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Creation of a Project Portfolio for a Construction Company by Using Lean Six Sigma Principles

Change Management, as part of Clarifying the Case Company's Strategy

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ABSTRACT:

Project Portfolio Management (PPM) is an important tool for an industrial companies to achieve a competitive advantage. Companies in the Construction Industry, especially in Infrastructure construction, where the majority of companies are small or medium-sized, generally do not have the capacity or knowledge for the strategic selection of projects as part of the company's future strategy, as there is a dearth of knowledge on project level PPM and Lean Six Sigma.

This causes companies to blindly bid on different projects, hoping for a good outcome, as the selection of projects is not based on knowledge or facts. This causes companies to offer projects, that are negatively correlated to their own strategy, which in the long run will worsen the company's ability to generate profit, as projects do not create synergies between the companies' different business areas. In the ever-tightening competition in the market, where the cheapest offer invariably wins, the company must consider the Lean Six Sigma -mentality in its production, where it strives to optimize its own processes to achieve a situation, where it produces more added value with its processes, more efficiently and at lower costs. Only by learning from its own production can company achieve a competitive edge in a market.

The methodology of the research has been based on the Case Company's interviews and internal documents, on which the analysis has been formed by using the literature of the field. This study focuses on analyzing the production processes of an influential infrastructure construction company in Finland, aiming to optimize the company's strategy-, production-, and bidding processes, by developing a Project Portfolio Management -tool, so that the company has a better competitive position in future.

KEYWORDS: Project Portfolio Management, Project Management, Key Performance Indicators, Lean Six Sigma, Strategic Management, Risk Management.

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TIIVISTELMÄ:

Project Portfolio Management (PPM) on tärkeä työkalu teollisuusyrityksille kilpailuedun saavuttamisessa. Erityisesti infra-alaan erikoistuneista rakennusalan yrityksistä suurin osa on pieniä tai keskisuuria. Tämän takia yrityksillä ei yleisesti ottaen ole kapasiteettia, tietoa tai projektitason PPM- ja Lean Six Sigma -osaamista, strategisesta projektien valinnasta osana yhtiön strategisia tavoitteita.

Infrarakentamisen parissa toimivat yritykset perustavat tarjouslaskentansa eri rakennusprojekteissa arvioihin, toivoen hyvää lopputulosta. Hankkeiden tarjouslaskenta perustuu tällöin arvailuun, eikä tietoon tai tosiasioihin. Tämä saa yritykset tarjoamaan omaan strategiaansa negatiivisesti vaikuttavia projekteja, jotka eivät luo synergiaetuja yritysten eri liiketoiminta-alueiden välille ja pitkällä aikavälillä heikentävät yrityksen kannattavuutta. Alalla vallitsevan kilpailun jatkuvasti kiristyessä, jossa halvin tarjous poikkeuksetta voittaa, tulee yrityksen huomioida Lean Six Sigma -mentaliteetti tuotannossaan. Yrityksen tulee pyrkiä optimoimaan omia prosessejaan saavuttaakseen tilanteen, jossa se tuottaa enemmän lisäarvoa resursseillaan tehokkaammin ja edullisemmin. Vain omasta tuotannostaan oppimalla yritys voi saavuttaa merkittävää kilpailuetua markkinoilla.

Tämä tutkimus keskittyy Suomessa toimivan infrarakentamiseen erikoistuneen yrityksen tuotantoprosessien analysointiin; tavoitteena optimoida yrityksen strategia-, tuotanto- ja tarjousprosesseja. Tutkimuksen lopputuotteena kehitettiin Project Portfolio Management -työkalu, jota hyödyntämällä yrityksellä on mahdollisuus parempaan kilpailuasemaan tulevaisuudessa. Tutkimuksen metodologia on perustunut Case Yrityksen haastatteluihin sekä sisäisiin asiakirjoihin, joiden perusteella analyysi on muodostettu alan kirjallisuutta hyödyntäen.

AVAINSANAT: Projektiportfolio, Projektinhallinta, Key Performance Indicators, Lean Six Sigma, Strateginen johtaminen, Riskienhallinta.

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Abbreviations

BCR = Benefit Cost Ratio

CPI = Cost Performance Index

DDDM = Data Driven Decision Making

DFM = Design for Manufacturability

DFT = Design for Testability

DPMS = Dynamic Performance Management System

DTA = Decision Tree Analysis

EAC = Estimated Duration at Completion

EMV = Expected Monetary Value

ES = Earned Schedule

EV = Earned Value

EVM = Earned Value Management

IRR = Internal Rate of Return

JIT = Just in Time

NPV = Net Present Value

OPM3 = Project Management Maturity Model

PBP = Project Business Plan

PM = Project Manager

PMO = Project Management Office

PP = Payback Period

PPM = Project Portfolio Management

PPR = Project Performance Report

PRF = Project Request Form

PV = Planned Value

ROI = Return on Investment

SPI = Schedule Performance Index

SV = Schedule Variance

TPS = Toyota Production System

VAC = Variance at Completion

1 Introduction

The Construction Industry differs from other industries in terms of monitoring business operations, and standardization of processes. This is largely due to the fact, that each building site is different, and there hasn't found a solution, especially in terms of infrastructure construction, where construction could be carried out so-called from the conveyor belt. When digging underground, the underlying conditions change radically; the soil may be rock, clay or moraine; frost behaves in different ways in different parts of the world, and the materials installed underground vary according to the needs of the area.

Companies operating in the construction industry are mainly small, which leads to the fact that the entrepreneurs' training or general knowledge does not support the strategic planning or monitoring of business operations; or at least that is the situation in the Case Company. When construction processes are not standardized, and the productivity or profitability of business operations is not constantly monitored, the company may find itself in a situation, where its business is not profitable, which leads to various of difficulties for payments and production challenges. The Case Company asked for my help with this problem; to create the conditions for the continuation of business operations, both in the eyes of the financiers, and to ensure continuity in general.

Lean Six Sigma -methods and tools are generally used to achieve improved capability in terms of performance and reduce variation in the processes. Performance increase shows up in defect ratio decreasing and improvement to business profits, employee satisfaction, and better quality of products and service. At construction sites; improved quality leads to reducing reruns, delays and reworks regarding completed tasks resulting in on time delivery and cost effectiveness. (Al-Aomar, 2012)

1.1 Research Questions

In this research we delve into the company's production processes, practices; both from the point of view of the company's production, tender calculation, traceability, and monitoring of financial key figures, and aim to create a standardized system for the construction of Project Portfolios for the

company; so that the Case Company will have an opportunity in the future to base the offered projects on profitability and thus enable the company's continuity.

Research questions, that we are trying to answer in this study are:

- What is Lean Six Sigma, and how it can be implemented in Project Management of Construction Projects?
- What is Project Portfolio Management, and why it is so important to have Project Portfolio Management, especially in Construction Industry?
- What problems is the Case Company facing now, what problems causes, and how can we generate solutions for these problems?
- What tools can the Case Company use for better future?

1.2 Research Gaps

Every organization, whether small, medium-sized, or large, is most likely spending money and labor on different projects at any given time. If you keep track of all your projects and put them in one place, you might have a project portfolio. If the planning, development, and management of the portfolio are not done in accordance with the best procedures, methods, and guidelines for structured project portfolio management, then it might not be a "true" portfolio. (Kodukula, 2014) This means that the Project Portfolio Management methodology is not necessarily understood in the right way in all organizations, which leads to the wrong kind of measures when the subject area is not known well enough.

Particularly in construction industry, where people from various backgrounds are involved, there is a dearth of literature on project level Project Portfolio Management and Lean Six Sigma. This may be since on a general level; the construction industry is often staffed by uneducated people who do not have the knowledge or ability to develop research of these methodologies. Up to 24% of the people working in the field have no education of any kind, and 70% only have a high school diploma (Sokanu, 2022).

Also, most construction projects don't leave enough time for reflection or innovation. The team constantly adapts to the current materials, including how quickly they can be delivered, and the skill of

the tradespeople available at the time. The need to make quick decisions for trade coordination and schedule drop off makes it difficult to sit down and evaluate and improve processes in a way that will allow project to be completed on schedule and within budget. (Case Company, 2023)

One of the reasons why Lean Six Sigma initiatives in businesses are discontinued is the low success rate of improvement projects. To enable Lean Six Sigma sustainability, it is crucial to pinpoint and assess the causes of failed Lean Six Sigma improvement projects. However, a deeper understanding of the evaluation, ranking, and prioritization of projects in the early stages is required to comprehend Project Portfolio Management and apply Lean Six Sigma principles.

1.3 Research Structure

In this research, we aim to create a Project Portfolio, the definition of which has been thought through Lean Six Sigma principles; how the opportunities brought by different projects can produce an advantage for the company through production efficiency. The framework of research including:

Chapter 1 – Introduction

- This chapter gives a brief overview of the research history and explains its purpose on general level.

Chapter 2 – Literature Review

- This chapter includes a map of the research showing where the research has started, which concepts were chosen to dive into deeply, and where following those concepts was brought. Generally, these concepts are theories and models established by academics in field of Construction, Strategic Management, Project Portfolio Management, and Lean Six Sigma.

Chapter 3 – Methodology

- This chapter delves deeply into the research's guiding principle and analyzes its methodology by showing the practical tools and methodologies that were used to perform this research.

Chapter 4 – Case Company

- In this chapter, we delve deeper into Case Company, its operating methods, problem areas, and general habits and problems of the construction industry.

Chapter 5 – Creation of Project Portfolio

- The definition of the Project Portfolio Management tool for the Case Company in presented in this chapter. To support this, we use theory of the industry, to create a well-founded, easy-to-use user interface.

Chapter 6 – Managerial Implications

- Case Company asked to take a position on practical measures, how the issues discussed in the study can be implemented in the company on a concrete level. In this chapter, we go through different tools to support daily management processes, to create a framework for the Case Company to follow, to implement methods on their daily management.

Chapter 7 – Conclusion

- In this chapter we are briefly summarizing the key arguments made in the research body, showing how each of them contributes with the research.

2 Theoretical Framework

Defining the project portfolio is part of the company's strategy process. In this chapter, we examine from different perspectives the definition of the project portfolio as part of forming the company's strategy - as part of risk management and measuring the company's profitability. Successful project portfolio implementation requires clear, standardized, and good management. For the definition of the portfolio to create as much benefit as possible for the company, the portfolio must be managed correctly.

By implementing Lean Six Sigma techniques, construction companies can find areas for improvement and take actions, so that the production is more cost-effective and higher quality. Combining Lean Construction with conventional project management methods makes it clearer to all parties involved how information, personnel, and resources can be used more effectively to deliver desired results on schedule and within the allocated budget. Using Lean methodology as part of building a project portfolio, the company creates a significant competitive advantage for the company to survive the fiercely competitive market. With a comprehensive approach, we aim to enable an understanding of the subject so that this research can be utilized as part of the company's strategy development process. We try to describe the causal relationships between different functions, so that the overall picture can be understood - and the importance is better known.

2.1 Strategic Management

Strategic management is the creation and execution of significant goals and initiatives by the management of an organization on behalf of its shareholders. The formulation process typically begins with an evaluation of the resources that are currently available, a competitive environment analysis of the industry in which the company operates, and an internal operations evaluation. A strategy is then developed to accomplish the desired goals; based on this overall assessment. Implementing the developed strategy aims to direct and align the business with its primary goals. (CFI Team, 2022)

Strategic accounting for corporate management refers to the transformation of accounting into a long-term tool for corporate management. It differs from traditional accounting as it consciously incorporates only strategic factors in an explicit and formal way, which facilitates the development

and implementation of a company's strategy and allows the company to achieve a lasting competitive advantage (Laitinen 1998).

A company strategy refers to a company's plan to achieve a desired goal that requires concrete action. It provides a blueprint for the future that will be implemented consistently, even if the measures are not always planned. The goal of a strategy in a changing environment is to gain a competitive advantage over other competitors, companies, and to meet the expectations of stakeholders. (Johnson, 2005)

Strategic management accounting is based on an understanding of the basic concepts of financial management. The financial management of an organization is a matter of managing the finances of the input-output process, which aims at the profitability of operations. The profitability of operations is based on the fact, that products / services are paid for more than the costs of producing them. The traditional diagram of the economic process is based on, that a company acquires factors of production from the factor of production market, converts them into outputs in the production process and sells the outputs produced in the output market. The company's real process corresponds to the money process. (Puolamäki, 2007)

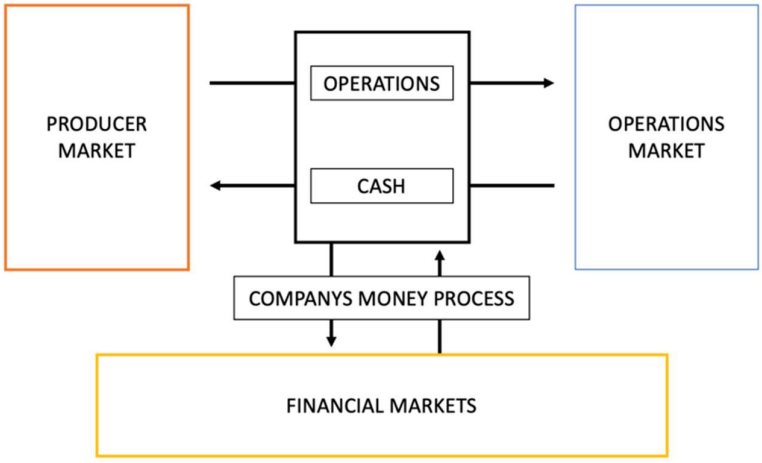


Figure 1. Input-output -process of operations. (Puolamäki 2007)

In the cash process, cash costs are incurred before cash income, so the company must obtain financing in the form of equity or debt from the financial markets to cover the costs. The company is obliged to pay dividends and interest on the financing. Profitability alone is not enough to secure a business because a company must also be solvent. For long-term operations, an appropriate

financing structure must be defined, i.e., the ratio of equity to liabilities. Efficiency, which determines productivity, is essential for the continuation of business operations. If a company does not operate efficiently compared to its competitors, the prices charged by the market will not be sufficient to cover the operating costs. A company that has operated in this way may operate inefficiently for a short time, but sooner or later the organization has exhausted its capital and must close down its business. (Puolamäki 2007, 61–62).

Strategic management can be divided into four phases, which are as follows:

1. Formation of strategies.
2. Communicate strategies throughout the organization.
3. Developers implement tactics to implement these strategies.
4. The development and implementation of a monitoring system to monitor the success of the implementation phase and the strategic objectives.
   (Laitinen, 1998, 47)

In these four steps, the views of John K. Sahnk and Vijai Covindaraja on the process by which lasting competitive advantage can be achieved are presented. At each stage of the process, the correct information in the accounting process is of great importance.

In the first stage, the accounting activity creates financial information that can be used to compare and evaluate strategies. In the second phase, the strategies are communicated to the organization's management through accounting reports. In the third phase, the information generated by accounting plays an important role in selecting and comparing effective tactics, and in the last phase, the development and implementation of a monitoring system is developed to monitor the success of the implementation phase and the strategic objectives. (Laitinen, 1998, 47).

A large part of the accounting of strategic corporate management is the measurement of business operations. Business productivity, losses, job security, and just about anything can be measured in some way. However, it does not make sense to measure everything, because it takes a huge amount of time to decompress the results, and not all the possible data is relevant or necessary. In today's society, large companies already spend tens of thousands of working hours collecting and analyzing data. Finding the right information about the right place is paramount for cost-effectiveness, which

is why business metrics have been created and are constantly being developed. A few indicators and measurement systems have been established in the business world and have been proven to work. However, the measurement methods vary from industry to industry, and the solution in industry A may not work in industry B. However, the measurement methods are flexible, and indicators are often valued based on their measurement theoretical properties, which means how useful they are in corporate management decision-making. The decision-making process, on the other hand can be divided into three different stages:

1. The creation of the measurement results and their recording in the decision-making system.
2. Human decision-making system.
3. The decision, followed by the results, the value of the decision.
   (Laitinen 1998, 147)

2.2 Project Management in Field of Construction

Originally project management is situation, where a group of people, materials and recourses have been assembled and organized by someone to achieve specific one-time objectives. “Projects have evolved from building pyramids to connected business environments.” Before it was normal, that projects lasted many decades, or even centuries, when nowadays a project may last only few hours. However, it is important that subject full-fills main things that define project, which are, that project is unique and non-repetitive, temporary, outcome could be measured, and it has clear start and finish. (Tidström, 2021)

Construction projects are complex, drawn-out endeavors. The various stages of the entire project development process typically require a range of specialized services. The typical job progresses through successive and distinct stages, requires input from diverse organizations like financial institutions, governmental organizations, engineers, architects, lawyers, insurance and surety companies, contractors, material manufacturers and suppliers, and tradespeople. This applies for projects of all sizes. Planning for the city to public works, even a structure of modest proportions requires hundreds of different operations, and a wide range of skills and materials during the construction process. The assembly process must follow a predetermined natural flow of events, which involves a complicated pattern of individual time requirements and constrained sequential relationships among the structure's numerous segments. (Sears, Sears, Clough, 2008)

It's crucial to keep in mind that projects are one-off, usually unique, time-limited endeavors that call for non-standardized, variable work. Field construction work may be significantly impacted by unpredictable events that are difficult or impossible to predict. Under these uncertain and erratic circumstances, field construction costs and time requirements are constantly fluctuating and can seriously decline with little or no warning. The presence of uncertainty in construction does not necessarily mean that planning is impractical, but it does suggest that it will have a big impact on whether the project is successful or not. More careful project planning and capable, persistent management are needed as a project's degree of uncertainty increases. (Sears, Sears, Clough, 2008)

The most common definition of "management" is the process of planning, leading, overseeing, and staffing a business enterprise. In essence, business management is an ongoing internal activity involving the company's employees, resources, and other things. Construction project management, however, only applies to a specific project, each of whose phases is typically completed by a different organization. As a result, managing a construction project is more about directing and coordinating all the parts needed to finish the job than it is about controlling the internal operations of a single company, which causes. that project managers typically work closely with stakeholders. In these situations, much of the authority is granted through contractual clauses or powers of agency, making it less direct than it would be for a typical business manager. In the case of a subcontractor, the project manager's authority is further limited. Effective project management is therefore much more often achieved through persuasion and influence than through the direct exercise of authority. In any case, project management is primarily carried out by employees from various employers working closely together to achieve shared goals. (Sears, Sears, Clough, 2008)

2.2.1 Project Management Maturity Model

Project management maturity refers to the development of a project management methodology, approach, systems, and processes within an organization. Depending on its distinct objectives, resource capabilities, scope, and overall needs, each organization or enterprise will need a different level of maturity. (Demir, C. & Kocabas, 2010) The aim of project management maturity, is to fulfill stakeholder expectations, and meet the needs of the markets. Organizations can analyze their activities and make strategic decisions by using maturity models. (Shamsuzzoha, 2022)

The term "maturity model" refers to a conceptual network that includes elements that characterize maturity in the relevant field. A process can be established by the project management maturity model, which can also establish a set of best practices and capabilities. This process results in a more mature organization by maturing the organizational state. The alignment of best practices across the program, project, and portfolio domains reveals the maturity of an organization's project management process. (MBA Knowledge Base, 2022)

There are numerous studies that demonstrate a direct correlation between project success and the degree of project management maturity. There can be a 50% increase in project success from the lowest maturity level to the highest maturity level. (Project Management Academy, 2022)

The three dimensions in organizational project management maturity model are:

Knowledge

- An organization's first step is to prepare for the process of assessing its maturity in relation to the model. This preparation requires familiarity with the organizational project management maturity model's operation, in-depth comprehension of the model's contents, and expertise in organizational project management. (MBA Knowledge Base, 2022)

Assessment

- The second step is to determine the organizational project management maturity. The organizational project management maturity model's characteristics are contrasted with those of the model's current maturity state (OPM3). To determine where an organization fits on the continuum, this step entails looking at the best practices that it employs and does not. Organizations have the choice of using the OPM3 tool or developing their own assessment tool. An improvement plan can then be developed, the assessment can be repeated, or the process can be ended after a more thorough examination of the organization's capabilities is carried out to identify any flaws. (MBA Knowledge Base, 2022)

Improvement

- **Plan for Improvement** – The improvement plan for the maturity of an organization will be produced as a result of the results of step two. The development of a clear plan to improve

and achieve the outcomes related to the capabilities of the best practices can be assisted by this step, which will rank the necessary capabilities and outcomes according to their importance. (MBA Knowledge Base, 2022)

- **Implement Improvement** - The modification or change will be visible at this stage. After the plan has been established in the step before, the Organization will put it into action by carrying out development activities to strengthen the organization's overall maturity and develop the necessary capabilities. (MBA Knowledge Base, 2022)

- **Repeat the process** - After completing the improvement activity, the organization will return to step two and reassess its position along the continuum of OPM3 maturity. If not, it will return to the improvement step and address any extra best practices found during the assessment. (MBA Knowledge Base, 2022)

2.3 Lean Six Sigma

2.3.1 Lean

Less waste, less labor, less manufacturing space, less money spent on equipment, and less engineering time spent on a project are all part of the lean manufacturing process. The primary sources of the general process management philosophy known as Lean manufacturing are the Toyota Production System (TPS) and other best practices in industry. The original "seven wastes" identified by Toyota were emphasized in Lean Manufacturing. To reduce waste and increase customer satisfaction; TPS defines waste in a process as any action that does not advance the process toward the final output or enhance the final output. (Wang, 2019)

The seven wastes include the following:

1. **Overproduction**

   To produce something more than is necessary is to engage in overproduction. A manufacturing facility must pay a high price for overproduction because it hinders the efficient flow of materials and lowers quality and productivity.

2. **Excess inventory**

   Excess inventory frequently conceals issues on the site, which must be found and fixed to enhance operational performance. Excess inventory lengthens lead times, takes up useful space, delays the detection of issues, and obstructs communication.

3. **Waiting**

   Any time goods are not being processed or moved, time is being wasted. Waiting for the next operation takes up a large portion of a construction project's lead time. Waiting is frequently the result of inefficient design-related material and information flow.

4. **Transportation**

   Material transportation between processes is a cost that the construction does not benefit from. Excessive handling and movement lead to damage and give room for quality to slip.

5. **Unnecessary motion**

   As compared to transportation materials, motion refers to the producer, worker, or equipment’s movement, which could cause damage, fatigue, wear, and safety issues.

6. **Overprocessing**

   Utilizing more expensive resources than necessary for the task or incorporating design elements that are not demanded by customers. Expensive resources encourage overproduction as a way to offset the high cost of the machinery.

7. **Defects**

   Quality problems affect a company's bottom line by causing rework or scrap and the related costs of quarantining inventory, reinspecting, rescheduling, losing capacity, etc. (Wang, 2019)

Whether a company is in the manufacturing or construction industries, its primary goals are to increase operational effectiveness, reduce inventory issues, cut down on errors, and keep to schedules. However, delays in construction are unavoidable due to a variety of reasons, including varying weather, unreliable vendors, shifting inventory requirements, or a labor shortage, all of which have an adverse effect on how quickly projects are completed. (Hill, 2020)

Applying lean principles can help to lessen both internal and external disruptions, but they do not eliminate inconsistent behavior. Thanks to lean management, the construction team can identify areas for improvement and take quick action to get results. All parties are better able to understand how information, people, and resources can be used more effectively to deliver desired results on time and within the approved budget when lean construction is used in conjunction with traditional project management techniques. (Hill, 2020)

2.3.2 Six Sigma

Lean Six Sigma is one of the leading approaches in a quality management process. The five-phase DMAIC process uses a scientific method and a wide array of tools and techniques to find and develop problem areas in the process. The purpose of DMAIC process is to improve an existing process. (GreyCampus, 2022).

The purpose of the first phase of the process (Define) is to identify the development target, delimit it and form a precise plan for the development project, which can be used to move to the measurement phase. Once the most critical problem in terms of operations has been selected, a description of the problem will be defined, and goals will be set. (Niiranen, 2022).

Measure phase is the second step in this methodical approach to problem solving. The phase's goal is to identify the problematic process's outputs, inputs, and process variables. The project bidding, construction work, materials, and subcontractors are the things that will be evaluated. The aim of the measurement is to show the current state of process performance, which creates a starting point for development work. The third step is Analyze phase. The target of this phase is to detect any patterns for the Improve phase. In Analyze phase, the results of the Measure phase are reviewed, and the problem areas of the project that need to be developed are illustrated. (Greycampus, 2022).

The Improve phase improves the manufacturing process for the problems and variables verified in the Analyze phase. At this stage, it is explained how the development work was carried out and how the identified problems are avoided during the implementation of the project. The final step in the DMAIC process is the monitoring of results, which should remain a permanent activity after the

project. The task of the Control phase is to ensure that the chosen solutions are used and remains in use. (Niiranen, 2022)

2.3.3 Lean Six Sigma Implementation in Construction Projects

Contractual in nature with predefined tasks, construction project management aims to achieve the ideal balance between the goals of various stakeholders. A centralized plan, that establishes the order of tasks from conception to completion effectively regulates the crew's coordination. With this strategy, all expenses, delays, mistakes, and learning take place as the actions are being carried out. By accelerating procedures or altering the workflow to allow concurrent work, productivity increases result in cost savings and faster project completion. (Hill, 2020)

Lean construction operates according to a very different model in which operations are coordinated to provide real value to the client. The project's timeline and overall budget are viewed as parts of the production system, where a centralized schedule regulates all coordination and communication. Team members, who are working are accountable for finishing the project by following the set workflow, by concentrating on maximizing throughput, raising customer value, and minimizing waste. The fulfillment of client requirements without delays or inconsistencies depends on effective communication, reliable workflow, and on-time completion. The workforce can improve and cut waste thanks to continuous observation. (Hill, 2020)

Lean construction places a strong emphasis on creating value throughout a project's lifecycle, even as the market fluctuates, tools and techniques advance, and business practices improve. Lean construction, in contrast to traditional construction, coordinates all action through pulling and continuous flow. In traditional construction, each operation is managed by a central authority and directed by a predetermined schedule. Lean construction's decentralized decision-making system and ensures accountability and transparency with the most recent information, enabling all parties to act appropriately at the appropriate time. (Hill, 2020)

2.3.4 Lean Six Sigma in Project Portfolio Management

The goal of applying Lean construction is to create a quick, efficient workflow that is reliable and consistent. The Lean construction process involves meticulous planning and sequential execution of

each step. To establish a structured and predictable workflow and avoid delays and interruptions, everyone involved must consistently communicate and collaborate at every level. (Hill, 2020)

Numerous authors have emphasized the importance of project prioritization, selection, reviews, and tracking for the success of Six Sigma. Project Portfolio Management also makes it possible to connect Six Sigma to business plans. When picking Six Sigma projects, many companies face difficulties and roadblocks, taking leadership commitment and strategy alignment into account. One important aspect of Six Sigma is its projectized structure, which connects to both the strategic and operational levels. The operational-level project execution used in Six Sigma's structured improvement methodology sets it apart from other quality-related methodologies. (Carvalho, 2013)

The alignment between projects and strategy is identified as one of the critical factors to the successful implementation of Six Sigma since the projects chosen should reflect the strategic needs. The management of ongoing projects connects the project activity to both the operational level and the strategic level. The project selection stage is typically in the core of the proposed Six Sigma Portfolio Management processes, which are also impacted by the stage-gate and development funnel models. For instance, some authors advocate removing Six Sigma projects with little financial or strategic implications utilizing project funnels, while others advise doing tollgate evaluations of ongoing Six Sigma initiatives. (Carvalho, 2013)

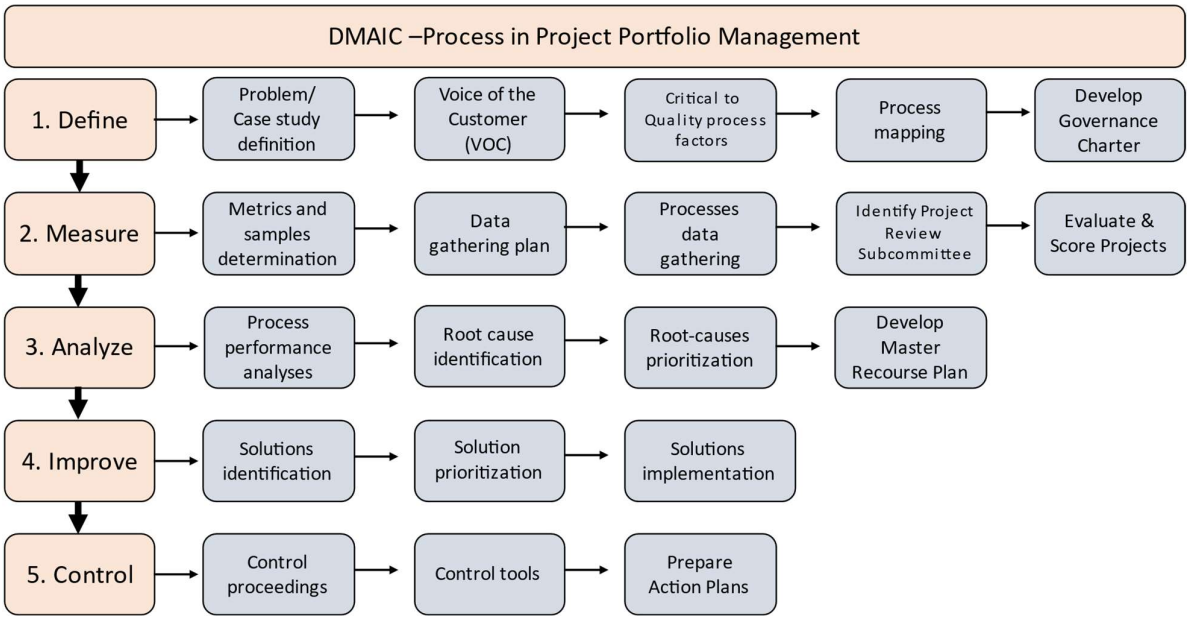


Figure 2. DMAIC -process in Project Portfolio Management (Darby Consulting, 2021)

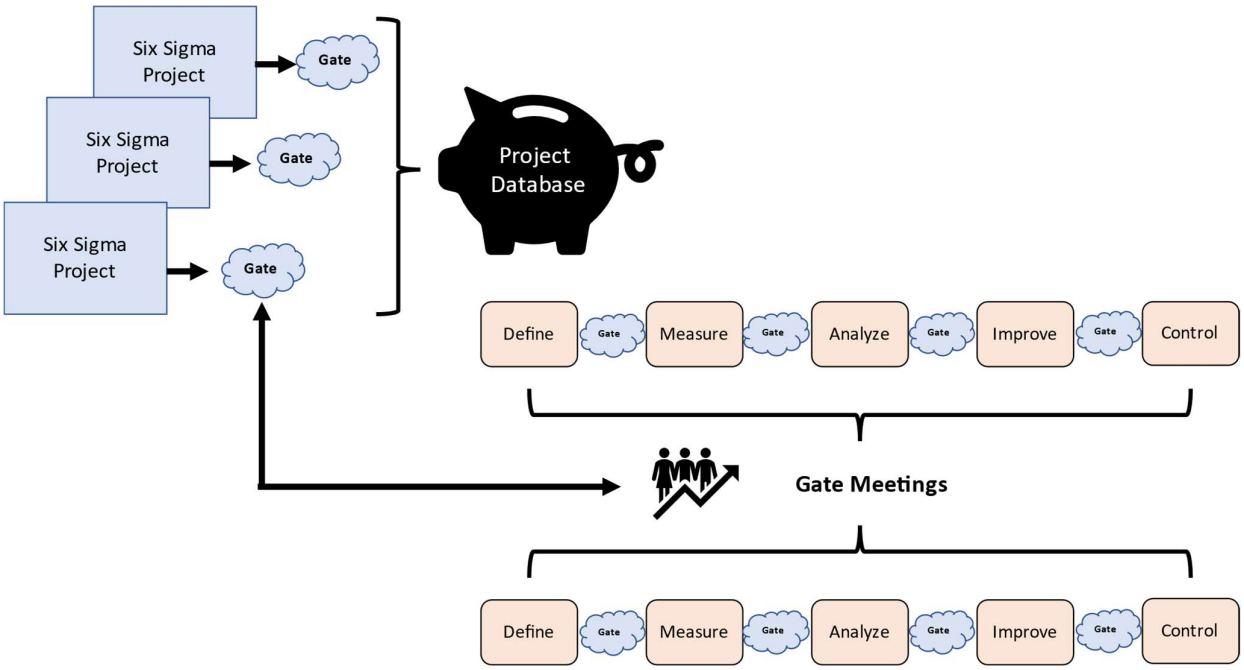


Figure 3. Project Portfolio Management Decision committees (Butt, 2022)

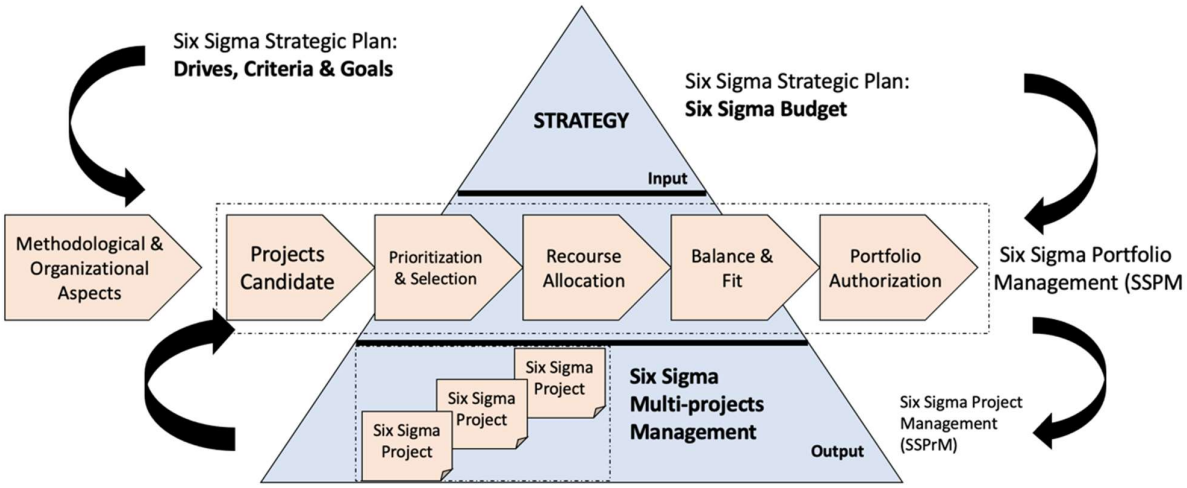


Figure 4. Six Sigma Project Portfolio Strategy (Carvalho, 2013)

2.4 Lean Six Sigma Tools

Understanding the Lean Six Sigma concepts is a prerequisite for effectively utilizing the process improvement approach. For its deployment to be effective, using the right techniques that are adapted to business needs is essential. Lean Six Sigma offers a range of tools to help you improve quality and process efficiency while getting rid of extraneous steps and variations. In the Define phase of the DMAIC cycle, the following strategies are frequently used. By using them, you may determine a problem's scope, customer expectations, and stakeholder perspective, among other things. (Greycampus, 2022)

2.4.1 Brainstorming

Brainstorming is the first step in every problem-solving process, which is why it is widely utilized in this stage of the DMAIC methodology. This process must be finished before using any tools. Brainstorming is the process of generating new ideas by bouncing notions off one another during protracted, unstructured group discussions. (Kumar, 2022)

2.4.2 Root Cause Analysis – The 5 Whys

Root Cause Analysis -technique is used to assist in determining the underlying causes of the problems being studied during the "analyze" phase of the DMAIC -cycle. The "why" question is asked

repeatedly until it identifies the core issue in the "5 Whys" approach. The number of questions can be more or lower depending on what is required to attain clarity, with "five" serving as a basic guideline. (Kumar, 2022)

2.4.3 Kaizen – Continuous improvement

Businesses can continuously improve by utilizing effective strategies like the Kaizen approach. It requires ongoing monitoring, selection, and implementation of improvements. This method has significant advantages for the entire construction industry. As a result of collective and continual improvements, waste is decreased, and adjustments are made as soon as even the smallest inefficiency is recognized. (Kumar, 2022)

The Kaizen strategy encourages continuous efforts for improvement that involve both managers and employees. The Kaizen methodology has been widely applied to enhance how work is organized in factories and the manufacturing processes themselves. The outcomes are implemented within a week, and they are immediate. Along with an immediate improvement in the process, the Kaizen will also generate a list of potential for improvement that staff members can investigate and utilize later. Kaizen will provide inspiration and continual, continuous improvement to the workplace along with instant, measurable outcomes. (Wang, 2019)

2.4.4 Just In Time -production, and Kanban

Just-in-time (JIT) manufacturing is an inventory strategy designed to speed up response times from suppliers and customers as well as production system flow times. Organizations can reduce costs while increasing productivity by using JIT manufacturing to control variability in their processes. (Lynn, 2022)

JIT allows businesses to receive goods only as they are required during the production process, which lowers inventory costs while increasing efficiency and reducing waste. This strategy has several benefits in terms of reducing manufacturing risk and expenses, but it does necessitate precise demand forecasting from producers. The inventory supply system has taken the place of the just-in-case strategy, when producers generated enormous inventories to be kept on hand in case a larger demand

needed to be satisfied. Adopting a JIT manufacturing system effectively has the potential to significantly affect an organization's productivity, risk management, and operating costs. (Lynn, 2022)

Kanban is a system for signaling when to act. As its name suggests, Kanban generally uses cards to show when a certain item is needed. Kanban controls the flow of resources in a production process by only replacing what has been consumed. Instead of relying on forecasts, these production schedules are influenced by orders and built around actual demand and consumption. By using Kanban, waste can be reduced in the handling, storing, and timely delivery of process. (Wang, 2019)

Kanban can assist firms in controlling the rate of production by ensuring that resources are only acquired when needed or when they are demanded by the customer. Manufacturers may manage their inventory more effectively by using Kanban to visualize how it flows through their systems. Kanban is not an inventory management system by itself. It is a scheduling system that directs a business's production by dictating what to produce, when to produce it, and how much to produce. By acting as visual cues that prompt action, Kanban cards are crucial in the implementation of JIT. Its suitability for use in JIT implementation is a result of its very nature. Kanban is used as a demand indicator that immediately alerts the entire supply chain. (Lynn, 2022)

Organizations can lower risk by optimizing inventory demand and requirement processes by integrating JIT and Kanban. Manufacturers can improve operational effectiveness and productivity while maintaining better control over their inventory by implementing a hybrid JIT Kanban system. (Lynn, 2022)

2.4.5 Benchmarking

The method of benchmarking uses a predetermined unit of measurement. Making comparisons with other companies is necessary to obtain a neutral appraisal of the current situation. Comparing significant business processes or departments using internal benchmarking, functional benchmarking, or comparing similar work areas or functions with industry leaders are a few examples of how benchmarking can be utilized (competitive benchmarking). (Kumar, 2022)

2.4.6 Value Stream Mapping

The value stream mapping method maps the current flow of information and materials to create a future project. Leaner operations are to be created by eliminating waste and inefficiencies in the value stream. It lists three types of waste removal operations and seven different types of waste. (Kumar, 2022)

2.4.7 The 5 S System

The 5 S system is a Lean management methodology, that once implemented, can better identify, and eliminate waste (non-value-added activities) from a company's processes. (Wang, 2019) The technique has its roots from the Japanese principle of workplace energies. (Kumar, 2022) The 5S method was created to increase productivity. Its effects are dependent on how workplaces are set up, how working procedures are standardized, and how non-value-adding activities and losses are minimized. The 5S method can be used to improve quality and safety by creating efficient and pleasant workplaces and working methods, including following. (Wang, 2019)

1. **Sort** – Sort through all items and remove nonvalue-added items.
2. **Straighten** – Set in order remaining items, set limits, and create temporary location indicators.
3. **Shine** – Clean everything and use cleaning as inspection.
4. **Standardize** – Standardize the first three S's by implementing visual displays and controls.
5. **Sustain** – Sustain the gains through self-displine, training, communication, and total employee involvement. (Wang, 2019)

2.5 Measuring the Profitability of Business Operations

2.5.1 Key Performance Indicators

The main principles of Lean construction are waste elimination and continuous improvement. Real-time task monitoring identifies these areas for improvement, which are then implemented for better business outcomes in subsequent construction projects. (Hill, 2020)

Key Performance Indicators (KPIs) are the essential navigational tools managers use to determine whether their company is sailing successfully, or if it is straying from the prosperous course. The proper set of indicators will shed light on performance and draw attention to the areas that require it. The adages "what gets measured gets done" and "if you can't measure it, you can't manage it" are just two examples of how crucial metrics are. (Marr, 2012)

The issue is that vast majority of managers find it challenging to understand and identify the few essential management indicators, preferring instead to collect and report a lot of data on anything that is easy to measure. As a result, they are overrun with information while hankering after knowledge. Effective managers and decision-makers may understand the performance of all the critical components of their business by distilling managers into the essential KPIs. Anxiety and a lack of progress can frequently result from not understanding important metrics. (Marr, 2012)

Key figures are always defined on a case-by-case basis for each different business area. The key figures of one business area, may not work directly with the other, or at least the measurement results cannot be assumed to be unambiguously comparable. This also applies to metrics used within the same industry. However, key figures are flexible, and the same meter can be used to measure in different ways within the same industry, but suitability must always be verified before implementation (Turunen 2020).

Traditionally, Key Performance Indicators include these basics:

- Key metrics are defined in advance and describe the importance of the project success factors.
- Read the Key Performance Indicators to see how well the project is progress towards the ultimate goals and targets set.
- The main principle of Key Performance Indicators is to measure performance issues and communicate controllable factors that can be utilized in decision-making, and lead to a positive result for the company.
- A well-defined key meter drives change without describing how it works. Key metrics show how close we are to targets, but they don’t tell the company what to do to correct deviations.
- Key metrics help companies set business goals.

- Key Performance Indicators differ from other indicators designed to monitor business operations in that Key Performance Indicators can be used to look to the future when other business indicators focus only on the past. (Kerzner 2013)

2.5.2 Dynamic Performance Measurement System

The Dynamic Performance Measurement System (DPMS) was originally developed by Erkki K. Laitinen. The operating principle of the system is based on the logic of resource use. Excellent performance is based on the optimal utilization of resources to achieve strategic goals. In a dynamic performance model, defining dimensions does not cause any difficulty because it is based directly on the logic of the model - the resource cycle in the company. The dependencies between these dimensions are a big part of this process because they describe this logic. The advantage of the Dynamic Performance Measurement System -model is its dynamism: when performance is improved, it can be immediately seen how the model, like the chain reaction affects other factors in the causal chain. The operating principle of a performance metric is simple to think and remember, as it is the same as the operating principle of a company's operations (Laitinen 1998).

The DPMS -model monitors the flow of resources, within the company and their transformation into revenue in business processes. The cycle is based on costs, which can be measured to determine; how efficiently resources are allocated as a cost among factors of production. The measurement can be performed with a traditional elementary cost structure based on the company's factor distribution, where costs are defined as a monetary measure of the factors of production. (Laitinen, 1998)

In the second stage of dynamic performance measurement, it is possible to assess how well the factors of production have been taken care of and how well the factors of production have been utilized. Factors of production can be, for example: raw materials, machinery, buildings, and people. The second dynamic performance measurement can be performed by assessing the work motivation of employees; the condition of the premises and equipment, and how well the company's production capacity has been utilized. (Laitinen, 1998)

The third step in measuring dynamic performance considers; how well time has been spent on the company's core activities, and how they have been performed. These are therefore indicators of cost-effectiveness and quality. Functions are used to create business productivity. (Laitinen, 1998)

Fourth, the measurement of dynamic performance asks how good products have been achieved and how good ones will be obtained in the future. This measurement can be performed with among other things: indicators of customer satisfaction, flexibility, and innovation. When the product is ready, it should get a certain price. (Laitinen, 1998)

Fifth, the measurement of dynamic performance focuses on yield and its adequacy. The adequacy of the return is measured by the profitability of the projects and calculated by customer. Returns affect external dimensions, i.e., they affect economic performance and competitiveness of the company. (Laitinen, 1998)

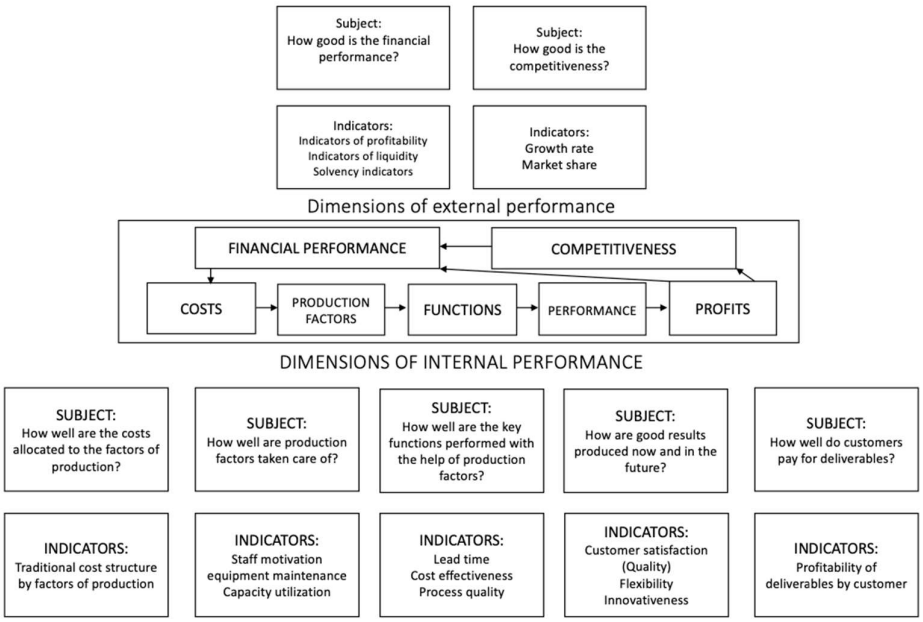


Figure 5. Dynamic Performance System (Laitinen 2003)

2.5.3 Value Chain Analysis

The basis of value chain thinking is to try to consider the company's social costs from a broader perspective, how one is accustomed to thinking at a general level. Generally, in all productive activities, it is possible to achieve the cost advantage, that value chain thinking seeks to create. From a

Porter's point of view, value chain thinking is only granted for cost mapping, although it can be used to create a better result for a company by creating added value for the customer's product. (Porter, 1998).

The value chain is made up of a list of procedures or tasks, that a business completes to market a good or service. Two functions make up the activities; primary activities, which include activities that directly contribute to the production of a good or service. They include activities like inbound and outbound logistics, operations, marketing, and sales, as well as product servicing, and support activities, which include chores that make it easier to produce the good or service. They include activities like procurement, infrastructure, technology, and human resources. (CFI Team, 2022)

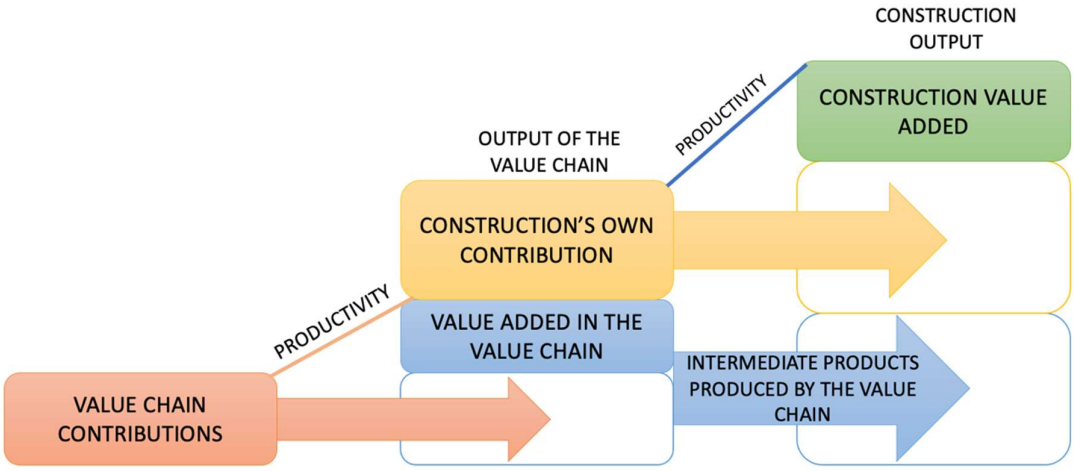


Figure 6. The value and productivity of construction are created in the value chain (Ahonen, Ali-Yrkkö, Avela, Junnonen, Kulvik, Kuusi, Mäkäräinen & Puhto 2020)

2.5.4 Performance Pyramid System

The Performance Pyramid was originally developed by A.S Judson in 1990. R.L Lynch and K.F. Cross, in 1991, began further refining the performance pyramid in his book "Measure Up! Yardsticks for continuous Improvement", on which the system opened in this section is based. The performance pyramid is based on four different hierarchical levels. It expresses the customer-oriented goals expressed in the company's vision hierarchically, from the top down and the related indicators from the bottom up. In this case, the foundation of the performance pyramid can be read as a vision,

which is commanded as hierarchically downward goals at different levels in the organization (Laitinen 1998, 385).

The development of the Performance Pyramid begins with the vision defined, i.e., the highest target level, which is converted to another level according to the hierarchy as the goal of the business units. By achieving the goals set for the business units, the vision set for the company can be realized. Business unit goals can be achieved by implementing operational level goals based on customer satisfaction, flexibility, and productivity. These goals can be achieved if the operational goals set for the lowest level of operations quality, delivery capacity, lead times and waste are achieved. When defining a company's performance pyramid, the measurement of the efficiency of the company's core processes and the causal relationships between metrics at different hierarchical levels should be considered. Despite the central importance of processes, the performance pyramid is a tool for goal management in an organization-driven environment, where management takes place according to goals set at the top of the hierarchy. (Laitinen 1998, 385).

The general errors in performance measurement have been corrected as follows:

- Metrics are linked to strategic objectives, allowing the company's departments to see how they can contribute to the achievement of the objectives.
- The system shall combine economic and non-economic metrics that can be used in operational management decision-making.
- The system shall assess all functions in relation to customer requirements. (Laitinen 1998, 385).

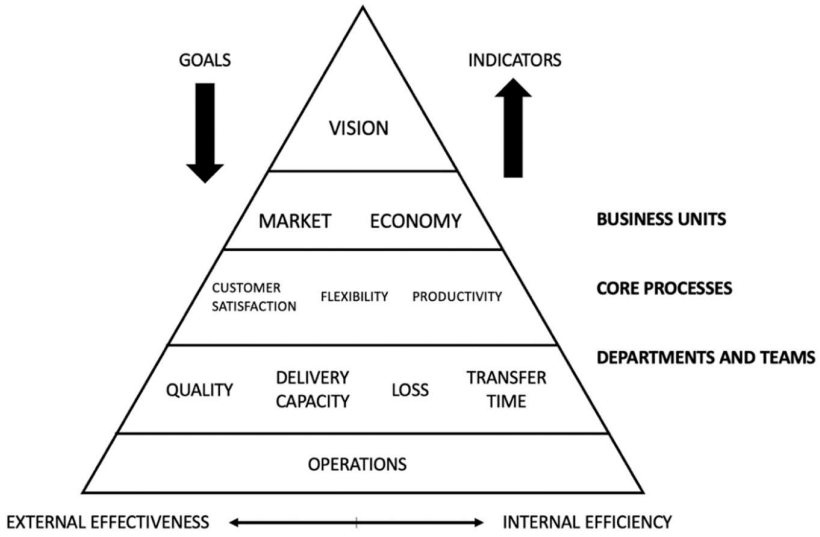


Figure 7. Performance Pyramid System (Laitinen, 1998)

2.5.5 Data Driven Decision Making

Using data, metrics, and facts to inform business decisions, that are strategic and in line with your goals, initiatives, and objectives is known as data-driven decision-making (DDDM). Everyone in an organization, whether they are a business analyst, sales manager, or human resource specialist, will be given the ability to use data to make better decisions daily, when they realize the full value of their data. (Tableau, 2022)

Organizations needs to create a culture that values curiosity and critical thinking by making data-driven decision-making the norm. Every conversation begins with data, and practice and application help people become more skilled with data. Fundamentally, this necessitates a self-service model where users can access the data they need while keeping governance and security in check. It also demands proficiency, creating opportunities for workers to receive training and development to develop their data skills. Finally, executive advocacy and a supportive community that makes data-driven decisions will inspire others to follow suit. (Tableau, 2022)

Structured

Structured data has elements that can be addressed for efficient analysis. It has been organized into a repository with a database-like style. It relates to all data that can be stored in a SQL database as

a table with rows and columns. The data has relational keys and may be rapidly mapped into pre-designed fields. Structured data is currently processed in the most efficient and modern manner possible. (Vishwakarma, 2021)

Semi-Structured

Semi-structured data is information that isn't kept in a relational database but has some organizational traits that make it simpler to analyze. Semi-structured data exists to conserve space, even though some types may be exceedingly challenging to store in relational databases. (Vishwakarma, 2021)

“Quasi” Structured

Quasi-structured data is more of a textual data, with erratic data formats. It can be formatted with work, the right equipment, and time. This type of data contains information from web clickstreams, such as Google searches. Other instances include texts that have been replicated, which create a network map based on the text's linguistic similarity and the closeness of its words to one another. (Mediratta, 2015)

Unstructured

Unstructured data is data, that is not predefined in terms of organization or lacks a predefined data model, making it a poor fit for a common relational database. Organizations employ unstructured data in a variety of business intelligence and analytics applications because it may be stored and managed on many platforms. Unstructured data is becoming more common in IT systems. (Vishwakarma, 2021)

2.6 Risk Management, and Evaluation

When used in decision-making processes, effective risk management adds value to organizations because it expressly addresses uncertainty. Organization should include risk management in a systematic, organized, and timely manner. No one size fits all approach to risk management exists. Risk management needs to be tailored for each organization because there is a strong correlation between organizational culture variables and human elements. The goal of risk management should be continuous improvement, and it should be open and transparent. Plans and actions for risk

management are based on the best information currently available, but they can be adjusted depending on the type of information. (Olechowski, Oehmen, Seering & Ben-Daya, 2016)

Risk evaluation is part of risk management plan. The risk management process enables organizations to ensure that they are adhering to all pertinent rules and regulations and to protect themselves from the potential consequences of risk, which can include things like data breaches and cybersecurity risks in addition to non-compliance. Simply put, risk evaluation helps businesses determine how significant a risk is. Risk analysis and risk assessment are the two steps in the risk evaluation process. (Reciprocity, 2021)

2.6.1 ISO 31000 – Risk Management

In a world where enormous volumes of data are processed at fast speeds, every organization will find it challenging to detect and mitigate risks. Risk is a necessary component of doing business. The fact that many contracts and insurance policies need strong evidence of solid risk management practices shouldn't come as a surprise. With the help of ISO 31000, businesses can learn how to incorporate risk-based decision-making into their governance, planning, management, reporting, policies, values, and culture. Because it is an open, principles-based system, organizations can adapt the standard's principles to their own unique circumstances. (International Organization for Standardization, 2018)

For managing risk, ISO 31000, Risk management - Guidelines, offers guidelines, a framework, and a process. Any organization may use it, regardless of its size, specialty, or industry. Organizations that implement ISO 31000 are more likely to meet their objectives, recognize opportunities and threats more effectively, and allocate and utilize resources for risk management effectively. Although ISO 31000 provides provide recommendations for internal or external audit processes, certification cannot be achieved through its application. It gives firms clear guidance for effective management and corporate governance and enables them to assess their risk management practices against a standard that is widely recognized internationally. (International Organization for Standardization, 2018)

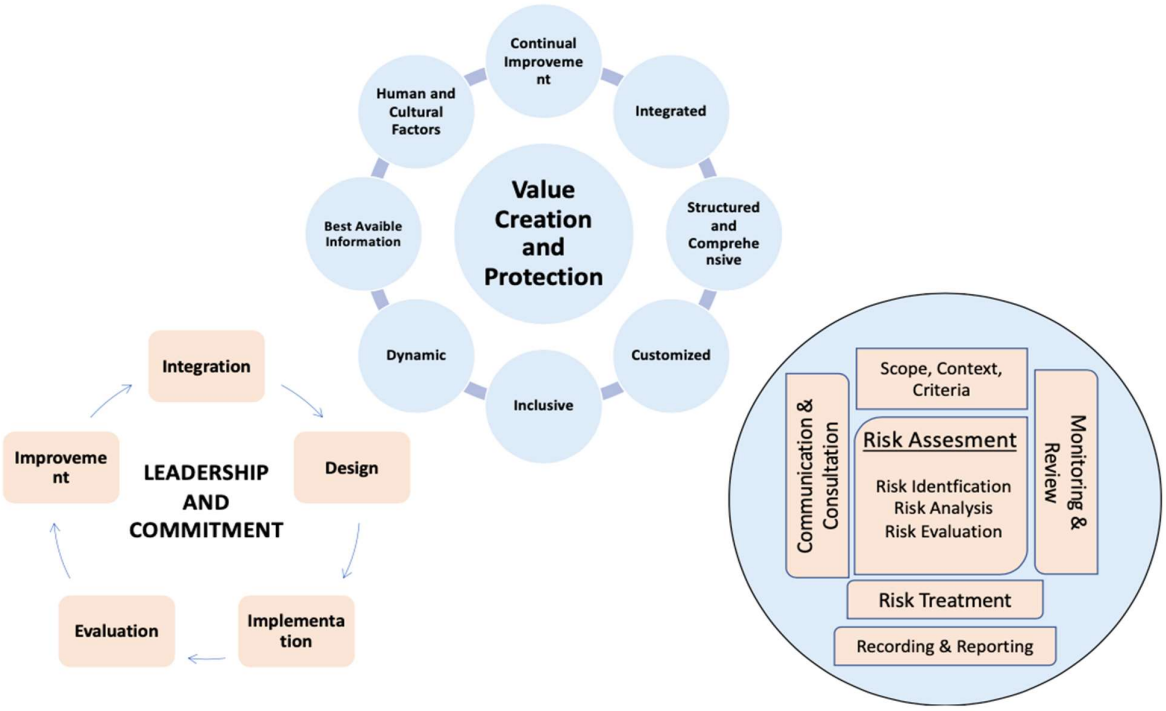


Figure 8. Principles, framework, and process (International Organization for Standardization, 2018)

2.6.2 Decision Under Risk and Uncertainty

Decision-making is simple when there is certainty. The risk is negligible, and the cause and effect are known. Making decisions in the face of risk and uncertainty is difficult because you don't have complete knowledge of all the options, so the result is unpredictable. When doing decisions under risk and uncertainty, there are multiple methods, to give perspective, to back up the decision. These methods are for example, ranking methods, elimination methods, weighted methods, and graphical additive methods. (Timilsina, 2022)

Teams that use decision-making models can make decisions more quickly and collaborate more successfully. Models offer practical steps that teams can follow to develop solutions and clearly communicate their processes to other team members. Everyone on a team can more readily contribute to the thought process and arrive at a fair, workable solution when they are all aware of the decision-making model being employed. (Indeed, 2022) There are many different models that helps in decision-making, for example, Physical models, Analogue model, Schematic model, Mathematical models, Simulations, and Experiments. (Timilsina, 2022)

Decisions aren't always made using quantitative methods. Individuals instead base their decisions on their past experiences, instincts, common sense, and several other things. Additionally, there are many decisions for which not a single performance metric is taken into consideration. This is particularly true in engineering where trade-offs between various factors are necessary to balance performance, cost, reliability, etc. (Vortarus Technologies, 2022)

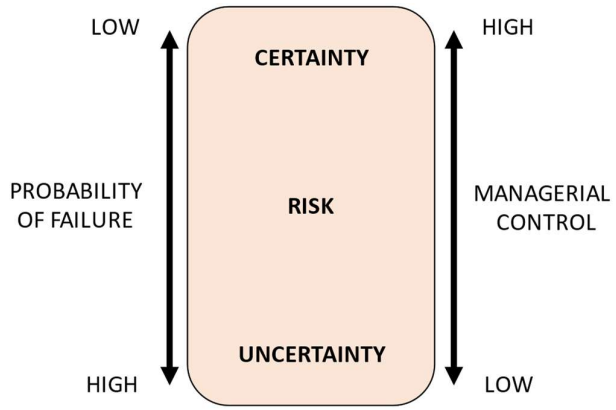


Figure 9. Decision Making Under Risk and Uncertainty (Timilsina, 2022)

2.6.3 Project Portfolio Risk Management Framework

The portfolio triple constraint is the primary variable affecting portfolio risks, which impacts how organizational goals are accomplished. Examples of negative effects include not all organizational objectives are met; value generation is lower than anticipated, unneeded projects are funded, wasting organizational resources; projects won't finish on time and on budget; and resources are not used to their full potential. When projects are completed on schedule and within budget, more value is produced than was anticipated, and higher resource efficiencies are attained, the organization has overtaken its goals. (Kodukula, 2014)

Before implementing the best response, organizations should first identify, assess, and rank the risks, and then repeat the entire process periodically. Project risks and portfolio risks are very different from one another because the latter's effects are not apparent until after projects are finished and their deliverables have been launched. The extended timeline increases the risk of making go/no-go decisions as well as the information's lack of certainty. To increase the upside and lessen the threats, every portfolio should implement a few of the mitigation strategies. (Kodukula, 2014)

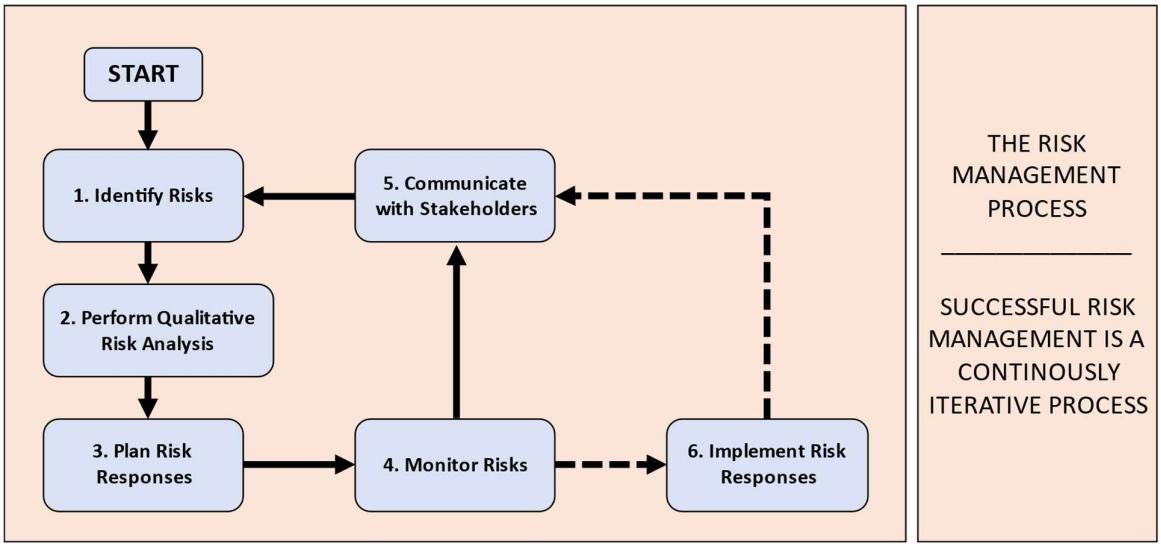


Figure 10. The Risk Management Process

2.6.4 Ishikawa Diagram

The Ishikawa Diagram, also known as Cause-and-Effect Diagram, and as Fishbone Diagram, is a tool that aims to organize the rationale in identifying root causes of problems. The most important factors are connected to the effect that will be analyzed. You may be able to better understand the issues that gave rise to a certain problem as a result. (Cancian, 2017)

These issues can be divided into six categories of significant issues, that have an impact on the entire process (machines, materials, manpower, mother nature, measurements, and methods). Additionally, it's critical to keep in mind that not all processes use all six M's to identify causes, so it's necessary to assess which ones are crucial to the process. (Cancian, 2017)

The use of this high-quality tool in a professional setting has many benefits. The diagram's visual nature; which makes it simple to understand and analyze, is its primary advantage; all employees involved in the process are influenced to commit to achieving the desired results; as finding the source of the issue is necessary. It is a statistical tool, that can be applied to complete quality control; making more informed decisions is facilitated by the detailed prioritization of the analysis, and it is applicable to issues of various types and has a general use and flexible structure. Although the tool has many uses and is simple in its cause definition, it also has a few downsides, including a failure to

accurately represent the real seriousness of the problem and a tendency to waste a lot of time attempting to identify the cause of inconsequential effects. (Cancian, 2017)

The Ishikawa Diagram is a useful tool for identifying a problem's underlying causes. The entire process benefits greatly from it. With a better understanding of the repercussions, it is feasible to handle the problem more successfully and take preventative and remedial action before eliminating the fundamental cause. This diagram is now widely utilized in all businesses, including those in marketing, finance, and other fields, demonstrating its importance. (Cancian, 2017)

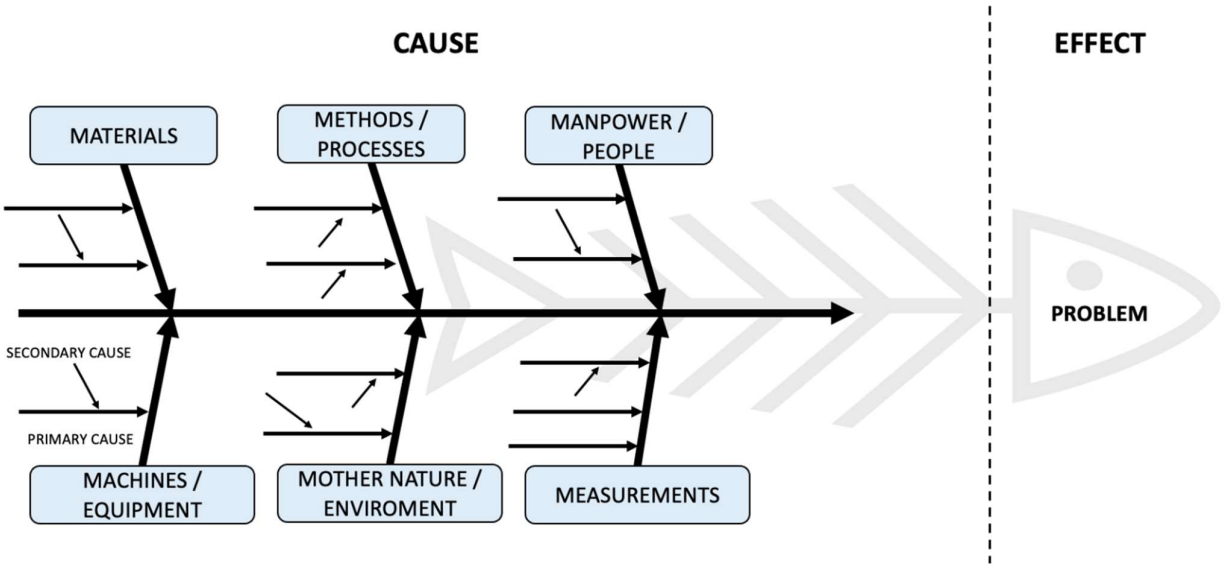


Figure 11. The Ishikawa Diagram (Cancian, 2017)

2.6.5 Decision Tree Analysis

A decision tree is a flowchart, that begins with a single central concept and branches out according to the outcomes of your choices. The model typically resembles a tree with branches, thus the name "decision tree." Trees are employed in decision tree analysis, which entails graphically illustrating the potential results, expenses, and effects of a complex decision. You can use a decision tree to calculate the expected value of each outcome based on the decisions and outcomes that led to it. The best course of action can then be immediately identified by contrasting the outcomes. Additionally, a decision tree can be utilized to identify possibilities, manage expenses, and address problems. (Asana, 2021)

Operational, financial, and project management decisions are all made using decision tree analysis. When possible, incorporate figures and quantitative information to create an effective tree. With additional data, it will be easier to identify predicted values and examine numerically based solutions. (Asana, 2021)

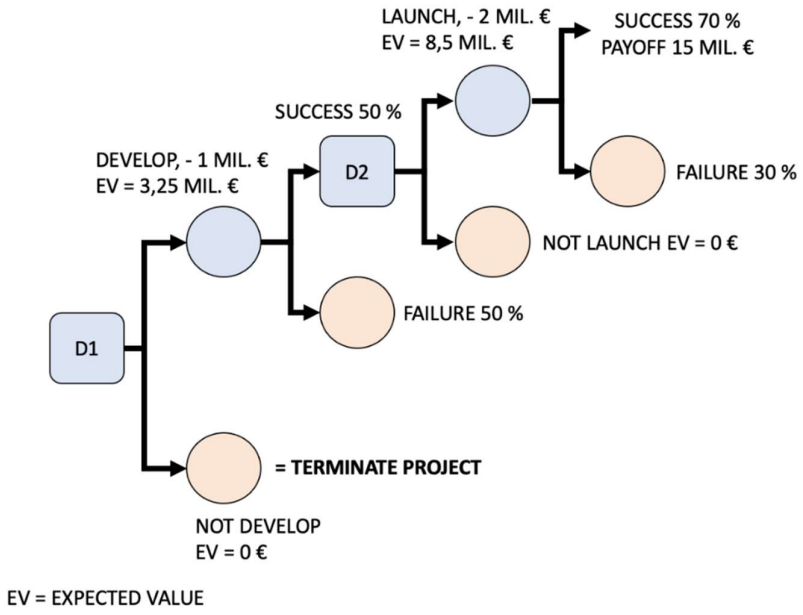


Figure 12. DTA Analysis presented in form of Decision Tree Analysis (Kodukula, 2014)

2.7 Project Portfolio Management

Successful organizations are those, that can quickly introduce innovations to the market, change course quickly to adapt to changes, use technology to gain a competitive advantage, and effectively manage risk in today's unpredictably changing environment. To accomplish the intended objectives, this entails first making the best strategic decisions, then investing in the best projects that correspond with those decisions, and then effectively completing them. Before deploying Project Portfolio Management in an organization, a strong project management process is required. As organizations' level of project management maturity rises, they often implement a PPM approach. Additionally, a good program management procedure will be required if projects are managed collectively as a part of a program. (Kodukula, 2014)

2.7.1 Project Portfolio

A Project Portfolio is a group of strategically coordinated, value-producing projects, that aid in the accomplishment of organizational objectives. Ultimately, the projects in a "true" portfolio add value for the stakeholders by assisting the organization sponsoring the portfolio in achieving its goals and staying on track with its overall strategy. This implies that each project in the portfolio must at a minimum meet these prerequisite requirements. The potential for value creation, as well as other aspects of the candidate projects' alignment must cope with the organization's strategy and goals. (Kodukula, 2014)

Projects that satisfy the portfolio's requirements and demonstrate a solid business case will be kept in the portfolio and funded. The portfolio's projects are periodically reviewed to see if they are still meeting the requirements as they progress through their individual life cycles. If not, their scope, time, and cost targets might be changed, or they might be even terminated. (Rad, Parviz F, 2006)

Organizations at the less mature end of the project management maturity spectrum manage specific projects by focusing only on the well-known project triple constraint, which consists of scope of work, schedule, and cost. There might be a finished project that adhered to this constraint and declared it successful. However, if you delivered a subpar product or made the customer unhappy, it was not truly successful. However, in addition to fulfilling the requirement, you could also produce a superior product that pleased the client, but if no long-term shareholder value wasn’t generated, this might not be a success for the company. According to PPM, the project triple constraint is just the beginning. It enables you to penetrate the iceberg and evaluate a project from a variety of angles, enabling you to make the best investment, that benefits all the major stakeholders. Additionally, an enterprise-wide coherent PPM process gives you a broad plan to manage the various organizational icebergs. PPM steers your company in the right direction for the foreseeable future by assessing, monitoring, and managing the project icebergs. (Rad, Parviz F, 2006)

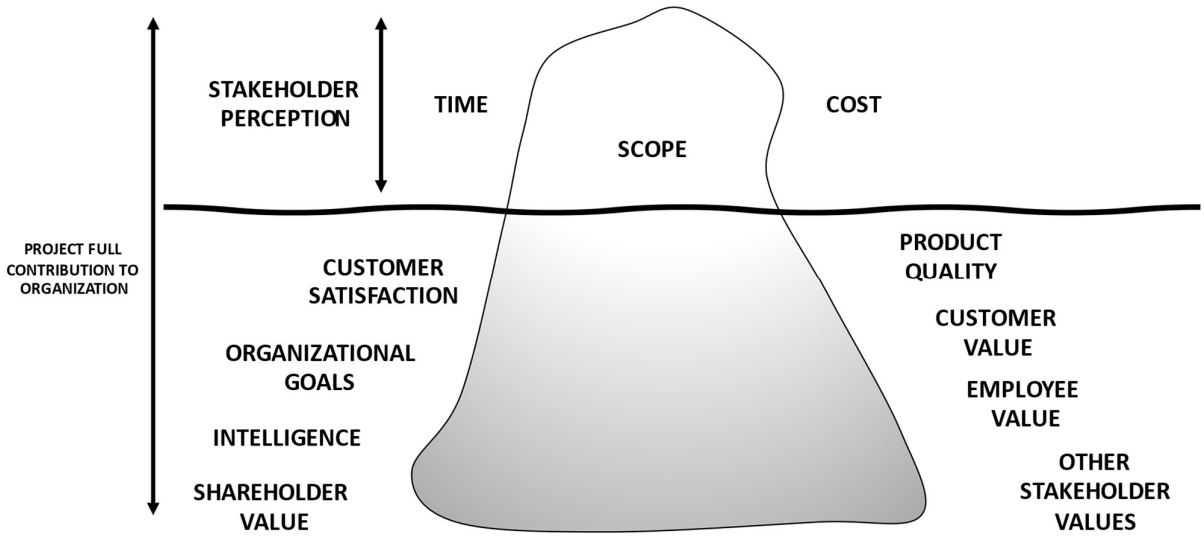


Figure 13. Project Iceberg (Kodukula, 2014)

Organizations must now more than ever develop new strategies or make minor adjustments to their existing ones due to the rapid changes in the economy, markets, technology, and regulations. When these concepts are turned into new initiatives supported by new programs and projects, portfolio management provides a framework to manage the transformation successfully. It helps choose the right investments to generate value for stakeholders. To quickly alter a company's course of action in reaction to unexpected environmental changes, it provides the essential instruments. When projects are started and conducted without the portfolio framework, project sponsors and managers frequently focus on the short-term risks related to project completion and give the long-term risks and benefits insufficient attention. They are also unaware of the project investments' overall risk profile. The risk-reward equation is examined for projects individually as well as collectively in the context of the overall business under a portfolio structure. (Rad, Parviz F, 2006)

Even if a project initially appears to have a strong business case, that does not automatically mean that funding should be provided until it is finished. Projects should be terminated as they move through their life cycles if the business case is no longer strong. By focusing on projects that will bring value and letting go of those that won't, organization may maximize the portfolio's overall value. Once a project has been approved and progressed into the implementation stage, it is likely to continue receiving financing until it is completed in the majority of organizations. It's frowned upon in most organizations to end projects. For many decision-makers and executives, it is a very

political and sensitive issue. Finding yourself in a situation where "the left hand doesn't know what the right is doing" is common in relatively large organizations. Organizational resources can occasionally be squandered on unrelated projects with the same purpose. Redundancy is reduced or eliminated due to the PPM process, which saves the organization a lot of money. When the Portfolio Management process is uniform throughout the entire organization and has adequate checks and balances to help uncover redundancy early on, projects become more visible. (Kodukula, 2014)

2.7.2 Project Portfolio Management

Portfolio Management is a difficult process, that begins at the top of the organization. It aids in transforming enterprise strategy, into the desired outcomes. It is a crucial stage in carrying out the overall strategy. The external business environment is constantly changing, and this could be due to a variety of variables, including changes in the economy, competition, customer needs, technology improvements, the opening of new markets, regulatory constraints, and a wide range of other factors. Even internal organizational changes, such as an expanding bureaucracy and a decrease in employee morale, could be categorized as changes. The executive managers create organizational goals and update the enterprise strategy in response to the changes. Transformational strategies and objectives are proactively introduced by visionary leaders. (Kodukula, 2014)

New business endeavors are developed, and the foundation of these initiatives are programs and projects. They produce goods and services that eventually help the organization achieve its goals by adding value. The PPM process offers a method for putting the plan into practice by adding value to a portfolio. PPM ensures the coherence of the business initiatives' implementation. It ensures that the appropriate organizational resources are allocated to the appropriate project priorities at the right time. PPM is applicable to all organizational levels. The underlying idea is the same; take any organizational component into consideration, such as a division or a function - it needs a plan and objectives all its own. Projects at that organizational unit will help you implement the strategy using the PPM process. (Rad, Parviz F, 2006)

Stakeholders expect that organizational resources will be allocated to the appropriate projects to provide the greatest possible value to them, regardless of whether you are a for-profit, nonprofit, or governmental organization. Additionally, they assume that you will finance a variety of initiatives that balance the advantages, disadvantages, and risks. Project investment management (PPM)

mainly comprises managing projects to satisfy stakeholders. Effective project prioritization and resource allocation within the organization result from this. It entails assessing, ranking, and choosing projects while integrating checkpoints for investment decisions. The initial invest/no-invest as well as ongoing continue/cancel decisions, collectively referred to as go/no-go decisions, span the life cycle of each project in the portfolio and are included in the checkpoints. The foundation of PPM is the procedure underlying the decision-making framework. (Kodukula, 2014)

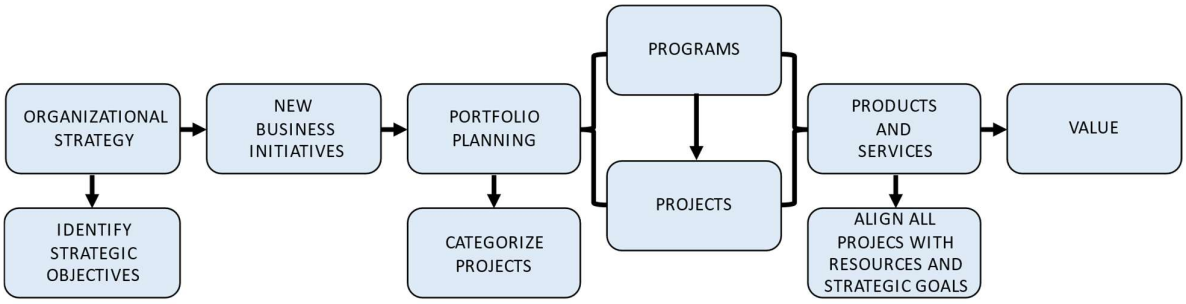


Figure 14. Role of PPM in Strategy Execution (Kodukula, 2014)

2.7.3 Project Portfolio Management Office

A Portfolio Management Office provides the decision support for Portfolio Management. It advises senior management on the composition of the portfolio, monitors progress at high level, resolves conflicting portfolio priorities and manages portfolio risk and issues. PMOs have traditionally concentrated on a single project or set of initiatives. Currently, the tendency is for PMOs to support Portfolio Management and management resources that are shared across numerous projects, programs, and activities. The functions of PMOs have developed in a similar way to Portfolio Management. Organizations have started embrace Project Portfolio Management, as a critical strategy execution process. PMO is a natural tool for support because its scope already does include the same domains. (Kodukula, 2014)

The primary goal of a PMO is to offer shared services to an organization's projects to increase consistency, quality, and efficiency. Functions and services generally refer to straightforward tactical and administrative tasks. The operational, tactical, and strategic groups make up the three main categories of PMO tasks. Project, program, and portfolio operations are correlated with operational functions. Administrative jobs include planning meetings, collecting minutes, printing reports, and other

related activities. Tactical functions are related to methodologies, processes, and tools, among others, that are common across many or all the projects, programs, or portfolios associated with the PMO. (Kodukula, 2014)

Main services of Portfolio Management Office include:

- Aggregating and providing performance results of the portfolio components
- Defining Portfolio Management methodology
- Forecasting supply and demand for a portfolio, that can be further broken down
- Defining a Portfolio Management strategy
- Identifying risks, analyzing risk and plan responses at a portfolio level
  (Kodukula, 2014)

The PMO can also be responsible for identifying the right PPM methodologies, processes, and tools and it can promote their consistent use across the organization. The PMO can be responsible for hosting, maintaining, and updating the portfolio information management systems. Working with project and functional managers, the PMO can be the conduit for gathering resource information and making it available for the portfolio team. It can also maintain and update the resource management database in its systems and facilitate strategic planning for the organization by ensuring that the organizational strategy and goals are made clear to the portfolio team. (Kodukula, 2014)

3 Methodology

3.1 Research Approach

For this research, there will be used a multidisciplinary approach to analyze the research results. To collect the data, I will use the Case Company's existing data, which comes from the company's financial management systems, where I can get an easy-to-read overall picture of the company's fixed costs, as well as the costs and income allocated to projects.

In addition to these, I interview the company's personnel, trying to find out possible pain points and bottle necks, that have not necessarily come to the company's management's attention, or their solution has not been implemented to bring about a positive change.

For this research I am using a multidisciplinary approach in the analysis of the company's data, which is why I have also included the principles of Lean Six Sigma in this research. I aim trying to find out the root causes of the inefficiency of your company's production and management, from which I can create solutions for turning the company's direction into a profitable one.

I believe that by utilizing the understanding brought by Lean Six Sigma literature and practical tools, the company's existing processes can be analyzed from the point of view of inefficiency, finding out; where the company does not operate effectively - productively and which business areas it should be profitable to give up.

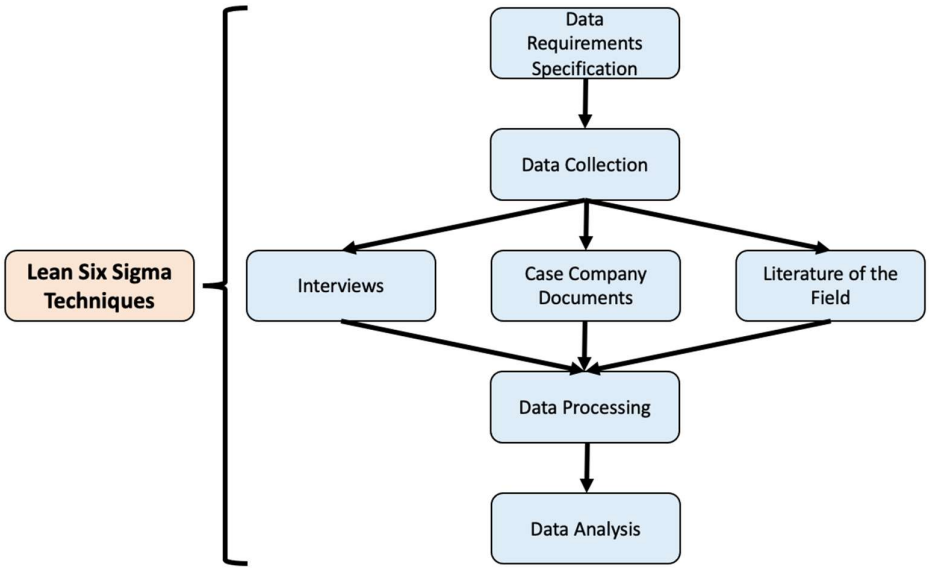


Figure 15. Methodology Flow Chart

3.2 Data Collection

It's critical to comprehend the big picture of the entire company to determine which type of data is needed. The company needs a skilled workforce, high-end machinery, and high-end materials for efficient production. All of these require investments from the business, and accurate calculations of invested options depend on accurate data.

For this research I chose “Case Study” -approach. A comprehensive review is one of case studies' most important advantages. A case study gives a researcher the chance to use a variety of tools on one topic, in contrast to standalone research techniques that provide more of a snapshot, such as interviews. This provides the time and space to develop a thorough understanding of the subject, creating a solid foundation from which to explore the factors influencing the case study in more depth.

Data collection techniques used in this research gave me the freedom to inquire about subjects' thoughts, drives, and emotions regarding the company. Additionally, it did raise the possibility of bias. I tried to create inquiries that didn't point them in any direction, so that the research results

would be as authentic as possible, and the employees wouldn't just tell me what the company's management wanted to hear.

3.2.1 Interviews

One of the data collection tools of this study have been obtained by Face-to-face discussions about questions, and issues taken place during interviews. When doing this research, the company was in the winter season, when it actively employed 30 people. Since interviewing all employees is neither efficient nor necessary for the results of this study, a sample size was defined; how many people will be interviewed for this research. Sample size was determined by using Sample Size Calculation - formula. (Kadam, Bhalerao, 2010)

$$Sample\ Size\ (n) = \frac{2(Z_a + Z_{1-\beta})^{2}{}_{\sigma}{}^{2,}}{\Delta^2}$$

Formula 1. Sample Size Calculation (Kadam, Bhalerao, 2010)

Since people from many different educational backgrounds work in the company, in different units and in different roles, the Confidence Level (%) was defined to be 80%, in which case the Margin of Error (%) is 20%. Based on the calculations, the Sample Size was determined to be 8 interviewees.

Focus groups had 2-3 participants, and interviews were also conducted one-on-one. I interviewed a total of eight different employees from the company, two of whom work in the company's management, three who work as foreman, and three of the company's production employees, who work in the field with construction.

Interviewee	Group	Education Background	Position	Work Experience	Business Unit
1	1	Vocational Degree	Management	30 years	Infrastructure
2	1	None	Tradesman	4 years	Maintenance
3	2	Bachelor of Engineering	Foreman	6 years	Infrastructure
4	2	Bachelor of Engineering	Management	18 years	Telecommunication and Electricity Network
5	2	Vocational Degree	Tradesman	12 years	Foundation
6	3	Vocational Degree	Tradesman	8 years	Infrastructure
7	3	Vocational Degree	Foreman	3 years	Maintenance
8	3	Bachelor of Engineering	Management	16 years	Infrastructure

Table 1. Background of interviewee's

In the interview, I asked a total of 18 different questions, to which I asked the interviewees to evaluate how well the company is currently performing in terms of its operational activities, both in terms of management and production, and where, and how the company could do better by improving processes. I tried to bring some variance to focus groups, by mixing employees of different levels in the same interview. People working in the same job may often think about things in the same way. When employees from different organizational levels were mixed. I think a more comprehensive interview result was obtained when the employees "sparred" each other over the questions.

By conducting interviews, I got good new opinions about new process implementation, from employees of field. There was great real-time observation, of how they see the company performance now, and the recording of their comments and questions gave me useful information about the features I should focus on with this research.

In this research, the personnel of only one company; company management and employees, were interviewed. The sample has remained limited to only one company, and it cannot be guaranteed that the research results would be fully applicable to other companies in the same field. While

analyzing the research results, I identified many examples from the literature in the field. Therefore, it can be believed that the answers are on some level valid when applied to other companies as well.

The interview session was largely informal, so that the interviewees would have the opportunity to share their thoughts more freely and creatively. However, I had already created a battery of questions for the interviews, to which I tried to get the answers by guiding the free-form interview. These questions included, for example:

Questions to support the interviews:	Management	Foreman	Employees
What is this companys strategy?	X	X	X
Where does the company want to go?	X	X	
What should the company do more of?	X	X	X
What is the biggest challenges the company is facing?	X	X	X
How does the company currently evaluate the projects offered?	X	X	
How do you think the bidding process should be part of the company's strategy process and what prevents this from happening at the moment?	X	X	
Can you set an accurate, data-driven budget on upcoming projects?	X	X	
What goals are you currently working on?	X	X	X
How does the company optimize resources in daily management and is it controlled?	X	X	X
What kind of goals would you have as part of your own career development for this company?	X	X	X
What kind of problems have you noticed in the company's production processes?	X	X	X
What have been the biggest changes in the company over the past few years?	X	X	X
What kind of effects have the changes had on daily work?	X	X	X
How could these processes be optimized, so that work would be smoother and more pleasant?	X	X	X
How can you predict and control risks on daily?	X	X	X
How do you engage and motivate your team?	X	X	X
How do you communicate with your team?	X	X	X
What is the best way to measure the companys progress?	X	X	X

Table 2. Questions to support the interviews.

3.2.2 Case Company Documents

The Case Company's documents were used as the second type of data collection. The documents used in the data collection, were an introduction to company’s current state. I aim to find out, which projects and business areas are currently productive for the company and which businesses even generate a loss for the company.

Since infrastructure construction is really a capital-related activity, due to the high prices of equipment, I will also evaluate; what kind of equipment is profitable for the company to keep overall, and what kind of equipment should be rented for specific projects. In general, certain types of projects

are carried out with a certain type of equipment, so the overall profitability of the business operator area can be evaluated from the company's point of view of these two factors.

3.3 Data Analysis

Based on the interviews and the company's financial documentation, a data analysis was performed. I tried to draw conclusions about the company's current situation and its prospects. The analysis technique used was "content analysis", which is probably the most popular and simple QDA technique. The simplest form of content analysis is the evaluation of patterns found within a piece of content (such as words, phrases, or images) or among various pieces of content or communication sources.

It's critical to enter analysis with a very clear question and goal in mind because content analysis can be applied in so many different contexts. With content analysis, I tabulated the data to summarize the frequency of various concepts or variables after grouping a sizable amount of data, summarizing it into categories. As a result, content analysis did inject a tiny bit of quantitative thinking into a qualitative methodology.

Even though content analysis has many applications, it is not without flaws. One of the main problems with content analysis is that it can take a lot of time because it necessitates reading and rereading the texts numerous times. Additionally, it is sometimes charged with losing key communication nuances due to its multifaceted focus on both qualitative and quantitative aspects.

3.4 Lean Six Sigma Techniques

The Six Sigma methodology uses a mix of statistical and data analysis tools such as process mapping, design, and proven qualitative and quantitative techniques to achieve the desired outcome. Lean manufacturing refers to production that produces no waste. For organizations looking to transition to lean manufacturing, there are many tools available. These tools, which include supplier networks, customer relationships, product design, and project management, help reduce waste in every stage of production. This toolbox gives businesses the ability to produce top-quality products in the most effective and cost-effective way possible while incorporating less human effort, less inventory, less

time to develop products, and less space, as explained in the following. (Wang 2019) Together with the interviewees, we used the following operating methods, evaluating the company's current operating methods.

3.5 Metrics

3.5.1 Financial Metrics

Financial metrics are a fantastic tool for a construction company's financial planning. The performance of the company in terms of liquidity, leverage, and financial efficiency can be quickly and accurately determined by looking at financial ratios. In the evaluation of the productivity of projects and equipment, we make use of financial key figures generally used in the industry when formulating the company's strategy and planning for the future growth.

1. **Current Ratio**

   The Current Ratio shows how easily the business can pay off short-term debts with its available assets. Greater than or equal to 1 is a desirable current ratio criterion. This implies that the business's present assets are large enough to cover its liabilities. A current ratio less than 1 can be a signal that financial problems is about to arise. However, a higher ratio indicates poor working capital management. (Neenu, 2021)

$$Current\ Ratio = \frac{Current\ Assets}{Current\ Liabilities}$$

Formula 2. Current Ratio. (Neenu, 2021)

2. **Quick Ratio**

   Another type of liquidity ratio is the quick ratio, which compares the total amount of current liabilities to the amount of current assets, which include cash, cash equivalents, short-term investments, and accounts receivable (but not inventories). (Neenu, 2021)

   The quick ratio therefore evaluates a company's ability to pay short-term obligations without converting assets into cash. Another name for it is the acid-test ratio. Investors are constantly looking for a fast ratio between 1.1 and 1.5. The quick ratio focuses on the simple assets that

can be promptly liquidated in the event of an immediate liabilities concern. This ratio doesn't include anything that takes a long time to liquidate. (Neenu, 2021)

$$Quick\ Ratio = \frac{(Cash + Accounts\ Receivable + \ Cash\ Equivalents)}{Current\ Liabilities}$$

Formula 3. Quick Ratio. (Neenu, 2021)

3. Debt-to-Equity Ratio

This leverage ratio calculates the amount of growth that the business has financed with debt. Therefore, it is the ratio of the company's total liabilities and debt to equity. A debt-to-equity ratio less than two is regarded as a good value. But if the value is greater than 2, it means that the business has accumulated too much debt to support growth. The company wouldn't be able to get more loans because of this. (Neenu, 2021)

$$Debt - To - Equity\ Ratio = \frac{Total\ Liabilities\ or\ Total\ Debt}{Equity}$$

Formula 4. Debt-to-Equity Ratio. (Neenu, 2021)

4. Working Capital Turnover Ratio

The working capital turnover ratio gauges how effectively a company uses its capital to support sales and business expansion. This ratio is regarded as a liquidity ratio as well as an efficiency ratio. (Neenu, 2021)

A greater ratio indicates that the company is making good use of its assets and liabilities to promote revenue. A lower ratio suggests that a company is less effective. Because it is challenging to quantify whenever the ratio surpasses 30, it is utilized based on the type of company. (Neenu, 2021)

$$Working\ Capital\ Turnover\ Ratio = \frac{Sales}{Working\ Capital}$$

Formula 5. Working Capital Turnover Ratio. (Neenu 2021)

$$Working\ Capital = \ Current\ Assets - Current\ Liabilities$$

Formula 6. Working Capital. (Neenu, 2021)

5. **Equity Turnover Ratio**

   The sales-to-equity ratio is used to calculate this efficiency ratio. This ratio assesses the effectiveness with which a company generates revenue from the construction industry. (Neenu, 2021)

   When calculating turnover ratio, equity is considered rather than capital. A ratio higher than 15 may be a sign of potential problems with future growth for a construction company. (Neenu, 2021)

$$Equity\ Turnover\ Ratio = \frac{Sales}{Equity}$$

Formula 7. Equity Turnover Ratio. (Neenu, 2021)

6. **Return On Investment**

   Return on investment (ROI) is a performance metric used to assess an investment's effectiveness or profitability or to compare the effectiveness of various investments. ROI aims to quantify the amount of return on a specific investment in relation to the cost of the investment. (Fernando, 2022)

$$ROI = \frac{Current\ Value\ of\ Investment - Cost\ of\ Investment}{Cost\ of\ Investment}$$

Formula 8. Return on Investment (Fernando, 2022)

3.5.2 Six Sigma Metric

It is crucial to emphasize that Six Sigma is both a metric and a performance improvement approach. As a methodology, Six Sigma is a collection of instruments that promote ongoing performance, or better still, breakthrough performance. (Marr, 2012)

Data is being collected from three primary sources: input, process and output.

- The input source is where the process is generated.
- Process data refer to tests of efficiency: the time requirements, cost, value, defects or errors, and labor spent on the process.
- Output is a measurement of efficiency.

A Six Sigma opportunity is the total number of opportunities for a defect, whereas a Six Sigma defect is anything that does not meet customer requirements. First, we determine the defects per million opportunities (DPMO), and then, using a predetermined table, a Sigma is determined. The total number of defects found is the number of defects, the number of units produced is the number of units, and the number of opportunities is the total number of potential ways for defects to be produced. (Marr, 2012)

$$DPMO = \frac{Number\ of\ Defects * 1{,}000{,}000}{Number\ of\ Units * Number\ of\ Opportunities}$$

Formula 9. Six Sigma Metric (Marr, 2012)

The 'control' principle of DMAIC is ensured by measuring the Sigma calculation at the start of the project (baseline), at the conclusion of the improvement project, and then on a continual basis. Unless data collection is automated and data are easily accessible, the costs and effort associated with gathering Six Sigma data may be substantial. Only essential organizational procedures call for manual data collection and analysis. The expenses are significantly reduced for operations where data is automatically obtained, such as automated manufacturing. (Marr, 2012)

4 Case Company

From the request of the Case Company, it will be treated as "Case Company" in the investigation. The research presents data critical to the company, and the profiling could cause negative effects for it; both for the company's competitive position and reputation in the market. For this reason, the company is treated anonymously in this research.

Case Company is an Infrastructure Construction company operating in the Southwest -Finland. The company's turnover has increased approximately 100% per year for the last few years, which has caused, that the company's management as administrative organization has not kept up with the pace of growth. This has caused a very critical impact on the company's ability to make a profit and caused the profit to be negative in recent years. To be able to continue business operations in the future, a major change program must be implemented for the company, where unproductive business projects are removed and the Project Portfolio is focused on strategic goals, focusing on business areas that are profitable for the company.

4.1 Analysis

The material for this chapter has been collected based on articles, interviews, and financial data provided by the company. The interviewees are the management, foremen, and blue-collar employees of the Case Company. The interviewees have requested the possibility to remain anonymous, which is respected in this study.

Company’s core competencies consist of project management for infrastructure construction projects, and the company utilizes subcontractors as employees in construction projects, reducing the risk of project-specific business. The company employs about 25-45 people full-time each year through subcontractors and own employees over a year. Infrastructure construction is largely focused on summertime, when the ground is not frozen, and construction is more profitable and safer. During the summer season, more people are working in the company than in the winter months. In the summer months, many employees work such long days that they often take vacations during the winter months and do not need to look for another job to maintain their standard of living. This means that in the summer season, most of the work carried out causes large overtime

compensations for the staff, which significantly reduces the company's profit margin, because for the same work, the company must pay its employees up to 100% more salary as over-time compensation.

The company's business is divided into different business areas, which are infrastructure construction (bridges, road network, etc.), telecommunication and electricity network construction, foundation work for buildings and winter maintenance.

The Case Company is a project management contractor, which means that the company mainly uses subcontractors on its projects. The subcontractor's contract always defines the subcontractor's performance obligation. Mainly used options for this are hourly billing and as small overall contracts as part of a larger projects, where clear performance obligations are defined.

Both methods have their pros and cons. Hourly billing is usually the cheapest way if everything goes as planned. When using hourly billing, subcontractor doesn’t have to calculate risk bonus to their contract, because the more time job takes, more money they will get. This is defined as risk for to the main contractor because the subcontractor has no schedule pressure to complete its own work. Quality will usually be better because there is no rush, but subcontractor needs to be reliable, or the whole contract will not succeed, as schedule is delayed and labor cost are more expensive, than estimated in the bid calculation. One solution to this is to agree with the subcontractor on a schedule in which the work can be handed over at the latest, but due to the urgent schedule and limited information, this is often disadvantageous for the subcontractor.

4.1.1 Problem

Currently, the company's management team feels that one of the biggest problems at the moment is that the company has not followed the data produced by the projects, and it has not utilized the data in decision-making. This means that the company has not previously acted systematically towards strategic goals, because the company's strategy has not been clarified as a common goal. So far, the company has tried to win as many projects as possible for itself, growing itself by recruiting new staff for projects and increasing its machine base. The company's management currently does not know which projects are profitable to undertake, and which have resulted in a loss. This is a

serious problem, because by spreading out as many projects as possible - without knowing their cost consequences, the company can further increase the company's loss when more money is spent on projects than can be billed to the customer.

The number of the company's personnel has been increased at a very aggressive pace. Employees have been attracted to work in the company, e.g., with a higher salary, new equipment, and a company car. Because of this, the company's current cost structure is unsustainable because it is competing with companies that have not offered similar benefits to their staff. Doing the same job costs Case Company significantly more than it costs a competitor. When the lowest price invariably wins the project in the tender calculation, Case Company's profit margin is already lower from the start.

4.1.2 Industry of Infrastucture Construction

The Case Company's main business area is in public sector infrastructures, bridge projects, telecommunication, and winter maintenance. This means, that most projects offered by the company comply with the procurement act. Typically, only the price is used as a criterion in the bidding process for projects in the industry, so the lowest bidder wins the contract (Rakennusteollisuus, 2022). The national threshold for construction contract procurement is 150,000 euros, and the EU threshold from 1 January 2022 is 5,382,000 euros. Projects below these limits can be tendered between a few contractors, or alternatively be done as direct procurement from a specific contractor. For those projects, the margin is generally better, but when the projects are so small and short-term, administrative expenses take up a large part due to the large volume.

Infrastructure construction is a very capital-bound business, due to the expensive acquisition, maintenance, and operating costs of the equipment (e.g., fuel). Excavators cost several hundreds of thousands of euros each, and due to tight contract schedules, several machines are needed on one site at the same time. For a new company, financing several hundreds of thousands, or even millions, without external capital is not simple. Because of this, many companies must resort to different financing options and loans. Loans often have a certain turnover limit as a condition, which the company must maintain to continue financing at all. This means, in its simplest form, that the company may have to offer the project, even at a loss, so that the company maintains the required turnover and does not have a collateral shortfall.

Carrying out projects at a loss is already problematic at the thought level, but the company should think about its long-term strategy, and not short-term quick profits. Competent personnel are extremely difficult to find nowadays, so layoffs in general in the industry cause the employee to quit, and not to come back, as there would be more projects to work on. (Päiviö, 2021) According to the Case Company's management, it takes about 5 recruited excavator drivers to find one good one. So, the company has a big threshold to lay off personnel, especially when the installments, rents and expenses of the equipment run continuously. In many cases, it is more profitable for the company to implement the project at a loss to secure the company's short-term continuity. Due to the suitable, similar equipment, several Infrastructure Construction companies contract snow plowing, when the ground is frozen, and the digging season is at its quietest.

In most construction projects, contractors are given only one opportunity to set cost and schedule targets. Prices are determined and milestones agreed upon when a bid is submitted, or a project contract is negotiated. From that point on, profits are determined by the project manager's ability to save money through smart sourcing, better planning of day-to-day operations, and the ability to make well-informed decisions. The utilization of Lean Six Sigma tools is therefore highly recommended in the industry.

Close control of field operations is essential to build project within budget and schedule. Project conditions, such as technical complexity, on-time completion, resource constraints, and high costs place great emphasis on planning, scheduling, and managing construction work. Unfortunately, the construction process, once set in motion, is not a self-regulating mechanism and requires expert guidance for the process to proceed as planned. (Sears, Sears, Clough, 2008)

Contract prices are usually index-linked in the industry, which has been a salvation for many companies in the construction industry during 2022. During the past year, the costs have risen explosively, both in terms of fuel and building materials. (Luukkonen, 2022) It is interesting to see; how the trends in the profitability of construction companies will be in the next few years, due to increases in the prices of materials and interest caused by inflation. Based on the interviews, 18.12.2022, the industry in general has a great fear about the future, how construction companies will survive in the future. During the last few years, the economy has been revived against Corona with the help of

infrastructure construction. Large stimulus packages and many projects to be implemented may have pushed entrepreneurs into too large growth spurts and investments, which may pose challenges to maintain in the current inflation-killing world situation. (Åberg, 2020)

4.1.3 Productivity of the fleet

The company did not have a clear understanding of the productivity of its own equipment. The company currently has approx. 4 million EUR worth of equipment, which is operated by a total of 13-26 operators. One of the company's activities, is to rent equipment and drivers for subcontracting in other companies' projects, for an hourly price. Based on negotiations and guesswork, the price was determined in cooperation with the customer, without knowing what the equipment actual cost for the company.

When examining employee cost, in addition to salaries, there are also costs referred to as wage incidentals when calculating salary-related expenses. These include wages and salaries paid outside of working hours (such as annual leave pay, sick pay, and holiday pay), social security contributions (such as contributions to an earnings-related pension, insurance against sickness and accidents, and group life insurance contributions), and personnel costs unique to the company, such as labor and training costs.

By using Reetta Palva's research "Konetyön kustannukset ja tilastolliset urakointihinnat". I calculated the cost price of the machine work for the company. A large part of the company's equipment is financed by leasing contracts, which costs are added as maintenance costs. Maintenance costs are billed per hour of use, so calculating a realistic price for machine work was easy to estimate. It came as a surprise to the entrepreneur, that the contracts made with some clients produce hundreds of euros in losses for the company every day, which is not favorable for the company's profitability in the long run.

A good example here is that the company has rented its equipment from the so-called hourly work for as subcontractor, i.e., the contract includes an excavator and an excavator driver. Since the company has not known its own costs caused by the combination, it has made a loss for every hour. At the moment there are contracts, where hourly pricing for such combination is 65 €/hours, but the

company has expenses of 75 €/hour, which causes a huge negative profit yearly. The more these projects are done, the more the company loses.

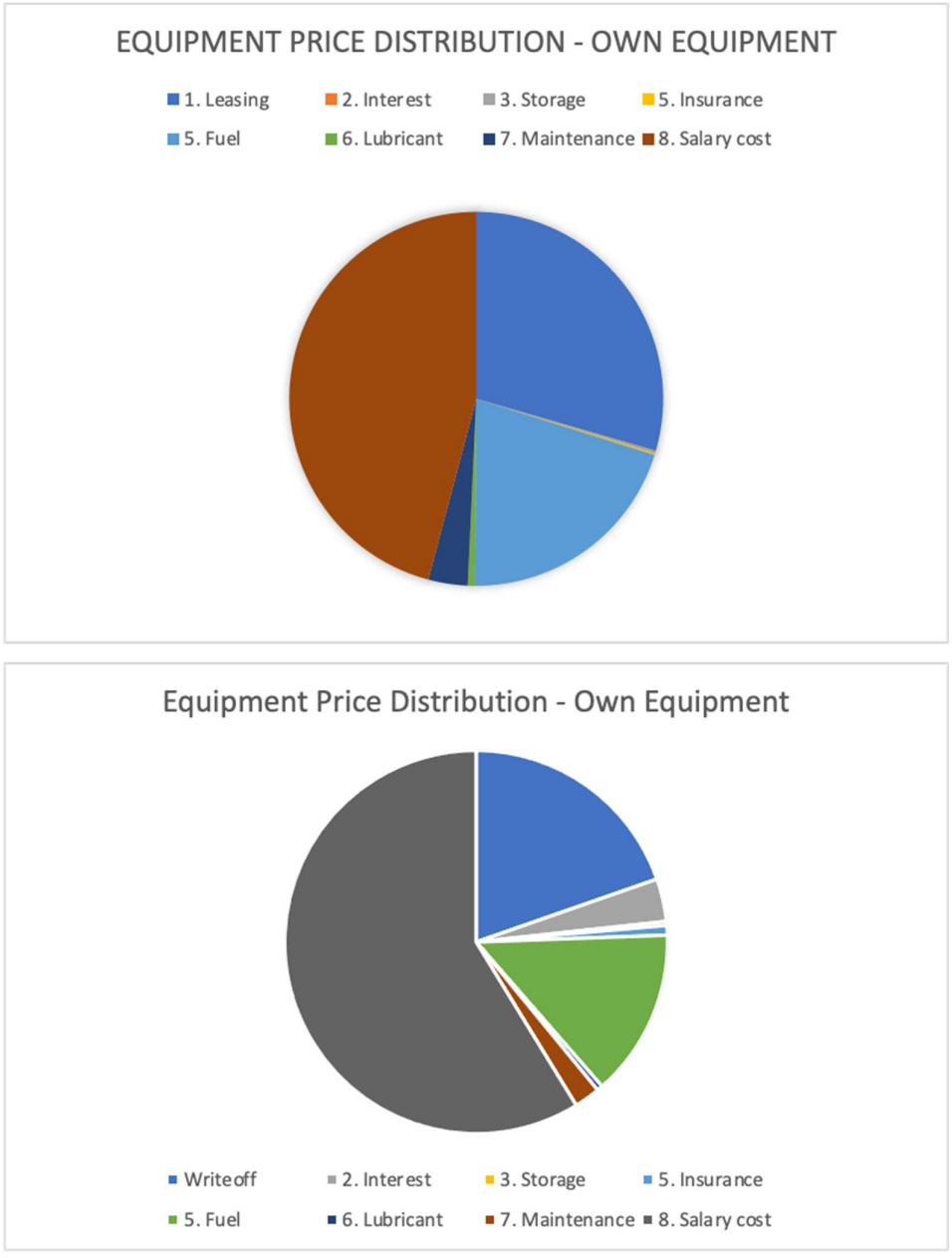


Figure 16. Cost breakdown of machine contracting

Figure 17. Cost breakdown of employee expenses

From the calculation, we can see that most of the contracting costs are caused by the hourly driver's salary, which is almost 50% of the total costs. In addition, machine lease payments and maintenance costs take up a large part of the total costs. By influencing these, e.g., significant cost savings can be achieved by using more energy-efficient equipment and by optimizing the equipment's price - power rating to support the company's needs. In the interview, the owner of the company said that in the past, when purchasing equipment, the aim was to acquire the most efficient equipment possible, so that it can be operated in as many locations as possible where power is required. However, by studying the company's current Project Portfolio, I concluded, that the company does not need such efficient equipment, and it would do just as well with a smaller – cheaper equipment. Larger equipment generally causes higher costs, e.g. equipment is cost more, more fuel is consumed, and maintenance costs and insurance premiums are higher.

The personnel currently have vans for work, which they use to move to their typical work sites, i.e., the construction site. In other companies, the personnel often use their own cars to get to their workplace, but the Case Company have been thought that getting for small items from the store can be done better by the personnel in the company's van. When we study the cost breakdown of employee expenses, we notice that for every hour worked, the car benefit takes a large part of the company's profit. By optimizing production, eliminating trips to store to get supplies, and planning the future flow of materials, the staff's car benefit can be eliminated.

5 Creation of Project Portfolio

In this paragraph, we will define the Project Portfolio for the Case Company. We will use the theory of the field to support the definition, with which we can justify and clarify to the reader; what the definition process is based on and what advantages the use of certain tools and methods of operation bring, when defining a Project Portfolio. The chapter particularly reflects the progress of the process from the researcher's point of view, how the thought process has progressed to create a ready-made tool, and what issues have been considered in the work to support the thinking work. This Project Portfolio has been specifically created for the Case Company based on the data and analysis collected in this study.

The utilization of Lean Six Sigma principles in the Project Portfolio definition process is not the most typical operating method, and there is not much research about such cooperation in the literature of the field. In this thesis, we aim to create a Project Portfolio, the definition of which has been thought through Lean Six Sigma principles; how the opportunities brought by different projects can produce an advantage for the company through production efficiency.

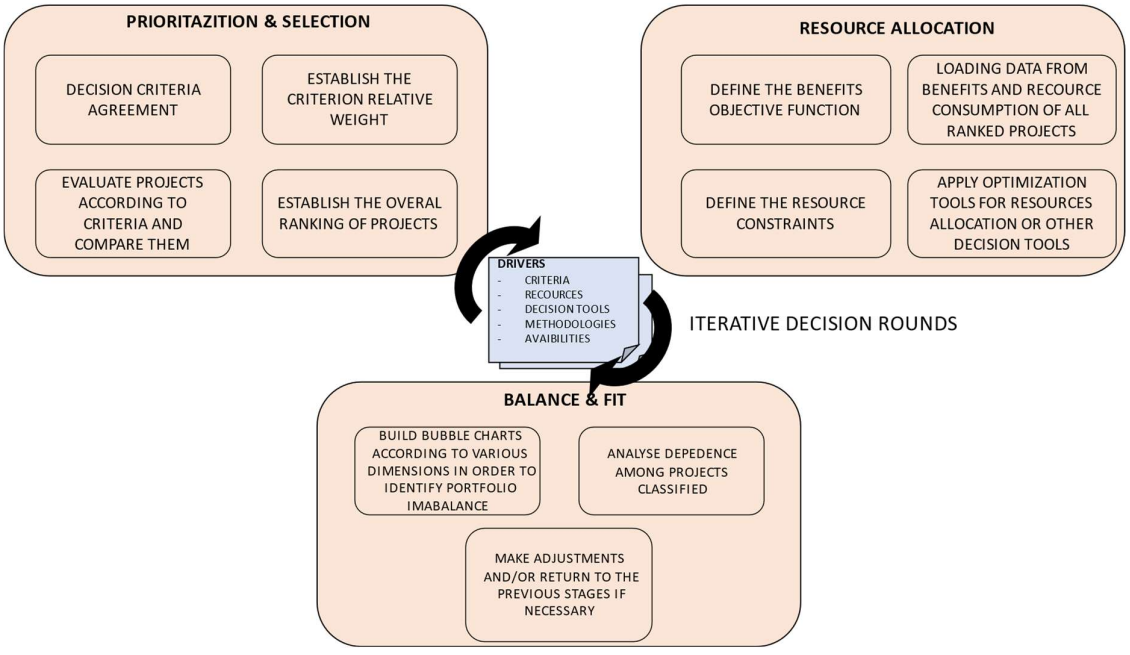


Figure 18. Iterative decision rounds (Carvalho, 2013)

5.1 Project Portfolio Management -tool

According to the data from the interviews, the respondents appeared to be giving contradictory accounts of how they thought the decision-making process should operate compared to how it did. For instance, respondents discussed the value of planning and forecasting while also expressing that nothing can be predicted with certainty.

Only projects that are in line with the organization's mission, vision, strategy, goals, and objectives, which make up its strategic framework, are included in an effective portfolio. The strategic framework that has been adopted by the organization supporting the portfolio must be fully understood by the portfolio manager and team. Every portfolio needs to be created and maintained in accordance with the predetermined design guidelines. The specifications include a list of tolerance upper and lower limits as well as weighting factors, discount rates, and contingencies. They also specify the project categories to be used in balancing the portfolio, relative resource allocations to these project categories, criteria for evaluating projects in each category, etc. (Lepak, Smith, Taylor, 2007)

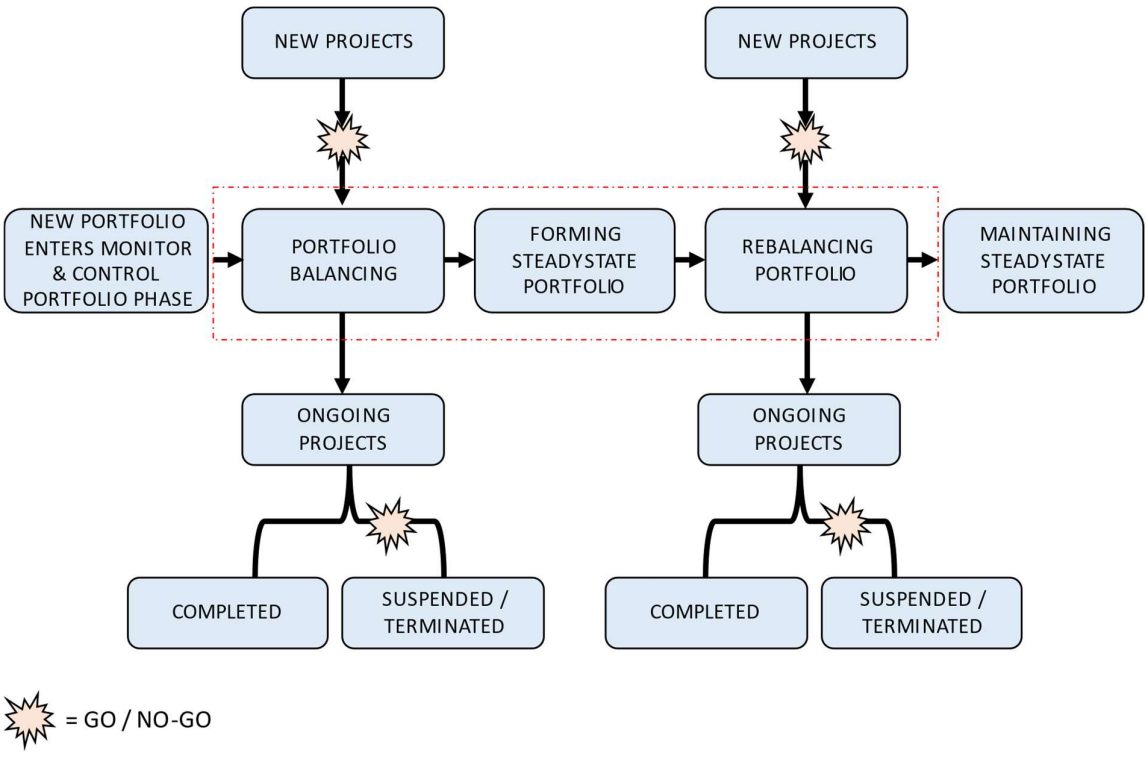


Figure 19. Steady state through balancing and rebalancing of portfolio (Butt, 2022)

5.1.1 Project Portfolio Design

Management of the company has currently no understanding of the status, accomplishments, capabilities, and capacities of the company's projects. The majority of management has lacked sufficient knowledge of the resources available to their companies. They frequently define the projects without providing any justification, and as a result, their projects have a poor success rate. Though they did know how to track and manage them, they did define their vision, mission, and strategic objectives.

Due to these issues, we must define the portfolio to accomplish our goal and avoid wasting any time, resources, etc. There are seven crucial steps we must take to design and implement a portfolio:

1. **Recognize where the OPM maturity assessment stands right now.** It's imperative to comprehend the current state of the organization before starting any work. The company may have policies, templates, or processes related to the portfolio that can help with comprehension of OPM maturity. (Forouzesh, 2018)

2. **Create a portfolio structure and specification based on the work inventory.** The term "inventory of work" refers to data that is consistently kept track of all the work that you company is engaged in, as well as the resources (materials, funds, information, etc.) that are used or needed for the work. The way it is set up makes it simple to complete tasks that require the information. Before defining the portfolio structure, The Case Company should be aware of the current status of all components and data within the organization. (Forouzesh, 2018)

3. **Examine portfolio elements.** We want to assess and compare the information from three sources—a list of the current parts (an inventory of the work), organizational strategic objectives, and organizational initiatives—using a set of standards. Remove certain initiatives and components from the list of portfolio components, for instance, to prevent duplication, slow progress, poor strategic alignment, etc. The criteria should be established by the portfolio governance board in accordance with the organizational vision, mission, and strategies. (Forouzesh, 2018)

4. **Categorize portfolio components.** In this step, we try to group the components of the portfolio according to business domains, themes, or something comparable. Some organizations favor using financial/non-financial groupings, while others favor using concepts of tangible/intangible benefits, etc. Typically, how you apply this idea depends on how mature the organization is. (Forouzesh, 2018)

5. **Set portfolio component priorities.** The portfolio elements in each category should then be given priority by the governance board and portfolio manager. Prioritization typically considers factors such as attractiveness (such as the NPV index, decreased cost, and strategic alignment), affordability (such as resource requirements), and viability (like technical risks, time-to-market risks, benefits realization risks). There are numerous decision models for prioritization, including financial models, scoring, and weighting models, and models for collaboration (NPV, ROI, IRR, etc.). (Forouzesh, 2018)

6. **Improve your portfolio.** Given our organizational capabilities, competencies, and limits, we try to optimize the advantages and values of the portfolio by optimizing the components. We should first recognize our shortcomings (such as funds, time, resources, etc.). Define the ideal scenario, then put it into action. Attention must be given to component dependencies, for instance, key SMEs and equipment. (Forouzesh, 2018)

7. **Approve portfolio components.** Authorize the portfolio components by allocating resources that were developed in their business case based on the previous steps and strategic objectives. (Forouzesh, 2018)

5.1.2 Monitoring plan

The Case Company's projects vary in size from around €1,000 to €1,000,000. It is extremely difficult to produce a model that would cover both perspectives seamlessly, enabling Project Portfolio monitoring to cover the entire business. In this research, we will focus especially on infrastructure construction projects, the size of which varies between €250,000 and €1,000,000.

When the size category of the projects is in the hundreds of thousands, the differences between them in practical implementation are quite small. The practical differences are the time spent on the project and the extent of the site. The actual work performance remains pretty much the same, only the amount varies.

As support for monitoring plan, we will use Kaplan and Norton, in their work “Strategy maps: turning intangible capital into measurable income”. General strategy map model describes the impact of different aspects of business operations on the value proposition, cost structure, operating processes, and capital. This helps to outline the overall picture when creating a Project Portfolio monitoring plan.

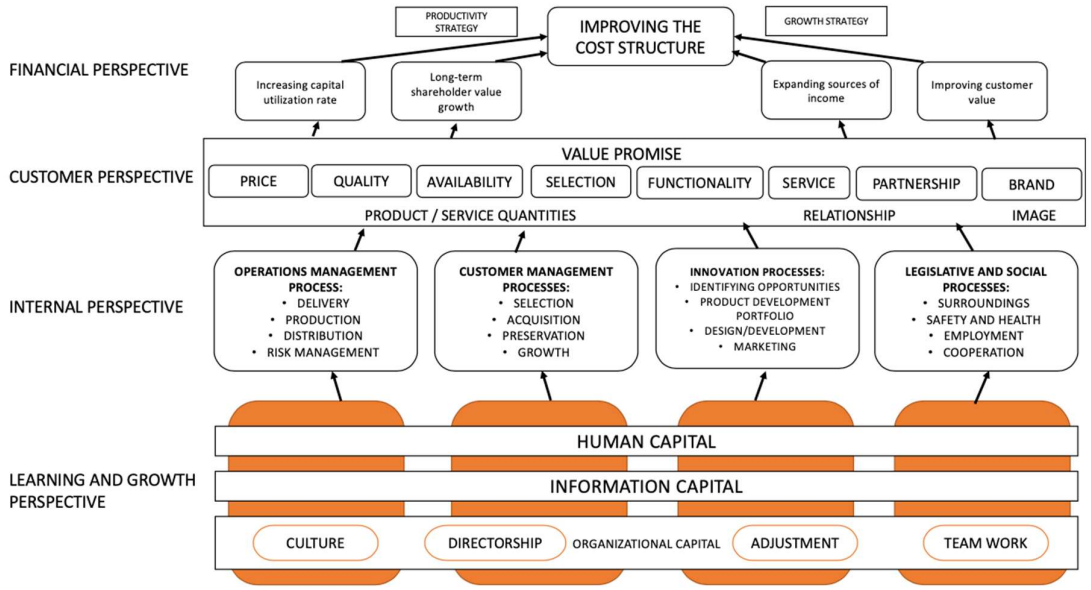


Figure 20. Strategy map (Kaplan & Norton 2004)

5.1.3 Evaluation

An essential component of Portfolio Management is project evaluation. The goal is to make it easier for the portfolio to prioritize and choose them, allowing for the pursuit of high value potential projects. Prior to evaluation, standards and metrics for project selection must be specified in the portfolio design phase. To make the evaluation process simple for the portfolio team, project initiators must be encouraged to use the necessary metrics. The criteria can be divided into two categories from an evaluation perspective:

Financials: These are things with a physical, monetary nature, like costs and benefits. Utilizing quantitative techniques, these can be evaluated.

Nonfinancial: These are intangibles that cannot be seen, touched, or measured and are not financial, such as alignment, nonfinancial benefits, threats, and opportunities. Most of their evaluation tools are scoring models. (Indeed, 2021)

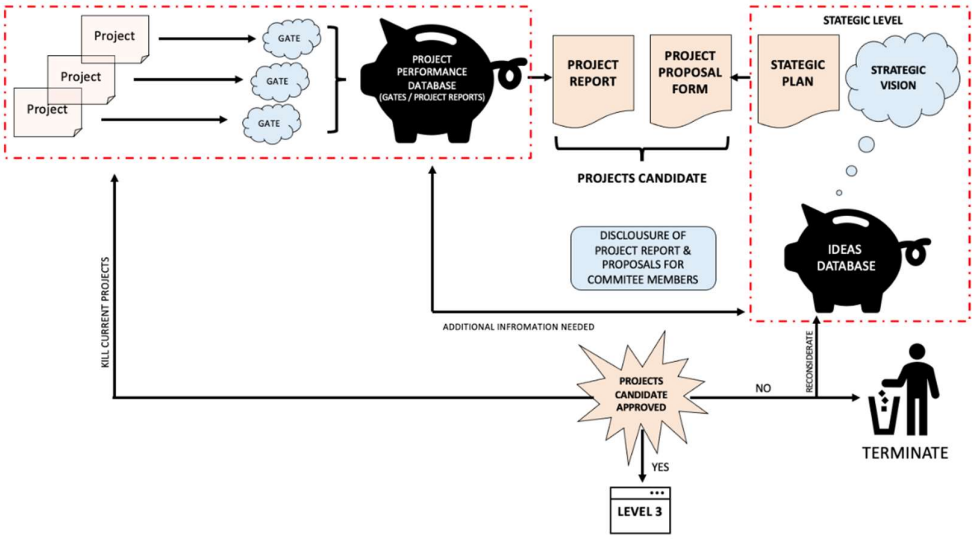


Figure 21. Portfolio Candidate – On-going project, and new project proposal (Carvalho, 2013)

	Project Status	Evaluation		
		Level 1	Level 2	Level 3
Objective	New	To screen the projects from further considerations	To evaluate whether it is investment worthy based on its own merit	To evaluate whether it is investment worthy based on its relative merit against competing projects.
	Ongoing	Not applicable	To evaluate whether the projects continues to be investment worthy based on its own merit	To evaluate whether it continues to be investment worthy based on its relative merit against competing projects
Documentation	New	Project request form	Project business plan	Project business plan
	Ongoing	Not applicable	Project business plan, project performance report	Project business plan, project performance report
Criteria	New	Screening criteria	Project selection criteria depending on the project category	Relative merit against competin projects
	Ongoing	Not applicable	Project selection criteria depending on the project category, termination criteria	Relative merit against competin projects
Frequency	New	Only once at the time of initial project request	Only once after the Pay Back Period is submitted	Quaterly or binnual
	Ongoing	Not applicable	As often as necessary. Typivally at the end of each phase of project or after a key milestone	Quaterly or binnual
Next Step	New	Pass here: Go to Level 2 evaluation	Pass here: Go to level 3 evaluation	Pass here: Go to Portfolio balancing
		Fail here: Termination (KILL)	Fail here: Termination (KILL)	Fail here: Termination (KILL)
	On going	Not applicable	Pass here: Go to level 3 evaluation Fail here: Termination (KILL)	Pass here: Go to Portfolio balancing Fail here: Suspencion

Table 3. Evaluation model

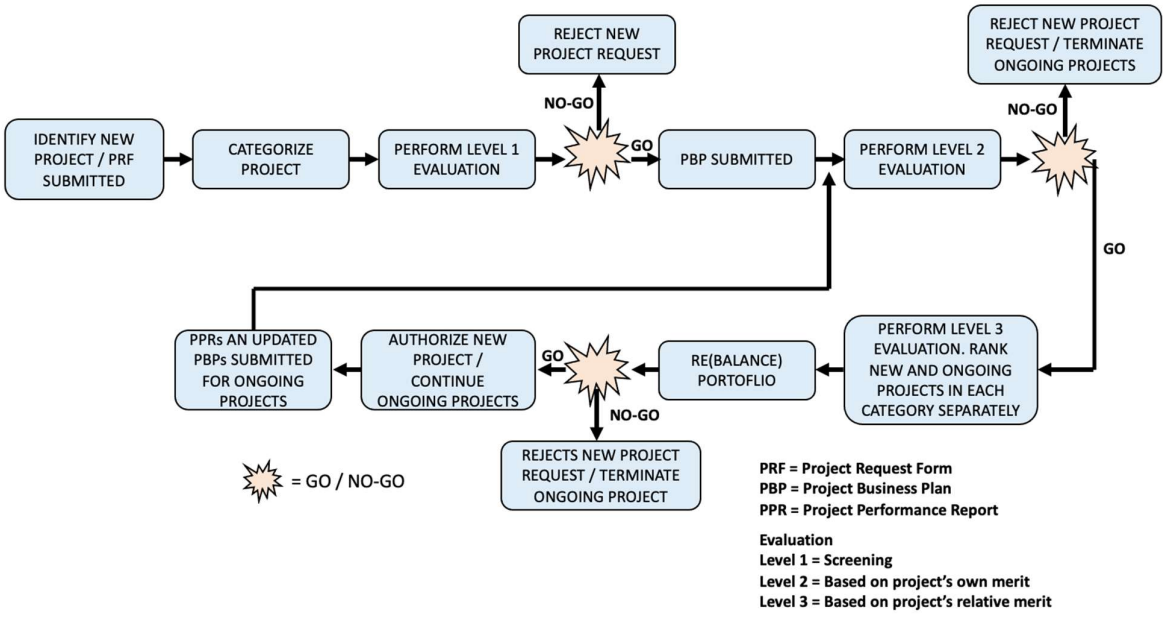


Figure 22. Process flow for project evaluation and go/no-go decisions (Kodukula, 2014)

5.2 Scoring Model for Projects

A basic scoring model involves rating a project on each one of pre-selected evaluation criteria. The criteria depend on the Case Company's business needs and the type of portfolio, that company is dealing with.

The scoring model developed by the company executives during the Portfolio Management consisted of the following five variables.

- Strategic fit
- Competitive advantage
- Market attractiveness
- Technical feasibility
- Financial payback

One point was awarded for the project's strategic fit in the category, five points were awarded for covering two to three strategies, and ten points were awarded for covering all four strategic initiatives. Unless they were deemed to be "joker" projects or initiatives, that were mandated by the

government, projects were removed from the portfolio if they failed to support any of the strategic initiatives at all.

The competitive advantage was the second factor. Following is a breakdown of how the points were allocated:

- More than two competitors are likely to offer on same project – 1 point.
- Either one or two competitors are likely to offer on same project – 5 points.
- No competitors are likely to offer on same project – 10 points.

For the company to get an idea of what the theoretical profit of the project will be, and what it will bring to the company if it is successful, we use the calculation to have an estimate, what will be the Internal Rate of Return, that the project will provide.

- Internal Rate of Return (IRR) < 5 % - 1 point
- 5 % < IRR < 10 % - 5 points
- IRR > 7,5 %

The market attractiveness factor was an additional category that was added to the prioritization model. The executives decided to relate this variable to how much it affected market share. The project scoring model thus appeared as follows:

- The proposed project will decrease the market share – 1 point.
- The proposed project will maintain the market share – 5 points.
- The proposed project will increase the market share – 10 points.

Senior management wanted to move away from larger, more complex projects requiring a lot of external—and frequently expensive—expertise, so they wanted to take technical feasibility into account when determining the project value. Therefore, projects requiring a great deal of expertise would be given 1 point, projects where the domain was only vaguely familiar to internal company staff would be given 5 points, and projects where the entire project domain was completely familiar would be given 10 points.

Additionally, in exceptional circumstances where the project knowledge was completely unknown and the project was deemed to be risky, the executives designated a "kill" variable, which removed the project form the evaluation.

Finally, the portfolio scoring model now includes the financial factor in the form of a project duration. The points were broken down as follows:

- Project duration > 3 months
- 3 < Project duration < 6 months – 5 points
- Project duration > 1 year – 10 points

When the business is project-based, long projects are valued longer than short ones. In this case, the so-called security for the continuity of business operations, when there is known work for a long time into the future. However, long projects have their risks; if the project is calculated incorrectly in the bid calculation, the costs caused by the error can be significantly higher than in short projects.

The infrastructure construction sector invariably goes quiet when winter arrives when the ground freezes. Because of this, the season only lasts about half a year, so we jump in the review from half a year to projects lasting more than a year.

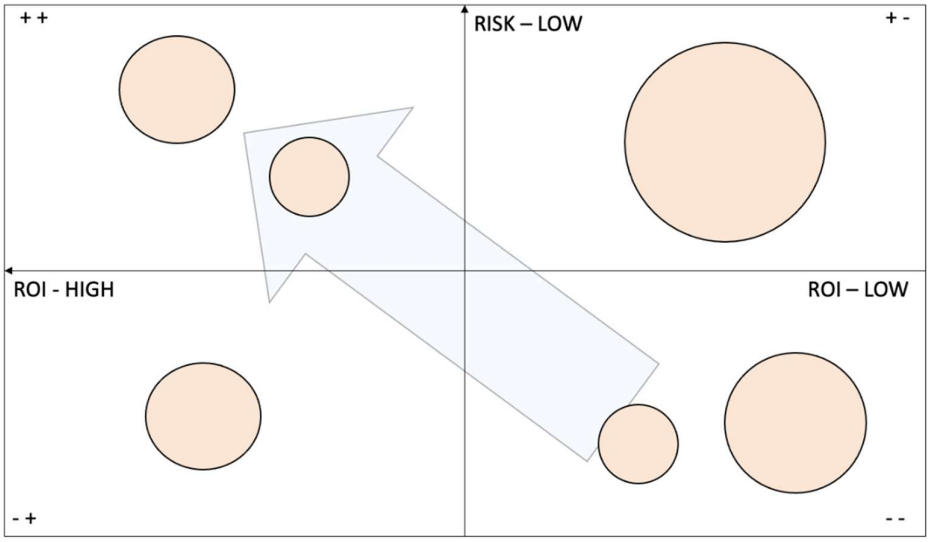


Figure 23. Portfolio balance – ROI vs. risk. (Lepak, Smith, Taylor, 2007)

The portfolio was divided into the following strategic buckets by the senior management in accordance with the traditional strategic alignment model:

- **Maintenance or utility projects:** Support ongoing projects and services – 30 %.
- **Growth or enhancement projects:** Support strategic initiatives and increase value 50 %.
- **Transformation projects:** The new projects, or services that will hopefully dominate the marketplace 20 %.

SELECTION CRITERIA	POINTS AWARDED			
	51 POINTS			
JOKER	1 POINT	5 POINTS	10 POINTS	KILL
STRATEGIC FIT	Fits one of the strategies	Fits two or three of the strategies	Fits four or five of the strategies	Yes, if fits zero of the strategies, and not a "joker"
INTERNAL RATE OF RETURN	IRR < 5 %	5 % < IRR < 10 %	IRR > 15 %	No
COMPETETIVE ADVANTAGE	LOW	MEDIUM	HIGH	No
	More than two competitors offering similar projects	Between one and two competitors offering similar projects	No competitors offering similar projects	
MARKET ATTRACTIVENESS	Will decrease the market share	Will maintain the market share	Will grow the market share	No
TECHNICAL FEASIBILITY	Completely unknown domain	Somewhat familiar domain	Very familiar domain	Yes, if completely unknown, and very risky, and not a "joker" or regulatory project
PROJECT DURATION	P > 3 MONTHS	3 < P 6 MONTHS	P > 1 YEAR	No

Table 4. Scoring Model for projects evaluation

PROJECT ID	*COST*	*BENEFIT*	*DESCENDING BCR*	*CUMULATIVE COST*	*CUMULATIVE BCR*
1	1 200 000,00 €	1 500 000,00 €	1,25	1 200 000,00 €	1,25
2	900 000,00 €	1 215 000,00 €	1,35	2 100 000,00 €	1,83
3	150 000,00 €	168 000,00 €	1,12	2 250 000,00 €	1,90
4	60 000,00 €	99 000,00 €	1,65	2 310 000,00 €	1,95
5	2 400 000,00 €	2 544 000,00 €	1,06	4 710 000,00 €	2,49
6	780 000,00 €	959 400,00 €	1,23	5 490 000,00 €	2,66
7	436 000,00 €	475 240,00 €	1,09	5 926 000,00 €	2,74
8	345 700,00 €	349 157,00 €	1,01	6 271 700,00 €	2,80

Table 5. Project ranking table

Steps for developing Project Ranking Table include:

- Estimate the cost and the NPV for each competing project
- Compute the BCR of each project
- Rank the projects starting from the highest BCR to the lowest
- Add the BCRs cumulatively, one project at the time, from the top to the bottom of the list.
- Similarly, add the cost of the projects cumulatively. Each cumulative cost represents the corresponding total cost of the component projects of the mix.

The projects can be ranked starting with the highest scoring one being the most appealing for investment after an aggregate score is obtained for each competing project reflecting their individual merit.

6 Managerial Implications

For the Case Company to be able to implement the measures presented in this study in its daily management, this chapter will present useful methods of operation and tools, that can be easily applied as part of clarifying the company's strategy process and daily management.

Better understanding of changing client requirements, better quality and delivery, less waste, lower costs, the development of resilient processes, improvement of competitive position, and sustainable competitive advantage are just a few of the advantages that these approaches and tools can provide for the Case Company.

6.1 Value Creation

To conceptualize the process of value creation, there are at least two different approaches: a single, universal conceptualization and a contingency perspective, which explains how value is created from the vantage point or perspective of a specific source. (Lepak, Smith, Taylor, 2007)

When an organization generates value, issues with innovation, knowledge creation, invention, and management typically take center stage. When businesses innovate and introduce new products or services, new management practices related to the products or services, or new ways of doing things using new methods, technologies, or forms of raw material, they create value. Strategic HRM research, which has shown that use of high investment develops employee skills, enhances the motivation to work toward organizational objectives, and provides the discretion needed to swiftly take appropriate actions to achieve organizational goals, is pertinent to the organization as a source of value creation. Organizations create value by focusing on how firms can create new advantages as existing ones are worn away by environmental changes. (Lepak, Smith, Taylor, 2007)

There has been a lot of research for different ways withing organizations to better understand; how value is really captured. The concepts of value chain and value chain analysis directly focus the ways; how companies can configure their primary and support activities to maximize and sustain competitive advantages. (Lepak, Smith, Taylor, 2007)

Company resources provide an isolating mechanisms and limit competition in cases, where they are rare, inimitable, no substitutable, and valuable. If profits from a creative innovation are great enough, competitors will find a way to replicate the innovation by destruction. Such replication may occur by stealing away key employees, preempting key resources, reverse engineering, or leapfrogging technology. (Lepak, Smith, Taylor, 2007)

Resource management is an important mechanism for capturing value after it has been created. They specifically recommend that businesses structure their resource portfolio, and resources to develop capabilities, and use capabilities to seize market opportunities. They can do this while also creating and utilizing value for both customers and owners. (Lepak, Smith, Taylor, 2007)

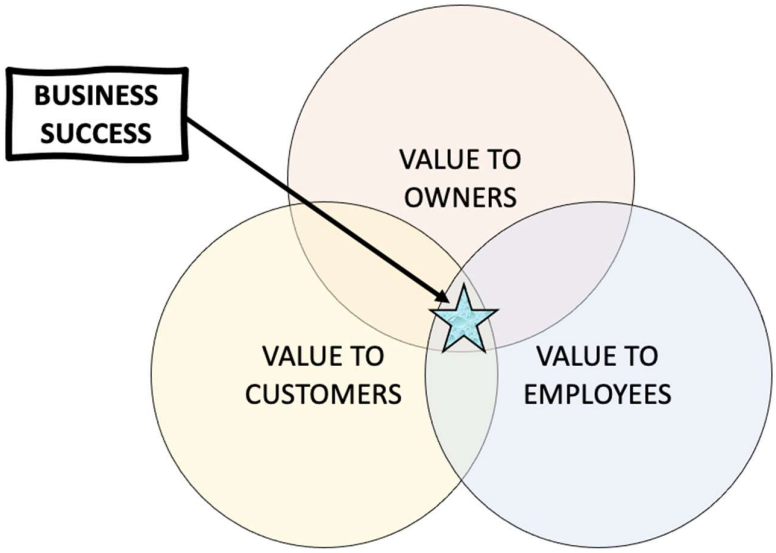


Figure 24. Value Creation for Business Success (Lepak, Smith, Taylor, 2007)

6.1.1 Monte Carlo Simulation

The probability of various outcomes in a process that cannot be easily predicted due to the interference of random variables is modelled using a Monte Carlo simulation. It is a method for comprehending the effects of risk and uncertainty in many disciplines, including finance, business, physics, and engineering. a Monte Carlo simulation is used to solve a variety of issues; a simulation with multiple probabilities is another name for it. (Kenton, 2022)

The financial projections for a project (cost, benefit, NPV, etc.) are deterministic. They represent a deterministic "base case" scenario in which one set of input variables is used to produce one value for the output variable. Each input carries its own uncertainty and has a different probability distribution that it can change with. With the help of the Monte Carlo Simulation, you can consider every possible value for each input variable and calculate an estimate of the probability distribution of the output variable. For instance, using this method to calculate NPV will require simulating thousands of potential project scenarios, computing the NPV for each scenario using the DCF method, and then examining the probability distribution of the NPV results. (Lepak, Smith, Taylor, 2007)

The Monte Carlo Simulation acknowledges a problem with all simulation techniques: random variable interference makes it difficult to pinpoint the probability of different outcomes. An emphasis in a Monte Carlo simulation is therefore placed on repeatedly repeating random samples. In a Monte Carlo simulation, the unknown variable is assigned a random value. After the model has run, a conclusion is provided. This method is repeatedly performed while a variety of values are assigned to the variable in question. After the simulation is complete, the data are averaged to create an estimate. (Kenton, 2022)

Although financial applications of the Monte Carlo simulation may be its most well-known use, this technique is used in almost every field, where assessing risks and preparing for them is required. (Kenton, 2022)

A Case Company might for instance, develop its network to support all its projects continuously. It must consider all potential future changes in the service's demand. To accomplish that, it must decide if the Project Portfolio can withstand the pressure of peak times and seasons. The Case Company may use a Monte Carlo Simulation to determine whether its system will be able to withstand the stress of the summer season and an average Monday in December.

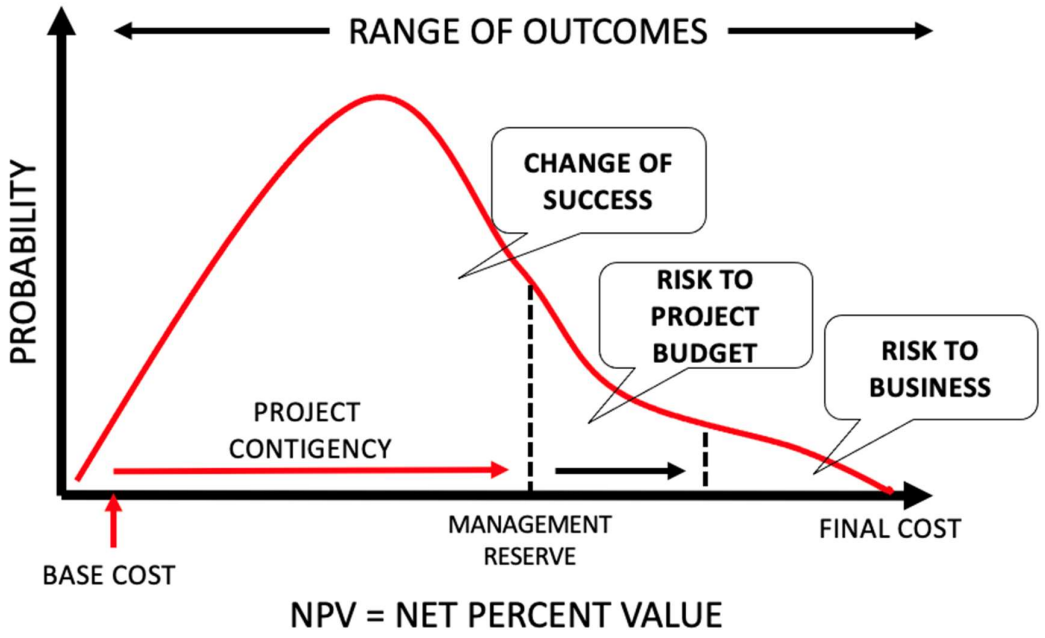


Figure 25. Monte Carlo Simulation Based Probabilistic Analysis (Kenton, 2022) (Kodukula and Papudesu, 2006)

6.1.2 Critical Success Factors

A Critical Success Factor is anything that must be achieved for a project, business, or organization to succeed. Critical success criteria can be used by a team or organization to decide where to concentrate their efforts and track their progress toward their goals. (Yarbrough, 2021)

Deliverables are another name for these objectives. The Critical Success Factors for each deliverable will vary, and these factors together will determine whether the effort is a success or a failure. A Critical Success Factor is therefore required to achieve a deliverable if that is the goal. A Critical Success Factor is therefore necessary to accomplish a deliverable if that is the goal. Critical success factors are not success metrics, but rather how a company can succeed. These systems are constantly running in the "background" of tasks and activities. (Yarbrough, 2021)

The only way to stay on top of whatever the deliverables require is to define and monitor them. It is simple to get bogged down in the details when a project or organization only knows the end goal and not how to get there. The only way to know exactly what is required to complete all deliverables

is to identify the Critical Success Factors, because deliverables are merely speculative without this information. (Yarbrough, 2021)

Together with the company's management, we defined five Critical Success Factors for the company's projects, which are organized as follows:

1. Open and effective communication
2. Clear and precise briefing documents
3. Clear project goals and objectives
4. Sufficient consultation with project stakeholders
5. Optimized use of recourses

6.1.3 Earned Value Management

A project's current cost and schedule status can be objectively evaluated, and future performance can be predicted by using the Project Performance Monitoring, and controlling technique known as Earned Value Management. It aids in the quantification of deviations from the plan in terms of costs and schedule. It is a quantitative tool for comparing the health of various projects at the portfolio level using the same metrics. Additionally, it offers you an unbiased evaluation of the portfolio's overall cost performance. EVM provides the objectivity that the Project Portfolio Management process requires to improve the reasoning behind go/no-go decisions. (Lepak, Smith, Taylor, 2007) Primary data points by EVM -analysis include following primary and derived data elements. Each data point value is based on the time or date an EVM measure is performed on project. (Defense Acquisition University, 2009)

This research used EVM-analysis to map a certain project performance for the Case Company. Based on the analysis, a forecast was created for the realization of the project, both in terms of schedule and costs.

Budget at Completion (BAC)

$$BAC) = \ Total\ cost\ of\ the\ project$$

Formula 10. Budget at Completion (Reichel, C. W. 2006)

Planned Value (PV)

$$PV = BAC * \%\ of\ planned\ work.$$

Formula 11. Planned Value (Reichel, C. W. 2006)

Budgeted Cost for Work Scheduled (BCWS)

$$BCWS = BAC\ /\ PV$$

Formula 12. Budgeted Cost for Work Scheduled (Reichel, C. W. 2006)

Earned Value (EV)

$$EV = BAC * \%\ of\ Actual\ work$$

Formula 13. Earned Value (Reichel, C. W. 2006)

Budgeted Cost for Work Performed (BCWP)

$$BCWP = BAC\ /\ Earned\ Value\ (EV)$$

Formula 14. Budgeted Cost for Work Performed (Reichel, C. W. 2006)

Actual Cost of Work Performed (ACWP)

$$Actual\ Cost\ of\ Work\ Performed\ (ACWP)\ /\ Actual\ Cost\ (AC)$$

Formula 15. Actual Cost of Work Performed (Reichel, C. W. 2006)

Cost Variances (CV)

$$CV = EV - AC$$

Formula 16. Cost Variances (Reichel, C. W. 2006)

Schedule Variances (SV)

$$SV = EV - PV$$

Formula 17. Schedule Variances (Reichel, C. W. 2006)

Variance at Completion (VAC)

$$VAC = BAC - EAC$$

Formula 18. Variance At Completion (Reichel, C. W. 2006)

Cost Performance Index (CPI)

$$CPI = EV/AC$$

Formula 19. Cost Performance Index (Reichel, C. W. 2006)

Schedule Performance Index (SPI)

$$SPI = EV/PV$$

Formula 20. Schedule Performance Index (Reichel, C. W. 2006)

Estimate Cost of Completion (EAC)

$$EAC = BAC \ / \ CPI$$

Formula 21. Estimate Cost of Completion (Reichel, C. W. 2006)

Estimate Time of Completion (ETC)

$$ETC = (BAC - EV)/CPI$$

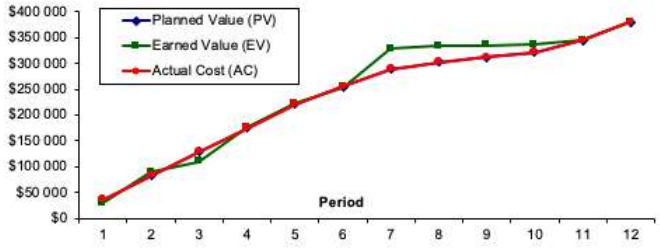
Formula 22. Estimate Time of Completion (Reichel, C. W. 2006)

Earned Value Analysis Report

Prepared By: _____
Date: _____

For Period: _____

Summary:



Planned Value (PV) or Budgeted Cost of Work Scheduled (BCWS)

WBS	Task Name	TBC	1	2	3	4	5	6	7	8	9	10	11	12
1,1	Pipe trench	50000	10000	10000	10000	10000	10000							
1,2	Grate structures	10000	2000	2000	2000	2000	2000							
1,3	Installation of pipelines	140000	20000	20000	20000	20000	20000	20000	20000					
1,4	Fillin the pipe trench	40000	5000	5000	5000	5000	5000	5000	5000	5000				
1,5	Road structural layers	90000		9000	9000	9000	9000	9000	9000	9000	9000	9000	9000	
1,6	Asphalt	50000											15000	35000
		0												
		0												
		0												
		0												
		0												
		0												
Insert new rows above this one														
	Total Budgeted Cost	**380000**	37000	46000	46000	46000	46000	34000	34000	14000	9000	9000	24000	35000
	Cumulative Planned Value (PV)		37000	83000	129000	175000	221000	255000	289000	303000	312000	321000	345000	380000

Actual Cost and Earned Value

Cumulative Actual Cost (AC)	37000	83000	129000	175000	221000	255000	289000	303000	312000	321000	345000	380000
Cumulative Earned Value (EV)	30000	90000	110000	176000	222000	253500	328500	334000	335000	336000	344000	380000

Project Performance Metrics

Cost Variance (CV = EV - AC)	-7000	7000	-19000	1000	1000	-1500	39500	31000	23000	15000	-1000	0
Schedule Variance (SV = EV - PV)	-7000	7000	-19000	1000	1000	-1500	39500	31000	23000	15000	-1000	0
Cost Performance Index (CPI = EV/AC)	0,81	1,08	0,85	1,01	1,00	0,99	1,14	1,10	1,07	1,05	1,00	1,00
Schedule Performance Index (SPI = EV/PV)	0,81	1,08	0,85	1,01	1,00	0,99	1,14	1,10	1,07	1,05	1,00	1,00
Estimated Cost at Completion (EAC)	468667	350444	445636	377841	378288	382249	334307	344731	353910	363036	381105	380000

Table 6. Example EVM -analysis provided for the Case Company

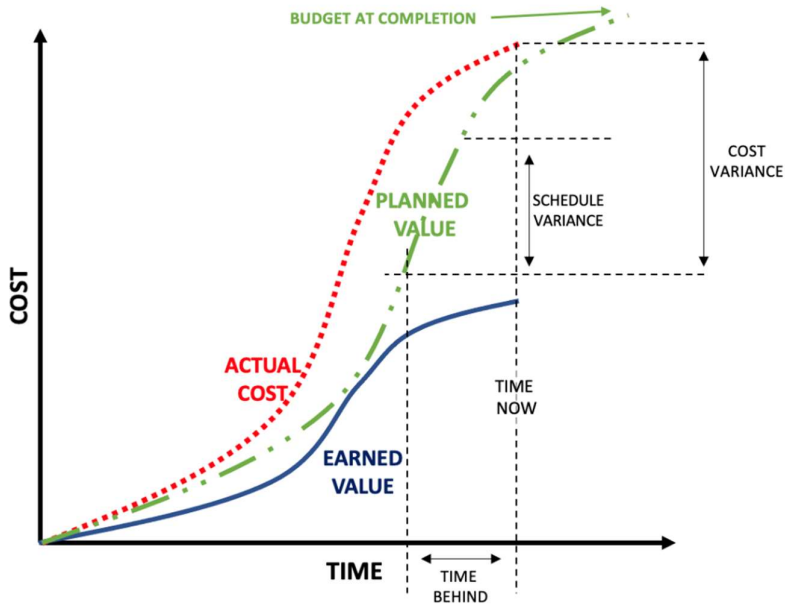


Figure 26. Earned Value Method (EVM) (Ruiz, 2019)

6.1.4 Data Visualization -tools

These tools are designed to communicate complex information effectively and concisely in a visually appealing way. They can particularly assist in synthesizing vast amounts of data and expressing them in a clear and understandable manner. The capabilities of some extremely sophisticated visualization tools are very impressive, but you should focus more on the purpose than the aesthetics of these tools.

6.1.4.1 Scorecards

A scorecard's main function is to present a process, system, or organization's Key Performance Indicators. A PPM scorecard displays the performance of the portfolio and its individual projects. Based on the project's past performance, you may determine if it is on track to achieve expectations. A spreadsheet is frequently used to display a scorecard. By using a small number of cells and only including high-level data, the spreadsheet may be kept straightforward.

PROJECT METRICS													
	Performance										Future Performance Forecast		
	TIMELINE			Number of Team Members	Critical Path Status			Schedule Variance (SV)	Cost Variance (CV)	% Contingencies Used	Estimate to Complete (ETC)	Variance At Completion (VAC)	Estimate At Completion (EAC)
Project ID	START	FINISH	# of DAYS		On Track	Ahead	Behind						
Project 1													
Project 2													
Project 3													
Project 4													

Table 7. Portfolio scorecard – Project Metrics

BUSINESS CASE STATUS									
Project ID	Alignment Score		Financials						
			NPV	ROI	Paypack Period	Non-Financial Value Score	Threat Score	Opportunity Score	Overall Score
Project 1									
Project 2									
Project 3									
Project 4									

Table 8. Portfolio scorecard – Business Case Status

6.1.4.2 Dashboards

Dashboards are graphs or spreadsheets that display the state of organizations, systems, or processes. Most of them use red, amber, and green symbols to indicate the status. Dashboards frequently aid in decision-making by containing high-level data for senior and executive management review. They

use straightforward, simple-to-understand, and visually appealing graphics to display the majority of the important high-level performance indicators. They have evolved into typical management tools in recent years due to their ease of use. (Calzon, 2021)

PROJECT STATUS									
PROJECT ID	STATUS			MAJOR ISSUES	MAJOR RISKS	PROGRESS			
	RED	AMBER	GREEN			0-25 %	26-50 %	51-75%	COMPLETED
PROJECT 1									
PROJECT 2									
PROJECT 3									
PROJECT 4									

Table 9. Portfolio Dashboard – Project Status

PORTFOLIO STATUS									
STATUS									
RED	AMBER	GREEN	Schedule Performance Index (SPI)	Cost Performance Index (CPI)	BUDGET AVAILABLE	BUDGET REQUIRED	MAJOR ISSUES	MAJOR RISKS	TASKS

Table 10. Portfolio Dashboard – Portfolio Status (Kodukula, 2014)

6.1.4.3 Radar Charts

Radar charts, also known as spider charts, are visual and simple tools that show ratings for different project characteristics. The chart displays the project's strong and weak points. (Kodukula, 2014)

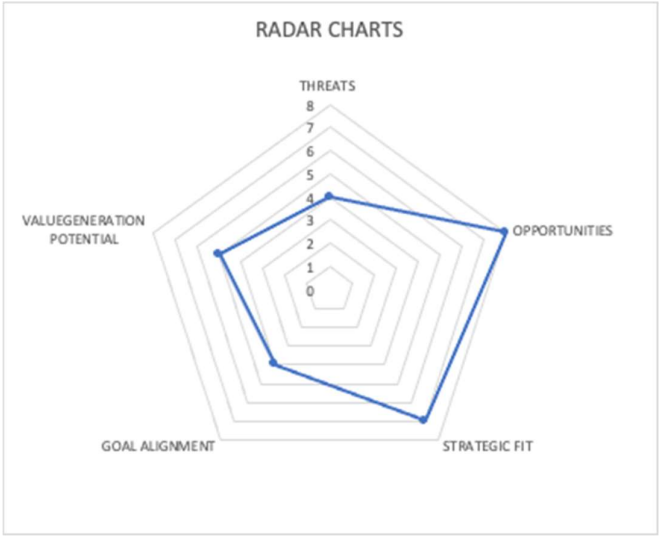


Figure 27. Radar charts

6.1.4.4 Bubble Diagrams

The ability to quickly display the balance of the current portfolio is one of the main advantages of a portfolio bubble chart. With the help of portfolio bubble charts, the portfolio governance team can better focus discussions to manage the portfolio. The portfolio governance team should consider adding more of the higher-value, lower-risk projects to the portfolio when evaluating projects that fall into these categories. The portfolio governance team should inquire as to how to steer clear of lower-value/higher-risk projects too. The portfolio governance team will be able to "manage the tail" and make sure that only the best projects are chosen and carried out thanks to these discussions, which will significantly improve the management of the portfolio. (Washington, 2016)

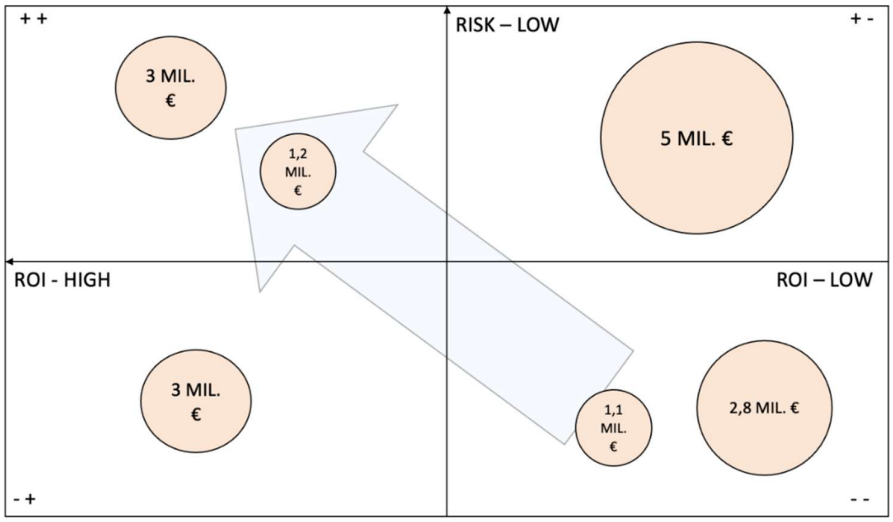


Figure 28. Portfolio Bubble Chart (Washington, 2016)

6.1.5 Resource Planning

The foundations of Portfolio Management can be found in capital Project Portfolios, which include significant investments, that are frequently made in equipment and materials. Examples of projects include constructing a necessary street and setting up an entirely new municipal technology network. Most of the project work is typically outsourced. In comparison to contractor and equipment costs, internal human resource requirements are relatively low, only 20-30 %. (Case Company) Once completed, the projects should produce income with a respectable Return on Investment and Payback Period. With the appropriate financial tools, PPM can be used to assess and rank capital project investments. (Pennypacker, 2008)

Projects requiring management resources have increased, because of the technological revolution and increased competition. The demand for effective resource allocation has increased due to the rise in matrix organizations and cross-functional projects, where resources are shared across functions. Once more, PPM proves to be the appropriate mechanism. It can do the same with human resources just as it can with the efficient allocation of investment funds to the appropriate projects. (Pennypacker, 2008) The PPM's main focus in terms of resource planning is making sure that the right competent people are accessible for all of the projects in the portfolio at the right time. By preventing or eliminating resource over- or under-allocation for extended periods of time, it also aims to maximize resource usage. (Pennypacker, 2008)

A resource may occasionally be overallocated due to a project's or other support work's excessive demands, or under allocated due to a lack of work. The "resource loading factor," which is a measure of the level of allocation, is the proportion of the time required for a given resource to complete his or her assigned on-project and non-project activities to the time available for that resource to complete those activities. This is essentially equivalent to the demand to supply ratio. Low factors indicate under allocation of resources, while high factors indicate overallocation. The former can result in burnout and a person losing motivation. (Kodukula, 2014)

Project	Project Managers				Architects				Design Engineers				Developers				Others			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Project 1																				
Project 2																				
Project 3																				
Project 4																				
Total Project Demand																				
Total Resource Supply																				
Demand / Supply																				

Table 11. Recourse Requirements Plan

Resource Name	Resource Skills						
	Infrastructure Construction	Telecom and Electrical Work	Crushing	Demolition	Bridge Works	Maintenance	Special Skills
Resource 1							
Resource 2							
Resource 3							

Table 12. Recourse skills matrix

Resource Loading Chart is a tool for resource planning and management. A resource loading chart's objective is to help comprehend the overall burden of a particular resource. It lists every project to

which a person is assigned as well as how much effort (measured in FTEs) they are expected to put into each project as well as non-project activities. Because it comprises long-term preliminary estimations, the time given for vacation, training, and other similar activities is often not defined. The tool implies that the resource has been utilized for a long time and that schedule overruns for his or her projects are likely, barring essential adjustments. The near-term resource loadings can be included in the resource management plan, as shown in tables, through iterative updates of the long-term plans. (Kodukula, 2014)

	Q1	Q2	Q3	Q4	TOTAL
Non-Project Work	0,2	0,3	0,8	0,1	**1,4**
Project 1	0,1			0,2	**0,3**
Project 2	0,5	0,4	0,5		**1,4**
Project 3		0,2	0,2		**0,4**
Project 4				0,8	**0,8**
Resource Loading Factor	0,8	0,9	1,5	1,1	**4,3**

Table 13. Resource loading chart

6.2 DMAIC

As part of the clarification process of the Case Company Project Portfolio, a lightweight DMAIC analysis of the company's typical construction projects and their problems / opportunities were carried out. The results made it very clear to the company; where the critical factors of the processes are and how to invest in their implementation.

Based on the interviews, I noticed that one of the biggest critical factors is the management of materials between different work sites. This causes delays in production, resulting in extensive overtime for workers. Employees are also unable to work with optimal efficiency during their working day, as a large part of normal working time is spent waiting or stopping the work to rush to get the materials. When the project schedule is tight, the workers must work in a rush when the materials arrive, which results in quality problems of the construction products. Quality problems cause complaints, resulting in repair costs during the warranty period.

In infrastructure construction, the same construction products are typically used in different locations, which are always tendered on a project-by-project basis. Building materials are also often

bought in bulk to make the price more affordable, which causes, that they are also delivered in bulk to save on transportation costs. However, I think this is a misconception. When materials are stored at other sites, it is more expensive to think of ways to meet demand to other sites, when the products could have already been driven directly from the wholesaler to the right site. For some objects, the storage area is not large enough, for example when working in a downtown environment, where there is also a greater risk of vandalism. Construction materials are stored at existing sites so that the company does not have to use its own resources for storage.

6.2.1 Define

Construction work and materials were both identified as critical factors during the definition phase of the project execution. Improvements can be made to both crucial aspects of materials, material quality, and delivery timeliness through the procurement process. When material is on site at the right time, subcontractors will not charge for idle time, waste in useless material is reduced, and capital is only committed, when necessary, which also affects cost effectiveness, being very crucial on industry, because the implementation of construction projects is very capital-related, and the company's cash management is currently poor.

Project planning starts with creating process description using GANTT -charts, which represents projects general schedule. As the project progresses, site management creates and updates weekly schedule for next two weeks to make production more manageable. Weekly schedule consists information of the inputs required for each stage of work, the variables related to the stage and the outputs of each stage. The process variables and outputs are very much the same at each stage, but differences were also observed.

6.2.2 Measure

Finding the problematic process's outputs, inputs, and process variables is the goal of the measure -phase. The project bidding, construction work, materials, and subcontractors are the operations, that will be evaluated. The measure -phase’s goal is to demonstrate the process's current performance state, which establishes a foundation for future work.

The project's bid calculation is performed by the company's Business Manager. During the tendering calculations, the willingness of potential subcontractors to participate in the execution of the project is identified, by requesting tenders from potential subcontractors for different aspects of the project. In addition, there is an active discussion with material suppliers about possible cooperation patterns for the project.

Tendering phase also identifies the company's own resources for carrying out the project. Infrastructure projects are often put out to public tender, which inevitably means, that the lowest price wins the contract. Therefore, many different alternative implementations need to be modeled in bid calculation, how to produce more with less, when the margin is reduced to a minimum.

6.2.3 Analyze

The analyze -phase is the third step. Finding any patterns for the Improve phase is the goal of this phase. The Measure phase's findings are examined in the Analyze phase, where the project's problem areas that need to be developed are highlighted.

The pace of work is measured by site management. Data collected is used as reference in bid calculation for new projects. Question, which collected data is trying to answer is “How long this kind of work will take under these conditions?” This is very valuable data in project bidding phase, which gives contractor an advantage over competitors to make more accurate calculation over the project.

When looking at the fishbone diagram from the different perspectives, the following observations can be made. In terms of materials, capital is unnecessarily tied up in materials in interim storage. Excessive storage exposes materials to the environment, such as weather and external threats, theft, and damage. Locating the necessary materials in a large storage area can be challenging and parts may be lost. As an environment, an undeveloped sparsely populated area offers opportunities. Currently, the environment may cause contamination of materials during storage.

In addition to monitoring the process, the goal of the management is to monitor and develop the project, in terms of equipment, the challenge comes from different suppliers and third-party deliveries. The constant movement of materials from site to site exposes the materials to breakage, also

being a high-cost procedure. A large storage capacity with long storage times and continuous internal movement of materials has been observed as a way of working. People are used to current business models and wasted time arises from the expectations of the goods. Materials management is challenging due to incorrect deliveries as well as delays within the site.

6.2.4 Improve

With the knowledge gained during the analyze phase, the Six Sigma project aims to eliminate the identified defects in this phase. Defects are eliminated, the sigma level is raised, and performance is improved as a result of eliminating the root causes of issues and changing crucial factors that lead to deviation from target CTQs and goals.

For the case company, the goal of the improve -phase is to create a system, where construction supplies don't require storage or inventory within construction projects. Additionally, it should be noted that the Case Company specializes more in the project management portion of project execution, so subcontractors are also found using procurement resources. Utilizing subcontractors to complete a project entails risks in terms of hourly billing, project progress, and duration.

Prior to the benchmark, internal logistics, and how it could be implemented in the target company were selected for consideration. Prior to the benchmarking, the interviewees were divided into groups to consider possible solutions to the problems already identified. The blue-collar employees working on the project know the construction processes best, because they are interacting with it daily on a practical level. It is therefore important to listen to their thoughts as part of the development work.

To improve the entire construction project, effective coordination of the various processes and activities is needed, as well as how they interact. However, despite the fact that the Six Sigma principles place a strong emphasis on cooperation and teamwork, it is crucial to inspire the team members to take responsibility for their own work and pursue their own individual objectives in relation to their tasks in addition to cooperating and making an effort to achieve the project's overall success. Material procurement can made simpler with benchmarking. New approaches, the progress model, and

practicing 5S could be one solution for creating various tools to support supply chain management, specifically at the site it will have a great effect on project efficiency.

6.2.5 Control

The control phase oversees ensuring the development and sustainability of the improvements attained through the application of Six Sigma principles. The following benefits and opportunities for the Six Sigma project are made possible by the requirement to continuously collect data throughout the project and assess performance.

The project management should make use of a monitoring tool; that allows comparisons between a project's progress, the material orders, and the estimated shelf life of materials. Failures in the delivery of the materials and the estimated waiting period should be recorded by the monitoring tool as well. Real-time monitoring should be mandated, so that errors can be corrected right away. If shortcomings are discovered, the employee should be able to report them via phone application, allowing management to take note of the issue. The report verifies, whether the product had been ordered, as well as its current location and expected arrival date.

To identify and minimize the occurrence of a similar issue in the future, the supplier should be required to conduct a root cause analysis. The necessary plan corrections must be made to the project plan when the issue surfaces. Existing staff must be trained to use the new operating model. Trainings should be conducted in stages during the control phase to implement change, coordinate employee behavior with management's strategy, and conduct a group review of the new strategy, that company is developing among this project.

When the supplier is delivering the materials, where the site is progressing, and the material need should be estimated in the model. Storage will be reduced thanks to tools and improvements made to the procuring process and material management. By implementing research results, the contractor is aware of impending deliveries while the project manager saves time with the automated ordering process, that estimates material need. Defects and waiting times are recorded in future system for improvements and supplier quality improvements; this data can be used to analyze the supplier if site work starts to run behind the schedule.

6.2.6 Analysis

An analysis was built based on the DMAIC analysis; what kind of impact the development program would have on the company's business, in different business areas. The analysis examined costs caused by complaints due to poor quality and overtime costs.

	Infrastructure Construction	Telecommunication	Foundation Work	Maintenance	
Projects turn over	1 800 000,00 €	850 000,00 €	1 200 000,00 €	1 150 000,00 €	5 000 000,00 €
Site reject rate atm (4 %)	80 820,00 €	30 430,00 €	62 400,00 €	31 510,00 €	205 160,00 €
Customer reject rate atm (4,73 %)	104 760,00 €	35 955,00 €	30 720,00 €	72 335,00 €	243 770,00 €
Site reject rate goal atm (3 %)	54 000,00 €	25 500,00 €	36 000,00 €	33 000,00 €	200 125,00 €
Customer reject rate goal atm (2 %)	36 000,00 €	17 000,00 €	24 000,00 €	22 000,00 €	236 250,00 €

Scernario where there is no overtime work, and reject rates are good

	Infrastructure Construction	Telecommunication	Foundation Work	Maintenance	Total
Projects turn over	1 800 000,00 €	850 000,00 €	1 200 000,00 €	1 150 000,00 €	**5 000 000,00 €**
Total material cost	988 325,05 €	404 054,53 €	459 496,26 €	768 284,17 €	**2 620 160,00 €**
Total Labour, regular	301 699,23 €	172 317,37 €	296 119,81 €	106 096,38 €	**876 232,79 €**
Total Labour, overtime	603 398,45 €	344 634,74 €	592 239,62 €	212 192,77 €	**1 752 465,58 €**
Total Other variable cost	208 276,50 €	101 310,73 €	148 264,13 €	119 523,07 €	**577 374,42 €**
TOTAL PROFIT	**- 301 699,23 €**	**- 172 317,37 €**	**- 296 119,81 €**	**- 56 096,38 €**	**- 826 232,79 €**
On-site reject cost	80 820,00 €	30 430,00 €	62 400,00 €	31 510,00 €	**205 160,00 €**
Customer reject cost	104 760,00 €	35 955,00 €	30 720,00 €	72 335,00 €	**243 770,00 €**
TOTAL REJECT COST	185 580,00 €	66 385,00 €	93 120,00 €	103 845,00 €	**448 930,00 €**
TOTAL PROFIT AFTER REJECT	**- 487 279,23 €**	**- 238 702,37 €**	**- 389 239,81 €**	**- 159 941,38 €**	**- 1 275 162,79 €**
On-site reject rate 2 %	36 000,00 €	17 000,00 €	24 000,00 €	23 000,00 €	**100 000,00 €**
Customer reject rate 0,5 %	9 000,00 €	4 250,00 €	6 000,00 €	5 750,00 €	**25 000,00 €**
BETTER REJECT COST	45 000,00 €	21 250,00 €	30 000,00 €	28 750,00 €	**125 000,00 €**
REJECT COST PROFIT	230 580,00 €	87 635,00 €	123 120,00 €	132 595,00 €	**573 930,00 €**
TOTAL PROFIT AFTER IMPROVEMENT	**- 71 119,23 €**	**- 259 952,37 €**	**- 419 239,81 €**	**- 188 691,38 €**	**- 939 002,79 €**
TOTAL PROFIT WITHOUT OVERTIME	**532 279,23 €**	**84 682,37 €**	**172 999,81 €**	**23 501,38 €**	**813 462,79 €**

Table 14. Analysis of rework and overtime cost

Currently, 4,3 % of all production is rejected, by poor quality as total reject cost is 448.930,00 €. Target of a total defective rates is decided to 2 %, and customer reject target is determined to 0,5 %. If these targets are made, would reject cost shrink to 125.000,00 €, creating 575.930,00 € more profit for the company. By shrinking reject cost, would business still be unprofitable by – 939.002,79 €, which is mostly caused by labor overtime work. If the company can improve its production, e.g., with material efficiency, overtime can possibly even be completely waived. As a result, the profit made by the company would be 813.462,79 €.

As a by-product of the analysis, the company's largest customers were divided into business areas for review. This showed that problems have arisen in cooperation with some customers, due to poor quality. This complicates the company's prospects when customer relations are poor.

Customer	Infrastructure Construction	Telecommunication	Foundation Work	Maintenance	Customer satisfaction level	Grade
Customer 1	630 000,00 €			805 000,00 €	Low	1
Customer 2		425 000,00 €			Moderate	3
Customer 3	270 000,00 €		400 000,00 €		Moderate	3
Customer 4	360 000,00 €		400 000,00 €		Moderate	3
Customer 5		425 000,00 €	200 000,00 €		Low	1
Customer 6	540 000,00 €			345 000,00 €	Sufficient	2
Customer 7			200 000,00 €		Low	1
TOTAL	1 800 000,00 €	850 000,00 €	1 200 000,00 €	1 150 000,00 €	->	2 / 5

Table 15. Customer satisfaction analysis per business area

7 Conclusion

The goal of the research was to create a standardized system for creating a Project Portfolio for a construction company engaged in infrastructure construction, while considering the efficiency of production; by investigating the utilization of Lean Six Sigma principles and methods in construction processes.

Research Questions	Research Results
What is Lean Six Sigma, and how it can be implemented in Project Management of Construction Projects?	Lean Six Sigma was originally created for the manufacturing industry, but it can be used for any process and has been successfully implemented in a variety of industries, including the construction industry. The construction industry, which is a major source of waste in terms of both time and material, is frequently referred to as the last major unreformed industry. Lean Six Sigma and lean construction employ technologies to streamline the building process, reduce wasteful labor, and generally improve the construction process in terms of money and quality.
What is Project Portfolio Management, and why it is so important to have Project Portfolio Management, especially in Construction Industry?	It is impossible to emphasize the importance of developing strong project management in the construction business, which is one of the most capital-intensive industries. In the construction industry, especially in infrastructure construction, companies often have several business areas, the synergy benefits between them can produce a considerable competitive advantage for the company. By utilizing PPM, the company is also able to understand the profitability of its projects, which reduces project-specific risk.
What problems is the Case Company facing at the moment, what problems causes, and how can we generate solutions for these problems?	In the future, Case Company should clarify its strategy and align; where it aims to develop its business in the future. In the future, bid calculations must be based on facts and collected data from the company's production processes.
What tools can the Case Company use for better future?	Practical tools for the company to use are listed in chapter 6 of this study. These tools include: Value Creation Analysis, Monte Carlo Simulation, Critical Success Factors, Earned Value Management, Data Vizualization, Recource Planning, and DMAIC -analysis.

Table 16. Research Questions and Results

To reduce the amount of ineffective work and create a Project Portfolio, that includes projects that are more profitable for the business than they cost. The Case Company should formalize the gates for the new Project Portfolio Management -process. By formalizing the gates, we mean informing the managers of their responsibilities as gatekeepers, in charge of outlining the criteria by which projects should be assessed, and facilitating, as a result, the quick assessment and commercialization of the projects. To keep track of how the process is being carried out, the management

team should concentrate on defining the right Key Performance Indicators. The turnover and profit, that the project has generated are the only two KPIs that the Case Company has used thus far.

The process of defining KPIs should be thought of, and the metrics list should be updated until the company is able to identify a set of appropriate KPIs that adequately reflect management requirements. The parties involved should be informed and receive a clear definition of a KPI.

Based on the EVM analysis, the company has great potential to create cost savings for itself, just by optimizing the use of its own resources; by optimizing material flows, a company can create significant savings in the long run. In the past, the company's personnel have worked a lot of overtime to be able to meet the tight schedules of the construction projects. It is profitable for the company to react to this by recruiting new staff for itself, which creates considerable cost savings, when a large part of the work does not have to pay employees double wages.

Additionally, the Case Company should consider implementing a post-execution review of the new projects. Each project should be assessed considering its intended goals after completion, with the managers by analyzing variations in the budget or cycle time, and then, take appropriate action to prevent similar errors from occurring in future projects.

Another component entails organizing weekly meetings for communication and information sessions, during which the process's goal and the roles of its various stakeholders are explained as well as the results and expected outcomes.

The Case Company should give the foundation for project evaluation some thought before moving on to the Portfolio Management process. The PMI standard's list of project classifications would be a good place to begin. A common set of ranking criteria for each category could then be thought of by the company. Afterwards, consider developing standards for grading projects according to each category and evaluating them. The criteria should place a strong emphasis on the financial, risk, and strategic alignment considerations that are currently being used by the business but have not yet been institutionalized. Investigating the process maturity models might be

another path for improvement. Understanding the maturity of a company's processes will undoubtedly aid in determining the efforts required to advance to higher levels.

Based on the discussions with the company's management, we agreed, that this study will serve as a comprehensive and comprehensive guide for the company's management for the management of future business operations. In this study, a position has been taken on both practical contracting, the typical problems of the field, and good methods and tools for overcoming them have been brought from the literature of the field.

Due to time constraints and privacy concerns, the analytical analysis in this research is only applicable to one Case Company. The adoption of Project Portfolio Management and Lean Six Sigma principles in the construction industry can be better understood with the participation of more responders. Future research should therefore be concentrated on increasing the sample size to enhance the generalizability of the results. Also, the data used in this research is also quickly becoming out-of-date because micro- and macroeconomics are always changing, which will cause the cost structures to rapid changes.

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Appendices

Appendix 1. Example DMAIC-analysis provided for the Case Company

Financial data, per product family 10403,42157 5941,978329 10211,02791 3658,496026

	Infrastructure Construction	Telecommunication	Foundation Work	Maintenance	
Sales price per hour (€)	173,02 €	143,05 €	117,52 €	300,67 €	
Material and equipment cost per hour (€)	95,00 €	68,00 €	45,00 €	210,00 €	
Labour cost per hour (€), regular	29,00 €	29,00 €	29,00 €	29,00 €	
Labour cost per hour (€), overtime	58,00 €	58,00 €	58,00 €	58,00 €	
Other variable costs per hour (€)	20,02 €	17,05 €	14,52 €	32,67 €	
Total turn over of projects	1 800 000,00 €	850 000,00 €	1 200 000,00 €	1 100 000,00 €	
Site reject rate	4,49 %	3,58 %	5,20 %	2,74 %	
Customer reject rate	5,82 %	4,23 %	2,56 %	6,29 %	Sum
Total sales for family (€)	1 800 000,00 €	850 000,00 €	1 200 000,00 €	1 150 000,00 €	5 000 000,00 €

	Infrastructure Construction	Telecommunication	Foundation Work	Maintenance	
Projects turn over	1 800 000,00 €	850 000,00 €	1 200 000,00 €	1 150 000,00 €	5 000 000,00 €
Site reject rate atm (4 %)	80 820,00 €	30 430,00 €	62 400,00 €	31 510,00 €	205 160,00 €
Customer reject rate atm (4,73 %)	104 760,00 €	35 955,00 €	30 720,00 €	72 335,00 €	243 770,00 €
Site reject rate goal atm (3 %)	54 000,00 €	25 500,00 €	36 000,00 €	33 000,00 €	200 125,00 €
Customer reject rate goal atm (2 %)	36 000,00 €	17 000,00 €	24 000,00 €	22 000,00 €	236 250,00 €

Scernario where there is no overtime work, and reject rates are good

	Infrastructure Construction	Telecommunication	Foundation Work	Maintenance	Total
Projects turn over	1 800 000,00 €	850 000,00 €	1 200 000,00 €	1 150 000,00 €	**5 000 000,00 €**
Total material cost	988 325,05 €	404 054,53 €	459 496,26 €	768 284,17 €	**2 620 160,00 €**
Total Labour, regular	301 699,23 €	172 317,37 €	296 119,81 €	106 096,38 €	**876 232,79 €**
Total Labour, overtime	603 398,45 €	344 634,74 €	592 239,62 €	212 192,77 €	**1 752 465,58 €**
Total Other variable cost	208 276,50 €	101 310,73 €	148 264,13 €	119 523,07 €	**577 374,42 €**
TOTAL PROFIT	**- 301 699,23 €**	**- 172 317,37 €**	**- 296 119,81 €**	**- 56 096,38 €**	**- 826 232,79 €**
On-site reject cost	80 820,00 €	30 430,00 €	62 400,00 €	31 510,00 €	**205 160,00 €**
Customer reject cost	104 760,00 €	35 955,00 €	30 720,00 €	72 335,00 €	**243 770,00 €**
TOTAL REJECT COST	185 580,00 €	66 385,00 €	93 120,00 €	103 845,00 €	**448 930,00 €**
TOTAL PROFIT AFTER REJECT	**- 487 279,23 €**	**- 238 702,37 €**	**- 389 239,81 €**	**- 159 941,38 €**	**- 1 275 162,79 €**
On-site reject rate 2 %	36 000,00 €	17 000,00 €	24 000,00 €	23 000,00 €	**100 000,00 €**
Customer reject rate 0,5 %	9 000,00 €	4 250,00 €	6 000,00 €	5 750,00 €	**25 000,00 €**
BETTER REJECT COST	45 000,00 €	21 250,00 €	30 000,00 €	28 750,00 €	**125 000,00 €**
REJECT COST PROFIT	230 580,00 €	87 635,00 €	123 120,00 €	132 595,00 €	**573 930,00 €**
TOTAL PROFIT AFTER IMPROVEMENT	**- 71 119,23 €**	**- 259 952,37 €**	**- 419 239,81 €**	**- 188 691,38 €**	**- 939 002,79 €**
TOTAL PROFIT WITHOUT OVERTIME	**532 279,23 €**	**84 682,37 €**	**172 999,81 €**	**23 501,38 €**	**813 462,79 €**

Customer	Infrastructure Construction	Telecommunication	Foundation Work	Maintenance	Customer satisfaction level	Grade
Customer 1	630 000,00 €			805 000,00 €	Low	1
Customer 2		425 000,00 €			Moderate	3
Customer 3	270 000,00 €		400 000,00 €		Moderate	3
Customer 4	360 000,00 €		400 000,00 €		Moderate	3
Customer 5		425 000,00 €	200 000,00 €		Low	1
Customer 6	540 000,00 €			345 000,00 €	Sufficient	2
Customer 7			200 000,00 €		Low	1
TOTAL	1 800 000,00 €	850 000,00 €	1 200 000,00 €	1 150 000,00 €	->	2 / 5

Appendix 2. Cost breakdown of employee- and Machinery cost

EMPLOYEE	SALARY EXPENCES	FOOD BENEFIT	WORK VAN	TOTAL
Employee 1	34,00 €	1,41 €	4,41 €	39,81 €
Employee 2	29,00 €	1,41 €	4,41 €	34,81 €
Employee 3	31,56 €	1,41 €	4,41 €	37,37 €

	CAT M315F	Volvo EWR 130 EL	Volvo 145 FLCR	HITACHCI ZX85US-5A BL TELA vm. 2018	WILLE 655	VALTRA T234 VERSU
Writeoff				12,50 €	14,06 €	17,58 €
1. Leasing	24,00 €	15,33 €	17,50 €			
2. Interest				2,29 €	2,58 €	3,22 €
3. Storage	0,19 €	0,24 €	0,24 €	0,21 €	0,25 €	0,24 €
5. Insurance	0,12 €	0,49 €	0,49 €	0,51 €	0,51 €	0,48 €
5. Fuel	16,49 €	9,74 €	11,99 €	8,99 €	14,99 €	15,17 €
6. Lubricant	0,50 €	0,35 €	0,35 €	0,30 €	0,28 €	0,48 €
7. Maintenance	2,77 €	1,50 €	2,58 €	1,39 €	3,01 €	2,87 €
8. Salary cost	37,33 €	37,33 €	37,33 €	37,33 €	37,33 €	37,33 €
TOTAL	**81,40 €**	**64,99 €**	**70,48 €**	**63,54 €**	**73,01 €**	**77,37 €**
Equipment Cost	47,40 €	63,58 €	66,07 €	23,72 €	73,01 €	77,37 €

Diesel price / Litre	1,4987
Lubricant / kg	2,5