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Ensuring Quality in a Fast-Paced Engineering World

Defining the Role of the Chief Design Engineer to Continuously Improve a Quality Way of Working

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Master's thesis

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MASTER'S THESIS

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Abstract

This master's thesis was done on a request of the Piping and Layout Management team within Citec to investigate and document current way of working for the Chief Design Engineer.

The primary purpose of this study was to investigate current way of working within the stated team with focus on quality. More specifically the study investigates current design quality levels and deliverables managed by the team and how to continuously improve quality to meet raising customer demands. The secondary purpose focuses on investigating the role of the Chief design engineer to create a first version of a document dedicated to quality. Both purposes have been achieved through this study.

The theoretical framework contains research on leadership, project management, project delivery and project quality. The empirical part of the thesis is based on a qualitative study conducted through interviews with the core team members within the stated team.

The results and conclusions show typical challenges within project leadership, project management and quality management and points out some key deviations between the theory and the current way of working within the stated team. Throughout this study a lot of recommended future work topics were identified, and these recommended future work topics has been collected and handed over to the stated team for future actions.

Language: English

Key words: Project leader, Project management, Quality, Quality management

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EXAMENSARBETE

Författare:	André Lassfolk
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Titel: Att säkerställa kvalité i en hektisk ingenjörsvärld

Datum: 08.06.2023 Sidantal: 66 Bilagor: 2

Abstrakt

Detta examensarbete gjordes på begäran av Piping & Layout Management teamet vid Citec för att undersöka och dokumentera det nuvarande arbetssättet för chefsdesignern (Chief Design Engineer).

Det primära syftet med denna studie var att undersöka nuvarande arbetssätt inom det specificerade teamet med fokus på kvalitet. Mer specifikt undersöker studien nuvarande designkvalitetsnivåer och leveranser som hanteras av teamet och hur man kontinuerligt kan förbättra kvaliteten för att möta kundernas ökande krav. Det sekundära syftet med denna studie var att undersöka rollen som chefsdesigningenjör för att skapa en första version av ett dokument dedikerat till kvalitet. Båda syftena har uppnåtts genom denna studie.

Den teoretiska referensramen innehåller forskning om ledarskap, projektledning, projektleverans och projektkvalitet. Den empiriska delen av avhandlingen bygger på en kvalitativ studie som genomförts genom intervjuer med medlemmar inom det specificerade teamet.

Resultaten och slutsatserna visar typiska problem inom projektledarskaps-, projektlednings-, och kvalitetsledningsfrågor och pekar ut avvikelser mellan teorin och det nuvarande arbetssättet inom det specificerade teamet. Under arbetet med denna studie identifierades många rekommendationer för framtida arbeten, och rekommendationer har samlats in och överlämnats till det specificerade teamet för framtida åtgärder.

Språk: Engelska

Nyckelord: Projektledare, Projektledning, Kvalitet, Kvalitetsledning

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OPINNÄYTETYÖ

Tekijä:	André Lassfolk
Koulutus ja paikkakunta:	Industrial Management and Engineering, Vaasa
Koulutustaso:	Ylempi ammattikorkeakoulututkinto
Ohjaajat:	Mikael Ehrs (Novia) ja Fredrik Lindén (Citec)

Otsikko: Laadun varmistaminen nopeatempoisessa tekniikan maailmassa

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Päivämäärä: 08.06.2023 Sivumäärä: 66 Liitteet: 2

Tiivistelmä

Tämä opinnäytetyö on tehty Citecin Piping & Layout Management -osaston pyynnöstä pääsuunnittelijan (Chief Design Engineer) toimen nykyisen työskentelytavan tutkimiseksi ja dokumentoimiseksi.

Tutkimuksen ensisijaisena tavoitteena oli selvittää nykyinen työskentelytapa Piping & Layout Management -ryhmässä huomioiden laatu. Tarkemmin tutkimus selvittää laatutasot kyseisen ryhmän suunnittelussa ja suunnitteludokumenttien toimituksessa sekä miten laatua voidaan jatkuvasti parantaa asiakkaiden kasvavien tarpeiden täyttämiseksi. Toissijaisena tavoitteena oli tutkia pääsuunnittelijan roolia ja luoda ensimmäinen versio laatuasiakirjasta. Tutkimuksessa saavutettiin molemmat tavoitteet.

Teoreettinen tarkastelu sisältää tutkimusta johtajuudesta sekä hankkeiden hallinnasta, toteutuksesta ja laadusta. Tutkielman empiirinen osuus pohjautuu laadulliseen tutkimukseen, joka on suoritettu haastattelujen muodossa pääsuunnittelijaryhmän ydinjäsenten kanssa.

Tulokset ja johtopäätökset viittaavat hankejohtajille, hankehallinnalle ja laadunhallinnalle tyypillisiin haasteihin, mutta ne myös paljastavat keskeisiä poikkeamia ryhmän nykyisen työskentelytavan ja teorian välillä. Tutkielman puitteissa tunnistettiin useita suositeltavia tulevaisuuden kehityskohteita, jotka on koottu yhteen ja toimitettu kyseiselle ryhmälle jatkotoimenpiteitä varten.

Kieli: Englanti

Avainsanat: Hankejohtaja, hankehallinta, laatu, laadunhallinta

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Preface

I would like to thank Citec for the opportunity to do this master's thesis. It has been an informative and educational opportunity filled with lots of new experiences.

Special thanks to my supervisors, Mikael Ehrs and Fredrik Lindén, who have given me a lot of valuable information and feedback throughout this thesis.

Thanks to my colleagues, the team, who happily assisted me by participating in the study and the many educational discussions that has occurred throughout this thesis.

Finally, I want to thank everyone who has assisted and encouraged me throughout his thesis in any way. Without your support, I would not have been able to complete it.

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Abbreviations

BIM	Building Information Modelling
CDE	Chief Design Engineer
CEO	Chief Executive Officer
LNG	Liquid Natural Gas
LOD	Level of Detail
UK	United Kingdom
USA	United States of America

1. Introduction

This chapter focuses on getting an overall understanding of the study. Firstly, a short presentation of the target company is presented to get an overall understanding of the environment to the problem formulation, then the problem formulation, main and secondary purposes are defined, and lastly the overall disposition of the study is presented.

1.1. Citec

Citec is an engineering and consulting company with its headquarters in Vaasa, Finland. Citec employs approximately 1 000 experts located in six countries and has a portfolio of over 10 000 projects and 1 000 powerplant design solutions delivered to approximately 120 countries. [1]

Figure 1: Citec's logo **[2]**

Citec, initially called Tri-Technic, was founded in 1984 by Rune Westergård and Rolf Berg in Vaasa and has grown steadily over the last 38 years. Citec has undergone several iterations acquiring new business areas while increasing the workforce over the years. Some examples are when Tri-tec changed name to Citec in 1994, when Wärtsilä outsourced the plant engineering to Citec in 2003, when Citec engineering was established in India in 2004 and when Sentica partners became the major shareholder in 2011. There are many more examples which can be seen in Figure 2, which is a summarized graph of Citec's history. [2] Missing from the graph below, Cyient completed the acquisition of Citec in 2022 and the integration process will most likely be finalized during 2023.

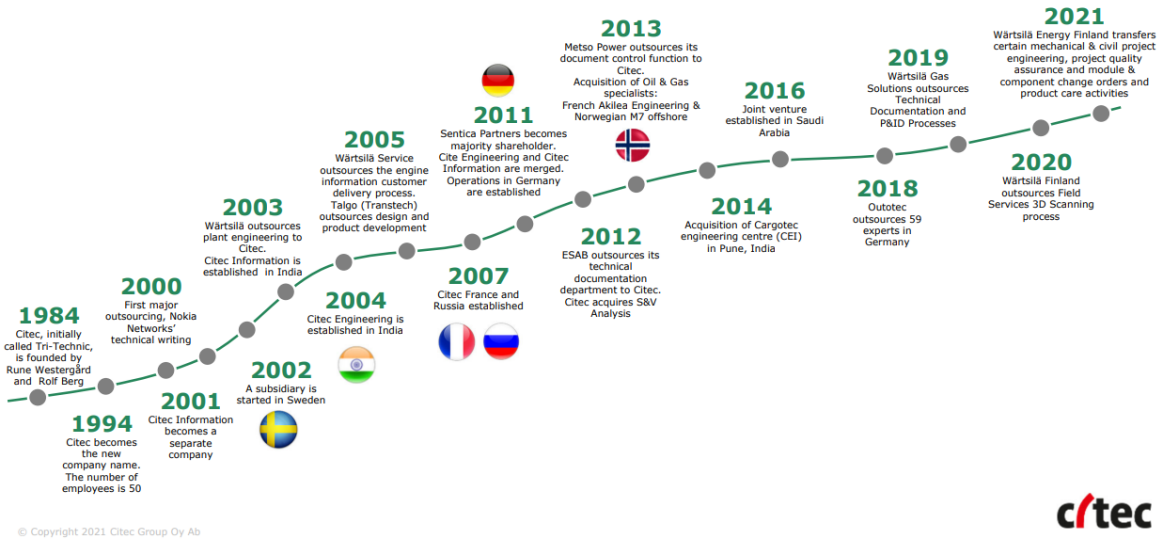

Figure 2: Citec's history timeline **[2]**

Citec's offering consists of several subcategories. The major categories are process engineering, piping and layout engineering, electrical engineering, instrumentation and automation engineering, civil and structural engineering, product and mechanical engineering, plant safety, technical documentation, project management and project engineering. The subcategories can be summarized into five major categories: Plant engineering, product engineering, engineering consultancy, technical documentation and digital solutions. Citec works within four key sectors: Energy and industry, process industry, oil and gas, machinery and equipment. [3]

Figure 3: Citec's key sectors **[3]**

Citec has also for many years focused on environmental and sustainability solutions, as Citec is working with projects within LNG, carbon capture, carbon storage, solar, hydrogen and waste to energy. Some examples are a multi discipline LNG terminal in Finland, heat storage for Vaskiluodon Voima in Finland and a biomass powerplant in Germany. [4]

1.2. Thesis specification

The thesis is done on a request of the piping and layout management team within Citec to investigate and document the current way of working for the chief design engineer (CDE) and how to continuously improve these to meet raising customer demands.

1.3. Problem formulation

During recent years, stress on engineering employees is constantly increasing, with many practises more than often requiring attention close to around the clock and answers are always urgently needed. With more stress, quality is often hit the hardest when everyone does their best to ensure deadlines, which will ultimately affect all parties in ongoing projects.

The aim of the study is to study the responsibilities of a typical CDE to better define what needs to be done to ensure that the correct quality can be maintained during the right phase in any project. The study focuses especially on when quality could be affected due to time constraints with the trend of a fast-paced engineering praxis.

The current learning method for the investigated CDE role is a learning by doing style approach. After a while one catch on what needs to be done but having to go through that process as a fresh CDE can be a challenging experience. It typically takes several years for a fresh CDE to feel in control. One can learn the basics of the project management part quite fast, but due to a big portfolio, the mechanical design expertise takes years to learn. The projects themselves are also typically long, ranging from a few months up to several years, so the experience is gathered over an exceptionally extended period of time, hence the constant need of assistance from other CDEs during the first years and mentors for first projects.

1.4. Purposes

The main purpose of this thesis was to investigate and clarify the role of the CDEs in the specified team regarding current way of working with primary focus on quality and how to continuously improve the quality levels to meet raising customer demands. The secondary purpose focuses on investigating the role of the CDE to create a first version of a document dedicated to quality. Both purposes have been achieved through this study. Additionally, intro material on how to introduce new team members to the team's normal way of working will be developed, to ease the overwhelming amount of information available for a new CDE.

1.5. Thesis limitations

Due to the sheer organisation size of Citec and Cyient, this thesis and all its material, will only be targeted for the CDEs in the piping project and management team.

1.6. Disposition

These are the chapters included in this thesis and shortly what they contain.

- Chapter 1:

  Gives a general introduction of the master thesis and its limitations.
- Chapter 2

  Presents the theory used throughout the thesis.
- Chapter 3

  Gives an understanding to why the used research method was chosen.
- Chapter 4

  Presents the result from the conducted interviews.
- Chapter 5

  Presents the conclusions derived from the result.
- Chapter 6

  Presents the recommended future work to the team which is in focus of the study.
- Chapter 7

  Discusses the credibility of the thesis and general thoughts about the results and conclusions.

2. Theory

The theory introduces the key subjects which are relevant to this study. Firstly the theoretical framework presents some background information on the studied role and the theory behind the role. That is theory on leadership, team leaders, projects and engineering projects in general. Secondly, the theoretical framework explores the relevant parts of project management, which in this case is the frameworks of project management actions, how project management tasks should be managed and key information on project delivery. Lastly the framework focuses on quality management related to the study, which are: quality control in projects, quality management and typical project management systems.

2.1. Theory introduction

Throughout history, mankind has sought to increase efficiency of everything that can be optimised. In that perspective, the concept of engineering "The activity of applying scientific knowledge to the design, building and control of machines, roads, bridges, electrical equipment, etc." [5] has existed since ancient times.

Even complex engineering was no exception in ancient civilisations. For example, the underground churches in Ethiopia, Mohenjo Daro, Leshan Giant Buddha, Saksaywaman, Teotihuacan, Chand Baori and El Mirador are only some of all highly advanced engineering achievements that has until more recent years only been speculated on how they could have been achieved. [6]

The biggest difference one could assume between modern and ancient engineers is most likely time. Time to do something controlled and with the time to focus solely on one problem at a time. The sheer amount of time needed to complete the huge engineering tasks mentioned could have taken up to several decades to complete. Today, on the other hand, many engineers face strict time schedules on multiple complex overlapping projects which all typically have its own engineering challenges. It is also commonly understood that many engineers are available more or less constantly due to the online availability with today's working culture.

Whether or not today's engineering projects ends up as an engineering wonder like Burj Khalifa [7], there are also many engineering projects which has been engineering disasters during the modern engineering era. For example, the nuclear plant explosion in Chernobyl, the collapse of the Charles De Gaulle Airport terminal and the space shuttle Columbia explosion, are just a few incidents that often are referred to as engineering disasters. [8] While all engineering disasters have their explanations on why something has failed, one could always argue over the term, quality. Were the quality levels good enough? What quality standard was used? Were all quality checks performed? and so on. So in that aspect, quality surrounds everything in the engineering world. Everything needs to keep an excellent quality level to ensure a smooth and successful project, even after it is handed over to the end customer. But the biggest question is not how to ensure excellent quality, but how to efficiently do it every single time throughout every single project and even under pressure by budgets and time limits. That is the engineering wonder that all engineers strive for.

2.2. The Chief Design Engineer

The CDE has a key role in all engineering projects within Citec. The CDE holds a project lead position, responsible for all design done within a discipline area, in this case, mechanical engineering.

2.2.1. The Chief Design Engineer in the organisational structure

The CDE works within a typical line organisation structure. However, the daily work hierarchy can be thought of as crossover structures based on project teams. So officially it is a line organisation structure, while in reality it is more a split of a process and a line organisation structure.

The processes are per project, so the process group is seldom identical, which gives some minor complications in the beginning of projects but usually works well. The size of the project often decides the size of the processes and then the people selected for said process are selected on availability. The reasoning for these processes is simple, the projects are long (a few months up to a few years) and the process group is an effective way to create a stable and on time progressing project.

In Figure 4 one can see a simplified and generalised organisation structure of the CDE's position at Citec.

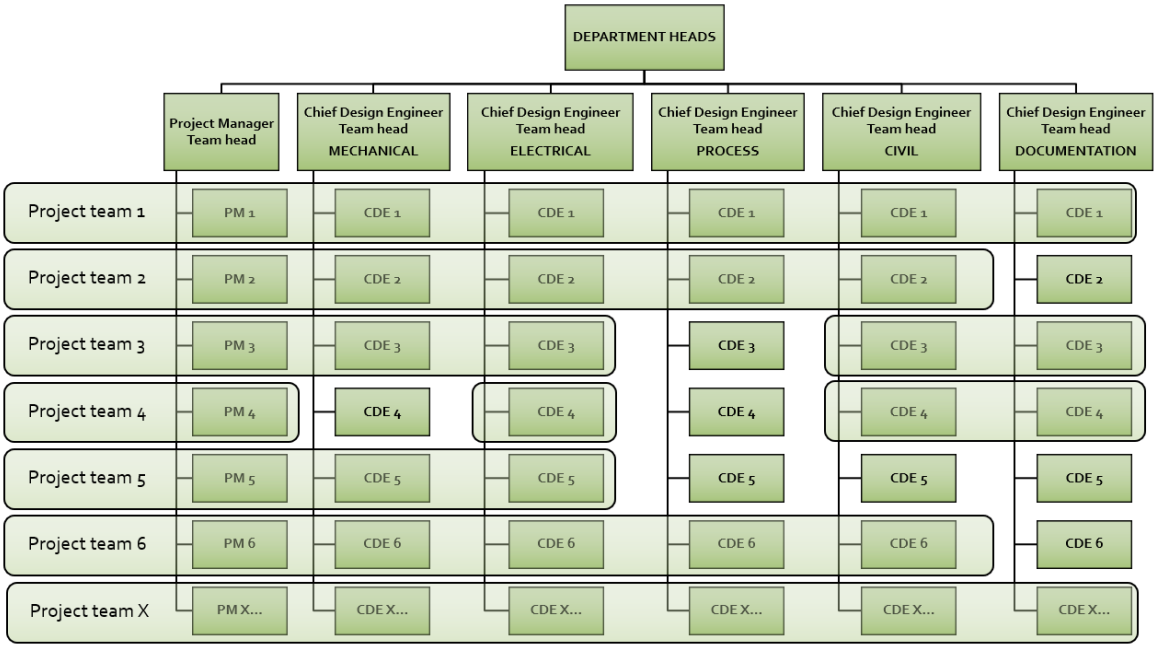

Figure 4: Organisation structure – Project teams as process in a line organisation **[9]**

2.2.2. What is a project?

Everyone knows the word "project", but many do not understand the full meaning of said word. Often there is confusion about what is and what is not a project, as well as the nature of project management. By definition a project is limited by time, it must have a start and an end. A project also typically requires human resources in the form of effort or time, or both, and often, an investment, in the form of capital resources. Frequently, projects also combine diverse expertise areas and experts together to work on projects alongside partners they have never worked with before. [10]

Two additional definitions that are especially important when discussing projects are project manager and project leader, terms that are often misused. A project manager has the role to focus on managerial responsibilities of the project, while the project leader is not a title, but a set of specific skills or mindset. It is for a fact that for every project to be successful, there is mix needed of both project managers and project leaders. [10]

In this study, the studied role, the CDE holds a project leader role. And is one of the key contributors to projects success within the studied organisation. Both, which are topics that will be presented more in depth throughout this thesis.

Projects also needs to be classified, and the range of project scopes are huge, so typically projects should be analysed before start. According to Antonio Nieto-Rodriguez which is known as the world's leading champion of project management and strategy implementation, one should categorize projects in two major areas, complexity and uncertainty, which then have a few sub criteria's: [10]

- Complexity
    - Size (How large is the project?)
    - Scope (how many features?)
    - Stakeholders (How many stakeholders?)
    - Alignment (Stakeholders agreement on relevance)
- Uncertainty
    - Novelty (has something similar been done before?)
    - Experience (needed expertise for the project available?)
    - Charity (How certain about scope?)
    - Budget (Budget and resourcing check)

Using the specified criteria's one can then analyse and classify projects. One typology that fits these specified criteria's perfectly is the three project types specified by Clayton Christensen; Efficiency-, Sustaining- and Transformative projects: [10]

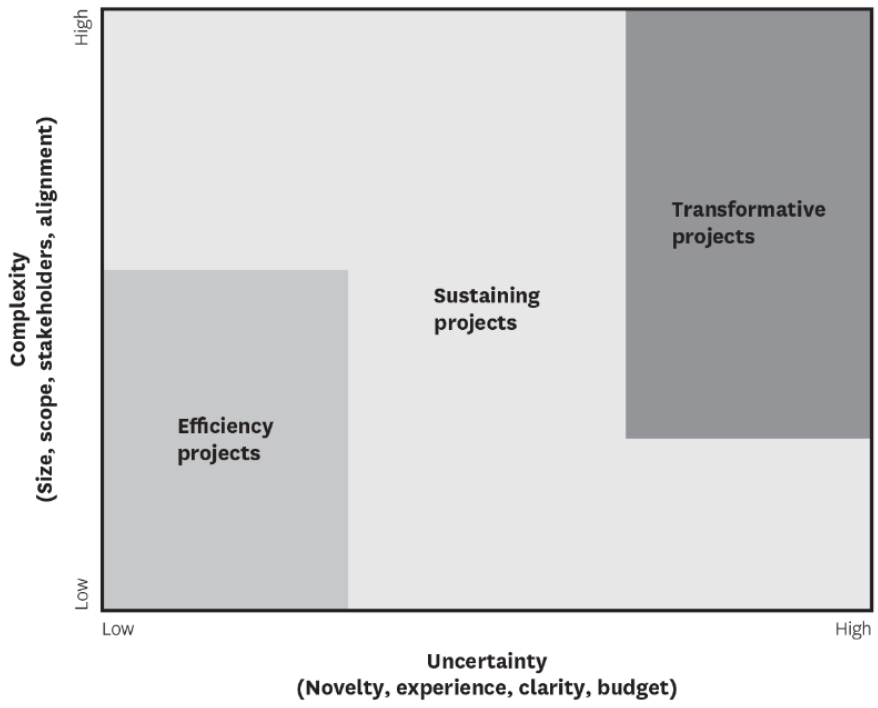

Figure 5: Project typologies **[10]**

Simplified definitions of the typologies can be summarised as: [10]

- Efficiency projects: keeping the organisation running efficiently.
- Sustaining projects: Expanding and investing in areas outside of the core business.
- Transformative projects: Radical innovations of the future.

This is now only a general overview of what is and what is not a project, and it is just a fraction of what exists in the realm of the word “projects”. [10] But the definition of the word “project” fits well with the day-to-day work for the studied team, as they typically deal with project classifications, however they do not deal with just any type of projects but more specifically, engineering projects.

2.2.3. Engineering projects

If one then further specifies the word projects as the phrase engineering projects, one can look at the definition a little more in depth. While the phrase “engineering projects” is not a technical term, it can refer to three different things. [11]

The first meaning for engineering projects is simply the general definition of projects where engineering plays a role. These types of projects do not follow any form of engineering design process. A good example is science projects which when completed give some information about the engineering theory but are not useful for engineering praxis. [11]

The second meaning for engineering projects is basically the same as the first, with the exception that the projects also use an engineering design process. To understand the full difference between the first and the second meaning we will also have to look at the differences between the scientific and the design process approach for engineering projects. The scientific approach most often involves research questions that can be answered using engineering theory by investigating the research problem using techniques to collect and interpret data. The design process on the other hand focuses more on the definition of the need, background research, design criteria’s and presenting a workable solution. Simply put, the scientific approach answers questions and the engineering process fulfils needed requirements. [11]

The third meaning of engineering projects continues on both the first and the second meaning. That is, incorporating the engineering process and focusing on meeting needed requirements to which implementing engineering qualifications are also added. [11]

All references to projects mentioned in this thesis is to be considered as the third meaning of engineering projects. The team in focus of this thesis works exclusively on engineering projects where the design process is considered. Furthermore, the kind of projects executed by the team is always considering all country specific engineering qualifications, as the team works on a global level. This team is a major contributor to the 1 000 powerplant design solutions delivered to the approximately 120 countries mentioned in chapter 1.1.

2.2.4. Chief Design Engineer - A project leader

A project team within Citec is typically organised so that there is one project manager which all project leaders report to. The CDE as stated in chapter 2.2, holds this kind of position. One exception must be added to this statement: If the project is a pure single scope project, for example only mechanical deliverables, then in that specific case, the CDE will also typically hold the project management role. Below in Figure 6 one can see a typical and generalised hierarchy of a typical project team within Citec.

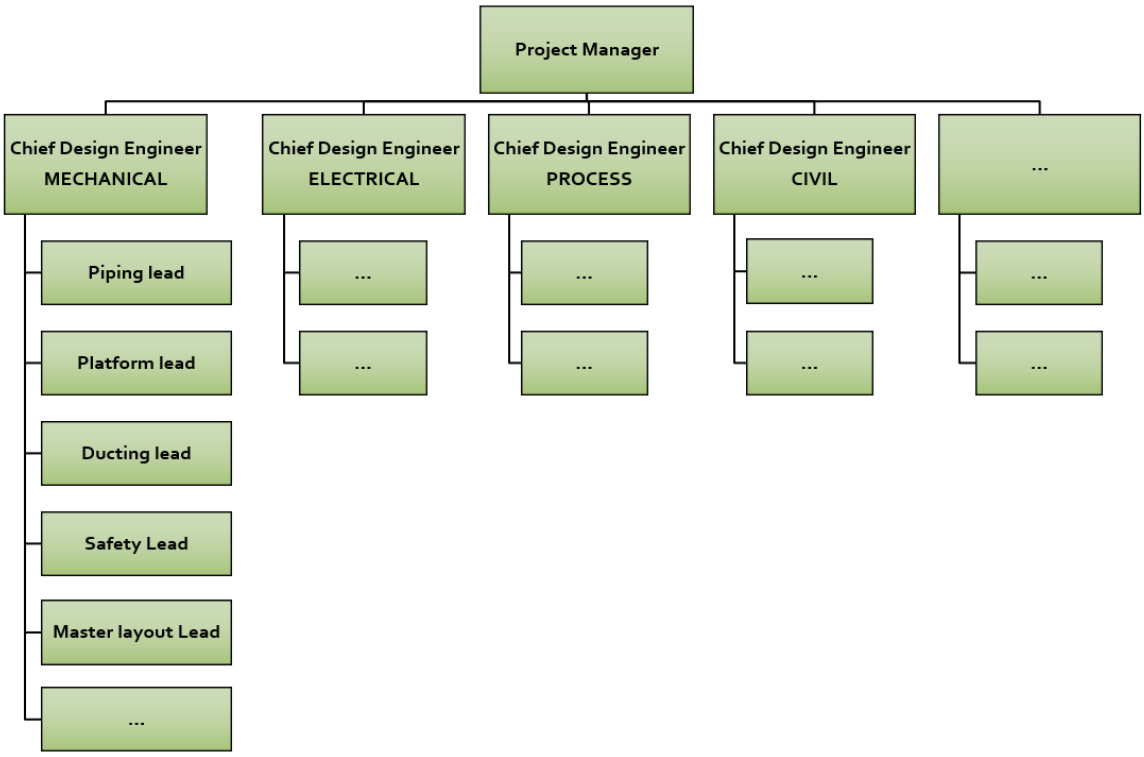

Figure 6: CDEs role in a typical engineering project within Citec **[9]**

One could state that the above figure fits perfectly with generalised project management structures, one such typical example can be seen in Figure 7.

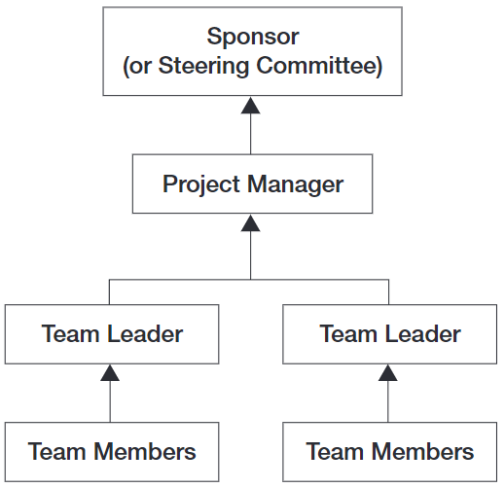

Figure 7: A typical project management structure **[12]**

While the team leader, in this study referred to as project leader, does not typically hold any managerial position, they still must manage their resources efficiently.

According to writer Richard Luecke, the project leader is usually associated with team-based work and should therefore be careful not to boss around their resources. According to Luecke there are also five important roles of the project leader: Initiator, model, negotiator, listener and coach. [12]

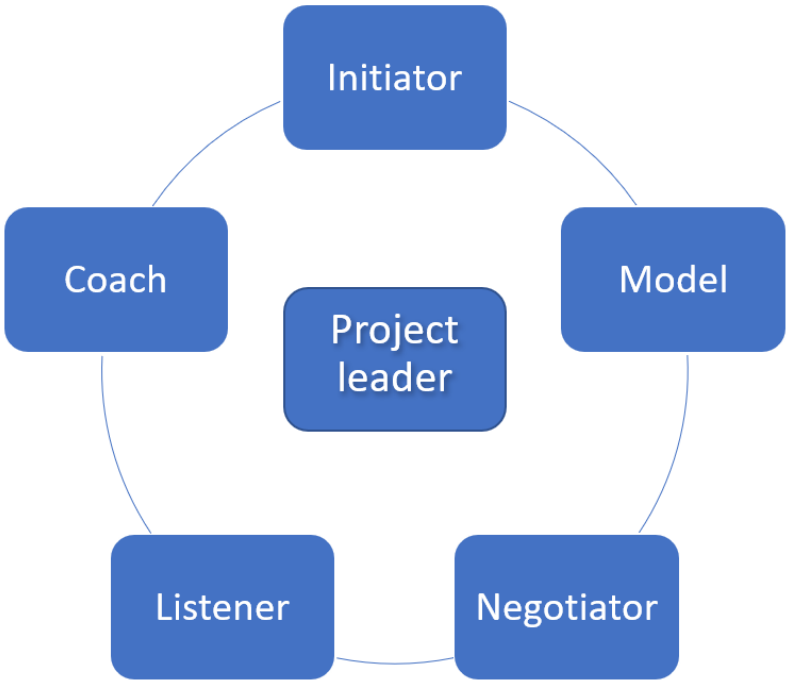

Figure 8: Project leader roles **[9] [12]**

Project leader as an **initiator**: Quite obviously project leaders must initiate actions needed for the project to progress. They should not micromanage their resources actions but focus on drawing attention to needed tasks to meet the project goals and targets. The project leader is in a naturally position to do this, as they typically are distanced to the day-to-day work of their resources. It is a position which allows connections between the project manager and higher objectives while the resources are deeply focused on single design tasks and problem solving. The project leader can then focus on the expectations for the outcome, steer resources into the next big objective or expectations. By using evidence and rational arguments the leader can influence the resources to achieve this. This is an important function, as sometimes the expectations of the project conflict with the expectations of the individual team members. [12] According to writers Sebastian Nokes and Sean Kelly, a phase of a project that is badly initiated is in considerable risk of creating extra costs and in worst case scenarios the starting point of imminent failure of a project. A project needs a clear idea of what is being done and when. [13] The above-mentioned shows how important the project leader, in this case the CDE is, which holds the initiator role in all projects for their set scope.

Project leader as a **model**: Project leaders can influence their resources behaviour and performance based on their own behaviour in project teams. The greatest difference between project leaders and traditional managers is that project leaders cannot rely on compensation, promotions or threats to influence team members. Model behaviour by the project leader is thus a powerful tool. It sets a standard that others will mirror to avoid feeling inefficient or petty. [12] This fits well with the general ideology to lead by example. Out of the many theories, Brian Tracy, a well-known motivational speaker and self-development author indicates that excellent project leaders set a high standard; they lead by example. They always function as though everyone is looking, even when no one is, since they consider themselves as role models for other people and want to carry themselves accordingly. [14] This overall ideology is in line with the day-to-day role that a typical CDE holds, as they are typically expected to lead by example in any project towards both the customer and internally.

Project leader as a **negotiator**: Project leaders often need to negotiate things over the course of a project, whether it is re-negotiating deadlines or just internally getting resources to the needed tasks which have varying difficulties. For effective leadership, the

project leaders need to recognise that not all can use the best performing resources in all projects but should of course negotiate to use them when needed. As a project leader one should emphasise the goal of the organisation and how the work can contribute to them and by emphasising the benefit of other parties helping in the project and how it will contribute to their success. To efficiently negotiate as a project leader, they should always present themselves as trustworthy, dependable and have realistic mutual benefits. [12] It is no surprise that the CDE must manage negotiation tasks, as according to this theory, CDE's mostly deal with resource management and negotiations with customers regarding time schedules.

Project leader as a **listener**: Project leaders should spend as much time listening as talking, because listening to the resources has many benefits. Everything from signals about incoming problems, discontent and gain opportunities. But the main benefit is that the resources will then be used to their full potential as they provide knowledge and insights that otherwise would not have been used. The resources will also be more encouraged when working with a project leader which listens to them. Project leaders that listen well, also tends to also act on the actions gathered from the resources through listening. [12] This topic relates well to coaching as there is a need for a two-way communication for this approach to be fully utilised and requires actively listening from the Chief designer to give the other person a feeling of full commitment and to avoid misunderstandings. [15] Using the resources knowledge by listening and acting on proposed solutions is also directly easing the workload of the Chief designer, as the resources, i.e. the experts in their specific area should have better ideas of current design solutions than the CDE, the project leader.

Project leader as a **coach**: Project leaders should find ways to help their resources excel, and this is typically done through coaching. And as mentioned, coaching is a two-way communication where both parties share their knowledge and expertise to achieve the set goal. Good project leaders should find coaching in their daily workday routine. A good practical example is when team members need a particular skill which they do not have but need for a project. For example, an engineer which is hired because of technical capabilities might have to suddenly present their progress to project management and hence need coaching by the project leader. [12]

Of course, no **coaching** situation is the same, and if you have a relatively new resource in the company which you are coaching, then you will have a more direct coaching approach, while those who has already been coached for a while only needs an supportive type of coaching and then there are all the types and styles of coaching that lies in between those generalised ends. [15] It should be noted that the CDE holds an extremely suitable position for coaching as the leads they are guiding are also steering their own resources as a project leader managing smaller parts and areas that are overseen by the CDE. Keeping in mind that the CDE typically handles many small teams at once, the opportunity to coach is widely available.

Additionally, to all the roles of the project leader, the project leader should also take a share of the workload from the resources, especially in areas where they have competence. Helping and taking a share of the workload further strengthens the perception that the project leader is a member of the team and not a traditional boss which only hands out orders. [12] As the CDE holds expert knowledge in all areas it should be possible if the time constraints allow it, to take a part of the workload in all of the teams.

So, to sum it all up, the project leader should on a regular basis: [12]

- Keep a regular communication with the project manager.
- Resist the urge and not act like a boss.
- Initiate actions and keep track of the team progress, assess the team members occasionally and check each resource views on their contribution.
- Check that everyone contributes, and everyone gets a saying. Listen to them and guide them along the way if needed.
- And finally, take a share of the workload.

So, who has all the characteristics to do all the things described perfectly? Probably no one, although it is highly unlikely, it should always be strived for to achieve the described characteristics. However, as a minimum, project leaders should have the leadership skills that everyone is familiar with: The ability to lead others through communicating a set direction and goals, the ability to hand out and receive feedback, integrity, effective communication skills and a high standard for performance. Other than that, the project

leader should have a positive attitude towards team-based work and preferably have experience of it. [12]

So, while the project leader does not necessarily need to have the managerial work parts for their daily work, they still need to act like a leader and rely on leadership as the primary work tool in their day-to-day work life.

2.2.5. Leadership

Before diving into the realm of "Leadership within an expert organisation" in chapter 2.2.6, one should first look at the fundamental question of: "What is leadership?" and the term leadership by itself.

There are many different definitions for leadership, it is a definition that is very personal and vary heavily based on one's own experience, perception and general thoughts about how a leader should be. For example, in the book: Bass & Stogdill's Handbook of Leadership, which is commonly known as a "bible" regarding leadership theory, Bass has summarised roughly ten pages of different perceptions out of famous quotes, persons and books regarding the definition on leadership. And there are many others who has done similar summarises. [16]

The Oxford English Dictionary defines "Leadership (Noun)" as: *"The action of leading a group of people or an organisation."* [17] Even though the Oxford English Dictionary states that it is a person leading a group or organisation there are many who do not define leadership in the same way. For example, Kevin Kruse CEO of LEADx and author of "Great Leaders Have No Rules" defines leadership as: *"Leadership is a process of social influence, which maximises the efforts of others, towards the achievement of a goal."* [18]

The western leadership, which is most applicable in this study, has been studied for thousands of years. Some of the most influential thinkers as Plato, Aristotle, Plutarch, Erasmus, Luther, Hobbes and Locke have all taken a deep dive into the realm of leadership. While many of these names can still be found throughout modern texts, there has been a drastic change to our view in leadership. Leadership and leadership knowledge has been defined from ancient times until quite recently by philosophers, historians, politicians and practitioners. While today, leadership is studied by more modern approaches such as

psychological professions and empirical studies which produces another kind of leadership knowledge. [19]

Though it can be argued that it is not in everyone's best interest that now all leadership knowledge comes from our new modern way of only using social scientists, we have rapidly shifted away from an over 5000-year-old habit of using several professions and a continuously tested way of gathering leadership knowledge. There is also a lot of empirical testing today that focuses on theories regarding leaderships behaviour and followers' response, to which Dr Suze Wilson is critical and says, *"In amongst all this 'science', the assumptions and political dynamics that I and many others argue unavoidably shape all forms of knowledge production get lost from view, hidden behind a mass of statistical tables."*. [19]

While social sciences are the majority, it is not the only factor of leadership knowledge in modern time. Recent discussions regarding leadership also refers to modern science on how our brain works, which is arguably one of the greatest challenges in modern science and could perhaps within the next decades greatly influence how leadership is managed if we knew in what way our brain reacts to certain scenarios. [20]

Leadership is hence not something concrete which all can agree on that "this" is the specific definition of leadership. Which is also why there is so many books on leadership theory. A quick search on amazon.com show more than 30 000 suggested books on "Leadership theory". One of many reasons for this is that most writers/researchers are very passionately attached to their definitions of leadership. If one then adds to the fact that leadership also evolves over time, this results in an enormous number of theories and research publications on the topic. [21]

To try to narrow it down even more, one can differentiate management from leadership, as a famous quote from Warren Bennis and Bert Nanus states *"Managers are people who do things right, and leaders are people who do the right thing".* Which suggests that leaders and managers have different ambitions, goals and personalities, and that leaders and managers are both critical for organisational success. However, it is stated that it is not until companies really has understood the fundamental differences between leadership and management until they can begin to fully train and harness both aspects of its personnel in leadership positions. [21] [22] Making this split between a manager and a leader in this

thesis is also relevant, as the investigated CDE typically holds no managerial position and as stated chapter 2.2.4 typically holds a project leader role.

Leadership can also be divided into different leadership styles depending on needs and what one is trying to define. One out of countless many examples of leadership styles, Julian Barling specifies his specific styles into: Transformational Leadership, Transactional Leadership, Charismatic Leadership, Authentic Leadership, Servant Leadership and Ethical Leadership. [21]

Now even if one does not take a deep dive into the above example, it is apparent that many have devoted themselves for decades to try to understand the nature of organisational leadership, which has resulted in many theories and lots of empirical research questions. It is somewhat apparent though that the very best of organisational development is characterised by great leaders who are relational, inspirational, future-oriented, focused on employee development while equally important expresses thought throughout meaningful behaviours at the right time. [21]

2.2.6. Leadership within an expert organisation

The CDE studied in this thesis does not only manage resources that fits the description, leadership in general, but leadership within an expert organisation. So, what is leadership inside an expert organisation? And what is the difference to traditional leadership theory? One could argue that, inside an expert organisation, leadership positions add even more complex variables to the already complicated term leadership. Everything from supply and demand to working both up and downstream inside an organisation, trying to balance employer to employee needs and massive amounts of communication. All while simultaneously trying to evolve as a leader. This makes it clear that one cannot become a leader overnight. This is something one must grow into, and it is something one develop during a great part of one's career, if a leadership position is the path which one chooses to follow inside an expert organisation. As John Graham says:

"Leadership is not a science to be picked up in one book or course, but an art to be learned over time. Good leaders sometimes tell people what to do, but leadership is not just giving directions – it's liberating people to do what is needed in the best possible way.". [23]

As already hinted in chapter 2.2.5 there are endless of quotes and definitions of leadership. However not all of them fits into the realm of expert organisations. There is also the issue of in what perspective one is looking. If one is looking from a company board perspective a leadership definition might be as Peter Drucker quoted by Kevin Kruse said: *"Effective leadership is not about making speeches or being liked; leadership is defined by results not attributes".* [24] While a line manager focused more on personnel's perspective could have a definition that Rosalynn Carter quoted by Kevin Kruse said *"A leader takes people where they want to go. A great leader takes people where they do not necessarily want to go, but ought to be"*. [24]

Point being that leadership is defined differently for all of us, and the definition of leadership oneself has, reveals a lot of how oneself defines and stands in a leadership position. Even though many claim they would not like to be in a leadership position, many are so indirectly, without even knowing it, even if is just to hand out a simple task and to follow it up. All are leaders in one way or another, and there should be a desire to try to develop as that leader within expert organisations. However, it is especially true for the CDE as they have already chosen the path of leadership within an expert organisation.

Leadership development in expert organisations is also something that is so much more than trainings and seminars, as leadership is as mentioned, something one must learn to be good at. The concept of experience-driven leadership development is therefore something that many companies would benefit from using more extendedly and which the CDE way of working is also built upon.

Carlos Ghosn CEO of Nisan and Renault wrote in his book, Shift:

"Tomorrow's leaders get their training by dealing with today's challenges. You have to take the ones with the most potential and send them where the action is. That way you achieve two ends: You get the problem taken care of, and you get a manager who is grown through experience. Leaders are formed in the fire of experience. It's up to the head of the company to prepare a new generation and send them to hot spots as part of their training. He must prepare for a smooth transition by training people, guiding them, pushing them forward, but not too hard. Then, from among them he must choose the successful ones, the future managers and directors, the ones he has confidence in, not because they're someone's protégé but because they have faced difficult tasks and accomplished them." [25]

The best part of this quote is that it is not HR speaking of development, as this is the thoughts of a driven line executive which has realised the need of developed and talented leaders for the company to be successful. While this is good starting point, it is only a glimpse of Ghosn's ideology, but it still reflects the need of talented leadership for organisations like the one investigated to be successful.

2.3. Project management

Even though the CDE hols no project managerial position, they anyhow need to manage the project management parts of their scope due to the sheer size of the typical engineering project done by the team. The project managerial tasks they are responsible for in their own scope includes all typical project management tasks and will be specified more in depth in within chapter 2.3. Also as mentioned in single scope projects they are responsible for all project managerial tasks, but as the scope is smaller, it is more or less the same information as they would provide in a normal scope project with more focus on documentation.

2.3.1. Project management as a concept

To be able to run big engineering projects, project management is needed to ensure smooth projects, to track budgeting, to manage resourcing and to live up to the quality assurance. According to Richard Luecke, the definition of project management is:

"The allocation, tracking and utilisation of resources to achieve a particular objective within a specified period of time. This form of management focuses on the characteristic activities of a project, namely, a set of activities that (1) aims to produce a unique deliverable and (2) is time-bound within clear beginning and ending points." [26]

Let us further discuss the definitions of a project in regard to project management. **Planning**, **build-up**, **implementation**, and **closeout** are the four phases that every project can be divided into. Splitting these makes the entire project chain much simpler to understand. [27]

Professional project managers that most think of when hearing the word project manager are the ones that are in charge of overseeing large projects like building a power plant from start to finish. Smaller projects, like developing a marketing brochure, are typically

managed by people who already have other tasks, but regardless of the size, they have a project manager role. They create the plan, assemble the team, choose how to distribute the resources, organise the work, keep an eye on the budget, resolve issues and many other things. Keep in mind that project managers are frequently assigned to collaborate with a team of colleagues who have normal tasks and supervisors but have agreed to contribute time to the project. When that is the case, project managers must have individuals working together efficiently without the project managers direct supervision, as they rarely have direct control over the team members. Concisely, project management calls for social, financial, and organisational skills. Fortunately, you may acquire all these skills through education and hands-on experience. [27]

Designing a car, creating a website, transferring a business, sanitising a disaster site or updating an information system all have one thing in common. All go through the same four stages: Planning, build-up, implementation and closeout [27]

Planning: The stakeholders are identified in this initial phase, which includes everyone with a role in the project. Both goals and objectives are outlined, including what is needed to reach them. [27]

Build-up: This is the phase when the teams are assembled and responsibilities are handed out. The timetable and a budget are prepared, and the kick-off meeting is held. [27]

Implementation: The project is now under work. Everyone is working actively on their allocated tasks. Reports are regularly made, meetings are held, and there is a need to keep an eye on the budget and schedule. In addition, addressing the numerous unforeseen problems that typically arise. [27]

Closeout: The project is done. The final task is to turn it over to whoever will be in charge of the finished item or the new procedure. The group’s successes and "lessons learned" are evaluated and the final report is created. [27]

Each phase includes a unique set of objectives, tasks, resources, and competencies. The project manager typically states the objectives, organises the team to complete the tasks, and use each set of tools and abilities as necessary (see Figure 9).

Project phases

Planning	Build-up	Implementation	Closeout
ACTIVITIES			
Determine the real problem to solve	Assemble your team	Monitor and control process and budget	Evaluate project performance
Identify stakeholders	Plan assignments	Report progress	Close the project
Define project objectives	Create the schedule	Hold weekly team meetings	Debrief with the team
Determine scope, resources, and major tasks	Hold a kickoff meeting	Manage problems	Develop a post-evaluation report
Prepare for trade-offs	Develop a budget		
KEY SKILLS			
Task analysis	Process analysis	Supervising	Follow-through
Planning	Team building	Leading and motivating	Planning
Cost-benefit analysis of options	Delegating	Communication	Communication
	Negotiating	Conflict management	
	Recruiting and hiring	Problem solving	
	Communication		
TOOLS			
Work Breakdown Structure	Scheduling tools (CPM, PERT, Gantt)		Post-evaluation report: analysis and lessons learned

Figure 9: Project phases split into activities, key skills and tools **[27]**

2.3.2. The frameworks of project management actions

While there is lots of theory on project management and project management actions, there is some theory that fits this study better than other. Richard Luecke has managed to pinpoint almost all the typical day-to-day work that the CDE works with regarding project management. Luecke does however also include some theory on decision-making spheres, and some theory behind decision-making regarding the “who and how of decision-making” that is not relevant to this study. Other than that all frameworks listed by Luecke hints that the organisations he has based his book on is similar to Citec’s way of handling project management, alternatively that the project management world is so common that many uses the same principles. Either way, the topics described by Luecke fits the frameworks of

project management as a CDE so well it has been used as a baseline for this study. The theory selected from Richard Luecke regarding project management frameworks are as stated the ones relevant to this study, those are: Decision making, maintaining control over open assignments and tasks, documenting project decisions and agreed actions, communication and budgeting.

- **Decision making**

Project managers with experience understand that making decisions is a sizeable portion of their job. Every project consists of a series of choices that are connected by actions. Thus, deciding (1) how decisions will be made and (2) who will make them is one of the crucial things that must be done incredibly early in the projects. [28]

There are even situations that one take for granted that someone will take decisions on. Especially when there are several factors to consider, multiple options to choose from and ultimately someone choses one of those based on expertise knowledge. [29] And this is especially true in a project hierarchy within an expert organisation where there are many fast-paced decisions and many rules, both spoken and unspoken about who gets to decide on what. To better define this, let us first look into the decision making done by executives and managers.

Executives and managers make judgments inside functional business units. These people recognise the problem, look for and evaluate potential solutions, and seek advice from the proper people. They then make choices and take accountability for the results. One of the things that managers and executives are hired to do is make decisions within the boundaries of their respective areas of responsibility. They may look for agreement and other people's perspectives, but they are not constrained by them. However, decision-making within project teams must be approached differently. [28]

Making decisions for projects is not as straightforward as making decisions for staff departments or operating units. It is obvious that sponsors and steering committees have the last say over the objectives of the team and the number of resources devoted to it. They also have complete control over personnel, budget spending, external resources, organisation policy or goals, pricing, specifications and lastly changes in the team's schedule and deliverables. But even they must consider the opinions of significant

stakeholders who might want a say in these choices. Contrarily, project managers should be given complete control over choices regarding project operations and procedures as long as they refrain from altering the deliverables, goals, schedule or budget. [28]

Both team members and project leaders must follow that same rule. However, these participants also require authority to make decisions within their limited scope, unless their decisions have significant negative consequences or impact the work of other project teams. There is typically the need to make sure that the project team, its sponsor, important stakeholders, and upper management all agree on which choices can be made by which parties involved in the project. As this will help to avoid any potential conflicts within the project. [28]

In contradiction to the theory the studied CDE holds more decision-making control than a typical project leader, as they have more or less the control over the project operations and procedures within their own scope. The Project manager holds the final saying on any given topic, but the typical day-to-day decision-making is done by the project leader, in this case, the CDE.

- **Maintaining control over open assignments and tasks**

Everyone working within expert organisations has probably attended meetings where significant issues were brought up but not resolved, even though everyone agreed that the particular topic was crucial. Why? Mostly because one is out of time, or alternatively that some parties require additional time to investigate the issue. Both are good justifications for postponing a problem. But what happens to the problems that one cannot fix during project work or project meetings? Do they still exist? If there is not a methodical and organised manner to manage them, unresolved issues may obstruct the decision-making process. They can also slow down project progress if a particular task needs to wait for a decision before continuing. [28]

Placing unsolved problems in a tracking log is one of the many techniques to manage them. Maintaining a tracking log has two advantages: (1) unsolved issues will not be lost, and (2) a process for ensuring their completion is more or less guaranteed. Figure 10 shows one of the many examples of a tracking log. [28]

Issue	First Raised	By (Owner)	Comments	Must Resolve By
Selection of materials supplier	3/03/04	A. Sandoval	Holding three bids	5/21/04
Find new tech team leader	3/07/04	K. McIntyre	Current leader will retire on 5/13/04	ASAP
Whether to attend the June 2004 APRQ conference	3/10/04	J. Johnson	Cost not yet calculated. Deadline for application is 4/18/04	4/16/04

Figure 10: Tracking log example **[28]**

Making a log by itself does not solve the issue of unresolved problems. It is simply that someone accepts accountability for them and ensures that they return with a decision within in a timely manner. The crucial aspect and advantage of having a tracking log is that the crucial concerns will not be overlooked or unresolved. [28]

While the typical CDE nor the Project manager in Citec's way of working uses a separate tracking log of unresolved issues, it is absolutely used in some other form throughout projects. Instead of the separate tracking log the open issues are placed with the agreed actions and documented in the Minutes of meeting of the project, or any review meeting template especially made for collecting information between all disciplines. As the review meetings are occurring based on project need there is no need for a separate follow up method in the current investigated way of working.

- **Documenting project decisions and agreed actions**

Those who attend multiple meetings each day, undoubtedly already know how simple it is to forget which choices were decided in each meeting and who was given which post-meeting tasks. *"That was never approved by me. I only recall that we agreed on…"* is a statement that quite typically is familiar when participating in lots of meetings. Minutes of meeting and progress reports are both methods for keeping track of these agreed tasks. [28] The two subtopics to this topic, fits perfectly into the project management world of the studied CDE as the Minutes of meeting and progress reports are the two main documents used for keeping track of progress and agreed upon actions, both internally and externally.

- **Minutes of meeting**

It is simple to lose track of what has been accomplished and what has not, as well as who agreed to do what and who did not in a project with numerous meetings and participants. Because of this, every project, aside from the smallest should have a methodical way to record decisions, tasks, and actions. Minutes of Meeting, often referred to as MoM, are notes taken by a designated individual and is widely used in organisations. At the following meeting the minutes are re-examined, approved and if required, kept open and updated. After the meeting, the minutes are placed in a file where participants can access them as needed. [28]

- **Progress reports**

While minutes are being collected in the meetings there is typically a lot of work being done elsewhere in the project where decisions and actions are made. For example, different designers and leads are implementing design updates in several areas, the documentation team is preparing some documents to be released to customer and the financial team is estimating the current cost of the project. Each of those tasks should tell the project manager of any problems or progress made so that the project manager can use that information to monitor the project's overall status. The reports required depends on the circumstances and the data the project manager needs to stay in control and contribute to the project. Progress reports, like meeting minutes, should be organised so that anyone who wants to access the data can find them. [28]

- **Communication**

One more thing that needs to be made at the beginning of project work is a communications plan. The significance of a plan like this depends on how many individuals, organisations, and departments will take part in the project, as well as how widely they will be located geographically. Plans may not be required for small projects involving a small group of co-workers, except for regular meeting times and a location. Anytime they enter the coffee room or go down the hallway, these folks can exchange information. In contrast, a project involving a considerable number of participants from diverse departments, locations, and organisations needs a thorough and well-organised communication strategy. It will be difficult to get these far dispersed individuals to communicate with each other

and exchange ideas. As a result, a system for communication needs to be established. It allows project participants to coordinate their work, manage issues, and meet deadlines. Major projects cannot function without it. [28]

Protocols for meetings, emails, and reports should be included in every project's communication plan. Larger projects should also consider technological linkages that can bring together stakeholders and team members that are spread out globally. [28]

This is relevant to any project, but the team studied has some key customers and the way of working regarding communication is already pre-determined, hence not relevant in the day-to-day work for the CDE but should always be present when dealing with new customers.

- **Meetings**

Meetings is a regular feature of projects. Meetings that are arranged on a regular basis, spontaneous meetings and emergency related meetings. Although meetings are the least preferred activity for busy, action-oriented people, meetings are frequently the most effective means of exchanging information. Meetings offer places for discussion and decision-making, and progress is typically dependent on those decisions. Maintaining a regular schedule is one of the ways one can make the most out of meetings. People can then schedule their other tasks around project team meetings by knowing, for example, that the meetings occurs every Tuesday and Thursday afternoon from 2 to 3 p.m. Additionally, having a set timetable saves meeting organisers the time-consuming process of locating a date and time on which everyone is available. [28]

- **Attendance principles**

To guarantee that important participants are present when decisions are taken, a policy on attendance should be created for project meetings. If travel is a barrier, meeting technologies can be used to connect people to the meetings. Meeting optimisation requires planning, procedures, and follow-up. [28]

- **Meeting technologies**

Sometimes team members must meet to discuss their work since emails are not enough. Sometimes verbal communication is all that is required. In other cases, it is also necessary

for people to be able to see one another or the actual things that other individuals are working on. Fortunately, there are several accessible technologies available today that enable all of those many modes of communication. [28]

Emails are a fantastic tool for communication. Messages can be sent from one party to another, over vast distances, almost instantly and for a minuscule expense. However, if the projects are very emails focused, one should make sure that there is protocol for how it should be used and be clear about who must be “copied” on what without overdoing it. Additionally, one must ensure that all parties are informed about decisions that will have an impact on them and that those who must participate in the decision-making process are consulted in the email correspondence. Emails in that sense, may aid in the creation of virtual paper trails and can offer vital information if miscommunications or disagreements later develop. [28]

Phone conferences lets the virtual team interact verbally in the quickest and easiest way. Additionally, it has a characteristic that email does not: it allows for open and dynamic dialogues. Teleconferencing is a superior medium for discussions, brainstorming, problem-solving, and decision-making because of its benefit. [28]

Video conferences is another means of project connectivity. Without spending time or money on travel, food or accommodation, it brings teams together. For instance, project teams in Finland may communicate and collaborate with colleagues in India without ever leaving their offices. The same items and documents may be seen and discussed in real time. However, videoconferencing is challenging and needs the assistance of experts in the field. Participants require a suitable computer, camera, microphone, software, and internet connection for basic video. If a team decides to use video, one must make sure everyone has a suitable system. [28]

All systems described above are used on a daily basis in Citec. Especially video conferencing with sharing documents and design solutions directly when discussing is a tool that is a great way of communicating when working with colleagues that is not in the same office or alternatively in this modern working life, working from home.

- **Bringing the people together**

When working in a team, distance matters. Participants in a project are more likely to connect and exchange ideas often the closer they are to one another physically. As MIT researcher Tom Allen found out: [28]

"People are more likely to communicate with those who are located nearest to them. Individuals and groups can therefore be positioned in ways that will either promote or inhibit communication. – Tom Allen" [28]

The extent of communication and information exchange is therefore greatly influenced by the physical locations of project team members. [28]

Establishing a project team room is one effective solution to the colocation problem, even when placing team members' separate workspaces close together is not practical. A team room is an area set aside for the team's and its members' work. It serves as a conference room, a gathering area for team members to exchange ideas, and a location to show or store all the team's work. To allow for group discussions with members who are not on-site, this team room should also have a speakerphone and videoconferencing technology. The team room, along with all its accessories, promotes teamwork and identification. The team room described might not be practical if project members are dispersed extensively across borders or in a big office complex. But using for example a project Web site will allow a team some of the same advantages. On the project website, a virtual team room with four walls like those in a physical team room can be created: [28]

Purpose wall: The team charter, goals, tasks, a list of deliverables, and current outcomes are all included on this wall. [28]

People wall: The team members are named, and their tasks are described in this section. Users may discover here who is participating in the different project's various parts. One can include a picture of each team member and a summary of their specific job and areas of experience. Virtual teamwork gains a crucial dimension when a name is associated with a face and some background information. [28]

Document wall: This section of the website features a calendar with upcoming meeting times and agendas. There are also meeting presentations and previous meeting minutes kept here. Also, team members can put their work on this wall for review. [28]

Communication wall: Links and details are put in this section that tie the team members together. [28]

While the theory behind this idea is getting outdated due to the theory being close to 20 years old, it still shows the need for team members to be able to join up in a common location. That is, a place to discuss, share ideas and discuss problems. Even though we live in a digital era it is important to remember that we are all humans. Especially the investigated CDE role which relies on expert knowledge that is handed down through coaching and massive information sets, needs a common location to be able to help the team communicate as efficiently as possible.

- **Budgeting**

A budget is the conversion of plans into defined expenses and expected returns over an agreed-upon period. In this sense, it serves as the project's financial strategy and action plan. A proper budget and commitment to said budget provide people the resources needed to perform the tasks, which can be the distinction between success and failure for business organisations. Budgets for individual projects perform a similar function. [28]

The initial question to address when creating a budget is figuring out what resources are needed to properly execute the project. Once the resources are defined the project can be divided into major expense categories that is anticipated to establish any costs. Project costs often fall into the following categories: [28]

Personnel costs: Employees often accounts for the largest portion of a project's budget, and this covers both full-time employees and subcontractors. [28]

Traveling costs: During a project, people may need to travel between locations. Especially, if the project requires the team to meet up at a common location. This cost includes housing and meals. [28]

Training costs: The budget needs to account for the fees and costs of any internal resources or external contractors that is used for needed trainings. [28]

Supply costs: In addition to the typical computers, pens, papers, and software, there might be unique appliances needed and one should try to foresee the unique needs of the project already in the planning phase. [28]

Housing costs: For several reasons, it might be necessary to move some individuals into rented spaces for some periods of the project. [28]

Research and third-party costs: Research studies, consultants, legal counsel, or similar third-party costs also needs to be included in the budget. [28]

The completion of the budget allows every key partner involved in the project the opportunity to reflect on whether they want to start the project given the created budget. Once costs are predicted, the sponsor, for instance, could choose to re-evaluate the project or scale it back. Likewise, the project manager and anybody else responsible for the project's success or failure may want to leave the project if the sponsor for example is not willing to completely accept the budget, as incompletely funded projects place themselves in an elevated risk of failure already at the beginning of the project. [28]

There are cases when the project budget may not be negotiable. An example would be a project defined by a contract with a fixed total price. However, typical customer projects and internal projects often offer more flexibility, which is also often required because it is difficult to predict every expense. [28]

The most successful projects are those that evolve as they confront challenges and seize advantageous chances. Because of this, many project managers provide some flexibility in their budgets and typically request about 5% on top of the budget, with which they can deal with unforeseen expenses, avoiding the need to ask the project sponsor for more funding. [28]

Once a project starts, the project manager can take advantage of the budget to track progress by compare actual results with those estimated. The team is then able to take immediate corrections because of this feedback, monitoring and evaluation progress. [28]

2.3.3. Managing project tasks

When the build-up and planning phase is completed in a project. I.e., administrative tasks, frameworks and budgeting has been done for the project, one can start the next steps of the project setup, the implementation phase.

According to Richard Luecke many of the tasks that are to be done by project teams are typically enormous and incredibly complex. For example, those who are not in the construction business find the task of constructing an eighty-story office tower to be incredibly challenging. Richard Luecke approaches projects of this size by referring to the old joke, "How do you eat an elephant?". Stating that even if the task is overwhelming, there is a straightforward solution: chop the elephant into manageable parts. Both large and small projects use the same methodology and one reason many projects fail, is that either a significant amount of the work was not included, or the time needed to finish the work was significantly underestimated. [30]

- **Work breakdown structure**

Project managers take advantage of the work breakdown structure, commonly known as WBS as a tool to create estimates, assign workers, monitor progress, and identify the project's work scope. This tool can be used to break down complicated jobs into multiple smaller ones. These tasks are often divided more than once. One will reach a point when tasks cannot be separated when one repeatedly asks the question "What is required to complete a specific task?" for each task and subtask. [30]

There comes a time when additional work breakdown is not necessary from a practical standpoint. At that stage, projects should have been broken down into reasonable one-week or one-day chunks. Work breakdown ends at that point. Usually, three to six layers of split tasks make up a WBS. The project will have more layers the more complicated it is. one should cease breaking down jobs whenever they will require the same amount of time to set up as the smallest time unit one is planning to schedule. Because of this, one should divide the job up such that each task takes a day to complete if one wish to schedule it to the next day. [30]

When the project manager is pleased with the work breakdown, these additional questions must be answered for each WBS task: [30]

- How long will it take for each task to be finished?
- How much will it probably cost to do each task?
- What competencies will be required to successfully perform each task?

The typical WBS structure used by Citec consists typically of WBS structures down to about a two-week duration. The large WBS tasks is due to the sheer size of the handled projects, as projects are ranging from hundreds to tens of thousands of Engineering hours.

- **Assigning the tasks**

After the WBS has been defined, the project managers can assign the tasks to the team members. Every task needs to be assigned to an owner who is responsible for the work. Furthermore, that person needs to have enough time available in their schedules to finish the task within the time schedule. If the teams have not yet been put together, the project manager should use what is known from the WBS to find the best candidates both internally and externally. If the teams have already been put together or if external resources are to be avoided, the project manager must make the greatest out of the available resources. This includes assessing the individuals' competencies and making the greatest possible job-task combinations. [30] In this case, it is the responsibility of the CDE to hand out the tasks for their own discipline.

2.3.4. Project delivery

Much like typical employee managers, getting results through people and other resources is one of the main problems shared by project managers and project leaders. Project managers and project leaders must make choices, resolve conflicts between those in charge and those below them in the project hierarchy while maintaining employee motivation and focus to achieve their objectives. They must also deal with individual issues, constantly promote communication, and oversee and manage commitment to the schedule, budget, and quality requirements. [31]

One must retain a good attitude to keep the team engaged during the execution phase, when controlling and tracking the project against the schedules and objectives that has been created. Additionally, one must keep an eye out for obstacles, bottlenecks, and mistakes. This balancing task might be challenging. In this phase, everything is being carried out so both the project leader and the team will notice progress. But there are always potential problems lying around the corner, and the details sometimes seem difficult or even overwhelming to finalise. These are some of the strategies for accelerating this process: [32]

- **Delegate and track the results**

The team that was formed during the planning stage, give each member a specific set of duties. However, one might discover that there is a need to delegate more tasks than initially planned. Adapting over the course of the project by making sure there is the flexibility to do so. [32]

In the past project managers and project leaders typically used to closely supervise their resources and give them instructions at every turn. This system is referred to as "command and control". Nowadays, most businesses have abandoned that style of management in favour of something more of a "trust and track" system. The tasks are assigned to team members while ensuring they have the knowledge, tools, and resources necessary to perform the said task. Then the project leader takes a step back and give the team room to perform the task. Then the project leader requests regular updates on what has been accomplished to be able to track the progress in relation to the plan and budget. [32]

As the CDE at Citec holds many active tasks, it is tricky to command and control any given task during all phases of the projects hence the CDEs typically utilizes a trust and track system to get the design and deliverables forward in the project.

- **Tracking progress in relation to the schedule**

Whether it is done manually or with some project management software, there is a need for an organised way to mark tasks when they are finished. For different types of projects, a different monitoring system is typically required. A good one for a big project might quickly overwhelm a small project with its complexity. Additionally, a system that is effective for small projects will not be effective enough for a large one. Most project managers use software for all but the smallest projects. However, the size and complexity of the specific project will determine the best application and features required. [32]

- **Tracking progress in relation to the budget**

Monitoring the budget is one of the most crucial tasks for a project manager or project leader. No matter how thoroughly the project is planned, actual costs infrequently match with the estimates. Experienced project managers keep track of where they have gone higher or lower than budget while still maintaining the initial estimations as a point of reference. They also present their arguments as quickly as possible to whoever controls the finances with a clear justification for why they will need additional funding if they sense that the overall budget is likely to go over the original amount. There is so to say a need to keep an eye out for major variations from the planned amounts when actual expenses begin to accumulate and find the reason for those variations. Budget news is not always bad either. One might discover that one has spent less than predicted when comparing the budget to actual expenses. If the tasks are being completed to the necessary quality standards, then all always welcomes that kind of news. [32]

2.4. Quality management

Whether one deals with organisational questions or any project related tasks, quality management will always be present. While organisations focus on quality management standards and systems like ISO 90001, TQM, CQI or Six sigma [33], projects typically have a more direct and experience-based quality management method. This study focuses on the latter.

2.4.1. Ensuring quality control

The success of a project is significantly influenced by quality assurance. A client, customer, supervisor, or stakeholders who is disappointed with the outcome is never desirable. Fortunately, there are many guidelines that help with ensuring the quality, these are some of them: [32]

- Establish the quality standards at the planning stage. Consider the project's scope, stakeholder requirements, the organisation's quality policy, and any applicable external rules or regulations. [32]

- To fulfil deadlines, do not perform hasty quality checks. The cost of addressing and resolving issues early is typically much lower than fixing them in a later stage or after the project is finished. [32]

- Use the best tools to examine deliverables. Statistical sampling, checklists, or thorough reviews are a few examples. [32]

- Depending on the previously established criteria, accept or reject the deliverables. Depending on the cost, rejected deliverables may be returned or revised. [32]

Consult with stakeholders to provide the right amount of information in a useful format and at correct quality levels and be honest with them at every step to prevent crises from growing. [32]

2.4.2. Level of detail

The engineering industry is today using complex 3D modelling software's like Building Information Modelling (BIM) because the level of complexity can range from a basic geometric representation to producing an exact as-built model. Projects needs everyone to communicate in the same language for it to be effective. The Level of Detail (LOD), which is a more effective method of expressing requirements amongst project owners, designers, subcontractors, etc., is therefore one of the crucial tools that can be used to express the demands to each other. [34]

"The Level of Detail (LOD) is to define the amount and degree of building information that needs to be placed in a BIM Model. This not only includes graphical objects or physical characteristics but also the data associated with the objects. In short, Level of Detail (LOD) is a framework that is used to specify the development of the BIM Model and this helps in communication and coordination with all the project teams." [34]

There are in total six levels of details in projects: [34]

- LOD 100 – conceptual level. Model elements are graphically simplified to gain an understanding of the design and spatial requirement. [34]

- Lod 200 – Approximate Geometry. Elements must be taken as an approximate. Non-graphic data may also be connected to the model element, but it lacks precise details and will only focus on displaying the geometry. [34]

- LOD 300 – Precise geometry. The model will be accurate in terms of quantity, size, position, orientation, details, manufacturing, assembly, and installation. The project's construction phase can take advantage of the information provided. [34]

- LOD 350 – Precise Geometry with Connections. This level of detail incorporates interfaces, supports, or linkages with other building components in addition to the same information as LOD 300. It demonstrates the interactions between various systems. [34]

- LOD 400 – Fabrication. When all manufacturing and assembly information is available straight from the model. I.e., information and specifications can be given directly to manufacturers from the different project components. [34]

- LOD 500 – As-built. The model contains all the necessary geometry and data to allow building lifecycle operations and maintenance. They have been finalised and installed, the contractor has confirmed their precise position, and they contain information that clients can use after construction, such as the model number, dates that the items were made, and dates that the items were purchased. [34]

2.4.3. Project Gate Model

Worldwide collaboration between Citec and Wärtsilä dates back a long time. As is common in long-term partnerships, the style of working can quickly become comfortable, with each party conducting tasks according to their predetermined "standard way of working". Basic though, is no longer sufficient in the modern world. Because Citec and Wärtsilä both aspire to constant development, they are currently working together to build their processes so that they complement one another. Operational Excellence is a program managed by Wärtsilä for operational improvement and to maintain the quality of its work. The program's goal is to guarantee complete transparency, documentation understanding, and information quality in every department and area of the organisation. The collaboration's Project Gate Model is one of the programs major accomplishments. [35]

The Project Gate Model is a template for project implementation. Each project is divided into smaller segments that are conducted in a specific order and consist of specified connected tasks. The model is comparable to a game of croquet in that every obstacle must be cleared before reaching the finish line. People tend to cut corners too frequently in the name of efficiency. To avoid this, the gate model ensures that everyone precisely completes the various steps of the model. By doing so, the gate model cuts down on mistakes and anticipates difficulties. Therefore, even if it may not appear so at first, the model expedites work and makes sure that everyone is moving in the same direction. [35]

The gate model is presented in Citec's Attitude stakeholder magazine as: *"Project execution with Citec's new gate model is like playing croquet – you systematically work your way to the finish line, one hoop at a time. The difference to the garden game, however, is that when projects cross the finish line, all the players are winners."* [35]

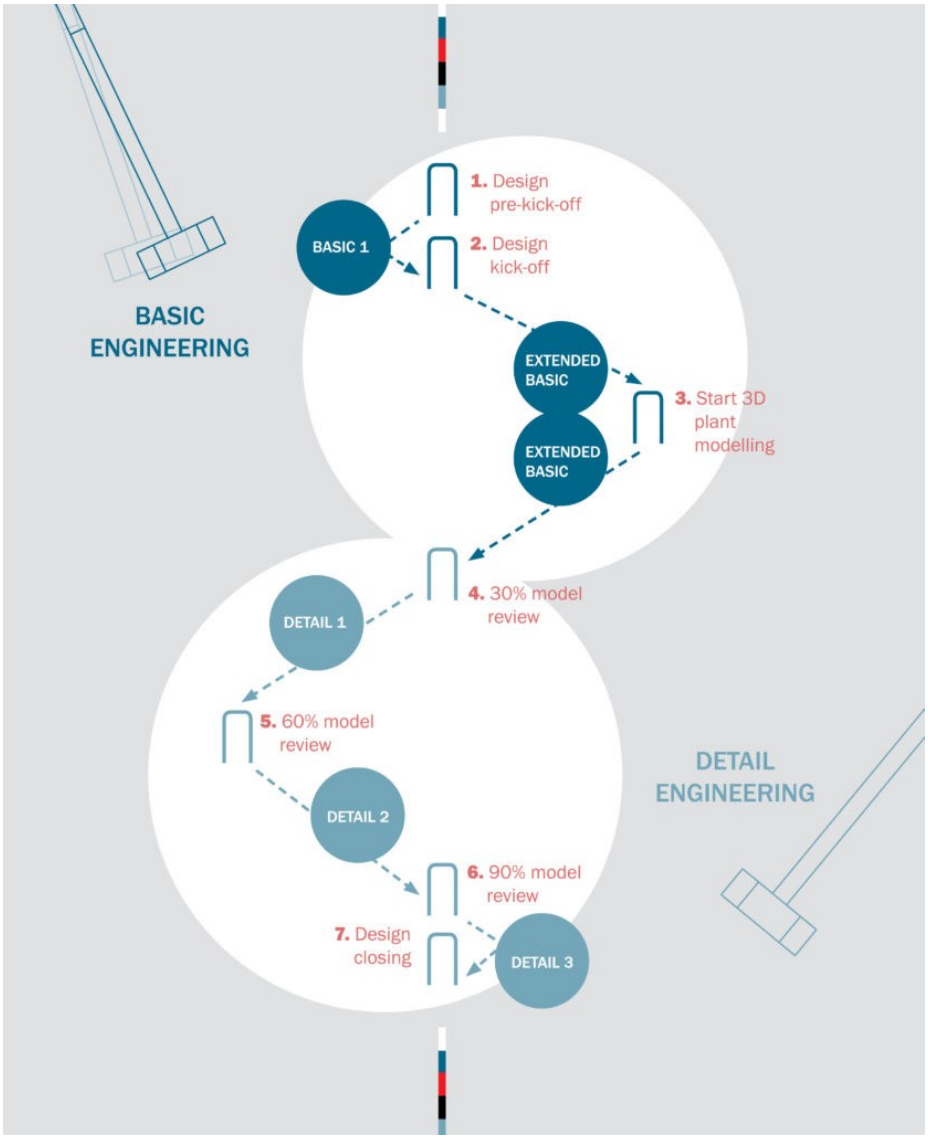

Figure 11: Simplified Project Gate Model **[35]**

2.4.4. Other project management systems

There are of course many other project management systems. While the Project Gate Model is a phase-gate process (also referred to as a waterfall process), all systems have some similarities. Whether referring to general procedures and guidelines or technological advancements, these systems allow teams a more organised way to approach projects. Several advantages result from those level of structures, including improved clarity, increased accountability, better collaboration and repeated success. When one combines everything, one gets the primary justification for using a project management system: The team can complete more successful projects on schedule and under budget because of it. [36]

3. Method

Being a CDE involves making rapid decisions throughout a project that impact the final quality of the whole project across all disciplines. Since the goal of this study is to investigate the elements that contribute to successful projects while ensuring that quality standards are being met, there was a need to extract the day-to-day tasks and quality-assurance procedures of the current CDE's, hence a qualitative methodology was chosen.

3.1. Research methodology

As this study is focused on people, and their daily way of working, it was quite obvious to take the route of interviews and a qualitative research method for this study. While a quantitative study probably could have roughly achieved the same output of the study, it would most probably not have generated as much useful material as the qualitative study due to the direct and honest answers gathered throughout the conducted interviews. Furthermore, due to the typically stressed environment of the CDE role, there is a risk that the CDE's would not have devoted enough time for the study due to said stressful environment if a quantitative research approach would have been selected.

A qualitative research approach involves gathering information by words and observations rather than numerical statistics. In contrast to manipulating statistics, analysis relies on the assessment of this data. Qualitative research focuses on phenomena of interest and research questions that require investigation of specifics to make comparisons, descriptions, or recommendations. [37]

According to David Partington, there are five important aspects of qualitative research within the managerial environment: [37]

- Firstly, qualitative research is made to function well in situations that are messy, complex, casually ambiguous, and have minimal prior information. There are numerous areas in the management sector that fit into this classification. [37]

- Secondly, qualitative research is typically descriptive or comparative but can also be prescriptive. [37]

- Thirdly, an important level of engagement with the interviewee's reality is essential to the effectiveness of qualitative research. As a result, rich information sets are produced by many methods used to gather qualitative data. [37]

- Fourthly, since the data is so rich, there are a wide variety of interpretations that can be used during the analysis stage. The difficulty in qualitative analysis is in offering the most convincing explanation of the facts. [37]

- Fifthly, and last, qualitative data analysis and collecting both depend on the development of skill. That is, the ability to search for, collect and gather rich information as well as the ability to find the hidden insights in the data. [37]

3.2. Research implementation

The interview questions were all developed with the problem formulation as a framework. The questions were drafted with the available information and later updated according to comments by this study's supervisors and hence considered finalized. The interview questions are discussed more in detail in chapter 3.3 and the full list of questions are also listed in appendix A. The interview questions were presented to the interviewees in the same order as in the appendix. The participants had not taken part in the questions before the conducted interviews, so that the questions would be solely based on those specific individuals experience, spontaneous thoughts and ideas. Furthermore, to avoid cross contamination of the data between the interviewees the participants were also encouraged not to discuss the questions in the team before the final interview was done.

For ethical reasons an information and consent form was developed before the interviews, which all the interviewees signed and agreed to. The information and consent form highlights that the interviewees are being recorded in this study, that data is collected throughout interviews, and that they can be quoted in this publicly available study. It also highlights that the participation is voluntary and that all collected data is treated confidentially and will be deleted upon the completion of this study. The full information and consent form can be seen in Appendix B.

The data collected in this study was as mentioned obtained through interviews, which all were conducted within the piping and management organisation in Citec, more precise, the core team of CDE's. Two exceptions apply to this rule, firstly, one of the interviewees

holds an expert title instead of CDE. However, this person is still relevant to the study, as this person even though the expert title does operative projects with the same role as the other CDE's. Secondly, the team has other CDEs that were not interview, these CDEs have no experience of operative projects in the studied role as the rest of the team, hence excluded from this study.

The data was recorded through Microsoft Teams even though we held face to face meetings for eight of the nine participants in the study. One of the interviews was an online meeting but followed the same concept. The recordings were captured using a microphone and Microsoft Teams built in recording system as well as the feature of automatic voice transcription as the interviews were all held in the team language, English.

The recorded interviews allowed the transcriptions to be re-written after the meeting to match the exact wording of the interviewees. The transcripts were then split by question and any material that was not a part of the research questions was left out of the study. The sorted transcripts were then used as the basis for the result and conclusions.

3.3. Interview questions

To give a better understanding of the chosen interview questions and their sub questions, the interview questions are presented and discussed one by one throughout this chapter. As will be noted throughout the rest of the study, not all questions fit into the framework of the primary purpose of this study but has been utilized for future recommendations and this study's secondary purpose instead.

Part A of the interview questions focuses heavily on the CDE and the different CDE's individual way of working. The idea with the first part was to document the current way of working to be able to produce a common baseline for the CDE's as well as give the necessary data to create some introduction material to the team. The questions in part A are hence focusing more on the secondary than the primary purpose of this study.

Part A – The CDE role and typical way of working

The first part of the interview was to get the discussion flowing and to provide insights into the general idea of the CDE. Especially questions 1 and 2 are meant as conversation starters, the questions however do give a good background understanding on the team and

the studied role. The second question is also meant to be utilized for the secondary purpose of this study.

1. **Background information, how long have you been working as a chief design engineer (CDE) and roughly how many projects have you done?**
2. **What is the mechanical CDE's role in the project?**

Question 3 is formulated with the secondary purpose in mind, except question 3a which is targeted for both purposes. 3a was on purpose asked from the point of view of a new CDE in the team, as that puts the interviewees in another state of mind, not focusing on personal challenges but thinking about the CDE role in general and the biggest challenges overall in the team. Hence why it is presented in the results as a generalized question.

3. **If you imagine yourself to be a fresh CDE in the mechanical team,**
    a) **what is the biggest challenge with the CDE role?**
    b) **what should you focus most on as a fresh CDE?**
    c) **what tips would you like to be given?**
    d) **how would you like to be introduced to the CDE task?**

In Question 4, 4a was deliberately asked in a way to be able to introduce 4b with the correct mindset. The mindset target for 4b was to get the CDE to focus on the key events during a typical workday and then answering 4b from that perspective. 4c focuses on delivery management and customer negotiation to get a better understanding of inevitable impossible situations managed by the team.

4. **The daily Way of working as a CDE**
    a) **Describe a typical workday as a CDE**
    b) **How do you work to keep tasks organised, follow up progress and meet deadlines?**
    c) **How do you tackle a delivery schedule request on your scope that is simply not possible to fulfil?**

Question 5 is totally focusing on the secondary purpose of this study and especially on quality management. The questions asked, are used as a guide to the format of the secondary purpose of this study and its contents. The questions also decide the extent to which the secondary purpose of this study will be executed and to what level of detail.

5. **If we were to implement some kind of document to help with the daily work as a CDE that could help improve quality and work as an introduction platform to a new mechanical CDE,**
   a) **what format would you like this document to be in? (Word, excel, software…)**
   b) **what do you think this document MUST contain to be helpful?**
   c) **how detailed do you think the information in this document needs to be?**

The second and last part of the interview shifts the focus over to the primary purpose of this study, focusing on quality, project management and project delivery in different scenarios.

Part B – Quality, project management and project delivery

Question 6 focuses on the term “Correct quality levels”. While the term can arguably be debated over the definition “What is correct quality levels?” the CDE’s face this concept in their daily work as quality levels are always debated. Hence the CDE’s should know the general ideology behind correct quality levels within their engineering praxis. However, these are without doubt the hardest questions out of all interview questions and to help with getting into the correct quality mindset, some examples were added after discussions with the supervisors to steer the discussion more clearly. Furthermore, the question is divided into subcategories of overall quality, basic design, detail design and the deliverables phase to give better results for the distinct phases of the typical projects.

6a focuses on quality control in general and the CDE’s way of working in how they steer their projects regarding quality. However, during the first interview it was noticed that this question needed an example, as the question was too unspecified. So, in addition to the question the general idea was presented. I.e., something like this: “How do you as a CDE manage quality in you projects to maintain correct quality levels in general

throughout all phases of the project?" and "What system do you use as CDE to follow up quality?".

The rest of the questions focuses on the stated subcategories to identify the current challenges and workable solutions to the same. Due to the nature of the questions, these answers to the already extremely specific questions did not generate a useable dataset to the primary purpose of this thesis. The answers were very technical and company specific, but overall, the answers provided high value feedback to the team and generated an enormous number of future recommendations.

6. **Correct quality levels are often discussed in today's engineering world (i.e., keeping the level of detail on a reasonable level) (e.g., ensuring the quality output needs of the ordered design, the needed level of detail to ensure smooth transition between basic and detail design and generally ensuring correct quality throughout all stages of the project). Now, focusing on correct quality for mechanical,**
    a) **how do you ensure that you keep the quality levels on correct level throughout projects?**
    b) **what are the biggest challenges to keep correct quality levels during basic design phase (e.g., start master layouts with enough info, lock master layouts for detail design at correct time, gather information within a reasonable time and so on)?**
    c) **what could be done to make it easier to keep correct quality levels during basic design?**
    d) **what are the biggest challenges to keep correct quality levels during detail design?**
    e) **what could be done to make it easier to keep correct quality levels during detail design?**
    f) **what are the biggest challenges to keep correct quality levels for mechanical deliverables?**
    g) **what could be done to make it easier to keep correct quality levels for the deliverables?**

Questions 7 and 8 continue the quality topic. 7a and 8a are numerical questions put on a non-standard scale to avoid the typical behaviour of human nature that no-one picks in either of the absolute ends of a typical scale, for example a 1-10 scale. The two categories, design and delivery phase were separated to get a more specified answer in both areas. In cases of cross communication on these related topics the data was transferred to the correct question during the transcription processing phase.

7. **Thinking about your recent projects, specifically the design phase,**
    a) **on a scale from 0–100 (0 = Terrible, 100 = Perfect), on what level would you typically put the general quality level of the mechanical design in any project?**
    b) **what are the main reasons for your given grade?**
    c) **what do you think needs to be improved to get better quality levels?**
    d) **what do you see would be the biggest issue in raising the quality levels?**

8. **With the same projects in mind, but now focusing only on mechanical deliverables (e.g. layouts, isometrics and manufacturing drawings),**
    a) **on a scale from 0–100 (0 = Terrible, 100 = Perfect), on what level would you typically put the general quality level of the deliverables in a general project?**
    b) **what are the main reasons for your given grade?**
    c) **what do you think needs to be improved to get better quality levels?**
    d) **what do you see would be the biggest issue in raising the quality levels?**

Question 9 was made with the consideration of the fast-paced engineering praxis that is common among engineers today. With this fast pace, stress is an inevitable subject for any project and there is always a need to control one's personal stress levels, especially regarding quality management. With that in mind, the questions below were developed. The original idea was to pinpoint the factors in the CDE's daily work that affects quality due to stress and how these stress situations could be optimised or even possibly avoided.

9. **Stress and Quality**
    a) **How often would you say that you cut back in <u>design quality</u> because of time constraints or other project load related stress?**
    b) **How often would you say that you cut back in <u>quality checking</u> because of time constraints or other project load related stress?**
    c) **What are the main stress factors of your daily work?**
    d) **How do you work to minimize stress related quality issues?**
    e) **What would you need to further improve quality when considering stress?**

Question 10 focuses on the project management done by the CDE to help pinpoint any struggles in the day-to-day work and to get an overall view of the different project management task.

10. **Project management done as a mechanical CDE**
    a) **On a general level, how big percentage of your daily work would you say is project management/project delivery?**
    b) **What are the biggest challenges with the project management part?**
    c) **What do you think could be improved with the current project management way of working for the mechanical CDE?**

Finally, question 11 is a round up question to the interviews and was known to not hold any analytical value as the question is too subjective to the CDE's own thoughts and own definition of quality in general. However, the purpose was to get an overall understanding and feeling towards the overall quality in the team.

11. **On a general level, looking back on all projects you have done as a CDE,**
    a) **would you say the quality has improved or declined over the years?**
    b) **what do you believe are the reasons for the said quality change?**

4. Results

All interview questions can be found in appendix A. As can be noted, not all the questions are presented as results in this thesis. The primary objective, the thesis itself, presents only the relevant interview questions for this study. The rest of the interview questions is used for the secondary purpose of this thesis.

4.1. The CDE role and typical way of working

- ***Background information, how long have you been working as a chief design engineer (CDE) and roughly how many projects have you done?***

The average experience for the CDE's in the team is 12 years and on average 40 projects each, ranging from 3–25 years of experience and 10–125 projects per person. This equals to an average of three projects per year, per CDE and the current team has a portfolio of about 380 projects in total.

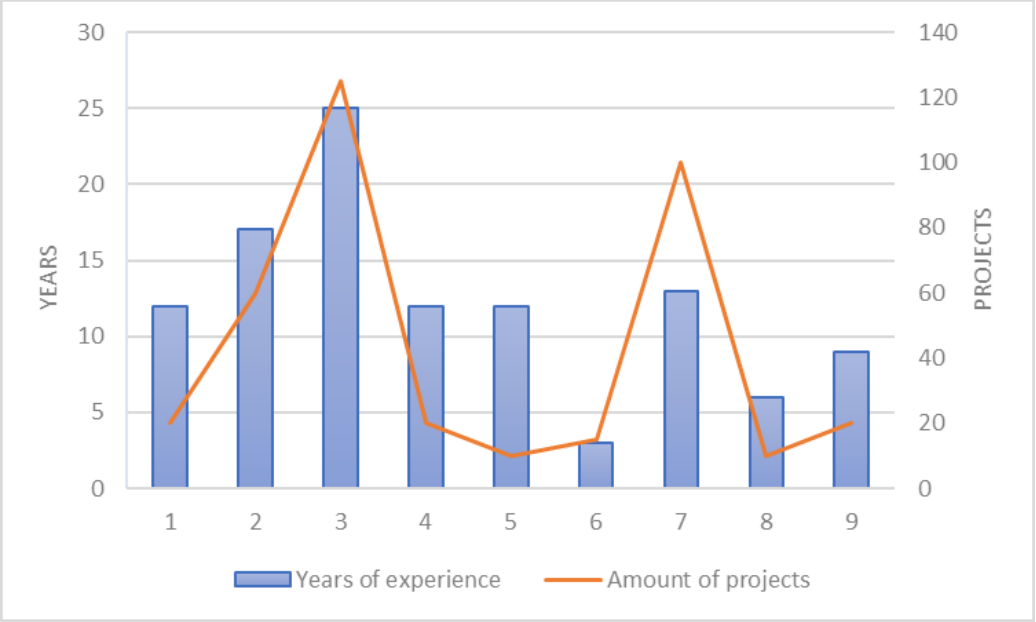

Figure 12: Visualisation of the studied team's project experience **[9]**

- ***What is the mechanical CDE's role in the project?***

If one tries to summarise the CDE's role in the project, it would be a:

- Coordinator
- Communicator
- Sub project manager
- Expert
- Supervisor

The role is however so much more than what can be summarised in a single word. The CDE role is to coordinate the whole design process of the mechanical scope throughout a project, which of course varies heavily from project to project. One description out of many that was used to describe the role:

"To coordinate, to communicate and to keep everyone on track for the mechanical part."

As a CDE one is also responsible for customer communication, i.e., by meeting with the different customers, negotiating and tuning the design according to customer needs:

"To keep the customer happy and support the customer in what they need."

However, internally the role is huge. Everything from project planning, resourcing, discipline alignment, design reviewing, time scheduling, budgeting, scope identification, technical support in the form of expert knowledge, steering and supporting the design leads, supervising projects being built and so on. All the tasks are achieved through a massive amount of communication. The role so to say involves some project managerial tasks and one description that was used to describe the role was:

"A sub project manager taking the lead of the mechanical part of the scope."

Most of the managerial tasks are listed above, and those are typically supported by the project manager which follows up all disciplines. However, in the case of single scope projects the CDE also holds the project manager role in the project. Which puts a little more focus on managing all the managerial documents.

- ***What is the biggest challenge with the CDE role?***

There were six major challenges that was identified for the investigated CDE's. **Communication**, **collaboration**, **task management**, **expert information**, **way of working** and **customer expectations**.

The biggest challenge in the position of a CDE was according to the interviewees most certainly the **communication** and **collaboration** between different parties, as these two naturally go hand in hand with each other for this position. There is a need to pass inputs downstream of the design chain, but also simultaneously discuss design issues sideways and upstream of that same design chain:

"Communication. Not just being a team leader passing inputs back and forth. You also have several other disciplines, and for a new CDE to stay organised and be able to communicate with all these other disciplines, making sure everyone uses the latest information available and so on, can prove a difficult task."

And it should be noted that the CDE is typically collaborating with new people all the time, so there is a need to communicate clearly with whoever is the other party discussing the tasks:

"The way of working and the technical aspects you can learn but the biggest challenge is the people. Because we are collaborating with new people constantly and we do not know how they are until after we have worked with them."

And these said tasks that needs to be communicated to all parties, are typically many at the same time. Creating a great challenge with **task management,** the sheer amount of information that goes through the CDE is enormous. Keeping in mind that a single CDE can have several projects at once:

"You can be involved in lots of different projects and tasks at once, and you need to be able to prioritise the different tasks depending on the importance. You need to be able to prioritise even without experience. To keep all the balls rolling so to say."

The tasks which are many are also mainly based on **expert information**, i.e., information that in the end, the CDE is responsible for. So, the CDE must know what things to check and follow up so that the design is matching the customer expectations and simultaneously fulfilling design requirements.

Generally, is also the typical **way of working** for the CDE. What is done in what order and so on, but that is something that typically comes with a little bit of mentoring and experience.

And lastly there is the **customer expectations** and understanding what the customer actually wants. There is always a need to tailor every single delivery to the customer and their expectations, and along the process updating them on why some things are like they are and negotiating the expectations so that you keep the project expectations fulfilled.

4.2. Quality in project delivery

Correct quality levels are often discussed in today's engineering world.

- ***How do you ensure that you keep the quality levels on a correct level throughout projects?***

The three answers that almost everyone answered in some form is by **reviews**, **communication** and **trust**. The results for these three are presented more in depth below.

Reviews: By constantly reviewing the design and digital twin of the project (the 3D model) throughout the whole design phase one can as a head of one's own discipline, steer the quality in the needed direction. Typically, in the beginning of the projects it is by guiding the design teams on what to do with improper inputs and preliminary information that is available. Then as the project goes along one typically only do spot checking if one has already worked with the design leads before so that one knows their typical quality output level and many point out that it totally depends on the resources regarding how much quality checking is done by the CDE. Review meetings are also mentioned several times, i.e., sitting down with all disciplines in a meeting reviewing the design at certain milestones to compromise in needed areas between the disciplines. The amount of checking is also individual between the CDE's as all has their own way of working. Some feel like triple checking the design is not needed:

"Because the designer is checking, the lead is checking, and they also have a third set of eyes before releasing it, so there shouldn't be a need for me to check it."

On the other end there are those who has a daily routine to open the 3D model and check what has happened since the previous day and that the design or changes is done as agreed.

Communication: Many CDE's talk about the constant meetings, and one claim that it is up to 60% of his daily work to communicate with the lead engineers. So, one could claim that the CDE spends a huge amount of hours communicating throughout the week. Typically, there are a mix of customer and internal project meetings every week but the majority of the time communicating is to agree on changes, then communicate the agreed changes in said meetings to the design leads and other needed parties. The communication in these

big engineering projects is not only up and down in the project hierarchy but also side to side as the CDE must think about all the disciplines even though they are only responsible for one part of it. So, there is always a need to plan and compromise with the other discipline CDE's in the project on for example who gets a certain space to do something in the project or what can be integrated with another discipline area to for example avoid dual steel structures.

Trust: Most of the CDE's pointed that they have periods of time that is very limited in how much time they can spend on communicating with the leads, hence they all have periods of time in their projects where they totally trust that the leads will take a responsibility to deliver on time and with a certain level of quality. However, this totally depends on the lead's experience level and what kind of project it is. For example, during phases when there are many leads and designers working in the same project you must be more alert:

"…to everyday try to follow up what happens in the design and then correct as soon as you see something that is not being done in a correct way. It is very important because if you let it go and you have a big bunch of designers, they are able to destroy quite much in just a few days."

However, In the late stages of the project when everyone is deeply focused on drawing production, one can more easily shift the responsibility and trust on the lead as there are anyhow quality processes which should be followed, i.e., checklists to be filled, reviews by non-involved resources and so on.

Even though there are as many ways to manage the quality levels as there are project leaders, they all summarised their answers on the three main identified areas, and there is one interviewee quote that summarises these three areas perfectly:

"Trusting the quality processes, I do spot checking, but I trust that the quality levels are on the level they should be at. Of course, discussing and informing the leads so that they have the latest information is available, design basis is referred to and so on..."

- ***Thinking about your recent projects, specifically the design phase, on a scale from 0–100, on what level would you typically put the general quality level of the mechanical design in any project?***

The average CDE answered that they think the design quality level is roughly 80 out of 100 points. The results ranged from 70–95 points.

- ***What are the main reasons for your given grade?***

The typical answer to this question is a version of this quote:

"Because it is somehow under control, but it is not perfect. That is mostly due to missing inputs and tight schedules."

The biggest factor for this grade is most likely time constraints. Typically, the projects have a tight agreed schedule, and according to the interviewees it has proven difficult to get all needed inputs in the beginning or at the right time of the projects, hence why many claim that the biggest impact is non-optimal inputs, because then there is always the need to make some assumptions which can cause trouble later on when the information is received. There are also time constraints due to lack of time to communicate. Understandably the projects have phases which are more hectical than other, and if one of those stages' lines up with the need to start locking the design to be able to start drawing production, then you might end up in situations like this:

"Usually at some stage you look at something in the model, but then it is maybe too late, and you see that maybe something could have been done a bit differently to make it more fluent or better. You should spend a lot of time in the model, but you do not always have time for it. But if you do, then you can find the ones that are not so practical or so logical."

However, there are projects, simple standard or limited scope deliveries that many claimed that they can achieve a perfect or really close to a perfect score on. However, typically there are still some very minor things that could have been improved, maybe not something that affects the cost or usability of the design but something that could have made the design more optimised or alternatively easier to install on site.

Another reasoning that was also mentioned as a factor to the grade was the narrow field of view when doing design. As the time schedules are as mentioned quite tight, the

different disciplines tend to focus too heavily on their own scope, missing the bigger picture and possibility to integrate solutions between disciplines and different teams.

- ***With the same projects in mind, but now focusing only on mechanical deliverables, on a scale from 0–100 (0 = Terrible, 100 = Perfect), on what level would you typically put the general quality level of the deliverables in a general project?***

The average CDE answered that they think the quality level on deliverables is roughly 83 out of 100 points. The results ranged from 70–90 points.

- ***What are the main reasons for your given grade?***

Most CDE's thought the deliverables are mostly on an acceptable level. There are certain things that are needed to show on the different deliverable and those they have gotten quite good at over the years. There are always some typical issues on the different deliveries that needs to be addressed but overall, they are on a satisfactory level. There are many of the CDEs who praise the good designers and leads they have, that are capable of creating the deliverables although there is almost never a close to identical reference to fall back on.

The problems that need to be addressed are all related to **lack of details**, lack of understanding the **installation process** and again the **time schedule constraints**. For example, lack of details are typical drawing related issues, relevant dimensions are not included or measured from a hard-to-reach location, welds are not clear enough and country specific standards that are needed on drawings. The lack of understanding the installation process points out flaws that are impossible to know without experience from site or site feedback, for example what information is needed and relevant to be able to install something. And finally, when you have tight time constraints you are bound to make simple mistakes that due to time constraints might be overseen by all parties before they are released to the customer.

However, one comment that is also relevant to the average quality level of 83 Is this quote from one of the interviewee's:

"If we would not currently have good enough quality levels, we would receive more feedback from site. So, we are within an acceptable level, at least at the moment. But we could always go one step further and improve the quality in general."

This highlights that the customer might be satisfied with the already reached level regarding the information the deliverables contain. Although the deliverables are not perfect, the achieved quality level is enough to be able to complete the installation process without comments.

4.3. Stress and quality

- ***How often would you say that you cut back in design quality because of time constraints or other project load related stress?***

All but one of the interviewee's unfortunately was of the opinion that they do not have enough time to be involved in the design as much as they would like. All of them was also of the opinion that during specific phases there are decisions that they, due to schedule or time constraints, are forced to go ahead with although the decisions are not optimal but fully functioning design solutions:

"Very often, more or less every case, and more or less every project. You have to let something go that you are not 100% sure of."

Many of the interviewee's talks about the time it takes to review the model, but also how much time it takes to simply set up inputs to the design team. Some inputs that can have been discussed and agreed with the customer to be made in a specific way, requires a lot of specified information to be written down and coordinated. It's not typically as simple as to say "I want you to route this pipe between point A and B". As that will result in the resource creating the pipe to produce a solution of their own. Not only do you have to re-do some or all parts of the same pipe, but also wasting design hours. To quote one of the interviewee's:

"It's a clear fact that time and quality go hand in hand."

The other typical answer to why CDE's cut back in design quality was input management. Whatever if it is late or constantly changing inputs it will interfere with keeping the design quality levels on a high level. As the changes often needs to be implemented quickly and

the space reserved in the design requirements might not be the same as previously agreed on, this can result in changes to several parties which are already close to their deadlines, creating hasty design solutions that fulfils the design requirements for all parties.

There is a need to trust that the designers and leads keep the quality levels on a reasonable level even though the CDE does not have time to steer quality during certain phases of the projects. None of the CDE's felt like the current WoW is optimal and all of them would have liked to have more time to make better design solutions and totally avoid the issue of not having enough time to properly handle the quality management in their projects:

"Overall, we should not cut back in design quality."

- ***How often would you say that you cut back in quality checking because of time constraints or other project load related stress?***

The trend of not having enough time continues for quality checking, as all CDE's feel like there is not enough time to do proper quality checking. There is one subject that all of the interviewees pinpointed for quality checking, and that is the lack of time to quality check deliverables. The CDE's are split on the topic on how much they generally check in the deliverables as some go through them all, while others only do spot checking, but all of them think there should be more time allocated for the quality checking. The typical issue is that the leads deliver the deliverables late compared to the customer deadlines, example:

"When we receive deliverables with extreme time constraints. Of course, we believe the quality is ok, but we still need some time to check the deliverables. Typically, you always find some small things that could be corrected."

and: *"Quite often, not every project, but quite often due to the leads being late."*

However, there are still quality procedures that most CDEs rely on, and as a CDE one sometimes must trust that the deliverables are delivered with a reasonable quality level:

"Sometimes. Depending on how the design organisation has been built and how well I know the lead engineer. Because when you have worked with the same lead for several years in several projects you know their strengths and their weaknesses. Certain things you just have to rely on, that the checking and quality process is followed."

- ***What are the main stress factors of your daily work?***

This topic seems to get as many answers as there are interviewees, as every CDE has different primary stress inducers. But if one would have to generalise the answers it is again, the lack of time.

There is getting design and deliverables late from the leads, causing stress as you do not have enough time to quality check, and fully know what one, as the project lead of the discipline, is approving. There is the resourcing, to get the needed resources, at the right time and the right amount of them including the change management of those resources. It is the overall quality of the design and deliverables and the image the CDEs are giving as experts, i.e., the possibility to get bad feedback or mistakes to be corrected from the customer after the fact that there should have been at least three sets of eyes that has checked and approved something. It is the lack of time due to constant meetings. It is the constant changes, the feeling that you know what direction design is moving in, and then the next day, that direction has changed again. It is to please all stakeholders which needs to confirm some design solution even though deadlines are approaching, and it is the endless mailbox:

"The mailbox, it screams with the undone stuff that I have somewhere down there."

It is the jumping between the different meetings and tasks that are pending:

"You have a meeting in the morning, and afterwards you think you should collect the points and send them out but realise in the afternoon that it is like unfinished. So, it is this jumping all over the place in the projects."

And finally, the misunderstandings and needs to sort out previously discussed and closed topics.

- ***How do you work to minimise stress related quality issues?***

Most interviewee's plan ahead in their calendars and have different variations of a system where they have pre-booked their calendars before submittal of deliveries or critical design phases that locks the design in certain area. The amount of time and when the pre-booking occurs variates but seemingly everyone has a similar way of working. An alternative to this is to have a separate internal delivery date to the design lead versus the agreed delivery

date to customer. One interviewee even had tried a way of working to hide the original dates from the leads, and if that could be managed then there would be enough time to do the quality checking.

Learning how to prioritise is another way one can minimise stress related quality issues. The CDE typically have several tasks ongoing at the same time and the ability to prioritise the most important tasks is a must in certain phases of the project, as you cannot treat all tasks equally important, or you would never be able to take some time off work. It is important to take the free time seriously, when you finish for the day, you should be able to put the work aside. It is quite self-explanatory that a tired and over-worked resource is bound to make stress related quality mistakes.

One can also try to be on top of the project and be initiative-taking throughout all phases to avoid the stress phase in the end:

"Being proactive and checking the design so that it is good all the time during the design phase. That means that there should not be so many things to check in the end."

4.4. Project management by the mechanical CDE

- ***On a general level, how big percentage of your daily work would you say is project management/project delivery?***

The average CDE spends about 28% or just more than two hours a day on project managerial tasks. Surprisingly, the results ranged all the way from 10–50% for a daily average, with an addition for some that it might be closer to 95% in the startup phase of the projects.

- ***What are the biggest challenges with the project management part?***

Two out of the nine interviewees did not have any particular challenges with the current project management way of working and considered the task straight forward.

The rest of the interviewees expressed three main challenge areas: resourcing, budgeting and scope management. As the CDE holds an expert role in the project and typically has done no project managerial tasks before the CDE role, it can also prove challenging to get

into that mindset and shift away from detailed technical questions to focus on the managerial tasks.

Resourcing and budgeting go hand in hand and typically comes with the issue of securing the right number of resources at the correct time in the projects, and to then follow up the budget effectively for these resources, so that you are able to keep the budget and finish the project on time. Resource management is also very influenced by customer impact. There are typically decisions that one as a CDE cannot make and which needs to be taken by the customer before being able to proceed with a certain task. To try to balance the workload for the resources and get the needed decisions from customers can be a tricky thing to balance.

The scope management can be split into internal and external challenges. Externally it is heavily depending on the customer and if you have a set way of working with the customer already, as new customers tend to create more challenges with the scope management, where you have to define unclear scopes and make sure that you include everything that is expected. Internally the CDE has received two new responsibility areas during the last year which has been transferred from the project manager down to the CDE and those are still not fully defined and causes some troubles due to unclear way of working and delivery scopes for the CDE's.

4.5. Quality in general

- ***On a general level, looking back on all projects you have done as a CDE, would you say the quality has improved or declined over the years?***

The majority (7 out of 9) of the interviewees claim that the general design quality has improved over the years. One is uncertain and believes it variates depending on design team and one believe it has just so slightly declined.

- ***What do you believe are the reasons for the said quality change?***

Many of the interviewees talked about the improvements in their way of working, re-usability of design solutions and that that the detail level in general has increased tremendously over the years. The increase in detail level is for the most part a good thing,

especially as all disciplines are starting to have the same high-quality level which gives an even greater role to the digital twin of the projects:

"Typically, today if you find an issue on site you can also find the issue in the 3D model."

Some interviewees also talked about themselves as a leader of the discipline in projects and said that as their experience has increased, so has the overall quality levels in their projects. The needed things to follow up, check and prioritise is something that only can come with experience. Typically, as you do not have the expertise experience you approve deliverables without knowing what to check for, but after a while one learn how to review the deliverables more critically, even rejecting them and have the resources re-do the needed parts.

The resources used by the CDE seems to be the only thing that divides the team. There are those who think the resources doing the actual design work has more knowledge now than before:

"It is the knowledge of the designers. Possibly we have more and more guys that are up to the needed level nowadays than we had earlier."

On the other hand, there are those who claim that the resources have changed too much over the last years and that they are not using all available design tools created for them:

"There has been to many changes in the resources, too much information has been lost and the current ones has not had enough training. We are also not in many cases using the tools we are having, not only checklists but other also."

Overall, the customer claims have dropped in the team year by year, which hints that the overall quality levels should have improved every year. There is a general feeling in the team that the team is focusing quite much on quality related improvements now, both internally and externally against their key customers.

5. Analysis of results and conclusions

By having the first five questions in the interview based on experience I managed to get a good discussion going with the interviewees. The rest of the questions that all were more precisely defined, often promoted cross over discussions to the previous topics, as it was quite often during the interviews that we discussed one key topic when the interviewees filled in something on the previous as it came to mind. Especially when discussing questions 6b–6g and when discussing question 8 but falling back on question 7 to fill in similarities between the two questions.

- **The CDE in general**

While it is quite obvious when observing Figure 12, it should be highlighted that the current piping and management team has a lot of **project experience** over a great time span. While the three projects per year is average it is quite clear that it is heavily varying between the CDEs. Some CDE's has had smaller or shorter projects, like Interviewees 3, 6, and 7, and some has had bigger or complicated projects like interviewees 1, 4, 5, 8 and 9. But the overall number of projects and years within a single team is still on an extraordinary high level, and it should be highlighted that it is a positive thing that the experience of these CDE's is collected and put down into best practises to be utilised in the team. The overall experience is also highlighted throughout the study, which is that most of the CDE's have a positive feeling regards to quality work and key improvements made to design concepts during the recent years. So it seems like the team is also using that combined knowledge in an excellent way to constantly evolve and deliver even better and optimised design solutions and deliverables.

The general idea of the role as a CDE or project leader in general, is matching quite well with the theory presented in chapter 2.2.4 as most CDE's had the interpretation that they should be **a lead of the discipline**, which manages **communication**, **collaboration**, **negotiation** and to be **customer oriented**. However, none mentioned anything about the typical coaching, and listening that according to the theory typically is a part of the project leader role. To make more out of the design teams, the CDE should implement some way of working to involve the design teams more actively in discussions and coach them where needed, not micromanaging them, but just pushing them in the right direction and have

more trust in the resources, praising them when they achieve something good and guide them when they have lost track of the target.

In contradiction to the theory, the word “responsible” is used by the CDEs to describe the responsibility towards the typical delivery scope of the CDE. This indicates that the role holds a somewhat higher level than what the theory for project leaders indicates in chapter 2.2.4, it is not the same responsibilities as a project manager, but a tailored responsibility in between those two theoretical roles.

- **The CDE’s challenges in their day-to-day work**

It comes as no surprise that **communication**, **collaboration**, **task management**, **way of working** and **customer expectations** are also some of the biggest challenges of the CDE. As it is highlighted throughout chapter 2.3, these are all the major project management tasks that also the CDE is expected to take part of, hence there can only be improvements in current ways of working to ease this part of the job. But it will never come naturally and will always be a challenge in the position of a CDE. Fortunately, as stated in the same chapter, all these skills can be learned through education and first-hand experience. Additionally, with correct documentation based and the team’s way of working this learning curve can also be increased.

The only data that does not match with any theory in the CDE’s day-to-day challenges is the **expert information**. As a CDE it is understandably crucial to hold key expert information and to have enough information on the whole discipline on a general level to be able to lead it. However, it was noticed during the interviews that the CDE’s have a collective understanding that they also should be the expert on every single design area. While it is obvious that the CDE must have the needed information to know what is going on and to be able to spot check, they should never be forced to micromanage the design and resources in the projects. Additionally, it is obvious that it would be ridiculous to expect that a project leader should know all detailed expert information within all teams managed. Even though the theory was not focusing on the **expected knowledge level** for a project leader, I would still draw the valid conclusion that the CDE is only meant to focus on leadership. The designer should be the expert on designing and the project leader should be an expert in leading.

This is also in line with Richard Luecke's ideology presented in chapter 2.2.4 that the project leader's or CDE's responsibilities should consist of: the ability to lead others through communicating a set direction and goals, the ability to hand out and receive feedback, integrity, effective communication skills and a high standard for performance. Other than that, the project leader should have a positive attitude towards team-based work and preferably have experience of it. [12]

- **Quality management by the CDE and Quality in general**

It was apparent during the interviews that reviews, **communication**, and **trust** were the only major tools that the CDEs uses to **ensure correct quality levels**. In other words, the current way of working is based on **experience**. The issue with this approach is that it is heavily varying between the different CDE's, as everyone has come up with their specific way of handling the quality approach in their projects, and these different styles will then be passed on differently depending on the mentor if there are no official guidelines to fall back on. However, there is nothing wrong in the quality levels by themselves due to this approach, but it could be beneficial to implement a common understanding as a baseline which everyone can base their custom approach on.

After conducting this study I deduced that, there is no documented way in how the projects should be designed in regard to level of detail or general quality assurance methods in different stages of the project, neither is the quality method and approach thought of in the planning phase when these projects are started. While the project gate model sets the limits to proceed before reaching a set gate, it does not specify what level of detail is needed to achieve the gate, just the output towards the customer. It would be beneficial to create a guideline like LOD but company tailored. I.e., what is required design wise to reach the certain gates, and to implement this guideline already in the planning phase, so that there would be enough time scheduled for the different gates and transition periods between the gates.

While the two 0–100 numerical values from the overall quality level questions hold no analytical value in themselves it gives an understanding that the CDEs believe the quality level for both design and deliverables are on roughly the same level. The reasoning for both is roughly the same with a few major contributors to the given grade. The greatest contributor to a non-perfect score in both is without doubt time constraints. This is however a typical project management issue and can only be optimised by further optimising time schedules and budgeting but will always to some extent impact on quality in phases with tight schedules.

- **Stress management by the CDE**

While it is apparent throughout the interviews that close to all stress and stress related quality issues are because of **time constraints** or factors that enhance time constraints like **delayed inputs**, **changing inputs** and **change management**, it is unfortunately not an easy task to solve. Due to the unexpectedly large result data received on this topic, it has been added as a **recommended future work** topic and therefore not considered in this study.

- **Project management by the CDE**

While the average CDE believes they only spend roughly 30% on project management tasks, personally, after studying the frameworks for project management and repeatedly analysed the interviews, I believe this number to be much higher. The CDE's claims they spends most of the time communicating and coordinating the design. Even if the discussions are on detail level it should be considered as project management, i.e., agreeing and communicating on how information should be used, hence if I would guess, the typical day-to-day project management is at least 50% on any given day.

Overall, the project management challenges that could be improved seems to all be within the organisations way of working hence implying that there should be more effective ways to utilise these current way of workings, for example better training material on project managerial documents and templates that should be filled. The rest of the project management issues fits perfectly in line with the theory presented in chapter 2.3. To optimise the challenges one would need to take an even deeper theoretical approach to provide some alternative solutions to current challenges.

- **Quality in general**

Even though the quality in general question holds no analytic value it is always interesting to check the overall feeling in the team on topics like quality management. The results clearly shows that the team has a very positive mindset regarding quality improvements on the deliverables towards the customer and the general development within both the team and the development for themselves as leaders, hence also why the team might be so active in continuously improving their overall quality and efficient way of working.

6. Recommended future work

The recommended future work was compressed into a practical excel sheet that is available for the target team. This document is based on the research questions not presented in the results chapter of this study. Said questions can be found among the full list of questions, Either in chapter 3.3 or appendix A (That is, the questions that are typically giving an answer to the already stated problem in all the sub-questions throughout appendix A). The reasoning for not including these questions in the study is that those are the CDE's personal ideas on what would fix the specific problem they had in mind, thus only giving an idea in one or a few of the specific improvement areas. Hence all these improvement ideas were analysed and collected in a single document to be investigated point by point within the team. A total of 48 improvement ideas regarding quality improvement were collected and sorted into four main improvement categories: Way of working, Quality, Design and Deliverables. These improvement ideas were then further split into several subcategories. This delivered document will be managed as a live document (i.e., always updated internally through the document system to be able to track the points case by case as they are handled). This document therefore starts a new way of working to promote the quality management, that is, if created document continues to be utilised within the team.

Stress management and stress management methods is treated as a separate item and was as mentioned in the conclusions excluded from the scope of this study. The research question is simply too big to be considered in this study and was vastly underestimated when the frameworks of this thesis were made. The theory and implementation behind this question is by itself a study on its own and therefore stress management, stress management systems, and stress optimisation is recommended to be done as a separate study.

7. Discussion

In my opinion, the time range, amount, and diversity throughout the sources used for the study is reliable, as there is consistency among the different writers even though they are for example written in USA and UK on the same topic.

As stated, the “Stress and quality” questions in appendix A was vastly underestimated when the research questions were made. However, there was an idea behind the questions. To get insights in how the CDE’s manage the quality management parts when stressed. However, the research question was asked to broad, and the result was completely different than thought of. The mistake could have been avoided if it were caught in the review phase of the interview questions or if a test interview would have been held and analysed before fully committing to the interviews. However, it does not in any way hinder the study itself, it just sliced of a tiny portion that was also meant to be investigated. Furthermore, if the team continue with the recommendation of studying stress as a separate study, the questions will inevitable be raised again and be answered in that study.

The main purpose of this thesis was to investigate and clarify the role of CDEs regarding current way of working with primary focus on quality. In my opinion, I have fulfilled the primary purpose as I have documented the current way of working that affects quality and quality management by the team. In addition to the primary purpose, many different recommendations regarding future work were collected throughout the study.

The secondary purpose was to create a first version of a document dedicated to quality and the creation of intro material to new team members to ease the overwhelming amount of information available for the CDE. Both which are created in Citec’s document system and as a “live” document for some time as they will be updated according to CDE comments for some time to come due to the needs of the CDE’s daily work. The documents are also considered as live documents as they should be used as a tool of information, and there will be a need to constantly update the documents for them to keep their practical value.

References

[1] Citec Oy Ab, “citec.com,” [Online]. Available: https://www.citec.com/about-us/citecs-history/. [Accessed 28 March 2023].

[2] Citec Oy Ab, “citec.com,” [Online]. Available: https://www.citec.com/about-us/. [Accessed 28 March 2023].

[3] Citec Oy Ab, “citec.com,” [Online]. Available: https://www.citec.com/engineering-and-technical-documentation-services-offering/. [Accessed 28 March 2023].

[4] Citec Oy Ab, “citec.com,” [Online]. Available: https://www.citec.com/references/. [Accessed 28 March 2023].

[5] Oxford English Dictionary, [Online]. Available: https://www.oxfordlearnersdictionaries.com/definition/english/engineering?q=engineering. [Accessed 28 march 2023].

[6] Norwich University, “online.norwich.edu,” 8 October 2018. [Online]. Available: https://online.norwich.edu/academic-programs/resources/7-man-made-engineering-wonders-ancient-world. [Accessed 28 March 2023].

[7] Burj Khalifa Emaar, “burjkhalifa.ae,” [Online]. Available: https://www.burjkhalifa.ae/en/the-tower/design-construction/. [Accessed 28 March 2023].

[8] K. Vyas, “interestingengineering.com,” 18 January 2021. [Online]. Available: https://interestingengineering.com/innovation/23-engineering-disasters-of-all-time. [Accessed 28 March 2023].

[9] *André Lassfolk, Own design.*

[10] A. Nieto-Rodriguez, “Harvard Business Review Project Management Handbook,” in *Harvard Business Review Project Management Handbook : How to Launch, Lead, and Sponsor Successful Projects*, Boston, Massachusetts, Harvard Business School Publishing, 2021, ebook. Chapter 2.

[11] M. Elizabeth, “www.allthescience.org,” 26 March 2023. [Online]. Available: https://www.allthescience.org/what-are-engineering-projects.htm. [Accessed 28 April 2023].

[12] R. Luecke, “Managing Projects Large and Small,” in *Managing Projects Large and Small: The Fundamental Skills for Delivering on Budget and on Time*, Boston, Massachusetts, Harvard Business School Press, 2004, pp. 13–38.

[13] S. N. a. S. Kelly, “The Definitive Guide to Project Management: The Fast Track to Getting the Job Done on Time and on Budget,” Harlow, PEARSON EDUCATION LIMITED, 2007, pp. 72–74.

[14] B. Tracey, “How the Best Leaders Lead: Proven Secrets to Getting the Most Out of Yourself and Others,” American Management Association, 2010, pp. 149–150.

[15] P. McManus, “Coaching People : Expert Solutions to Everyday Challenges,” Boston, Massachusetts, Harvard Business School Press, 2006, pp. 19–46.

[16] B. M. Bass, “Bass & Stogdill´s Handbook of Leadership,” New york, The free press, 1990, pp. 6–16.

[17] O. E. Dictionary, Oxford English Dictionary, 2021.

[18] K. Kruse, “www.forbes.com,” 9 April 2013. [Online]. Available: https://www.forbes.com/sites/kevinkruse/2013/04/09/what-is-leadership/?sh=30a6b51a5b90. [Accessed 1 May 2023].

[19] S. Wilson, “Thinking Differently about Leadership: A Critical History of Leadership Studies,” Glos, UK, Edwards Elgar Publishing Limited, 2016, pp. 17–18.

[20] D. P. Badcock, "www.researchoutreach.org," 15 November 2019. [Online]. Available: https://researchoutreach.org/articles/explaining-how-the-mind-works-new-theory/. [Accessed 1 May 2023].

[21] J. Barling, “The Science of Leadership - Lessons from Research for Organizational Leaders,” USA, Oxford University Press, 2014, pp. 1–25.

[22] B. N. Warren Bennis, “Leaders - Strategies for Taking Charge,” 1985, pp. 21–52.

[23] J. Graham, “Technique, common sense & Self-Confdence - Outdoor leadership,” Seattle, The mountaineers, 1997, p. 9.

[24] K. Kruse, “forbes.com,” 16 October 2012. [Online]. Available: https://www.forbes.com/sites/kevinkruse/2012/10/16/quotes-on-leadership/?sh=38eccb402feb. [Accessed 1 May 2023].

[25] C. G. a. P. Riès, “Shift,” in *Shift: Inside Nissan's Historic Revival*, 2005, pp. 152–153.

[26] R. Luecke, “Managing Projects Large and Small,” in *Managing Projects Large and Small: The Fundamental Skills for Delivering on Budget and on Time*, Boston, Massachusetts, Harvard Business School Press, 2004, p. xi.

[27] h. b. r. press, in *Managing Projects*, Boston, Massachusetts, Harvard Business School Publishing Corporation, 2014, pp. 2–8.

[28] R. Luecke, “Managing Projects Large and Small,” in *Managing Projects Large and Small: The Fundamental Skills for Delivering on Budget and on Time*, Boston, Massachusetts, Harvard Business School Press, 2004, pp. 49–67.

[29] N. Brunsson, The consequences of decision-making, New york: Oxford University Press Inc., 2007.

[30] R. Luecke, “Managing Projects Large and Small,” in *Managing Projects Large and Small: The Fundamental Skills for Delivering on Budget and on Time*, Boston, Massachusetts, Harvard Business School Press, 2004, pp. 69–79.

[31] R. Luecke, “Managing Projects Large and Small,” in *Managing Projects Large and Small: The Fundamental Skills for Delivering on Budget and on Time*, Boston, Massachusetts, Harvard Business School Press, 2004, pp. 129–144.

[32] h. b. r. press, in *Managing Projects*, Boston, Massachusetts, Harvard Business School Publishing Corporation, 2014, pp. 63–74.

[33] [Online]. Available: https://www.nibusinessinfo.co.uk/content/quality-management-standards. [Accessed 18 May 2023].

[34] “www.united-bim.com,” [Online]. Available: https://www.united-bim.com/practical-approach-to-level-of-detail/. [Accessed 18 May 2023].

[35] “attitude.citec.com,” 12 September 2018. [Online]. Available: https://attitude.citec.com/2018/09/12/gate-gate-towards-excellent-projects/. [Accessed 18 May 2023].

[36] Wrike, [Online]. Available: https://www.wrike.com/project-management-guide/faq/what-is-project-management-system/. [Accessed 18 May 2023].

[37] D. Partington, “Essential Skills for Managment Research,” London, SAGE Publications Ltd, 2002, pp. 109–115.

Interview questions

Part A – The CDE role and typical way of working

1. Background information, how long have you been working as a chief design engineer (CDE) and roughly how many projects have you done?
2. What is the mechanical CDE's role in the project?
3. If you imagine yourself to be a fresh CDE in the mechanical team,
   a) what is the biggest challenge with the CDE role?
   b) what should you focus most on as a fresh CDE?
   c) what tips would you like to be given?
   d) how would you like to be introduced to the CDE task?
4. The daily Way of working as a CDE
   a) Describe a typical workday as a CDE
   b) How do you work to keep tasks organised, follow up progress and meet deadlines?
   c) How do you tackle a delivery schedule request on your scope that is simply not possible to fulfil?
5. If we were to implement some kind of document to help with the daily work as a CDE that could help improve quality and work as an introduction platform to a new mechanical CDE,
   a) what format would you like this document to be in? (Word, excel, software…)
   b) what do you think this document MUST contain to be helpful?
   c) how detailed do you think the information in this document needs to be?

Part B – Quality, project management and project delivery

6. Correct quality levels are often discussed in today's engineering world (i.e., keeping the level of detail on a reasonable level) (e.g., ensuring the quality output needs of the ordered design, the needed level of detail to ensure smooth transition between basic and detail design and generally ensuring correct quality throughout all stages of the project). Now, focusing on correct quality for mechanical
   a) How do you ensure that you keep the quality levels on a correct level throughout projects?
   b) What are the biggest challenges to keep correct quality levels during basic design phase (e.g., start master layouts with enough info, lock master layouts for detail design at correct time, gather information within a reasonable time and so on)?
   c) What could be done to make it easier to keep correct quality levels during basic design?
   d) What are the biggest challenges to keep correct quality levels during detail design?

e) What could be done to make it easier to keep correct quality levels during detail design?
f) What are the biggest challenges to keep correct quality levels for mechanical deliverables?
g) What could be done to make it easier to keep correct quality levels for the deliverables?

7. Thinking about your recent projects, specifically the design phase,
   a) on a scale from 0–100 (0 = Terrible, 100 = Perfect), on what level would you typically put the general quality level of the mechanical design in any project?
   b) what are the main reasons for your given grade?
   c) what do you think needs to be improved to get better quality levels?
   d) what do you see would be the biggest issue in raising the quality levels?

8. With the same projects in mind, but now focusing only on mechanical deliverables (e.g. layouts, isometrics and manufacturing drawings),
   a) on a scale from 0–100 (0 = Terrible, 100 = Perfect), on what level would you typically put the general quality level of the deliverables in a general project?
   b) what are the main reasons for your given grade?
   c) what do you think needs to be improved to get better quality levels?
   d) what do you see would be the biggest issue in raising the quality levels?
9. Stress and Quality
   a) How often would you say that you cut back in <u>design quality</u> because of time constraints or other project load related stress?
   b) How often would you say that you cut back in <u>quality checking</u> because of time constraints or other project load related stress?
   c) What are the main stress factors of your daily work?
   d) How do you work to minimize stress related quality issues?
   e) What would you need to further improve quality when considering stress?

10. Project management done as a mechanical CDE
    a) On a general level, how big percentage of your daily work would you say is project management/project delivery?
    b) What are the biggest challenges with the project management part?
    c) What do you think could be improved with the current project management way of working for the mechanical CDE?

11. On a general level, looking back on all projects you have done as a CDE,
    a) would you say the quality has improved or declined over the years?
    b) what do you believe are the reasons for the said quality change?

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Participant information sheet and consent form

Information for those who participate in the study "Ensuring quality in a fast-paced engineering world". The study is done as a master's degree project at Novia University of Applied Sciences and is carried out by Industrial Management and Engineering student André Lassfolk.

The study will consist of an interview, which is either carried out by a face-to-face meeting or via Microsoft Teams. By signing this document, you confirm that you are ok with the interview being recorded, transcribed and analysed. There will be anonymous quotes from the interviews in the finished thesis. Personal data and collected material will be treated confidentially and privacy will be considered. Your participation is voluntary, and you have the right to cancel your participation at any time without reason. After the study is completed, all collected material will be destroyed. The thesis will then be published publicly on www.theseus.fi.

I have understood the meaning of the information above and consent to participate in the study.

Signature	Location
Name clarification	Date

Thank you for your participation!

Student
André Lassfolk

Supervisor Novia
Mikael Ehrs