within a safe environment, and it is both safe in terms of workers safety and safe in terms of managing the process. There is equal conditions for every project and every phase, which enables possibilities of standardized procedures and work tasks.

The concept of Lean has been around for a long time and origins from Toyota and is compiled in the *The Toyota way* (Kanbanize, 2021). Lean has been a successful philosophy, and there is an adaptation of the philosophy for the construction industry. How well does the methodologies and tools from Lean and Lean construction apply for modular construction, which could be seen as a hybrid of manufacturing

and construction industries?

## 1.2 Problem Definition

The construction industry is known for exceeding budgets and deadlines, with processes that contain a large number of losses or non-value adding activities (Habibi et al., 2018). This is often described to be due to that construction companies operates in a different location for every project, and there are uncontrollable aspects that effects projects, such as weather (Chan & Kumaraswamy, 1997). Though, this is also described at the Case company in focus, a modular construction company that construct their buildings at an off-site facility with identical conditions for each project. The Case company's deliveries to customers are always kept on time. However, the profit margin is often diminished throughout the projects due to exceeded internal deadlines. In general, companies that produces buildings, whether if it is in an off-site factory or an on-site construction, operates with a high amount of losses within their processes.

## 1.3 Aim

This thesis aims to analyse EPC projects, more precisely the engineering phase, and to find out why construction companies often fails to have an accurate and efficient execution process. By determine the problems and obstructions, improvements and solutions will be presented on how companies, such as the case company Emtunga Solutions, could handle this types of problems and prevent them for occurring in the future. Methods as Continuous improvements and Visual planning from the Lean methodologies will be investigated to solve the problems. This thesis further aims to solve the currents problems at Emtunga Solutions and propose suitable solutions for them in mind.

## 1.4 Research Questions

A problem definition has been stated and the aim for the thesis has been presented. Three research questions has been determined to solve the problems and reach the aim.

- Which are the most important/critical performance measurements within the engineering phase of EPC projects, and how do they impact project performance?
- What benefits could a modular construction company that operates through EPC projects withdraw from Visual planning in the Lean concept?
- How could a modular construction company that operates through EPC projects benefit from Continuous improvements?

## 1.5 Delimitation

- This will be executed with Emtunga Solutions as a reference point and the report will be based on findings at this company.
- The thesis will only consider the engineering phase of EPC projects
- Proposed improvements will not be tested in reality, only based on literature and stated conclusions.
- Only one company will be observed and evaluated.
- The evaluation will be concentrated and limited to the most critical problems and correlations found in the data collection. Other areas will be excluded.
- The study was performed under the ongoing Covid-19 pandemic, which has limited the company visits and other real-life interactions with supervisors and other influencing individuals.

### 1.5.1 Delimitation's Towards Case Company

- The thesis will only result in an evaluation of the current project execution model process at Emtunga Solutions. An entirely new process will not be presented, only proposed improvements.
- The project will only consider the project execution model of the engineering part, but the interface towards production and purchase will be determined.
- The interaction with external parties such as the customer and subcontractors will not be included.
- Evaluation of the production process will not be included.

## 1.6 Case Company Background

Emtunga solutions AB is a leading EPC projects supplier of modular industry accommodation facilities. With over 45 years of experience in the offshore industry, combined with the clever modular execution model, which enables flexibility in the degree of offsite construction, puts Emtunga Solutions in a position as a globally leading supplier. Their projects range from entire, complete offshore living quarters to smaller extension projects, with deliveries worldwide. An example of an offshore living quarter, designed and produced by Emtunga solutions, can be seen in Figure 1.1.

**Figure 1.1:** An offshore living quarter by Emtunga solutions (Emtunga, 2021)

## 1.7 Sustainability contribution

As this thesis is performed as a case study, the sustainability contribution will mostly be concentrated to the case company. However, the contribution could be applied in a broader perspective. In regards of the triple bottom line with the perspective of social, economical and environmental sustainability (Slaper & Hall, 2011), the impact of the thesis will mostly affect the economical and social areas for the case company. With a more accurate execution process that corresponds better with reality and with time plans that are kept , it will benefit the case company in terms of better profit and increased economical sustainability. In a tough market as the case company are active in, a better economical sustainability will also thrive social sustainability. Economical success for the company, will increase the chances of more stability, in terms of employments for the workers.

# 2
# Methods

This chapter describes the research strategy of this case study. Furthermore, it describes the research methods, data collection and literature review. The ethics trustworthiness is also described.

## 2.1 Research strategy

This project was carried out as a case study at Emtunga solutions, including their whole organisation within engineering and design. A qualitative research strategy was applied to this case study due to the approach of emphasizing words rather than data analysis (Bryman & Bell, 2015). Since the purpose of this study is to evaluate and improve deficiencies in Emtungas engineering execution process, it was crucial to comprehend the execution process from the engineering and design disciplines perspective, and in that manner, receive their experience and perceive a broad understanding of their problems. The aim of this study is not to experiment with new theories but to emphasize an inductive perspective on the theory and research (Bryman & Bell, 2015), that could be valuable for this specific case study and how lean methodologies could improve critical areas during the engineering and design phase of modular construction. The qualitative research strategy combined with this case study was realized using two different data collection methods: qualitative interviews and a quantitative survey. The results from the qualitative data collection recommended by Bryman and Bell (2015) were partly used to design the survey where the quantitative data can confirm the theories and findings from the qualitative interview (Bryman & Bell, 2015).

## 2.2 Research methods and data collection

The different research methods used for this case study are documents analysis, study visit, semi-structured interview, survey, and literature and are presented below. A research method is an approach used to collect data (Bryman & Bell, 2015).

### 2.2.1 Documents

Internal documents from Emtungas document database regarding how and why their execution process should be performed was reviewed to receive fundamental knowledge and understanding of their execution process before the qualitative research began. When reviewing internal documents, it is essential to consider that

the documents are affected by the authors perspective and role within the company (Bryman & Bell, 2015).

### 2.2.2 Study visit

A study visit was performed at Emtungas location in Arendal, Gothenburg, where the construction of their modular EPC projects is performed. The purpose of the study visit was to gain insight regarding how Emtunga functions as an organisation and of how Emtungas executes their modular EPC projects. The study visit also filled a purpose of creating a better relation with the supervisors and other employees at the company for the authors. The study visit lasted three hours.

### 2.2.3 Interviews

According to Bryman and Bell (2015), there are two appropriate interview methods for qualitative research, unstructured and semi-structured interviews. The selected method of this study was semi-structured interviews, with ten employees from different engineering and design disciplines at Emtunga, and each interview proceeded approximately 60 minutes. The purpose of the semi-structured interviews was to gain an extensive understanding of the execution process. However also to discover deficiencies and their root causes, based on the interviewee's experiences and opinion about the execution process. The layout of the semi-structured interviews enabled a structured framework of topic-specific questions, but the interviewees were maintained space to express their own experiences and opinions. This facilitated a two-way communication of both questions for clarification and actual situation examples of previous experiences of the execution process. Both notes and recordings were taken during the interviews to capture all valuable data.

The interview list of employees was provided to this case study by the supervisors at Emtunga. The selection consisted of experienced representatives from all the seven engineering and design disciplines with different responsibilities and excellent knowledge about Emtungas execution process. Representatives from all the different disciplines were selected to receive a broad and transparent data collection from as many perspectives as possible. The representatives were spread out on all three different geographical locations, and the interviews were performed using video calls. All interviews were performed in Swedish to reduce the risk of misunderstandings and due to Swedish being Emtungas internal organisational language.

### 2.2.4 Survey

To reduce the risk of one employee subjective opinion about the execution process from a specific discipline, a survey was conducted to complement the interviews and confirm the interview results and findings with quantitative data. The survey consisted of 27 questions, with the majority of the questions was closed questions with six different answer options. A few open questions were asked where the respondents could comment on their own opinion and experience in addition to the closed answers. The supervisor at Emtunga sent out the survey to all 28 employees

within their engineering disciplines. The final response rate was at 85.7 % with a total of 24 answers. The language used for the survey was Swedish because of the same reasons as the interviews. The closed questions make it easier to compare the survey result (Bryman & Bell, 2015). This might entail that the respondents could be forced to answer an opinion that they did not agree to, but this risk was reduced using a spectrum of six different answer options instead of only using yes/no answers. Using this spectrum of answer options creates an opportunity to compare the quantitative data results and create a scoring list of the question with the worst result, which was recommended by the examiner of this thesis, Dag Bergsjö.

## 2.3 Literature review

An extensive literature review was conducted during this research to gain knowledge within relevant fields of the subject. The databases used to find literature was Chalmers Library and Google Scholar, and keywords such as *EPC projects, EPC project planning, Modular construction, Lean methodologies, Lean construction, Continuous improvement, Kaizen, Successful project communication, Visual planning, Visual management,* was combined, mixed and used.

## 2.4 Ethics of the research

Four principles have been used during this research to fulfil the ethics of the research as suggested of Diener and Crandall (1978) and are described below.

### Harm to participants

No participants of the research should be harmed because of this research. They should be informed of the research purpose and that their participation is anonymous (Diener & Crandall, 1978). The participants in this study were informed that their experience and opinions would hold the case company to improve their execution process and be anonymous.

### Lack of informed consent

Lack of informed consent is to avoid by informing the participants about the study purpose and their role. After that, be able to decide if they want to participate or not (Diener & Crandall, 1978). All interviewees were informed of the study by the case company supervisor where they were informed of the study and their role as participants. Furthermore, the interviewees were informed at the beginning of each interview. The same procedure was performed before the survey, and a describing text was also added at the beginning of the survey document.

### Invasion of privacy

All results in this study are being presented in a way that does not intrude on the participant's privacy. The focus has been on keeping all participant anonymous as suggested in Diener and Crandall (1978).

### Deception

Deception is the risk of using the participant's input in a way that was not informed (Diener & Crandall, 1978). The participants of this study have been offered to view the results and can, in that way, ensure that their inputs are valuable and used in the right way.

## 2.5 Trustworthiness

Four categories that Bryman and Bell (2015) refers to when striving for trustworthiness is *credibility*, *transferability*, *dependability*, and *confirmability*. *Credibility* in this research is confirmed by sharing literature findings, qualitative data, and quantitative data with the interviewees, survey respondents, the case company, and university supervisor. *Transferability*, how others can apply the findings of this research, can mainly be used by the case company and other companies within the same industry or business model in need of guidance. *Dependability*, audit of the research and results, has been fulfilled due to all collected data and progress notes saved throughout the whole project and are available for audit. However, the recorded interviews are deleted due to invasion of privacy, but the interview notes are conserved. *Confirmability* suggests that complete objectivity is impossible to avoid, and some bias will occur. However, the interview result combined with the survey result reduces the risk of one employee's subjective opinion.

# 3
# Theory

This chapter provides findings from relevant and corresponding literature. Which in the end provides a solid foundation to enable trustworthy answers to the research questions.

## 3.1 EPC projects

The method of Engineering, Procurement and Construction, also called EPC, is a model where one organization is in charge and ultimately responsible for the entire process, including the areas of design, procurement and construction in a construction project. This method is getting more recognition throughout the world due to the achieved efficiency through the one-single-organization responsibility (Shen et al., 2017). As mentioned, EPC projects consist of engineering, procurement and construction. Moreover, engineering can be branched into three main parts, front end engineering design (FEED), basic design and datasheet and detailed engineering (Tahir, 2004). FEED is basically the conceptual design of the determined and purchased project, which functions as a basis for detailed design. Basic design and datasheet is a data sheet created by the EPC contractor of the main equipment, brought from the FEED. Detailed engineering is created from the FEED and basic design according to Tahir, 2004, and the included areas can be seen in Table 3.1;

**Table 3.1:** Detailed engineering (Tahir, 2004)

| Detailed engineering | |
|---|---|
| - | General layouts (e.g. piping) |
| - | Bill of materials (BOM) |
| - | General arrangement drawings (GA) |
| - | Fabrication drawings |
| - | Process and instrumentation drawings (P&IDs) |
| - | Process flow diagrams (PFDs) |

Although, the method of EPC still leaves out some difficulties for the organisations in charge. There is continuous pressure for EPC projects to follow and deliver within the time limits. With several stakeholders active in the projects and interacting with one another, together with possible overlapping processes in the stages of design, procurement and construction, it creates much stress to the time limits (Shen et al., 2017).

Projects within the construction industry are often considered unique. However, some processes and procedures reoccur in each project, which enables improvement potential and possible standardisation. *"Every time we do something again, we should do it better than last time"* said BP's Groups CEO John Brown in Prokesch in 1997 (Carrillo, 2005). There is also a steady increase of competition in the industry where time-to-market and time-to-delivery are of great importance, and reducing these two deliveries can create a competitive advantage (Mahmoud-Jouini et al., 2004). The sacred way to prevent problems from reoccurring and to enhance the process is a method called *Lessons learned*. This is a session held after every project to evaluate both negative and positive outcomes of the recently finished project. These sessions consist of a topic, e.g., *"What should be changed and what should elaborate on in upcoming projects? How can we avoid that the same problems will appear again in future?"* (Carrillo, 2005). Although, Lessons learned is often problematic, and the excepted results are not always reached. There is a logistic challenge to perform these sessions after projects. Many employees, consultants and contractors have moved on to other projects or finished their employment. Lessons learned has a role in continuous improvements, but not only by themselves. The challenge is to create a systematic approach, with strong connections to the business process, imbued with continuous improvement for the entire organisation (Carrillo, 2005).

The planning department within EPC projects could be seen as the eyes and ears of the process. According to Tahir (2004) can planning be defined as influencing the future by decisions based on determined objectives. How well a project is succeeding is mainly depending on how well the planning department can influence and predict the future outcome through effective techniques and still keeping a harmonised atmosphere between stakeholders (Tahir, 2004). The main objective of planning is to decide;*" What should be done? When should it be done? And by whom?"* Tahir, 2004 explains seven steps that the planning process for EPC projects consists of, and these steps are presented in Table 3.2.

**Table 3.2:** Planning steps for EPC projects (Tahir, 2004)

| Planning steps for EPC projects | |
|---|---|
| 1 | Work break down |
| 2 | Arranging activities in sequence |
| 3 | Establishing activity relationships |
| 4 | Assigning durations levels to the plan |
| 5 | Establish milestones and identify constraints |
| 6 | Leveling of resources |
| 7 | Determination of Critical Path Method (CPM) |
| | Progress reporting |

### 3.1.1 Performance measurements

The construction industry commonly is exposed to delays and costly disruptions. As mentioned, over 50% of the projects are in the end delayed, which indirect is affecting the budget of the project (Habibi et al., 2018). Chan and Kumaraswamy, (1997) conducted a survey to gather a broader understanding of the caused delays in the industry from the perspective of contractors, clients and consultants. The scope of the survey were construction projects in the region of Hong Kong. The survey found five major and common causes of delays, which are (Chan & Kumaraswamy, 1997):

- 'Poor site management and supervision'
- 'Unforeseen ground conditions'
- 'Low speed of decision making involving all project teams'
- 'Change orders by customer'
- 'Necessary variations of works'

In regards to a constant increasing economy, fast transitions and the intense competitiveness within the construction industry, it is more pressure than ever before at the organisations active within the industry. Companies are more or less forced to evaluate and improve their process performances continuously (Habibi et al., 2019). The project performance of construction projects is determined through the constraints of time, cost and quality. These three constraints are the measurements and determine a project's efficiency and productivity. However, it is hard to define what quality actually is, making it hard to measure and evaluate. For calibrating a project's performance, the focus lies instead entirely on the constraints of cost and time. (Habibi et al., 2019).

In the study performed by Habibi et al. (2019) with the target to find KPI's that were phase-based and had the largest impact at both cost and time in EPC projects, to further enable improvements to eventually save money and time. The study showed that *Order changes by customer* was the KPI that had the most significant impact in the engineering phase, both to time delays and exceeded budgets. *Lack of communications between design teams* and *Slow decision making* were two other KPI's that had a significant impact at the time and scheduling part of the engineering phase. For the cost aspect, it was found that *Client and consultant experience* had the most significant impact (Habibi et al., 2019).

Maintaining and not exceeding a project budget is always a critical aspect of project performance. One word that is a synonym with exceeded budgets is, *Changes*. In Figure 3.1 the relationship between the cost of changes and the ability to make changes. If changes are made early in a project, it will not significantly impact the cost of the project. However, as further gone the project is, the more careful should the management be with allowing changes when this could have tremendous impacts (Cost-link.Associates, 2017).

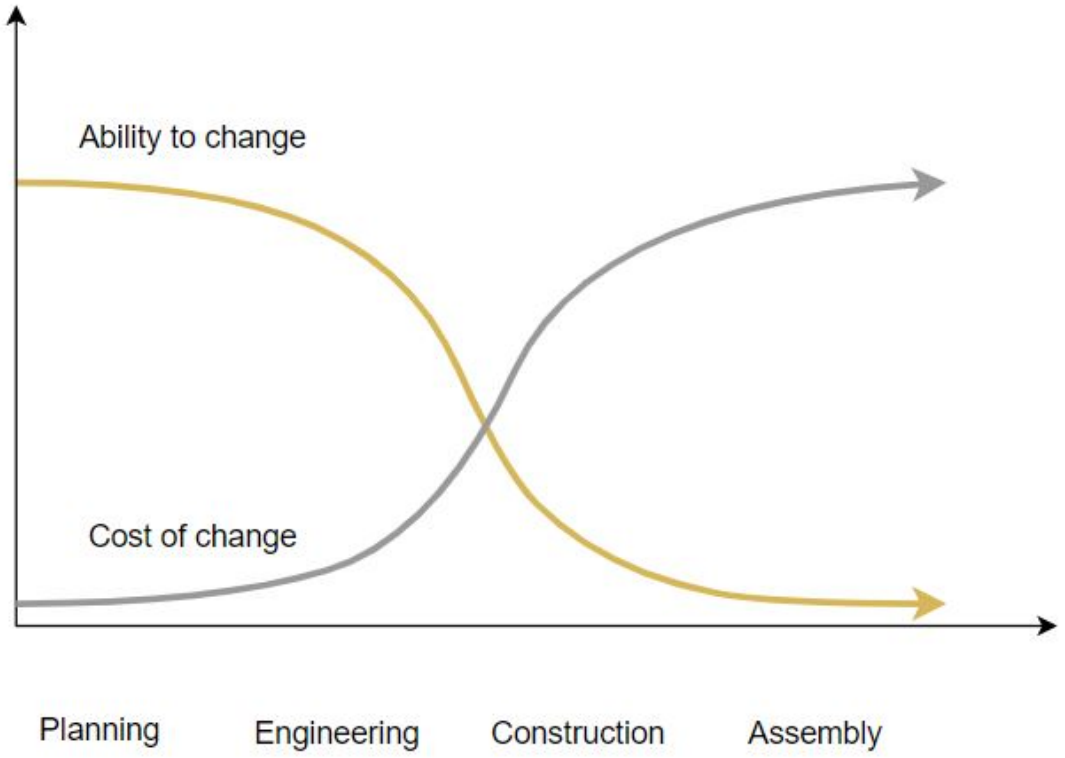


**Figure 3.1:** Cost of change, adapted from the figure from Cost-link (Cost-link.Associates, 2017)

### 3.1.2 Modular construction

The definition of this type of construction is that structural components of various size are produced in controlled off-site factories, and the construction site is more or less only used for assembling the prefabricated components (Generalova et al., 2016). There is a broad spectrum of how much that is done in these off-site factories. At most, up to 95 % of the constructions can be completed at the off-site facilities and the last 5 % is finished at the construction site (Smith, 2016). There is also modular construction with 3D modules as building blocks. This type of construction enables, even more, to be done at the off-site factories, e.g. interior with complete kitchens, data centres or even entire apartments. Several positive aspects come with this type of modular construction. A quicker assembly process, a process that is easier to manage and control at the production facility, safer work environments and less waste are some of the benefits with 3D modular construction (Generalova et al., 2016). Figure 3.2 shows Emtunga Solutions AB *Single unit delivery*, where engineering, module fabrication and assembly is performed off-site at Emtungas modular fabrication site before the entirely completed living quarter is shipped off to the customer ("Emtunga", 2021).


**Figure 3.2:** Modular construction ("Emtunga", 2021)

Modular construction is seen as a merge of construction and manufacturing, which opens up for implementing frameworks for manufacturing. The focus is on optimizing quality and productivity within the process (Innella et al., 2019). This can have a significant effect because the construction industry is stated to consist of a high amount of non-value adding activities. 57 % of the activities in the industry are approximated to be non-value adding, compared to the manufacturing industry where this number only reaches 38 % (Smith, 2016).

## 3.2 Lean methodology

Lean methodology originates from Toyota's production system *The Toyota Way* but can be used and applied in most business and processes. There are three main objectives to fulfil in Lean methodology, deliver customer value, eliminate waste, and continuous improvement. If an organisation succeeds with implementing Lean methodologies, they can, among other things, expect improved productivity and efficiency and better-utilised resources (Kanbanize, 2021). The following section further provides a comprehensive description of lean methodologies concepts applicable for this research.

### 3.2.1 Continuous improvement

In order for companies to survive and succeed, they need to adapt to a changing market, with customer expectations higher than ever before. A fundamental part of companies survival and success is always to improve their products and execution process to exceed the customer expectations (Nicholas, 2010). Continuous improvement is a strategy concept from Lean philosophy. Continuous improvement means that a company commits to improving every part of their organization (Liker

& Franz, 2011). Companies should implement continuous improvement to make short-term profits, sustain them, make long-term gains, and make the company more competitive (van Aartsengel & Kurtoglu, 2013). Continuous improvement works as a preventive problem-solving tool to get the correct work done the first time without a wasteful corrective action. The iterative execution used to archive this is called plan-do-check-adjust (PDCA) (Liker & Franz, 2011), see Figure 3.3.

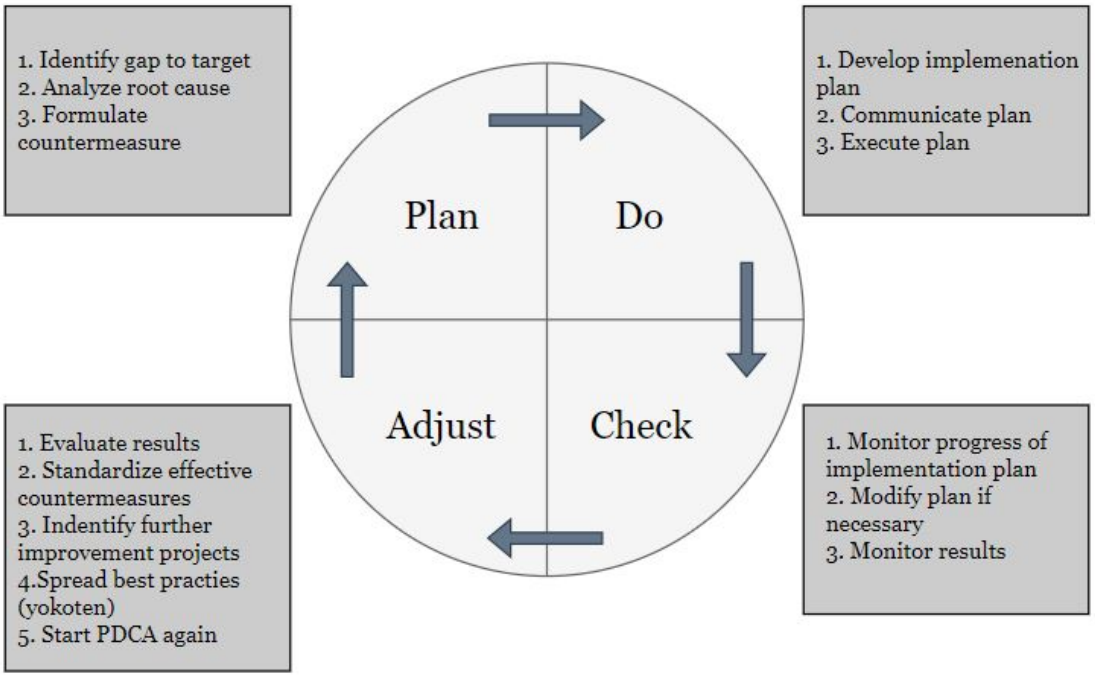


**Figure 3.3:** PDCA, adapted from the Toyota way (Liker & Franz, 2011)

A previous study by Terziovski (2001) regarding continuous improvement in small to medium-sized companies shows positive results of adopting this strategy concept. Small companies were defined as between 20-49 employees and medium companies between 50-99 employees. The result shows that continuous improvement is essential to achieve high performance within three specific practices. These practices where; continuous improvement was of vital importance to achieving strategic goals and objectives, adoption of core technologies and organizational objectives to drive new ideas, and monitoring progress using action plans or timetables as a part of the continuous improvement (Terziovski, 2001).

### 3.2.2 Kaizen and Kaizen events

Kaizen, which is Japanese for continuous improvements, can be minor improvements suggested by employees or disciplines at any time. The benefits from Kaizen improvements can be anything that will contribute to a better work process or better work quality, and simple problems can be solved right away. Another way to perform continuous improvements is through a specific methodology called Kaizen events. A Kaizen event focuses on a specific part of the process with the primary goal of

improving it for the better. A Kaizen event is performed for three to five days with the goal of finding significant, fast and straightforward improvements. The event is team-based, where the employees suggest solutions that can improve their everyday work, usually finding solutions that can reduce the time required to perform activities within a process and remove non-value adding activities (Manos, 2007).

### 3.2.3 Lean construction

Lean construction has been around since the beginning of the 1990s, with the target to enable more effectively and efficiently management of the construction industry. Different tools and techniques have been adjusted from lean production to be instead beneficial for construction companies. Increased profitability, improved planning accuracy, reduction of waste and increased productivity are some of the benefits gained from the concept of lean construction (G. Ballard et al., 2002).

The usual way of managing construction projects is to break down the project into activities or pieces, implementing the CPM, estimate the money and time needed for the activities and then establish the responsibility of the activities, either internal or external. The managers supervise the projects and monitor how the project follows the planning and increases the workforce in areas that are lacking behind, which has a harmful effect on productivity. This approach sounds legitimated, however, it is often failing in practice (Koskela et al., 2002). The reason behind that, according to Koskela et al., 2002 is that project management tries to manage the process only by central applied scheduling based on activities and controlling them using output measurements. In contrast to lean construction were the focus instead is at the value of single activities in the process, if they are value-adding and non-value-adding, throughout the project process. The idea is to highlight the value-adding and eliminate the non-value adding activities (Koskela et al., 2002). Solutions for waste reduction, reducing non-value adding activities, could be implementing standardised work routines and visual control of the process (Innella et al., 2019). In lean construction, there is also a continuously evaluating and improving process in place to prevent problems to reoccur in the future and continuously making the process better (Koskela et al., 2002).

The most famous technique of lean construction is Last Planner System (LPS), which is a management tool for planning, overviewing and monitoring constriction processes and projects (G. Ballard & Howell, 2003). The actual "Last planner" in LPS is a person or group that are in charge of the production unit control, which in other words, are the completion of assignments on an operational level. LPS was developed to increase the predictability in construction processes, which results in increased chances of delivering on time, both internally and to the end customer (AlSehaimi et al., 2014). The LPS focus on three areas to increase reliability in the process, and these three are; lookahead planning, the manager's guarantees that information, resources and materials are available for the process. Secondly, checking the upcoming weekly activities that will be executed and that the preceding activities have been done, and at last by seeking reliable commitments from the involved

resources of labours (H. G. Ballard, 2000). The LPS consists of five major stages, which are; master planning, phase planning, lookahead planning, weekly work planning and percent plan complete (PPC) and evaluation of incomplete activities (H. G. Ballard, 2000).

## 3.3 Communication

Communication during projects is essential, but it is not always clear what good communication implies. According to Ann (2013), good communication is based on clarity on both the role of communication and its message. Time spent in an early stage of a project defining what communication is and is not, is well invested hours (Ann, 2013). The impact that effective communication has is that it can improve the management of an engineering discipline and help the discipline to build confidence. This is because effective communication creates a loop of constructive feedback (Lee & Kim, 2018). A previous study found out that lack of communication between the design team, i.e. Engineering, within an EPC project was a primary performance indicator regarding how well the time schedule was kept (Habibi et al., 2019). Efficient communication will assist in keeping the time schedule during projects, but also assist in keeping it within budget(Lee & Kim, 2018). The amount of communication errors that can be made during a project is unlimited. The most common error is that important information regarding a project is mediated in an unclear manner. This unclear manner of communication will result in important information being overlooked, and project stakeholders and the involved disciplines will not have a complete understanding of challenges or problems regarding the project (Cervone, 2014).

### 3.3.1 Visual planning

Communication during projects can be simplified and more apparent if the correct tools are available. A visual representation tool can streamline communication, making the project more efficient (Lee & Rojas, 2013). An example of a visual representation tool is visual planning. Visual planning originates from lean methodology and is a collection of visual tools that organise information and activities between all involved disciplines to establish a collaborative project. According to Tjell and Bosch-Sijtsema (2015), it supports communication and mutual understanding in the engineering design phase. The purpose of visual planning is to create a common view on a project, both as a whole but also on a discipline level. It is essential that an organisation has a common target and objective. The tasks need to be clear on every level of the organisation, and deviations from the common target must be noted and opposed (Catic et al., 2016). Visual planning within the production phase of a construction project is often performed through post-it notes and whiteboards (Tjell & Bosch-Sijtsema, 2015). Visualisation of the project results in that issues and problems can be highlighted in an early stage of the project. They can therefore be solved in a matter that fulfils the customer requirements (G. Ballard, 1999).

Transparency is a well-established management principle in production processes.

A transparent production process enables complete control and improvement potential due to a high degree of communication between the process and the production workers (Formoso et al., 2002). In fact, transparency is an essential foundation for achieving an excellent production process because it creates a more communicative process (Dos Santos et al., 1998). This can be compared to construction sites where transparency is needed in the communication between all involved disciplines in a project rather than between people and process within a production. Regarding transparency and transparent communication within construction, there is a major requirement to handle much information at once, and lack of transparency is commonly occurring, resulting in decreased efficiency (Dos Santos et al., 1998). There are several ways to increase transparency within the construction process. One is to use visual controls that enables all involved parties to discover and avoid potential problems and issues (Dos Santos et al., 1998). In a pilot project between SBUF and PEAB, where visual planning was introduced in the planning and production phases, these benefits were shown. A planning procedure that was supposed to take four months was completed after only three, as an example. In general, were the opinions very positive throughout the pilot project from all stakeholders (SBUF, 2005).
*"With the help of visual planning, we settled 72 significant decisions early in the planning process. Otherwise, we would probably have taken two of these decisions and have been unaware of 70 problems"* (SBUF, 2005).

A study at Skanska with the aim of making the engineering and design phase of a construction project more efficient, performed by Roslund and Wålstedt (2015), show positive results of implementing visual planning. The majority of the project involved disciplines, and stakeholders have a positive attitude towards visual planning and believes that implementation of it works well. Furthermore, the implementation resulted in short and efficient meetings, increasing the engagement of the engineering and design disciplines. However, digitalisation of the visual planning implemented at Skanska was requested (Roslund & Wålstedt, 2015).

### 3.3.2 Visual software tool

An example of how visual planning from lean methodology can be performed is Yolean. Yolean is a software tool developed and based on several years of academic research that enables visual planning in both project management and site management. The visual planning tool in Yolean is a digitisation of planning through whiteboard and post-it notes where pulse and status checks, and problem-solving can be performed collaboratively and straightforwardly, see Figure 3.4 for a demonstration of it. Yolean can be reached through a website by all involved disciplines within a project or construction site ("Yolean", 2021). Previous research by Bertilsson and Wentzel (2015) shows that this type of digital visual planning is liked by the users and a very successful tool for team and organisations that want to succeed. It will help the organisation discover project risks early, but it is still essential to work proactively with the risks and not only identify them. It is also essential to make the employees comfortable with visual planning by providing knowledge and a purpose.

If not, the benefits of visual planning can not be utilised to their full extend, and resistance might arise among the employees (Bertilsson & Wentzel, 2015).

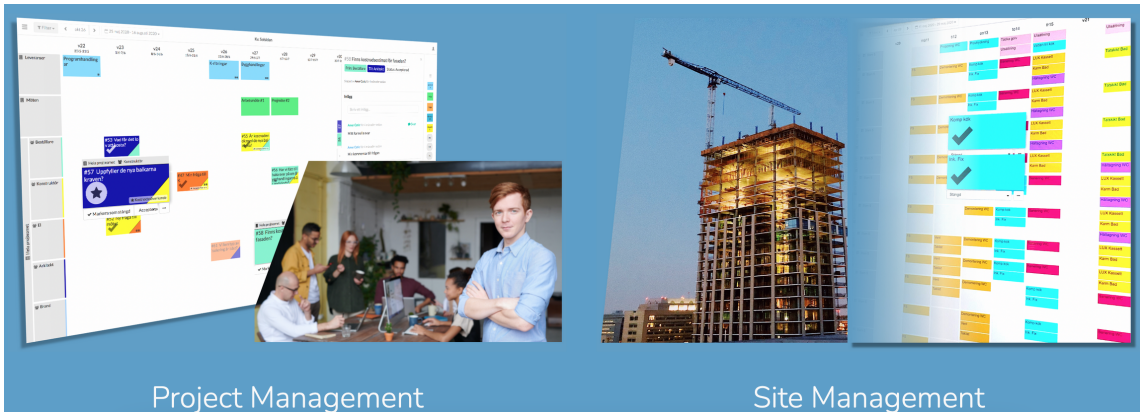


**Figure 3.4:** Yolean demonstration ("Yolean", 2021)

# 4

# Results

The results are based on the findings from the interviews and the survey. Firstly, is Emtungas executions process described. Secondly, are the results presented regarding the working procedure at Emtunga, more specific regarding the execution process and software that are used. At last, are the following sub-chapters presenting problematic areas that was located through the interviews and the survey.

The time plan during EPC projects at the Emtunga is decided at the beginning of each project. This time plan is mainly based on two variables, the fixed end date and the disposable resources. The end date is never negotiable whenever it has been decided upon, so it is essential to follow the time plan in order to avoid issues that may arise at the final stage of the project. The projects at Emtunga are always delivered on time to customer, but the internal deadlines tend to be exceeded during the projects. This results in an unstable execution process that demands many reactive problems solving throughout the entire project. The interviews conclude that several areas have a significant impact on the progress of the engineering disciplines. Some of these areas are directly influenced by the existing execution process at Emtunga, while the routines and communication at Emtunga influences other areas.

## 4.1 Emtungas execution process

The projects made by Emtunga are through the method called engineering, procurement and construction projects. This means that Emtunga is responsible for delivering a complete modular facility within a set time frame. An example of how Emtunga perform their projects can be seen in Figure 4.1. The engineering organization at Emtunga for an EPC project is divided into seven different engineering disciplines, each with a specific area of responsibility. The size of each discipline is adjusted after the total amount of hours required for the EPC project. Each engineering discipline consists of a lead engineer who holds the ultimate responsibility, and this person is always an experienced employee at Emtunga. The other discipline members can be a mix of employees at Emtunga and hired consultants. There are three engineering areas that Emtunga always outsource, and these are global structure calculations, noise analysis, and safety and working environment (Emtunga, 2019).

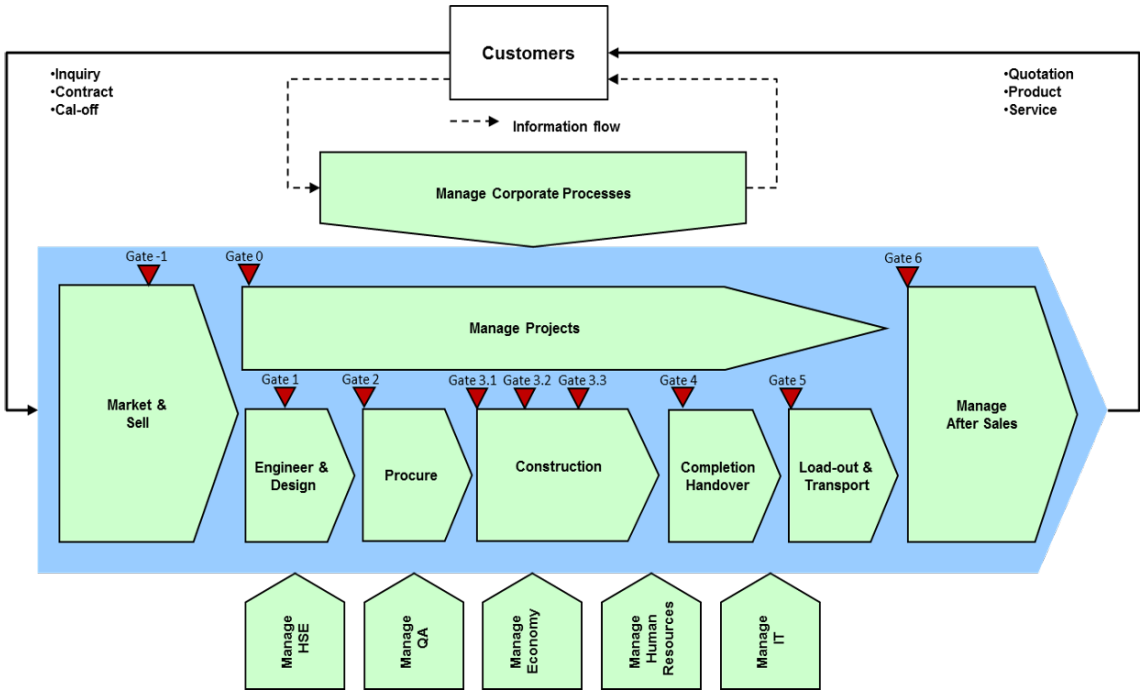


**Figure 4.1:** Emtungas project execution model for EPC projects (Emtunga, 2021)

### 4.1.1 The Engineering execution process at Emtunga

The engineering process used at Emtunga during projects is divided into five different levels of detail, shown in Figure 4.2. At level 1, the process phase, the engineering process is described at an overall level. While level 5 is broken down into detailed checklists of activities that need to be performed to finish the project.

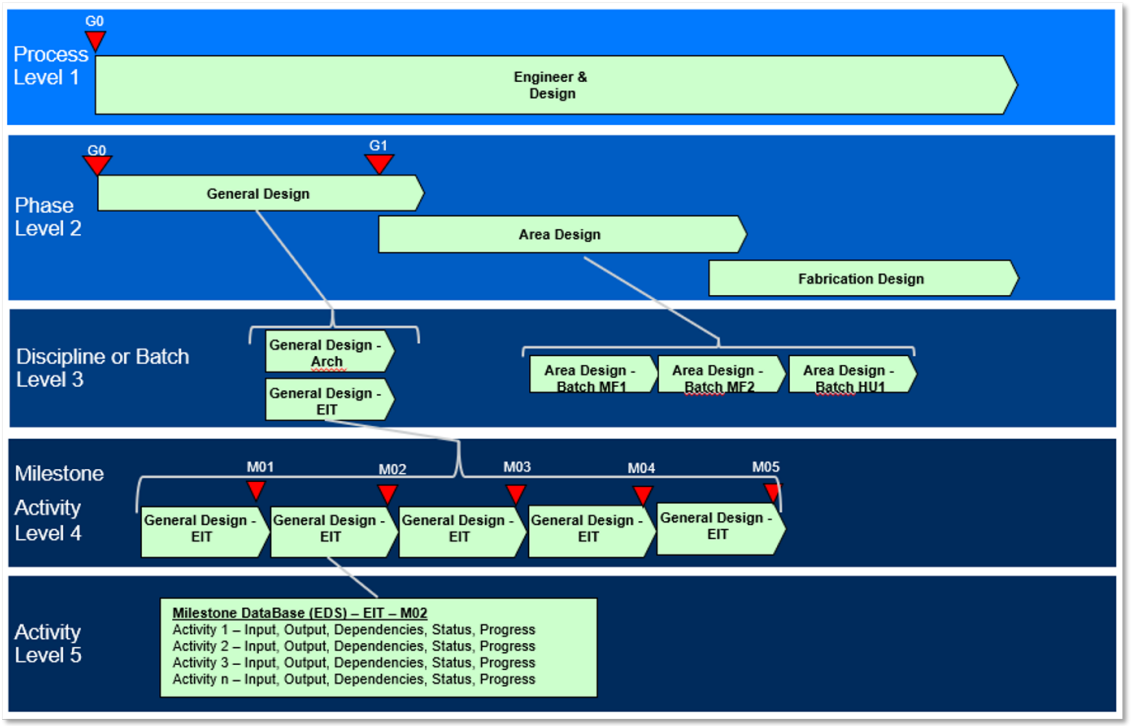


**Figure 4.2:** The engineering process at Emtunga solutions (Emtunga, 2021)

At Phase level 2, the engineering process is divided into three engineering phases, General Design, Area Design, and Fabrication Design. These phases include discipline or batch allocation, progress milestones, and detailed checklists of activities. Dependencies between other processes are presented at level 2 as well, e.g. procurement and construction, see Figure 4.3.

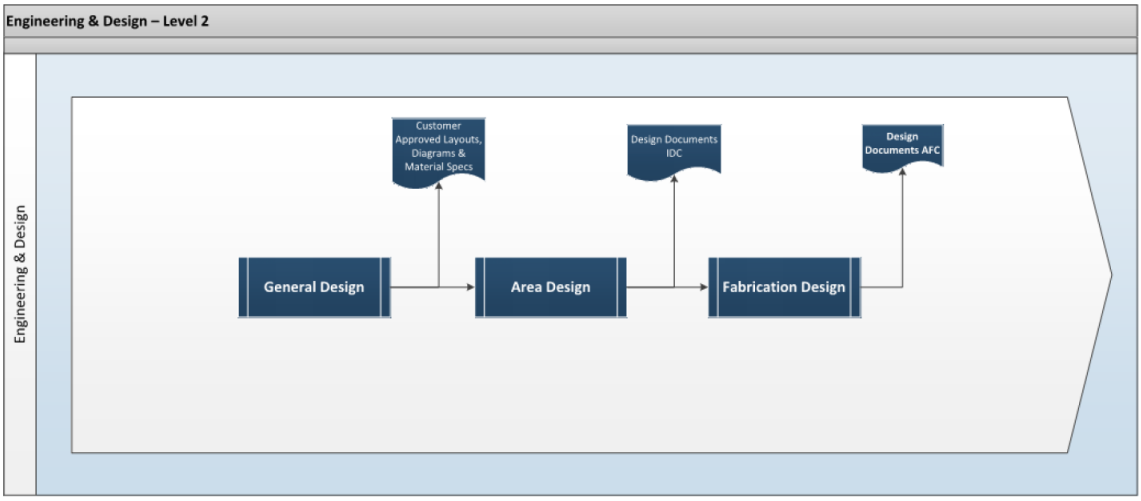


**Figure 4.3:** Phase Level 2 (Emtunga, 2019)

At the discipline level 3, the phases are broken down into a step where several tasks are presented with associated achievement objectives and milestones for each discipline, customised for their requirements. However, all the engineering disciplines

are still included in the same process chart. The next level, Milestone activity level 4, includes discipline-specific milestones where each engineering discipline has there own process chart. Each milestone has a fixed end date when it should be completed in order to follow the project schedule. E.g. in order for an engineering discipline to complete their first milestone, the task "Establishing project has to be completed". The difference between level 3 and level 4 is presented in Figure 4.4 and Figure 4.5.

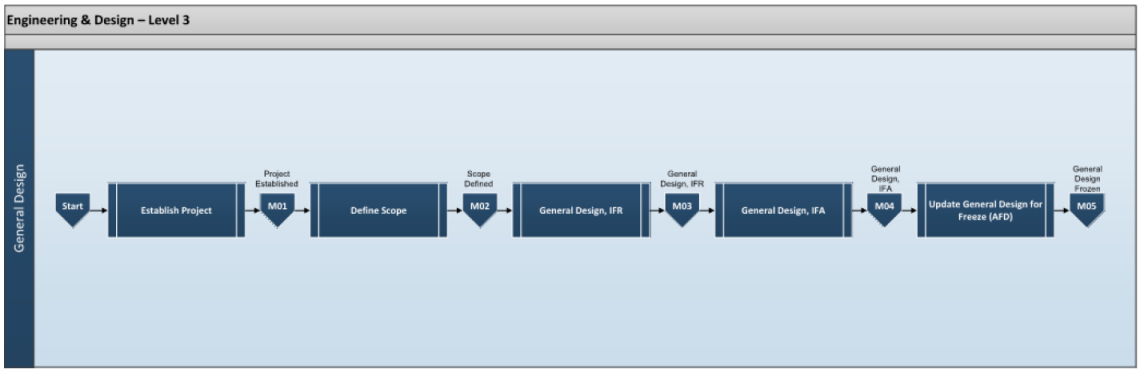


**Figure 4.4:** Discipline Level 3 in General Design (Emtunga, 2019)


**Figure 4.5:** Milestone activity Level 4 for Piping in Area Design (Emtunga, 2019)

The Activity level 5 is the most detailed level of them all. Here are the discipline-specific milestone broken down into several engineering activities that have to be completed in order to complete the milestone, see Figure 4.6. These activities are listed in a separate milestone database (Milestone DB), Emtungas engineering database, as a checklist for each discipline. The lead engineer for each discipline is responsible for registering each activity's progress as either 25 %, 50 %, 75 % or 100 % complete. Every activity is time-weighted depending on how much time it requires to complete. There is a set deadline for each milestone, and the available time is divided between the activities based on their weighting. The weighting was

done several years ago by senior engineers with great experience within Emtunga. Beyond the activities, there are also inputs and outputs listed in the milestone database. The inputs are needed to complete the activities and shows who are responsible for them. The outputs are results from the completed activities and who the recipient is. Neither inputs nor outputs are weighted by time but are instead seen as something treated in the activities. Every activity in the milestone database has the same deadline as the milestone. The Activity level 5 is meant to be the engineering disciplines primary tool during the project execution process at Emtunga, a guide for the engineers and the engineering leader.

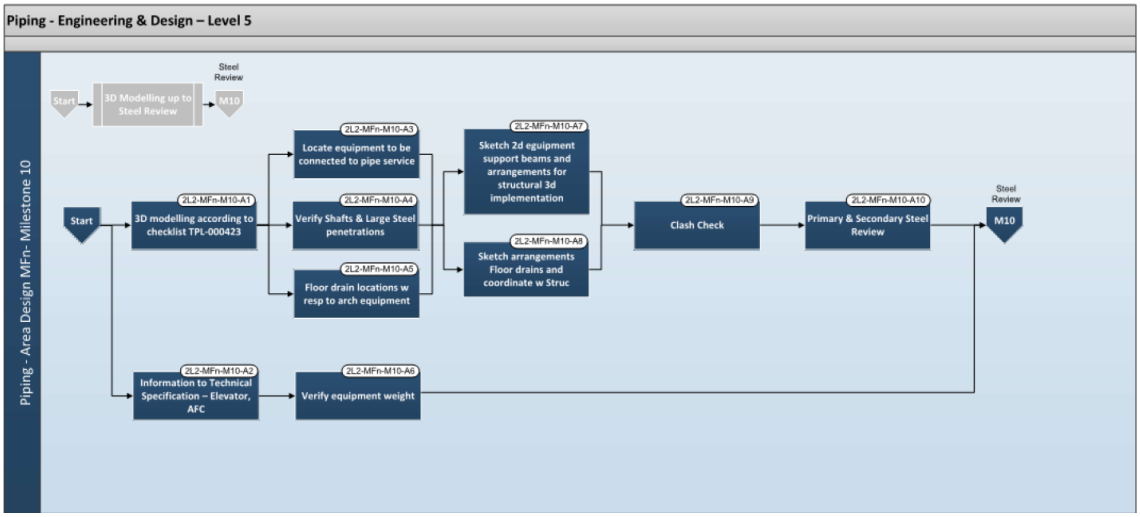


**Figure 4.6:** Activity Level 5 for Piping in Area Design (Emtunga, 2019)

## 4.2 Working procedure at Emtunga

Milestone DB, including the activity list and progress chart, are the primary software tools used at Emtunga to support the engineers in their daily work tasks. What should be done, when should it be done, how many hours are allocated to the activities and how much progress has been made, are some examples of what Milestone DB are contributing to help the engineers. A gathered opinion from the interviews is that EDS with Milestone DB is a great tool and has a lot of possibilities. However, the interviews also reveal some problems and obstructions with the software the averts the fullest potential.

*"We have some great tools, but they aren't used in the right way"*

After the marketing department have determined a deal with the customer including budget and deadline, the planners creates a project plan which is based on the weighting of each activity under each milestone in Milestone DB. Depending on which budget and deadline the project have, each milestone gets a certain amount of hours allocated to perform the underlying activities. This weighting has been determined in the past by senior engineers and should provide an effective planning tool. From the interviews it was shown that this is not truly the case. The weighting

are in many cases not working as accurate as planned. This weighting is based on older project when customer interactions were not as common as it is today. The weighting has not been evaluated and updated since the software was introduced at Emtunga a couple years ago.

*"When the customer interfere "to much" nowadays the hours easily flies away and the weighting tend to be very inaccurate".*

With the variation of budget and an allocated amount of time between different projects, it results in that each project differs in the amount of time dedicated for every single activity to be executed, and it requires assumptions and experience of the employees in charge.

EDS activity lists and progress charts are not always corresponding with reality. This could be due to both to how the software is designed, that progress could be reached in the software without that activities actually have been performed. Furthermore, also due to routines faults, how the employees use the software without considering the links and relations towards other colleges, disciplines, customers, and the following consequences can occur because of this. Especially mentioned is when one discipline declares that they have performed an output activity in EDS, but the receiving discipline has not got an input. Activities can be declared as completed in EDS, but towards the customer in reality only be 70% completed, which results in an inaccurate digital visualisation of the reality. A common opinion throughout the interviews is that each discipline works in closed environments with lacking communication and transparency towards other disciplines. Milestone DB can, in some cases, enlarge this problem.

*"If we are executing an output that is for our self, then it is quite easy, however, it's a lot harder when the output is towards another discipline"*

The required information is not always determined in Milestone DB. Output for one discipline is not always verified as to what input the receiving discipline is expecting. Names of milestones, activities, inputs and outputs are in some cases incorrect or difficult to understand, which leaves room for misunderstandings. In general, is the clarity of links and relations between the different disciplines in Milestone DB vague.

Emtunga get paid in different ways from project to project, based on which premises and what payment model were determined in the deal with the customer. Emtunga often get paid based on progress made during the projects, and these payments rely on the progress recorded in Milestone DB in EDS. The progress easily tends to be misleading, e.g. a discipline can be working at several different activities at once without fully completing any of these activities. To enable an even flow of ingoing payments from customer to the project, progress can, on some occasion, be made in Milestone DB to enable this without that the activity actually is fully completed. For the internal control of the project, this tends to have a bad effect. Payment progress and working progress are not aligned; they are not even the same thing,

which causes problems. Incomplete drawings and documents have sometimes been released to enable in-going payments, which causes disruption in the project and has a poor effect on the project's governance.

As mentioned earlier, the Milestone DB revolves a lot around the activities, inputs and outputs. There is an immense workload attached to this in administrative tasks when reporting progress in Milestone DB. Especially mentioned in the interviews were the phases of Area design and Fabrication design, where the administrative workload sometimes gets out of hand.

*"In Fabrication design, there is often a colossal amount of activities that need to be checked off. Many reiterations of activities, maybe this could be lifted to a higher level. So we do not need to check off every single activity, over and over again."*

There are reoccurring opinions of the level of detail in Milestone DB. Almost without any exceptions, is that the level of detail is too high. Several think that EDS, which is supposed to support the engineers and function as a helping tool in their daily work, instead evolves to a burden in some areas. For employees with long experience of working at Emtunga, EDS tends to feel redundantly in some aspects. These employees have a lot of tacit knowledge that has been gathered throughout their years of working at Emtunga.
*"In the ACE project, the activities have been too decomposed, I get a headache every week when I'm checking of the progress".*

*"EDS functions well as a cheat sheet but is a bit extensive to always work in. The standard view should be more shallow, not be that decomposed and detailed; however, the details should be in a level beneath because they are essential."*
The area of routines is a broad subject, and it affects many aspects of the execution process. One particular and vital aspect noticed is that Emtunga is working in a more reactive way, solving problems when they already have appeared, instead of working proactive and preventing future upcoming problems. This can clearly be seen in Milestone DB, and if deliveries are close to being delayed, it is not visualised in Milestone DB. It is not until the deliveries are delayed when it is visualised in Milestone DB. Problems regarding when the project should move into the next design phase were also reoccurring in the interviews. It is stated that General design must be completed before entering Area design, but this is not always followed, and disciplines can sometimes start working in the next phase before closing the current one.

*"Having a complete and settled design before entering production, it is Emtungas entire philosophy, to close the current design phase before entering the next. If this is not fulfilled, it will cause larger obstructions further on in the project."*

To achieve a successful execution process, it is crucial to have a great experience from a former project within every engineering discipline. The DPL (Discipline leader) at the engineering disciplines is always an employee at Emtunga with much former

experience. This is due to the complexity of the execution process and the required learning time of a new employee or consultant. A standard solution to solve the issue when an engineering discipline is lagging behind is to increase the workforce where it is needed. However, it is very time-consuming for the current engineers to include a new engineer, and there is a lack of helpful tools and routines to involve these new group members quickly.

*"If we should include more engineers to a project, it takes a lot of working hours from the already active engineers to involve the new ones."*

If the project is not following the time plan, it is only solved by adding more resources to the part that is lagging behind. It is time-consuming to involve the extra resources, but it can also cost a lot of money in means of salaries, which will reduce the project's profit margin. Otherwise, this issue would delay other activities, a sort of a chain reaction. E.g., a required internal delivery could be missing when the production should start welding, and the welding process is delayed until the internal delivery is complete.

*"The engineering disciplines does not work as a team, they need to collaborate more and deliver at the right time"*

## 4.3 Multidisciplinary components

A subject that was repetitively mentioned during the qualitative data collection was that the multidisciplinary components were poorly handled at Emtunga. It appears that the multidisciplinary components often becomes a critical subject regarding the time plan. The responsible engineering discipline for the multidisciplinary component is exposed to a very high workload, especially the affected DPL. One of the reasons behind the high workload is because the affected DPL has no extra time scheduled to solve problems and coordination related to the multidisciplinary components.

An example of the high workload is from a former project where the engineering discipline HVAC was responsible for the ventilation unit, a multidisciplinary component. The ventilation units are always unique and require a delivery time of 36 to 50 weeks from the supplier. The responsible DPL was busy with the regular work tasks and was overwhelmed with the responsibilities of the multidisciplinary component. The result of this was that the regular work was delayed and someone else had to fill in. It was mentioned that it would have been more successful to have someone else responsible for the multidisciplinary components rather than the DPL.

It also appeared that engineering disciplines that are involved in the multidisciplinary component but are not responsible do not feel any ownership of the component. The effect of this is that the responsible DPL is left alone with all of the

the responsibilities of multidisciplinary component ownership. An effect of this is that engineering disciplines without ownership can deliver inadequate information. E.g., the responsible DPL has to compile information from all the involved engineering disciplines and provide it to the supplier. Crucial information can be missing when the component needs to be ordered. A situation like this is critical for the responsible DPL, and it is still the DPL's responsibility to meet the time plan. An interviewee expressed,

*"It is hard to deliver the correct information to the supplier when I have not received crucial information from another discipline. Especially when the component is extensive or complex, then you must guess and make your own conclusions to meet the time plan"*

## 4.4 Customer interactions

One area that often was mentioned in the interviews was customer interactions in regards of customer changes throughout the execution process. It is more common today than ever before that the customers want to implement changes to their products after the acquisition of the deal has been done. The time plan for each project is based on the base scope that was determined in the acquisition, and there are no buffers of time planned to take care of the customer changes. The resulting effect of this is that virtually every customer change moves the project's critical path further forward in the time plan. With increased interactions from customers, there is also an increased stress at the time plan. The stress of the time plane intensifies as further into the project these changes occur, as one of the participant mentioned,

*"Late customer changes creates a greater impact on the time plan, if the changes could be done in the phase of general design, these changes would have less impact at both budget and deadlines."*

It is noticeable that customer changes have not been as frequent before as it is today, by how these interactions are handled in EDS. These changes are not updated and shown visually or in the progress mapping in EDS. This makes it challenging to see and understand how each change order affects the project's progression and budget.

Several of the interviewed employees highlighted the possibilities with customer changes and how it could be an area of high profit for Emtunga, as it normally is for producing or supplying companies. However, it is declared that there is a lack of understanding of the impacts these changes have on the execution process at Emtunga, which makes it difficult to know what the customer should be charged extra for.

## 4.5 Continuous improvements

Emtungas main process for project evaluation and continuous improvements was a format called *Lessons learned*, which works as an evaluation meeting after each finished project. Participants at these meetings are all the project leaders and managers that were involved in the project. The recently finished project is evaluated, problem areas in the project are highlighted and documented so these will not occur in future projects.

There is a difference of opinion of how effective *Lessons learned* are and how well they actually prevent that mistakes are repeated in the future. Some states that the notes from *Lessons learned* are used as a basis in the new projects to eliminate the chance of repeated problems. Others state that the same problems have been brought up at several different meetings and still occurs in upcoming projects.

*"We are working, in the same way, today as we did ten years ago, which is not a great sign of improvement"*

The projects at Emtunga are as shortest around six months and up to a couple of years, and due to the length, most of the problems that are evaluated at the *Lessons learned* are larger problems. Smaller problems, concerning, e.g. single activities, are not discussed at these meetings, and there is no evaluation routine for this type of problem. Another area that was noticed is that there is no existing tool at Emtunga to compare the number of budgeted hours to actually used hours in the process, which was problematic according to the interviews. The overall opinion, besides from *Lessons learned*, is that there is a lack of continuous evaluation throughout the execution process.

*"There is no room for improvements within the execution process, improvements are only made from own initiatives."*

It was expressed that Emtunga are working in a more reactive approach today, solving problems and obstructions when they already interfere with the process. E.g. there are not any warning signals in Milestone DB, it is only visible when something already has passed the deadline. If possible delays could be noticed earlier, actions could be taken to avoid this. Ambitions to work more proactively, with an evaluation of the process in a preventive perspective was noticed.

## 4.6 Communication at Emtunga

Communication at Emtunga is performed in many different ways, and there is no standardized way to communicate. The interview result shows that communication is done through emails, video calls, phone calls or in person. Emtunga has offices in three different geographic locations, which affect the way of communicating. Fur-

thermore, the way of communicating depends on mainly two points: whom you are communicating with and the purpose of the communication. Some employees strongly prefer email, while others strongly prefer oral communication. An immense advantage of communication through emails is the written documentation of essential decisions or verification of information. It is also easy to reach out with the same information to several people at once. A perceived disadvantage of communication through emails is the large number of emails that are received each day. It is time-consuming to read all of the emails and at the same time be aware of which who contains important information. Important information can also take detours before ending up at the right person.

*"I am not a big fan of emails. I like oral communication. I do not have time to read every email I receive each day"*

The perceived advantage of oral communication is that problems are solved much quicker. This is because questions can be understandable to a higher degree compared to emails. It is also possible to reach out to the right person, and it opens up the opportunity to ask follow-up questions. A disadvantage is that there is no written documentation of what has been decided upon and that people outside the conversation does not know what has been said. However, there are existing action trackers where the important parts of the oral communication can be documented and mediated to employees who need the information. Furthermore, it appears that no communication is done through visual tools at Emtunga.

The general opinion at Emtunga is that communication needs to be more transparent throughout the whole execution process. The interviews show that a lot of work within the engineering disciplines is done in closed environments without transparency, which means that it is hard to follow what other engineering disciplines are working with. This issue is amplified due to the three different locations of the offices. Nevertheless, what is common for all engineering disciplines is that internal communication is more successful than external communication between the engineering disciplines.

*"Daily oral communication in between the engineering disciplines would avoid a lot of complications and delayed internal deliveries"*

An issue that frequently arises during a project is rotation or loss of employees, meaning that information that one employee holds can be stuck or lost if the employee is removed from the project. For example, the information could be own annotations or important emails that can be difficult to transfer to the next responsible employee or DPL. There is no existing tool that enables transparent knowledge transfer, which facilitates these kinds of employee losses. Furthermore, it can also be challenging and time-consuming to include new employees or consultants in a project due to the complicated execution process at Emtunga.

The meeting at Emtunga is an essential part of their execution process. Each engineering discipline works independently to a high degree, and meetings are the main opportunity to share progress, problems, or information with each other. The data collection shows that each engineering discipline usually has an internal meeting once a week where the DPL collect information about status, progress and problems. These are normally performed through video calls due to the different office locations. If needed, the internal meeting can occur more frequently and be demand-driven. Each DPL then mediates this information in a weekly meeting with all the other DPL's together with the project Engineering and procurement manager. This is the primary opportunity to coordinate the project and highlight issues that can affect the time plan. E.g. if an internal delivery from the activity list in the milestone database is missing, this is the main forum where it can be flagged. Despite that, active decisions to solve problems during meetings is not made to a high degree. It often occurs that no specific solution is decided upon during the meeting. A consequence of this is that there is a big responsibility on the affected individual to solve the problem. Being able to solve problems outside meetings is also desired, and there are no tools to facilitate this today except the existing communication channels.

*"Every issue can not be mentioned at each meeting. We need to be able to solve problems in between meetings, employee to employee"*

## 4.7 Interface towards construction and procurement

The interface from the engineering disciplines towards construction at Emtunga is presented as, in its places, somewhat deficient. The most critical problem is that construction does not receive the right information at the right time, making the production time plan challenging to follow with the pre-decided man-hours and resources. The underlying problem for this is that the engineering disciplines and construction have different ideas of what each delivery should include. An output at an engineering discipline can differ from input at construction. E.g., problems can arise when construction notice that the dimension of a drawing is insufficient and needs to be adjusted before being sent to production, but the engineer who delivered the drawing thinks differently. And the further into a project it gets, the more severe does the delays get.

*"The engineers output is not specified, a direct consequence of this is that construction needs to make own decisions within the production process"*

It can be very expensive if the construction has to make post-construction changes because of a preliminary drawing, and the documentation of what has been built would also be incorrect. A lot of production expenditures could be avoided if construction always receives inputs containing sufficient information, an area with a lot of improvement potential. Furthermore, the outcome of each project is different each

time, and it has a lot to do with who works with the project. Thus, the engineering outputs differ from project to project. Every week there is a construction meeting where one representative from each engineering discipline should attend. The production manager is responsible for the meeting, and subjects such as current problems, delayed deliveries, and time plans are handled. It is important that issues are taken care of during these meetings because it could be stressful to solve them during production. Nevertheless, the attendance at these meetings is usually insufficient, and the meeting loses its full potential. Construction sees great improvement potential if the engineers were more present at the production site; issues could then be solved quicker compared with today. E.g., engineers should perform continuous spot-checks on the production, but this rarely occurs. An engineer might deliver a drawing and then moves on to the next one. However, the reality requires close collaboration between construction and engineers to achieve an effective production process. As it is today, construction needs to contact the responsible DPL whenever a problem occurs.

Procurement at Emtunga is satisfied with how the interface with the engineering disciplines are but believes that the communication between the disciplines could be more effective. At procurement, it is customer interactions that influence the most and not the engineering disciplines. The planned purchasing plan can therefore be challenging to follow with late customer changes. However, problems can arise when the engineering disciplines place an order too early for a specific production batch. What could have been a single order can result in five different orders. This is a specific area where communication is very important to avoid such inefficiency. Meetings between procurement and engineering occur on a weekly basis. A procurement order list is generated from the activities that the engineering disciplines have completed. The procurement plan does not always work without complications, and further communication is therefore needed. The communication between procurement and engineering is continuous and occurs daily in between the weekly meetings. A big part of the communication is about the multidisciplinary components. The engineering discipline responsible for the multidisciplinary component should ensure that the other disciplines control the procurement orders correctness. When this is not done correctly, delays in the procurement order will occur. If the procurement order is placed without being checked, it can create terrible issues later in the production process.

*"Multidisciplinary components makes the communication much more challenging"*

## 4.8 Survey

After the completion of the semi-structured interviews, a survey was conducted. A survey with the purpose to validate the findings from the semi-structured interviews and observing the opinions from a larger crowd. The survey consisted of 27 different questions spread over different topics, similar to those in the semi-structured interviews. The target group for the survey were the engineers at Emtunga which are scattered across the departments of *Structural*, *HVAC*, *EIT*, *Architectural*, *Piping*,

*Document control* and *Engineering management*. A total of 24 employees participated and answered the questions. The survey questions had six answer options and were graded from one to six, where one means *Does not agree* and six means *Agree completely*. The total score of each question is thereby created by adding the value of each answer (from one to six). The question with the lowest sum is the question with the lowest score. Figure 4.7 shows a compiled picture of the survey results where the questions with the lowest score are the subjects that performed worst and are the ones in greatest need of improvement. The questionnaire, together with the complete survey result, can be found in Appendix A.2.

Furthermore, three introducing question results are presented below in Figure 4.8, 4.9, and 4.10 to visualise the diversity of the survey.

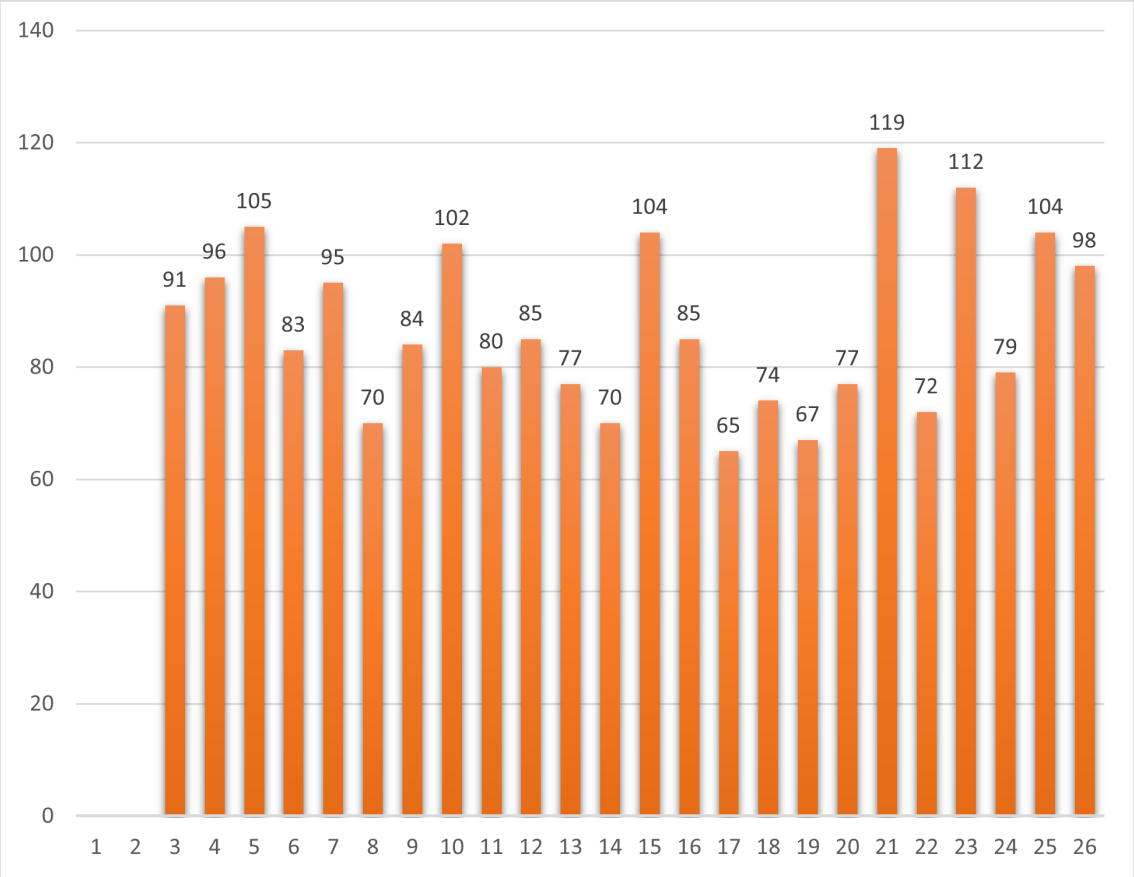


**Figure 4.7:** Scores from the conducted survey

Figure 4.8 displays the distributions of the engineers discipline belongings.

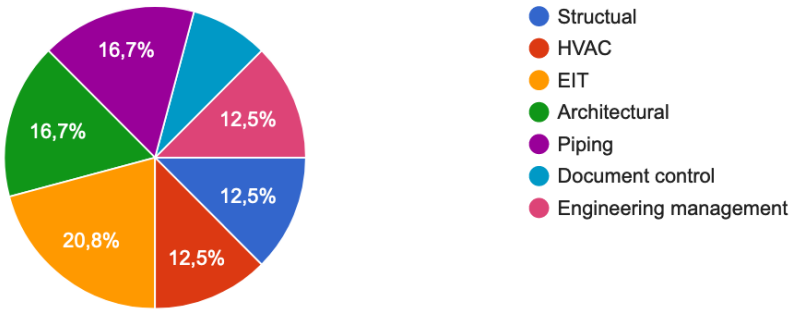


**Figure 4.8:** Question 1, Discipline belonging

The survey shows that 41.7 % of the engineers has over ten years of experience at Emtunga. It also shows that 29.2 % of the engineers have two years of experience or less.

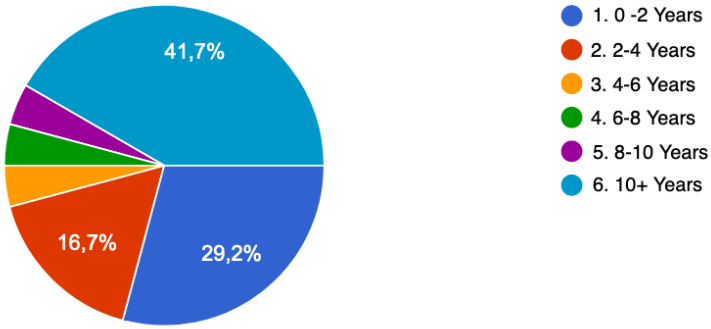


**Figure 4.9:** Question 2, Years of experience at Emtunga

Regarding how well the engineers at Emtunga are knowledgeable about the execution process, 0 % of the engineers answered that they were very knowledgeable, and 54.2 % answered at the lower spectrum. See Figure 4.10.

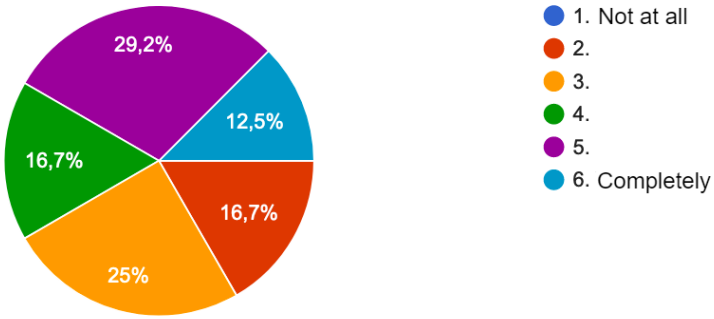


**Figure 4.10:** Question 3, How knowledgeable are you about the current execution process at Emtunga?

### 4.8.1 Survey findings

To clarify the following diagrams, Figure 4.11 shows what answer option is represented of which specific colour. One equals *Does not agree* and six equals *Agree completely.*


**Figure 4.11:** Answer options

The question with the lowest score was question number 17, *"The weighting of activities in EDS, that the time plan is based on, corresponds entirely with reality"*. 79.2 % of the engineers answer at the lower spectrum of the answer options while 0 % thinks that the time weighting of activities fully corresponds to the actual time required, see Figure 4.12. The question with the second-lowest score was question number 19, *"There are well functioning tools to quickly involve new employees/consultants into projects"*. 75 % of the engineer's answers at the lower spectrum of the answers options and zero % fully agree that good tools exist to include consultants and new employees in projects, see Figure 4.13.

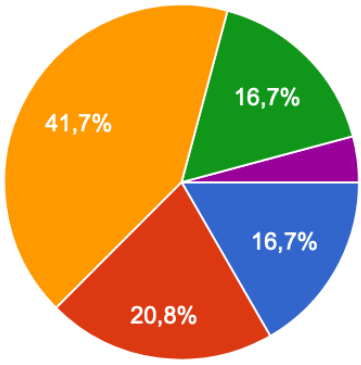


**Figure 4.12:** Question 17, The weighting of activities in EDS, that the time plan is based on, corresponds entirely with reality

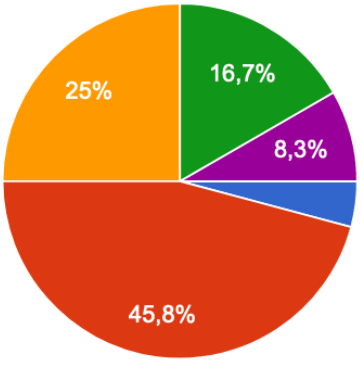


**Figure 4.13:** Question 19, There are well functioning tools to quickly involve new employees/consultants into projects

Questions number 8 and 14 had the same score at 70 points, which was the third-lowest score. Question number 8, *"I am using the activity lists in Milestone DB in EDS in my daily work"* shows that 70.8 % of the engineers answered at the lower

spectrum of the answer options and does not use milestone DB in their daily work, see Figure 4.14. On question number 14, *"It is documented when delays or other problems occur, to prevent that the same issues happens in the future"* does 66.6 % answer at the lower spectrum of the answer options regarding how well delays and problems are documented to avoid and improve this in a future. See Figure 4.15.

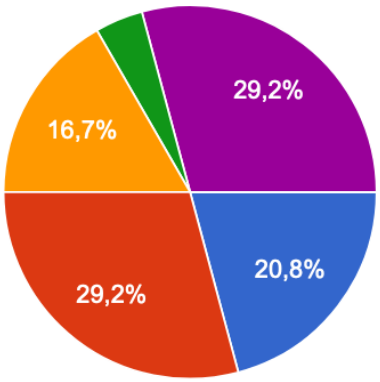


**Figure 4.14:** Question 8, I am using the activity lists in Milestone DB in EDS in my daily work

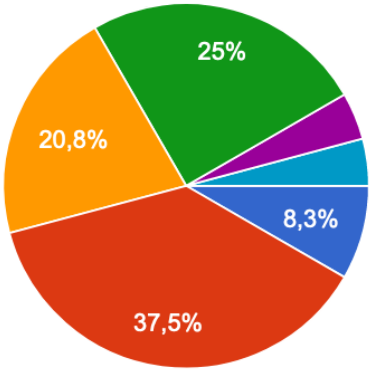


**Figure 4.15:** Question 14, It is documented when delays or other problems occur, to prevent that the same issues happens in the future

Question number 22, *"The communications between disciplines functions well"* had the fifth-lowest score, and 58 % of the engineers answered at the lower spectrum of the answer options regarding how well the communication between the engineering disciplines works, see Figure 4.16. Question 18, *"There are existing continuous improvement routines at Emtunga to evaluate the execution process"* had the sixth-lowest score with 66.7 % of the engineer's answers at the lower spectrum of the answer options, see Figure 4.17.

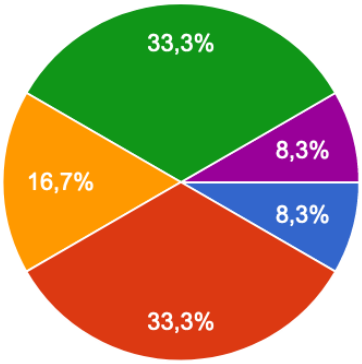


**Figure 4.16:** Question 22, The communications between disciplines functions well

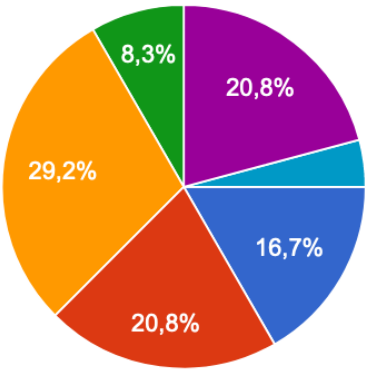


**Figure 4.17:** Question 18, There are existing continuous improvement routines at Emtunga to evaluate the execution process

Question number 13 and 20 had the same score at 77 points and had the seventh-lowest score. Question number 13, *"There are explicit routines how to handle delays of activities and internal deliveries between disciplines"* had 41.7 % of the answers at the lower spectrum, which indicates that there is no tool to handle delayed deliveries between the engineering disciplines, see Figure 4.18. Question number 20, *"There are existing visual tools to support a comprehensive view of the projects. Both how the project plan looks like and continuously updates regarding the project status"* had 54.2 % of the answers at the lower spectrum regarding how well visual tools are used, and supporting current projects, see Figure 4.19.

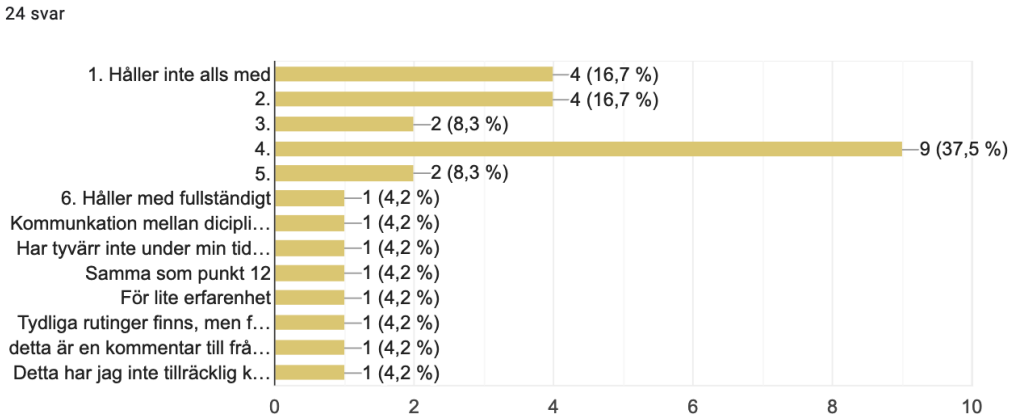


**Figure 4.18:** Question 13, There are explicit routines how to handle delays of activities and internal deliveries between disciplines

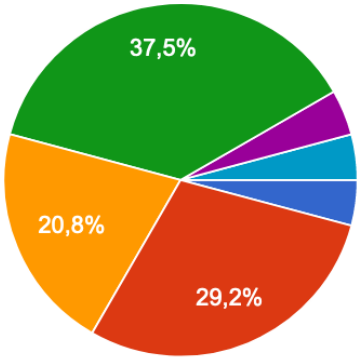


**Figure 4.19:** Question 20, There are existing visual tools to support a comprehensive view of the projects. Both how the project plan looks like and continuously updates regarding the project status

Question number 24, *"Meetings between disciplines occurs continuously"* had the ninth-lowest score with 79 points. 58.3 % of the answers were at the lowest spectrum of the answer opinions regarding if meetings between disciplines occur continuously, see Figure 4.20. The question with the tenth-lowest score was number 11, *"The internal time plan is kept well during projects(activities, internal deliveries and milestones)"* with 80 points, see 4.21. With 45.8 % of the answers was at the

lower spectrum of the answer options regarding if the internal time plan is kept well during projects.

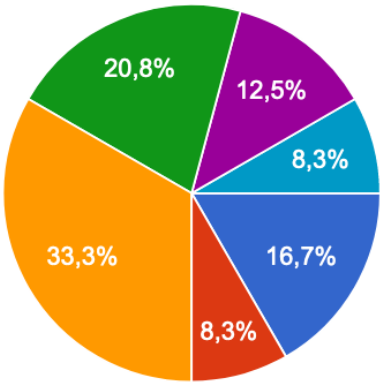


**Figure 4.20:** Question 24, Meetings between disciplines occurs continuously

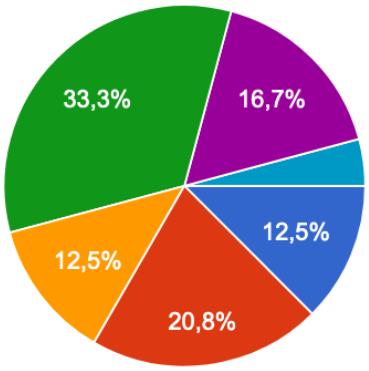


**Figure 4.21:** Question 11, The internal time plan is kept well during projects(activities, internal deliveries and milestones)

# 5
# Analysis and Discussion

In the theory, it was stated that change orders by customer had the most significant impact on the project performance, moreover, slow decision making and communication between design teams had also an immense impact. This was further confirmed in the result from the interviews and survey at the case company. This chapter will further discuss these areas, the effects, and possible solutions.

## 5.1 Communication through visual planning

The current way of communicating at Emtunga differs depending on whom you ask, but there is also a need for various ways of communication due to the three different geographic locations. It is also understandable that some employees prefer written communication over oral communication and vise versa. As stated in the interviews, the benefit of written communication is that important decisions or information can be verified at a later stage, but the downside is the number of emails each day and that the receiver does not know which email is important and which email that is not important. The benefit of oral communication is that problems can be solved much quicker without following misunderstandings due to easy access to a follow-up question. But written documentation of important information and decision can be missing due to oral communication. The interviews also show that the communication between the engineering disciplines is deficient because of too much independent work throughout the disciplines. This makes it difficult to understand how the project is performing in relation to its internal deliveries and time plan, and it appears to be a communication gap regarding this. This communication gap can also be found in the interface towards construction and procurement. Construction experience issues to receive the right information at the right time that enables an efficient construction process. Procurement expressed that the communication between themselves and engineering works well, but that change orders by customers are causing the majority of the problems. Furthermore, there are a low degree of communication through visual tools or visual planning which can make communication more efficient according to Lee and Rojas (2013) and the communication at Emtunga has great improvement potential.

The survey result confirms the apparent communication gap discovered in the interview findings. Survey question 22 with the fifth-lowest score, *"The communications between disciplines functions well"*, support this statement of a communication gap at Emtunga. Survey question 24 had the ninth-lowest score which also confirms that

the engineering disciplines work too independently, *"Meetings between disciplines occurs continuously"*. Survey question 20 which had the seventh-lowest score, *"There are existing visual tools to support a comprehensive view of the projects. Both how the project plan looks like and continuously updates regarding the project status"*, supports the interview findings of a low degree of communication through visual tools and also strengthens the argument of a communication gap.

The effects of Emtungas communication gap between the engineering disciplines, combined with the lack of communication through visual tools, results in a less efficient and flexible execution process. Furthermore, it directly impacts how well the time plan is kept due to it being a primary performance indicator according to Habibi et al. (2019). It will also assist in keeping a project within budget according to Lee and Kim (2018). A visual planning tool would organise information, activities and internal deliveries at the engineering disciplines at Emtunga and support the mutual understanding between them according to Tjell and Bosch-Sijtsema (2015). It also would create a shared view on projects with a common objective according to Catic et al. (2016). Therefore, communication through visual planning could result in a reduced communication gap between the engineering disciplines at Emtunga and make them work more collaborative rather than independently. Problems and issues can thereby be highlighted in an early stage of a project. Previous research by Bertilsson and Wentzel (2015) shows that Yolean is a visual planning tool that the users like, a helpful tool when striving to reach success and that it has great potential to strengthens collaboration within an organisation. At Emtunga, this digital visual planning tool would create a standardised way of confirming important decisions or information regardless of previous oral or written communication, and also creating a place where all the engineering disciplines can access a transparent overview of a project. A tool of this kind would primarily be of value for Emtunga when handling multidisciplinary components, an area that the engineering disciplines expressed as very problematic. Risks that potentially could delay a project or exceed budget, in terms of delayed internal deliveries, misunderstandings of activities, transparency of the engineering discipline work, or critical deadlines regarding multidisciplinary components could be reduced. Moreover, a visual planning tool like this would also benefit the experienced issues at the interface towards construction and procurement. Creating a more transparent platform between the engineering disciplines, procurement and construction. Furthermore, it is important that the engineering disciplines receive knowledge and become comfortable with Yolean to utilise its full potential and avoid resistance according to Bertilsson and Wentzel (2015).

Lack of transparency within Emtungas execution process and communication was frequently mentioned in the interviews. Much work is done in closed environments within the engineering disciplines, making it challenging to acquire a broad, comprehensive overview of the project performance and status. The lack of transparency also creates problems when employees or consultants are rotated or excluded from an ongoing project. Important information can be lost in emails, own annotations or loss of experience. This, together with Emtungas detailed execution process, makes it challenging to involve new employees and consultants in ongoing projects. This is

confirmed by survey question 19 "There are well functioning tools to quickly involve new employees/consultants into projects". The modular EPC projects performed at Emtunga requires the engineering disciplines to handle a lot of information at once, similar to construction projects (Dos Santos et al., 1998). Without the ability to handle much information at once, the project can have a reduced level of efficiency, which is the effect at Emtunga. According to Dos Santos et al. (1998), one way of increasing the transparency would be to implement a visual control. This visual control can, for example, be implemented at Emtunga by introducing visual planning from lean methodology in terms of the visual software tool Yolean.

## 5.2 Continuous improvement

Emtungas current approach towards improving their execution process is performed with *Lessons learned* where they evaluate a finished project and document problem areas to avoid them during the next project. The interviews confirm that similar problems still occur in projects after projects despite the *Lessons learned*. The improvement work at Emtunga is not always sufficient enough to eliminate confirmed deficiencies in their execution process. Moreover, because the *Lessons learned* only are performed after each project, only the major problems are discussed, and the smaller problems are overlooked or neglected. Therefore, it is missing a method that captures the smaller, more specific problems that can be solved during the project. This execution process without continuous improvements contributes to the reactive approach towards problem-solving Emtunga holds today. The interviews also show that these smaller improvements only are made from own initiatives. However, there needs to be a systematic approach that utilizes these improvements and makes own initiatives a natural solution.

The survey results confirm the interview findings of insufficient improvement work. Survey question 18, which had the sixth-lowest score, *"There are existing continuous improvement routines at Emtunga to evaluate the execution process"*, clearly support this statement. Survey question 14 *"It is documented when delays or other problems occur,to prevent that the same issues happens in the future"*, also confirms that problems during the project is not documented enough and that the same problem can occur more than once, which contributes to the reactive approach towards problem-solving. An example of the deficient improvement work at Emtunga can be seen in their weighting of activities which has never been changed or adjusted to suit the changing market with new customer requirements. Survey question 17, *"The weighting of activities in EDS, that the time plan is based on, corresponds entirely with reality"*, with the lowest score of all questions confirms this example of the time weighting of activities not corresponding to reality.

The consequences of an execution process that is not continuous improved combined with a reactive problem-solving approach is an unstable project execution process where small problems constantly are interfering with the engineers daily work and progress. The project's productivity is directly affected, and the execution process at Emtunga would benefit if implementing the continuous improvement strategy

concept from Lean philosophy. The whole organization at Emtunga has to adapt to this strategy to benefit from its full potential (Liker & Franz, 2011), both gaining short-term profits and sustaining them to make a long-term profit and being more competitive (van Aartsengel & Kurtoglu, 2013). Nevertheless, smaller adjustment at Emtunga towards continuous improvement could also result in a more competitive and efficient execution process. By performing continuous improvements, problems at Emtunga can be solved right after they occur, which will reduce the risks of it happening again and reduce time spent on wasteful corrective actions (Liker & Franz, 2011). In other words, transferring Emtungas problem-solving approach from being a reactive approach to being a proactive approach. A medium-sized company such as Emtunga would, according to Terziovski (2001) show positive results of adopting this strategy. More specifically, the result shows that continuous improvement is vital if Emtunga want to archive their strategic goal and objectives. Emtunga needs to adopt its core technologies and organizational objectives to drive new ideas, and monitoring of Emtungas progress using an action plan should be a part of their continuous improvement (Terziovski, 2001). Continuous improvement can be both small improvements suggested by the engineers at Emtunga and performed as a Kaizen event where more immense improvements of the current execution process can be made (Manos, 2007). Nevertheless, the focus should always be to utilize the engineers improvements suggestions, both small and big, in order to always be better and reach development within Emtunga.

## 5.3 Change orders by customer

Change orders by customer are increasing every year at Emtunga in their projects. Customers are changing the product specifications throughout the projects, and Emtunga struggles to handle this type of interference. There are two significant problems noticed regarding change orders by customer. The first one is that there is no room for change orders by customer in the time plan. Time plans are created based on the allocated budget and time from the project purchasing, and then are the hours divided across the activities, based on the weighting in EDS. There is not any buffers or extra allocated hours for change orders by customer. Literally, every change orders by customer of notice disrupt the internal time plan and move the critical path forward in the project. The second problem is to charge the customer for these changes. There is a lack of understanding of the impact these changes have on the execution process, making it hard to charge the customer the right amount. However, there is a thorough understanding at Emtunga that change orders by customer are an area of significant financial potential if it is handled and managed in the right way.

As mentioned, customer change orders affect and obstruct the internal time plan, mainly because the changes are not included in the weighting of activities in the planning process. In the survey, Question 11 *The internal time plan is kept well during projects (activities, internal deliveries and milestones)* and Question 17 *The weighting of activities in EDS, that the time plan is based on, corresponds entirely with reality* had low scores, also indicating this problem.

In the construction industry, over 50 % (many even says that this number is higher) of all projects exceeds budget by a large margin and is exposed to serious delays of time (Habibi et al., 2018). This is a huge number, and there are a variety of reasons for this. Construction project are vulnerable and exposed to several issues, as *Unforeseen ground conditions* and *Poor site management and supervision* (Chan & Kumaraswamy, 1997). However, a reoccurring topic that is often mentioned and seen as one of the most important KPI's, if not even the most important, with great impact on cost and time in EPC projects is *Change orders by customer* (Chan & Kumaraswamy, 1997) (Habibi et al., 2019). This KPI definitely affects Emtunga, and this, unfortunately, results in that the profit margin decreases through the projects. In Emtungas framework, it is stated that General design should be entirely completed before entering the next phase of Area design, though this is not always fulfilled, as an employee stated; *"Late customer changes creates greater impact on the time plan, if the changes could be done in the phase of general design, these changes would have less impact at both budget and deadlines."*. As seen in Figure 3.1, Cost change analysis, the importance of that changes occur in the early stages is highlighted. The cost of changes increases dramatically over time, and meanwhile, the ability to make changes decrease in an equal dramatically manner. Changes that need to occur should in all possible ways be performed in the early stages of the process to enable that the changes can be performed and to reduce the cost effects.

## 5.4 Future development for Emtunga

This case study has evaluated the execution process for engineers at Emtunga Solutions AB, where stated inefficiency was conveyed, and solutions for this has been searched for in corresponding literature. The presented discussion highlights the issued areas at Emtunga, and with proposed improvements, great benefits could be reached. Through the evaluation to find root causes of this inefficiency, it has also resulted in an evaluation of the software tool EDS, more specific the Milestone DB used at Emtunga. The general opinion regarding the software is that it is very powerful and helpful if used correctly. However, it is not always the case, and some other problems aroused. Five main problematic areas were noticed in the interviews regarding the Milestone DB;

- EDS activity lists and progress chart does not always correspond with reality
- Payment progress and working progress are not aligned
- The weighting in the activity lists are in many cases not working as accurate as planned
- High level of detail in activity list
- The required information (input/output) is not always determined in Milestone DB

The survey confirmed the accuracy of the activity weighting that had the lowest score of all questions. The level of detail in the activity list had a reasonably low score, but the expectations were even lower. This could be explained through the interviewed employees' mostly were DPL's, which highlighted the problem of the

detail level when it comes to documenting progress, which only affects the DPL's. Worth mentioning is that the employees seemed satisfied with the execution process and that Milestone DB should have a central role within the organisation. The process is suitable for large, small and pharma projects, according to the employees.

The recommendations for Emtunga will be at two different levels. Firstly, there is the areas of; Visual planning, Continuous improvements and Change orders by customers mentioned in the headings above. Visual planning could easily be solved with software such as Yolean. It will probably greatly affect the transparency between engineering disciplines, procurement, construction, and other involved parties in the projects. Yolean could also solve problems regarding Change orders by the customer; however, these problems are not only due to communications faults. The routines for change orders by customer need to be evaluated and later determined to create a better foundation for handling these interactions in the process. Continuous improvement is needed in the execution process and would solve many problems, from tiny to major ones, within the process. Without a self-critical perspective, it will not be easy to have an accurate and efficient process. An extra recommendation for a company like Emtunga would be to consider the Last planner system, which could create a more predictable process and increase the chances of delivering on time, both internal and to customer.

Secondly, is the more detailed problems found in the in the Milestone DB. If these problems could be inspected and solved, the trustworthiness of the process would increase, and the process would correspond better with reality. Problems as these could in the future be located and removed through the Continuous improvement routines.

# 6
# Conclusion

In this research, the focus was to determine the most critical performance measurements for EPC projects, more precisely within the engineering phase, and how these critical aspects could be handle in a modular construction company with the help of frameworks from the manufacturing industry. It was also further analysed how visual planning and continuous improvement could enable a more efficient and transparent execution process. The significant findings from this research can be summarised in three bullet-points.

**The problematic area of Change orders by customer**
In regards of performance measurements, the most critical was determined to be *Change orders by customer*. Customers interfere more than ever before in projects, which has a severe effect at both cost and time. Changes should always be carried out as early as possible in the process to reduce these effects. However, *Change orders by customer* does not have to be a negative aspect for a company. Suppose the organisation possesses a thorough understanding of how these changes interfere with the process and knows the amount the customer should be charged for it. In that case, it could then instead be an area of great profit-making.

**The possibilities with Visual planning tools**
Furthermore, there are several benefits that a modular construction company operating through EPC projects can withdraw from visual planning that origins from Lean methodology. Visual planning can reduce the communication gap, create a mutual understanding between engineering disciplines, and contribute to a collaborative execution process where inefficiencies due to independent work can be reduced. A digital visual planning tool, such as Yolean, would create the correct prerequisites to benefit visual planning and create a transparent organisational environment. This is important because it contributes to an execution process where engineering disciplines can handle a lot of information and increase the total project efficiency.

**The everlasting importance of Continuous improvement**
An organisation that utilises continuous improvement will contribute to a stable execution process and can benefit from short term and long term profits, and at the same time be more competitive. It creates a natural way of working proactively with the execution process instead of spending time on wasteful corrective actions. The consequences of an execution process that is not continuously improved combined with a reactive problem-solving approach, is an unstable project execution process

where small problems constantly are interfering with the engineers daily work and progress.

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# A

# Appendix

## A.1 Interview

**Time plan**

1. How do you think the project time plan is followed? Give examples
   - What can cause the time plan not to be followed?
   - What could cause the delays?
   - How do you think the weighting of the activities works?

**Execution process**

2. How do you think your project execution process works? Give examples
   - Do you know the five different levels in your execution process?
   - What works well / less well with the execution process?
   - What can be changed to have a more efficient work process?
3. When problems arise that push the critical time line, how are these problems solved? Give examples
4. Is everyone responsible for ensuring that the activity progress in EDS is followed and filled in?
   - How often does it happen?
5. If an activity at level 5 has passed over time, is this documented and if so, how?

**Tools**

6. Describe how you use the process tools in your daily work?
   - If not, why?
7. Does the current process tools feel user-friendly?
   - For example, dependency link between activities?
8. How do you use the visual tools available? Give examples
   - How does time planning in EDS work as a visual tool?

**Communication**

9. How does communication take place within your discipline? Give examples
10. How does communication take place between disciplines? Give examples
11. How and how often does meetings take place internally?
    - Is it enough?
12. How and how often does meetings take place between disciplines?
    - Is it enough?

**Procurement**

13. How does the communication between engineering and procurement function?
14. What happens if you do not receive your deliveries from engineering? Give an example

15. Is it something that does not function well?

**Construction**

16. How does the communication between engineering and Construction function?
17. What happens if you do not receive your deliveries from engineering? Give an example
18. How is the planning of construction evaluated?
19. Is it something that does not function well?

## A.2 Survey

| Number | Score | Question |
|---|---|---|
| 1 | - | Discipline belonging |
| 2 | - | Years of experience at Emtunga |
| 3 | 91 | How knowledgeable are you about the current execution process at Emtunga? |
| 4 | 96 | Im satisfied with the current execution process |
| 5 | 105 | Emtungas execution process functions well for larger projects. |
| 6 | 83 | Emtungas execution process functions well for smaller projects. |
| 7 | 95 | Emtungas execution process would function well for pharma project production. |
| 8 | 70 | Im using the activity lists in Milestone DB in EDS in my daily work. |
| 9 | 84 | Im satisifed with the level of detail of the activity lists. |
| 10 | 102 | The activity lists i Milestone DB should function as a core tool at Emtunga |
| 11 | 80 | The internal time plan is kept well during projects (activities, internal deliveries and milestones). |
| 12 | 85 | There are explicit routines how to handle delays of activities and internal deliveries in my discipline. |
| 13 | 77 | There are explicit routines how to handle delays of activities and internal deliveries between disciplines |
| 14 | 70 | It is documented when delays or other problems occur, to prevent that the same issues happens in the future. |
| 15 | 104 | There are always distinct deadlines in the projects |
| 16 | 85 | That all activities under a single Milstone has the same deadline functions well |
| 17 | 65 | The weighting of activities in EDS, that the time plan is based on, corresponds entirely with reality. |
| 18 | 74 | There are existing continuous improvement routines at Emtunga to evaluate the execution process. |
| 19 | 67 | There are well functioning tools to quickly involve new employees/consultants into projects. |
| 20 | 77 | There are existing visual tools to support a comprehensive view of the projects. Both how the project plan looks like and continuously updates regarding the project status. |
| 21 | 119 | The communications within my discipline functions well |
| 22 | 72 | The communications between disciplines functions well |
| 23 | 112 | Internal meetings within my discipline occurs continuously. |
| 24 | 79 | Meetings between disciplines occurs continuously |

| Number | Score | Question |
|---|---|---|
| 25 | 104 | The communications between my discipline and Procurement functions well |
| 26 | 98 | The communications between my discipline and Construction functions well |
| 27 | - | Do you have any other experience from other executions processes that Emtunga could profit from? |

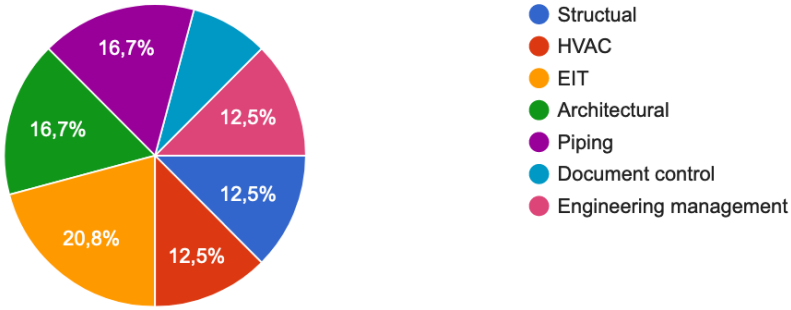


**Figure A.1:** Question 1, Discipline belonging

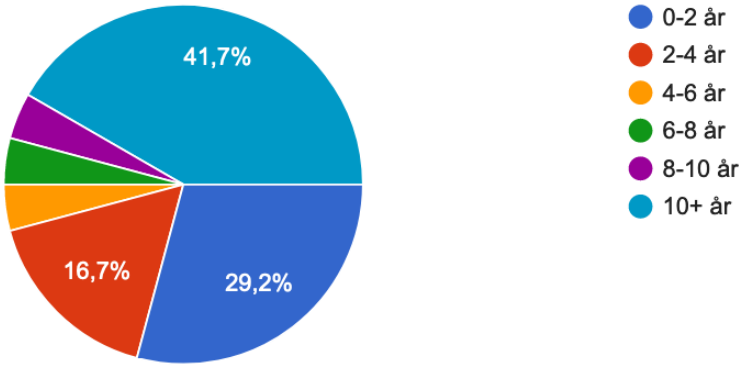


**Figure A.2:** Question 2, Years of experience at Emtunga

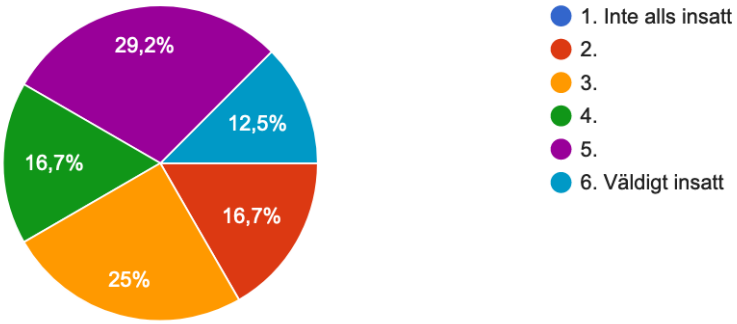


**Figure A.3:** Question 3, How knowledgeable are you about the current execution process at Emtunga?

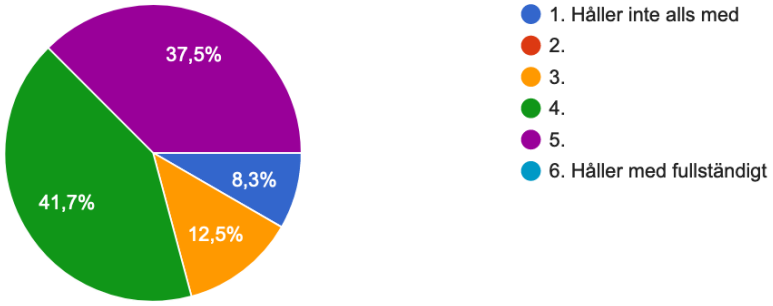


**Figure A.4:** I am satisfied with the current execution process

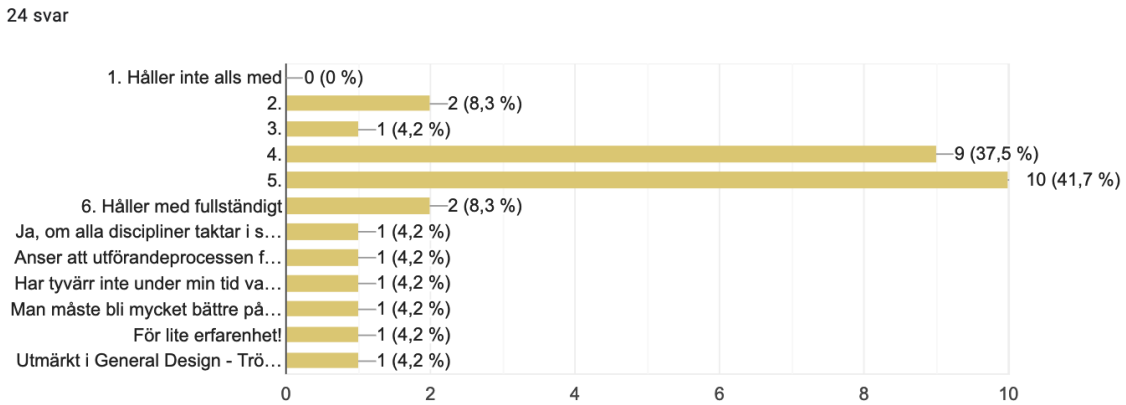


**Figure A.5:** Question 5, Emtungas execution process functions well for larger projects (Options for clarification available)

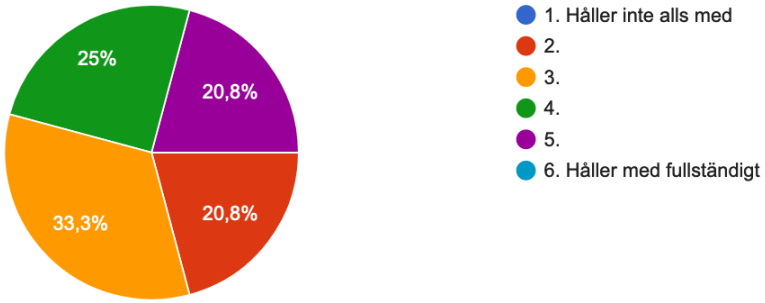


**Figure A.6:** Question 6, Emtungas execution process functions well for smaller projects

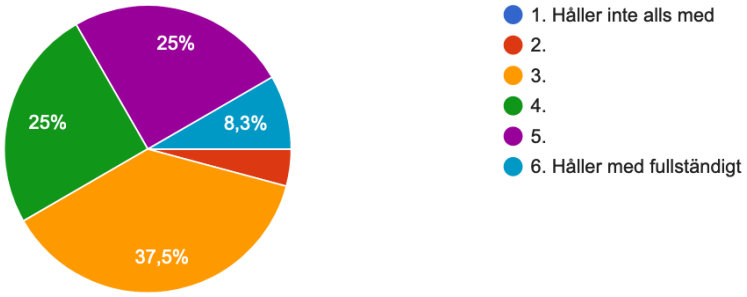


**Figure A.7:** Question 7, Emtungas execution process would function well for pharma project production

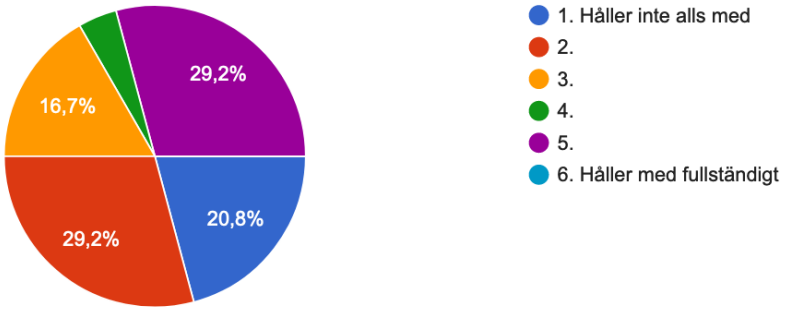


**Figure A.8:** Question 8, I'm using the activity lists in Milestone DB in EDS in my daily work

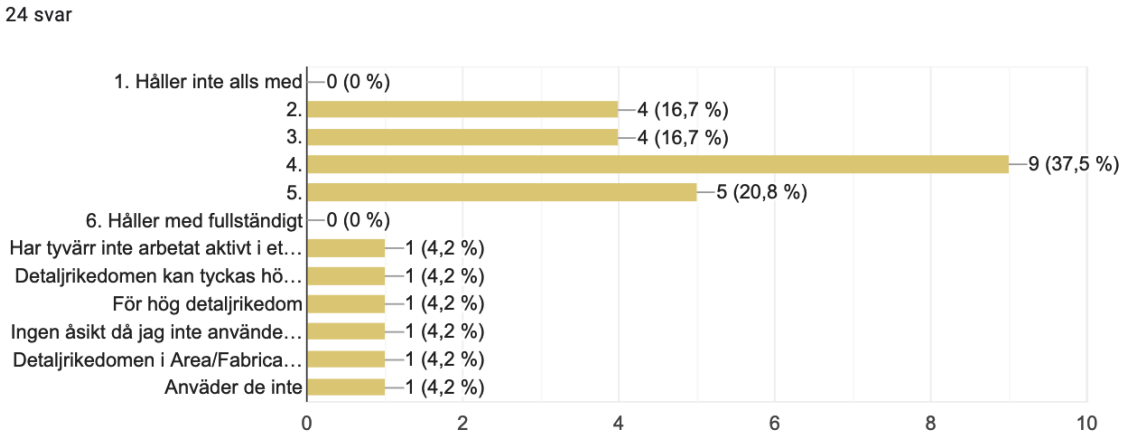


**Figure A.9:** Question 9, I'm satisfied with the level of detail of the activity lists

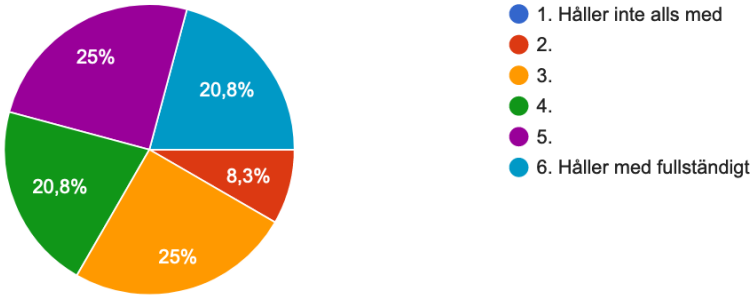


**Figure A.10:** Question 10, The activity lists i Milestone DB should function as a core tool at Emtunga

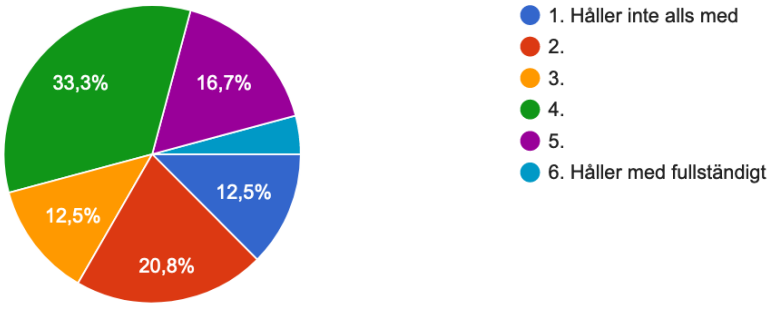


**Figure A.11:** Question 11, The internal time plan is kept well during projects(activities, internal deliveries and milestones)

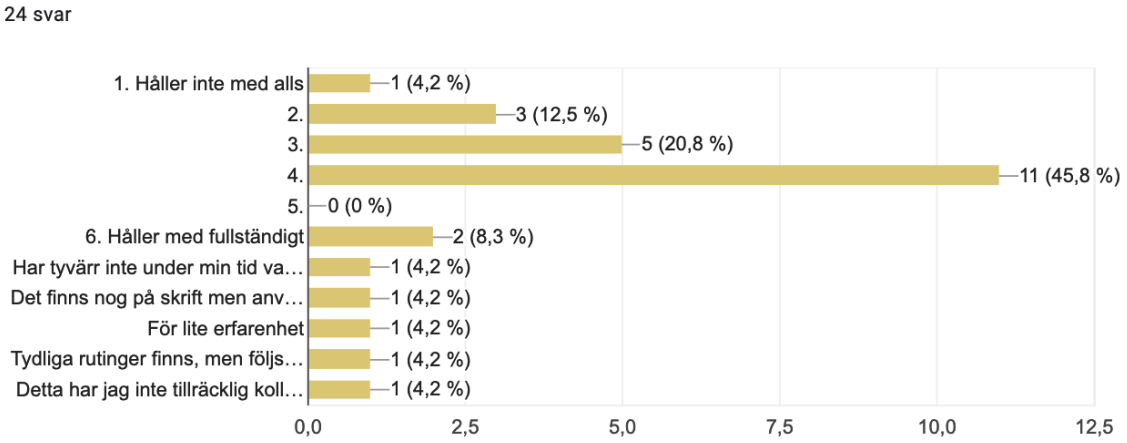


**Figure A.12:** Question 12, There are explicit routines how to handle delays of activities and internal deliveries in my discipline

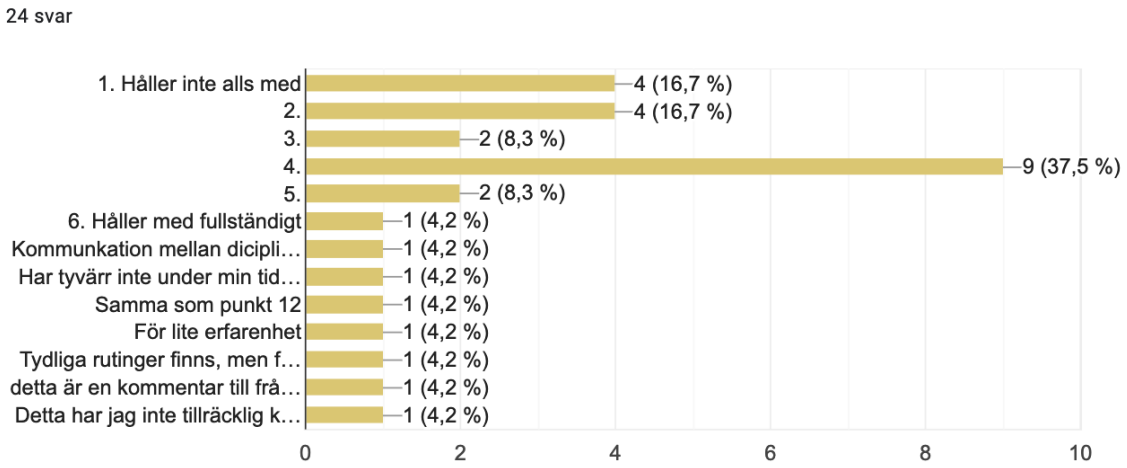


**Figure A.13:** Question 13, There are explicit routines how to handle delays of activities and internal deliveries between disciplines

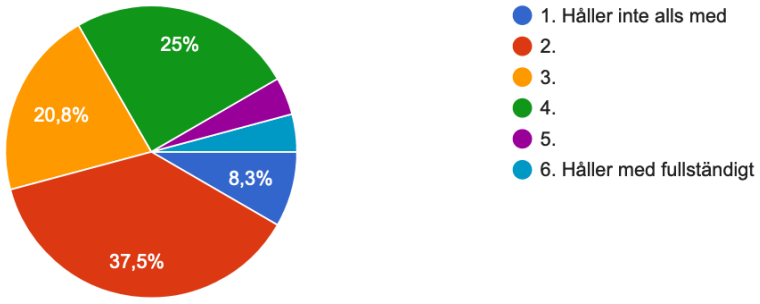


**Figure A.14:** Question 14, It is documented when delays or other problems occur, to prevent that the same issues happens in the future

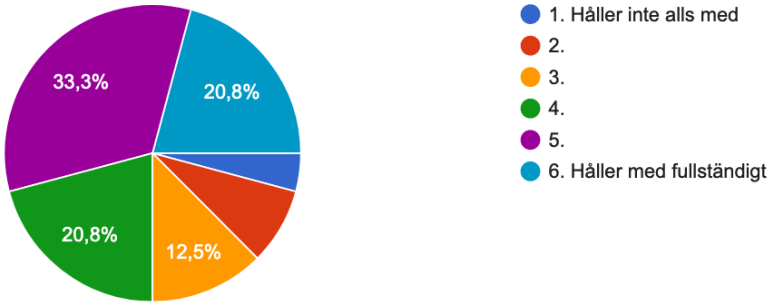


**Figure A.15:** Question 15, There are always distinct deadlines in the projects

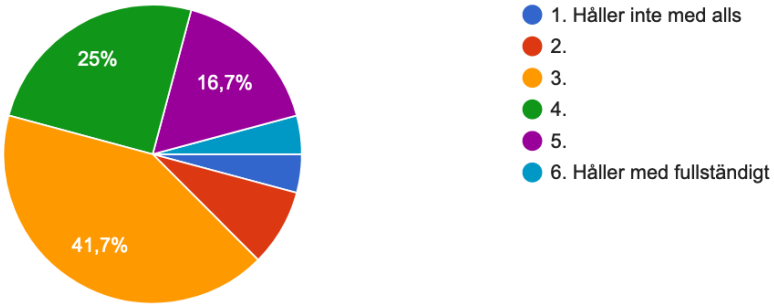


**Figure A.16:** Question 16, That all activities under a single Milstone has the same deadline functions well

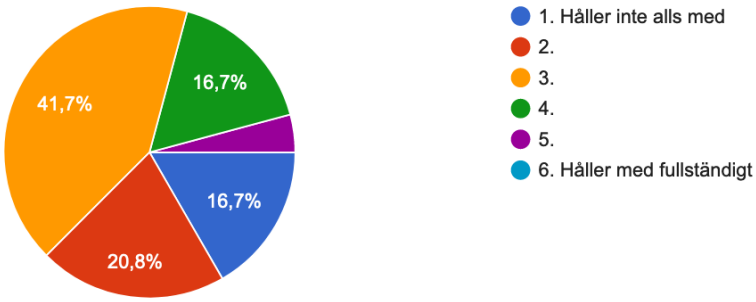


**Figure A.17:** Question 17, The weighting of activities in EDS, that the time plan is based on, corresponds entirely with reality

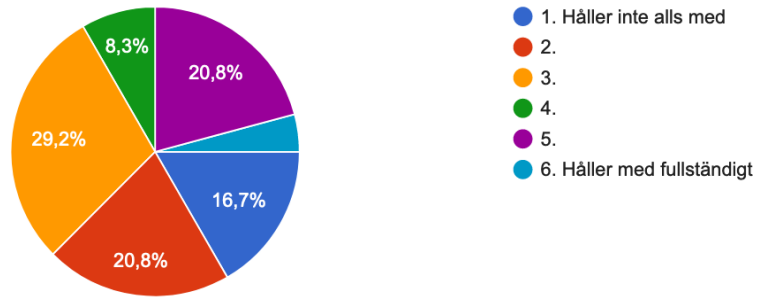


**Figure A.18:** Question 18, There are existing continuous improvement routines at Emtunga to evaluate the execution process

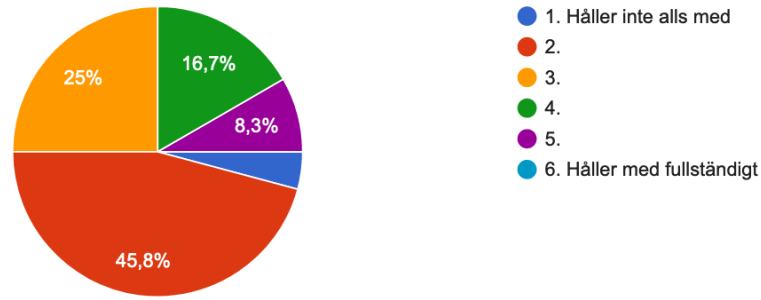


**Figure A.19:** Question 19, There are well functioning tools to quickly involve newemployees/consultants into projects

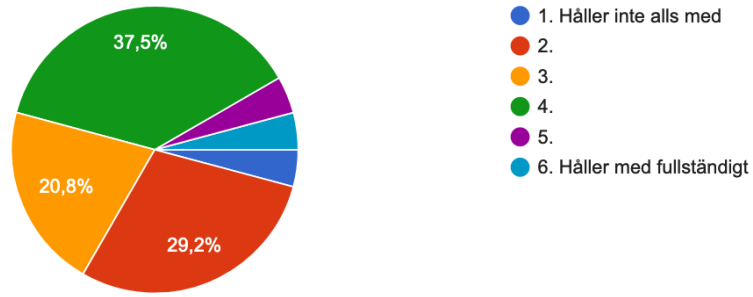


**Figure A.20:** Question 20, There are existing visual tools to support a comprehensive view of the projects. Both how the project plan looks like and continuously updates regarding the project status

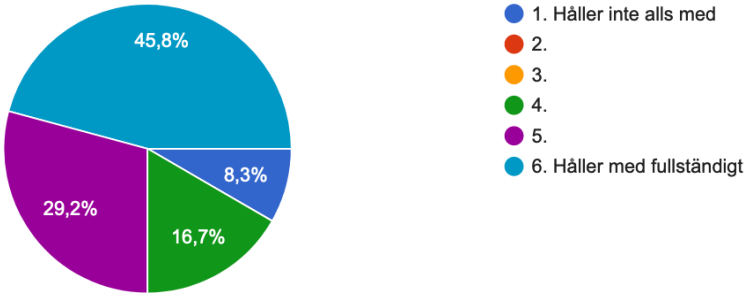


**Figure A.21:** Question 21, The communications within my discipline functions well

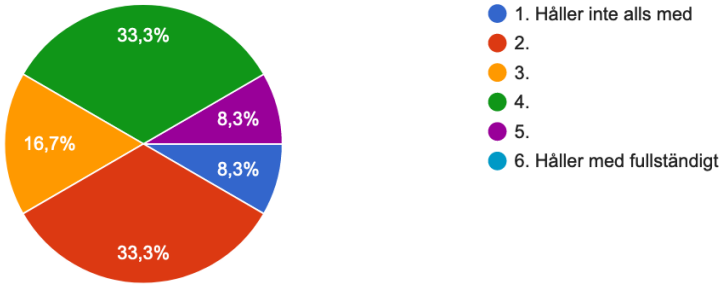


**Figure A.22:** Question 22, The communications between disciplines functions well

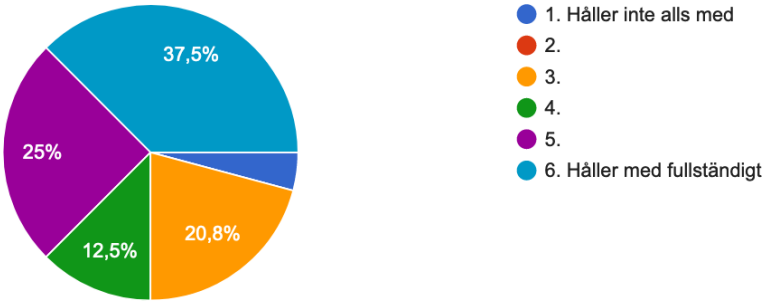


**Figure A.23:** Question 23, Internal meetings within my discipline occurs continuously

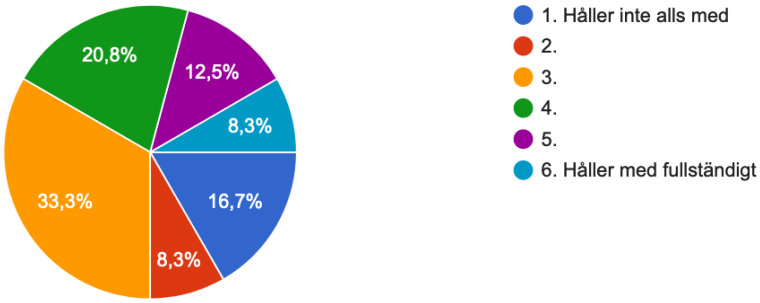


**Figure A.24:** Question 24, Meetings between disciplines occurs continuously

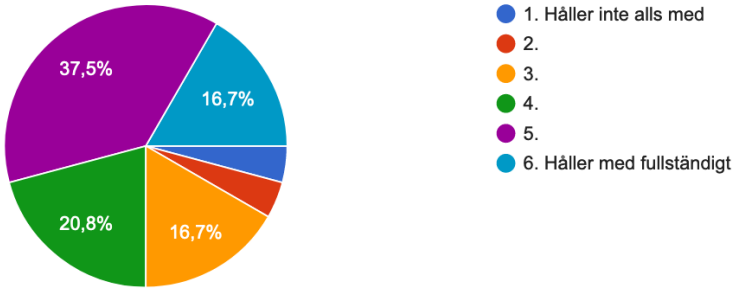


**Figure A.25:** Question 25, The communication between my discipline and Procurement functions well

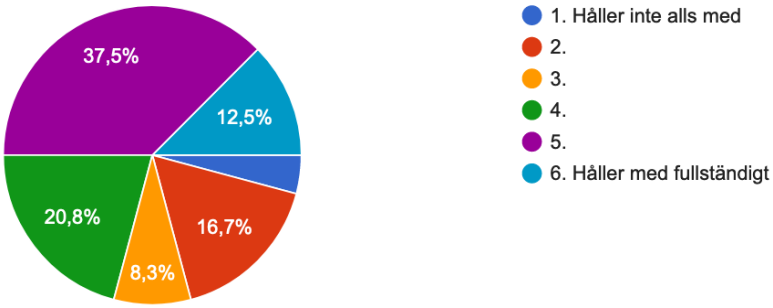


**Figure A.26:** Question 26, The communication between my discipline and Construction functions well

The results from survey question 27 *Do you have any other experience from other executions processes that Emtunga could profit from?*, did not provide any new insights. And no experience from other execution processes were introduced.

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