**UNIVERSITY OF VAASA**

**THE SCHOOL OF TECHNOLOGY AND INNOVATION**

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# IMPLEMENTING PROJECT PORTFOLIO MANAGEMENT MODEL TO SMALL AND MEDIUM SIZED PROJECTS IN A MULTINATIONAL COMPANY – A DYNAMIC APPROACH

Master's thesis in Technology for the degree of Master of Science in Technology submitted for inspection, Vaasa 04.07.2019

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# PREFACE

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# SYMBOLS AND ABBREVIATIONS

*Abbreviations*

| | |
|---|---|
| BSC | Balanced Scorecard |
| C | Checkpoint |
| CEO | Chief Executive Officer |
| CPM | Critical Path Method |
| CRM | Customer Relationship Management |
| CV | Cost Variance |
| DL | Deep Learning |
| DSS | Decision Support System |
| DTA | Decision Tree Analysis |
| EAC | Estimate at Completion |
| EBP | Etteplan Business Portal |
| EPP | Etteplan Project Portal |
| ERP | Enterprise Resource Planning |
| EV | Earned Value |
| EVM | Earned Value Management |
| FAT | Field Acceptance Test |
| G | Gate |
| HMI | Human Machine Interface |
| IoT | Internet of Things |
| IRR | Internal Rate of Return |

| | |
|---|---|
| KOM | Kick-Off Meeting |
| KPI | Key Performance Indicator |
| KRI | Key Risk Indicator |
| M | Milestone |
| ML | Machine Learning |
| MSVM | Multi-Class Support Vector Machine |
| NPV | Net Present Value |
| PBP | Project Business Plan |
| PLC | Programmable Logic Controller |
| PM | Project Management |
| PMMM | Project Management Maturity Model |
| PMO | Project Management Office |
| PP | Payback Period |
| PPM | Project Portfolio Management |
| PPR | Project Performance Report |
| PRF | Project Request Form |
| RAM | Risk Assessment Matrix |
| ROI | Return on Investment |
| SAT | Site Acceptance Test |
| SRM | Structural Risk Minimization |
| STECO | Steering Group Meeting |
| SV | Schedule Variance |
| SVM | Support Vector Machine |
| WBS | Work Breakdown Structure |

**VAASAN YLIOPISTO**
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## TIIVISTELMÄ

Hektinen projektiympäristö kannustaa organisaatioita investoimaan projektien portfolion hallintaan ja täten parantamaan projektienhallintaa kokonaisuudessaan. Näin voidaan saavuttaa parempi resurssien hallinta, projektien priorisointi ja samanaikaisesti maksimoida portfolion arvoa sekä asiakastyytyväisyyttä. Täten työn tarkoituksena on tutkia projektisalkun käyttöönottoa Etteplan Finland Oy:n sähkö ja automaation, sekä teknisen dokumentoinnin yksiköissä, jotta voidaan vastata asiakasprojektien dynaamisiin vaatimuksiin.

Tutkielmassa haastateltiin yksikköjen päälliköitä ja projektitoimiston henkilöstöä, sekä tutkittiin kattavasti yrityksen käyttämiä tämänhetkisiä työkaluja. Tutkimustulosten avulla selvitettiin toteuttamiskelpoisten dynaamisten projektinhallintatyökalujen käyttömahdollisuuksia yksiköissä. Tämän jälkeen toteutettiin laaja case-tutkimus ja vertailu nykyisten ja uusien toimintatapojen välillä, sekä arvioitiin toimintatapojen käyttökelpoisuutta ja liiketoiminnallista arvoa. Lisäksi, työssä otettiin käyttöön SVM-malli tuomaan uusia näkökulmia tehokkaaseen projektien johtamiseen.

Työn tulokset todensivat dynaamisen projektijohtamisen vaikutukset projektin tehokkuuteen ja kokonaiskustannusten alentumiseen. Tämän lisäksi työ toi esille toimintatapoja läpinäkyvään kommunikointiin, sekä korosti suorituskykymittareiden tärkeyttä. Yrityksen jatkuvan kehityksen ja kannattavuuden näkökulmasta työssä painottuu työkalujen ja metodien käyttöönoton tärkeys pienissä ja keskisuurissa asiakasprojekteissa.

**AVAINSANAT:** dynaaminen, projektien portfolio, projektinhallinta, tehokkuus

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**ABSTRACT**

Hectic project environment encourages organizations to invest more in developing overall project management through portfolio management to improve resource allocation and project prioritization whilst maximizing portfolio value and customer satisfaction. Thus, this thesis is conceived to examine the implementation of a project portfolio management model to respond to the dynamic customer project needs in the departments of electrical and automation as well as technical documentation in Etteplan Finland Oy.

There were five separate interviews conducted together with the essential managers accompanied with thorough research on the current methodologies. Exploiting the interview results, a comprehensive research on the feasible dynamic management methodologies was executed. Based on results from the mentioned research methods, there was a broad case study implemented to compare the current methodologies with the new proposals and evaluate their feasibility and business value for the departments. Additionally, a SVM implementation was performed to find new aspects to efficiently managing projects.

The results of the thesis showed the positive impact of applying dynamic project management methods for improved efficiency and reduction in projects overall costs. This enabled better understanding of KPI's as well as methods for transparent communication. From a profitability perspective, this thesis emphasizes the need of implementing the methods for the companies small and medium sized projects for continuous development.


**KEYWORDS:** dynamic, efficiency, project portfolio, project management

# 1 INTRODUCTION

This Master's thesis is done as a project work to Etteplan Finland Oy. The topic of this thesis was realized when discussing of the need of implementing a portfolio management approach to manage small and medium sized customer projects. The need for this kind of management approach was especially noticed in the departments of electrical & automation as well as in the department of technical documentation in the Business Unit South of Etteplan Finland. Focus is on the company's competitive landscape and competition. The demand is based on the scope of the projects, which in the above-mentioned departments are measured in hundreds of hours. There is a need to streamline operations and aim at better profitability, management and forecasting of resources in small and medium size projects.

Currently, these customer projects are managed and controlled by lead design engineers and department managers according to their availability and ability. Due to having simultaneously several customer projects to be handled in the execution and quotation phase, the resources in these departments are hard to monitor. This has caused mistakes in the execution phase of a project as well as unsatisfactory deals and loosing potential projects when handling quotation requirements. It is important that project management competences are required not only for individuals, but also for the whole organization for better overall management (Turner, 2003: 31-33). The option of hiring a lot of new managers to handle these projects would not only be a big investment but also strategically inefficient.

Based on the above mentioned needs and requirements of the departments and the organization, the goal of this master's thesis is to *form a model and way-of-working to manage and monitor simultaneous projects in the quotation-phase and the project execution phase*. The purpose of this thesis is to form a model and a way of working of this approach and implement it into the electrical and automation department. In addition, the *feasibility of applying* this in the department of technical documentation is viewed by *analyzing the requirements and needs of their processes* based on interviews and comparing the requirements with the ones in electrical and automation department.

The thesis is based on the interviews that are done with personnel from electrical and automation and technical documentation department. There will be interviews about the quotation offerings and the execution and monitoring of the projects. Also, the current databases, standards and documents are viewed and exploited throughout the thesis to form a structured and efficient model.

The theoretical framework and execution of the model and way-of-working is supported by a thorough theoretical research from resources such as IEEE database and other reliable locations. The portfolio structure, tools, screening, milestones et cetera will be done based on these main activities.

After applying the methodologies, portfolio structures and tools, *a case study will be implemented* in the department of electrical and automation project(s). Based on this case study, there will be a feasibility and business-based analysis.

## 1.1 Case company

"Etteplan provides design engineering services, embedded systems, IoT services and technical documentation solutions to the world's leading companies in the manufacturing industry. Our services are geared to improve the competitiveness of our customers' products and engineering processes throughout the product life cycle. The results of Etteplan's innovative engineering can be seen in numerous industrial solutions and everyday products." (Etteplan, 2019).

# 2 THEORETICAL FRAMEWORK

## 2.1 Problem, objective, research questions and sub questions of the thesis

The objective of this thesis is to form a dynamic framework for small and medium sized projects in the departments of electrical and automation as well as technical documentation in Etteplan Finland Oy, Business Unit South. By forming a dynamic approach, the projects can be reviewed, processed and executed faster and more efficiently. Fast process leads to less costs, time consumed and thus faster project lead times and more optimized project portfolio.

The problem is that the company has a delineate framework for complex and large projects, which does not support handling and monitoring of small- and medium-sized projects simultaneously in a dynamic manner. Therefore, the current methods are based on the know-how of the persons in charge as well as customized models for the more complex projects. Thus, not being standardized and explicit, it has increased the overall costs of the departments.

As the competition between companies accompanied with the ever changing dynamic environments, companies are forced to be more agile and innovative in terms of project investments (Lerch & Spieth, 2012). To maintain competitive advantage and compete against other companies, Etteplan must continue pursuing to manufacture and engineer with a difference maintaining a compelling price.

Also, the maturity of projects needs to be managed to help the alignment with organizational goals in addition to creating values to stakeholders. This, on the other hand, helps to generate value in long-term perspective. (PM College, 2019). In addition, prioritizing, monitoring and controlling projects whilst managing the risks is as important throughout the projects’ lifecycle.

The main research question is how to form a dynamic model for monitoring and handling projects in their quotation and execution phase whilst maintaining reliability and quality of each project.

The sub questions of this thesis discuss upon the right tools and techniques used for managing projects as efficiently as possible in a portfolio level. Also, the goal is to examine whether this application could be implemented into other departments, such as technical documentation. In addition, the impact, feasibility and way-of-working will be clarified in this thesis to the organization.

## 2.2 Theoretical background of project portfolio management, risk management and applying these in the case company

As stated earlier, there are existing models and ways-of-working which gives a background to begin this work. These models are inflexible to adjust to dynamic project needs, and thus a majority of them need to be modified. There is currently a tool which is based on software called Qlik, but it is not currently in use for small and medium sized projects due to the complexity. Thus, it is even more important to form a model to manage projects in a portfolio level for these projects.

Risk management is also in use, but currently the models are optimized for bigger projects due to the complexity. An approach to form a more dynamic risk management plan will be discussed later in chapter 4.4.

## 2.3 Project portfolio

"A portfolio is a collection of projects or programs and other work that are grouped together to facilitate effective management of that work to meet strategic business objectives." (Project Management Institute, 2008).

The purpose of a portfolio is to be within an organization and it handles both current and future or planned initiatives. In this case it handles projects. An organization can consist of several portfolios, which are often addressed to a specific business area or certain objective. The portfolio has a set of existing initiatives. Such as with growth and maturity in companies, this also means the expanding of e.g. sales, stable management and interested in research and development for continuous improvements in portfolio (Cohen & Zinbarg, 1967: 559-567). In addition, through systematic measurements and qualifications, new proposed initiatives can be added into the portfolio after approval. Thus, they are added with the existing initiatives into the portfolio. The combination of these initiatives forms a representation of the selected criteria's which fulfill the strategic goals and visions set for the organization. Therefore, by carefully taking into account and reflecting the investments and aligning to the strategy, the portfolio may identify the organizational priorities, help in allocating resources and be part of making investment decisions.

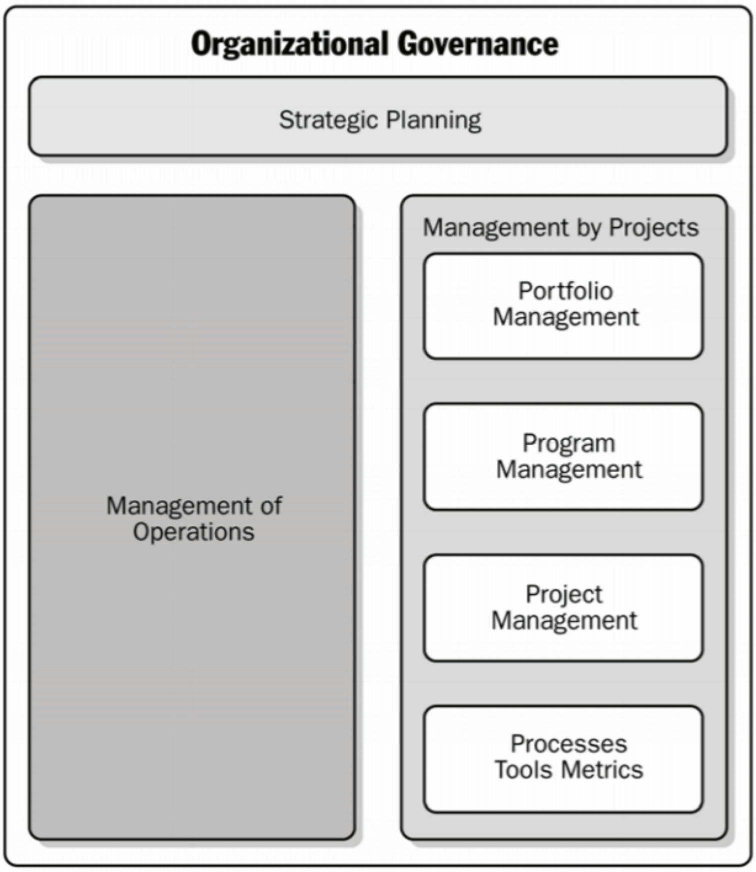


Figure 1. The organizational governance and relationship among different areas inside the organization (Project Management Institute, 2008).

The portfolio is said to be a measurement of the organizations capability in terms of progress, direction and intent (Project Management Institute, 2008). In an optimal situation the portfolio is constructed to focus on minimizing the potential risks and thus maximizing the remuneration which is between the investment and risk performance (Chang, 2006). However, as taking business risks is part of every business, it is a part of every management teams evaluation to take smart risks to be able to compete (Suominen, 2004: 51-52).

“The portfolio approach means that decisions are based on the full set of company projects, allowing a trade-off between projects requiring more effort than expected and those requiring less” (Fewster et al., 2003).

Portfolio management, on the other hand, is handling of these above mentioned portfolio components in a coordinated manner in aim to achieve the specific objectives of the organization (Project Management Institute, 2008). Portfolio management is set within four main goals – to maximize the portfolio’s value, find a way to balance the portfolio, strategically align the portfolio and lastly choose the right amount of projects to the portfolio (Cooper et al., 2001).

By interrelating organizational governance within the portfolio management helps in achieving and aligning the organizational strategy by providing reasonable assurance (Project Management Institute, 2008). With good portfolio management, the managing and execution of projects is made more efficient and transparent, which helps both within your organization as well as working together with the customer by giving more importance and visibility for the stakeholders (Le, 2004).

Naumov (2004) states in his paper that the efficiency of projects, therefore also the efficiency of the portfolio, and the estimation of efficiency can be exploited by using criteria’s such as internal rate of return (IRR), maximum and minimum risks of the projects and the payback period (PP) of the project investments.

### 2.3.1 Strategic foundation

As project portfolio management (PPM) is often described as "doing the rights projects", strategy is closely aligned in the successful execution of this. This helps in avoiding having strategically unimportant projects, which every organization avoids. (Rungi, 2010). A well strategically aligned and designed portfolio not only helps the managing of projects, but also explicitly improves the overall time and investment consumed to the whole process. The portfolio is strategically aligned to respond to the competences of the managers and provide thorough knowledge to support project teams, as well as defining the organization vision and mission. The objective of the portfolio is to obtain a steady state to generate stability and long term profitability. As with every investment and development process, the thorough implementation of such a portfolio model needs the support and contribution of the management team in Etteplan. This gives the project the opportunity to be fully exploited as well as delivers the message to the whole organization of the importance and need of the process. In addition to organizational support, each department needs to have some type of administration to help in department specific problems and keep the process up-to-date.

The portfolio's strategy dictates which of the potential projects should the organization invest in and how to prioritize the right projects at the right time. The goal of the project portfolio is to ultimately form a balanced and executable plan according to the organizational strategy which will help the organization to achieve its goals. Also, one of the key targets is to be able to balance the resources to maximize value when executing the project activities. (Project Management Institute, 2008).

The strategic alignment of the portfolio is done by following five main areas while planning: 1. Maintain the portfolio alignment, 2. Allocate the financial resources, 3. Allocate the human resources, 4. Measure the contributions of the components and 5. Manage the strategic risks (Project Management Institute, 2008).

Thus, the project portfolio can be aligned to answer to these common objectives: maximization of the value both in long-term and short-term, balancing the portfolio to adjust to different types of projects and aligning the project to reflect to the organizations strategic goals (Cooper et. al, 2001). When maximizing the portfolio value, the values should be matched with the strategic goals of the business, and this should be decided by the senior responsible personnel of the portfolio management team (Iamratanakul et al., 2009).

However, even though these goals are all important, there is a need to prioritize, rank and balance the impact of these objectives according to the organizations own needs. By approaching by ranking, the management team is able to form an appropriate model to answer to the right points to satisfy the ultimate goal. (Cooper et. al, 2001).

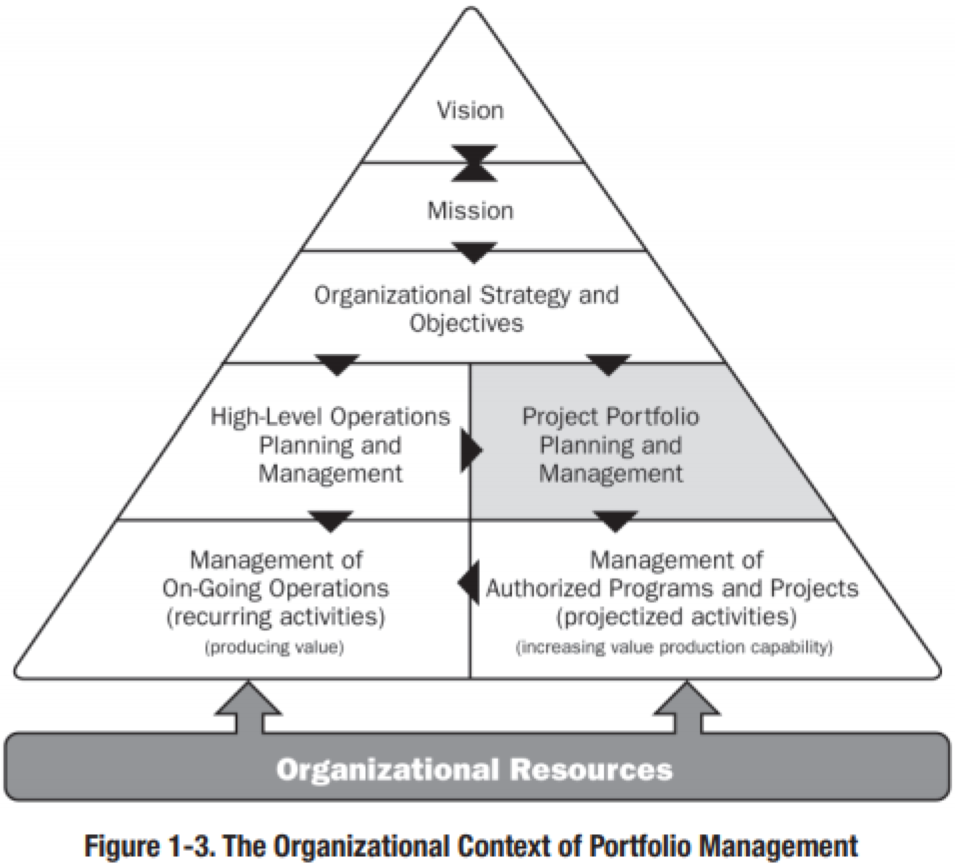


Figure 2. The common organizational structure using portfolio management (Project Management Institute, 2008).

As the above figure shows, the vision, mission and strategy of the organization are closely aligned with project portfolio management.

### 2.3.2 Portfolio structure, design and construction

The vision of this project portfolio is to obtain new projects for the targeted programs as well as prioritize, manage and execute the existing projects in the portfolio. This project portfolio will consist of two different programs which will work independently. However, as these two programs consist of similar types of projects, they may have some similarities in their evaluation processes. The existing projects are monitored in a weekly basis and the quotations, also described as new business opportunities, are evaluated using different methods. The purpose of the evaluation is to eliminate unsatisfactory projects candidates and business opportunities, go further with the most suitable projects and also prioritize according to their suitability. The importance of resourcing and prioritizing is especially important in dynamic environments where resources are not limitless (Cooper et al., 2001: 10-12).

The evaluation and handling process is done by each programs responsible persons, e.g. department manager or lead engineer. The evaluation and handling process is done following the models and gate-model described further in chapter 3 quotation phase project screening. Due to the size of the small projects, there is no actual project manager assigned for each project. Instead, there are lead engineers responsible for handling the projects. When needed, the lead engineer may inquire from other design engineers for specific information and help with the valuation. In case of projects with value of over 100 000 euro, the verification of the quotation needs the acceptance of the Business Unit Director in the company. This is done to ensure that the quotation is valued, offered and done according to the organizations standards and that the project follows programs and organizations strategy. When the value of the quotation is above 500 000, there is a need of approval from the management team. Then, when the value is above 1 000 000, it is also reviewed by the President and CEO of the company. In addition, there are rules according to which the quotation shall be additionally evaluated by a member of the project management office (PMO), e.g. in case the scope includes material and external services.

The execution is organized and managed by the lead engineer or the department manager in case of scarce resources. However, what is the most important thing in a project is to have the same person in the lead engineer role throughout the project. As shown in the research paper by Dubber et al. (2016), the change of the project manager during the project has a negative affect to projects performance, schedule, risks, has an increase in the total costs and may affect also in the project teams morale and weaken the communication.

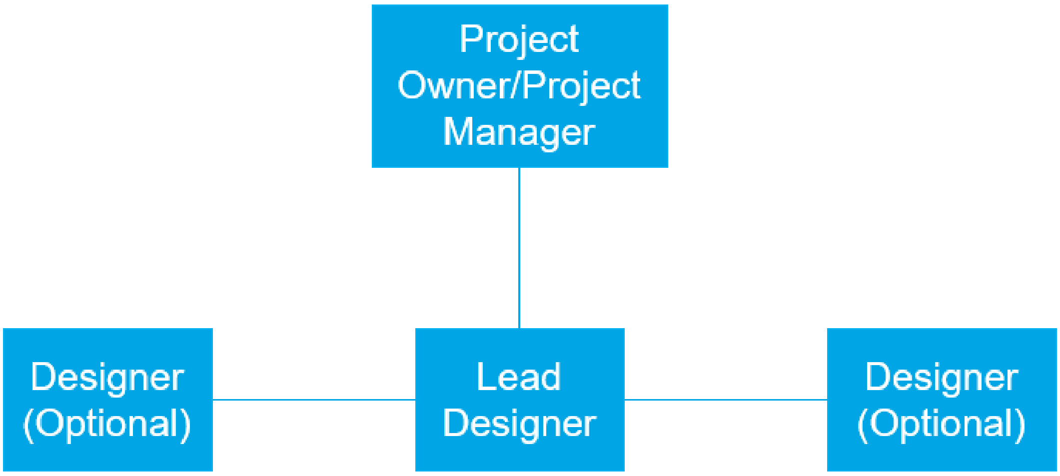


Figure 3. Project organization in the simplest form with optional additional designers

As shown in the above figure, because the projects are mostly relatively small the project teams are also. Within the smallest projects, the project manager is not included in the project organization. As mentioned earlier, the lead designer/lead engineer works as the project manager and is responsible for the monitoring and execution. As the project size gets bigger, the need for more designers and an actual project manager increases. During the beginning of the project the demand for the project managers effort is less, whereas during definition, planning and controlling phases the need for project managers effort is higher due to need of coordination (Thurm et al., 2016).

The projects lead engineers duty is also to inform the portfolio manager about the current progress of the project so that the communication is transparent within the organization.

The thorough communication plan within the project portfolio will be further explained later in chapter 3.5. In addition to having good communication to express current process, the balancing of the portfolio by distributing the scarce resources efficiently is a result of effective communication and needs to be facilitated for successful portfolio management (Project Management Institute, 2008).

To be able to understand the outlines of the portfolio of this thesis, there is a portfolio structure shown in the figure below. This portfolio structure represents the ambiguous form of the portfolio for electrical and automation as well as technical documentation programs.

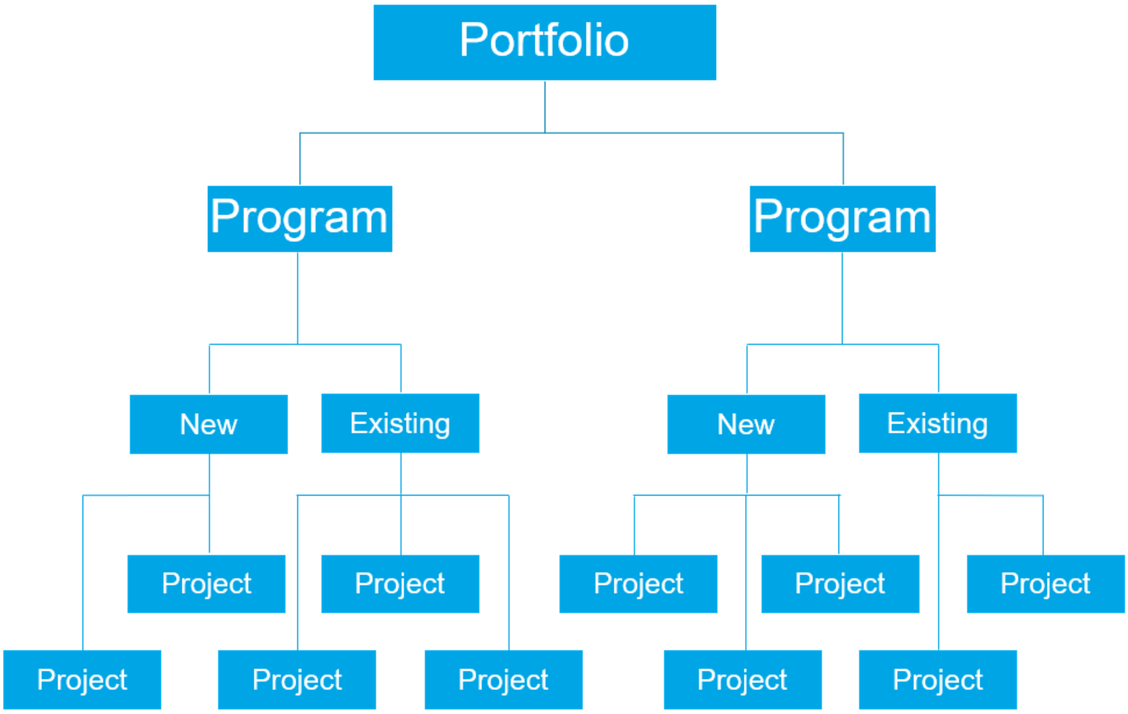


Figure 4. A high level structure of the portfolio model including portfolio, program and project levels.

As seen from figure 4 above, the portfolio consists of programs which have several projects of their own. The programs' projects are separated to new projects, which means the projects that are in quotation-phase, and the project which are existing already in the portfolio. The above figure is a draft and does not show the actual size of the portfolio or the programs.

Role of the portfolio manager is to establish, manage and monitor the assigned programs or portfolios. This is done by establishing and maintaining a framework and portfolio management processes such as risk management. Also, portfolio manager helps in guiding, prioritizing, balancing and maintaining the infrastructure of the portfolio. In addition, the portfolio manager reallocates, reviews and optimizes the portfolio as well as provides key stakeholders with necessary data, measures and key performance indicators (KPI's) such as NPV and PP. By having the help from project management office (PMO) as well as participating and having conversations with senior level decision makers and program review meetings helps to maintain the portfolio aligned and within the standards. (Project Management Institute, 2008).

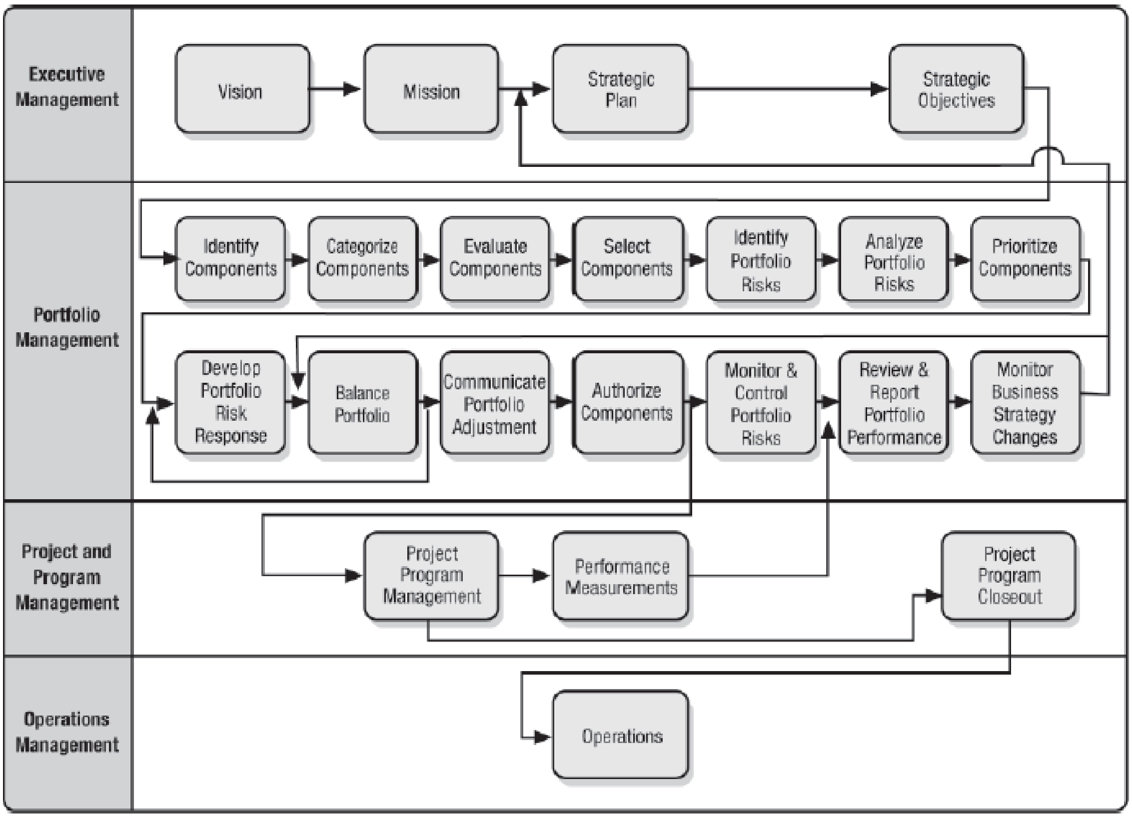


Figure 5. Effect of project portfolio management across the organization (Project Management Institute, 2008).

Figure 5 expresses well how portfolio management has an effect to the whole organization. Especially, this figure expresses how the strategic objectives determine the structure and components of the portfolio. Furthermore, figure 5 proves how the management process is iterative and needs to be continuously exploited to further develop the processes.

### 2.3.3 Conventional project management versus dynamic project management

In todays' changing environments project management needs to be responsive and in a dynamic manner to answer to the needs. Management is still a core process of every organization and is present all the way from planning an activity to managing groups, and thus needs great understanding to be efficient and structured (Linstead et al., 2004: 11-20; Lock, 2003: 3-5). Agile management method is a good approach for dynamic situations where the processes are iterative. A simple implementation of agile method is to use scrum, which is a project management method based on weekly meetings which should be productive and informative about latest and upcoming processes (Del Marmol, 2016). Scrum method is being used as part of technical documentations project management methods. Below is a figure presenting a traditional scrum process diagram:


Figure 6. A traditional process diagram for scrum in a organization (Freudenberg, 2013: 10).

Project management needs to be fast paced and accurate, yet as efficient as possible. In practice, dynamic character means that the organization is required to respond to the rapidly changing environments and techniques (Eijndhoven et al., 2008). Therefore, there has been development from traditional project management techniques towards dynamic project management. Traditional project management follows a waterfall model, which is structured to follow the assumed original scope and objectives throughout the projects' lifecycle. The process was described as a step-by-step model with no iteration, and each process would be the final form. (Educba, 2019). Below is an example waterfall model of traditional project management method:

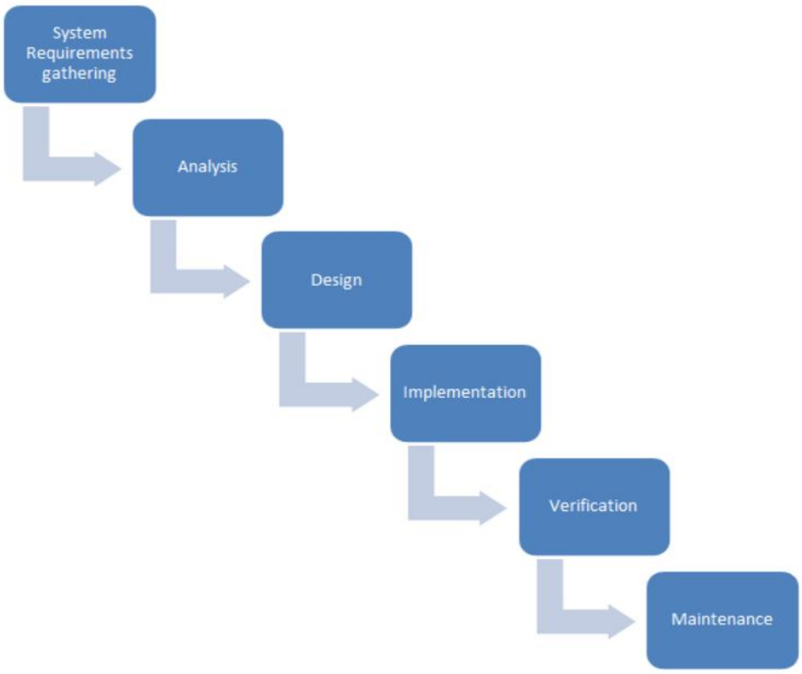


Figure 7. Waterfall model of an example traditional project management process. (Educba, 2019).

In this method a change is not taken into account and the project must follow a straightforward path. Traditional project management follows a cycle of project initiation, project planning, project execution, project monitoring and control and project closing phase. As with the waterfall model, one phase needs to be fully completed before the transition to next phase is allowed. The leader of a traditional project management project is the project manager, and thus has the responsibility of updating plan, schedule, budget, prioritization etc. (Educba, 2019).

On the other hand, dynamic project management is a more flexible framework which adjusts to the changing environments of projects. By enabling iterative approach to project management, it is possible to manage process dependent factors better and thus apply easier to need of change management. (Educba, 2019). Below is a sample picture of dynamic project management method:

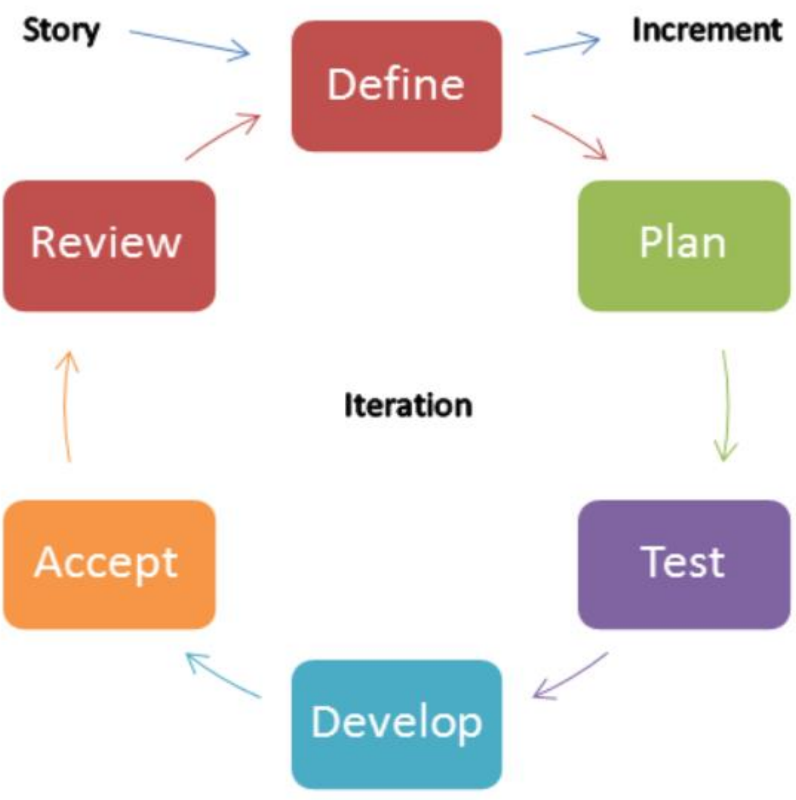


Figure 8. Iterative process model example for dynamic project management approach (Educba, 2019).

This type of project management method, closely related to agile project management, is especially applied with software development projects. This type of project management allows continuous improvement by feedback, from both customer and inside the company, and development cycles in addition to making planning more agile. Dynamic project management enables easier change in plans, less responsibilities and clearer roles due to more centralized data system, better performance due to better understanding of the timeline and prioritization as well as better response to risk management. (Educba, 2019).

As the customers are more demanding and the digitalization is moving fast, scheduling and planning is hard as well as predicting and managing risks on-time is difficult, the need for more efficient and flexible project management is real. One of the biggest advantages of dynamic project management is mapping the projects to the real world, which enables change management within schedules, plan, risks and overall process. (Sussex, 2016a).

Especially with small and fast paced projects, there is no time for mistakes or going to the wrong direction. In addition, innovation is becoming a essential part of project management. The seven principles for managing projects dynamically are as follows: 1. Scheduling predicting uncertainty, 2. Proactively responding to risks, 3. Scheduling is based on resource availability and is sustainable, 4. Real-time schedule updating, 5. Prioritization of tasks, 6. Collaboration within the team using a common platform or tool, 7. Project insight up-to-date. (Sussex, 2016b).

### 2.3.4 Hierarchical figures and plan

Portfolio infrastructure needs to be appropriately established to be able to support the functions of the portfolio. The portfolio should have proper systems, tools and techniques to be able to balance the portfolio and its components. (Project Management Institute, 2008).

As described in the above sections, the project team is often very small and thus there are not many roles. Especially with small projects, the project team can be only one person. When the size of the project gets bigger, the amount of project team members grows accordingly. Because this thesis concentrates in small projects, study does not go deeper into the hierarchy of bigger scaled projects.

Project management office (PMO) is the department or group of experts, who are responsible for developing, maintaining and supporting project management tools, techniques and processes. Also, PMO personnel are often in charge of expanding the expertise within the organization as well as supporting the development and maintenance of project portfolio management. (Projekti-instituutti, 2019).

In Etteplan, there is a project management office which is also supporting this development process of project portfolio management. PMO has provided and supported the process with process description, tools and models which will be further exploited to form a dynamic approach for this thesis.

## 2.4 Tools

In this section there will be a brief description of the tools that would fit best in the management of the portfolio and projects of this thesis. First, the project evaluation tools will be reviewed, which means the tools that would help the lead engineer in finding the most suitable projects for the portfolio. Next, the reporting and scheduling tools for the projects quotation and execution phase will be described. Then, the efficiency and maturity tools are reviewed, which help in understanding the maturity of the projects and thus helps in prioritizing the projects.

After this, the financial tools will be analyzed. Financial tools are used to support the project follow-up and monitoring throughout the project, for example EVM and NPV. Lastly, additional execution tools are reviewed to make the project and portfolio management process efficient and transparent.

### 2.4.1 Project evaluation tools

Funnel and filter is a method that could be used for example to evaluate quotation-phase projects. It aims to filter out the non-feasible projects and let through only the projects which match the organizational and portfolio strategy and objectives. The method can be decided to contain as many levels as necessary to thoroughly evaluate the feasibility and the fit in the portfolio. The importance of the feasibility study is to point out the projects direction and define whether the risks and objectives are manageable or not (Lock, 2003: 57-59). In this case, the funnel and filter method will contain three levels for evaluating the portfolio candidates.

Especially designed for small and medium sized projects, the funnel and filter method will help in the evaluation process by pointing out the KPI's and KRI's in the early stage of the process. The reason for having several levels in the funnel and filter is to be able to prune out the projects that have very little or no chances of being successful against the given criteria's (Le, 2004). Below is a sketch of a three-level funnel and filter-method:

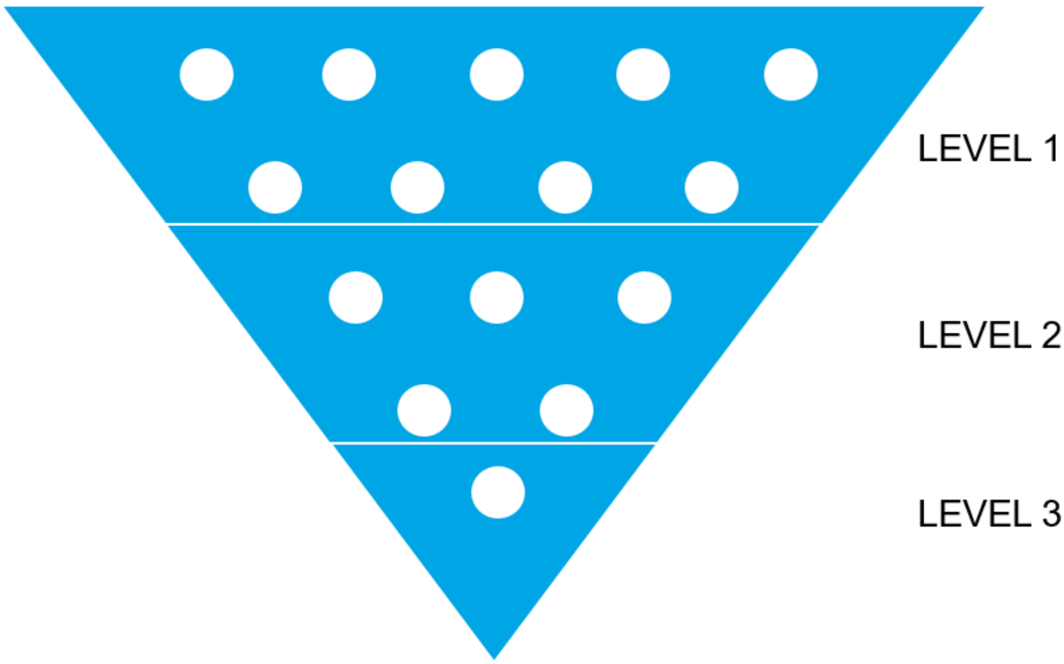


Figure 9. Funnel and filter method for project evaluation in quotation-phase.

Collecting project proposals and then deciding which of them to pick will be further explained and given a detailed description of what are the actual key criteria's to be evaluated upon in chapter 3.

### 2.4.2 Reporting and scheduling tools

Progress report is made to view and manage ongoing projects and their process versus the scheduled process. This report may also include expectations of the future and some risk management as part of supporting functions. (Projekti-instituutti, 2019).

Gantt-chart represents the schedule. The basis of the chart are the tasks and the planned time for each task. It is good to present the correlation between the tasks as well as the potential critical path exploiting the Gantt-chart. (Projekti-instituutti, 2019).

Critical path is the optimized project path consisting of interrelated tasks which form the shortest possible project time. In addition, it points out the critical tasks which will delay the project length. (Projekti-instituutti, 2019).

### 2.4.3 Efficiency and maturity tools

Project management maturity model (PMMM) is an indicator of how efficient and advanced is the organizations, and in this case portfolios, project execution. After identifying the current situation and going deeper into the immaturities, it is easier to set up future development goals and prepare a development plan. (Projekti-instituutti, 2019).

Prioritization in portfolio management is essential when there is lack of resources and decision needs to be made of which project should be chosen to be done first. The decision is often made by evaluating the projects urgency and importance upon other projects as well as comparing to the portfolios and organizations strategy. (Projekti-instituutti, 2019). Example of project prioritization scoring model:

Strategic Alignment:
- Degree to which project aligns with our strategy
- Strategic importance

Product/Competitive Advantage:
- Offers customers/users unique benefits
- Meets customer needs better
- Provides value for money for the customer/user

Market Attractiveness:
- Market size
- Market growth rate
- Competitive intensity in the market (high=low score)

Synergies (Leverages Our Core Competencies):
- Marketing synergies
- Technological synergies
- Operations/manufacturing synergies

Technical Feasibility:
- Size of technical gap (large=low score)
- Technical complexity (barriers to overcome) (many/high = low score)
- Degree of technical uncertainty (high=low score)

Risk Vs. Return:
- Expected profitability (magnitude: NPV)
- Return on investment (IRR)
- Payback period (years; many=low score)
- Certainty of return/profit estimates
- Low cost & fast to do

Figure 10. A model for scoring in project prioritization (Cooper et. al, 2001).

As shown from the above figure, the prioritization values are both qualitative and quantitative. Taking both of them into account is important to evaluate as efficiently as possible.

### 2.4.4 Financial tools

Earned value management (EVM) is an approach that is designed to help forecasting for example cost and time for each task in a project, and is part of Estimate at completion (EAC) estimation. EVM as a concept is made for measuring projects progress, and in addition, to calculate the Earned value (EV) as well as forecasting EAC in the periods of project progress to control. Thus, this helps in achieving project goals by being able to indicate overruns in e.g. cost and time. (Attarzadeh et al., 2009).

Net present value (NPV) is a tool that can be used e.g. to determine the feasibility of a project using calculations as well as a decision making tool for multiple alternatives. In the Portfolio, NPV could be especially exploited for decision making purposes. Due to increasingly many projects experiencing overruns, the profitability, costs, schedule and other calculations need to be monitored and project managers have to be aware of the situation and consequences at all times. In addition, NPV can help the PM to have a better approach to the given situation. Reliable project forecasting is also supported by NPV calculations. (Wetekamp, 2011). NPV equations is as follows below:

$$NPV = \sum_{t=0}^{N} \frac{CF_t}{(1+r)^t} \tag{1}$$

In this calculation, $CF_t$ is the net cash flow that is expected during the period of time (t), r is the capital costs of the project and n is the lifetime of the project. As well as for forecasting and budgeting, NPV can be exploited in risk management, project reporting and estimating the promises and deliverables according to the promises. (Wetekamp, 2011).

### 2.4.5 Project execution tools

Benchmarking as a process means the capturing of both qualitative changes in systems characters as well as the quantitative changes from the performance perspective. In Etteplan's projects, this means importing both qualitative and quantitative metrics for different stages of the project to be able to understand the process and locate the most important parts in terms of decision making. Decision support systems (DSS) can be used in objective manner in benchmarking efforts to improve repeatability, costs, speed, accuracy and the overall benefit of the whole process. (Kaupp et al., 2007). In addition, we can generally view the competence of project managers by benchmarking projects by certain criteria's (Turner, 2003: 40-41).

Risk management is a managerial approach to monitor and handle information of events or tasks which might effect or are critical to the execution of the project. The effect of those events and tasks are evaluated upon how they effect to e.g. project budget and scheduled time. Proper risk management also enables to understand the risks and take advantage of the opportunities and prepare for the threats as well as prioritize them. (Projekti-instituutti, 2019). Risk assessment, meaning the determination and assessment of the project specific risks as well as understanding the impact of the risks, is often described to be the key part of risk management in the company (Jia et al., 2008).

Balanced scorecard (BSC) as a method is made to make sure that all the indicators in terms of performance management are being balanced. It is often said to be a framework which helps in transposing the organizations strategy into operational objectives. (Peng et al., 2008). Using BSC efficiently by grouping the key financial figures as well as the non-financial metrics, it drives the implementation of strategy more effectively (Epstein et al., 2018).

# 3 QUOTATION PHASE PROJECT SCREENING

The quotation phase is the beginning of the project where the lead engineer goes through potential new project candidates and selects the new projects to the portfolio. The quotations are chosen and evaluated by the responsible person. In the case company Etteplan, the lead engineer for choosing the project candidates is either the department manager or area manager.

The quotations are a result of calls or exchange of e-mails. Also, some quotation leads are gained by customer visits or when customers are visiting the company. In addition, some of the project quotations are part of continuous projects, which means there are coming continuously projects from the same customer. In this case, the project quotation screening is done with fewer steps. All in all, the goal is to get both delivered value to the customer and gain value to the company itself.

Until now, the process for project screening has been based on experience of earlier projects and hence the processes have varied case-by-case and there has not been any standardized methods. Therefore, the training of new potential responsible has not been that easy due to non-existing materials and knowledge-based execution. That is why one of the objectives is to form a standardized way-of-working so that the process could be done dynamically and efficiently.

When a quotation request is received, the value of the customer and the project is first evaluated, and thus the feasibility of the project is estimated as well as the KRI's. This is part of the level 1 evaluation in funnel and filter method. After the first level identification of the project proposals, the projects that fit to the criteria go to the next level evaluation in which KPI's are taken into the evaluation process. Some of the KPI's are scope, schedule, resources, budget and reliability of the customer. Also, the project needs to match the vision and the strategy of the organization and the portfolio. After the second level evaluation, the projects performance is being measured to evaluate how the projects performance matches to the desired performance evaluating using e.g. cost variance and schedule variance. To help the evaluation, earlier similar projects are often used as comparison, especially when estimating the offer. If the evaluation process meets the criteria, the quotation process is forwarded to the execution phase. At this stage, the scope, schedule and the budget already have an outline. Next, these indicators are specified.

The quotation phase project screening can also be described as a three level evaluation process. Quotation phase should represent a GO - NO GO type of approach considering the most important factors in a project:

1. Project screening (project request form (PRF)).

2. Evaluation against its own merit (project business plan (PBP)).

3. Evaluation for its relative merit (project performance report (PPR)).

The evaluation criteria should consider whether it is strategically appropriate, technically appropriate and commercially appropriate through key criteria's and indicators. We can say that most business opportunities (projects) are strategically appropriate simply because of the need to grow, wish to expand the market share, target to get new customers et cetera. Therefore, most quotations are taken forward after the initial study.

In the first level, also known as project request form (PRF), the project is evaluated with Etteplan's own chosen key criteria to evaluate how the project would fit into the portfolio and to Etteplan's organizations vision, mission and strategy. The key indicators and criteria for the first level evaluation are: payback ability of the customer, scope of the project, feasibility, our own capabilities, similar experience from earlier projects, network and knowledge of the business area as well as resources and key risk indicators (KRI's). These criteria can be easily evaluated using points to evaluate how it matches Etteplan's vision. In addition, by including weighted coefficient, the importance of some indicators can be emphasized. The weighted coefficients are marked in brackets behind the indicators in the list and the value is multiplied by the coefficient. Weighted coefficients are between 1-5 and the indicators are marked between 1-5. If the total project score is under 60 in the key criteria table, the project will not be chosen to the portfolio. The projects that pass the first level evaluation will be proceeded to level two evaluation. An example of a table which includes the key criteria's is shown below:

Table 1. Project evaluation table for key criteria's in the first level of evaluation process

| KEY CRITERIA's | PROJECT NUMBER | | | | | | |
|---|---|---|---|---|---|---|---|
| | PR1 | PR2 | PR3 | PR4 | PR5 | PR6 | PR7 |
| Payback ability (3) | | | | | | | |
| Scope (4) | | | | | | | |
| Feasibility (3) | | | | | | | |
| Capabilities (in house) (3) | | | | | | | |
| Knowledge of business area (2) | | | | | | | |
| Related experience (2) | | | | | | | |
| Resources (3) | | | | | | | |

Because the key risks should be pointed out as soon as possible to be aware of the most important threats, key risk indicators are defined already at the first level stage as part of the evaluation. Below is an example of what kind of data will be included in the table:

Table 2. KRI's for the project evaluation phase.

| RISK IDENTIFICATION | PREVENTION PLAN | PREVENTION METHOD |
|---|---|---|
| Description:<br>Impact: | Plan: | Action: |
| Description:<br>Impact: | Plan: | Action: |

The second level, known as project business plan (PBP), of the evaluation includes a more precise financial evaluation and also includes in this case some scope and budget evaluation. Therefore, this gives a more thorough understanding of the actual figures of the project. Furthermore, this level allows the project manager or responsible person to evaluate the return of investment (ROI) of the values. Other tools that can be used during this level are net present value (NPV) and risk evaluation tools such as risk assessment matrix (RAM). The reason behind bringing RAM into this phase is especially for larger scale projects due to their complexity. With a thorough risk assessment, the project team is able to be prepared for both the opportunities and threats that may occur and can prepare to them accordingly. When the projects investment size increases, the need for a more thorough risk analysis grows. However, the financial tools described above will be mostly in use during this level. The purpose of the second level of evaluation is to find if there is actual business potential from that project.

Third level evaluation, also known as project performance report (PPR), is about evaluating the current situation of the project. The main metrics that we want to obtain and evaluate during this phase are schedule variance (SV) and cost variance (CV). In addition, to further evaluate the project candidates there will be used forced ranking to be able to finally eliminate the project that the company and portfolio does not find beneficial or potential.

However, because the thesis concentrates in small and medium sized projects, the quotation phase evaluation needs to be tailored to be as dynamic as possible. Thus, the third level of the funnel and filter method is limited out from the process. Nevertheless, the full three-leveled funnel and filter evaluation method will be brought into the process after transition to large-scaled project. The initial data is an important factor affecting the demand of the tools and models.

As the process needs in some occasions a verification from higher management levels, the project is handed for review to the appropriate unit. For majority of reviews, department manager has enough authority to accept or decline the project quotations. Additionally, if the project is big enough, the process needs the acceptance of the business unit director.

## 3.1 Current method

There is current methodologies inside the company databases for evaluating and monitoring quotation phase projects, but they are not distinguished and used inside the project organizations efficiently. Therefore, until now it has been mostly knowledge-based as well as tailored from old projects and the project database. Especially for Vantaa area departments, the project data has been stored into the local server. However, due to the large amount of files inside the local server, it is sometimes hard to find the locations for some certain files, unless the person knows already where to find them. For larger scale projects, Etteplan's own project portal and a system dedicated for sales-phase, also known as Sales Point, has been used to monitor and form models using their existing tools.

The reason why Sales Point has not been used for the small and medium sized projects is because it is not dynamic enough to answer to the fast-paced project environment which those projects needs. Also, the existing models are done to fit to the most complex projects and thus are too informative for the smaller projects.

Because the scheduling and budgeting may sometimes be difficult, the lead engineer often reaches out for other designers for help in the evaluation process. In addition, a tool used for project reporting called Maconomy is used to view old project data used. The most common pricing model for Etteplan's projects is by hour waging. According to the interviews with Hietikko et al. (2019) in Etteplan, the hour wage model is within 10-15% accuracy.

The existing step-by-step scheme is shown in the process figure below. As the figure shows, the process should take around 8 days at maximum to complete all of the steps. If going through all the steps, it includes evaluation, creating the quotation, evaluating and giving feedback of the quotation, refining quotation, submitting the quotation and in the end confirming the order and finalizing the contract. This process would include three different tools: Etteplan Business Portal (EBP) for processing and forming all the models, Etteplan Customer Relationship Management (CRM) software Sales Point and Quotation storage to store all the necessary data of the quotations. According to Kuisma (2019a), the quotation process should be applied using the process below when the quotation value is bigger than 50 000 euro's. Addtionally, there will be extra criteria included to the process when the quotation value exceeds 100 000 euro's, including wider risk evaluation and cashflow calculations (Kuisma, 2019a).

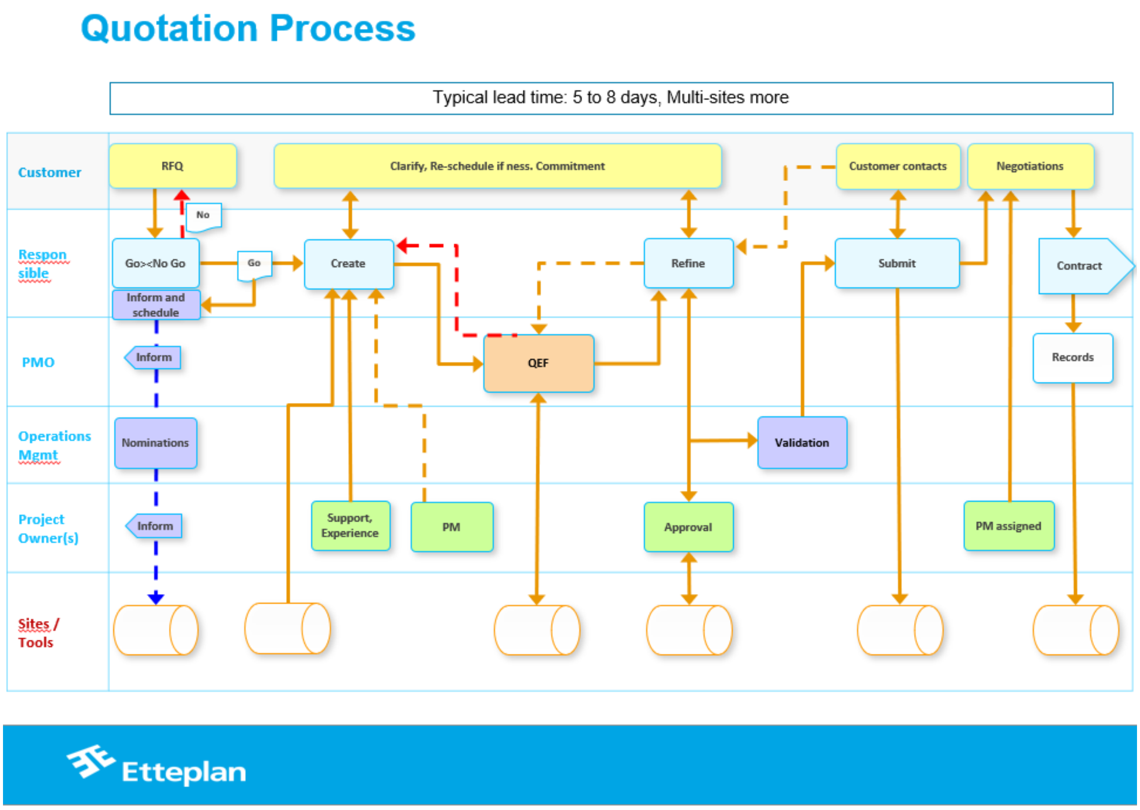


Figure 11. Step-by-step process diagram for quotation, review and authorization process in Etteplan.

As mentioned, this type of process walk-through is only done to projects of 50 000e or over due to the complexity and need of precise handling and revisions. The process diagram shows the processes needed by each party of the process. The information in the process diagram has been simplified due to privacy protection, and thus in the actual version the process is more precise.

### 3.1.1 New customers

In the mentioned departments, the valuation and estimations are made together with other designers and lead engineers to understand the outline of the project. When working with new customers, the iteration rounds and refining the quotation takes often several rounds. This is due to discussions and reviewing together the quotation and pricing. By using old models, it is easier to evaluate and form more precise estimates. The goal is to answer to their needs as quickly as possible with minimal effort and thus start the work task as soon as possible.

In addition, reference data is gathered from old projects and by searching enterprise resource planning (ERP) software Maconomy for the actual working hours per discipline and work task. In small and medium sized projects there is not an official kick-off meeting. Therefore, it has been done by a conversation between the lead engineer and the other designer. Because there is not a standardized way to go through the most important parts of the quotation, some parts may not always receive sufficient focus and are therefore noted very late in design phase. In the worst case scenario, they are left out completely.

Generally, it is the customer who asks for more precise information about the project and asks for some specific additional details. With new customers, there needs to be a more clear review of the most important contractual requirements. However, because Etteplan has a wide portfolio of existing customers, only a few new customers arrive each year.

For example, the electrical and automation department has their own excel sheet for pricing the projects. When talking about projects in the scope of tens of thousands of euro’s, the projects work load needs to be broken down to smaller parts to understand the complexity. This can be done exploiting e.g. work breakdown structure (WBS).

Almost all quotations are commercially acceptable by Etteplan, based on that the calculated hours and costs are in line with the assumed “acceptable sales price” and the desired profit target. However, there are cases in which the final set-up may turn out to be commercially inacceptable. In such case the particular quotation will not be sent, not sent as prepared, or customers terms and conditions are posing too large a risk, which would raise the cost and price respectively. Thus, that the deal is not any more attractive or acceptable, an agreement with the customer will not be reached.

### 3.1.2 Continuous customers

When working with continuous customers and their projects, the process is tailored to be more straight-forward to make the process faster and more efficient for both parties. Regular customers have their own standardized contract which is used in every project. Only the order specific details such as technical and financial details need to be changed.

The purpose of this kind of an approach is to increase the reliability and transparency between the customer and Etteplan. In addition, one of the objectives is to make Etteplan easily available and prompt to order from. For example with one of the biggest customers, ABB and Outotec, the process is made as easy as possible to handle within one phone call or one email. When the process is user friendly and efficient, the customers tend to utilize the same provider.

For example in technical documentation department, continuous customers' quotations might be handled by the lead writer to make the process more dynamic. This can be done based on the earlier contracts and mutual understanding of the requirements and needs as well as capability to handle flexible quotations. (Pukki, 2019).

## 3.2 Improvements to the current methodology

The improvement suggestions have been gathered from interviews together with the department managers from both electrical and automation department as well as technical documentation department.

First of all, the whole project quotation should be started with a proper check list for going through the most important requirements of the project. This is done to avoid missing the important details of the quotation. Also, the quotation check-list should be short-listed to be as dynamic as possible to both enable as competitive price as possible for the customer as well as minimize workload and increase efficiency for Etteplan. The shortlisted checklist should include some major risk assessments to limit out e.g. startups and other companies that are not financially capable to handle the project (Hietikko & Leinonen, 2019). According to Pukki (2019), customers have given feedback that the quotations have been too long. Thus, the quotations could be simplified and made more dynamic for both the customer and the actual project team. However, the most important terms and conditions shall always be stated.

All of the project work hours are based in Maconomy during the project and are adequately marked under certain tasks to be able to follow the progress. However, the usage of Maconomy is not as efficient as it could be due to not fully exploiting the possibilities in Maconomy and thus the project progress reporting is not viable to do as frequently as wished. Furthermore, the process of getting the registered working hours through is too slow. By enabling a better monitoring approach for the projects, the actual hours versus the expected hours could be better analyzed and thus estimate the remaining process more efficiently. Because the usage of Maconomy is not only dependent in the department, the improvement process might take a long time. Thus, as already used in the technical documentation department, a progress report meeting together with project teams could be an efficient approach to start off also with the electrical and automation department. Additionally, the combination of project databases in Etteplan Vantaa servers could increase transparency for both technical documentation and electrical and automation department.

As milestones and benchmarking have been used to form a better understanding and a more clear vision of the most important tasks and events throughout the lifecycle, the same type of method will be implemented to the quotation phase as well as the execution phase later. Through better understanding of the key events and tasks, the project team has a more clear vision of the tasks ahead and can also be better prepared for certain phases of the project. In addition, it helps in forming a critical path for the project.

Currently, the project management used especially in electrical and automation department is based on traditional project management. As described in chapter 2.3.3., dynamic project management approach would give a more iterative and flexible opportunities to manage projects especially within change. This type of management allows more opportunities and responsibilities to the project team members, which then motivates the staff to be more productive and efficient.

The scope of the project is the most important part to understand and therefore it should be also generated and communicated in a way that it is easily understandable. During the conversations with Hietikko et al. (2019) and Pukki (2019), we concluded that an abridged PowerPoint presentation generated from the original quotation would promote this approach the best. The goal of this generated PowerPoint would be that the scope and other necessary information for the project team could be generated easily from the quotation so that it could be then communicated as quickly as possible. This could also point out easily the pain points and important notices made during the negotiations. In addition, because of the uniformity with the earlier projects, it would be easy to read through. Furthermore, it should be flexible enough so that it could be used to the small and medium sized projects as widely as possible. This is done using the expertise from the technical documentation department.

As already described, there is a gate-model in Etteplan's project portal for the execution of the project described with gates. The original gate-model is shown below:

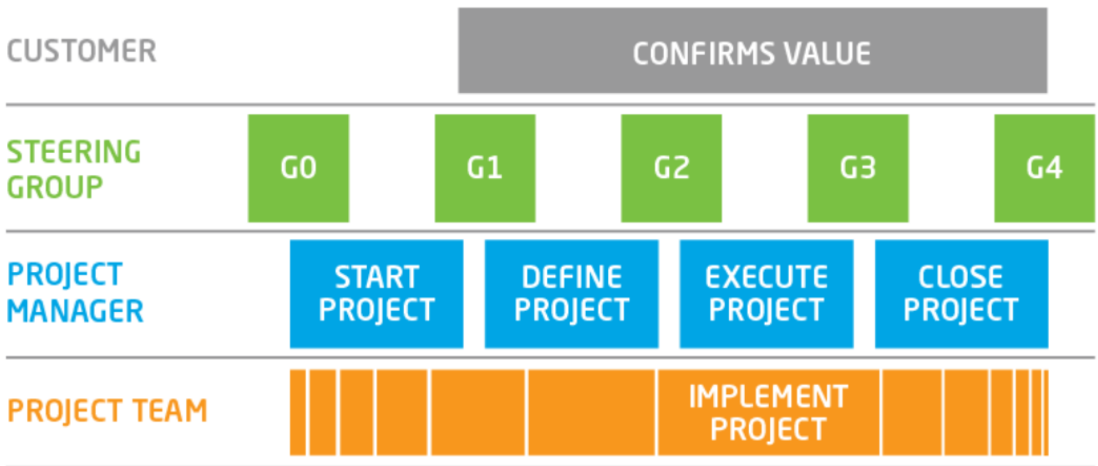


Figure 12. Original gate-model for project execution in Etteplan's project portal.

By modifying the above mentioned gate model with milestones and important benchmarks, the process is made more visible and transparent. In addition to this, it is easier for project personnel to understand the most important parts of the project and see actual view of the whole process. Visibility of the actual process helps to work better for the target and helps to understand the prioritization criteria at each gate or milestone (Cooper et al., 2001). Also, visibility through classification has been seen as a way to make project more visible and thus increase the follow-up of e.g. resources (Crawford et al., 2002). Better visibility should also be linked with the documents, because currently the revisions might not be easily found and therefore the management of the latest versions is hard.

Lessons learned model is for collecting and viewing the most important turning points and vital lessons that have had an impact to the success or execution of the project. In the conversations with Pukki (2019) and Hietikko et al. (2019), the department managers pointed out that this type of model would be too complex for small and medium sized projects. However, the importance of these types of documents was pointed out also and thus the implementation of these would be beneficial for the whole organization. As Kuisma (2019) stated, the importance of understanding the earlier mistakes accompanied with the good things in the project will increase the overall reliability and efficiency of the projects execution. The combination of a dynamic weekly meeting together with going through the lessons learned of the projects during the week could enable thorough understanding of the strengths and weaknesses of project execution. Not only can the company benefit from finding out the pain points in project execution and quotation phase, but also note the strengths in the process and project organization. Additionally, by taking notes from managers personal experience and the important skills they use, the company can benefit by encouraging knowledge sharing and thus improve the overall level of management for the project managers (Yu et al., 2009).

## 3.3 Project planning methods

Work breakdown structure (WBS) is a tool used especially in complex projects to breakdown complex processes into smaller parts to gain a better understanding of the project.

The goal of WBS is to make complex parts of the project easier to manage and understand. As described in PMBOK Guide (2000), it is an iterative process which allows the project team to gain knowledge of all of the parts of the project and then decompose the work. This is also valuable information in terms of project scope. Also, by breaking down the project into smaller parts helps in understanding the total budget and timeline. The decomposition is often done using a top down decomposition approach, which means gradually decomposing the system or hierarchy into smaller parts by starting from the major system (Chiriac et al., 2011).

Project cost management includes the resource planning, cost estimation, cost budgeting and the controlling of the costs. This task is made to ensure that the project is finalized within the desired budget. The importance of doing such cost estimations and cost management procedures is crucial for the project execution and needs to be done in different stages throughout the project (El-Sawalhi, 2015). Not only does it consider the resources needed for the completion of the project, but also the effect of decision done towards the costs of the project. In this case, this can be seen e.g. in the reduced amount of revisions of the design approvals or by making the quotation and execution project more dynamic. Ultimately, by broadly exploiting the chances of project cost management, the company can gain valuable lead to the competitors by offering competitive prices. This type of broad project cost management is sometimes referred to as life-cycle costing, which aims to reduce cost and time while improving quality and performance as well as optimizing the decision-making process. Project cost management can include additional ROI calculations to support the decision making. In most small project cases, resource planning, cost estimating and cost budgeting are found as one single process due to the resemblance of the activities. (PMBOK Guide, 2000).

In addition to thinking about project team's needs, it is important to take the important stakeholders needs into account in the planning phase. As some of the key stakeholders have high interest and high impact in the project, it is a necessity to understand their requirements and needs for profitable and efficient execution. This implies especially in resource planning and cost estimating phase. (PMBOK Guide, 2000).

Based on the above project cost management processes, a thorough scheduling plan and execution plan can be made. Also, by applying critical path method (CPM) to the scheduling plan enables the thinking of the earliest and latest starting and finishing dates for each activity as well as find out the critical path for the whole projects execution. By this type of approach we can find the most critical, least flexible, tasks and thus find the bottlenecks of the project which have the most impact to the projects execution. (PMBOK Guide, 2000).

## 3.4 Transfer from quotation phase to project execution phase

“A project sales phase is completed in a kick-off meeting. In this meeting, the responsibility for a project is transferred to the project organization which includes the project owner, the project manager and the project team. A meeting memo is made and distributed.” (Etteplan, 2018).

Currently, there is not a standardized approach to communicating the information from sales phase to the execution phase. As already mentioned in the last chapter, a generated PowerPoint model would fit the need of gaining all the necessary information from the quotation model to form a clear and straightforward description corresponding to the original information. Thus, as part of the later development process, together with the technical documentation and electrical and automation department this type of an automatically generated PowerPoint model will be formed.

## 3.5 Internal and external communication

During the negotiations between the customer and the company, the communication criteria and rules are confirmed and written into the quotation and they are often also in the final contract. It is important to have clear communication borders defined for both sides to allow transparent flow of information and details. In addition, this also makes the project execution more clear for the project team because they have a better understanding of which of the data should be clearly presented and informed for the customer. Also, when having good communication, the number of iteration rounds will be decreased because the risk of going to the wrong direction decreases and the probability of staying in the right scope increases. This is also avoided by following the original scope.

Additionally, in the end of the project the steering group gathers to discuss about the strengths and weaknesses of project execution and overall customer experience. This brings valuable information for the organization by highlighting the necessary details given by the customer. Also, if needed, this information can be put into practice inside the project organization. This type of feedback is valuable and can be for example combined with the earlier mentioned lessons learned platform. Even though the reviewing and writing consumes time, the profit gained from the learning experience is extremely beneficial.

# 4 MONITORING OF PROJECTS

During projects execution phase, it is extremely important to be able to estimate and predict the project duration, budget and forecast the future explicitly. As proven in the research done by Attarzadeh & Hock (2009), projects future predictions can be done and visualized easily using EVM calculations. Of course, it is mostly based on future predictions on how the project would unfold in the future, but at least it gives insight to how the budget and costs would go. For the lead engineer it is extremely important to use methods that give reliable estimates for project forecasting (Wauters & Vanhoucke, 2014).

The project management maturity in an organization or department is also an indicator of the level of capability and maturity to handle projects. This can be especially seen in the ability to handle change, stay within the projects scope and handle different resource and planning challenges. According to the research done by Grant & Pennypacker (2006), industries face particularly problems in the maturity when handling schedule development, cost control, cost resource planning, organizational planning and change control. Thus it is important to take into consideration the capabilities of the project manager and project team to handle these aspects in the execution and monitoring of projects.

In the technical documentation department the progress monitoring is done using scrum twice a week. In the scrum event one person is elected the scrum master, and the purpose of this event is to go through the projects statuses and any upcoming important events or noticed risks. Each scrum event should be approximately 15 minutes long to manage the projects promptly.

Firstly, schedule development is the process of viewing and analyzing the activity durations, their sequences and the resources required to do the activity. In practice, this means determining the beginning and end dates for each project activity. Through these events, it is easier to analyze and further create the project schedule. Being part of projects time management, it is crucial to work on these processes throughout the project to avoid delaying the project. Hand in hand with schedule development comes schedule control, which helps in controlling the changes that happen to the projects schedule. With better understanding of the constraints, the project team can manage limiting factors better. Tools such as CPM helps in determining the schedule dates and thus help in visualizing the full project schedule. (Grant & Pennypacker, 2006).

Cost control describes the projects budgets controlling in case of change. As a key part of projects cost management, this is a critical part for managing changes in the budget and seeking for the influencing factors. The processes included in cost control are e.g. monitoring cost performance, informing the relevant stakeholders, recording all of the changes and staying in acceptable limits. Cost controlling is performed using for example EVM calculations. (Grant & Pennypacker, 2006). As earlier mentioned in lessons learned, the valuable methods and ways of working from cost control could be documented there to further exploit the information.

Resource planning as part of project cost management is a key part of successful budget estimation. In the resource planning phase the amount of resources needed is determined so that the amount of people, materials and equipment's should be reserved for each activity. As a vital part of project cost managements planning phase, this is again a critical task to be executed. Tool that could be used in here are e.g. WBS and historical data from lessons learned. In case of smaller projects, which is closely aligned to this thesis, tasks such as resource planning, cost budgeting and cost estimating is done as one single process to minimize the use of time and maximize efficiency. Organizational planning is also linked closely to resource planning as it is overlapping with assigning and documenting the roles and responsibilities of the resources. (Grant & Pennypacker, 2006).

Change control is the process for managing and controlling the changes happening for example is the projects scope. This means following up with the terms and factors that have already been agreed upon. It is important to be aware of the procedures that may affect to the change of the projects scope. Being able to coordinate the changes throughout the project is an important skill for managers. (Grant & Pennypacker, 2006).

## 4.1 Monitoring plan for growing project sizes

Due to the size of the projects changing from 5000 euro's up to 100 000 euro's, there is no standardized way to monitor these different sized projects. Thus, as part of the thesis, a step-by-step model was implemented with increasingly more tools and models to monitor the projects as the scope and price gets bigger.

As the main focus of this thesis is to monitor small and medium sized projects, the biggest input has been put to the aforesaid project sizes. Small projects range from 5000 - 25 000 euro's, medium-sized projects range from 25 000 - 80 000 projects and big projects then are from 80 000 euro's and above. Etteplan Finland Oy gives support from the corporation's side for projects of over 50 000 euro's.

Table 3. Project monitoring plan for different sized projects in quotation and execution phase.

| Price of the project (*1000e) | Tools used | | |
|---|---|---|---|
| | Quotation phase | Execution phase | Project size |
| 5 | +Scope<br>+Deliverables planning<br>+Schedule<br>+Budget | +Handing over of the details from quotation phase using PowerPoint model (budget, scope, deliverables, schedule)<br>+Initial data review<br>+Communicating details<br>+Change management<br>+Acceptance of delivery | Small |
| 10 | | | Small |
| 15 | | +Customer approval | Small |
| 20 | +Work breakdown structure (WBS) | +Resource planning | Small |
| | | | |
| 30 | +Technical specifications, review and communicate<br>+Customer requirement specifications | +Risk management<br>+Progress control<br>+Lessons learned | Medium |
| | | | |
| 40 | | +Additional internal/external communication | Medium |
| | | | |

| | | | |
|---|---|---|---|
| 50 | | +Additional progress meetings<br>+Milestone reviews | Medium |
| | | | |
| 60 | | | Medium |
| | | | |
| 70 | | +Stakeholder communication | Medium |
| | | | |
| 80 | | +Initial data, review and communicate | Large |
| | | | |
| 90 | | +Kick-off meeting (KOM)<br>+Steering group meeting (Steco)<br>+Multi-site projects | Large |

Having had the GO – NO GO evaluations during the quotation phase earlier, the projects have been evaluated to meet the project criteria's of Etteplan. Therefore, the technical expertise from Etteplan can be exploited for the projects. When efficiently using the above model for monitoring projects, Etteplan gains standardized way-of-working to fulfill the project requirements accordingly.

Utilizing the PowerPoint model for communicating project data within the project team, the kick-off meeting could already be applied in small- and medium sized projects if noted necessary together with the customer.

## 4.2 Prioritization

Prioritization is important especially in the situation when there are multiple projects being worked on simultaneously and there is not enough resources to work on all the projects at the same time. Prioritizing as a term mean evaluating the most important task or activity according to the specified criteria which helps in achieving the overall goal the best. For example in qualitative point of view this means analyzing the qualitative risks and other conditions and thus trying to minimize the negative effects towards the project objectives (PMBOK Guide, 2000). Also, prioritization means allocating the right resources at the right time to be efficient in the long run (Cooper et al., 2008).

Overall, the prioritization, methodologies and strategies used for prioritization have to be aligned with the strategy and vision and thus must be consistent. It is important to understand that some of the resources may be constrained. An aspect which helps to prioritize more efficiently is to categorize the components into business groups so that they are easily visible for prioritization. This could mean e.g. categorizing personnel according to department or discipline. Prioritization is even described as a prerequisite activity for balancing the portfolio. An easy and consistent way for prioritization is by using a ranking model to prioritize according to the given score. Each of the key indicators have a weighted criteria value for measuring the importance and thus helping the prioritization. The selection is then based on the score and is done by the responsible person. (Project Management Institute, 2008).

A lack of prioritization has led into many organizational risks, and is therefore extremely important to take into consideration. This can be seen especially in our project portfolio, where there is a majority of small and medium sized project with nearly no space for delay or change in scope. The lack of prioritization can result into conflicts with e.g. project scope, time and costs. (PMBOK Guide, 2000). Sharing of information and best practices between departments would help further to distribute the best practices within the organization.

## 4.3 Gate-model for small and medium sized projects

The full project consists of 4 separate gates which define the transition from one phase to another. When moving from one gate to another, the person responsible needs to confirm the phase is fully completed. Before the official start of the project, there are quotation reviews and negotiations which are described in the below figure as agreement-phase. When the agreements are done and the quotation is signed, or if there is a formal customer order, the actual project is kicked-off and gate G0 passed.

After the kick-start of the project, the first phase of the project begins. The tasks include approving the resources, the project manager (or as in most cases the lead engineer) and handling and organizing the essentials for the project to begin. When moving on in the projects gate G1, the resources and project lead are approved. This phase includes defining the project, for example defining the projects reporting, communication and documentation plan and overall project schedule. In bigger projects, risk management and thorough quality plan are done.

Moving on from gate G1 to G2, the project should be planned and approved and also the technical solutions should be clear for all the stakeholders, including especially the customer. During the execution phase, most of the actual work should be done. During this phase the scope should be clearly followed and monitored and try to avoid any changes in the schedule or budget to maintain the original plan and be prepared for change management in case of unexpected events. In case of larger projects, there will be many meetings and other milestones during this stage to keep all the relevant stakeholders updated on a sufficient time basis. Schedule and budget can be monitored using e.g. gantt-charts and the progress reports from Maconomy as well as weekly or bi-weekly progress meetings together with the project teams. Field acceptance tests (FAT) or site acceptance tests (SAT) are often delivered within this phase to gain approval from the customer and present the project in action.

Moving on to Gate G3, the projects work implementation should be ready and the results should be presented, reviewed and the customer should start verifying and accepting the project result. During G3 the handing over of the project starts. This also means that the closing phase of the project starts. During this phase the project should be accepted by the customer as well as the final reports and feedback. In optimal situation, this would also include gathering the lessons learned during the project for further improvement and continuous learning.

When going into the last gate of the project execution, which is G4, the project is decided to close. At this point of the project, all of the results should already be handed over to the customer and all of the reports and documentations should be done. For future improvement in project execution, it is extremely important to gather all the feedback and lessons learned from the customer to gather information to company's database for future knowledge and also for learning material for newcomers.

Below is a sample picture of Etteplan's current gate model taken from Etteplan's project portal. The current phase of the project can be followed through gate progress in real-time from the portal. As already mentioned, the responsible for this follow-up is the lead engineer or project owner in case of small and medium sized projects. For large-scaled projects, the responsible is project manager.

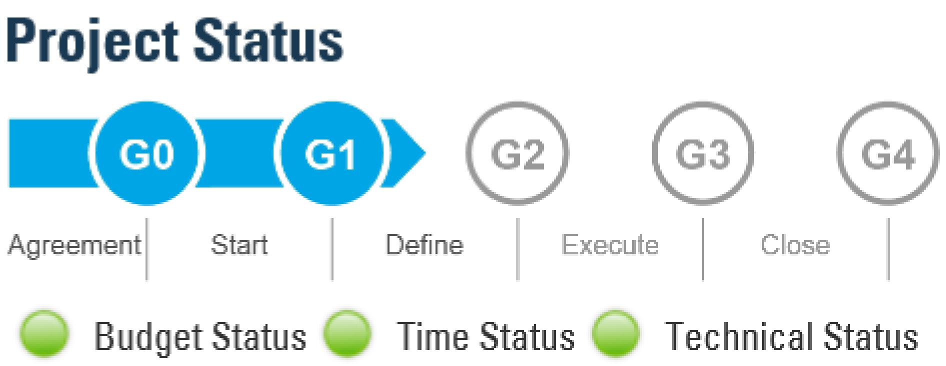


Figure 13. Sample picture of project gate-model from Etteplan's project portal (EPP).

As the above figure shows, there are five different gates. The gates are named as follow starting from the first gate:

- Gate G0 = Customer order
- Gate G1 = Project organized
- Gate G2 = Project planned
- Gate G3 = Project work implementation ready

- Gate G4 = Decision to close the project

The above mentioned names are according to Etteplan's official models for gate-model. To make this model even more transparent and dynamic, some major milestones will be involved to this process that would fit to the dynamic project environment. One of the most important milestones are e.g. quotation completion, design process acceptation, project handover and feedback & lessons learned. Below is an example of a proposal for a gateway model for handling of small and medium sized projects.

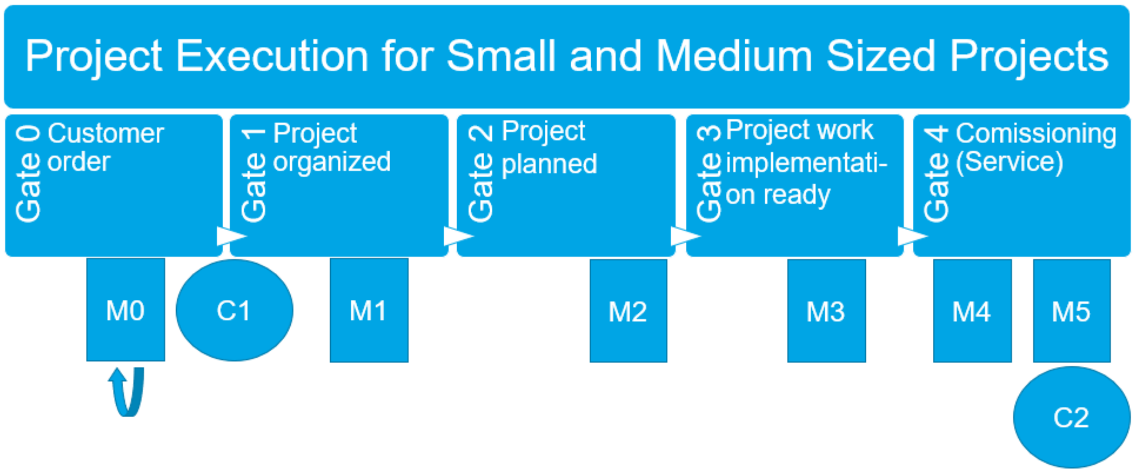


Figure 14. Project gate-way model for small and medium sized projects including important milestones and checkpoints for projects execution.

In the above picture the boxes marked e.g. M0 is a Milestone, whereas e.g. C1 is a checkpoint. Milestone is described as a significant event during a project which often includes completing a certain major deliverable to proceed forward in the project. Thus, they are key events or they are part of a sequence of activities which are made to assure that the requirements for that current milestone and point of project are being met. (PMBOK Guide, 2000). Milestones can include a start date and finish date to make the milestone better defined.

Checkpoints on the other hand are in the gateway model to remind and structure the important points in the projects execution so that the key information and other documents and details go from one unit to the other efficiently. E.g. in case of C1 which is the handing over from quotation phase to execution phase, the checkpoint lists the most important documents and details which should be at least given before proceeding to the next gate as a confirming step.

The actions for the milestone and checkpoint abbreviations in figure 14:

- M0 = Quotation completed
- M1 = Design process acceptation
- M2 = FAT or SAT tests
- M3 = Approval from the customer
- M4 = Project ready for handover
- M5 = Feedback & lessons learned
- C1 = Handover from quotation phase to execution phase
- C2 = Handover from execution phase to customer

## 4.4 Risk management plan

According to the research done by Kalliney (2009), good upfront plan for the portfolio including risk management increases the stability and predictability of the projects as well as makes the management process more dynamic due to better understanding. As Shi-Qi & Yong (2007) phrase, between risk and return the relation will always be subject of finance. It is said that often a high reward is accompanied with a high risk. The efficient, broad and precise usage of tools and methods is often seen as a comprehensive risk management plan (Suominen, 2003: 27-32).

Due to continuously new risk management methods for project management, such as decision tree analysis (DTA), the risk management is progressing towards a more thorough scheme to analyse risks based on the influence of risk elements (Li et al., 2008). However, as this thesis and the portfolio is seeking for a dynamic and fast-paced solution for risk management, there cannot be chosen a complex tool with too many steps. Instead, a clearer and easily repeatable method responds to the dynamic needs.

When rationally thinking from the point of view of a stakeholder in this situation, the optimal target for the investor is to be able to maximize the return whilst also minimizing the risk. Generally speaking, this can be described within three different types of risks, which are limited risk, limited return and lastly a trade-off between the risk and the return. Shortly, limited risk means that under that certain level of risk the goal is to maximize the expected return. On the other hand, limited return means minimizing the risk under that defined return level. Lastly, the trade-off is about balancing the end return between the risk and return to optimize the situation. (Shi-Qi & Peng, 2005). Exploiting this in our portfolio, we can think of managing the portfolio in such manner that the risks and returns are closely viewed by estimating the above mentioned situations. As mentioned in the article by Le (2004), the key points for selection criteria should at least be with these remarks: must be objective, unambiguous and measurable, the quantitative criteria should be ranged by an upper and lower limit as well as the qualitative criteria must be evaluated as including or excluding. These above given hints help in making the risk management process more transparent.

Criterion crucial for the organization and portfolio, such as payback time, market acceptance, percentage of sales and engineering contribution, a four-pointed criterion could be used for evaluation. These evaluation criteria are e.g. low, fairly low, fairly high and high, which correspond to evaluation on a scale from 1 to 4. The management team or responsible team members should together decide on the values which fit into the evaluation criteria. After the evaluation, it has shown to be effective to present graphically the results, e.g. using bubble charts. (Le, 2004).

In a similar manner as lessons learned model, the found risks, both opportunities and threats, would be good to be listed out in a standardized way for future knowledge and training. Without a good listing of risks, the major risks may appear as big threats again in the future and cause delays to the project. By being already prepared for the biggest risks helps both the project lead and project team to have better knowledge and be better prepared.

# 5 CASE STUDY ON E&A DEPARTMENT PROJECT

"Case studies are a standard pedagogical tool used to initiate students into the practice of communicating in a professional workplace, both in business and in engineering practice." (Berndt & Paterson, 2009). Case study is a combination of collaborative training and involving the learned subjects in practice. The case study goal and mission are clear to the attendees. The content used for the case study can vary depending on the usage whether the topic is familiar or not to the participants. The goal of a case study is to involve to the subject so that they can better understand the purpose of the function, closely related to the objective of another popular trend gamification (Kokcharov et al., 2013).

In terms of the case study used in this thesis, the aim is to learn how to exploit and use the tools. In addition, this case study will proof the benefit of the results the tools give to the project. Furthermore, the aim is to give insight and teach the managers to work more efficiently and respond quicker to the situations (Kokcharov et al., 2013). Kitchenham et al. (2012) state that it is extremely important to gather a variety of different studies and sources as well as personal expertise when validating the results.

Case studies are described and related to the institution or organization so that the audience and students can get the most out of it (Bolinger et al., 2011). This is especially important as the amount of projects increase and the new workers need to be introduced and educated to the topic as soon as possible. When the topic is closely integrated with the engineering discipline, the attendees' interest is easily captured and motivated. It is an advantage to make a strategy for conducting the case studies so that it could be made as automated as possible to make the process more efficient and would require less continuous inputs (Di Nardo et al., 2013).

## 5.1 Project cases

This case study was conducted using three different projects to implement and apply the earlier mentioned methods and tools. The objective of this case is to exploit the benefits and present the results and give a proof of concept to the earlier introduced issues. The purpose of this case study together with all other case studies is to result in trustworthy end-result which require credibility, transferability, dependability and confirmability (Bass et al., 2018). These factors give the results and conclusions trustworthiness as well as reliability and validity for the organization.

First, the implementation of the methods and tools in the quotation phase was reviewed. After the quotation phase, the process of transferring the information effectively between quotation phase and execution phase was analyzed. Lastly, the processes in execution phase was reviewed whilst discussing how the implementing of new ideas could further improve and make the process even more dynamic. Having all of the data in the end, the information was concluded and a comparison between the old and new methodologies is formed.

**CASE 1: Authentic case study**

The first case study is an authentic project made for Stora Enso Packaging Oy on renewing the control unit for a cardboard packaging machine. The project of case study 1 is mainly focusing on updating the combined electrical and automation unit as well as the design of the operator's console by mimicking the old control system. Thus, the project team has to first work on forming a preliminary design from which they start the actual design work.

The project team has tasks such as:

-A new Siemens S7 -logic and programming programmable logic controller (PLC) and human machine interface (HMI), testing and commissioning of the new logics.

-Training the usage and controlling of the new updated system to the team members in Stora Enso.

-Update safety regulations to match to current regulation 403/2008

The quotation has a predefined estimate for the project duration and has described the main responsible for certain assignment. The quotation has specified certain regulations, such as for the case of the project documents, programming or other project specific matter is delayed due to changes made by the customer or change requests, which are not from Etteplan's proposal. For these occasions, Etteplan can request the hours as additional man hours and charge the customer accordingly. This applies also to delays from the subcontractors.

The pricing of the project is as follows:

-The quotations pricing is based on fixed price for design activities

-For testing and commissioning pricing is based on hourly wage

-Only the work in the quotation are included to the fixed price

-The estimate valuation for the whole project is around 38 000e

**CASE 2: Two new projects evaluated into the portfolio**

In the second case study the process of analyzing and evaluating two new projects into the portfolio was implemented as well as going through the execution of the project(s) which are applicable. Both of the case projects simulate real projects, which could be assigned by a customer to Etteplan.

*First project of case two*

The first project of case two is focused in updating the controlling system as well as the HMI layout. The preliminary description is provided by the case company, which includes the most important details.

The project team tasks are as follow:

-Updated Siemens S7 -logic to match the new specifications and human machine interface (HMI) design. Additionally, the testing and commissioning of the new logics.

-Training the usage and controlling of the new updated system and HMI.

The quotation has estimated the duration of the project to be approximately 1 month. As in the last case example, the quotation has specified certain regulations, such as for the case of the project documents, programming or other project specific matter is delayed due to changes made by the customer or change requests, which are not from Etteplan's proposal. In these cases Etteplan can request the hours as additional man hours and charge the customer accordingly, which is also applicable with delays from the sub-contractors.

The pricing of the project is as follows:

-The quotations pricing is based on fixed price for design activities

-In case of testing and commissioning pricing is based on hourly wage

-The work has been separately defined in the quotation

-The estimate valuation for the whole project is around 15 000e

*Second project of case two*

The second project analyzed as part of case two is the automating of a robotic system to hand e.g. prescribed medicines in the hospital or pharmacy. The case company already has the materials ready – they have a robotic hand as well as a station for distribution of the medicine. Also, they already have a preliminary system programmed, but it does not yet work as supposed and needs the expertise from Etteplan automation unit.

The project team tasks are:

-Updating the current system to answer to the needs of the customer. This means first understanding the software and then adjusting the commands to work flawlessly. Also, the project team needs to do the testing and teaching to the customer

-One year long guarantee of assistance when the system is in use and encounters with a problem. This is part of the quotation.

According to the quotation, the project duration is approximately 2 months with additional assistance with the system calculated alongside with the guarantee. As with the earlier case examples, the quotation has specified certain regulations, such as for the case of the project documents, programming or other project specific matter is delayed due to changes made by the customer or change requests, in which the same rules are applicable as with the two earlier cases.

The pricing of the project is as follows:

-The quotations pricing is based on fixed price for programming activities

-For testing and commissioning, the pricing is based on hourly wage

-The work has been separately defined in the quotation

-The estimate valuation for the whole project is around 15 000e

### 5.1.1 Quotation phase

In the quotation phase the aim is to be able to answer the customers' needs and requirements as quick as possible and form a quotation for review. This phase may need some iteration rounds before the final version of the contract is ready.

Evaluation tools:

-Funnel and filter

-Historical review for features and pricing of old projects

-Criteria-based checklist (feasibility using KRI's & KPI's)

**CASE 1:**

The project negotiations started on the 8th of October together with Stora Enso. The next meeting about the safety of the production line was held on the 19th of October. The draft of the first version of the contract was made on the 7th of November. The first contract revision, revision A, was sent to the customer on the 26th of November. There were made three revisions in total: revision A, B and C until the contract was accepted by the customer.

During this process there was not used any kind of check-list. Instead, the contract was fully made by negotiating about the final pricing methods and quotation terms. The main goal of the negotiation is to make clear of what terms are assigned for which party and that everyone understands the scope and the requirements. It is extremely critical for both parties to understand which assignments belong to the customer and to have a common understanding of what belongs to the offer. As already brought up in the quotation phase interviews in the beginning of this thesis, a checklist would be suitable in terms of concluding the most important parts for every quotation when negotiating. When performing enough quotation negotiations with the customer, the responsible person will learn important questions which would fill in most of the missing information, which then could be easily and sufficiently filled in as a checklist of questions for further usage (Lock, 2003: 57-61). The quotation differs a lot whether the customer wants a full delivery project or just a part of the project to be done by Etteplan.

In this project, the lead engineer used WBS for understanding and calculating the total price of the project more precisely. Because the project team had decided to keep a high level on documentation, the pricing of the project was made accordingly to have a longer schedule. The sketching and designing work requires a lot of hours from Etteplan project team, which requires a lot of time. This is due to working on an existing system – while making a unique platform or implementation, the project team can make their specifications them self from the beginning. However, in this case the project team first needs to fully understand the existing process and then start implementing the new process and think of totally new improved systems.

First quotation review with the customer was held on the 10th of January, which also included the extra quotation for the security implementation to the process line. At this point of the negotiations it was not fully clear what the customer wanted, as there were many additional suggestions to the quotation. Therefore, Etteplan conducted a specified quotation to fit to the suggestions and to make a sense of the project proposals. On the 31st of January there was the second revision round with the customer to which they wanted a few additions concerning the quotation. The add-ons from the negotiations from the 31st of January were then added to the quotation and the final revision was sent to the customer on the 25th of February which was then ordered. (Leinonen, 2019).

Overall, this process took from the first negotiations to the finalization and ordering the contract a total of 5 months. As the situation is often so that the customer has a certain amount of money to invest to the certain project, it is crucial to try to make a contract that would fit the both parties interest the best. There is also a conversation going on about an additional mechanical design implementation to the project which of course would include an additional quotation.

Referring to the earlier mentioned Etteplan's quotation, review and authorization protocol, which states that the quotation process typically takes approximately 8 days when based on a clear request for quotation and technical specification, we can conclude that this process took too long to finish. According to Leinonen (2019), this negotiation could have been compressed to a one month long process. The reason for the length of this process is mainly due to the need of initial design needs and the extended negotiations about the scope. Despite the extension in the project there was not any significant additional to the total cost.

**CASE 2:**

The initial discussions for both of the new projects have been done by the sales persons and the project requests have been taken into consideration in the electrical and automation departments. To begin the early stage evaluations to determine which projects should be put out to quotation reviews and finalize, the project request form (PRF) is filled inside the project organization to find out the potential projects which fit to the project portfolio. After the PRF, the project business plan (PBP) is done to make better estimates for the final quotation to the customer.

1. PRF

Table 4. KPI's and their evaluations per project for the two new projects in the case.

| | **PROJECT NUMBER** | | | | | | |
|---|---|---|---|---|---|---|---|
| **KEY CRITERIA's** | PR1 | PR2 | PR3 | PR4 | PR5 | PR6 | PR7 |
| Payback ability (3) | 2 (6) | 2 (6) | | | | | |
| Scope (4) | 4 (16) | 3 (12) | | | | | |
| Feasibility (3) | 4 (12) | 3 (9) | | | | | |
| Capabilities (in house) (3) | 4 (16) | 3 (9) | | | | | |
| Knowledge of business area (2) | 4 (8) | 3 (6) | | | | | |
| Related experience (2) | 4 (16) | 2 (4) | | | | | |
| Resources (3) | 2 (6) | 2 (6) | | | | | |
| **TOTAL POINTS:** | 80 | 52 | | | | | |

Due to Project 1 being the only one that exceeded the minimum allowed points (60 points) in the key criteria table, only that project will continue to the next steps of the evaluation. Thus, even though the KRI's are part of the initial steps of the quotation phase evaluations, the risk identification of project 2 will be left out due to the low score in the above evaluation. The evaluation is made strict and standardized to make the process transparent and straightforward – keeping the evaluation as stabilized as possible and therefore dynamic.

The key risks of the project is in an optimal situation observed in the early stage of the project. Because the case project is familiar in terms of scope and deliverables to the project team, it should not consider any major risks. However, one key risk is the lack of resources in-house during the project execution phase. Even though the project type is familiar to quite many, the amount of experienced professional with earlier knowledge and whom are not occupied at the time could be lacking. Thus, lack of resources or inexperienced resources is one risk. Another risk is related to the payback ability – even though the customer has approved of their capability to payback, there is some suspicion about the final payback ability. Because the customer is new to Etteplan, there has not been any type of earlier feedback. Below is the KRI table formed for project 1 from case two:

Table 5. KRI's for project 1 in case two after preliminary evaluations.

| RISK IDENTIFICATION | PREVENTION PLAN | PREVENTION METHOD |
|---|---|---|
| **Description:**<br>Lack of resources / inexperienced resources<br><br>**Impact:**<br>Delay in project execution | **Plan:**<br>-WBS in the beginning to figure out the complexity<br>-Communicate the scope to project team<br>-Early work task prioritization<br>-Continuous monitoring of progress<br>-Transparent and open communication inside project team and with the stakeholders | **Method:**<br>-Continuous monitoring of the current project needs and prioritization of the project resources. |
| **Description:**<br>Payback ability of the customer | **Plan:**<br>-Include payback time frame in the contract<br>-Surcharge if payment is delayed | **Action:**<br>- Transparent communication with the customer and highlight contractual regulations |

| | | |
|---|---|---|
| **Impact:**<br>Prolonged payback; Not able to payback at all | | -Explicitly detailed quotation |

As project 1 is the only project that got through the first level funnel and filter evaluation, only that project is taken to the project business plan (PBP) evaluation.

2. PBP

The first project of case two was chosen to continue to the next phase of the evaluation process because it is satisfying the portfolio's needs in terms of projects. Project type is familiar to the project team in Etteplan, so the implementation could be started of soon after the project is kicked off. Working closely with the case company's project team, Etteplan is able to modify the new system to match perfectly to their needs and form a more reliable and efficient system for usage. This update will significantly increase the monitoring efficiency as well as increase the quality of the system by being more precise and effective.

Return on investment (ROI) is one of the metrics used to evaluate the project. The purpose of this calculation is to forecast the profit gained from the projects lifecycle. An estimate for the projects costs for Etteplan, including the work hours, trainings, resources et cetera, adds up to the investment from Etteplan to be 11 000 euro's. The project cost for the customer, meaning the gain from the investment, is 15 000 euro's. ROI calculation can be easily implemented by using the following equation:

$$ROI = \frac{Gain\,from\,Investment\ -\ Cost\ of\ Investment}{Cost\ of\ Investment} \tag{2}$$

Putting the above mentioned values into the equation, results to ROI = 26,67%, which means the projects returns a 26,67% profit to Etteplan. This percentage-amount of profit equals to 4000 euro's.

The net present value (NPV) is more applicable in larger scale projects, so this tool will not be used for this small project type. Additionally, NPV is a better tool for the execution phase of the project due to the quarterly or yearly follow-up method. Also, the risk assessment matrix (RAM) is not dynamic enough to use for this stage of evaluation. Thus, these two methods do not support the dynamic approach in this section. As earlier mentioned, only the two levels of the three-leveled funnel and filter is brought into the case study.

Through the analysis done above, we can conclude that the project 1 from case two is fit to the project portfolio. The project quotation is finalized and transferred from quotation phase to the execution phase.

### 5.1.2 Communication between the phases

**CASE 1:**

The projects execution phase was started by having a kick-off meeting with the project team members. Because the project included both electrical and automation design and the participants were not able to attend in the same place and same time, the kick-off meeting was held separately. The kick-off meeting was held for the electrical designer via Skype because he was not able to meet in person. The two automation designers are both in Vantaa department so the communication and kick-off meeting was easily held for them in person.

In this case the project is relatively small and thus the communication between the project team is easy and effortless. As this project was already done before the new implementations, the project specific data were communicated using their own chosen methodologies. The communication standards, including the communication of the project process and communication between the different disciplines, was organized by weekly follow-up meetings by the lead design engineers.

**CASE 2:**

When the quotation has been accepted and contract is valid, the project team lead will kick-off the project together with the project team. The key details of the project would be optimally generated straight to the PowerPoint, which could be easily demonstrated and given to the team members. In this case, as the project is relatively small, the project only consists of one person additional to the project lead. Therefore, the communication is only between these two personnel inside the company.

The project lead decides how frequently the project progress is reported within the team and also how often the details should be documented and communicated to the customer. As the project takes one month according to the quotation, the schedule needs to be precise and the documentation needs to be constant.

### 5.1.3 Execution phase

**CASE 1:**

Currently, the project is already close to being finalized. As the contract was based on a fixed price for the design processes, the follow-up of the project has been simple. Currently, the electrical design work is around 2 week behind the schedule and thus exceeds the budget roughly 2 weeks. This has been due to as earlier mentioned preliminary design activities. The lead design engineers have been following the process by looking at the project hours used and compared to the original planned hours for that certain time. This gives a good overview of the current situation.

The automation design process is also quite close to being finalized. This work has been closer to the original planned budget. There will also be additionally mechanical design work when the project team has come to a deal with the customer about the final price and design metrics for the mechanical work.

**CASE 2:**

The project team is part of the weekly electrical and automation department progress meeting, where the overall progress and resource handling of the department is discussed together as well as the risks and pain-points. This is a valuable time to discuss also about alerting factors and if needed, discuss about changes in the projects scope or plan.

Working hours can be documented and visualized using project tools such as Maconomy generating work progress figures. Also, open communication within the team helps to detect difficulties and solve challenging objects. The progress of the project can be also followed by watching at the milestones of the project life-cycle. As the regular project model consists of five gates (Gate 0 to Gate 4), the project lead can express the most important factors of each gate as well as bring in the contractually important factors for the phase. Comparing the actual project data (e.g. schedule and budget) versus the projected data, it is easier to estimate the actual time left for handover.

### 5.1.4 Case study wrap-up and comparison

The case study consisted of two different case studies presented one after another in each step. The project in case one was a real-life case which had already been mostly implemented to the customer. Therefore, this case study was based on interviews and historical data of the project. In case study two, the two projects were evaluated using the methods and tools presented in this thesis and made the process correspond to a realistic situation.

The first case verified the need of a more dynamic approach in both quotation phase and execution phase. Already during the quotation phase the project was delayed from the original plan due to extended negotiations about the scope and Etteplan's demand to make a thorough preliminary design and research to form a accurate design solution. Therefore, the original 8 days for quotation process would have been unreachable. However, as already mentioned, Leinonen (2019) described the process could have been finalized in a month instead of taking a total of five months. This proves the importance of having a standardized method to manage the project quotations as well as that the responsible person is dedicated to execute it in the chosen manner. The quotation process must be therefore managed as a holistic process using the given methods and tools in the thesis to enable the maximum benefit and efficiency of the whole portfolio.

The second case allowed the implementation of the tools by using simulated case project data. Tools were especially utilized in the quotation phase, which was also seen as the most problematic phase of the project in case one. The effective application of project request form (PRF) and project business plan (PBP) enabled the identification that the other project was not fit to the project portfolio. KPI’s and KRI’s accompanied with the financial tools and project selection criteria qualified the projects with straightforward ranking. This indicates the actual value of using these mentioned methods as part of the management of simultaneous quotations.

Due to the dynamic nature of the projects, the execution phase is not easily proven through case studies. Therefore, it is mainly justifiable through the interviews and research based proof of the concepts. The most important part for a successful execution is the structured and efficient communication of the important data of the project to the project team. When the generated quotation model is utilized, the communication is enhanced significantly. Thus, the whole process time is decreased and mistakes due to misunderstanding and miscommunication are mostly mitigated. This also helps in assisting the management of the whole portfolio budget by communicating and keeping the portfolio return on investment (ROI) aligned with the strategy and vision (Project Management Institute, 2008).

## 5.2 Machine learning implementation for project

As an additional part for the thesis, a machine learning based solution was implemented to further show methods in how to make the process even more dynamic. The usage of such tools is increasing in organizations and helps in achieving more precise predictions and support other project portfolio management tools. Machine learning (ML) is getting omnipresent in every business by its ability to work as a tool to help with decision making whilst keeping the accuracy high. This is seen especially within tools concerning neural network based learning platform. One of the neural network based regression tools is support vector machine (SVM), which was used as the tool for the this ML implementation case. (Han et al., 2017).

SVM as a regression tool differs from conventional technique by having included a structural risk minimization (SRM) implementation as part of it. SVM is capable of nonlinearly mapping the inputs enabling kernel representations. (Huang et al., 2004). Viewing at the origins of SVMs, it was a method which was originally made for binary classification problems, representing both object recognition and optical character recognition representations (Lu et al., 2007; El-Sawalhi, 2015). In this case, SVM is introduced as a binary classification tool due to presenting it in a simplified problem analysis case. For further improvements within the case company, the analysis can be extended into multiple input classification. Furthermore, this optimization tool can be exploited all the way to optimization using all of the data at once by using multi-class support vector machines (MSVM) (Lu et al., 2007; Wang & Lu, 2006). SVM model is constructed by first mapping the input vectors into the plot, to which the linear regression model is then executed to distribute the input vectors (Wauters & Vanhoucke, 2014).

Below is the mathematical model for SVM classification system, which involves the training for minimizing the error function based on article by Hsu et al. (2003):

$$\frac{1}{2}w^T w + C\sum_{i=1}^{N} \xi i \qquad (3)$$

The above function is subject to these constraints:

$$y_i(w^T \varphi(xi) + b) \geq 1 - \xi i \qquad (4)$$

$$\xi i \geq 0, i = 1 \ldots N \qquad (5)$$

The training of the above SVM model aims to predict the target values for the given test data values. The solution for the optimization problem is acquired using equation three having the constraints from equations four and five (Hsu et al., 2003).

In the above equations, capacity constant is marked as C, vector of coefficients as w, $\xi i$ is used as a parameter to handling inputs and b is a constant. Parameter for kernel function, marked as $\varphi(xi)$, is applied to transfer the input data to the feature space. The constant C determines the trade-off between the flatness of the final solution and the training error. When the value of constant C gets bigger, the less is the final training error. However, when the value is too big, the model starts over fitting, which should be avoided. (Hill & Lewicki, 2007).

Classification is done to provide a better access and understanding of items, context of the factors in the system and even form boundaries to which the certain factors are associated to. In addition, classification can reduce the complexity by giving a better access and view to the factors by presenting them in more clearly. Thus, the classification system can be effectively used in project management to provide better knowledge. (Crawford et al., 2002).

By analyzing the correlation between the factors and understand the trade-off between the risk and reward of understanding and taking input of the results of the regression helps in better decision making. As described in the article, as a part of Harvard Business Review articles, Ritter (2014) concluded a figure to present the correlation in the data highlighting confidence of the relationship of the data and do the benefits outweigh the risks. Next is the picture presented in the article:

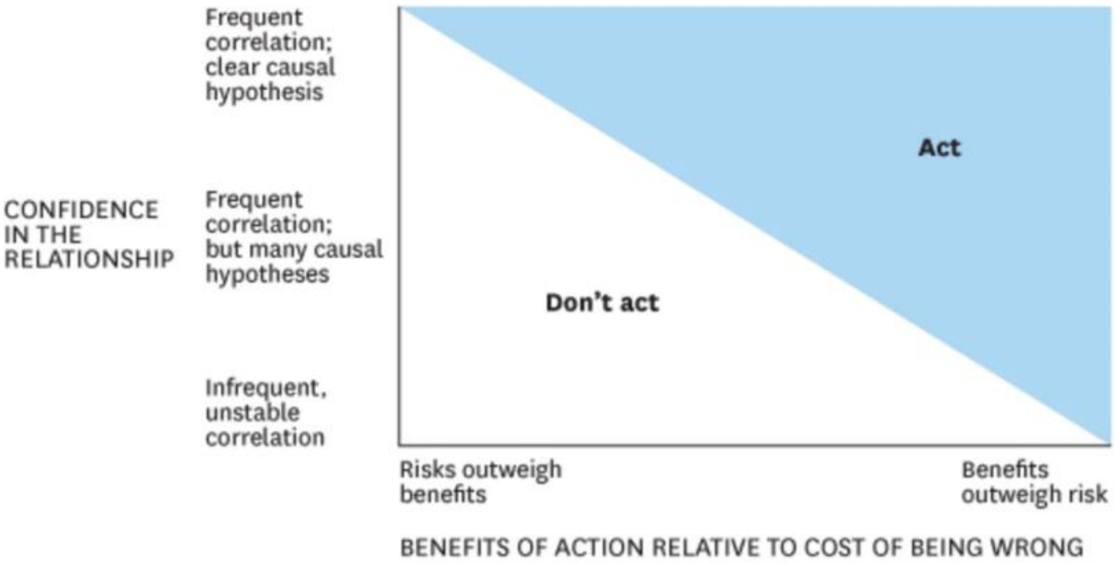


Figure 15. A figure presenting the correlation between the factors and when to act accordingly (Ritter, 2014).

Apart from the above figures straightforward act or do not act setup, in this case the correlation scheme will provide support in helping to realize whether the project would fit to the dynamic approach or does the project need more in-depth management methods. When taking the implementation further, the correlation can be used as shown above to manage risks and help in many types of decision making schemes.

Similar to most of development processes, the implementation the evolving of ML in industries does not happen immediately. Instead, it is best to be done step by step with clear goals and milestones as with every process. Figure 16 in the next page shows the evolving of ML and deep learning (DL) in industries starting from the prototyping phase all the way to making the processes autonomous.

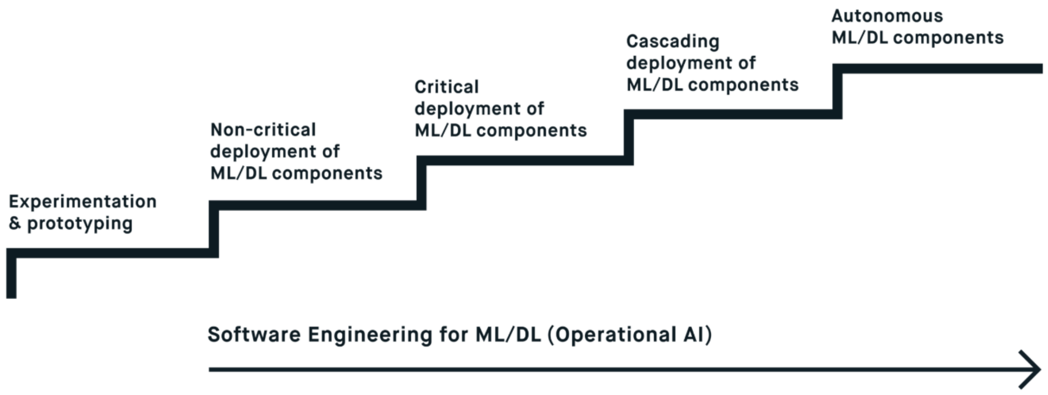


Figure 16. A sample process delineation of ML and DL in industry while implementing software engineering (Bosch, 2019).

A key factor in the process described above is to have sufficient quality throughout the development, and thus maximize the efficiency (Bosch, 2019).

### 5.2.1 Support vector machine (SVM) implementation case to simulated project data

The SVM implementation was done by using online-scripting software. During the scripting part, Python-coding language was used due to its efficiency as well as compatibility with the usage of SVM. Jupyter software was used as it has easy usability as well as that it has all of the packages ready for Python, whereas usually the packages need to be downloaded separately.

To begin with the preparation for the SVM analyzation, packages are imported for analyzation and visualization of the data. This is formed by importing ready packages to the script by making simple commands such as in the figure below:

```
# Packages for analysis
import pandas as pd
import numpy as np
from sklearn import svm

# Packages for visuals
import matplotlib.pyplot as plt
import seaborn as sns; sns.set(font_scale=1.2)

# Allows charts to appear in the notebook
%matplotlib inline

# Pickle package
import pickle
```

Figure 17. Import packages to the system for getting ready with the analyzation and visualization.

Next, the data is loaded in to system. To be able to do it, you have to be aware of the file location. The file can be as well loaded already in to the system files in the software. The file format needs to be as '.csv' to be compatible. Using the earlier imported packages, the loading of the data is easily done by using below shown command line:

```
# Read in the data from the library for projects
df = pd.read_csv('datasets/case_tutkimus.csv')
df
```

Figure 18. Command line for reading the dataset used for the implementation project.

As on output of the above figures dataset, the system sets as an output the given data in the form set in the file, as shown below:

| | Type | Cost | Earlier knowledge | Complexity | Resources | Deliverable |
|---|---|---|---|---|---|---|
| 0 | Proj A | 1 | 2 | 1 | 1 | 1 |
| 1 | Proj A | 1 | 3 | 2 | 2 | 2 |
| 2 | Proj A | 2 | 1 | 1 | 3 | 2 |
| 3 | Proj A | 2 | 3 | 2 | 2 | 3 |
| 4 | Proj A | 1 | 2 | 2 | 1 | 2 |
| 5 | Proj A | 2 | 1 | 3 | 1 | 2 |
| 6 | Proj B | 3 | 3 | 4 | 1 | 3 |
| 7 | Proj B | 3 | 4 | 2 | 3 | 3 |
| 8 | Proj B | 3 | 2 | 4 | 3 | 4 |
| 9 | Proj B | 4 | 4 | 3 | 4 | 4 |
| 10 | Proj B | 3 | 3 | 4 | 3 | 3 |
| 11 | Proj B | 3 | 2 | 3 | 2 | 2 |

Figure 19. Simulated project specific data for factors such as cost, earlier knowledge, complexity, resources and deliverable.

The project specific data were chosen randomly scaling the points from 1 to 4. The project types were chosen to be Project A, abbreviated as Proj A, and Project B, abbreviated as Proj B in this case implementation. Project A consists of the small and medium sized projects which are the ones studied in this thesis. Project B consists of the larger projects, which are for example projects that are priced above 80 000 euro’s and are often more complex, needs more resources and consists of more deliverables. The aim of this support vector machine system is to be able to plot project specific data into the graph and view if the given data would describe the project to be included in the small and medium sized projects with more dynamic project management methods, or would it need more complex methodologies and tools as for larger sized Project B projects.

Next step is to plot the data to see how the data for the projects are scattered in the figure. To make the plotting easier and compatible with a simple two dimensional graph, complexity and resources were chosen as the factors to present the differences between the projects. This is of course not the most efficient choice for every type of project, as for example the deliverables have a great impact in the complexity and resources. Therefore, it is recommended to take the deliverables also into account in some occasions. The figure below shows the simple command line to plot to of the chosen factors into the plot:

```
# Plot two factors
sns.lmplot('Complexity', 'Resources', data=df, hue='Type',
           palette='Set1', fit_reg=False, scatter_kws={"s": 70});
```

Figure 20. Command line to plot two of the chosen factors into the plot.

As the output of the above command line comes the plot below:

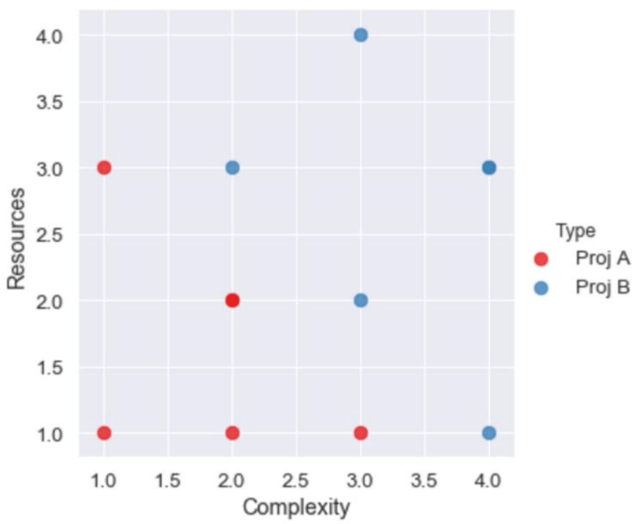


Figure 21. Resources and Complexity shown as a plot, based on Project A and Project B data.

After plotting the data we can see how the data is scattered. Next, the inputs are prepared for performing SVM model for the final hyperplane to separate and categorize the data. The inputs specified below were used to form the fitting of the SVM model for optimization of the hyperplane.

```
# Specify inputs for the model
# factors= df[['factor','factor']].as_matrix()
factors = df[['Complexity','Resources']].as_matrix()
type_label = np.where(df['Type']=='Proj A', 0, 1)
```

Figure 22. Forming the two inputs ‘factors’ and ‘type_label’ for the SVM model.

Now that the inputs had been specified, the fitting of the SVM model was done by using the below shown inputs:

```
# Fit the SVM model
model = svm.SVC(kernel='linear')
model.fit(factors, type_label)
```

Figure 23. Fitting the SVM model using kernel function.

Next step is to further specify other inputs for the hyperplane using the models coefficient values and determine the support vectors. Below are the command lines for all of the additional inputs needed for the hyperplane and support vectors:

```
# Get the separating hyperplane
w = model.coef_[0]
a = -w[0] / w[1]
xx = np.linspace(1, 5)
yy = a * xx - (model.intercept_[0]) / w[1]

# Plot the parallels to the separating hyperplane that pass through the support vectors
b = model.support_vectors_[0]
yy_down = a * xx + (b[1] - a * b[0])
b = model.support_vectors_[-1]
yy_up = a * xx + (b[1] - a * b[0])
```

Figure 24. Inputs for finalizing the hyperplane and support vectors for the SVM model.

Lastly, using the above specified inputs, the plotting of the hyperplane to the given dataset was done. The command line for plotting is similar to the above mentioned plotting command, except that there needs to be plotted the additional hyperplane to fit to the dataset.

```
sns.lmplot('Complexity', 'Resources', data=df, hue='Type', palette='Set1', fit_reg=False, scatter_kws={"s":70 })
plt.plot(xx, yy, linewidth=2, color='black');
```

Figure 25. SVM model for plotting hyperplane to the dataset.

The output of the above shown command line is shown below:

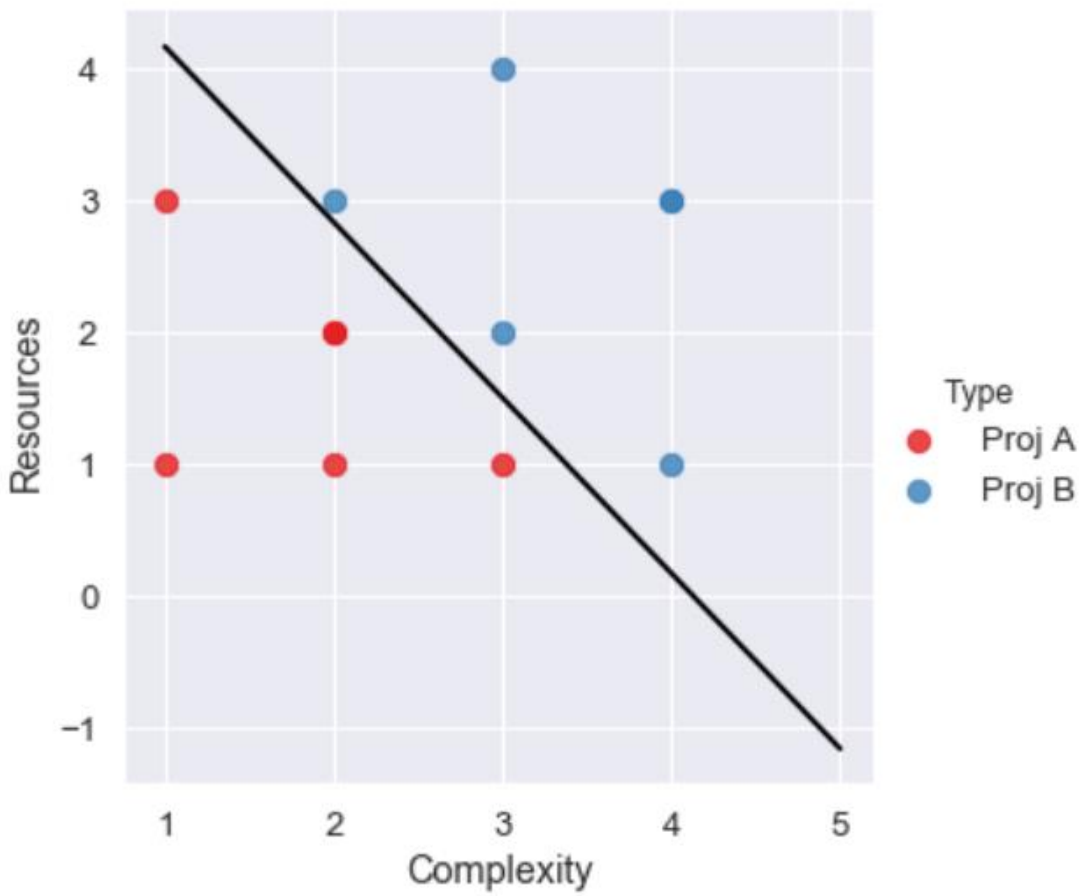


Figure 26. SVM model for plotted dataset and hyperplane separating the data.

As seen from the figure above, the hyperplane separates the two project types based on their resource and complexity factors. The data representation is expanded by simulating new inputs to the plot. Based on the hyperplane, the location of the new inputs in the plot determine whether the input belongs to group Project A or Project B. A simple example is shown next:

```
# Plot the new random points to see to which project it fits
sns.lmplot('Complexity', 'Resources', data=df, hue='Type', palette='Set1', fit_reg=False, scatter_kws={"s": 70})
plt.plot(xx, yy, linewidth=2, color='black')
plt.plot(4, 2, 'yo', markersize='9');
plt.plot(4, 1, 'go', markersize='9');
plt.plot(2, 1, 'co', markersize='9');
plt.plot(3, 3, 'mo', markersize='9');
```

Figure 27. Command line for implementing a new points to the plot with randomly chosen values.

The command line from figure 27 gives as an output the similar plot as shown in figure 26 but with additional new plot points, which are the new simulated projects. The projects are marked as yellow (‘yo’), green (‘go’), cyan (‘co’) and magenta (‘mo’) in the script. Below is the new figure:

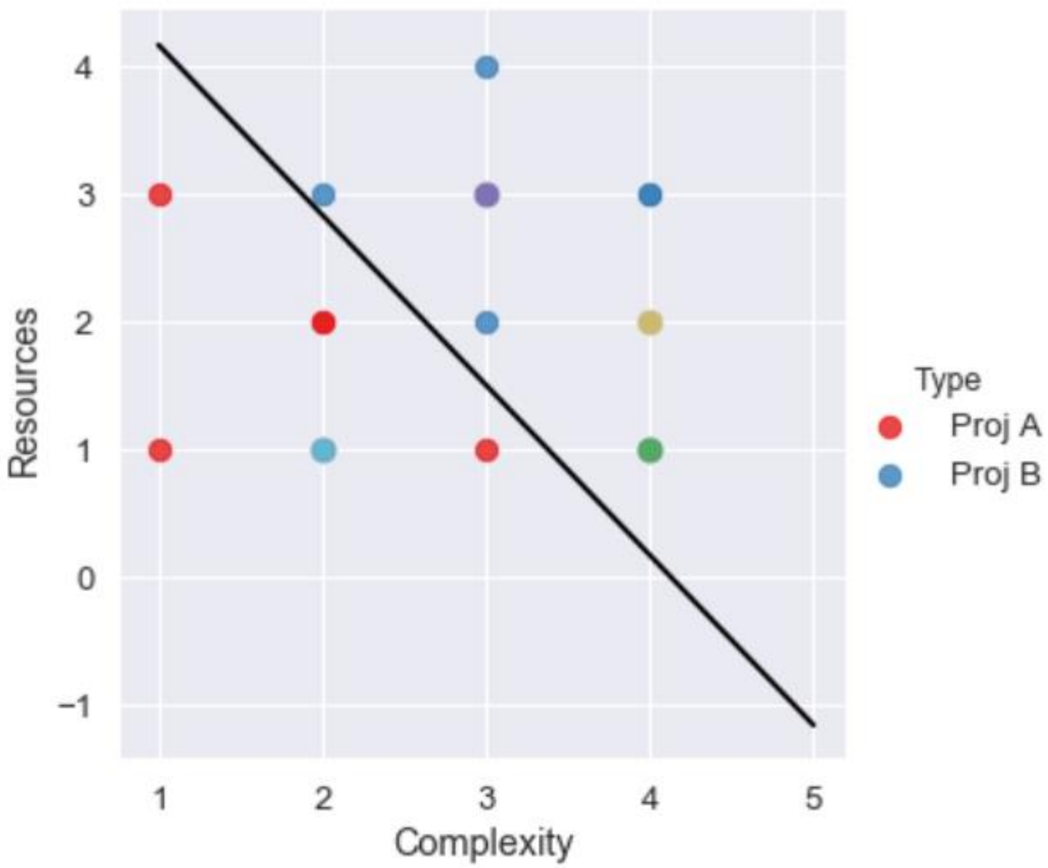


Figure 28. Plotted data set with new input points marked with different colors.

The figure above shows that the new project points, projects yellow, green and magenta, are above the hyperplane and thus belongs to group Project B. The new project with the color cyan belongs to group Project A, so it is a fast-paced project. The similar categorization could be done by forming a function to predict according to the amount of resources and complexity whether the project belong to group A or group B. An example of a function to solve this problem is shown below:

```
# Create a function to predict if the new input belongs to Project A or B
def ProjA_or_ProjB(Complexity, Resources):
    if(model.predict([[Complexity, Resources]])==0:
        print('Project belongs to Group A')
    else:
        print('Project belongs to Group B')
```

Figure 29. Function for predicting the projects group based on complexity and resources.

Using the if- and else-clause, the function predicts to which group the project would belong. Thus, this helps the manager to make the decision straight away. The function works by putting values for complexity and resources to the above set function as shown below:

```
ProjA_or_ProjB(3,3)

Project belongs to Group B
```

Figure 30. Example of setting the function and the output of this function.

The function goes through the if- and else-clause and gives an output based on it. In this case, the output is: ‘Project belongs to Group B’.

This SVM implementation study proofed the opportunities of using SVM as a tool for project management. The purpose of this case was to give an overview of the capabilities and consider of how to further implement this type of an approach. As earlier mentioned in the beginning of chapter 5.2, the most efficient implementation could be used in risk management and other decision making schemes where the characterization is more clear and the boundaries are set firmly. Additionally, through risk analysis the managers may estimate the project costs probability distribution for better understanding of the project pricing and bidding (Pentico, 1985). In this case, the outcome does not display additional value to project decision making, but does show opportunities.

## 5.3 Business aspects and feasibility

As business processes are in the core of the efficiency of an organization, it is extremely important to be aware of the capabilities of the processes and understand how to execute them in the most effective way. Not only does this mean the continuous development of the processes, but also bringing in new innovations and ideas to make the process more dynamic. Business processes can be very complex and needs high detail modeling to make the process transparent. Also, the effect of certain elements in the business helps to understand how the process is executed. (Lodhi et al., 2009).

These types of business processes need to be constantly improved and should be able to answer to the changing requirement needs. The organizations ability to answer to change is a increasing trend in business world. (Boukhebouze et al., 2009). In the case of this thesis, we have been exactly answering to the new requirements by the business – both for Etteplan and for the customer. For example, the ability to increase flexibility and be more dynamic to answer to the changes in a project helps in executing projects more efficiently. The automatization of processes such as project model for project team and customer help in mitigating the errors of communication and maintains the transparency. This on the other hand corresponds to making the team more aware of the project clauses, and therefore increases overall awareness of costs and impacts of the changes in the project (Boukhebouze et al., 2009).

The flexibility of the project team as well as automation of business processes is needed to be able to respond to dynamic business aspects (Milanovic et al., 2011; Eijndhoven et al., 2008). Well organized communication accompanied with consistent follow-up of the project is the key in project environment. By keeping the communication transparent and understanding the requirement of the customer, it is easier to respond to upcoming change and requests.

As the project environment is indeed dynamic in the departments introduced in this thesis, the need and feasibility of these models and techniques is actual.

## 5.4 Financial impact

While there is a clear financial impact in this implementation process, the whole change management and development project needs the support and approval of the management team to enable the thorough implementation and realization as efficiently and rapidly as possible. Often, the lack of managerial support has lead to a poor end result due to not having enough resources and enough incentive for the new development. It gives a positive impact to the process when there is an organization-wide trust. The overall process improvement helps in increasing the total revenue of the departments by enabling the strategical prioritizing of projects, answering to offers faster and optimizing the resources and time (Cooper et al., 2001).

Enhanced communication improves satisfaction with customers and stakeholders. This enables a possibility for continuous customers and better relations in the future. Customer experience has become a central part of companies producing service and products and thus needs to be in high value within Etteplan's processes. These values are improved within the processes introduced in the thesis by *creating more value* and better cost-effective solutions. Conformance of requirements, meaning generating what has been said, as well as the real value of usage by fitting to the actual concept are in the core of high customer experience (PMBOK Guide, 2000). Thus, the financial impact can be concluded to effect both Etteplan internally by increasing the revenue and process productivity, and impact the customer by bringing better total value.

# 6 CONCLUSION

The object of this thesis was to combine the expertise of Etteplan professionals through interviews together with the knowledge gained from research and personal experience. Core objective was to *implement a model and way-of-working* for the electrical & automation department to *enable the project business processes more efficient and dynamic*. By forming explicit interviews and research, the subject was thoroughly examined and the best practices were exploited.

Kuisma (2019) expressed in the beginning the *importance of systematic, dynamic and efficient process* for managing a project in both its quotation and execution phase. Hietikko & Leinonen (2019) as well as Pukki (2019) supported the significance and gave valuable hands-on reviews from their project experiences. As the department managers, they had gathered the best practices and future improvement ideas through year of experience. In the quotation phase, the biggest flaw was noted in the efficiency of quotation reviews as well as keeping the process systematic and transparent within the project team and the customer. Also, the scope was not effectively communicated – this led to misunderstanding and team members unaware of the most important objectives in the project. On the other hand, this had sometimes occurred also as inefficient change management.

Transition towards execution phase needed improvement to be more dynamic – the current process was experience-based and relied on the understanding between the two personnel in the communication. The projects execution phase required *improved follow-up* and *transparency and efficiency* in the communication of the current process. Additionally, the full portfolio view was inquired for better understanding of the departments processes through a wider project view.

To gain a better understanding of the complexity of the scope and form precise budget and schedule, the usage of work breakdown structure (WBS) was seen as the key process (PMBOK Guide, 2000). Standardized checklists for negotiations with the customer accompanied with exploiting the former project data enables a structured process for consistent quotations. When working with simultaneous projects, funnel and filter method was noticed as a dynamic approach for evaluations. An automatically generated PowerPoint model of the scope and the important objectives of the project was noted as an potential approach to mitigate communication errors between the execution and quotation phase from the quotation (Pukki, 2019; Hietikko & Leinonen, 2019). This also improves risk assessment and preparation for the need of change management by *early stage assessments* (Project Management Institute, 2008). Improved follow-up and enhanced stakeholder involvement was acknowledged to help in boosting the customer experience value.

Case studies supported the positive effect of the improvements presented in this thesis by creating greater overall value. Strategical optimization and smart exploitation of tools offers faster responding to quotations and continuously efficient use of resources and time (Cooper et al., 2001). The additional opportunities found in the support vector machine (SVM) implementation case provided future improvement ideas and even more dynamic processing of quotation offers. Furthermore, the importance of providing machine learning (ML) solutions to the departments was expressed.

Overall, this thesis has provided tools and models to support the aim towards the value driven goals of these departments. Not only does this thesis provide ways-of-working, but also *opportunities and methods for future growth* and support overall experience of the key stakeholders. The overall improvement in the management will enable long-term financial impact through better competences (Turner, 2003: 31-33).

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