Bachelor's thesis

NTNU
Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
Department of Computer Science

Andreas Torkildsen Hjertaker
Irnis Besirovic

# Project Management in Industrial Applications of Machine Learning

## What are the Success Criteria for Project Management in Industrial Applications of Machine Learning?

Bachelor's thesis in Digital Business Development
Supervisor: Xiaomeng Su
May 2022

NTNU
Kunnskap for en bedre verden

Andreas Torkildsen Hjertaker
Irnis Besirovic

# Project Management in Industrial Applications of Machine Learning

## What are the Success Criteria for Project Management in Industrial Applications of Machine Learning?

Bachelor's thesis in Digital Business Development
Supervisor: Xiaomeng Su
May 2022

Norwegian University of Science and Technology
Faculty of Information Technology and Electrical Engineering
Department of Computer Science

NTNU
Norwegian University of
Science and Technology

[THIS PAGE IS INTENTIONALLY LEFT BLANK]

# Preface

To the reader,

This paper is the culmination of a three-year bachelor's degree program in Digital Business Development at the Norwegian University of Science and Technology (NTNU) in Trondheim. We chose this problem formulation because we found Project Management and Business Information Systems, Big Data, Digital Change, and Transformation exciting and wanted to build synergies between the subjects.

We want to express our gratitude to Cognite for the opportunity to carry out our thesis in collaboration with them and to Petter Svingen, our contact in Cognite, for his assistance and input during the semester. Additionally, we would also thank the PMs that we got to interview for their sharing of experience and knowledge within the field.

Thanks to our supervisor Xiaomeng Su, for her assistance and input during the semester. In addition, we would like to thank Hasan Besirovic and Oda Steinland Skaug for taking the time to read a draft and give comments on our thesis. Finally, we would like to thank our families for their unwavering support and encouragement, not just during the thesis writing process but throughout our whole study period. It is much appreciated.

May 20, 2022
Andreas Torkildsen Hjertaker and Irnis Besirovic

[THIS PAGE IS INTENTIONALLY LEFT BLANK]

# Abstract

With the increased usage of *Machine Learning* (ML) in settings such as the *industrial field*, there is a need to manage these projects properly to ensure a successful outcome and understand the criteria for such success. *Project management* is a field that has emerged to ensure the goals of projects are met through the utilization of specific project-relevant knowledge, tools, and techniques. The purpose of this thesis is to investigate what are the success criteria for Project Management in Industrial Applications of Machine Learning. As project management is a broad subject, four focus areas that are of particular relevance were chosen for the thesis: *Quality Management, Risk Management, Stakeholder Management, and Change Management.*

This thesis is based on a case study with qualitative data from eight semi-structured interviews. Interviews with Project Managers (PM) are used to understand the first-hand experience of essential factors in ML projects within the industrial field. Combined with theory from related studies, our research has shown that the chosen four focus areas hold elements of importance to project management. Several factors impact the success of an ML project due to the *complexity and uncertainty* of these kinds of projects. Some project success criteria discovered in this research are more generic and applicable to many other types of projects, such as those related to various aspects of *customer satisfaction and project time, cost, and scope*. Other success criteria are relatively unique to ML projects, such as having the appropriate *competencies, managing customer expectations, and ensuring data quality*. Finally, project management of ML in industrial applications is a field that has yet to be extensively explored, and the results are limited to a narrow scope with success as a measurement.

[THIS PAGE IS INTENTIONALLY LEFT BLANK]

# Sammendrag

Økt bruk av maskinlæring i industri skaper behov for å lede prosjektleveransene til suksess og forstå hva kriteriene for slik suksess er. *Prosjektledelse* er et praktisk fagfelt som har vokst frem for å sikre prosjektets mål hvor benyttelse av relevant kunnskap, verktøy og teknikker skaper verdi. Hensikten med denne oppgaven er å undersøke hva som er suksesskriteriene for Prosjektledelse innen Industrielle Applikasjoner av Maskinlæring. Ettersom prosjektledelse er et bredt fag, er det valgt fire fokusområder som vil få oppmerksomhet i løpet av oppgaven: *Kvalitetsstyring*, *Risikostyring*, *Interessentledelse* og *Endringsledelse*.

Denne oppgaven er basert på en casestudie med kvalitative data fra åtte semistrukturerte intervjuer. Teori og empiri brukes om hverandre med en abduktiv tilnærming til å besvare problemstillingen. Intervjuene som gjennomføres brukes til å bedre forstå de vesentlige faktorene i maskinlæring-prosjekter innenfor industrifeltet. Resultatene har vist at alle de valgte fokusområdene inneholder elementer av betydning for prosjektledelse. Noen faktorer påvirker suksess ved et maskinlærings-prosjekt på grunn av *kompleksiteten og usikkerheten* som kommer naturlig i maskinlæring. Slike prosjekter sine sentrale suksesskriterier er behandlet i denne forskningen og relatert til ulike aspekter av *kundetilfredshet og prosjekttid, kostnad og omfang,* mens suksesskriterier som er mer unike for maskinlæring inkluderer å *bruke agile metoder, besitte relevant kompetanse, behandle kundenes forventninger og sikre datakvaliteten.* Imidlertid er prosjektledelse av maskinlæring i industrielle applikasjoner et felt som fremdeles ikke har blitt grundig utforsket, og resultatene her er begrenset til et relativt begrenset omfang med suksess som målingsenhet.

# Table of Contents

# List of Figures



# List of Tables

# List of Acronyms

| | |
|---|---|
| NTNU | Norwegian University of Science and Technology |
| PM | Project Manager |
| ML | Machine Learning |
| PRINCE2 | PRojects IN Controlled Environments |
| CDF | Cognite Data Fusion |

# 1 Introduction

Industrial application of Machine Learning (ML) is emerging as new technology allows existing industries to be more efficient. Improved efficiency has an enormous impact because industries often represent the backbone of society with substantial cash flows. Larrañaga (2018) reports that the fourth industrial revolution, also called industry 4.0, is underway. With the help of emerging digital technologies, large companies can gather and analyze data from across manufacturing units, lines, and sites (Larrañaga et al., 2018). Industry 4.0 includes data exploration using intelligent technologies like ML automation (Sarker, 2021), and everyday actions become something the ML system can learn from and improve (Alzubi et al., 2018).

Companies implementing such a system require awareness and focus on the success criteria to be efficient in the long run. Implementation is often done through a project delivery from a specialized external company. A *project* is defined as achieving a goal through a series of activities and tasks with defined start and end dates, and project management is the process of achieving the project's goals (Munns & Bjeirmi, 1996). Understanding how to cope with ML-specific considerations in project management is necessary for the project's success. This work set out to contribute to such an understanding through a case study on Cognite, a leading software company specializing in ML enhanced industrial applications.

This thesis begins by reviewing the literature on what makes a project successful, the success criteria for project management, and the ML industrial application. It was soon noticed that ML in industrial application is an emerging field that has not been extensively studied. That makes our work both somewhat tricky but also relevant and timely. Due to the lack of ML-specific material, we have decided to use James Cadle and Donald Yeates's book Project management for information systems (2008), where success criteria for project management in software applications are introduced. By researching the success criteria for project management for information systems and conducting interviews as a case study with Cognite, we uncovered details about the success criteria for project management in industrial applications of ML. Project management covers various topics, and not all of them are equally critical for our study. Based on a literature review and pilot interview with a Project Manager (PM) and supervisor from Cognite, Petter Svingen, we agreed on four focus areas

that are of most relevance to our study. These four areas are quality management, risk management, stakeholder management, and change management.

## 1.1 Research Question

To help concretize the study and focus on the most pertinent subjects, the thesis will attempt to answer two main questions:

- What are the criteria for successful project management in industrial applications of ML with respect to quality management, risk management, stakeholder management, and change management?
- How are these criteria ensured?

The thesis has focused on what defines a successful project and whether the focus areas contain essential elements of success, what they are, and how they are ensured. At a more specific level, the thesis also tries to identify the ML-specific considerations in each area and in general while looking for patterns of success criteria across the focus areas.

## 1.2 Scope

The literature review and pilot interview indicate that the selected focus areas are some of the main success criteria for project management in software applications. Due to the scarcity of research on success criteria for project management in industrial applications of ML, we studied the literature on standard practices of project management in software applications and other Information Systems/Information Technologies. These practices could be compared, as ML projects fall into this category.

## 1.3 Case Organization

Cognite is a global industrial software as a service (SaaS) firm founded in 2016 and based in Oslo, Norway, with locations in Tokyo, Japan, and Austin and Houston, Texas. They are assisting with the full-scale digital transformation of asset-heavy industries worldwide, partly ML fueled. By freeing, contextualizing, and making industrial data actionable for users, their technologies convert them into customer value, acting as a supplier of the industry 4.0 technologies.

Software engineers, product managers, designers, domain experts, and commercial professionals are working together under the management of a PM to take the industrial revolution onward. Working directly with customers, they provide industrial users with insightful access to contextualized data for the first time. Their Industrial DataOps platform and core technology, Cognite Data Fusion (CDF), enables data and domain users to cooperate in developing, operationalizing and scaling industrial ML solutions and applications (Cognite, n.d.).

Their teams work on a project basis with ML deliveries to companies like Aker BP, Saudi Aramco, and other sizable industry players. Project delivery is based on customers' data points and might result in a live dashboard solution, anomaly detection, or digital twins. Many of their projects are arguably ML projects, which the foundation of the CDF platform empowers. Hence, Cognite qualifies in large part for being a case study for this thesis, and luckily, we got a data basis on interviews with eight of their project managers.

## 1.4 Outline of Thesis

Chapter 2 begins with an overview of the research methodology used in the thesis. Methods are discussed, along with justifications. In the conclusion of chapter 2, a discussion of the difficulties of reliability and validity is included. Chapter 3 introduces fundamental principles in project success, project management, ML, and industrial applications. Additionally, an in-depth examination of the four focus areas selected is conducted based on findings from the literature, which lays the groundwork for the subsequent study in chapter 4 of the results. The results section provides the findings from the interviews conducted.
Furthermore, in chapter 5, the discussion highlights exciting findings, with correlations and differences between literature and our research. The current best practices and the findings from the interviews are emphasized. Finally, the publication finishes with a review of the significant findings, limitations, and recommendations for further research.

# 2 Research Methodology

Theoretical debate and argumentation are systematic processes that are founded on fundamental principles of logic and language use:

- **Precision** in applying concepts and language formulations, including the use of standard terminology in the subject area, definitions of essential concepts, and explicitly stated reasoning regarding these concepts and their relationships.
- The argument's **validity** emphasizes tenable premises and the logical relationship between these premises and the argument's implications or conclusions.
- **Completeness** in the argumentation, considering and evaluating all essential factors. (Grønmo, 2021)

## 2.1 Research Approach

This thesis uses the *qualitative* approach, which is a way to learn about a particular group of people, known as a sample population (PMs in this case), and relies on observed or measured data to examine questions about the sample population (Grønmo, 2021). One does not evaluate the prevalence of anything in qualitative research but seeks to identify patterns, behaviors to the circumstances, and the dynamics that function. In contrast, *quantitative* research establishes that something occurs, whereas qualitative research elucidates why (Hoffmann, 2013). Hence, the latter is more suitable for our problem formulation, as this thesis aims to understand the project management of ML in industrial applications in depth.

## 2.2 Research Design and Methods

The authors, PMs, and stakeholders will have varying perspectives on what can be accomplished. We can better understand project management and its potential obstacles by working with existing literature and others' experiences. The thesis studies the case company in detail and begins with a hermeneutic perspective based on interviews, concentrating on the meaning content of the research findings and interviewee contributions. Interpretation is intensive and in-depth, with a few interview units and detailed information from each unit. Daniel Little reports that the hermeneutic approach indicates that the most basic fact of social life is the meaning of an action, as social actions constitute social life. Actions are meaningful

to the actors and the other social participants (Little, 2008). Hence, the hermeneutic perspective is central to the gathered data and our results.

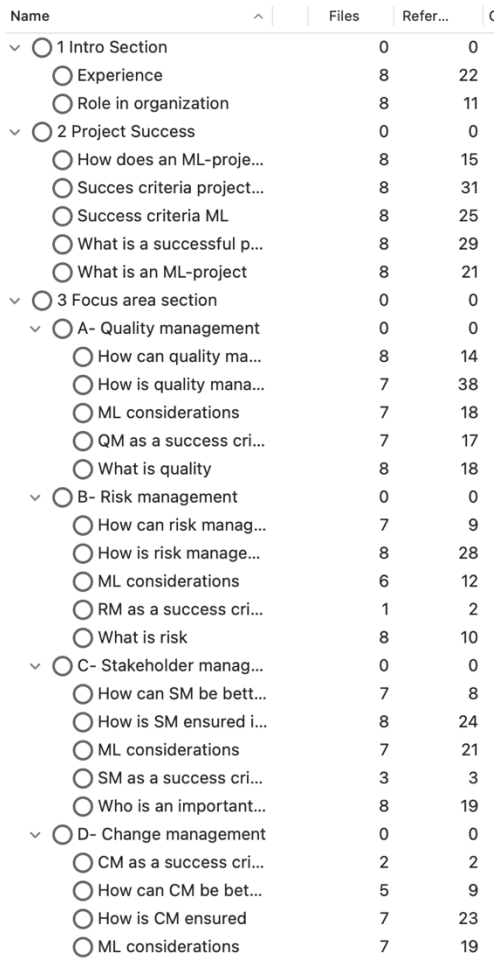
We have already formed opinions on the theme's actuality due to our studies and experiences in other disciplines. As a result, an inductive approach will be detrimental to the thesis. Furthermore, a purely deductive method based on established theory does not suit well because the topic is relatively unexplored, and the theory cannot always be accurate. As a result, we employ an abductive technique called SDI.

SDI: Gradual-deductive inductive method (Tjora, 2021) is a sequential procedure that employs inductive and deductive reasoning. Inductive methods are used in data analysis to generate theory and feedback, whereas deductive methods compare the theoretical analysis to empirical facts. The theoretical starting point is updated as empirical evidence is gathered, and the data gathering process is altered as new theories are produced in this case (Busch, 2013, p. 51). SDI was incorporated into an iterative and progressive approach that got operationalized and improved our ability to see connections, adjust, and produce a more reflective output.

This research utilized eight semi-structured interviews on a 45–60-minute basis to assist the researchers in obtaining critical quality data. The interview is a source of determining how much knowledge the respective PMs possess regarding what theory refers to as success criteria and a high level of their adherence to them. The interviews aided the research by confirming or disclosing the distinction between the PMs' experience and literature statement management. The research focused on the project management of ML in industrial applications. In contrast, most literature frequently takes a broad view of general project management or information systems/information technology considerations.

After the interviews were conducted, they were transcribed into eight comprehensive documents. We utilized the tool NVivo as we encoded statements from the transcripts for the analysis before the results. Encoding is reflected in the results, as all conclusions directly or indirectly originate from statements in the analysis. No arguments are presented as a product of our interpretations, as the sections remain almost directly quotable. To emphasize this, we supplemented the results with direct quotes where we found them suitable. Then our discussions are presented as a mashup of theoretical literature and empirical research

material. Hence, the conclusion should reflect weighted filtering of the most important or relevant aspects to the problem formulation. Contrary to the initial code-structured grouping, the result was grouped into focus areas and frequently mentioned aspects to improve readability. The code structure can be shown in figure 2.1.



| Name | Files | Refer... |
|---|---|---|
| 1 Intro Section | 0 | 0 |
| Experience | 8 | 22 |
| Role in organization | 8 | 11 |
| 2 Project Success | 0 | 0 |
| How does an ML-proje... | 8 | 15 |
| Succes criteria project... | 8 | 31 |
| Success criteria ML | 8 | 25 |
| What is a successful p... | 8 | 29 |
| What is an ML-project | 8 | 21 |
| 3 Focus area section | 0 | 0 |
| A- Quality management | 0 | 0 |
| How can quality ma... | 8 | 14 |
| How is quality mana... | 7 | 38 |
| ML considerations | 7 | 18 |
| QM as a success cri... | 7 | 17 |
| What is quality | 8 | 18 |
| B- Risk management | 0 | 0 |
| How can risk manag... | 7 | 9 |
| How is risk manage... | 8 | 28 |
| ML considerations | 6 | 12 |
| RM as a success cri... | 1 | 2 |
| What is risk | 8 | 10 |
| C- Stakeholder manag... | 0 | 0 |
| How can SM be bett... | 7 | 8 |
| How is SM ensured i... | 8 | 24 |
| ML considerations | 7 | 21 |
| SM as a success cri... | 3 | 3 |
| Who is an important... | 8 | 19 |
| D- Change management | 0 | 0 |
| CM as a success cri... | 2 | 2 |
| How can CM be bet... | 5 | 9 |
| How is CM ensured | 7 | 23 |
| ML considerations | 7 | 19 |

*Figure 2.1: Code structure of interviews*

## 2.3 Quality and Limitations

The approach influences the overall quality of the study, which determines if the results can be trusted. Busch (2013, pp. 61–62) identifies three factors of a method's overall quality:

1. **Reliability** is connected to the measurement quality and the degree to which we can trust the mapped data. The data we have comes directly from Cognite, as we obtained data directly from the source during the interviews. There is always the possibility of

misinterpretation of what is stated here, but we were asked follow-up and clarifying questions while both sides were virtually present.

2. **Validity** is determined by how we analyze and is more concerned with the data's applicability to our problem. At this stage, we should frequently have a more extensive database due to combining numerous data collection methods. When a phenomenon is based on records generated by aligned individuals, it is straightforward to obtain an unvarnished image.

3. **Transferability** refers to our ability to apply our findings to similar situations. While each project is unique, several share a common framework. Parallels in scope, time, cost, and desired gain can be observed. Due to the context and circumstances surrounding the data collection at Cognite, it will likely be easier to form a generalization than for projects at other firms. The thesis's validity is examined, and we have attempted to be systematic in our criticism throughout this thesis. It has been attempted to maintain reflexivity through an open exposition of the process and conversation.

We have attempted to protect the confidentiality of our informants by avoiding the use of names or other personally identifiable information. Although the selection of employees is limited, we have taken care not to provide anything from the interview that could cast the employees in poor light or result in undesirable consequences.

# 3 Literature Review

We chose to do a preliminary literature review of ML, project success, and project management with different methodologies. The Projects In Controlled Environments *(PRINCE2) Agile* framework gets introduced as it combines qualities from more methods, and the results indicate that Cognite leverages this. Moreover, we introduce a review of the four focus areas to learn how to ensure and standardize these aspects according to existing literature.

## 3.1 Machine Learning in Industrial Applications

ML is an algorithm that tries to emulate human intelligence by observing its environment. The techniques have been successfully used in various fields, including pattern recognition, computer vision, aerospace engineering, finance, entertainment, and computational biology (Issam & Murphy, 2015). These techniques are often viewed as complex. The term "black box" frequently gets initiated at issue and refers to models that are so complex that they are not easily interpretable by humans (Petch et al., 2022). According to Jordan and Mitchell (2015), machine learning is focused on one challenge when designing computer systems that automatically learn from experience.

ML is essential for addressing important scientific and technical questions and building beneficial computer applications. ML has evolved from a scientific curiosity to a widely used method in the industry throughout the last two decades. Its data utilization is becoming the dominant method of developing helpful software for computer vision, speech recognition, natural language processing, robot control, and other artificial intelligence applications (AI). Many applications find it challenging to manually develop a system by predicting the appropriate response to all potential inputs. ML has a broad influence on computer science and data-intensive industries such as consumer services, complex system diagnostics, supply chain management, and other industrial applications (Jordan & Mitchell, 2015).

Industrial applications are custom-built to meet the exceptionally high reliability and cost-effectiveness requirements (Halozan, 1990). These applications can take on various forms, including process control, factory automation, energy management, and application development (Tariyal & Cherin, 2003). Numerous studies indicate that ML is one of the

primary facilitators for evolving a traditional production system to the industry 4.0 level (Bertolini et al., 2021).

The fourth industrial revolution, often known as Industry 4.0, is characterized by the fast development and maturity of new information and communication technologies (ICT) applied to industrial processes and products. Data scientists can now extract valuable insights from monitored assets using intelligent monitoring and data fusion strategies and ML and optimization approaches. One of the critical goals of data science in this setting is to detect unusual behavior in industrial gear, sensors, and processes (Diez-Olivan et al., 2019). In Industry 4.0, ML has a significant impact on production. ML techniques extract meaningful insights from collected data, allowing increased production efficiency without requiring significant resource changes (Rai et al., 2021). Solutions such as failure prediction are increasingly being bought, utilized, and delivered in a project-based process (Leukel et al., 2021).

## 3.2 The Project

The success of a project is a critical issue in project management, yet there is little consensus on the criteria for success. Many projects we hear about in the news are either over budget, late, or inadequate (Robert et al., 2008). A project is a temporal organization that consists of a single distinct task carried out by a team within a specified time frame. It is essential to recognize that projects are intricate activity systems in which context is critical. Working with abstract and built things like computers, software, and other technical instruments requires bridging borders to work efficiently and successfully (Maaninen-Olssona & Mullern, 2009).

*Cost, scope, and time* are frequently used as project success criteria. A project is successful if completed on time and within budget while meeting its stated scope (Asana, n.d.). The triangle in Figure 3.1 shows how these three variables are interconnected; changing one affects the other two.

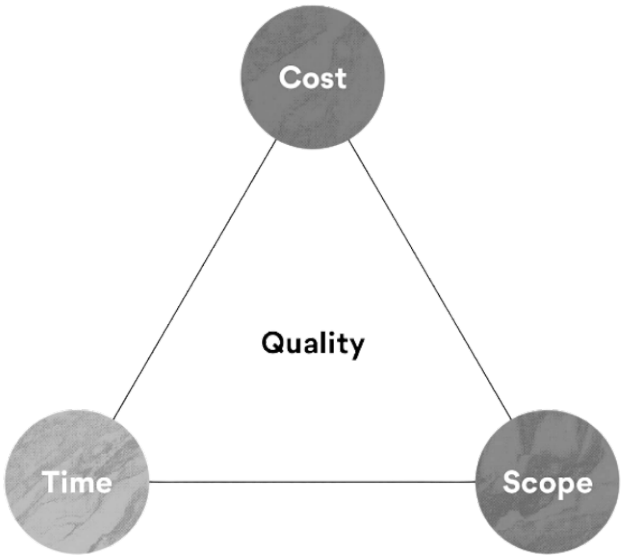



*Figure 3.1: The iron triangle of project management (Asana, n.d.)*

**Scope** refers to the project's 'scale' in terms of the project's quality, detail, and scope of deliverables. As the project's scope grows, it will necessitate additional time and resources to accomplish. The following are examples of project scope elements:

- Complexity of the project
- Finished product quantity(s)
- Quality of the output
- Resilience (e.g., the number of simultaneous users an app can support)
- Level of precision
- The number of elements and their complexity

**Cost** is not restricted to financial quantities for the project triangle. This triangle point, also known as 'resources,' contains all the tools, equipment, and support needed to finish the project. The following are examples of scope elements:

- Monetary budget
- The total number of team members
- Infrastructure and equipment
- Important possibilities

**Time** is important to keep in mind when it comes to both the amount of time and the type of time. Extended deadlines, changes to team calendar software, the deletion of planning phases, and other tradeoffs may be required. The following are examples of time elements:

- Timeline for the entire project
- Working hours on the project
- Goalposts and internal calendars
- Planning and strategy time provided.
- Phases of the project

## 3.3 Project Management

A changing, complex, and unpredictable environment necessitates project management. Project management is widely acknowledged as requiring tools and techniques. Stakeholders remain disappointed despite practitioners' tireless efforts. PMs are all too familiar with failed projects (Lavagnon, 2009).

Opland (2021) discussed the project of balancing *leadership and administration* during a project management and business information systems class at NTNU. Leadership often emphasizes interpersonal skills and emotional engagement. A leader encourages reasonable effort, takes personal responsibility for work tasks, and actively pursues goals. Additionally, it inspires commitment and thrives in ambiguity. On the other hand, the administrator often distances himself from the interpersonal and emotional aspects of administration. This role coordinates, controls, and communicates within defined frameworks of responsibility and authority. Administrators contribute to the organization's security, order, and structure. A PM must balance administrative and leadership responsibilities within the project team (Opland, 2021). An illustration of this balance is shown in Figure 3.2.

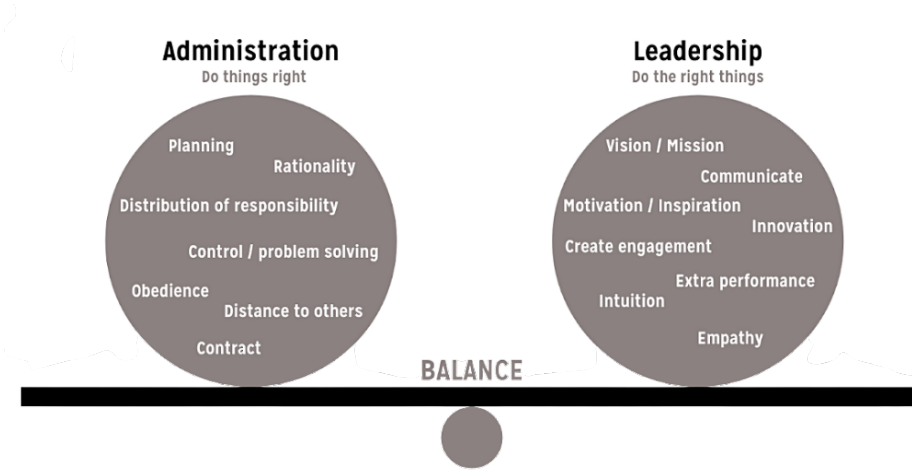



*Figure 3.2: Balance between administration and leadership*

Furthermore, PMs must meet three needs: *the tasks, team, and individuals* of a project, as shown in Figure 3.3. According to Opland (2021), the PM ensures that the tasks have been defined and plans out the workday in advance while allocating available resources and assigning different levels of responsibility to different people. This person is vital to maintain a record of progress and evaluate performance. Moreover, it retains control over the overall quality of the product as the delivery team achieves goals and objectives.

The PM establishes the team and its culture. First, it is responsible for setting effective operation techniques, as it establishes, enforces standards, and establishes lines of communication. Furthermore, it is essential to take responsibility for the training and development of the team.

Ultimately, the PM is responsible for individual growth and development, as it strives to balance the group's requirements and the individual's needs. It is essential to recognize and reward outstanding performance and assist when personal concerns emerge (Opland 2021).


*Figure 3.3: Three dimensions of project management*

Elaborating more on this triangle from a project management perspective gives a deeper understanding. The responsibility of the PM is to balance these three components to maintain the project under budget and on time while still meeting the project's scope (Asana, n.d.). Figure 3.4 illustrates the coherence of the constraints.

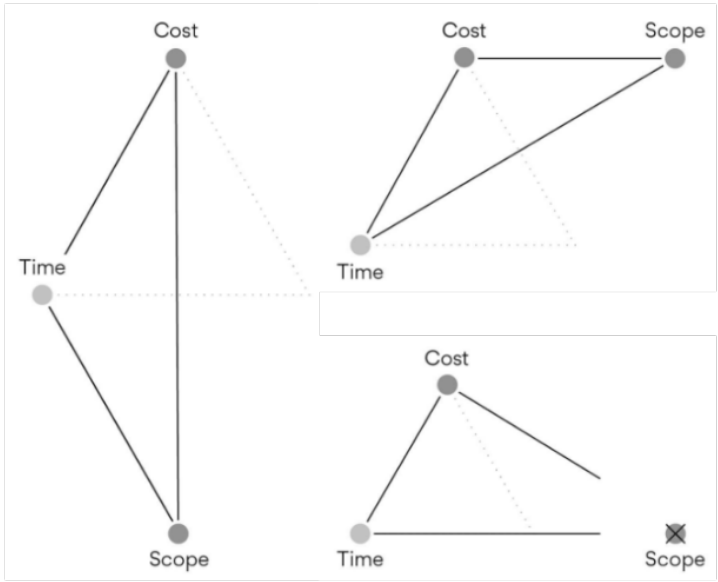



*Figure 3.4: Working with triple constraints (Asana, n.d.)*

## Methodologies of Project Management

The PMs can utilize methods for handling the quality triangle. Asana (n.d.) mentions different methods for *reducing project cost and project time while maintaining scope*. The project management strategies which prioritize practical resource usage will assist projects with stricter budgets and more flexibility in timelines. Waterfall and Lean are examples of such cost-reducing methodologies.

- **Waterfall** focuses on that project steps are performed in order, schedules must be flexible, as delays in one phase will necessitate changes in all following phases.
- **Lean** focuses on the lowest possible costs and resources, allowing for extended schedules or scope reductions to keep the project on track.

Other project management approaches can avoid unnecessary downtime and expedite project processes to keep teams moving quickly in instances where time is of importance. Agile, Scrum and Kanban are typical time-reducing methodologies.

- **Agile** prioritizes flexible procedures so that teams are ready to respond to change requests with minimal time or cost increases; organizations that follow this strategy may use agile management software.
- **Scrum** is a sort of agile project management that is most used in software development. It employs aspects of Scrum methodology such as sprints and daily team touch-bases to reduce time spent in work-in-progress stages.
- **Kanban:** minimizes work-in-progress time by using continuous, high-visibility collaborative procedures; teams using this method frequently use Kanban software.

Many programming organizations are adopting agile approaches to improve agility and time-to-market. These methods rely on collaborative techniques like pair programming, refactoring, and having customers work on-site as team members (Reifer, 2002). During a research Reifer (2002) surveyed fourteen companies to gather information on agile effectiveness. Seven of the fourteen firms that employed agile methodology gathered monetary cost, productivity, and quality statistics. Productivity, cost, and time-saving benchmarks are shown below.

- Increase in productivity: 15% to 23%
- Average cost savings of between 5% and 7%
- Compression of time to market: 25 to 50% less time than past projects at participating firms.

PRINCE2 is traditionally a process-based approach for project management, providing an easily tailored and scalable method for managing all types of projects. Each process is defined with its key inputs and outputs and the specific objectives to be achieved and activities to be carried out (ILX Group, n.d.). However, Nader (n.d.) introduced the PRINCE2 Agile concept as a tailored form of PRINCE2, suitable for environments such as Scrum.

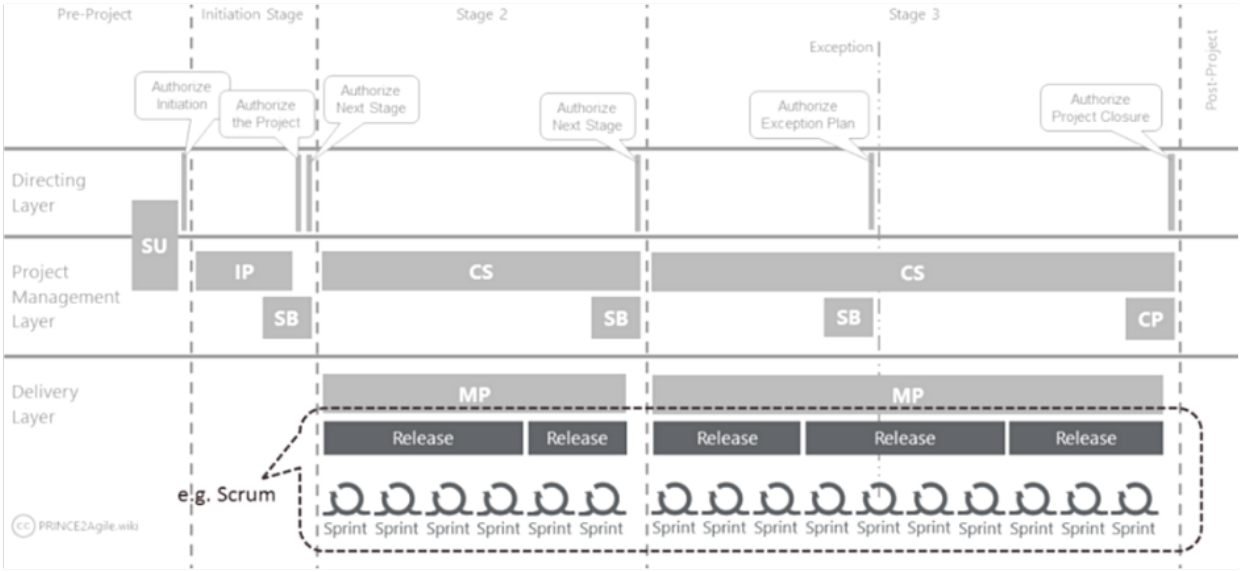



*Figure 3.5: Process model (Nader, n.d.)*

Figure 3.5 presupposes the adoption of Scrum at the delivery level, and the stages, releases, and sprints are merely examples. Stages are not Agile iterations but, like the traditional PRINCE2, are determined by the management requirements of the project. Each stage consists of one or more' releases,' each consisting of one or more 'iterations.'

In PRINCE2 Agile, the project's duration and cost should be fixed. As a result, the Contracts are structured as fixed-price agreements. When a consumer demands a new feature, the existing feature of the same size must be substituted. PRINCE2 Agile defines a set of behaviors and practices rather than an adaptive lifecycle. Members of the delivery team can

make minor adjustments if they do not disrupt the management products that have been configured (Nader, n.d.).

## 3.4 Quality Management

Quality management is about making organizations perform for their stakeholders, from enhancing products, services, systems, and processes to ensuring fit and effectiveness. Managing quality requires continuously improving what the organization does, and quality management is more than just producing defect-free widgets or ensuring trains arrive on time (Cadle & Yeates, 2008. P. 237). It is critical to ensure that everyone participating in a 'quality' working environment uses the phrase consistently. According to Gundersen and Halbo (2018), quality refers to the way things are or their inherent essence. When the term 'quality' refers to sensory sensations, it refers to their unique character. Quality is simply the capacity to meet the user's criteria and expectations for an object or service. In daily speech, 'quality' refers to good nature and desirable characteristics. In commerce, the quality of a product is frequently referred to as prime depending on the product's adopted standards. The Norwegian Standard, NS-EN ISO 9000, defines *quality* as to how a set of inherent characteristics satisfies stated, typically implied, or mandated needs or expectations (Gundersen & Halbo, 2018).

A well-controlled process does not guarantee the delivery of a 'quality' product. Looking at the *'Total quality management'* of Japanese industry, this 'quality culture' is embedded in the attitudes and behaviors of the entire workforce. The removal of hierarchical differences in the workplace, a commitment of all workers to the organization's objective, appropriate resources, and continuous improvement are evident results (Cadle & Yeates, 2008. P. 240). Figure 3.6 illustrates the interrelationships between people, processes, and outcomes. In other words, processes are how an organization uses its people's talents to achieve results. Total quality management literature tells us that customer satisfaction, employee satisfaction, and impact on society are achieved through Leadership driving policy and strategy, people management, resources, and processes, leading to excellence in business results.

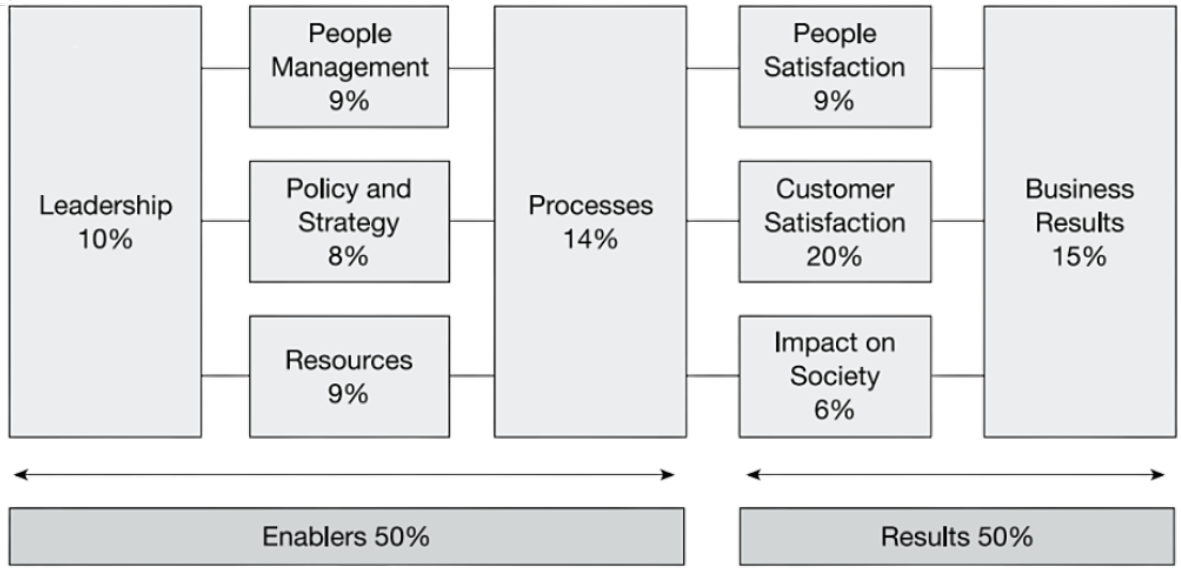



*Figure 3.6: Total quality management (Cadle & Yeates, 2008. P. 241)*

Figure 3.6 has nine aspects that are the criteria used to assess an organization's progress towards excellence. Each criterion is assigned a relative value for quantitative assessment against the model. Enablers and results each 50%. Within those totals, the figure shows the relative relevance of each criterion as a percentage (Cadle & Yeates, 2008. P. 241).

Meanwhile, the international standards for a *quality management system* (QMS), ISO 9000, are generic and represent maximum agreement across all industry sectors. As a result, the standards represent minimum, not maximum, best practices within any sector. A quality system combines all the functions, goals, and activities that contribute to constant product or service quality. Writing down these policies and processes shows how the quality system works together to improve overall efficiency, performance, and cost-effectiveness. The phrase 'quality management system' may be used instead of 'quality system' to represent the added management responsibilities (Cadle & Yeates, 2008. P. 243).

## Data Quality

Venkat et al. (2017) goes in further dept about the *data quality*. More data tends to compensate for less sophisticated ML models. In ML, raw data is typically unsuitable for learning, and the raw data is analyzed to extract variables/features. Although domain-specific features exist, generic patterns are required to help identify them. Data quality issues included missing data, duplicate data, highly correlated variables, and outliers. While techniques

include missing data imputation, outlier detection, data transformations, dimensionality reduction, and robust statistics to help control data quality.

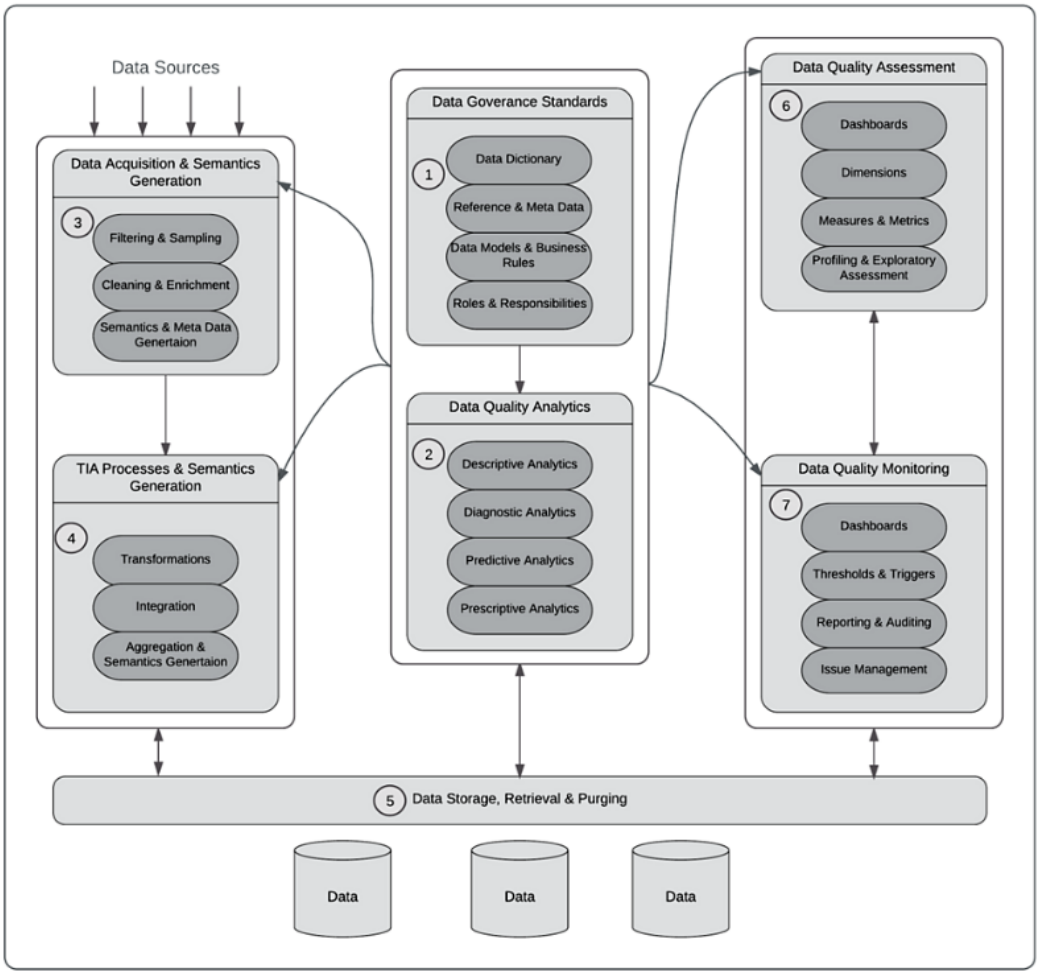



*Figure 3.7: A framework for the lifecycle of data quality based on data governance (Venkat et al. 2017)*

A business employs *data governance* best practices and controls to monitor and improve data quality actively. Planning, cleansing, profiling, analyzing, issue tracking, and monitoring are all part of data governance, defining roles and duties for maintaining data quality. Without good data governance, organizations reactively respond to data quality issues. Contrarily, data governance promotes a proactive, holistic approach to data quality. It strives for data accuracy and imposes measures to maintain data quality. The data lifecycle represents data migration across processes and systems. Figure 3.7 depicts a data governance-driven lifecycle suitable for industries, where circled numbers show the lifecycle processes' order.

## 3.5 Risk Management

All projects include somewhat of a risk. Risk is simply the possibility of complexities and difficulties in completing a task or achieving a goal (Cohen & Palmer, 2004). Risks can be from the nature of work, resources available, contractual relationships, or political factors. Risk management has become an increasingly important tool for handling risks. Using these techniques might be a factor in achieving success in the development of Information systems (Cadle & Yeates, 2008. P. 259).

*Identifying risk, assessing risk, and taking steps to reduce risk* to an acceptable level is known as risk management (Stonerburner et al., 2002). Getting an overview of the process will give insight into handling risk from a management perspective, and a suggestion is shown in Figure 3.8.

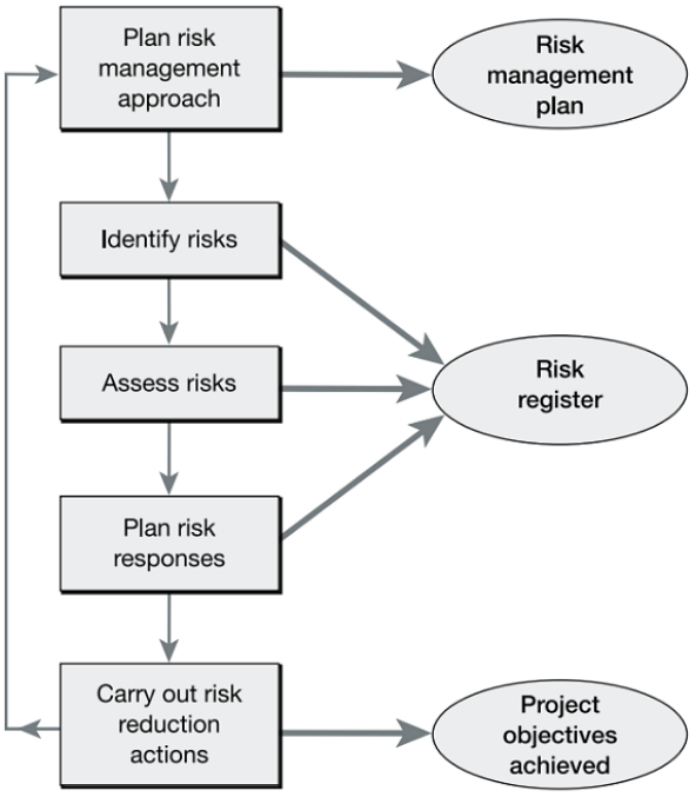



*Figure 3.8: The risk management process (Cadle & Yeates, 2008. P. 260)*

The first step in risk management is *identifying* the risks, which might be more challenging than expected. Projects are different, which causes various risks. Even though some might be less popular, all known risks must be highlighted. After identifying the risks, the next step is to give each risk a description to understand the impact and what to do to counter it if the risk

occurs (Cadle & Yeates, 2008. PP. 260-261). A risk breakdown structure can have more levels and be a good supplement for PMs and their organization. The risks commonly encountered and constructed on engineered and constructed projects stem from several primary sources.

- Modifications to the Project Scope and Requisitions
- Errors and Omissions in Design
- Improperly Defined Roles and Responsibilities
- Incorrect Cost and Time Estimates
- Inadequate Skilled Personnel
- Event of Force Majeure
- Innovative Technology

  (Cohen & Palmer, 2004)

After the risks have been identified, the *risk assessment* is the next step where the risk's impact and likelihood are considered. The management usually focuses on the risks with the most significant probability of occurring and those that might do the most damage. It is essential to consider that one risk can cause more than one possible impact (Cadle & Yeates, 2008. P. 267). It can be by assessing the impact in large, moderate, or small. Another factor to consider is the likelihood or probability of the risk materializing. Using a simple scale as high, medium, or low makes it possible to estimate the probability (Cadle & Yeates, 2008. PP. 268). A simple matrix such as the one illustrated in Figure 3.9 can be used.

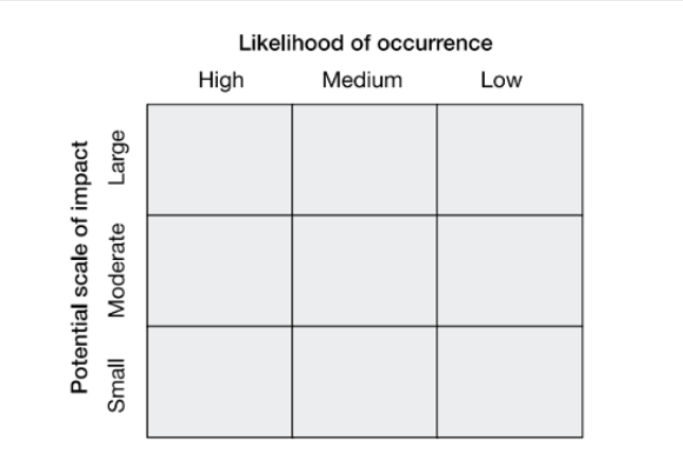



*Figure 3.9: Risk assesment matrix (Cadle & Yeates, 2008. P.269)*

If no *action* is taken, then the identification and assessment are useless. By having a mitigation plan for each risk, it is possible to handle the recovery of the risks if they still occur. Countermeasures can create secondary risks, and these risks should be handled as any other risk and subject to a risk assessment process if they are severe. After the actions have been identified, the urgency of taking actions can be determined. Cadle and Yeates (2008) describe the primary responses to risks:

- **Acceptance:** If there are no ways of avoiding the risk or that it might be a more negative effect of dealing with the risks than just accepting it, the best rational response might be to let the risk happen.
- **Avoidance:** Doing things that try to prevent the risk from occurring.
- **Mitigation:** Something that can be done to reduce the impact of the risk if they occur.
- **Transfer:** If the risk occurs, things can be done to make the impact fall on someone else.

  (Cadle & Yeates, 2008. P. 269)

A *risk register* is frequently used to track and document the data generated by project risk management (Patterson & Neailey, 2002) and can come in various forms based on the scale of the project and the setup of the document. The register is a central repository for information gained on each risk, and the current status of the risk and potential impacts are presented. A risk owner is added in this document to identify who is responsible for handling the risk actions. The actions for avoidance, mitigation, and transfer actions identified are also present, and the action log indicates what discharging events have been made to avoid the risk (Cadle & Yeates, 2008. PP. 270-271).

Initial identification and risk assessment is one part of risk management, but changes happen during the project, which can cause changes in risks. Risks also disappear and become overtaken by other events. Unanticipated risks can also appear, and Risk management is an ongoing process. There must be procedures to revisit the risk register and reassess the risks. Some projects are vast and complex, and they usually need specific risk review meetings, while others can have risk review in ordinary meetings (Cadle & Yeates, 2008. PP. 272).

## 3.6 Stakeholder Management

The PM must ensure that everyone has realistic expectations and feels successful at the end of the project. This focus area examines the major project stakeholders and strategies for managing them. According to a study by Karlsen (2015) of the Norwegian School of Management BI, *clients and end-users* are much more critical than other stakeholders. Collaboration between these stakeholders is critical for success, as clients define and finance the project while end-users determine the project's value (Karlsen, 2015). When working on general IT projects, the customer may be an external organization or an internal information systems manager who has assigned the PM to fulfill a portion of a contract with the delivery team or the end-user itself. Each change can have a beneficial or harmful effect on them. The PM must be sensitive to all the difficulties, worries, and gripes associated with system use, as customers and end-users are frequently critical to the success of a project (Cadle & Yeates, 2008. P.298).

Additionally, according to Cadle & Yeates (2008), stakeholders critical to success are usually shareholders, employees, and managers. Those who manage the finance have a stake in the company's financial future, govern its operations, or oversee its direction and are held accountable for their decisions. The relationship between the stakeholders can be examined in Figure 3.10.

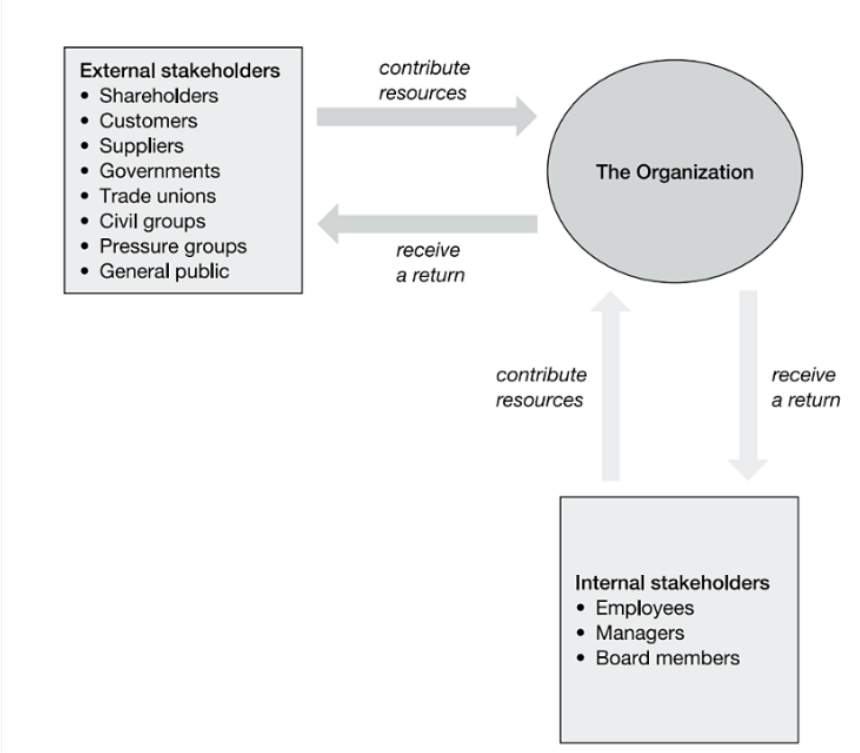



*Figure 3.10: Stakeholders and their relationship with the exchange (Cadle & Yeates, 2008. P.299)*

Consensus on success criteria with all stakeholders is critical to project success. Karlsen (2015) did a study where he asked sponsors, users, designers, and PMs to recall recent projects on which they had worked and indicate whether they considered the projects successful or unsuccessful and the criteria they used to make their determinations. All groups recognized the same success criterion for successful projects: the project must add value to the sponsor. These separate sets of stakeholders sought to accomplish various goals on failed projects. Therefore, it should be a PM's priority to elicit a clear set of success criteria for the project from the project stakeholders. However, not all stakeholders will share the same goals as they are unlikely to share the same stake in the project (Karlsen, 2015).

Karlsen's (2015) findings indicate that additional efforts should ensure stakeholder management. The informants in Karlsen's study emphasized developing strategies and plans. Additionally, data indicate that goals, targets, tools, methods, processes, routines, and evaluations are critical areas to develop. This does, however, imply that some stakeholder analysis can be carried out, the results of which may be tied to the project's risk analysis. The PM can then determine how to persuade the various stakeholder groups to support the project, what type of support they desire, what the project will deliver to address their

concerns, how stakeholders may indicate their lack of support, and what remedy they have if this occurs (Karlsen 2015).

Cadle and Yeates (2008) presented a matrix for stakeholders power an interest from G. Johnson and L. Scholes (2002) Exploring Corporate Strategy that classifies stakeholders into four categories denoted by the letters A, B, C, and D. Each of these categories should be treated differently. This matrix is represented in figure 3.11.

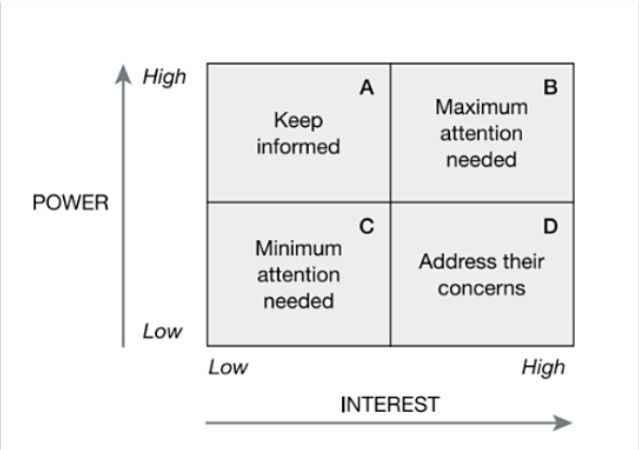



*Figure 3.11: Stakeholders' power and interests (Cadle & Yeates, 2008. P. 300)*

***A) High power but low interest.*** If this quadrant's stakeholders use their power, they can significantly impact the project. They could be top managers whose departments are unaffected by the project and unconcerned about its path, and changes in the project's direction can alter their interest. Stakeholders are usually kept informed about the project, emphasizing its minimal impact on their activities. In other cases, the reverse may be best. Getting an influential yet neutral stakeholder to support the project can result in new resources or success from others. This set of stakeholders does not overburden the PM, and hence a 'minimal effort' approach is used.

***B) High power and high interest.*** These are the project's primary stakeholders, and they are actively involved in the project and can advance or halt it, proclaim it a success or failure. They are frequently department heads, PMs, or executives from corporate areas like audit or finance. It is necessary to examine whether these stakeholders are supportive or critical of the project. Positive views should be nurtured, and

unfavorable views should be persuaded to change by being addressed as much as possible. A low-interest/high-power supporter may help here.

C) ***Low interest and low power.*** These individuals have no direct stake in the project and no genuine ability to influence it. While it may be tempting to disregard this group, recognizing that stakeholders' locations on the map are fluid; periodic briefings on current events might have a positive impact

D) ***High interest but low power.*** They are immediately impacted by the project but cannot shape or direct it. This might lead to project frustration and passive resistance. In this situation, they drag the project down, which is worth taking action. This group of stakeholders must be kept informed, but not passively. A proactive approach to address their concerns and market the project is required (Cadle & Yeates, 2008. PP. 300-301).

## Expectations and Conflicts

At the start of a project, *expectations* should be established and revisited at regular formal and informal intervals during the project's duration. If this is not done, the likelihood of misunderstanding, *uncertainty*, and *conflict* increases significantly (Cadle & Yeates, 2008. P. 303). Each customer has a unique set of project management expectations. These expectations are rational or irrational and are influenced by controllable and uncontrollable factors. According to Karlsen's (2015) research, stakeholders wreak havoc on project execution by introducing complications and ambiguity. According to some informants from his research, these problems and uncertainties are caused by" ... decisions that were not taken,"" ... unexpected changes in specifications,"" ... the client was too focused on details,"" ... the stakeholder did not understand his or her role in the project,"" … political guidelines that were unexpected changed," and" ... the end-user did not know his or her needs." These observations underline that communication with the client and other stakeholders cannot be stressed too much (Karlsen, 2015).

Cadle and Yeates (2008) classify controllable expectations into short-term and long-term categories. In the short term, controllable expectations include sales promises, marketing, the nature of products and services, and first impressions. In comparison, manageable long-term

expectations include product and service innovation, marketing initiatives, and long-term quality requirements (Cadle & Yeates, 2008. P. 303). Customer satisfaction is frequently quantified by frequently meetings with the customer to discuss what works well and what could be improved, conducting customer satisfaction surveys, tracking the number of escalations up the management chain before issues are resolved, or tracking the number of disputes or complaints. According to Cadle and Yeates (2008), customer expectations management consists of four steps.

1. **Define what customer satisfaction means in the project.**
   The project's time, cost, and quality will be specified.
2. **Discover the source of the expectation.**
   In order to deliver realistically and efficiently, the customer must know where the PM stands and vice versa.
3. **Calibrate where the project stands**
   PMs will want to learn as much as possible when assessing what is reasonable in the situation and the motivators for each party.
4. **Create an action plan.**
   Creating an action plan forces the customer to be explicit about their expectations. The first step is to set realistic and mutually accepted boundaries. Then outline the methods for keeping the customer satisfied (Cadle & Yeates, 2008. PP. 304-306).

Cadle and Yeates (2008) explore the emergence and resolution of conflicts in projects. Conflicts can happen anywhere and anytime during the project's life cycle. They may arise because of practical considerations and occasionally due to personalities and personal agendas. If they arise, the PM should attempt to deal with them quickly and clinically. The delicate business of dealing with people and their feelings makes addressing conflicts difficult. Several of the most well-known sources of conflict are due to different expectations based on time, cost, or scope. Other conflicts may arise due to the inability to comprehend one another's stance due to technical, commercial, or personal causes.
Furthermore, unresolved or avoided issues resurface at a critical point. The physical distances, proximity, and culture all contribute to this. After recognizing how conflict might occur, the next step is to try to resolve it. A procedure that can be effective is as follows:

1. **Know the desired outcome.**
2. **Triage the conflict.**
3. **Agree on a process.**
4. **Confirm the positions.**
5. **Act.**

Progress can be made after both sides agree to end the conflict. The PM and the customer must share the same goals knowing that there may be consequences. Together, they can develop new ideas, examine and rank the options, and agree on a strategy. Resolving a conflict may improve working relationships (Cadle & Yeates, 2008, PP. 309-311).

## 3.7 Change Management

Changes in processes or procedures occur when new technologies get implemented. These changes may create new roles and responsibilities or lead to organizational restructuring. Managing change is dealing with people and involving them throughout the process. Getting the commitment from the people to use these systems is central to the success of the project (Cadle & Yeates, 2008. P. 331). Edmonds (2011) discusses *resistance to change* in organizations, primarily due to people's dread of the unknown. However, when change management approaches are correctly used, it is possible to bring about change successfully while meeting defined goals and objectives and staying under budget. Individuals react differently to change. Hence, it is critical to precisely inform those impacted by the upcoming shift how things will change. Venkatesh et al. (2003) discuss that any technology acceptance theory is predicated because certain factors indicate whether a user will intend to utilize a new technology, which results in user behavior. Change management is changing user behavior in response to the introduction and use of digital technologies.

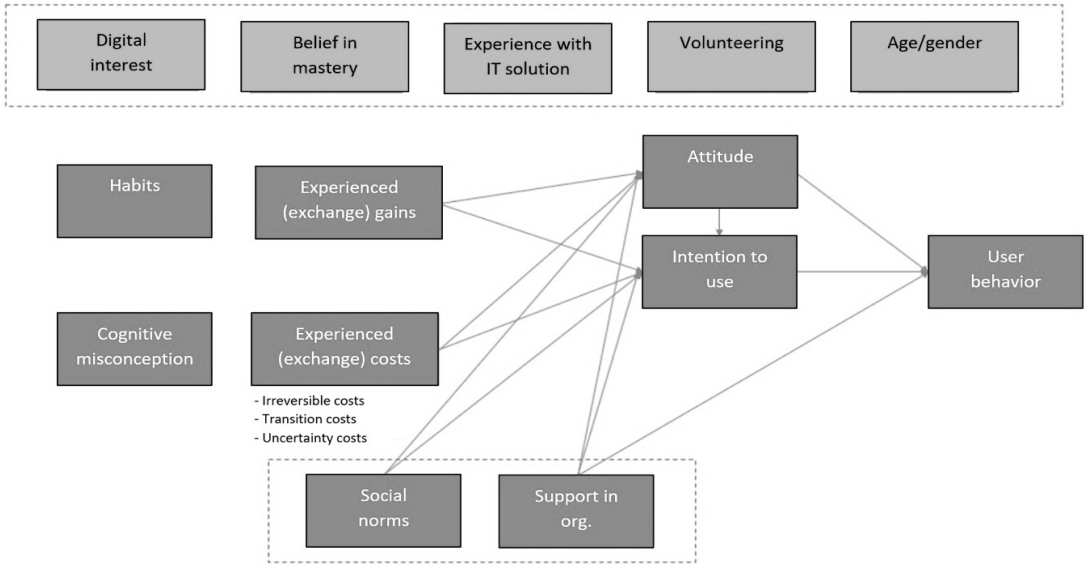



*Figure 3.12: User adaption model*

Figure 3.12 represents a *user adaption* model and represents information about a specific user that is necessary for an adaptive system to produce the adaptation effect. The two critical moments that influence user intention and behavior are experienced gains or benefits and experienced costs or effort. Experienced gains are about assessing and anticipating how implementing a new IT solution will result in benefits or gains in the work environment and differ by group and individual. Moreover, social norms, culture, and the manner of a new solution can all influence the gains one perceives. The evaluation of perceived exchange cost/effort versus perceived exchange gain/benefit will be concatenated to anticipate whether the user will embrace new technology. This cost-benefit analysis is only partially rational and based on an expectation generated and influenced by individual, technological, societal, and organizational factors. Several of them are encapsulated in the other yellow components at the top of the graphic and in the factors 'social support' and 'organizational support.' (Venkatesh et al., 2003).

Cadle and Yeates (2008) suggest planning the change program in the same way as planning the system's development and implementation – these processes are integral to the project, not separate from it. A PM should select development methods that allow the people who will use the new system to contribute to its development. In this case, agile development techniques could be considered. Ensure that the change management program considers communication and training and the impact of the change on the users: the timing and

methods used to implement the system should be planned to make the transition as easy as possible for the user. Allow for periods of consolidation to allow people to become comfortable and confident with new responsibilities, processes, or environments. Phase the introduction of change ensures that people are not bombarded with too many changes. Involve users in the planning and implementation of the change program because they understand the user community's issues: this will help ensure that those in the business are in control of the change and managing it, rather than being helpless bystanders to something that is imposed on them. (Cadle & Yeates, 2008. PP. 331-332)

The term 'resistance to change' refers to any occurrence that obstructs a process's beginning or growth to preserve the current state (Del Val & Fuentes, 2003). Change resistance can be aggressive or passive. If the resistance is active, it is shown and visible. While passive resistance to change is more difficult to detect, it can be as destructive to projects as active resistance. Cadle and Yeates (2008) emphasize that to understand how to handle resistance to change in organizations, understanding the typical pattern of ups and downs of project implementation is necessary.

The change curve in Figure 3.13 demonstrates that initial enthusiasm for change wanes as challenges arise but then resurfaces as individuals emerge from the 'dip.' Therefore, regardless of the type of change, the project brings, the need to push individuals and groups down this curve will occur (Cadle & Yeates, 2008, PP. 335-336).

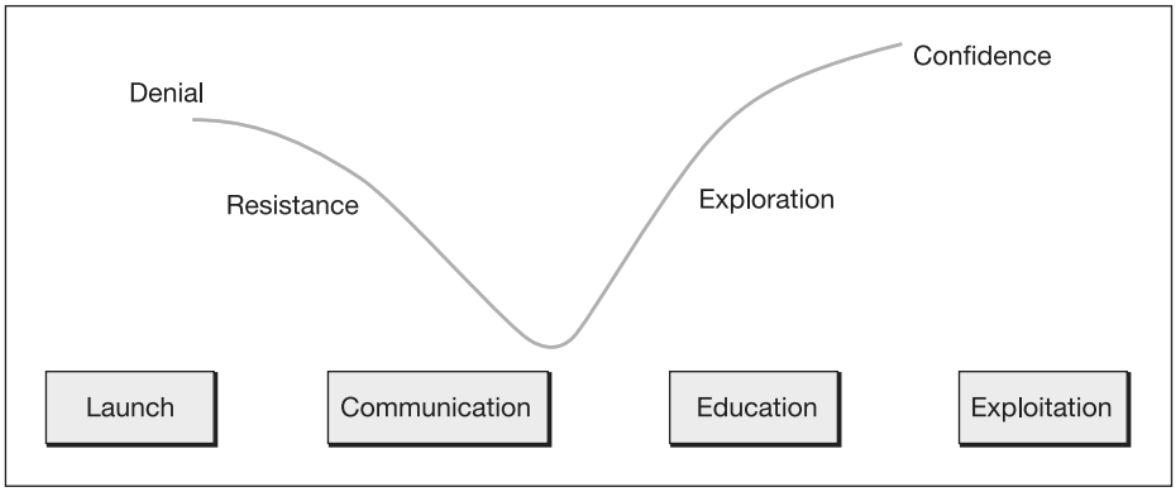



*Figure 3.13: Change curve (Cadle & Yeates, 2008, P.336)*

The organization's *culture* defines the impact of the change curve. Organizational culture models exist, and Charles Handy created a model that categorizes organizations based on centralization and formality. Figure 3.14 depicts organizational cultures (Cadle & Yeates, 2008, PP. 336-337).

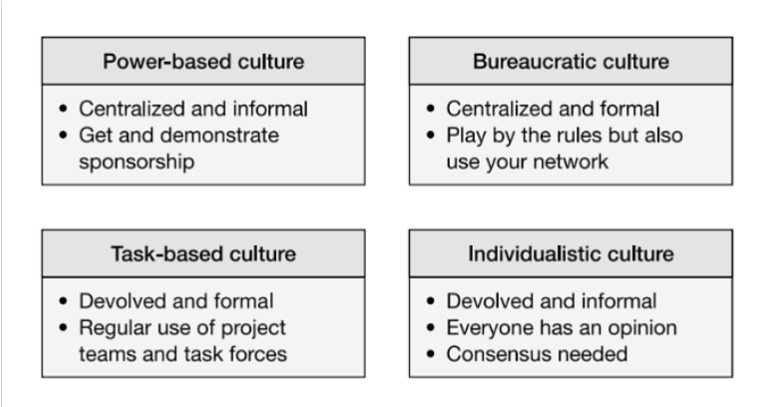



*Figure 3.14: Organizational culture model (Cadle & Yeates, 2008, P. 337)*

Launching is the first stage, and the users might be in denial and resistant to change. A PM should focus on the senior management and the user project team. Cadle and Yeates suggest identifying a business sponsor who will serve as the change manager; they should be reputable and influential rather than senior. Collaboration with this sponsor is needed because they are the ones that endorse decisions and take a leadership role in enacting change. Increase their goals to the point where they become radical champions for the initiative and manage their technical expectations.

During the early stages of the start of the project, there will be many questions, and handling this communication is vital. It is crucial to communicate with all the departments that will be affected to avoid resistance. A communication plan can be made to handle this. Giving people the possibility to give feedback can also make handling resistance easier. During the next step, *educating the end-users* are essential. Here it is needed to involve the users that will use the system and allow them to learn how to use it. Getting user acceptance is critical for successful change. Hence, users should also be able to give feedback during the whole process (Cadle & Yeates, 2008, P. 346).

# 4 Research Results

The following sections present the results from the conducted interviews from the case study Cognite. We present the empirical findings from the interview based on interviews with eight people that hold a PM title at Cognite. In the first section the informants get presented and their views on project success and how ML projects are handled in Cognite. Furthermore, the last sections examine their viewpoint on the four focus areas that are chosen in this thesis.

## 4.1 Understanding ML Projects at Cognite

In this section, the informants' demographics and their experience get examined to obtain a sense of the informants' trustworthiness and relevance. The questions then shifted to the domain of project success, inquiring about the ML definition and the measurement of critical factors of project management success.

### The Informants

All eight informants confirmed that they have a "Project manager" (PM) position or similar roles. Some elaborated on the typical PM duties.

*"I am responsible for reaching the milestones on time and on the scope."*

*- Informant 1*

*"My position is the project manager, so that means that I lead the projects and make sure that the people in the team are not blocked. That's kind of mainly what I do, and I'm kind of bridging the customer and Cognite."*

*- Informant 5*

The informants' experience varies, and most of the informants seem to have at least some years of experience in working with projects, many of which are as a PM. Informant 7 has 17 years of experience as a PM, while informant 2 has 1,5 years in that role, so there is a large diversity, while most tend to state about three years. The informants may have experience in management consulting, working as solution architects, working with "normal" and "ML-projects," or having experience with other companies. Many informants have worked on ML projects while in Cognite or earlier in their careers.

*"I've been heavily involved in projects delivering data-driven solutions where machine learning has been part of the product."*

*- Informant 3*

Many do argue that Cognite projects usually hold elements of ML and that they are working with industrial applications. Such a project typically involves extracting data from many sources, then enriching the data with context related to the platform, and then making the enriched data available to the customer, often with some front-end applications to ease the access.

*"Most Cognites platform stack holds elements of machine learning, or machine learning techniques."*

*- Informant 1*

## Definition of a Machine Learning Project

The eight informants defined an ML project differently. All informants agree that it's about project complexity, with ML projects being typically more difficult. Some define an ML project as one in which their team directly builds technologies using ML modeling. Others define ML-projects as delivering solutions using the CDF or other pre-made ML functions. An example of a project outcome involving ML could be a condition-based monitoring application for oil and gas blowout preventers. Some participants referred to ML as a black box project, which it is. Other informants cited complexity as a major risk factor.

*"I would also say the risk is higher due to the complexity, so the kind of risk of failing is a bit higher" which is a viewpoint that others also had."*

*- Informant 3*

## The Project

The results comprise several entries about customer satisfaction. Informants advise closely discussing and agreeing on the target outcome with the customer. Defining important deliverables and adapting to changing consumer needs is essential. The client's goals are defined collaboratively, and their acceptance is related to a successful project. Also, upselling

and developing a long-term relationship with the customer are commonly highlighted. Success is linked to long-term subscribers who desire to scale the use case. Finally, the customer's willingness to promote Cognite is emphasized.

*"A successful project is a project where the customer is satisfied and we reached the scoped out goals."*

*- Informant 2*

The second-largest group of answers deals with customer care. Project success, according to informants, depends on meeting goals on time, overcoming obstacles, and delivering a product to the customer. The PM's job is to deliver the planned scope and solve a business problem. Lastly, they claim that "correct quality, good quality" solutions are linked to project success. In some cases, quality may imply reusability while in others it may imply customer adoption.

### Project Management

Overall, there is a resemblance between the success criteria of the project and project management. We did receive answers related to customer satisfaction, gaining trust was explicitly mentioned, and understanding what is at stake for the customer is generally emphasized, along with the customer's problem. Moreover, creating solutions that the customer will use is mentioned, in addition to upselling, evolving the relationship with the customer, and scaling the use case.

*"Success is when the value potential that you have defined for the project and product is realized for the client."*

*- Informant 5*

Another common answer is leadership, with the team setup being critical. Project management requires close collaboration with and support from the internal delivery team. The PM must understand how data scientists and solution architects work and must be able to assist them. We also noticed a significant portion of answers regarding administrative tasks and project requirements. Some informants think that using agile methodologies is a success criteria. Numerous informants focused on the right order, right matters at the right time,

prioritizing project work, and complying to timelines and milestones. The results show a strong focus on time, cost, and scope, as those metrics produce working models that solve customer business problems.

## Machine Learning

Projects using ML are more uncertain because their outcomes are unpredictable. One knows the outcome but tends to lack data to build a successful ML model. When asked about ML projects and success criteria, the informants mentioned complexity. Due to the complexity of an ML project, it is critical to focus on different stakeholders to assure them that everything will work as expected.

Having the right people to develop the solution and handle customer requests is critical, say informants. After the solution is delivered to the customer, it should be maintained and supported by either the solution provider or the customer. Having the right skills to maintain the solution in the future is critical.

Customers' expectations of ML's potential vary. Everyone must understand that ML is a tool. There are many tools in project delivery. In many cases, ML can be used to solve a customer's problem and help create value for the customer. Using ML models that aren't required may end up burdening the project. Managing customer expectations and educating them is critical in ML projects. Stakeholders should be kept informed throughout the process to build trust.

*“ML is just a tool in the toolbox. I say in the project delivery you will have many of these tools and ML can be one of them.”*

*- Informant 1*

Finally, informants believe good data is critical to successful ML projects. This includes both the quality and quantity of available data. The data in industrial ML applications can be messy and difficult to use.

## 4.2 What is Quality Management and how it is Ensured

First, we received many suggestions on what the informants defined as quality. We will group the results into product quality, data quality, and customer satisfaction. Some informants think Cognite focuses more on risk than quality and that the industry seems to focus more on risk than quality. Informant 6 argues that risk comes from lack of quality, and that Cognite needs to ensure that they are above every industry standard.

*"If you have excellent quality or all over the base. Most of the risks would disappear."*

*- Informant 6*

The results shows that product quality reflects project quality. For example, the look and feel of the user-friendliness. If the product is run transparently, communication is a quality aspect.

*" I think the quality is very much focused on the users so it's the quality of the product, it's also reflecting back the quality of the project"*

*- Informant 5*

The quality of the *algorithm* itself is essential according to informants. For example, to what degree the product predicts correctly at the right point in time. A goal is to enable the algorithm with past data to identify a potential problem in advance. However, the technical *robustness* of the product is also essential, as ML solutions might break if misused. The robustness defines how thin a line the user must balance when ensuring that the product predicts correctly at the right point in time. Moreover, quality might be defined in terms of *reusability*. A more reusable product or service will have higher quality and be more valuable to the receiver organization.

*"If we develop some kind of process or products that can be reused and scaled then that's quality."*

*- Informant 8*

When talking about ML, it is central to think about the algorithm's quality and that it can make the correct predictions. Cognite emphasizes the product or algorithm because it adds complexity to a more straightforward project.

*"It doesn't really differ that much. There are just other elements to consider, like the quality of the models itself."*

*- Informant 3*

Furthermore, several informants state that *data quality* is essential to get high-quality results.

*"If you have good data quality going in, then it´s fair to assume that you should be able to get some good results based on the use cases that you set up"*

*- Informant 2*

A large cluster is related to *customer satisfaction*. Informants state that the high-level quality of the project itself only facilitates solving the customers' needs. Quality is that what they developed in the project meets the customer's requirements and that it is good enough that the customer actually will use it. In other words, that the project has been delivered according to the user stories and success criteria defined together with the customer.

*"Quality for me is that what we developed in the project, meets the customer's requirements and that it's good enough that the customer actually will use it"*

*- Informant 4*

To better understand how quality management is ensured in ML projects, the informants were asked how they ensure quality management in Cognite. The results show potential improvements regarding the data quality, quality management culture, customer success, QA-testing, and evaluation. However, some informants tend to be satisfied with the status quo.

## Team Setup and Culture

As of today, quality management is not particularly important or explicitly stated in Cognite. Informant 8 states that Cognite does not only look at internal success factors like handling

scope or delivering on time and budget but also got a larger strategy when it comes to obtaining the right people, competencies, and culture.

Ensuring the quality of team competencies, setup, and internal quality culture is essential for complex projects with ML algorithms according to a number of the informants. If the right resources or mindset are not available, it will be hard to ensure quality.

*"We actually have a culture where everyone is eager to bond, deliver high-quality projects and also where we can now arrest each other if the process is not followed"*

*- Informant 3*

Some informants stated that Cognite does not have a quality management system that everyone uses, and informant 1 suggested defining quality and agreeing as a company on what quality means to optimize for it. One said that training the PMs in quality management would be great, as Cognite could try to elevate the knowledge about quality management. Many employees do not have the necessary training or introduction to the subject today.

*"We should define quality and agree as a company on what quality means for us in order to truly optimize for it."*

*- Informant 1*

### Customer Success

The interaction with the customer is an essential factor in quality assurance. With demos, Cognite shows the project's progress, but it also makes it possible for the customer to give feedback on the development. Having an open dialogue along the way is a critical element of managing the quality based on the answers from the interviews. Informant 5 thinks that Cognite can communicate much better with the whole value chain. Their vision is data liberation and not being in silos, which is even done within their company.

### Data Quality

Data should be of decent quality and completeness, structured in a good way, and stored in an accessible place. The quality of the ML model and project is only as good as understanding the data and data labeling. The project requires proper cleansing, which is the most critical

part. If the customer gives good quality data, then one should be able to maintain that level of quality throughout the systems. So have enough historical data to manage quality, have everything structured in a good way with correct completeness, and maybe remove outliers if needed, or they will likely affect the results. It does not make sense to have inadequate data and use ML, at least not for the production-grade software that Cognite is delivering.

*"The quality of the data when you're using machine learning is Super important because any outliers can and will affect the results"*

*- Informant 2*

Cognite uncovers a lot of insufficient quality data, according to informant 2. Hence, quality management is essential for projects because it directly correlates with the results. Factors to ensure the quality are everything from what datatypes the customer has, the quality of the data, completeness of the data, structure of the data, and if it is accessible. During the work with the customer, they reveal weaknesses in the data and try to figure out solutions to ensure a better quality of the data.

Cognite set up tests to review the data completeness and quality. These tests also look for outliers and try to manage these. Cognite ensures the quality of data by working on it and interpolate to fix the data. Informant 2 suggested looking into how they might fix the new incoming data quality. They might replace some sensors or perhaps remove some middle layers set up. It is important to fetch the data at the needed frequency, and there may be adjustments that can be made with the underlying systems.

*"The core value proposition of Cognite is to gather and contextualize data"*

*- Informant 2*

### Standardizing

The informants stated that standardization is critical to quality. Processes are becoming more standardized, making quality assurance easier. They have coding standards, agile work informants, a project management framework (PRINCE2), and ISO standards like ISO9001. PMs are properly trained in agile methods and Cognite has become more standardized. The organization has a lot more resources for project management than before and is moving in

the right direction without being too rigid. Informant 4 appreciates that each PM can add their own personal touch if they want to.

The informants mentioned retrospectives to improve future projects. This improves future project quality management. In addition, informant 7 suggests accounting for QA reviews like code testing rather than just quality reviews of the dashboard. Putting proof of concept in production before delivery would help speed up the process.

Some informants want to make sure they get the same evaluation after a project and share it with the rest of the organization. Cognite has retrospectives from projects but getting all that knowledge into other people's heads and preventing others from making the same mistakes is difficult. They claim that since Cognite has evolved over time, it is necessary to change its processes, and that new processes can always be learned.

*"It's a challenge how to get all that knowledge from the individual projects into other people's minds within the same company so they don't have to make the same mistakes"*

*- Informant 6*

## 4.3 What is Risk Management and how it is Ensured

The informants' definitions of risk varied. Some risks stem from poor project quality, inability to deliver on time, budget, or scope, and potential threats to the project's success. External and internal factors may impact the project delivery, according to Informant 1. A common example is that the project may not be delivered on time. Two informants elaborated on risks based on stakeholder expectations, as a risk to the project is that stakeholders may not want to use the new software developed. We asked the informants how they manage risk in Cognite. Based on the informants' responses, this section can be divided into identification and assessment, management and supervision, and standardization. Risk management is more important than quality, according to some of the informants.

*"I think the risk is of course really important ... The industry, in general, focuses more on risk than quality"*

*- Informant 3*

## Identity and Assess the Risks

The first step is to define the risks, probable outcomes, and consequences. Then make a mitigation plan for each of these points. The mitigation plan can either reduce those risks or turn those risks into opportunities. Because of the project's complexity, informant 5 believes Cognite could improve its planning skills. The PM must plan ahead of the project to avoid potential risks.

Concerning ML project risks, informant 7 believes it is critical to start preprocessing data early on since the ML model's success is uncertain until the end of the project. This includes knowing that the data quality is good enough for the ML model to work. Initially, poor data quality may be a risk. Project delivery is uncertain due to complex ML components that may be difficult to understand and varying customer technical expectations. Having the right skills and resources is critical to completing the project.

## Management and Supervision of Risks

Some tools and resources are used to handle the risks. Such as a risk register that keeps track of risks within Cognite and the customer.

> *"We have risk registers. Basically, it can be as simple as a table where it's kind of a risk ID or a number, it could be the description of the risk, the likelihood, the consequence or severity, and proposed mitigating actions."*
>
> *- Informant 6*

The PM is typically in charge of managing risks, and the project support team is partly responsible as well. Weekly meetings with other PMs help PMs escalate any risk to higher-ups. Continuous management reduces the likelihood of risks occurring by proactively identifying and preventing them. Cognite also uses a weekly progress sheet. Informant 2 stated that knowing whom to communicate risks to is critical to risk management in Cognite.

> *"Cognite has a project support team that is somewhat responsible for the risks since they have to provide the project delivery team with processes, a team, process templates, tools, slide decks, etc."*
>
> *- Informant 1*

Better project leadership could lead to better risk management in Cognite. According to informant 8, people are good at making lists but not at revisiting them, updating them, and discussing them with customers. For example, informant 4 says the PM should better communicate common hazards and how to mitigate them. Before deciding on scope, sales could better communicate with PMs. Because PMs are more familiar with project timelines, they may be able to help the sales team better assess the project's completion time. Informant 6 agreed, stating that risk trends and patterns could be exploited to avoid future risks.

The solution must be monitored even after implementation. Cognite's support organization may be unable to assist. This may be due to the projects' complexity and lack of ML method description. When the customer organization lacks the knowledge to manage the solution, then issues arise. Due to the complexity of ML algorithms, the project requires ongoing monitoring and data pipelines.

### Standardizing

Cognite's PRINCE2 Agile framework defines risk clearly with suggestions and templates for risk management. Most people adapt the framework to the use cases ad hoc. Cognite also uses examples from other projects to learn from past mistakes and avoid them in the future.

Informant 1 said standardizing risk management could help. The informant had some concerns about standardization because standardization could go at the expense of pragmatism. More tools, templates, and processes can lead to overheads that cause more problems than benefits. Pragmatism is a way of dealing with problems or situations that emphasizes practical solutions rather than theoretical ideals. The informant concluded that Cognite is learning as it grows based on standardization. Standardization may be beneficial, but it is up to the projects to decide how to mitigate it.

*"I think all of these themes/categories can always be standardized more and more for each in each company, but standardization will always go on the account of the usability or pragmatism."*

*- Informant 1*

## 4.4 What is Stakeholder Management and how it is Ensured

Stakeholder management, according to some informants, is the most critical success criterion in this thesis. A PM is a link between the Cognite project team, the customer project team, and relevant stakeholders. Another informant states that stakeholder management takes up 60% of their day. Stakeholder management appears to include dimensions of high importance for PMs interviewed. The informants introduced key stakeholders; this section will elaborate on each. Most informants categorize stakeholders as internal or external. Top management, sales executives, key account managers, and the project team are internal stakeholders. However, external stakeholders include top management, the project owner, IT, end-users, and possibly third parties. Every claim is still based on informants' views.

This section briefly describes how each stakeholder is managed. People in the delivery organization constantly collaborate to ensure their communication is aligned and has the right touchpoint with key stakeholders, say informants. Keeping everyone informed directly impacts the PM's time spent on stakeholder management. Stakeholders may find the project, delivery, or scope too complex to comprehend. The PM must then provide the stakeholder with the knowledge and tools necessary to discuss and comprehend the project. A key takeaway is to educate the stakeholder on their project. In Table 4-1 a categorization of the stakeholders can be found based on the viewpoint of the informants.

| INTERNAL STAKEHOLDERS | EXTERNAL STAKEHOLDERS |
|---|---|
| • TOP LEVEL MANAGEMENT<br>• SALES EXECUTIVES<br>• PM<br>• PROJECT TEAM | • TOP LEVEL MANAGEMENT<br>• PROJECT OWNER<br>• IT-DEPARTMENT<br>• END USERS<br>• THIRD PARTIES |

*Table 4-1: Categorization of stakeholders*

### Internal Stakeholders

**Top-level management.** It was unclear how the informants would ensure top-level management in their own organizations.

*"Our top-level management is invested in the project and wants this project to succeed either because they have their name on the line, or they were involved in the*

*selling of the delivery, or because the project is a flagship delivery in with some of our components."*

*- Informant 1*

**Sales executives.** The PM should leave the customer's sales organization to its salespeople, as they can speak and negotiate on equal terms and language.

*"The person has actually sold the project. That's a typical stakeholder for me as a project manager as well."*

*- Informant 8*

**PM.** The internal PM typically manages day-to-day interactions with the client, users, developers, and project owner. A PM in Cognite must be a line of communication between the Cognite Core project team and the customer project team, as well as other departments. If they build an app, they must work closely with the product manager or product team. The PM tries to manage sales, project continuation, and people who will influence the project.

*"In Cognite you have a kind of key account manager, but we call it a customer success manager. That's also someone who is involved and will follow the customer throughout the whole life cycle. But for me as a project manager that kinda counts as a stakeholder as well."*

*- Informant 8*

*"Understand what relationships you need to build in order to have the most kind of speed and process and impact in the project. That represent certain individuals and you need to report with them."*

*- Informant 6*

**Project team.** The project team is dedicated to its project. If the project is poorly managed, the team suffers. In some cases, the product team is heavily involved in the project and becomes an essential stakeholder.

*"Without them the whole cardhouse kind of collapse, so they are quite important."*

*- Informant 6*

The project team is not responsible for stakeholder management for the lowest levels. However, if they are implementing an application, then the Cognite product team is usually someone that takes some effort to ensure as well.

## External Stakeholders

**Top-level management.** The external top-level management decides how much revenue Cognite gets. They are very influential, despite being less frequent in dialogues. They are also concerned about the project's cost and value, as they want a positive business case. They must have a high or positive return on investment.

Several informants stated that they would target decision-makers, as they fund the project. The PM must ensure that the project exceeds expectations and simplifies the lives of all businesspeople while the technology is easily managed by IT. If all stakeholders are happy, upper management is usually happy with the effort and willing to pay for it. A dissatisfied project owner is bad, but a negative customer organization's top-level management is even worse. They can always fail a good delivery.

*"There have been project deliveries where I've spent 80% of my time fighting with the executive management or top management, and only 20% doing actual work. And there's been projects where I almost seemed to have been able to work each day with a very competent and supportive organization on the customer side where we could then do the right things technically, without any fighting."*

*- Informant 1*

When dealing with external upper management, Cognite usually brings in Cognite's upper management. Someone more commercially minded ensures the CTO and upper management are happy with the software they deliver and how it is used. However, a PM must include them in demo reviews, and Cognite usually invites upper management to such reviews or sprint reviews. Management may attend demos and ask critical questions, so a PM must

follow up to ensure their concerns do not become a risk and maintain good relations with them.

*"Someone above me more commercially focused are ensuring that the CTO and the upper management are satisfied with what we deliver and how this software can be utilized."*

*- Informant 2*

**Project owner.** The customer usually has a PM/owner and a project team. The owner manages the project or receives it, and their name is usually on the line. This type of project usually involves solving business problems using ML, and the owner might be a process engineer working on an oil rig. This person likely ordered the product and owns the contract.

*"His or hers involvement can vary a lot, but I think that might be one of the main stakeholders, perhaps the most important stakeholder."*

*- Informant 6*

Some informants say the project owner is the most vital stakeholder. This person represents businesspeople, and the project seeks to make their lives easier and their decisions easier. The product owner is usually interested in the ML solution's ability to create value. Increasing product quality and uptime reduces maintenance costs. This person wants to see results quickly and have a high-level overview.

*"Most important is probably the one with the project mandates, the one who can sign off: Yes, we're doing this project or no, we will stop the project. The person who kind of signs the contract and the check, which is kind of the project owner."*

*- Informant 8*

The PM take care of project owners, and they are also those the PM usually has almost daily contact with. Either the PM senses problems or else the project owner often tells if something is wrong. One informant thinks most of the time as a PM goes with the project owner and core customer team.

*"I would say day-to-day business. I concentrate on their customer project manager and the customer project team. That's kind of where most of my effort goes, It depends on the project."*

*- Informant 8*

If the project owner is satisfied, there is no need to speak with the top-level management. If that is not the case, the PM might have to have more dealings with the management to negotiate things and make them an active stakeholder. People in business are usually really impressed with what Cognite does because they usually manage their expectations.

**IT department.** Technical people frequently have strong preferences for software and tools. They can also be a data office, handling all the company's data. Good quality, on time delivery to all data consumers around the world. IT owns the data pipeline and data structure Cognite uses on-premises or in the cloud.

The informants repeatedly stress the importance of close collaboration with IT. To ensure customer and project owner satisfaction, clear communication with solution managers is critical. The customer's project owner is important, but IT also has a lot of influence and has a lot to gain. IT is usually required to certify the project, and it is much easier to manage other stakeholders if IT fully understand and agree with the project. The data engineer on the internal project team is in charge of the data office, and another solution architect is in charge of the IT people. Training and educating IT personnel on the importance of technology maintenance is critical to success.

*"It's almost just as important to have the technical leadership on their side to be aligned with us as it is to have the users themselves to be aligned with what you're doing."*

*- Informant 2*

Cognite may be under-communicating with IT stakeholders. This group is vital because they will ultimately manage the technical solution. Even if the solution does not provide IT value,

it is critical that they are satisfied with the overall management process. Keep in touch with IT and show them how to manage the solution and how valuable it is to the business.

If IT resources are not fully onboarded early enough, they can sabotage the project's progress. An informant did mention the IT department preferring someone else to fix the customer's problems. Cognite failed to manage IT early enough, resulting in a conflict due to a lack of communication and empowerment. Other providers trying to solve the same issues caused another conflict. Negotiation and teamwork with all stakeholders, including the third party, resolved the conflict.

**End users.** Some informants said they spent the most time with the ML application's users from the start. The PM's job is to keep them satisfied while using the software, so they must be continuously advised. They participate in the UI design sprint and learn that ML is a device with its own uses. For example, one informants project required a process engineer to maintain machine uptime. PMs spend most of their time with operators, maintenance engineers, or process engineers.

*"It´s super important to satisfy users and product owners since they are the ones letting the owner know how it goes."*

*- Informant 5*

*"My job is to make sure that the end users are satisfied and utilizing the software to the Max."*

*- Informant 2*

Top management may question the project's value. Then the end users may clarify that value in ways that the internal project team may not understand. PMs frequently work with end-users to show management the project's potential and technology.

*"If the project is scoped without an actual fundament or not to actually solve the customer problem then user adaptation is very difficult"*

*- Informant 1*

Cognite may work to create labels that are easily understood. Spending time with users impacts the outcome of ML projects. End-users are vital stakeholders in any project, especially when there is a solution that requires the PM to build trust and experience with the tools.

**Third parties.** Cognite sometimes collaborates with others. Third parties can be IT consultants or other companies that the customer already works with. Stakeholder management is made more difficult by third-party involvement.

*"Instead of just working with 2 parts, you have 3 parts, who needs to organize work together, so that can be a bit more complex."*

*- Informant 8*

## Managing Stakeholders Expectations and Conflicts

Different expectations cause conflict, which must be resolved, according to the informants. Without a clear project scope, there may be confusion about what the project should deliver and how wide the scope should be. Cognite may be waiting on the customer to provide something that is holding up the project. That will be a problem if they can't deliver on time. The customer may believe that ML is so powerful that it will work with any data quality, but then they don't understand how models work or what ML is. The lack of technical knowledge may make it difficult to argue for upper-level-management but bringing in experts or handling concerns as a PM may help.

Misunderstandings may occur due to poor communication or a complex subject. Timelines can become tense, and people may try to rush. When the timing is critical and people are expecting things, people may mistakenly believe they are talking about the same thing. Misunderstandings are a common cause of conflict. Cognite may take different approaches to addressing the issues, but close communication and openness are good practices. The PM needs to determine the necessary actions to get on track or resolve the conflict. So, with the relevant stakeholders, decide on the next steps is advised.

*"Generally, the key turning point for conflict is misunderstandings."*

*- Informant 6*

*"Really talk through how we got there and agree on that and agree on the steps to get out. If both don't agree on those two things, then it's a bit challenging to get rid of the conflict."*

*- Informant 6*

When working with ML, it may be clever to reduce expectations, clarify the assumptions needed to succeed, and create a projection of a possible outcome. However, some informants stated that the expectations in ML projects might be lower, as they often extend to some proof of concept. In that case, people may be aligned to the expectations, and the customer organization shows that they are open to failing and looking for ways to find better solutions.

*"Reduce the expectations a bit and say that actually in order to get this properly to work there is a clear set of assumptions that we're doing"*

*- Informant 1*

Nevertheless, customers must be rational when investing in ML projects and consider the results' performance. It's possible to deliver many projects without reinventing the wheel, and simpler models can be just as valuable as more complex ones. To avoid conflict, it is critical to agree on expectations, especially with management.

*"I would say simplicity is key, focus on getting good people to work with good quality data, and have a simple use case."*

*- Informant 2*

## 4.5 What is Change Management and how it is Ensured

This section summarizes the informants' views on change management. Some argue that change is inevitable in any organization and that adapting to it is critical. Many of the informants highlighted user adoption as a critical factor in industrial machine learning applications. Using new technologies is changing the way you work. This creates both

potential and opposition for organizations. In the industrial sector, digitalization can modify people's work habits and routines.

*"Implementing new technologies should usually result in changing the ways of working and that also can cause some resistance because they don't want to change."*

*- Informant 3*

*"field workers going from using only paper-based documentation to now using handheld devices like mobile phones … related to maintenance, doing maintenance in a particular way like each month and then transitioning to doing maintenance when a machine learning model tells you that you should do maintenance. That's like a good example related to maintenance."*

*- Informant 4*

The informants suggest many activities for effective change management. Change management assurance falls into three primary categories: resistance to change, user adaptation, and education and training. The informants differed on what should be improved in their organization's change management and what ML considerations exist for change management. The informants' perspectives are shown below.

## Resistance to Change

When it comes to change, culture is an important aspect. The culture of an organization affects the likelihood of transformation. Organizations with a conservative change culture may be reluctant to change.

*"In culture organizations with the conservative change culture. Then there's very little incentive for them to actually adopt this new tool."*

*- Informant 1*

Smaller businesses are more willing to reform, says informant 5. Larger firms may be less likely to adapt since their employees have been using their methods for many years and are

suddenly forced to change. The industry can be a factor, where some companies, like heavy asset industries, are less eager because it has been successful in the past. It might also be based on the employees' personal interests. The digital journey in the customer organization is a component of this, according to informants. According to Informant 1, resistance to change is natural in all organizations.

*"All this heavily depends on the customers. Some customers are on their digital journey, for instance, so they have been working on this for a couple of years. They have a strategy, they know that they wanna change and they know that they have to do something to change and they're quite mature digitally"*

*- informant 8*

*"in some dimensions all organizations are prone to change when that change is so core part of what you do and how you work."*

*- Informant 1*

The stakeholder may not comprehend the underlying processes or the ML model's mechanism, for example. The ML model becomes a black box if it is not interpretable. Simpler projects allow management to grasp what they are getting and trust the makers.

*"If the machine learning model is not interpretable enough, it becomes a black box. And with this black box there is a resistance to it."*

*- Informant 7*

## User Adaptation

Adapting to the technical competencies of the customer organization is vital, according to certain informants. To make the transformation succeed, Cognite needs to include the customer more in what they do and how they do it. Less technical organizations would focus on demos and making them comprehend the benefits rather than digging deep into the solution's technicalities.

*"if you have a very technical customer where they are working on our platform in parallel. While we were going to use case then we would kind of bring them more into what we do, how we do it, and interact with them more during the project*

*delivery while for less technical customers we would maybe focus more on the demos and make them understandable and not necessarily forcing them into diving deep into what we've done and all the back-end stuff."*

*- Informant 2*

It's also critical to keep the departments affected by the change informed throughout the process. Depending on the department's technical skills, it may be required for various forms of communication. The customer's IT department should be included in the development process as they will likely be the ones maintaining the solution in the future. They can also suggest enhancements to the solution while engaging with the company. It's critical to help them improve and appreciate the solution's benefits.

*"Involving the right people and if you're developing a solution that will affect several departments you need to make sure that you are going to involve those departments from the beginning and that the right people are kept informed during the development and that they're able to come comments along the way."*

*- Informant 4*

It is also important to handle stakeholders and help them comprehend the project's goals, otherwise, it would be perceived as a black box. Communication with stakeholders should consider the project's technical difficulty, and the customer's industry experience may be required. For non-technical people, the project is often a black box, requiring stakeholder management and communication.

*"The level of technical difficulty is a factor to be aware of when communicating to stakeholders."*

*- Informant 4*

Understanding the use case is required for successful change. Escalating a system that does not directly benefit customers is difficult. Examining the use case where they waste time and communicating the improvements to the customer can help them adapt.

*"forcing people to adapt to a system that is not giving them any direct value is not easy. So it's a matter of looking into use cases where they are either wasting a lot of time and recognizing that the wasting their time and then trying to make that simpler"*

*- Informant 2*

The customer is responsible for adapting, but Cognite is available to help. The end-user must be mapped out before the solution can be tailored to achieve user adaption.

*"It's usually on the customer's responsibility to achieve user adaptation. ... We are technical provider who develop solutions But of course we support customers to achieve this adaption."*

*- Informant 3*

Some of the informants mentioned that developing trust in the solution might be difficult for people. Building trust in solutions that are being delivered is vital. Spending much time on Q&A and other things might improve this level of trust. For example, when the project becomes multidimensional, it is more difficult to understand, and then Cognite might try to put on a simple visualization. While being more of a black box, it is more challenging to communicate and have all stakeholders understand the project. Then it will be constructive to do demos and show examples of how the ML affects the projects and how valuable it is for their company.

*"Build trust in solutions that are being delivered, by spending a lot of time on Q&A and other things. ... You also have to kind of define a kind of almost philosophically with how what you've made is going to be used and how you can trust it. Especially in like in industrial setting."*

*- Informant 6*

*"Developing trust in the solution when it's maybe a black box might be a bit difficult for people to understand. That's like an important factor I guess. So maybe spending time explaining what it does and how it works is important. I think that that probably will help the process change."*

*- Informant 4*

## Education and Training

With ML projects, the PM needs to have a more educational relationship with the customers and provide them with the understanding and equipment necessary to comprehend the project scope. Understanding will be essential when they communicate with their peers and associates about what the project is doing. Nobody likes to be responsible for a project that they do not understand, and the outcome is to educate the stakeholder for them to understand their project.

*"We have to provide them with the understanding and the equipment necessary for understanding, so that they feel equipped to not only talk about and comprehend the project scope, but also for them to again communicate with their peers and their associates on what they're actually doing"*

*- Informant 1*

Cognite Academy is a department in Cognite made especially for the training and educating the customer so they can understand the solution. Customers can be skeptical of new solutions and thereby it's important to make the transition slowly and controlled so that they get the feeling of control and that it works.

*" I think it is kind of educating people on those tools that are really important and that's the reason why we have for instance Cognite Academy."*

*- Informant 3*

*"it's important to spend a lot of time with the customers on application training or training the end users because it takes time to get to know of the usage of a new tool or a new solution."*

*- Informant 4*

Training the end-user that will use the solution can be underestimated sometimes. This can cause problems with the project delivery where the end-user doesn't know how to use the solution. In some organizations that have a conservative culture, it can be important to refer to something that the customer requested in the solution to have a smoother transition and adaptation.

*"application training or training the end users because it takes time to get to know of the usage of a new tool or a new solution. And I think sometimes we can underestimate the amount of effort needed."*

*- Informant 4*

Cognite works in an agile way. As a young company, Cognite is eager to change and have talented people in all parts of the company. Some customers organization adopt the agile ways because of the benefits that Cognite has from working in this way.

*"I think the customers who worked with us love to work with us because they see how much we can do when they work in a way we do right, but they actually adopt agile ways of working and all the customers see the value of it"*

*- Informant 3*

*"We've kind of introduced agile to some of the clients and that they've liked it and it sticks. So then they do It outside of working with us and that also helps us a lot when we continue to work with them."*

*- Informant 5*

# 5 Discussion

In this chapter we will initially discuss the findings based on the reviewed literature and conducted interviews with Cognite.

## 5.1 What are the Success Criteria for Project Management?

In conformance to the dimensions of a PM introduced by Opland (2021), the results show that the team structure is vital, and project management requires close collaboration with the internal delivery team. The PM must understand how data scientists and solution architects work and must be able to assist them. Hence leadership is emphasized and that is in accordance with the leadership-administration theory introduced by Opland (2021). We also found a considerable concentration of administrative duties and project requirements in the results.

Methods of project management, such as agile methods were mentioned by the informants, which have got a positive experience with the processes in PRINCE2 Agile, just as Nader (n.d.) mentioned for IS/IT projects. Moreover, numerous informants focused on the appropriate order, right matters at the right time, prioritizing project tasks, and adhering to timetables and objectives. The results show a strong emphasis on meeting the project's time, cost, and scope goals. All of which are in line with the quality triangle of success criteria presented by Asana (n.d.).

> *"Achieving goals at the correct times …. Delivering the planned scope"*
>
> *(Asana, n.d.)*

Stakeholder management were one of our initial focus areas based on literature research and a pilot interview. Just as Karlsen's (2015) study indicates, most informants emphasize the customer as the key stakeholder without an unprovoked mention of any others except the end-users. Statements regarding this domain, such as customer satisfaction and managing customer expectations, were the most commonly stated success criteria in the results. Defining a set of key deliverables and adjusting as the customer's needs evolve are undoubtedly critical. At the same time, most other stakeholders did not get mentioned until we asked for comments. On the other hand, the reference "customer "in Cognite's situation

may be some different stakeholders, as most discussed stakeholders fit into the description. Hence, the initial choice of "Stakeholder management" might not be an inaccurate suggestion.

The informants stated some essential aspects in the customer domain that are quite extensive, these include e.g.:

- Satisfaction
- Expectations
- Upselling
- Creating advocates/champions
- Solving their problems
- User-adaptation
- Building trust
- Education

Furthermore, the study's findings are contingent on the project's quality. Informants first state that "correct quality" or "good quality" are related to the project's success. Furthermore, good data is critical to the success of ML projects, and those assertions validate the decision to choose quality management as a focus area. However, the classification is difficult to define and may be used to describe various aspects of project delivery.

The results suggest that it is more uncertainty about working with an ML project because it is hard to predict the project's outcome. One knows the expected outcome, but does not know if the end result will actually end up being as the expected outcome because there might not be enough data to create a successful ML model. Complexity was a factor when the informants talked about ML projects and the success criteria. According to the informants, due to the complexity of an ML project, it is crucial to have a focused approach in different sectors to reassure that everything will work in the end. The statements indicate that risk management holds elements essential for project management success.

According to the informants, it is vital to have the right personnel to develop the solution and handle the customer's requests for technical resources. After the solution has been delivered

to the customer, there should be someone that can maintain the solution and help the users that have questions. Assuring that the right competencies are there to maintain the solution in the future is an essential factor. This can either be in the organization delivering the solution or in the customer organization. The informants suggested all these aspects before the focus area was brought to attention during the interview.

## 5.2 How is Quality Management Ensured?

Gundersen and Halbo (2018) give some insight into the meaning of the abstract phrase "quality". We can see from the results that informants primarily point at the aspects of the product and customer satisfaction. A correlation can be made that a successful project might be defined by the customer's satisfaction with the product, and then the product becomes an essential factor. Furthermore, data quality essentially defines product quality, which is how ML algorithms work where the input is important for the output. With this in mind, it might seem natural to begin with data quality governance. However, the informants stated that the team setup and culture are also essential for creating quality products and achieving customer satisfaction. The literature has some perspectives on how a PM should standardize workflows to improve quality management, and most informants appreciate the concept of standardization.

Informant 1 mentioned that Cognite should define what quality means to optimize for it, and that mindset is closely related to the literature about total quality management. Our review uncovered that the Japanese industry has an embedded quality culture in the attitudes and behaviors of the entire workforce, and machine learning for industrial applications might be equally prone to get the perks of better culture. When a PM ensures the quality with a focused approach to all the enabler criteria presented in the literature (leadership, people, resources, policies, and strategy), then the results aspects of the equation may naturally occur. Total quality management includes people management, and the informants indicate that team setup is more critical in ML projects than in other IS/IT projects. That may be because of the complexity of those projects that requires specific competencies to create technically sound products. The results also indicate that an ML team should fill roles with different attributes, such as customer-focused PM, solution architects, and data engineers.

## Discussion

There seems to be a solid ML-specific important factor that the data quality is sufficient in an ML project. The algorithm needs to be well made, but a perfect algorithm will not produce valuable results by itself. The data flow is the heart of any machine learning model because the technology is defined as an algorithm that creates output based on historical data. The nature of machine learning suggests that data quality is crucial, which the informants confirm, even though not all Cognite projects are pure ML projects where the team works to create an ML algorithm. Our results highlight the importance of reviewing the data sources, pre-processing, and ensuring quality in all data governance steps. Venkat et al. (2017) suggested a 7-phase approach to govern data quality from the source to the completed dashboard. Many of these steps are part of a standard process of managing big data to achieve any insights. However, while some steps or actions may be evident in project delivery, others can be neglected, as informant 2 mentioned. Then the machine learning company may suffer from the low-quality consequences.

Currently, Cognite utilizes PRINCE2 Agile as a project framework and work methodology, and it has some common traits with a quality management system. PRINCE2 was not intended to be a complete quality management system. However, three of its constituents make up a sizable portion of such a system. These include quality control, well-defined technical and management procedures, planning based on products and product descriptions that describe the product's quality requirements, and the organization that follows the PRINCE2 methodology. Because PRINCE2 is not a quality system in and of itself, its implementation does not automatically result in ISO 9000 compliance. Indeed, PRINCE2 may require customization to match the organization's unique requirements. Cognite also enforces the ISO 9000 compliance to meet the customers and other stakeholders needs.

The quality metrics are time, cost, and scope according to the quality triangle of the theory. Even though the informants do not consciously conform to this definition, we can observe signals that this might be true. Several stated that the scoped out goals should be defined together with the customer, including a timeline, price, and managing expectations of what the project can deliver. The quality concept may be too abstract to work practically effectively, which might be why total quality management and defining a quality culture prove to increase performance.

## 5.3 How is Risk Management Ensured?

Overall, both the literature and informants reveal considerable similarities regarding the importance of risk management and its enforcement. The nature of risk may have different shapes, but many of the examples mentioned are relevant for quality management, stakeholder management, and change management. Several informants claimed that risk occurs due to a lack of quality, and everyone conforms that it is external or internal factors that might impact the project delivery. Risk management and quality management are undoubtedly related, but the way of ensuring the two have a fundamentally different focus. Risk management is mainly trying to prevent a problem, while quality management aims to create something good. Creating something good might not be sufficient by itself due to the complexity of a machine learning project. Uncertainty causes risks to appear. As of this, enforcement of both quality management and risk management may be necessary to deliver successful projects.

The results reveal that more can be done with risk planning because of the complexity of machine learning projects. Cadle and Yeates (2008) state that risk planning is complicated for all IT projects but using some breakdown structure can help to identify risks. Before considering how to handle the risks after identification, it can be insightful to understand what kind of sources the risks own their heritage. Using Cohen and Palmer's (2004) overall risk structure at the beginning of a project may assist in identification. According to literature and results, the risks should be mapped out and registered according to the likelihood of occurrence and potential scale of impact.

The risk register is central in both literature on risk management and is referenced by the informants several times. PMs in Cognito are usually responsible for managing the risk actions Acceptance, Avoidance, Mitigation, and Transfer, as Cadle and Yeates (2008) described. Planning mitigation might be needed for all risks since avoidance might fail, and the risks occur. Cooperation with other PMs and support from the organization might make the mitigation planning easier. The informants also stress the importance of leadership qualities described in the literature because project management tends to create lists without revisiting or updating them. Communication with relevant stakeholders to mitigate risk is not only mentioned in this focus area but stakeholder management as well. The complexity of

machine learning projects might demand even more risk monitoring, especially after project delivery compared to other projects.

Our results show positivity toward standardization of risk management and quality management. Though some informants appreciate pragmatism, they even argued for more structure in managing their machine learning projects. Informant 7 elaborated on the risk matrix that Cognite uses when mapping out and managing risks, just as we presented by Cadle and Yeates (2008) in the literature. PRINCE2 uses the term 'risk log,' which indicates the risk register where the purpose is the same.

Cognite utilizes the PRINCE2 Agile framework and using such a project management framework can lead to advantages where the framework provides some recommendations on project risk management. PRINCE2 distinguishes between project risk and business risk, according to Cadle and Yeates (2008). Business risk, which is the project board's duty, refers to issues that could jeopardize the project's business objectives. As defined earlier, risks in projects could prohibit the attainment of the project's narrower goals. A risk assessment should be done at the start of a project, and risks should be revisited at critical periods throughout the project's lifecycle. For example, in the transition between stages, according to PRINCE2. As part of the regular highlight report to the project board, the PM should comment on the pattern and status of risks according to Cadle and Yeates (2008).

## 5.4 How is Stakeholder Management Ensured?

Karlsen's (2015) research findings indicate that additional efforts should be made to present new perspectives on project stakeholder management and are supported by our research results. Stakeholder management seems to be the most critical focus area based on the informants' answers.

However, is the importance of stakeholders a general factor of any project management, or does ML create extra elements to it? Managing expectations and conflict resolution seems like a vital element of these projects. Moreover, the informants have identified the most critical stakeholders in a project of ML in industrial applications.

Furthermore Karlsen's (2015) study identified that customers and end-users are much more critical than other stakeholders, confirmed by our results. However, the "customer" in Cognite's situation fills almost all the most critical external stakeholder roles. Based on the results, some stakeholder categories in the customer organization can be mapped out and examined. Based on our results, the most important stakeholders are all included on the customer side, as relevant departments. This includes top-level management, project owners, IT-department, and end users.

Top-level management in the customer organization is not necessarily always a stakeholder that the PM communicates with frequently. However, it might be on some occasions. According to Johnson and Scholes (2002), such individuals with high power and low interest would be mapped in the A-category of the stakeholder matrix. They are usually kept informed about the project, emphasizing the minimal impact on their activities. Influential and neutral stakeholders who support the project can result in new resources yet not overburden the PM. Both informants and literature suggest that a 'minimal effort' approach is used.

On the other hand, the project owner is both influential and interested in the project and falls naturally into Johnson and Scholes' (2002) B-category in the matrix. The results show that the PM has to take care of project owners, usually daily. Cadle and Yeates (2008) state that these are the project's primary stakeholders, and they are actively involved in the project and can advance or halt it, proclaim it a success or failure. Our informants state that the product owner is usually interested in the ML solution's ability to create value. Increasing product quality and uptime reduces maintenance costs. According to both literature and our results, this person wants to see results quickly and have a high-level overview, which the PM should ensure.

The informants argue that the IT department should also be considered a stakeholder with high power and high interest, just like the project owner. They have strong preferences, and PMs should constantly be communicating with them from the beginning and beyond the project delivery. The IT is responsible for the data pipeline and managing the final delivery and is a critical stakeholder in approving the project from the start, according to our results. These are especially essential in machine learning because of the data and technical maintenance involved. Cadle and Yeates (2008) say it is necessary to examine whether the B-

category stakeholders are supportive or critical of the project. Positive views in the IT department should be nurtured, and unfavorable views should be addressed.

End-users are typically a stakeholder with high interest and low power. However, in machine learning projects, the dashboards or other deliverables tend to work as tools for decision making, and decision-makers tend to have high power. Meanwhile, another project might make it easier to maintain industrial facilities, and then the end-users might fit into the D-category. They are immediately impacted by the project but cannot shape or direct it, which might lead to project frustration and passive resistance. When applying a new IS/IT system, then these stakeholders are essential and influential. We address this in the change management focus area.

The management of expectations is expressed throughout both the literature and the results of our case study. According to Karlsen, stakeholders wreak havoc on project execution by introducing complications and ambiguity. At the same time, Cadle and Yeates (2008) think expectations should be clearly articulated at the start of a project and reassessed at formal and informal intervals throughout the project. Our informants state that there may be confusion about what the project should deliver and how broad the scope should be without a clear project scope. These statements support the common claim that managing expectation is crucial, especially for machine learning projects. While Cadle and Yeates (2008) argue on behalf of IS/IT projects, our results show a clear correlation in the machine learning for industrial applications domain.

Moreover, the authors suggest a 4-step expectation management approach to unwind any conflict before it begins. Define customer satisfaction, Discover the source of expectation, and calibrate and create an action plan. The 4-step approach from the literature has similarities to suggestions from the informants when managing expectations, but these actions are not directly articulated or standardized in Cognite.

Furthermore, the informants agree that the critical turning point for conflict is misunderstandings, and the complexity and uncertainty of machine learning projects add to this. For conflict, we have a 5-step approach from the literature. Know the desired outcome, triage the conflict, agree on a process, confirm the positions, and take action. Cognite may have different approaches to address the issues, but close communication and openness are

good practices based on the informants' reflections. One of the essential takeaways from literature and results is to decide on the next steps in a collaborative process with the customer.

## 5.5 How is Change Management Ensured?

Change management has two definitions that sometimes tend to be confusing. The first one, which we are treating in this thesis, is the process of changing the way of working in an organization. Another suggestion presented by an informant is the process of changing the scope of project delivery. We spent some time getting all informants on the same understanding of the change the thesis is looking at. After the informants had the same understanding user adoption and resistance to change got mentioned frequently, just as in the literature. Edmonds (2011) introduced resistance to change, which is caused primarily by people's dread of the unknown. The change culture curve introduced by Cadle and Yeates (2008) consists of four steps, where denial and resistance are natural initially before exploration and confidence in the acquired system are achieved.

While the informants divide "change culture" into whether or not the customer organization is conservative, Cadle and Yeates (2008) present a model consisting of four cultures that may affect the resistance to change (Power, Task-based, Bureaucratic, and individualistic). Cognite as an organization is probably in a task-based culture due to how they work with teams and task forces, while their customers probably are either power-based or bureaucratic. Suppose the customer has a power-based culture. In that case, it is essential for a PM in a machine learning supplier to get and demonstrate sponsorship by an advocate in the customer organization. However, on the other hand, bureaucratic organizations are known to be centralized and formal while playing by established norms and rules. The probability of resistance is higher in such organizations.

ML companies could leverage the cultural insights about the customer organization to decide how much resistance management is needed. Some informants claim that larger companies are more reluctant to change, which is very relevant when looking at industrial machine learning applications. However, the informants state that change is natural in all organizations, and most of all when implementing ML systems. The product of a project delivery tends to change how the customer organization works, and their as-is processes

change. Especially in ML, end-users may not completely understand the product's underlying processes, which creates resistance.

The expanded technology acceptance model describes all aspects of the underlying user adaptation process and how primary factors contribute to user behavior. A PM's job is to have the factors in mind when communicating with the end-users throughout the change process and project development. Informants state that Cognite needs to include the customer in what they do and how they do it. The technical background is essential to consider when ensuring user adaptation, and the approach needed will be different depending on the technical level. Less technical organizations would demand a higher-level focus on the benefits of the solution to build trust, or more technically advanced end-users could learn more of the underlying processes in the delivery without being intimidated by the complexity.

The literature on user adaptation is summarized by building end-users self-confidence while emphasizing the gains of new systems and processes. Our results stress that communication and expectation management need to flow from the PM to any relevant stakeholders in the customer organization. Mistrust is pervasive when working with ML that the end-users do not understand. The level of trust is vital because ML products are prone to make decisions that end-users need to respect to gain advantages. That is probably why many informants emphasize building trust by spending time on Q&A, education, and training.

We can see that the literature and informants treat the planning, education, and training slightly differently. None of the informants mentioned anything about planning a change program or creating a plan before the project development. However, the literature states that agile work methodologies have a natural way of dealing with change management. The means in change management of both the literature and our results are the same considering communication and training to reduce the negative impact of the change on the users. Literature suggests involving the users in the planning and implementing of the change program, which is something to consider when applying ML as Cognite does.

For instance, informants report success regarding initiatives that aim to train and educate end-users with Cognite Academy. However, they state that training the end-user can be underestimated sometimes, which can cause problems with the project delivery. All in all, informants state that PMs need to have an educational relationship with the customers and

provide them with the understanding and equipment necessary. Literature suggests that a standardized four-phase management change model ensures a smooth transition. Launch, Communication, Education, and After go-live phases and their descriptions should enforce a more certain change process in the uncertain and complex ML environment.

## 5.6 Methodology as a Success Criteria

The literature and Cognite indicate that the methodology used in their projects is a significant factor in achieving good results and having good project processes. Much of the structure regarding how PM work depends on the methodology utilized. Furthermore, we might then discuss the strengths and weaknesses of using PRINCE2 Agile as a framework for success as a PM in ML for industrial applications.

The complexity and uncertainty of ML projects demand a flexible approach. The PM needs to respond to change requests with minimal quality consequences. Scrum sprints with embedded customer communication reduce time spent in work-in-progress stages. That seems to support many of the essential factors we have discovered and discussed throughout this thesis.

An important factor we want to take another look at the is the PRINCE2 Agile structure in **Figure 3.6** presented in chapter 3.3 about project management. Agile emphasizes iterative development, providing bits of the project to meet customer needs. Frequent delivery allows for ongoing end-user feedback, resulting in better delivery and user adaptation. This is positive for ML in industrial applications due to expectation management and change management. Revisits and rewrites of steps are encouraged to achieve the desired results in agile projects, and tasks are tested in flight, allowing for faster delivery and better project results. Frequent delivery also allows for quick changes in project direction while maintaining project scope. These strengths in agile methodology are likely a sizeable supporting factor to success in the ML environment. Agile methodology is a success criterion for the delivering company and the customer organization to several informants in the results section.

However, agile does not set a strict schedule, which, if not managed, can be difficult under a tight deadline. Changing project requirements may cause problems in other areas of the

organization. Moreover, agile requires a consistent team, as mentioned in the quality section. A weak link in the Agile team or management could result in wasted time and money.

Some projects require both the rigidity of waterfall and the reactivity of agile. Communication and expectations provide for positive consequences when mixed. Mixing techniques does not mean forcing one group to adopt a solution that does not work for them. Using a platform that allows for multiple approaches should help all groups and the business. Mixing techniques will enable complete insight into what work is in the queue, what work is in progress, and what work will be completed in the future. ML teams can use agile to boost code output, while PMs can use waterfall to meet deadlines and dependencies. Choosing a work style enhances productivity.

## 5.7 Machine Learning Considerations

This last section focuses on ML-specific project management considerations for industrial applications. The thesis mapped the informants' opinions on broad project management topics. All interviewees work with ML for industrial applications, but not all aspects of ML project management are ML exclusive. The traits of a ML project are affected by technological complexity and uncertainty of the results. This demands a structured and competent internal delivery team, among others, but what indicates to be the essential part due to the results are *data quality and managing expectations*.

The informants agree that data quality is paramount when a team creates value with a ML approach. The data quality directly correlates with the results, as the model makes predictions based on these historical datasets, just as mentioned earlier. Without good data governance, organizations tend to respond to data quality issues reactively, and the delivery team will fail to deliver according to stakeholders' expectations. Contrarily, the literature reports that data governance promotes a proactive, holistic approach to data quality. Informants state that pre-processing and mapping the data pipelines and post-delivery monitoring in cooperation with the IT department is essential and could even be done better.

Additionally, expectations management has been mentioned frequently throughout the results due to the complexity and uncertainty of the ML projects. Expectation management is arguably the most important part of stakeholder management, which is significant because

stakeholder management is the informants' most critical focus area in this thesis. The PM needs to always communicate and level with the expectations of all relevant stakeholders. Changes in the project delivery frequently occur due to uncertainty. When risks appear, they should be communicated to relevant stakeholders, and if risks occur, the expectation might be leveled just enough to avoid a conflict. For example, the data quality can be worse than expected, or resistance in the customer organization may be higher than anticipated. All these risks should be mapped out and shared with the project owner of the customer organization continuously. Agile ways of working facilitate this, and with consistency, then expectation management might enforce project success in the ML project.

# 6 Conclusions and Recommendations

The concluding chapter summarizes the key findings and limitations of the study and provides suggestions for future research.

## 6.1 Summary

This thesis has conducted a qualitative study based on interviews with eight PMs. The information was gathered from the Norwegian company Cognite, and the informants have considerable experience with ML for industrial applications. Our results show both diversity and correlations amongst the informants and compared to available utilized literature in the thesis.

This thesis tries to answer the following problem formula; What are the success criteria in project management in ML for industrial applications? It breaks the problem into *the project*, *project management*, and *ML*. The project success criteria discovered in this research are related to various aspects of customer satisfaction and project quality. Project management, however, tends to have a similar end goal, with more emphasis on leadership and administration of the project. The ML project got defined as a complex and technical type of project with uncertain results and is frequently compared to a black box. ML exclusive success criteria are related to having the right competencies, managing the customer's expectations, and ensuring good data quality.

The project management areas of interest include quality management, risk management, stakeholder management, and change management, all of which contain certain aspects essential for success. Quality management is related to ensuring the time, cost, and scope, and results show potential improvements regarding the *quality management culture*, *customer success*, *data quality*, and *standardizing*. Team setup and *quality culture* are essential, with a total quality culture and a team of the right competencies for ML. Customer success is also a part of quality management, as the customer collaborates with the delivery team to ensure quality. The thesis uncovered significant importance regarding the data quality, as ML algorithms predict based on historical data where any outliers will affect the results. Standardization may be done to manage the quality or risks, using either a quality

management system, ISO standards, or a methodology like PRINCE2 Agile with built-in assurance mechanisms.

Risks may come from poor project quality, inability to deliver on time, budget, or scope, and potential threats to success. Our results divided risk management into *identification*, *assessment*, *management*, *supervision*, and *standardizing*. The first step is to define the risks, probable outcomes, and consequences, then make a mitigation plan to reduce or turn risks into opportunities. Continuous management reduces the risks by proactively identifying and preventing them. Frameworks with *risk registers* do much to assist continuous assurance of the risk management by the PM with support from relevant stakeholders throughout the project.

According to some informants, stakeholder management is the most critical success criterion in this thesis, where both Karlsen's research and our results reveal that customers and end-users are critical. PMs in ML projects need to communicate the expectations, namely time, cost, and scope, continuously with *top-level management*, *product owners*, *IT departments*, and *end-users*. Top-level management with high power and low interest should usually be informed about the project with a minimal effort approach. Project owners want results quickly, and a high-level overview is suggested as the stakeholder may advance or halt the project and proclaim it a success or failure. Moreover, the IT department may be supportive or critical of the project, and PMs should nurture positive views and address unfavorable ones to ensure project success. Finally, the project immediately impacts the end-users, which might lead to frustration and resistance, so ensuring end-user collaboration with change management is essential.

Change management, in this thesis, manages the implementation process of ML solutions that change the way a customer organization work. The PM in ML projects needs to address *resistance to change* and ensure *user adaptation* by *educating and training* the customer end-user. The customer organization's culture and end-users lack of understanding of ML processes create resistance. The PM must ensure user adaptation by building end-users self-confidence and technical capabilities while emphasizing the gains of new systems and processes. The PM should have a holistic approach to the project delivery by planning out education and training with the customer end-users. Hence, agile work methodologies have a natural way of dealing with change management.

*Agile methodologies* appear to be a significant driver of success in ML projects when ensuring iterative development, frequent delivery with end-user feedback, and quick changes in project direction while maintaining project scope. ML projects are *complex* and *uncertain*. While most of the mentioned aspects are essential in the project management of ML in industrial applications, *data quality* and *expectation management* appear in every focus area and are claimed to be especially ML critical.

## 6.2 Limitations

This thesis has only studied one company and could have a more robust perception of the problem formulation with more companies and different stakeholders. Furthermore, much of the presented theory has been retrieved from Cadle and Yeates' (2008) book Project Management for Information Systems based on the essential course Project Management and Business Information Systems that we had during our bachelor's. Even more theories and consistent comparison of books could have been beneficial, though PM in ML for industrial applications is still an undiscovered field.

Additionally, the research approach might have been improved. Perhaps using the abductive SDI technique is not necessarily the best choice as it does not have a solid theoretical basis. On the other hand, it might be suitable when the problem environment shares an experimental basis. Moreover, the qualitative method is exposed to interpretation by the researchers, which may be subject to bias where informants likely interpret concepts slightly differently, which may undermine the data basis. However, we tried to clarify concepts in advance and summarize key findings.

Finally, our results significantly focus on essential factors or criteria in project management but lack a clear hierarchy of what factors are more significant than others. It creates complications because the projects have limited time, cost, and scope, and it is impossible to achieve everything. It could also have been clearer what PMs should NOT do in contrast to what PMs should do, or more emphasis on conditional project management.

## 6.3 Further work

These pages lay an early foundation for success criteria for project management in industrial applications of ML, which is quite an undiscovered field. More research should be done to create a foundation for project management in the ML for industrial applications environment. Further contributions can be made to create a more nuanced and complete overview, and some suggestions would be to build on the presented limitations of this thesis. More research allows for possible future standardization structures specific to ML to improve industries' efficiency worldwide, which is undoubtedly appreciated in this fourth industrial revolution. Further work also requires that emerging companies like Cognite allow themselves to be researched and contribute to creating future standard best practices. As of this, we thank Cognite again for its cooperation.

# Bibliography


Alzubi, J., Nayyar, A., & Kumar, A. (2018). *Machine Learning from Theory to Algorithms: An Overview*. Iopscience.iop.org; IOP Publishing Ltd. https://iopscience.iop.org/article/10.1088/1742-6596/1142/1/012012/meta

Asana. (n.d.). *The Project Management Triangle: What It Is and How to Use It.* Asana.Com. https://asana.com/resources/project-management-triangle

Bertolini, M., Mezzogori, D., Neroni, M., & Zammori, F. (2021). *Machine Learning for industrial applications: A comprehensive literature review* . ScienceDirect.Com https://www.sciencedirect.com/science/article/pii/S095741742100261X?casa_token=XqRk_SM0KvcAAAAA:5PxID7efN9Xm4qu0yCamxZYjXssLjZy-LPDL4t3xglwK-JxeE5qgQCismjqUVl8pGMWqxb7tKA

Busch, T. (2013). *Akademisk skriving - for bachelor- og masterstudenter* (1. Edition). Fagbokforlaget.

Cadle, J., & Yeates, D. (2008). *Project Management for Information Systems* (fifth edition). Pearson Education.

Cognite. (n.d.). *About us | Cognite*. Cognite.Com; Cognite. Retrieved May 5, 2022, from https://www.cognite.com/en/company/about-us-cognite

Cohen, M. W., & Palmer, G. (2004). *Project risk identification and management*. Proquest.Com; AACE International Transactions. https://www.proquest.com/scholarly-journals/project-risk-identification-management/docview/208202179/se-2?accountid=192066

Del Val, M. P., & Fuentes, C. M. (2003, March 1). *Resistance to change: a literature review and empirical study* . Emerald.Com; Emerald Insight. https://www.emerald.com/insight/content/doi/10.1108/00251740310457597/full/html?casa_token=RoQTBKCH1qgAAAAA:XXYu_xhs6j-j8kKdF3Rtq_R3a_KHplcMlxhNlHfDgb0XtSYRWCSetCaR3ozY2AOHb5REFokcKEFVQZ3l1nqiVh2Q9bTsuvXwG2GbRte3VWB44NWLvPI

Diez-Olivan, A., Del Ser, J., Galar, D., & Sierra, B. (2019). *Data fusion and machine learning for industrial prognosis: Trends and perspectives towards Industry 4.0*. ScienceDirect.Com https://www.sciencedirect.com/science/article/abs/pii/S1566253518304706?casa_token=BvHibESHx7EAAAAA:ImixsD6fIAMoUsJrmbVcvrrZmgyz_IzdCZZKtHZGhDIv6vOKNE63LsAYvloocJ2njrSC5qRdKg

Edmonds, J. (2011, September). *Managing successful change | Emerald Insight*. Emerald Insight; emerald insight. https://www.emerald.com/insight/content/doi/10.1108/00197851111160478/full/html?casa_token=RqtwbCBt4g0AAAAA:Tuc7bD-JI3OBmwuCROtNh9ib2RSIiZw67iBCxYmnP9W9l99qaDPsWj552TUDthRlU3lDmTbVq_oLe4Efk6bHV7TfPgIaiOy0k-5Z1f9CRIbwbOXMa5k

Grønmo, S. (2021, May 10). *forskningsmetode - samfunnsvitenskap*. Store Norske Leksikon. https://snl.no/forskningsmetode_-_samfunnsvitenskap

Gundersen, D. G., & Halbo, L. (2018, May 28). *kvalitet* . Store Norske Leksikon. https://snl.no/kvalitet

Halozan, H. (1990). *Market Niches in Europe*. ScienceDirect.Com ; TAKAMOTO SAITO. https://www.sciencedirect.com/science/article/pii/B9780080401935500419

Hoffmann, T. (2013, September 22). *Hva kan vi bruke kvalitativ forskning til?* Forskning.No. https://forskning.no/sosiologi/hva-kan-vi-bruke-kvalitativ-forskning-til/610839

ILX Group. (n.d.). *PRINCE2 Methodology Explained* . PRINCE2 Information & Courses | Project Management Certification |. Retrieved April 27, 2022, from https://www.prince2.com/uk/prince2-methodology

Issam, E. N., & Murphy, M. J. (2015). *What Is Machine Learning?* . SpringerLink; Springer International Publishing. https://link.springer.com/chapter/10.1007/978-3-319-18305-3_1

Jordan, M. I., & Mitchell, T. M. (2015). *Machine learning: Trends, perspectives, and prospects*. Science.Org. https://www.science.org/doi/full/10.1126/science.aaa8415?casa_token=w3UhOUxaXg8AAAAA%3Ail3Ld22-XTtYnvF4bakb4crlFQBvSDUXWXKKaSAlNdYVR8VB8zeMjN7P0cFep_mYuPEYF41fY7RC7A#con1

Karlsen, J. T. (2015). *Project Stakeholder Management: Vol 14, No 4*. Taylor & Francis; Engineering Management Journal. https://www.tandfonline.com/doi/abs/10.1080/10429247.2002.11415180

Larrañaga, P., Atienza, D., Diaz-Rozo, J., Ogbechie, A., Puerto-Santana, C. E., & Bielza, C. (2018). *Industrial Applications of Machine Learning*. CRC Press.

Lavagnon, A. Ika. (2009). Project Success as a Topic in Project Management Journals. *Project Management Journal*, *4*, 108–109. https://doi.org/10.1002/pmj.20152

Leukel, J., González, J., & Riekert, M. (2021). *Adoption of machine learning technology for failure prediction in industrial maintenance: A systematic review* . ScienceDirect.Com https://www.sciencedirect.com/science/article/abs/pii/S0278612521001849?casa_token=5T7On-KjGikAAAAA:Sja3InXa9BK4SSq4BcrY2r1fzoxJfgERPFA-FebVh3cEYz_rV-LndZHq446cAmlnWqwlbjeINg

Little, D. (2008, February). *What is hermeneutic explanation*. Personal.Umd. http://www-personal.umd.umich.edu/~delittle/Encyclopedia%20entries/hermeneutic%20explanation.htm

Munns, A., & Bjeirmi, B. (1996). *The role of project management in achieving project success*. ScienceDirect.Com https://www.sciencedirect.com/science/article/pii/0263786395000577

Nader, R. K. (n.d.). *An Overview of PRINCE2 Agile*. PRINCE2 Agile® Wiki. Retrieved April 27, 2022, from https://prince2agile.wiki/

Patterson, F. D., & Neailey, K. (2002). *A Risk Register Database System to aid the management of project risk*. ScienceDirect.ComInternational Journal of Project Management; International Journal of Project Management. https://www.sciencedirect.com/science/article/abs/pii/S0263786301000400?casa_token=zltBfA0gIkUAAAAA:s2fTQctswUEDYVVwPBHB-sMCJpIyIGeMLTSvVeHL90RQ9PaETpPtM7kMMoJ5z2ZknhB6SNeWKg

Petch, J., Di, S., & Nelson, W. (2022). *Opening the Black Box: The Promise and Limitations of Explainable Machine Learning in Cardiology* . ScienceDirect.Com. https://www.sciencedirect.com/science/article/pii/S0828282X21007030#:~:text=%E2%80%9CBlack%20box%E2%80%9D%20is%20shorthand%20for,literally%E2%80%94life%20and%20death%20issues.

Rai, R., Tiwari, M. K., Ivanov, D., & Dolgui, A. (2021, August 14). *Machine learning in manufacturing and industry 4.0 applications*. Taylor & Francis. https://www.tandfonline.com/doi/full/10.1080/00207543.2021.1956675

Reifer, D. J. (2002). *How good are agile methods?* . IEEE Xplore; IEEE . https://ieeexplore.ieee.org/document/1020280

Robert, J., Smith, T., & Liu, D. (2008). Project Success. *International Journal of Business and Management*. https://doi.org/https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.669.99&rep=rep1&type=pdf#page=4

Sarker, I. H. (2021). *Machine Learning: Algorithms, Real-World Applications and Research Directions*. SpringerLink. https://link.springer.com/article/10.1007/s42979-021-00592-x

Stonerburner, G., Goguen, A., & Feringa, A. (2002). *Risk Management Guide for Information Technology Systems* . Icsdefener.Ir; NIST Special Publication 800-30. http://www.icsdefender.ir/files/scadadefender-ir/paygahdanesh/standards/NIST%20-%20800-30R0%20-%20Risk%20Management%20Guide%20for%20IT%20Systems.pdf

Tariyal, B. K., & Cherin, A. H. (2003). *Optical Fiber Communications*. ScienceDirect.Com. https://www.sciencedirect.com/science/article/pii/B0122274105005214

Tjora, A. (2021). *Kvalitative forskningsmetoder i praksis* (4. Edition). Gyldendal akademisk.

Venkat, Gudivada. N., Apon, A., & Ding, J. (2017, July). *Data Quality Considerations for Big Data and Machine Learning: Going Beyond Data Cleaning and Transformations*. Reserchgate.Net; Researchgate. https://www.researchgate.net/publication/318432363_Data_Quality_Considerations_for_Big_Data_and_Machine_Learning_Going_Beyond_Data_Cleaning_and_Transformations

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (n.d.). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*, *27*(3), 425–478. https://doi.org/10.2307/30036540

Opland, L.E. (2021). Dift 2011 Prosjektledelse og Forretningssystemt[PowerPoint presentation]. Retrieved from Blackboard - NTNU.

# Appendix A

## A Interview Guide

**Interview guide**
**Estimated time: 45min – 1hour**

The interview guide serves as a template for the interview and will ensure that all topics related to the issue are discussed. The questions cover the topics of the problem formulation: Managing Change, Risk Management, Managing stakeholders, and Quality management.

Abbreviations

| | |
|---|---|
| **PM** | Project Manager |
| **ML** | Machine Learning |

**Intro (5 min)**

- Intervjuer explains what the interview will be used for
- NTNU Bachelor thesis in Digital Business Development
- Anonymous answer in thesis
    - Obs! Consent form
- Inform about the task and problem
- Our focus areas
- **Use examples**

What defines an ML project?

*"One of the most important aspects is that it often involves technical complexity that is difficult to understand, especially for domain experts who are also potential users of whatever you create. A non-ML project that is still technically complex can be the construction of one or another model that requires a lot of domain knowledge. When it comes to pure ML models, much of this domain-specific aspect is removed, and there is much more black boxing and the process itself from input to output becomes more incomprehensible. The same applies when creating Hybrid models (which is a mixture between domain models and machine learning models), but then to a lesser extent than for pure ML models (input in -> some model -> output). This means, among other things, that a certain type of use must be convinced to a much greater extent that the model(s) work, in that they cannot logically follow the process from start to finish." - Input from Petter Svingen* (Cognite)

**Part 1: Introduction (5 min)**

1. What is the position of the informant in the project team?
2. What experience does the informant have? Has the informant worked on a lot of ML projects?
3. What kind of projects do you work with? E.g. Only ML for industrial applications, or perhaps others?

**Part 2: Focus areas (35-50 min combined)**

Intro Project Success (7-10 min)

1. How would you define the difference between ML projects and non-ML projects?
2. Can you elaborate on the main phases of a project cycle in Cognite?
3. How would you define a successful project?
4. Do you have an estimate or **measurement** of project success frequency in Cognite?
5. Can you state a couple of key elements regarding success as a PM in your/Cognite´s projects?

Quality Management (7-10 min)

What do we mean by Quality management?

Getting good quality is different from quality **management**. Quality management from a PM's perspective. Quality management refers to processes for ensuring the quality of project delivery meets a certain standard.

Questions:

1. What does quality mean in your projects?

2. How do you as a PM manage quality in a project?

3.1. What is the role or extent of utilization of quality management in Cognite?

3.2. Do you use a quality management system?– *Follow up if Yes*

4. Is there anything that could be done better with quality management in Cognite for the future?

5. How does quality management differ in ML projects compared to other projects (with less technical complexity)?

6.1. Why would quality **management** be important for a project?

6.2. Why would quality management not be important?

Risk Management (7-10 min)

What do we mean by Risk Management?

How risk is **managed** from a PM's perspective.

Questions:

1. What does risk mean in your projects?

2. How do you as a PM manage risk in a project?

3.1. What is the role or extent of utilization of risk management in Cognite?

3.2. Do you use a risk management system?– *Follow up if Yes*

4. Is there anything that could be done better with risk management in Cognite for the future?

5. How does risk management differ in ML projects compared to other projects (with less technical complexity)?

6.1. Why would risk **management** be important for a project?

6.2. Why would risk management **not** be important?

Managing stakeholders (7-10 min)

What do we mean by Managing stakeholders?

How the stakeholders are managed from a PM's perspective. Various forms of communication with personnel who have a direct or indirect interest in the project. E.g. customers, top management, employees, etc. Stakeholders have different interests or "stakes" in a project.

Questions

1.1 Who are typically your project's stakeholders, and how do you typically rank them by importance?

1.2. How can you determine where to put your management effort?

1.3. How do typical conflicts with the stakeholders evolve and resolve?

2. In what ways does stakeholder management differ for ML projects compared to other projects (with less technical complexity)?

3.1. Why would managing stakeholders within Cognite (Internal), and also with the user organization (External) be important for a project?

3.2. Why would managing stakeholders **not** be important?

Managing Change (7-10 min)

What do we mean by Managing Change?

How change is managed from a PM's perspective. This implies changes for the customer organization with various levels of user adaptation, culture, process change, and resistance to change.

Questions

1.1. How would you describe the change culture in typical customer organizations?

1.2. What cultural and organizational regards are important when implementing (IS/IT) ML solutions?

2.1. Is it difficult to achieve customer user adaptation?

2.2. How might other forms of change resistance occur? (with no regard for the user)

3. What kind of process change might an ML project/product imply?

4. How is managing process changes different for an ML project compared to other projects.

5.1. Why would change management be important for a project?

5.2. Why would it not be important?

**Part 3: Summary (5 min)**

1. What do you think in general are the main differences in achieving project success with a normal project and a heavily assessed ML project? (other than already mentioned)
2. Will the informant add anything?
3. Is there anything that is unclear?

NTNU

Kunnskap for en bedre verden