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Profit margin forecasting based on the project schedule, readiness and current margin in cruise ship outfitting projects

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Description

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Abstract

Profitability has always been one of the most important key elements for sustainable businesses. Cruise ship outfitting projects are large scaled, complex and long-term projects which profit margin is crucial to keep in the target from start till the delivery. The aim was to investigate the ship building specific project challenges for scheduling, readiness reporting and conduct a comprehensive theoretical background study in profit margin forecasting methods to bring up concrete proposals on how to forecast the profit margin more professionally and most importantly more accurately throughout the whole project based on the current schedule and readiness. A mixed method approach was selected for the search. The survey was conducted as quantitative research with specific participants who had experience in ship building industry and more specifically in the same environment where the research took place. A total of twenty-five responds were received and examined carefully with cross relations to bring up insights from correlations and frequency. Five different interviews were completed with people from different units to perform qualitative research. Different aspects of the research topic were discussed broadly, and the results were documented with coding method. As the main result from the conducted research and theoretical background study, earned value management (EVM) was proven to be the best fitting method in ship building projects as a tool for forecasting the profit margin to increase accuracy. In addition, correct and detailed construction of work breakdown structure (WBS) was crucial for success together with improving cross functional teamwork between project and planning to maximize the effect of EVM.

Keywords/tags (subjects)

Profit margin forecasting, earned value management, cruise ship interior outfitting, project scheduling challenges, readiness calculation, readiness reporting, profit margin forecasting methods, project scheduling methods, risk evaluations in project operations, cruise ship building, accuracy in profit margin forecasting

Miscellaneous (Confidential information)

The study has been conducted under confidentiality agreement with Merima Oy. Thus, whole chapter 7 and sub-chapter 8.2 aren´t allowed to be published openly. The confidentiality agreement duration is 6 years and will end on 01/06/2031.

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1 Introduction

1.1 Background and motive of the study

One of the main cores of project management is the project triangle. As a principle, project triangle consists of quality, schedule and cost. A project is defined as successful when it is delivered within the agreed quality/scope, within cost/budged and on time. There is a challenging balance between these three fundaments and a project manager´s most important task is to ensure that this balance is in its best form throughout the project´s whole lifecycle. Combination of quality, scope and the budget have a direct effect on project profitability.

Throughout recent years, many industries have been financially affected negatively by serious events that took place on the earth. Some of these events are global financial crisis in 2007-2008, Covid-19 pandemic in 2020, Russia-Ukraine war and energy crisis in 2022. It is important to note that sectors, industries took years to recover from the negative outcomes. The cruise shipbuilding sector under maritime industry realized these outcomes heavily. Some projects in orderbooks for future years have been postponed or cancelled, meanwhile some projects in initiation phase totally stopped. Shipyards filed bankruptcy meanwhile shipowners become financially unstable. As a domino effect starting from shipowners to shipyards and to turnkey outfitting companies which are the focus of this study, have realized their share as a deep financial pressure. As an outcome of this financial pressure, profitability enhanced as a way out which later has been implemented into normal process in daily activities of outfitting companies.

End result(final) forecasting of the profitability during the project is as important as increasing the profitability. In another words, forecasting the final profit margin of a currently on going project is as crucial as growing the profit margin. This correct final forecasting creates many opportunities. Enables project managers to take corrective actions, finance team to arrange the cash flow accordingly and communicate/report the data with stakeholders like banks and investors openly.

The aim of this research is to study the theoretical background of project schedule, project readiness and project profit margin with the purpose of giving insights into the methods that may be used for forecasting final profit margin of a project in the initiation phase.

1.2 Objectives and implementations of the study

The main objective of this study is to understand the challenges behind correct, accurate profit margin forecasting as well as investigating the theoretical background and combining it with implementation results to make possible proposals and give wider understanding from best practices. It can be listed as below:

- Define the importance of project scheduling in shipbuilding and correlate it with project profitability and forecasting.
- Investigate the challenges of project scheduling in shipbuilding, meanwhile examining the good practices for quality control of ready project scheduling.
- Evaluate the project readiness calculation methods that are relevant to profitability forecasting.
- Review the literature genuinely for different profit margin forecasting methods.
- Conduct both quantitative and qualitative research to collect data and combine the outcomes with literature reviews to propose the best suitable current and possibly new methods into cruise shipbuilding projects, specifically to turnkey outfitting companies.

1.3 Structure of the study

Considering the very specific and detailed topic of the research, it might be considered as challenging to understand for people who don´t have previous shipbuilding experience. Therefore, the study structure is designed to give any reader who has different educational backgrounds to understand the topic and gain knowledge. To achieve this aim, firstly project schedule and project readiness categories widely take place to create fundaments as well as to highlight the importance of scheduling and readiness calculation in correct profit margin forecasting. The core literature review of this study is found under profit margin category. Different types of profit forecasting methods present professional insights. Readers grasp to use core fundaments of project management to deepen their knowledge on profit margin forecasting. Some methods contain more detailed information than others. The reason behind this is the thought of best matching practical implementations to shipbuilding industry.

Research methodology and implementations are specifically designed to answer both research questions as well as to create direct correlation between literature reviews. This aims to prove the best current methods of profit margin forecasting and to enable new proposals and ideas.

2 Research Outlines

2.1 Research objectives and questions

“Project managers are often the gatekeepers to the profits. They are charged with the task of maintaining the estimated profit carried in the bid, in addition to the profit that comes from negotiating, effective decision making, controlling the participants, and superior management of the schedule.” (Del Pico, 2013). As mentioned in this quote, profit margin and most importantly maintaining the estimated profit margin till the end of the project adds tremendous responsibility to project managers. The duration of an average cruise shipbuilding projects for an outfitting company approximately is two years. Project managers forecast the current profit margin based on that exact moment´s cost estimations but what about the profit margin in the end delivery of the project?

“In general, the higher the percentage of completion, the more accurate the forecast will be.” (Del Pico, 2013). This research seeks to investigate and provide currently available best methods for forecasting the profit margin correctly for future and possibly propose new solutions in shipbuilding perspective.

As described in chapter 1.3 Structure of the study, secondary research questions are characterized with the purpose of constructing better background knowledge to respond to primary research question.

Secondary research question-1: What are the challenges with project scheduling in the turnkey contracted cruise ship outfitting projects?

This research question aims to investigate the challenges in project scheduling in cruise ship outfitting projects. The purpose is to find answers, what are the root causes for these challenges and how it can be improved. Literature to be reviewed genuinely as well as providing valuable insights on quality control methods of a ready project schedule.

“Costs for schedule compression are a combination of the contractors (and subcontractors) direct and indirect expenses or costs.” (Del Pico, 2013). Insufficient project scheduling is high likely to put

the project team to fall behind the tasks and therefore force the project manager to take corrective actions. As quoted above, this can result in direct and indirect expenses or costs. Considering scheduling is counted as one of the main fundaments for correct forecasting, this research question is crucial to study.

Secondary research question-2: How to calculate the readiness of turnkey contracted cruise ship outfitting projects?

Correct and accurate readiness calculation in cruise ship outfitting projects play an important role for forecasting the profit margin.

“Based on different interpretations and goals, the project progress can be defined differently. Although more often one of these definitions seems to be superior in comparison with the others, it is clear that depending on the purpose and different points of view it can be correct.” (Angiz & Keramatpour, Developing a new method to determine the actual project progress percentage, 2021). The primary purpose of this research question is to investigate the different methods of readiness calculation and propose the best suitable methods for cruise ship outfitting projects with the perspective of profit margin forecasting.

Primary research question: Is there a scientific method or a formula for forecasting the future or possibly the end result profit margin of projects based on the current readiness, current schedule and the currently estimated profit margin at a random time during the project?

This is the core research question which the thesis is constructed around tightly. Once the theoretical background from the secondary research questions highlighted as fundaments, the primary question process will begin. Literature reviews are considered as key element and therefore, multiple types of forecasting methods to be studied. Besides this, the aim is to collect important data from both qualitative and quantitative research methods and combine them with literature review outcomes. Implementations to be listed to answer the research question and possibly propose new or alternative methods. It is important to note that the research question aims the specific sector´s specific industry and all implementations considered accordingly.

Considering the research question aims a specific field, some methods aren´t suitable totally for shipbuilding. In this case, the purpose is still to study the different methods and report the limitations in framework with research question.

2.2 Research methods

In this chapter, research methods are defined. The selected methodology is expressed and the reasons behind the selection are explained. The aim is to give a general overview of how and with what research is carried out.

“A quantitative approach is one in which the investigator primarily uses postpositivist claims for developing knowledge (i.e., cause and effect thinking, reduction to specific variables and hypotheses and questions, use of measurement and observation, and the test of theories), employs strategies of inquiry such as experiments and surveys, and collects data on predetermined instruments that yield statistical data.” (Creswell, 2003)

Profit margin forecasting, scheduling and readiness calculation. When the meaning of these three fundaments thought, perhaps the first a few common denominatore are numbers, statistics, calculations and data therefore being quantitative terms. In order to prove and provide effective methods for correct profit margin forecasting, it can´t be missed to use the benefits of quantitative approach. Carefully designed quantitative studies will help to create or utilize the general knowledge about phenomenon.

“Alternatively, a qualitative approach is one in which the inquirer often makes knowledge claims based primarily on constructivist perspectives (i.e., the multiple meanings of individual experiences, meanings socially and historically constructed. with an intent of developing a theory or pattern) or advocacy/participatory perspectives.” (Creswell, 2003).

Even though the phenomenon that will be researched is mostly related to quantitative terms, it will be a mistake to miss the qualitative factors and approch towards the study. Cruise shipbuilding has a history in each country and therefore has different traditions, differeny ways of working. This tradition or so called ways of working cases can be even different within the same country but in different shipyard. This general situation might effect the way scheduling, readiness calculating

and therefore profit margin forecasting. It is correct to categorize the qualititative effects as human factors in cruise shipbuilding.

“Mixed methods research is a methodology for conducting research that involves collecting, analyzing, and integrating (or mixing) quantitative and qualitative research (and data) in a single study or a longitudinal program of inquiry.” (Bulsara, 2015)

This research methods collects the advantages of both quantitative and qualitative approach to ensure the research implementations on strong grounds.

Selected methodology for the thesis:

A mixed research method will be implemented in this thesis to meet with objectives defined and answer to research questions widely. Numerical analysis, formulas and calculation results will be received from quantitative methods meanwhile human factors and their outcomes in the research will be implemented from qualitative approach. Even though research topics are highly covered by quantitative terms, there is still an extensive amount of personal experiences, way of approaches and opinions which can be implemented to select the best methods for profit margin forecasting.

Quantitative methods: Survey is selected as quantitative method for research. Outcomes to be shown in different graphs, tables and formulas. Surveys will be steered to gather more data on the research topic. Surveys will be designed in a logical way to receive only numerical outcomes about scheduling, readiness calculations and profit margin forecasting. Due to the nature of survey application, it is aimed to reach a broader selection of people both in number and with different backgrounds.

Qualitative methods: “There are three major sources of data for qualitative research study – interviews, observations, and documents.” (Merriam, 2002). In this thesis, interviews will be exercised mainly as qualitative method. Observations and documents are seen as another important tool for the thesis research questions, however due to confidentiality and time limitations, they won´t be executed.

The research topic is seen as a general challenge in shipbuilding outfitting projects for many turn-key outfitting companies based on personal experiences. This common problem makes the human factor more interesting and thus adds extra importance on qualitative methodology for data collection.

“Qualitative research attempts to understand and make sense of phenomena from the participant´s perspective. Interviews range from highly structured, where specific questions and the order in which they are asked are determined ahead of time, to unstructured, where one has topic areas to explore but neither the questions nor the order are predetermined.” (Merriam, 2002)

Interviews are planned to be conducted as semi structured. Some certain questions will be directed to each participant meanwhile it is aimed to take the time to discuss the research topic freely without the limitation of the same questions. Randomly improved idea exchange and encourage the interviewee to express his/her opinions freely. Interviews are seen fundamental to collect data to answer research questions in this thesis because the human factor in cruise shipbuilding is undeniable. Coding methods will be used for examination.

2.3 Research environment

The research is conducted and aimed at Maritime sector´s cruise shipbuilding industry. The research is carried out for Merima Oy in Meyer Turku shipyard in Finland. Two main reasons for research environment selection can be listed as the background of the author and the availability of shipbuilding outfitting companies in the shipyard and their long-term expertise on research topic. The quantitative data was collected from the actual projects which took place in the shipyard from the outfitting companies. The qualitative data was collected among the shipbuilding experts who are actively working or worked in the shipyard. Considering the number of available experts who has different educational backgrounds and talents in the cruise shipbuilding industry made the research environment valuable.

2.4 Data collection and sources

Surveys and interviews will be the data collection method of this study. These methods will also be the primary sources of data meanwhile, literature review will be the secondary data sources.

Surveys will be conducted in two different groups. One group will be pear students of the author in the same university, meanwhile the second group will be experts in shipbuilding at the shipyard.

Interviews will be executed with the shipbuilding experts from the shipyard. Experts will be selected based on different criteria. Selection details are mentioned in Chapter 6. Implementations.

As secondary source, literature review will be the main tool. Hard copies and e-books, case studies, articles, reports, lecture notes are some of the examples. Additionally, online tools will be used actively. Some examples are Google scholar, ResearchGate, Theseus, Statistics Finland (Tilastokeskus), YouTube, Open libraries of universities, project management institute, cruise industry news magazine.

It is important to note that open AI such as ChatGPT won´t be used as primary or secondary source at all but only will be utilized to find and reach secondary sources. Even in this scenario, fact check of the source will be conducted.

2.5 Ethics, scope and limitations

There are three main limitations defined for research. These limitations prevent the study implementations applicability in different industries, countries and even in different project types. This can be seen as discouraging; however, it will also enable other researchers to conduct numerous other studies in different environments for implementations.

The first limitation is the industry and project type. This study is aimed at cruise shipbuilding projects. More detailly cruise shipbuilding projects which are conducted by Turnkey contracted outfitting companies. Implementations might give different results for other types of projects or differ for the shipyards or subcontractors which are working with different types of contracts.

Secondly, research environment is another limitation. Cruise shipbuilding techniques, project management types and styles, managerial accounting applications in project management might differ between different shipyards, specifically between countries and continents. Each shipyard has its

own shipbuilding culture which is founded in hundreds of years. The effect of this culture on project management and therefore the thesis topic is undeniable. For example, Meyer Turku shipyard has history since 1737 meanwhile Saint-Nazaire since 1955, Fincantieri since 1912, MHI Nagasaki since 1857, RMC (Rauma Marine Construction) since 2014. It would be wrong to accept that all shipyards have the same ability and culture on project management.

Finally, cruise shipbuilding projects are intensely unique projects. Even sister ships which are built without a gap time have different challenges compared to her previous copy. On top of this, the construction year and its worldwide challenges, time of the year, different owners have impact on outcome on the projects. Therefore, accuracy of methods aren´t same for each ship. The exact reasons will not be covered in this study due to confidentially.

All quotes from different sources will be mentioned in reference chapter. Interview participants' names will be either kept as secret or published based on the confidentiality agreement between the author and interviewee. The same principle will be established also for benchmarking projects. Project names, project numbers or any other details which can relieve the project detail will not be shared.

3 Project Scheduling

3.1 Definition and importance of project scheduling in shipbuilding

"In order some chain of tasks and events to be called as a project, it needs to hold a start-end point, produce a unique product or service. Project scales vary tremendously, depending on the company size, industry and the product or the service to be received. Ship building, more specifically ship outfitting projects are large scaled, complex and intensive. As a nature of this combination, it requires professional planning. Project planning serves as a foundation for several related functions, such as cost estimating, scheduling, project control, quality control, safety management, and others." (Mubarak, 2010)

As can be retrieved from above mentioned quote, scheduling is a part of project planning. "Project planning and scheduling are totally two different subjects which should not be mixed. Scheduling

is the determination of the timing and sequence of tasks in the project and their assembly to give the overall completion time." (Mubarak, 2010).

One important step in scheduling is arrangement of relations and rules between the tasks. In complex projects where thousands of tasks under different categories which might have direct or indirect effect with each other can be challenging. Thus, sequencing terminology and methods have been implemented into scheduling.

"Sequence activities is the process of identifying and documenting relationships among the project activities. Activities are sequenced using logical relationships. Every activity and milestone except the first and last are connected to at least one predecessor and one successor." (A guide to the project management body of knowledge, PMBOK Guide, 2008)

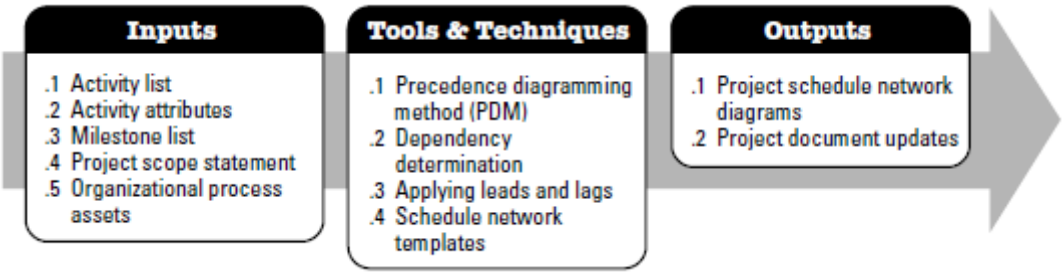

Figure 1 – Task sequencing process: Input, tools & techniques, and output (PMBOK guide, 2008, p. 136)

There are universally accepted four different sequencing methods in the literature. These can be listed as Precedence diagramming method, dependency determination, Leads & Lags and schedule network templates. Each type has benefits and shall be selected depending on project type and size. One of the most common sequencing method in constructions projects is precedence diagramming method. In this method tasks are linked as finish to finish, start to start and start to finish. Most used computer scheduling software MS Project has an automatic built-in feature for this method. Considering there is a specific section reserved in this thesis for scheduling methods, the detail of this topic is covered in there.

Each tasks require an owner, responsible to conduct the work. These are referred as resources. In general, in the cruise ship outfitting projects, these resources called subcontractors such as electrical outfitting subcontractor, HVAC subcontractors, interior installation subcontractors. It must be noted that resources are limited, and each resource unit has a capacity. Resource management takes an important place for successful scheduling. Resource has direct impact on task placement. Therefore, it is beneficial for project manager to know contracted supplier´s capacity, maximum resource availability. Resources are related to budged and has an effect to the profitability. "All construction projects, due to their relatively short life span and intense use of resources during that life span, require a formal detailed plan to get the work done within the schedule and budget." (Del Pico, 2013)

Task duration is the amount of time required to conduct a specific task with the identified resources in the project scope. Task duration estimation requires experience and know how in the relative industry. Environmental factors, local working community, work standards have significant impact on the task durations. These topics tend to be learned by active working which is equal to experience. Specifically, shipbuilding sector has quite many variations between the shipyards. Even in some cases, within the same shipyard, working instructions might vary depending on the shipowner. Thus, experience in the shipyard brings even more added value to the scheduling. "The inputs for the estimated of the activity duration originate from the person of group on the project team who is the most familiar with the nature of the work in the specific activity." (A guide to the project management body of knowledge, PMBOK Guide, 2008)

In general lines, project scheduling, its definitions and scheduling steps have been covered above. Following figure summarise and describes the process even in further understanding.

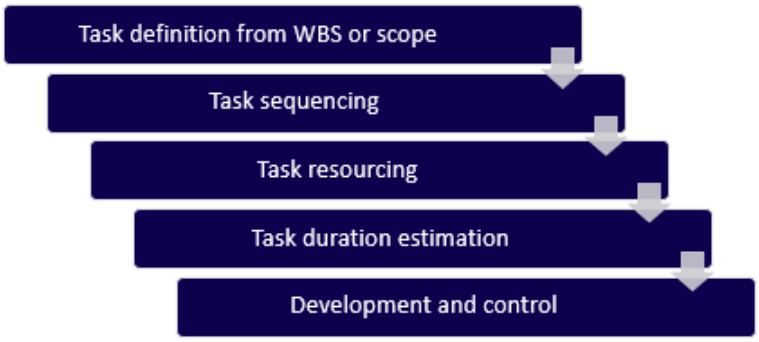

Figure 2 – Scheduling process

Until here, scheduling definitions and scheduling steps have been covered but why scheduling and project schedule is important? What is the relation between project schedule and project margin forecasting which is the core point of this studies main research question. It is a good idea to mention to generate a concrete understanding in the reader´s mind.

To forecast the profit margin, project manager must have a valid, trustworthy schedule. A wrong scheduling might easily lead the project to be delayed. Time and cost might sound to be irrelevant from each other but in fact it is connected. A delayed project will require more resource or time than originally planned to deliver its contractual scope. Most of the time, this more time or resource equals to extra cost. If the project scheduling done correctly, Project Manager can oversea or at least realize the delay as soon as possible and take corrective actions to prevent the bigger damage. It must be noted that, most of the ship outfitting projects are contracted as fixed price and has a delay penalty clause. This situation brings even more importance to project scheduling. In summary, as mentioned above, project scheduling has a direct role on profit margin forecasting during the project. It makes financially project controlling easier. “Project control is the function of integrating cost and schedule data to establish a baseline or guidance system for monitoring, measuring, and controlling performance.” (Del Pico, 2013)

An identified number of resources conduct the work within the given duration and scope to complete a task which is a part of the project. In this sentence, let´s take a second to focus on “resources and duration”. Cost of a task can simply be changed by adjusting the number of resources and/or the given duration. Both resource and duration are defined in project scheduling. This

proves that project scheduling plays an important role on cost, thus profit margin forecasting for the rest of the project.

"The type and quantity of resources and the amount of time which those resources are applied to complete the work of the project are major factors in determining the project cost. Schedule activity resources and their respective durations are used as key inputs to this process." (A guide to the project management body of knowledge, PMBOK Guide, 2008)

3.2 Project scheduling types

One vital fundament is to understand the difference between scheduling and sequencing. In many resources these two subjects are used together which might create confusion. Scheduling already contains sequencing. In other words, sequencing is a part of the scheduling process. Scheduling is the management and the presentation of resources on a timeline to conduct all the tasks belonging to the project, meanwhile sequencing focuses on the order/relationship of the tasks to be completed within the given resources.

Sequencing methods and scheduling types are possible to be combined based on the industry, project type and challenges. Precedence diagramming method is the most used and described in detailly below.

Precedence diagramming method: This method in short is called PDM method in literature. PDM generally combined with critical path method as project scheduling type. Specifically, the very well-known project scheduling software MS project bases its structure on this combination.

"PDM is a method used in Critical path methodology for constructing a project schedule network diagram that used boxes or rectangles, referred to as nodes, to represent activities, and connects them with arrows that show the logical relationships that exist between them." (A guide to the project management body of knowledge, PMBOK Guide, 2008)

What makes precedence diagramming very important is the ability to define the relationship between the tasks. These relationship illustrations can be reflected as: Finish to start (FS), Start to start (SS), Finish to finish (FF), Start to finish (SF).

- Finish to start: To start the next task, the previous task must be completed.
- Start to start: Next task can´t start, before the previous task starts.
- Finish to finish: Next task can´t be completed before the previous task is completed.
- Start to finish: Next task can´t be completed before the previous task starts.

"Theoretically, all tasks in a project are possible to be independent, however in practice it tends to belong one of the categories mentioned above. The most common type of relationship is the FS (Finish to start) relationship. Many project managers still insisting on using only this type." (Mubarak, 2010)

Nowadays, in complicated projects, precedence diagramming´s only relationship factors are being used as sequencing. Below is an example of precedence diagramming network shown. Only twelve tasks sequenced with SS or FS type with some lags.

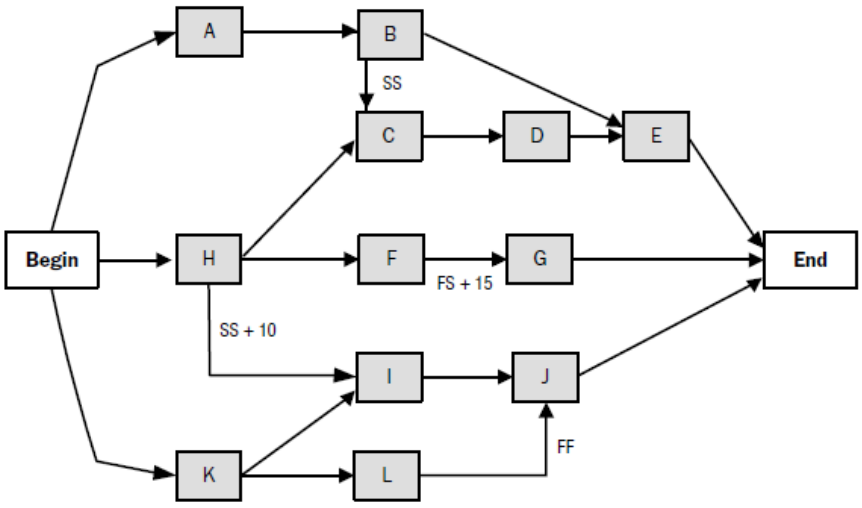

Figure 3 - Precedence diagraming network (PMBOK guide, 2008, p. 139)

3.2.1 Gantt method

Gantt method is a universal most used scheduling method in project management. It doesn´t require special knowledge and is easy to use. This method is also known as bar chart and receives its name from the inventor Henry Gantt. Almost in every sector, it is a great tool to describe the tasks, their durations, when to start and end. Before the actual, detailed project schedule is determined, Gantt method is seen as powerful tool to visualize basic scope of tasks in the project.

“The main advantage of the bar chart is its visual properties. It is easily understood and is a highly successful “big picture” tool. It is frequently used in presentations to senior management, the client or the general public, when the detail of a critical path method is unnecessary or too complicated.” (Del Pico, 2013)

As can be understood from Wayne J. Del Pico´s quote from his Project control book, Gantt method´s most important negative side is the lack task dependencies. It doesn´t present the prerequisites between tasks. Therefore, Gantt isn´t recommended as the only tool for project scheduling. However, when combined with a sequencing method like precedence diagramming, it becomes a super powerful scheduling method. Nowadays, many project scheduling software implemented this combination in their core mechanism. “The bar chart requires updating by hand and is devoid of the logic included in scheduling software.” (Del Pico, 2013)

To implement a successful Gantt chart, a correct level of WBS (Work breakdown structure) is crucial. Project is divided into different categories and categories divided into main, big tasks. These tasks are presented in the chart. In general, to achieve more professional way of implementing the Gantt chart, more axis are possible to use. Instead of indicating only task durations and timeline, Gantt allows to feed more info such as man hours or budged. Below are shown some examples of using the Gantt chart method.

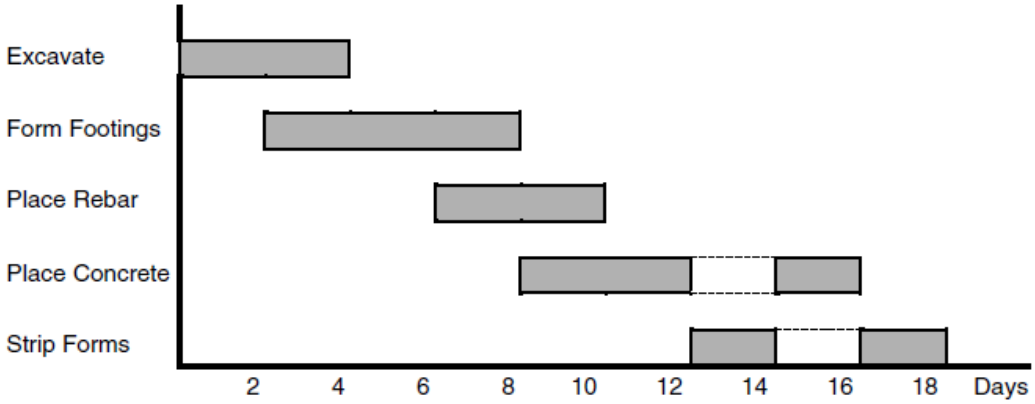

Figure 4 - Basic Gantt chart only in one axis (Mubarak, 2010, p.15)

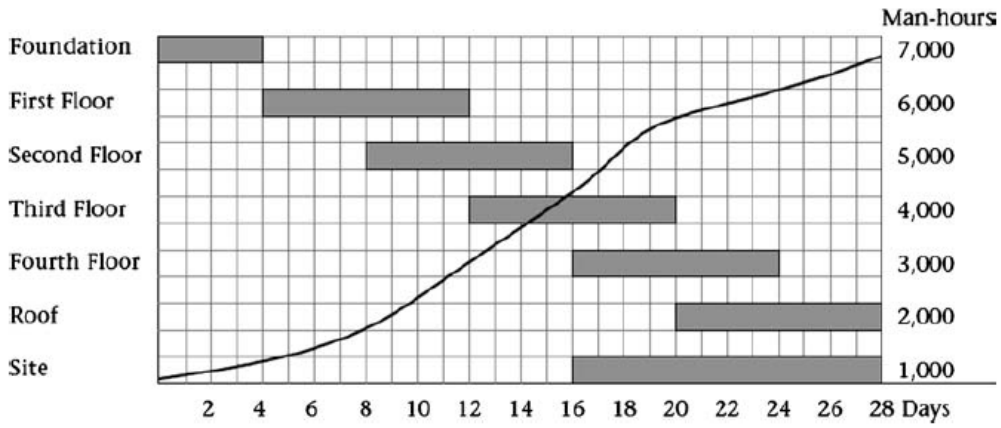

Figure 5 - Gantt chart in two axis, presenting both duration and man hours planned (Mubarak, 2010, p.16)

Gantt chart is not seen as the main tool as project scheduling method in complex projects such as cruise ship outfitting projects where thousands of tasks exist. However, Gantt is still applicable and crucial tool to be considered. For example, Saleh A. Mubarak, in his Construction project scheduling and control book, for using the Gantt chart effectively and eliminating the limitation of it, says that “You show a subset of the work activities to maintain the simplicity of the chart. For example, the general contractor can produce bar charts for activities during only a certain period, for critical activities (activities that cannot be delayed, or the entire project would be delayed) in a certain section of the project of for activities under a certain subcontractor.” (Mubarak, 2010). As can be understood from this quote, this way, it enables the project manager to lead the project´s certain supplier in certain timeline for critical activities.

Gantt method is in use heavily in cruise ship outfitting projects. Mainly for pre-planning phases before the actual scheduling is completed or during the project to micromanage certain tasks. However, as can be understood from the literature review, Gantt charts lack of information as task dependencies, task costs and resources. These are crucial elements of project margin forecasting which the lack of these elements might mislead the project manager in correct forecasting.

3.2.2 Critical path method

“Recently added to the growing assortment of quantitative tools for business decision making is the Critical Path Method—a powerful but basically simple technique for analyzing, planning, and scheduling large, complex projects.” (Levy, Thompson, & Wiest, 2024)

Decision making is one of the important benefits of CPM methods in project management. By identifying the activities on a critical path and their durations, some management decisions can be made. It enables the project manager to allocate the resources correctly, lead the team with correct critical tasks, meanwhile using the slack on tasks which aren´t on the critical path. This way, project manager enables the different options with comparison to their cost impacts for decision making. Projects without critical path tasks defined might be being led by one´s opinion or experience in the field which might result with project delays, specifically complex projects. Therefore, identifying critical tasks through CPM is a key factor in success.

“CPM is an integrated network consisting of a series of activities with one another intended to obtain maximum work efficiency. In determining the total time, the CPM project is simpler, it is obtained by summing the duration of each activity and taking the last / greatest finish time. The path where delays may not occur in each project activity is called the critical path.” (Atin & Lubis, 2019)

(Mubarak, 2010) in his book, summarizes the steps required to schedule a project with CPM method followingly: 1. Determine the work activities, 2. Determine activities duration, 3. Determine logical relationships, 4. Draw the logic network, 5. Review and analyse the schedule, 6. Implement the schedule, 7. Monitor and control the schedule, 8. Revise the database and record feedback, 9. Cost allocation, 10. Resource levelling.

Any kind of projects consist of different category and subcategories. These categories have variety of tasks under them. It is extremely important to define work activities in suitable levels. Smaller multiple tasks are seen better then one tough task. Dividing into smaller tasks reflets it´s advantage in duration and cost calculations. An example can be retrieved from shipbuilding. Installation of steel fundaments. Surely, depending on the area size and the number of the fundaments, this task can be acceptable as one but also possible to divide into sub tasks such as steel fundament installation on Fire zone 2, Fire zone 3, Fire zone 4. By doing this the bigger task divided into three smaller activities which enables the CPM method function more efficiently.

Perhaps one interesting step of the CPM method is determining logical relationships. Previously mentioned precedence diagramming and sequencing in this thesis study, heavily used in CPM´s logical relationship determination. Which tasks are linked to each other? Which tasks are freely start without a dependent? When all the dependencies written down with each task durations, construction of logic network diagram can kick off. Nowadays, computer software have been implemented heavily to automate the logic network diagrams in easier way to demonstrate.

3.2.3 Program evaluation and review technique (PERT)

One of the core elements of project scheduling is defining the task durations. In most cases, project managers or schedulers use their experience in the field, data from previous projects to estimate the task durations. What if there is a high uncertainty in the task durations? In this case, the uncertainty is better to be formulated to receive the most realistic outcome. Program evaluation and review technique (PERT) is an exceptionally useful tool in these situations.

Mubarak (2010) mentions that an event-oriented network analysis method called the program evaluation and review technique (PERT) is used to estimate project duration in situations where estimations of the length of individual activities are rather ambiguous. PERT uses a weighted average of the CPM. Estimate the duration. PERT is regarded as a stochastic, or probabilistic, approach.

Development of PERT isn´t any different than other scheduling methods. Yudistira et al. (2024) in their journal, summarizes PERT process as follow:

- Define the project and identify all significant activities or tasks.

- Establish connections between these activities, determining which ones should precede or follow the others.
- Describe the network that connects all activities.
- Assign estimated time and cost to each activity.
- Calculate the critical path, the longest time path through the network.
- Use the network to help with project planning, scheduling, and control.

Graphically PERT is demonstrated in a similar way as PDM and shows the relationships between the tasks. There are two main pillars what makes PERT development different from others (a) formulated approach for activity time estimation; (b) calculation of critical path to define the whole event duration. In all cases, PERT outputs three different results. It wouldn´t be wrong to call PERT as a simulation. The key concept is defining the duration times within the best and worst case to calculate the optimum, most realistic numbers.

“PERT uses a probabilistic approach, which requires a duration frequency distribution for each activity. In most cases, such distributions are unknown or unavailable. Because of this, PERT requires the user to set three durations that constitute the practical range of duration for each activity.” (Mubarak, 2010)

PERT and its calculations are named as Three-point estimated in PMI´s PMBOK guide. In the same book, Institute (2008) summarizes the formula (a) most likely (tm), the duration of the activity, given the resources likely to be assigned; (b) optimistic (t0), the activity duration is based on the best-case scenario; (c) pessimistic (tp), the activity duration is based on the worst-case scenario.

The mean weighted value for all these three durations is called expected duration (Te). It is calculated as follows (Mubarak, 2010)

$$Te = \frac{T0 + 4Tm + Tp}{6}$$

This is the core basic calculation of PERT to identify the expected duration. In addition, probability of an event occuring in a certain time and prediction of a certain event completion date with a changing confidence level are also possible to calculate with different formulas by using PERT.

Author highly recommends Mubarak (2010) chapter 11 and Yudistira et al. (2024)´s journal section to read for those who wishes to deepen their knowledge about the calculations.

To summarize the PERT concept, it is correct to say that PERT gives opportunity to project managers, schedulers to calculate expected duration of a task by using three different value. Thus, it enables to calculate (a) probability to finish the project by the end of day X; (b) probability to finish the project no later than day Y; (c) expected delivery date of a project with minimum confidence level of %Z.

Today´s technology creates many opportunities to project managers to use computational softwares for formulas. Software itself also presents usefull tables, charts and numerical statsitics which visually enables the whole concept to be more easy to understand and straightforward in presentations towards different stakeholders of the projects.

3.2.4 Last planner

“The Last Planner System is a system for project production that promotes the creation of a predictable workflow among various parties so that it achieves reliable results. The LPS® allows potential hurdles to be found and addressed before they slow down the flow.” (Lean Construction Institute , 2024)

During the recent years, LPS has gained popularity significantly in shipbuilding industry. One main reason for this popularity is LPS being a solution provider for multi complex projects in relatively limited project duration. Material suppliers, outfitting companies, shipyards, shipowners, in short most stakeholders put tremondous effort to reduce the amount of work need to be completed in the last final run of the project delivery. LPS helps to prevent these last minute husstle by planning and executing the works as in scheduled flow.

“The Last PlannerTM system has been successfully implemented in construction to increase the reliability of planning, improve production performance, and create a predictable workflow.” (Hamzeh, Ballard, & Tommelein, 2009)

The last planner system cycle has been demonstred in the figure below:

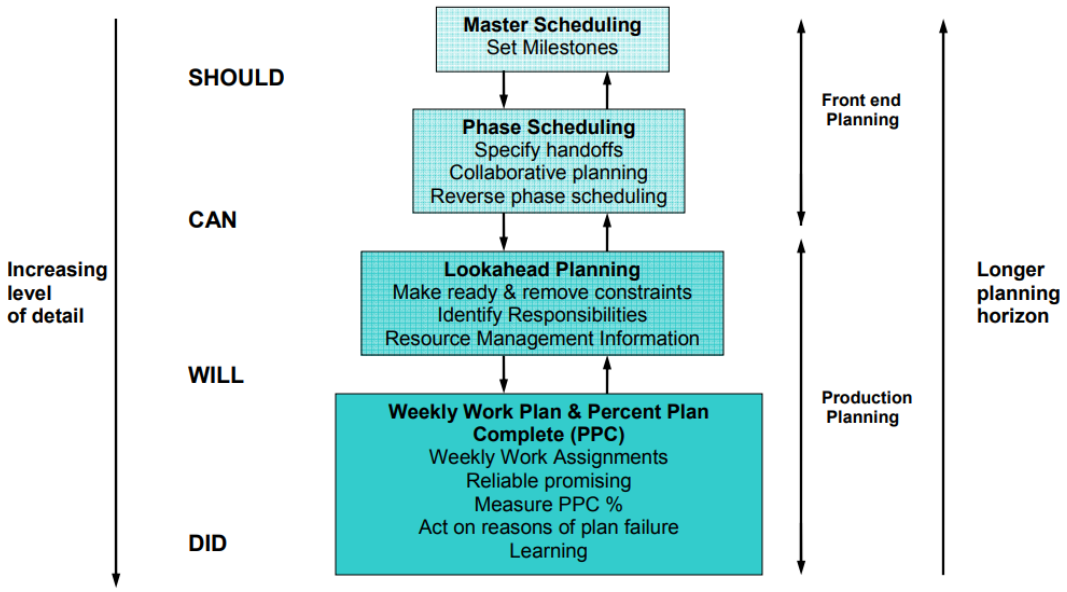

Figure 6 - Last planner system cycle. (The Last Planner System® (LPS®), 2024, p.2)

As can be seen from the figure above, LPS starts with master scheduling and ends with weekly and in some cases even daily planning details. Thesis author has studied LPS in two different aspects. (a) planning of normal tasks; (b) planning and scheduling of unseen tasks in project schedule. In order to complete a task, material-man power-conditions must meet. These three elements are critical to present in correct time, on correct place and amount to prevent loss of time. LPS, with it´s detailed planning of next three to six weeks of tasks, reduces the risk of loss time in projects.

“Pull planning is a method in which personnel, materials, information, equipment, and the like only arrive at the time and place in which they are needed to maintain the flow of the production process.” (Lean Construction Institute , 2024)

PROJECT: Pilot — 5 WK LOOKAHEAD

ACTIVITY	1/13/97						1/20/97						1/27/97						2/3/97						NEEDS
	M	T	W	T	F	S	M	T	W	T	F	S	M	T	W	T	F	S	M	T	W	T	F	S	
Scott's crew																									
"CUP" AHUs-10 CHW, 2 HW	X	X	X	X	X		X	X	X	X	X		X	X	X	X	X								CHW delivers 1-8-97 thru 1-13.HW delivers 1-20.
Punch, label, & tag AHUs															x	x	x								Materials on site
Ron's crew																									
DI Steam to Humidifier			x	x	x																				Materials on site
DI Steam Blowdown	x	X																							Check material
DI Steam Cond. to coolers (13)							x	x	x	x	x		x	x	x	x	x		x	x	x				Material on site
Charles' crew																									
200 deg HW 1-"H"	x	x	x																						Matl delivery 1-8-97
200 deg HW 1-"B" & 1-"D"							x	x	x	x	x		x	x	x	x	x								Release matl for 1-15-97
1st flr 200 deg HW guides & anchors	x	x	x	x	x								x	x	x	x	x								Material on site. Need West Wing flr covered.
Richard's crew																									
2-"A" HW & CHW	x	x	x	x	x																				Control valves for added VAV coils
CHW in C-E-G tunnels	x	x	x	x	x		x	x	x	x	x		x	x	x	x	x								Need tunnels painted & release materials
Misc FCUs & cond. drains in "I", "J", & "K" 1st flr							x	x	x	x	x		x	x	x	x	x								Take off & order materials
Punch, label & tag							x	x	x	x	x		x	x	x	x	x								Material on site

Figure 7- Look ahead planning example (The Last Planner System® (LPS®), 2024, p.16)

Even though LPS is mentioned several times as a planning tool, it still helps with detailed scheduling. Shipbuilding interior outfitting projects are complex and consist of different levels and milestones. In some cases, due to complexity of creating schedule, some details aren´t clearly visible which surely consists of task must be tackled to complete the project. These unseen tasks, thus, missing materials which are tied to the tasks are possible to identify and take necessary actions to prevent losses and delays. In the figure below, 6 weeks of internal from the project has been selected, placed into lookahead plan and planned in weekly/daily. This demonstration presents also the flexbility of LPS. It enables the project manager or the team to change the focus and concentrate on some specific group of tasks, if needed.

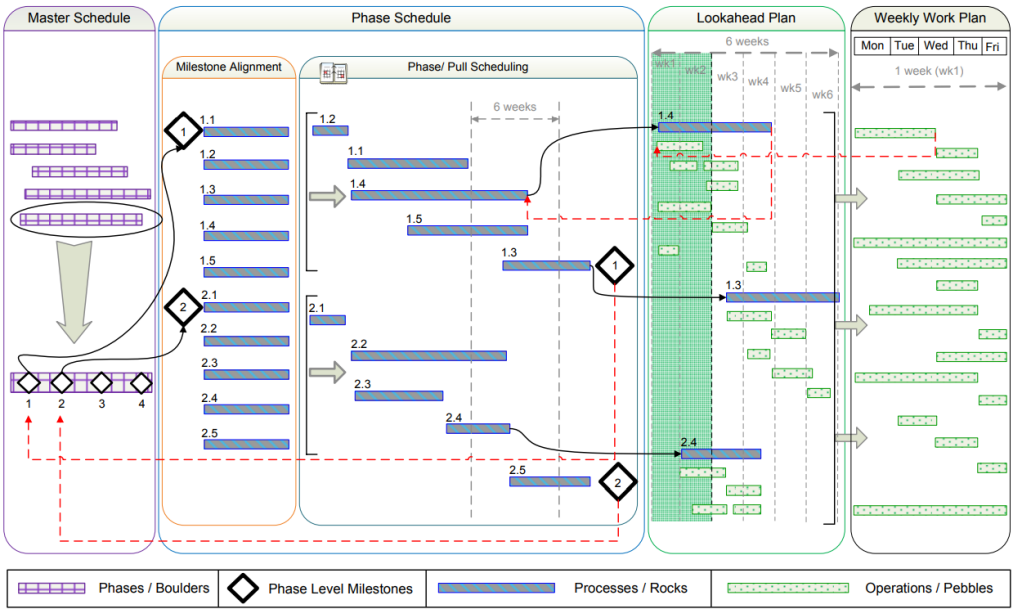

Figure 8 - LPS Scheduling development model (Hamzeh, Ballard, & Tommelein, 2009, p.172)

3.3 Task duration estimations and resources

“Tasks are the activities that make up the schedule. They consist of an action that consumes time, requires labor hours from rescources, may involve equipment, and almost always cost money.” (Del Pico, 2013)

There are several different factors which have an effect onto the task durations. (a) skillset of the workers; (b) climate conditions; (c) amount of resources; (d) used tools and equipments; (e) design. Different combinations of these factors will change the task duration which might have an effect on project cost as well.

There are standardised formulas availabe to calculate task duration. However, most of these formulas are based on linear scheduling which may not be the best match for shipbuilding industry because of changing geometry, external conditions and different background requirements.

“The most common and simplest method of calculating task duration is called the daily production rate method. It is based on the productivity of a specific crew and the assumption that the productivity of this crew will remain constant over the life of the task, provided that the conditions under which the work is performed do not change.

$$D = Q \div DO$$

In this equation, D represents; the total duration of the task measured in workdays, Q represents; the total quantity of the task being perfomed by the crew in units, DO repserensts; the daily output of the task performed by the crew-day in units per day." (Del Pico, 2013)

When the production or installation isn´t linear and productivitty changes over time due to internal or external factors, this mentioned formula isn´t the best to use. At this stage, it is recommended to recall the formula used in PERT to assess the mean weighted value for duration calculation where most likely, optimistic and pessimistic estimated durations were used. PERT formula is possible to modify with its weight to forecast the duration where there is lack of experience or the installation/production isn´t linear.

3.4 Quality control of project schedule and project schedule analyzers

During the literature review, it has been realized that project management and specifically scheduling methods have been mastered widely in different resources. However, there was found to be a lack of resources related to quality control of a completed project schedule. Zwikael & Globerson (2004) discuss that despite its acknowledged significance, there is currently no specific tool for evaluating the quality of project planning.

Due to the lack of quality control evaluation a PMPQ model has been developed by Zwikael & Globerson (2004) on top of the project management processes implemented by PMBOK. In this model there is 33 products in total, 16 of which are related to project knowledge processes and the remaining 17 to organizational support processes. These 33 questions are weighted averaged to create the PMPQ index, which assesses the organization's project planning quality. Project scheduling is an important part of project planning. The latest technological improvements and increase demand for software usage in project management brought advantages to assess the quality control of prepared schedules.

"There are some other commercial software packages which can be used for simulating uncertainties in the schedules. Tools include possibility to perform different analyses based on Monte Carlo simulation." (Hietala, 2009)

(Hietala, 2009) in his research continues to summarize some of the software packages (a) risk+; (b) pertmester, nowadays primavera pertmaster; (c) @risk; (d) planalyzer. In addition, researcher highlights the applications of Planalyzer which is an add-on scheduling module for MS Project.

4 Project readiness(progress)

4.1 Importance of project readiness

Once the planning phase of the project is completed, the execution phase begins. During the execution phase the progress of each task is reported to the project stakeholders. Generally, reporting is conducted weekly. Only progress reporting itself isn´t the most effective but comparison of reported progress to the expected baseline progress from the schedule is illustrated for better understanding. Project team and stakeholders conduct their examinations on the report to assess the project status being in track or various actions needed.

“When the project progress isn´t in acceptable level, the project manager should take corrective actions to get the project back on the track. Therefore, calculating the project progress by considering effective criteria in addition to time and cost can help to create a more comprehensive understanding of the project status to be utilized by project team members, managers, stakeholders and officials.” (Angiz & Keramatpour, Developing a new method to determine the actual project progress, 2021)

Another important factor of reported project readiness is related to project finance. Nowadays, quite big portion of ship interior outfitting contracts have been made as fixed price. Subcontractors which are working to the main contractors are also included into this statement. One basic and perhaps the most important element in the payment terms of the contract is readiness and drives the payment schedule. (Angiz & Keramatpour, 2021) in their study for calculating the actual project progress mentions that for both employers and contractors, the project progress percentage is an important consideration, particularly when it serves as the foundation for payments.

No	Condition	%
1	When contract is signed and insurance papers delivered	10
2	When installation readiness is %10	10
3	When installation readiness %30	10
4	When installation readiness %50	10
5	When CP: Closing of ceilings completed	10
6	When CP: Closing of walls completed	10
7	When installation readiness %70	10
8	When installation readiness %90	10
9	When installation readiness %100 and all remarks closed	20

No	Condition	%
1	When contract is signed and insurance papers delivered	10
2	When steel supports welded	10
3	When sub construction for walls completed	10
4	When sub construction for ceilings completed	10
5	When CP: Closing of ceilings completed	10
6	When CP: Closing of walls completed	10
7	When fixed furniture installation completed	10
8	When painting completed	10
9	When final inspection completed and remarks closed	20

Table 1 - Comparison of two different payment methods

A basic level contract´s two different approaches of payment methods are demonstrated above. The conditions in the left table are mostly tied on to the progress of installation, meanwhile in the right table it is tied on to completion of the important main tasks. Decision on which one to choose depends on the project scheduling software, coefficiency of each completed task and project management methodology.

One final fact about the importance of project readiness is the relation between profit margin, progress and cost. Project readiness isn´t only compared to the expected readiness but also reviewed in comparison to realized costs and in parallel to planned budged. A project which produces less progress compared to the expected outcome of realized costs might be red alert of profit margin drop. In some industries, this situation is called as burning money.

“A burn rate is not necessarily good or bad, it’s simply a fact of doing business. Good burn rates fall in line with company expectations, don’t suddenly change in the middle of a project, and result in a healthy profit margin.A bad burn rate is unpredictable and out of control, leading to increased spending and erratic changes in how much is being spent to complete work from month to month or even day to day.” (Project Burn Rate: How to Effectively Gauge Your Project Progress, 2024)

Properly and regularly conducted project progress reviews help project managers to understand how the current progress on site will affect project´s profit margin in long run. Overall, project progress importance and it´s capabilities listed as below:

- Informs the project´s stakeholders on where project stands on the timeline.
- Enables the PM to understand if the project is late or on schedule to decide for further actions.
- Enables the PM to create payment terms for closing contracts.
- Enables the PM and the finance team to define burn rate and compare where the project stands.

4.2 Readiness calculation methods

Readiness calculation takes place during the execution of the project. In extreme basis, it is the calculation of completion rate of each task that is defined through WBS. When each task which belongs to the project has been calculated, it will enable the PM or the project team to calculate the whole project progress.

It´s important to note and understand what is being calculated and what items required to be included in the calculation. In some circumstances, project readiness might include design and procurement, meanwhile some don´t which is referred to as only installation readiness. This concept depends on how outcomes will be used as input for the next process or comparison.

(Del Pico, 2013) in his project control book states that accurately measuring the work's progress is essential to the project control process since without it, it would be impossible to determine the project's current condition. The project's total development is summarized by the measurement of each individual item's progress, regardless of how different they are from one another.

On top of this, he has also listed the traditional accepted methods of readiness calculation as “(a) units completed; (b) incremental milestones; (c) start/finish; (d) cost ratio; (e) experience/opinion; and (f) weighted or equivalent units.” Below some of mentioned methods described in parallel to shipbuilding interior outfitting projects.

Units completed: This approach is applicable in situations where the same or similar task is conducted repeatedly. Simply, the completed unit on site is checked and divided to the total unit required to be completed. In some cases, the task might include sub-tasks but as long as it's a repeat, it can be still calculated the same approach. For example, in a specific public space of a cruise ship containing the same type of 600sqm ceiling panel, is a great opportunity to calculate by units completed method.

Incremental milestone: "The second method is best used for a cost account that is comprised of subtasks that must be completed in sequence. It is called the incremental milestone or steps method." (Del Pico, 2013).

An example from shipbuilding would be the bar counter installation:

1. Welding of border bars, 20hrs. %7,5.
2. Welding of vertical plates to level the fundament, 15hrs. %5,7.
3. Placement of bar fundament and fundament welding, 120hrs. %45,3.
4. Coaming welding, if any inside the bar wet area, 50hrs. %18,9.
5. Bar counter furniture lifting and welding, 60hrs. %22,6.

Total: 265hrs, %100.

Hours in this example randomly given but illustrates the expected labour hour means given budged. Actual hours and progress are possible to calculate through this and update for next project´s budged.

Start/finish: "The Start/Finish method has its greatest appeal for those tasks that lack readily definable intermediate milestones or for which the time required for each operation is difficult to estimate." (Del Pico, 2013)

There are different variations of start/finish method which depends on the duration of the tasks as (a) 50/50 rule for short tasks when %50 gained at the start, remaining when task is completed; (b) 20/80 rule for longer tasks when %20 gained at the start, %80 at completion and (c) 0/100 rule for quite short tasks which the whole readiness gained at the completion.

Weighted or Equivalent Units: "This method has its greatest appeal where the task under control has a long duration and is composed of multiple subtasks with dissimilar units of measurement." (Del Pico, 2013)

An example of the method for piping installation in a toilet on a cruise ship public space demonstrated below with randomly selected numbers. In this method, key factor is to define the necessary tasks already in the WBS phase so that a proper budged is already addressed.

Weight (Coef.)	Subtask	Unit	Qty Total	Completed	Readiness Individual	Earned Value
0,05	Welding of piping supports	Qty	50	50	100 %	5,0 %
0,05	Black water piping	Meter	10	2	20 %	1,0 %
0,3	Fresh water line installation	Meter	40	12	30 %	9,0 %
0,2	Sprinkler line sector 1	Meter	30	15	50 %	10,0 %
0,2	Sprinkler line sector 2	Meter	30	15	50 %	10,0 %
0,1	Grey water line	Meter	20	8	40 %	4,0 %
0,1	Pressure tests and comission-ing	Sys-tem	6	0	0 %	0,0 %
					TOTAL READINESS	39,0 %

Table 2 - An example of weighted or equivalent units for piping installation

"Having reviewed the accepted methods for measuring progress on individual tasks, the next challenge is to determine the percentage of completion for the project as a whole. The process for determining either the progress on an individual task or the project as a whole is called Earned Value Analysis." (Del Pico, 2013).

"Earned Value Management (EVM) is a technique of performance measurement focused on project physical, financial and time progress, indicating planned and actual performance, variations of them and forecasts on final project duration and cost." (Cândido, Mählmann Heineck, & Barros Neto, 2014)

Earned value management will be examined in detail in the next chapter 5. project profit margin. However, it was a clear need to define at this moment for the sake of understanding how to calculate the overall project readiness through earned value analysis.

(Del Pico, 2013) in his book, conducts a fixed price approach through earned value analysis to calculate the overall readiness of the project which to do so, first step is to apply the following formula to calculate respective cost account´s earned value (EV).

$$\text{Earned Value (EV)} = \text{Percent Complete} \times \text{Maximum Budget}$$

Considering all the cost accounts have been assigned a fixed budged and percent complete(readiness) calculated with one of the methods described in previous pages, each cost account´s earned value is possible to calculate with the formula above which gives the result for readiness of project with the formula below.

$$\%\ \text{Complete} = \text{Sum of EV of all tasks} \div \text{Maximum Budget value of all tasks}$$

Author of the book also states the limitation of this approach depends on the accuracy of estimated budged. In these cases, when poor budged estimation realized, it has been recommended to distribute correctly to achieve accurate results.

Schedules, formulas, readiness, budged, realized and expected costs and similar other mathematical terms have been discussed to calculate the readiness of the project. However, human factors play a crucial role in readiness calculation as well. During the theoretical background research, thesis author has found valuable research conducted by Atefeh Angiz and Mehdi Keramatpour.

(Angiz & Keramatpour, 2021) in their “Developing a new method to determine the actual project progress percentage for construction projects” study has conducted a new approach by including human factors, supplies and criticality status of an activity for readiness calculation which resulted in %10 more accuracy compared to the traditional methods.

In this study, among the fourteen identified factors that could be effective in the volume of activities, in several brainstorming meetings with experts and managers of the construction project, the following 5 factors were confirmed as the main factors:

- Activity costs.

- Manpower required for the activity.
- Resources other than manpower.
- The criticality of the activity.
- Activity procurement status.

(Angiz & Keramatpour, Developing a new method to determine the actual project progress percentage, 2021)

In the same study, to calculate the impact of above-mentioned factors, they have designed a numerical tool in excel with first mean, second mean and third mean calculations. Then depending on the time of the project and the impact, if formula has been used to define a number between one to five. Finally, normalization formula is used to calculate the readiness much precise and effective than traditional methods.

Thesis author highly recommends their study for those who wish to deepen their knowledge on alternative, precise methods for readiness calculations.

4.3 Readiness and cost performance

Readiness, budgeted costs, actual realized costs and planned readiness don´t bring much valuable input to evaluate the cost performance. Various combinations of comparisons of these main fundaments are essential for conducting an effective analysis of readiness and cost performance. Project manager´s one of the important tasks is to understand how well the project is performing compared to the planned schedule and planned budged. Earned value system and it´s formulations are one way to perform this important project managerial task successfully.

- **“Planned Value (PV)** is the budgeted cost for the work scheduled to be done. This is also known as the budgeted cost of work scheduled (BCWS).
- **Actual Costs (AC)** is simply the money spent for the work accomplished. This is also known as the actual cost of work performed (ACWP).
- **Earned Value (EV)** is the percent of the total budget actually completed at a point in time. This is also known as the budgeted cost of work performed (BCWP).”

(Joseph , 2012)

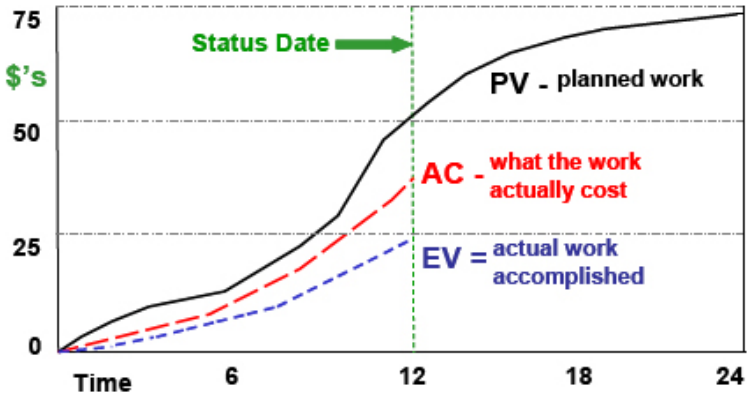

Figure 9 - Typical Graph Showing PV, EV, and AC (Joseph , 2012, p.15)

"The newly introduced category of ACWP is the final component in the trinity of Earned Value Management. It is defined as all actual costs measured against the budget amounts for the cost elements in each cost account." (Del Pico, 2013)

SPI (Schedule performance Indicator) is one important gauge to examine for the projects. (Del Pico, 2013) in his book defines it as the comparison between what was planned and what was completed is known as performance compared against schedule. Stated differently, it is a ratio of earned value to budgeted value. It is a gauge of how well a timetable works. He, in the same book, formulates the SPI followingly:

$$SPI = \frac{Earned\ Value\ (in\ dollars\ or\ labor\ hours)}{Budgeted\ Value\ (in\ dollars\ or\ labor\ hours)}$$

"A SPI value of 1.05 implies that for every dollar of work the project had planned to accomplish at this point in time, US$1.05 worth of work was actually done. A SPI greater than one and a positive SV indicates more work has been accomplished than was planned." (Joseph , 2012)

Even though outputted number is defined in dollars, SPI as per it´s name provides insight on where the specific cost center stands in schedule. The value greater than one might mean the specific task which belongs to the calculated cost center is ahead of the schedule. However, critical path always must be checked to understand where the task takes place.

There has been now defined a scientific formula for schedule performance but still a formulation needed for cost performance. Referring back to (Del Pico, 2013)´s book, CPI (Cost performance indicator) is defined as comparing the actual cost to the projected cost for the contractor is how performance is evaluated against cost. Schedule performance and cost performance are evaluated in a similar manner and formulated as following.

$$CPI = \frac{Earned\ Value\ (in\ dollars\ or\ labor\ hours)}{Actual\ cost\ (in\ dollars\ or\ labor\ hours)}$$

Or alternatively,

$$CPI = \frac{BCWP}{ACWP}$$

“A CPI value of 0.83 implies that for every project dollar spent, only US$0.83 in earned value was accomplished. A CPI of less than one and a negative CV indicates project cost performance is below the plan.” (Joseph , 2012)

CPI value less than one is a red flag for the project manager. Further evaluations are required to evaluate the root cause. Is it only one time event that has been affected by third sources temporarily or has the lower value been a trend for a while due to internal processes? Answering to this question will help the PM to take further actions and enables scientific presentations in reporting to the stakeholders.

There is many different approaches on how to demonstrate the CPI and SPI values on a graph. Those values can be illustrated on Microsoft Office programmes in comparison with baseline, months, readiness, remaining time till delivery and more. Illustrations are totally open and possible to create based on the reporting or evaluation need.

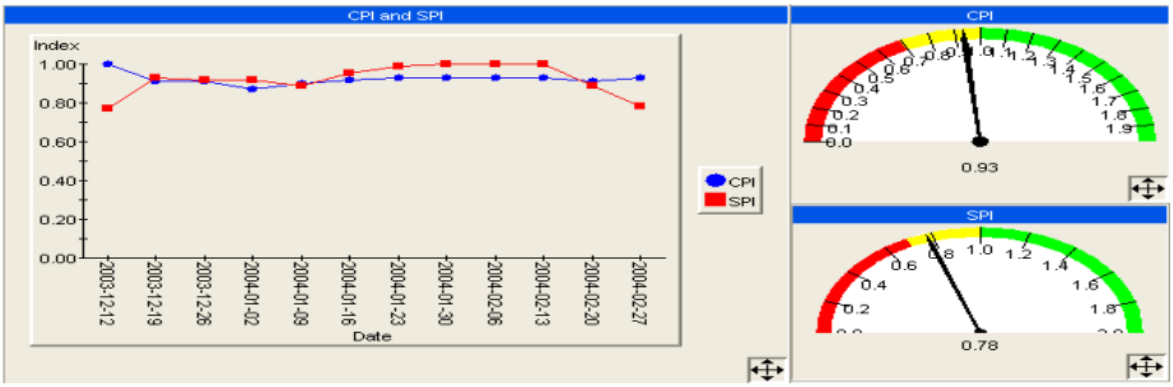

Figure 10 - Cost Performance Index (CPI) and Schedule Performance Index (SPI) (Sharma, 2009, p.74)

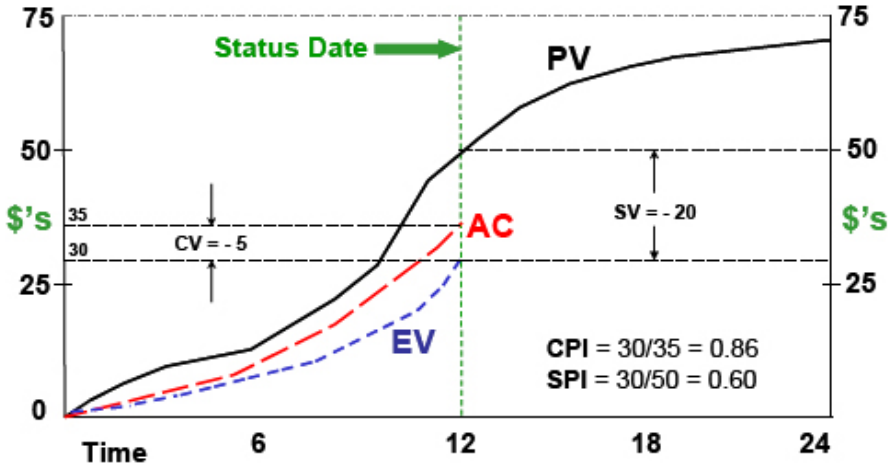

Figure 11 - Earned Value Analysis illustration

When the analysis shown in Figure 11 is examined, some straightforward results can be read easily. At the reporting week of 12, PV shows much higher value then EV and AC. The SPI result which is 0,60 shows that project might be late, behind the schedule. In addition, AC value is also higher than EV. CPI result which is 0,86 indicates that project is spending more money compared to achieved progress. This might be a bad sign for burning money and requires investigation.

5 Project Profit Margin

Project scheduling, project readiness and their correlation with project profit margin and thus the effect on the project´s future profit margin have been covered as literature in the previous chapters. In this chapter, methods for forecasting the project profit margin in the future of the project up to its calculation have been studied. Different types of methods are investigated, examples and formulas integrated.

Project managers regularly report the project performance to the stakeholders. PM conducts these performance evaluations based on the realized data and compares them to the planned baseline to comment on the performance. In most cases, project stakeholders require to know the future estimates such as forecasted profit margin up to project´s delivery date, forecasted delivery data. Due to the scope of this study, forecasted profit margins have been covered mainly.

(Del Pico, 2013) in his integrating cost and schedule in construction book states that examining past and present performance as well as attempting to forecast future events at pivotal junctures throughout the project's duration is one of the main benefits of project control. In addition, he highlights a crucial fact that in numerous situations, pretty poor performance from a budgetary and scheduling viewpoint can be stopped and returned to baseline values with the correct diagnosis and mitigation plans. However, schedules and budgets are presumed to have been created in accordance with accepted professional standards.

One main outcome would be important to note from Del Pico´s statements. It is possible to figure out the bad performance and take corrective actions to place the project back to the planned margin line as much as possible with the condition of schedules and budgets have been conducted correctly. Since all the profit margin forecasting methods are predictions based on the realized data, constructed schedule, budged and calculated readiness, mistakes in one of these core elements might give wrong results depending on the selected method.

5.1 Monte carlo method

“A Monte Carlo simulation is a computer model in which a range of possible outcomes are simulated and presented along with their probabilities of occurrence. (The name “Monte Carlo” refers

to the famous gambling city in Monaco. The same techniques used to model the probabilities of winning at roulette wheels and craps tables are also applied to investment portfolios and project outcomes." (Smith, 2020)

Monte carlo method and its simulation are widely used when multiple uncertain factors and different range of risks exist in an activity. (Hussain, 2019) His article mentions that Monte Carlo simulation determines the risk factors linked to the likelihood that those elements will occur, which lowers the production rate. It effectively illustrates the extreme possibilities for almost all dangerous circumstances and the most conventional choices.

The conducted literature review shows that the method can be applied in different industries widely such as laboratory examinations, project management, production facilities. Combination of collected data defined uncertain risks and formulation make the simulation applicable in various research designs. Simulation repeats itself thousands of times with the given values to output results with probabilities.

"Monte Carlo simulation is a type of simulation that relies on repeated random sampling and statistical analysis to compute the results. In this context, Monte Carlo simulation can be considered as a methodical way of doing so-called what-if analysis." (Raychaudhuri, 2008)

(Raychaudhuri, 2008) in his conference proceeding paper summarizes the general steps of monte carlo simulation in order followingly:

Figure 12 - Monte carlo simulation stages

Static model generation: In this step, a mathematical formula or a model created. This can be very simple formulation or advanced equations depending on the subject. Below is an example given for calculating Pay Back Period(PBP).

$$PBP = \frac{Investment\ needed}{Cash\ inflows\ + depriciation\ amount}$$

(Hussain, 2019)

Input distribution identification: "When we are satisfied with the deterministic model, we add the risk components to the model. As mentioned before, since the risks originate from the stochastic nature of the input variables, we try to identify the underlying distributions, if any, which govern the input variables. This step needs historical data for the input variables." (Raychaudhuri, 2008)

Random variable generation: This step requires creating variables by using static model generation and the distribution defined. The variables created will be used as an input for the simulation. The more set of variables will make the simulation more accurate. (Raychaudhuri, 2008) in his conference proceeding highlights this step and its importance as in the deterministic model, a single set of output values will be produced from a single set of random numbers, one value for each of the input variables. Next, we generate additional sets of random numbers—one for each input distribution—and gather various sets of potential output values in order to repeat this process. The core part of Monte Carlo simulation is this section.

Below, two different random variable generation figures have been presented. First figure shows random variables from a project which outputs the task duration as minimum, likely and maximum in corelation with delay weeks. In the second figure, more complicated and formulated values are presented for distinc point estimates of cash inflows for a company.

	Pipeline Project	Task Duration (Weeks)						
WBS	Task	Est. Duration	Min.	Likely	Max.	Delay (Weeks)	Start	Finish
1.0	Project Planning	4.86	4	5	6	0	1/1/2010	2/4/2010
2.0	Permit Acquisition	11.87	8	12	20	0	2/4/2010	4/28/2010
3.0	Right-of-Way Acquisition	10.40	6	12	18	0	2/4/2010	4/17/2010
4.0	Engineering Design	7.36	4	6	8	0	1/1/2010	2/21/2010
5.0	Materials Procurement & Delivery	10.89	10	14	18	0	2/21/2010	5/8/2010
6.0	Contractor Mobilization	0.58	0.25	0.5	1	0	5/8/2010	5/12/2010
7.0	Pipeline Construction	17.97	16	18	22	0.5	5/13/2010	9/16/2010
8.0	Testing	1.53	1	1.5	2	0	9/16/2010	9/26/2010
9.0	Commissioning & Startup	0.72	0.5	0.75	1	0.5	9/27/2010	10/2/2010
10.0	Project Complete	0.00	0	0	0	0	10/2/2010	10/2/2010

Table 3 - Variables for Monte Carlo simulation as random input (Smith, 2020, p.7)

				Discount	Net Present	
Year X	Cash Inflow Y	Cash Outflow Z	Net Flow $NF = (B - C)$	Factor $1/(1 + K + p) \wedge t$	Value $NF \times$ (Disc. Factor)	Inflation rate
2019	$ –	$ 145,000	$ (145,000)	1.0000	$ (145,000)	0.04
2019	–	120,000	$ (120,000)	0.8621	$ (103,448.28)	0.04
2020	–	80,000	$ (80,000)	0.7432	$ (59,453.03)	0.04
2021	70,000	–	$ 70,000	0.6407	$ 44,846	0.04
2022	140,000	35,000	$ 105,000	0.5523	$ 57,991	0.04
2023	135,000	–	$ 135,000	0.4761	$ 64,275	0.04
2024	125,000	35,000	$ 90,000	0.4104	$ 36,940	0.04
2025	117,000	–	$ 117,000	0.3538	$ 41,398	0.04
2026	110,000	35,000	$ 75,000	0.3050	$ 22,877	0.04
2027	102,000	–	$ 102,000	0.2630	$ 26,821	0.04
2028	85,000	–	$ 85,000	0.1954	$ 16,609	0.04
2029	55,000		$ 55,000	0.1954	$ 10,748	
Total	**$ 939,000**	**$ 450,000**	**$ 489,000**		**$ 14,605**	

Table 4 - Distinct point estimates of cash inflows (Smith, 2020, p.14)

Analysis and decision making: Design is ready and simulation can start. (Smith, 2020) summarizes this step and highlights that It is also necessary to specify the number of trials. Up until a certain point, the simulation gets better the more trials there are. A good simulation can typically be produced with 5,000 to 10,000 trials, which won't take much time on most computers.

MS Excel, Crystal Ball Professional, Minitab, Simul8 are only a few well known softwares for Monte Carlo simulation. On top of this, specific aim and industry based softwares are available as well. Selecting the correct software for the intended purpose can play an important role for saving time and preventing misunderstandings.

“The most common format for presenting Monte Carlo simulation results is in a histogram, a chart that displays the frequency of results that fall within certain intervals.” (Smith, 2020)

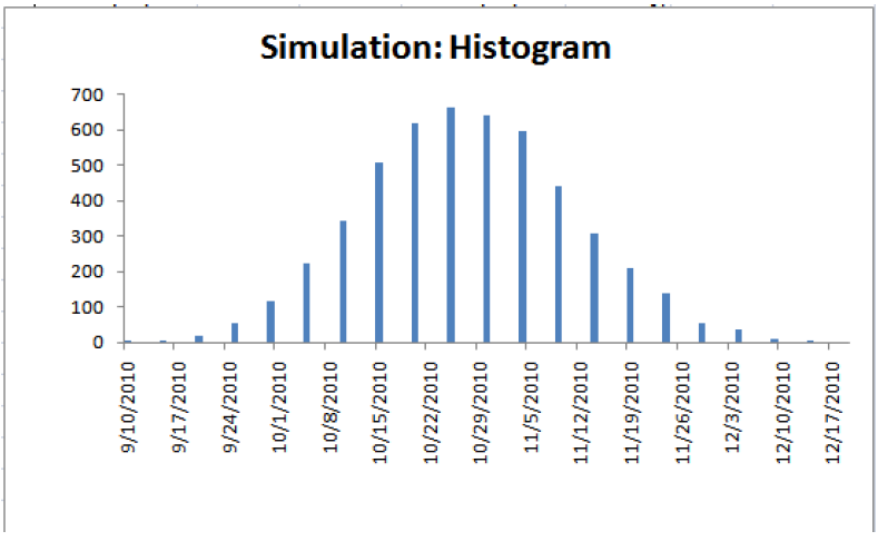

Figure 13 - Monte Carlo Simulation result in histogram graph (Smith, 2020, p.10)

Mean, median, range, percentiles are standard result values from the simulation. Project manager or reporter can prepare different kinds of presentations by using the result values. One example is demonstrated below in Figure 16. For the probability of completing the project in certain dates.

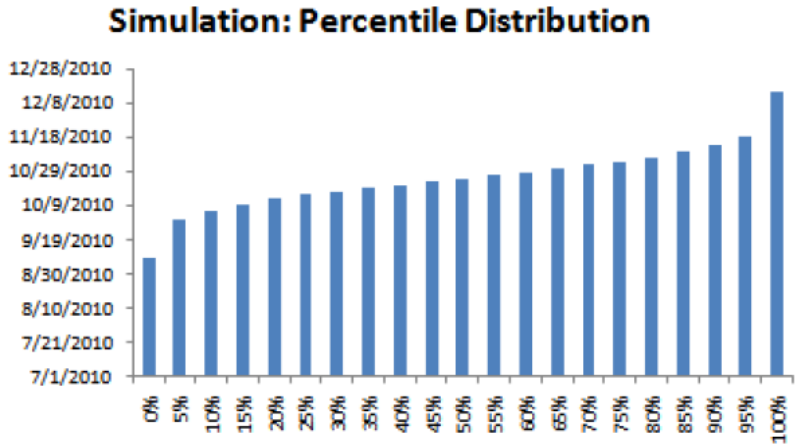

Figure 14 - Percentile distribution (Smith, 2020, p.12)

5.2 Risks and risk evaluations

Risks and risk evaluations are one of the critical elements for forecasting the project´s profit margin. Risks take place in every phase of the project in different levels. Even though risks can be under different categories, one can always say that they are associated with cost either indirectly or directly. In order to illustrate the importance of risks, risks assessments and evaluation in shipbuilding projects, following table prepared.

CRUISE LINE	SHIP NAME	YARD	PRICE($)
MSC Cruise	World Class 3	Chantiers de l'Atlantqiue (France)	$1,125 bil.
Royal Caribbean International	Icon class 2	Meyer Turku (Finland)	$1,590 bil.
Carnival Cruises	Carnival Celebration	Meyer Turku (Finland)	$900 m
Royal Caribbean International	Oasis 6	Chantiers de l'Atlantique (France)	$1.425 m

Table 5 - Order book section with ship contract price estimations (Cruise, 2022)

The money exchange and the contract prices within the supplier chain of shipbuilding projects are tremendously large, which requires professional risk management to ensure sustainable profit margin throughout the whole project cycle. Thus, to forecast the profit margin realistically and correctly, the possible cost effect of the risks must be considered.

Ryyppö (2012) in his master thesis for risk management in shipbuilding project network summarizes the risk management process in the following figure.

Figure 15 - Risk management process (Ryyppö, 2012, p.17)

These processes can be shortly defined in order as (a) risk management planning which the base template is created, severity impact formulated and template owners are defined; (b) risk identification which any team member can input under different categories; (c) risk analysis and assessment which is the stage where PM or team members decide on the probability and the severity of the risk; (d) risk response and mitigation which is the stage where team members brainstorm, investigate and utilize a plan to mitigate the risk to eliminate or reduce the severity or the possibility; and (e) risk monitoring and control which is follow up of the mitigation plan to locate and asses the new values.

“The impact scale provides just such a rating system. It allows the project manager to prioritize what risks need attention. The impact scale employs a numerical value ranging from a very low (1) likelihood to a very high (5) likelihood. The same applies to the impact: very low (1) impact to very high (5) impact.” (Del Pico, 2013)

Severity identification can be challenging in some cases. Team members might have different opinions when working individually. Thus, a systematic process or a formulation is a proposed method. Del Pico (2013) in his book implemented a useful tool to help severity identification. In the tool, the severity is tied to cost increase or time increase in percentage.

	Numerical Impact Scale				
	1	2	3	4	5
Category	Very Low	Low	Moderate	High	Very High
Cost	Insignificant cost increase	<10% cost increase	10–19% cost increase	20–49% cost increase	Greater than 50% increase in cost
Time	Insignificant time increase	<5% time increase	5–9% cost increase	10–19% cost increase	Greater than 20% increase in time

Table 6 - Impact scale for a fixed price contract (Wayne J. Del Pico, 2013, p.173)

When a project team completes the severity and probability assignment for risks, then they place the risk in a matrix to evaluate the risk category such as minor, moderate and severe. Right after, the mitigation plan and follow up processes continue.

Considering risk management has been in the modern shipbuilding industry for a while, many companies have already adopted in some way or form into their processes. However, there is still further improvement possibilities exist. These improvement possibilities aren´t related to the actual process of risk management but using the data to build probability analysis as an extension of risk management. Probability analysis and its usage in shipbuilding industry will be researched in the implementation chapter and outcomes will be shared in results chapter.

Del Pico (2013) in his book´s risk management chapter, specifically mentions about the probability analysis as associated with risk management. He proposes PERT method for the risks which concern the schedule delays. It is mentioned that the project manager has access to an analytical method that allows them to examine how risk affects the timeline. It is designed for tasks on the critical path that carry a high risk of schedule disruption. This method, known as the Program Evaluation and Review Technique (PERT), can be applied during the planning stage to assess how long particular tasks on the schedule will take.

Another probability analysis method is Monte carlo which has been covered earlier in this study. Project team can use the risk management with monte carlo method to output the % wise possibility of risk occurance or possibility of risk cost impact in euros. The theoritical background is on a side, the real life applicability of the probability analysis as an extension to risk management

in shipbuilding industry is a valuable topic to argue. In most cases, the compressed schedules, limited human sources, workload and implementing the unusual might not work efficiently. How probability analysis can be implemented effortlessly into shipbuilding require further study.

5.3 Forecasting with earned schedule and earned value

Earned value method have been defined, basic formulas explained and illustrated with figures under chapter 4.2 and 4.3. Thus, details and EVM method´s applicability on profit margin forecasting is the focus in chapter 5.3.

Forecasting the profit margin with EVM is possible to consider under cost management. Li (2023) defines EVM as earned Value Management (EVM) is a project management methodology that helps with cost management. As a cost- and schedule-focused project management tool, it guarantees that the project moves forward as planned and eventually yields the intended results.

Project managers estimate the workload and duration, then plan and schedule it accordingly. However, in some cases uncertainties in the processes or in the contract, risks throughout the project cause the estimations being unstable. Always, indirect effects should be considered and included in the estimations.

“Uncertainties in actual cost performance arise from various sources and exogenous factors beyond the control of the project team. A good estimating practice is to indicate the uncertainty in cost estimates in a quantitative way, along with the assumptions made in the estimate, instead of providing deterministic point estimates.” (Kim & Reinschmidt, 2011)

CPI, SPI values were defined in previous chapters. To formulate and estimate the cost at project completion, some new terms must be defined. Deltek (2023) summarizes these terms as followingly (a) an estimate of the total cost needed to finish a project, taking into account its performance up to the reporting date, is called an estimate at completion (EAC); (b) the difference between the budgeted and expected total costs at project completion is known as variance at completion (VAC); and (c) VAC = BAC – EAC, where BAC stands for budget at completion).

Estimate at completion have been summarised for different scenarios in the following figure.

Name	Definition	Formula
Estimate To Completion (ETC)	How much the remaining work will cost in addition.	(1) At the present CPI, if the remaining work is still completed: ETC=(BAC-EV)/CPI (2) Complete the remaining work at planned CPI (CPI=1): ETC=BAC-EV (3) If the project is strictly required to be completed by the planned time (with additional costs to meet the schedule): ETC=(BAC-EV)/(CPI*SPI)
Estimate At Completion (EAC)	Estimate the project's overall cost at a specific point in time.	The actual cost already spent plus ETC: EAC=AC+ETC At the present CPI, if the remaining work is still completed: EAC=BAC/CPI
Variance At Completion (VAC)	The total project cost deviation at the time of completion is known at a certain point in time.	VAC=BAC-EAC

Table 7 - ETC formulation (Li, 2023, p.106)

Alternatively, two different simplified formulations can be used.

$$EAC = \frac{1}{CPI} * SPI(BAC - EV) + AC \quad \text{or} \quad EAC = \frac{1}{CPI} * (BAC - EV) + AC$$

Project manager can calculate the cost estimate at completion for each cost centre or for the whole project. Once the estimated cost is known for the future, it is easy to calculate forecasted profit margin based on the output from EAC formulation. This means EVM itself doesn´t automatically calculate the forecasted profit margin of a project but solves, perhaps the biggest problem to calculate the forecasted profit margin of a project in a future timeline. It is important to note that EMV doesn´t take risks into account. It is expected as project manager´s responsibility to either estimate the risk within the budgeted costs or conduct another formulation to implement the risks on top of the EAV value.

Since all these results are crucial for project financing, it is in many cases required to report to the company management or to the stakeholder up to an extend. During the reporting, it is recommended to use graphs, charts for demonstration. Li (2023) in her application of earned value management in project management titled proceeding, illustrates three different cases scenarios. These are shown as graph below.

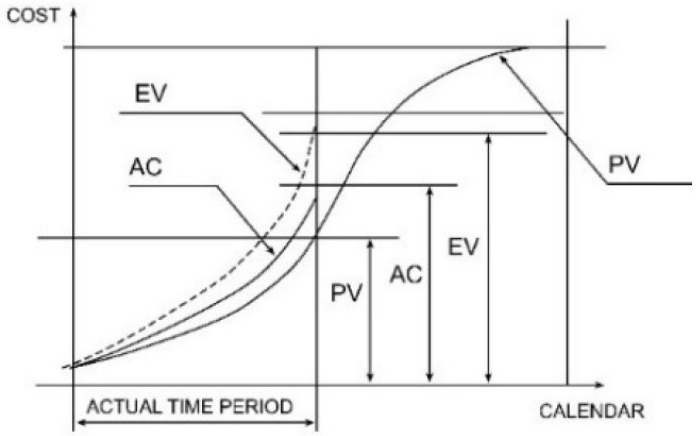

Figure 16 - Under budged & ahead of schedule (Li, 2023, p.105)

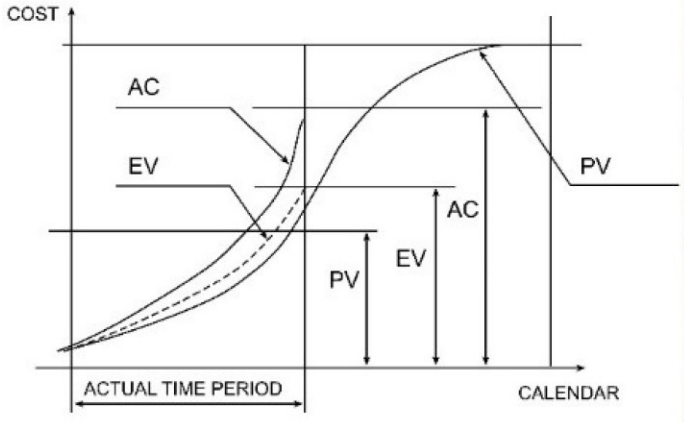

Figure 17 - Over budged & ahead of schedule (Li, 2023, p.105)

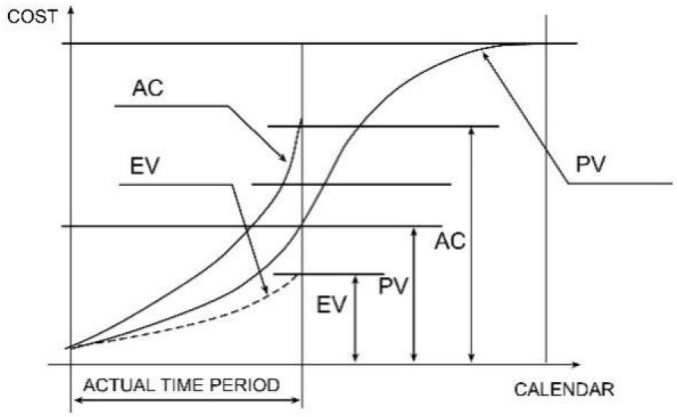

Figure 18 - Over budged & behind of schedule (Li, 2023, p.16)

During the theoretical background study of EVM methodology, an interesting journal article called cost performance index stability: fact or fiction by David S. Christensen and Kirk Payne have been found and read through. Christensen & Payne (1991) in their paper claims that CPI would stabilize once a contract was at least 50% finished. In addition, it is mentioned that the study's database, which included cost performance information from 26 CPRs for seven aircraft procurement programs, was taken from the U.S. Air Force Systems Command Aeronautical Systems Division (ASD) cost library.

Christensen & Payne (1991) highlights their research outcome that CPI range (less than.20) and interval (+/- 10 percent) from the 50% completion point were used to define CPI stability. The hypothesis was validated using performance data of 26 CPRs from seven aircraft procurement programs that were taken from the ASD cost library. From the 20 percent completion point, the CPI range remained constant. The CPI interval remained constant from the 50%

Based on their research, it is remarkable to highlight that %20 and %50 completion rates can be considered as magic numbers for project managers in EVM when they forecast the profit margin for their projects. This being said, project management world is extremely wide and different sectors might show different results. A further study on stability of CPI in cruise ship interior outfitting projects from turnkey company point of view is highly required and suggested for those who wish to deepen their knowledge on the topic.

“Of course, the generalizability of these results to other Armed Services or programs are suspect, since the results are based on a database limited to only U.S. Air Force aircraft.” (Christensen & Payne, 1991)

5.4 Scenario analysis method

There are various seen and unseen elements that can affect the project profit margin. Project manager´s one of the important tasks is to take the time to identify, categorize and mitigate these elements. In some cases, especially the unseen elements which might occur in the future require special examination to assess. Scenario analysis method is found to be a useful tool in this respect.

“Scenario analysis is a process of examining and evaluating possible events or scenarios that could take place in the future and predicting the various feasible results or possible outcomes.” (Vipond, 2025)

In this method, project team lists the unseen elements and creates three different cases such as base, worst and the best scenarios to evaluate the topic further. Dean (2019) in his technical report for multi-modal optimisation of road-space in Europe project highlights that a scenario can be characterized as a coherent and credible depiction of a potential future reality that includes details about the developmental pathways that led to that future state and can be used as a foundation for action. Based on these thoughts, scenario analysis method enables the project team to asses and play different scenerios to predict the future unseen events. Thus, project manager can utilize the data from scenario analysis study to forecast the profit margin with less errors and less surprises. It is important to note that this method only itself isn´t considered as a full profit margin forecasting tool but as a secondary support for accurate forecasting.

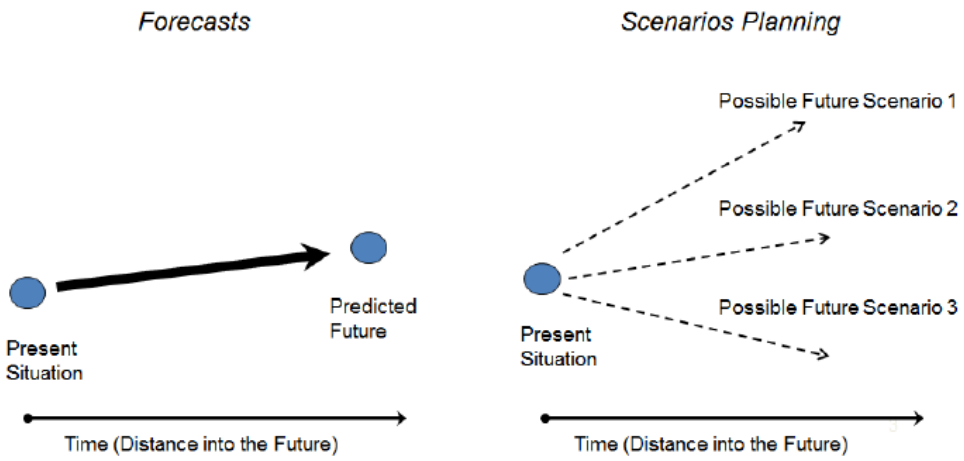

Figure 19 - Comparison between single-point forecasts and scenarios planning (Dean, 2019, p.5)

Dean (2019) lists the basic steps of explorative scenario planning in order followingly: “

1. Scoping
2. Information search
3. Trend and uncertainty analysis
4. Scenario building
5. Strategy definition

6. Monitoring”

One of the important tasks in this process is to decide which topics to build the scenario around. Impact/uncertainty grid is a powerful tool for this purpose.

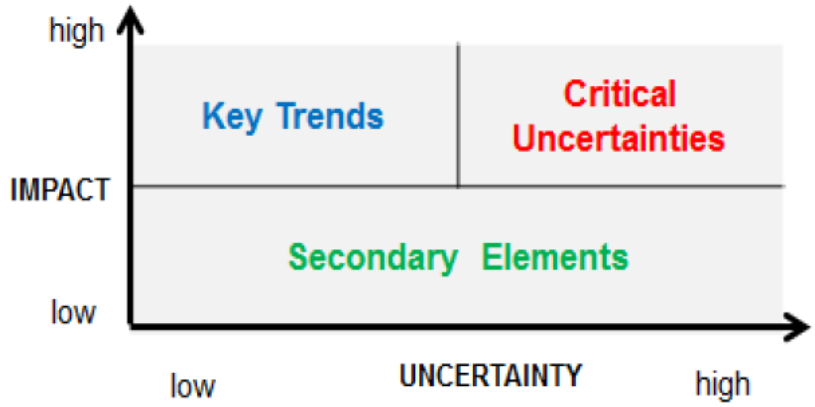

Figure 20 - Impact/uncertainty grid (Dean, 2019, p.9)

Secondary element section consists of elements which have low impact and are not considered in the scenario planning. Even though the top left section has high impact, it still isn´t included in scenario planning due to its ‘low uncertainty, meaning easy to predict the outcome. Finally, the top right section which has high uncertainty and high impact is directly the focus point for scenario planning.

To make the process simplified and easier for project teams to handle, only two critical uncertainties are suggested to select. These uncertainties placed into 2x2 matrix and project team creates four different scenarios around based on their development. The results are seen in different categories such as positive-negative, negative-negative, negative-positive, positive-positive. Dean (2019) demonstrates the matrix in the following figure.

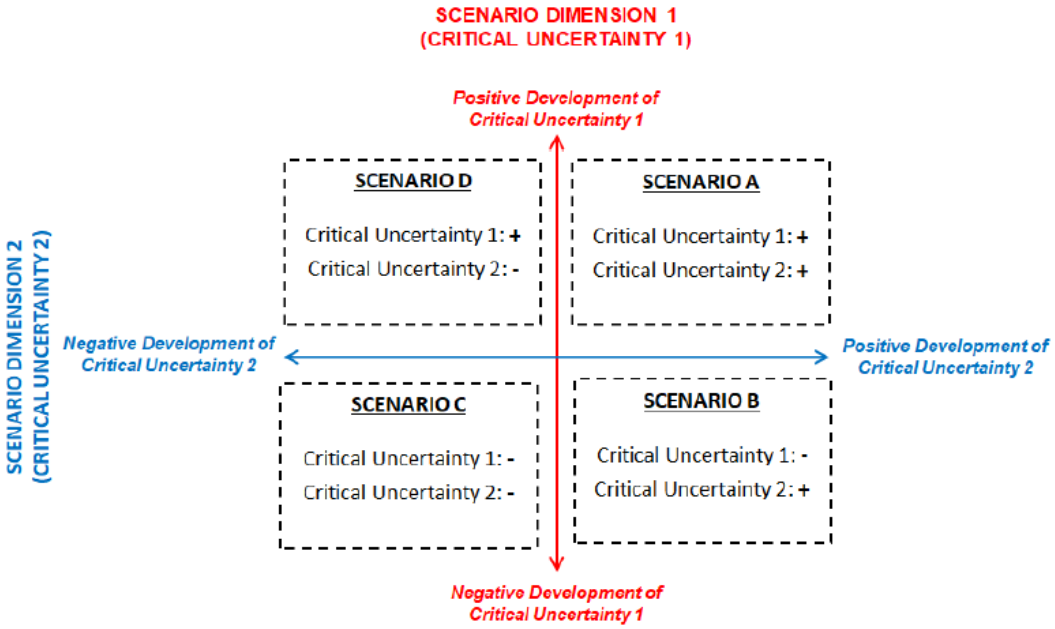

Figure 21 - Example of a 2x2 scenario matrix (Dean, 2019, p.10)

Once the different scenarios have been defined and placed in the matrix, the detailed examination can be conducted. Project managers or the management team then make strategic decisions with options to simulate the outcome and calculate the effect of different decisions and its effects on profit margin. In summary, the project manager can assess the value of different scenarios and decision impacts in euro values. Thus, PM can implement the outcome into project´s profit margin forecasting.

5.5 Quick overview of the methods in comparison with shipbuilding challenges

A modern, high class shipbuilding project for an interior outfitting turnkey company is roughly 18-24 months. Even though the duration might seem long enough, project managers are booked in their calendars. Surely depends on the shipyards, however in many cases there isn´t a specific planning period for outfitting projects. Installation, more specifically early-stage tasks such as steel outfitting, piping and hvac background works take place while design process continues. Meanwhile, PM and the purchaser create the procurement plan so that material sourcing can continue as per installation needs without causing a delay.

The above-mentioned short description explains the busy atmosphere in ship interior outfitting projects. As can be anticipated, it might be challenging for the project manager to take the necessary time to create the basis to implement modern, scientific profit margin estimation methods. Thus, easy and fast applicability of the methods are crucial.

6 Implementation

The main aim of this thesis was to study theoretical background and conduct both qualitative and quantitative research to compare the relation. Thus, clearly to bring outcomes for how to professionally forecast a ship interior outfitting project´s profit margin accurately based on schedule and readiness meanwhile considering their challenges in cruise ship building environment. A mixed method approach has been used in implementation. Survey for quantitative research; interviews for qualitative research have been selected and implemented.

A summary of the implementation methods used in the research has been summarized in the figure below.

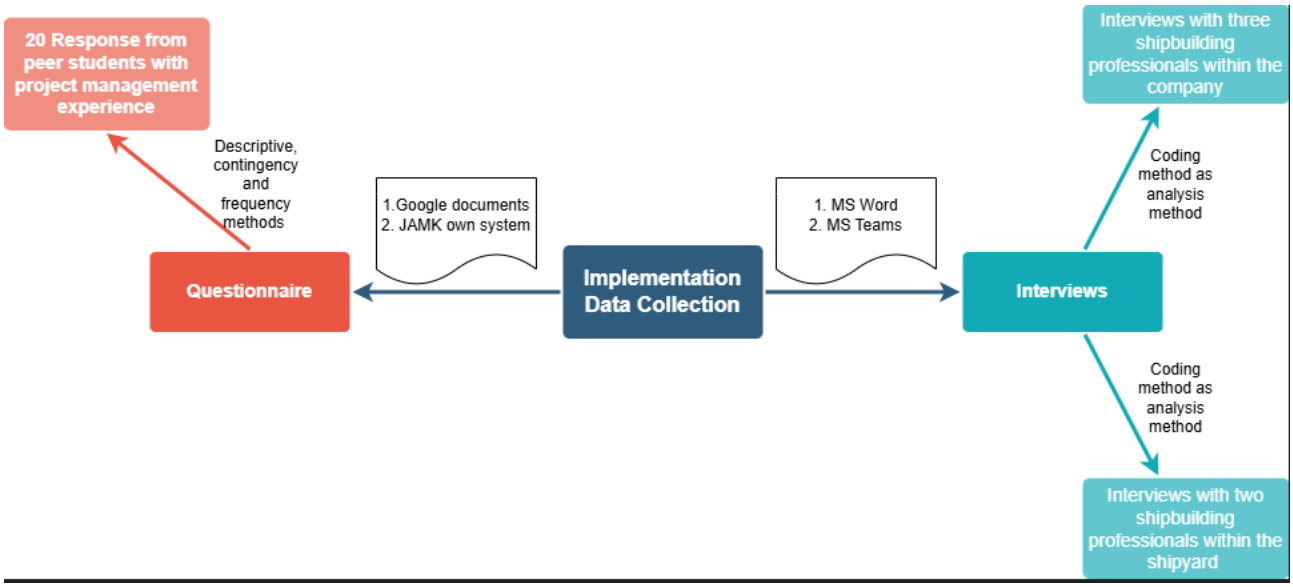

Figure 22 - Implementation methods summary

6.1 Sampling and data collection methods

Even though modern cruise ship building takes place in different shipyards around the globe, there are still significant differences within them such as building methods, environmental approaches, client requirements and order book. These factors can fully affect the project management style and create different challenges. As mentioned in the earlier pages of the thesis, this study has been focused on Meyer Turku shipyard in Finland. Due to this reason, sampling has been also targeted within the shipyard to receive accurate data for better examination results. All interviews, the first part of the survey and the benchmarking are directly executed among the experts who have worked in Meyer Turku shipyard. Moreover, to obtain further accurate data, sampling has been specifically aimed at experts who have experience mainly from ship interior outfitting side through main or sub-contractors. This way, it is aimed to compare the theoretical backgrounds to the implementation results more realistically within the same environment where the study has been conducted. Surely, this implementation, sampling and research design brings limitations as well such as a question mark of outcomes being able to be implemented into general project management practices or relatively similar projects such as construction on a land basis. All the limitations and suggestions/proposals for future research topics have been covered under chapter 8. Final remarks, sub-chapter 8.5. Implementation and results process of the study has been summarized in the figure below.

Figure 23 - Implementation and result process

6.2 Interviews

Five semi structured interviews have been conducted under qualitative research. Totally, six same questions were directed to each participant. In addition, due to the nature of semi structured interview, some extra questions in the thesis subject frame were also asked.

Interviewees were selected based on their role, experience, general motive and willingness to participate in the research process. The first participant, who has 25 years of shipbuilding experience which of 20 years are directly as a project manager. The second participant is a project planner who has five years of experience in project scheduling and reporting. The third and forth participants are project managers who has seven years of experience in the field. Finaly, the fith participant is currently a project director but had experience in the past as a project manager.

As mentioned in the previous paragraph, a motive was one main criteria during the participant selection. It is worth opening the motive meaning in detail. It would be too easy to interview only project managers. However, it was aimed at receiving expert opinions from different fields but yet still related to project management. Thay is why a synthesis of one project planner, two project manager and one project director have been selected.

Interviews have been conducted in the dates between 14th of March and 28th of March in 2025. One interview was on through MS Teams application; meanwhile all others were face to face principle. All participants were informed in advance about the thesis and confidentiality. The average duration of an interview was forty-five minutes. During the interviews, the author aimed to keep as silent as possible and let the interviewees speak. Interference was made In situation such as where the topic is enlarging out of the thesis subject, where interviewee needed some input to continue the conversation.

All interviews were recorded either with automatic record function of MS project or with smart phone´s record function. This way, it has been ensured to secure the data and examine them multiple times when needed. Recording also enabled us to make direct quotes from the participants.

6.3 Surveys

Surveys were executed for two different groups under quantitative research. The first group was focused on people who are working at Meyer Turku shipyard with direct or indirect experience with project management. The second group was peer students at JAMK´s Professional Project Management Master´s degree programme in different years.

JAMK´s own survey tool was used for the JAMK students; meanwhile Google forms were used for the other group. It was ensured that survey link didn´t allow to input participant´s personal information or any kind of secondary information which might lead to identifying the person. This way, total anonymity took place and didn´t have an effect during the result examinations.

Survey questions prepared in a way that covered the whole theoretical background studied in the thesis. It has been synthesized with research questions and participants were asked a total of fourteen questions which of (a) three generic questions, (b) three questions from project scheduling, (c) three questions from project readiness, (d) one question from risks, and (e) four questions from forecasting. Eight questions for close ended, four questions were multiple selection enabled, and two questions were selected through a scale.

The survey questions were also designed to retrieve answers from how they see the current state, what are their challenges, how they see the ideal state and how it should be. This way, results were aimed at being analyzed systematically and logically. Survey links were sent to the participants via email on 21st of March in 2025 and surveys remained open two weeks until 04th of April in 2025.

In summary, the survey was precisely prepared to gain data and statistics from participants on directly the practicality of theoretical background and most importantly data on research questions.

7 Results

Due to the confidentiality agreement, this chapter of the thesis has been limited for full access. Confidentiality agreement duration is 6 years and will end on 01/06/2031.

8 Final Remarks

8.1 Summary of the research

The driver of this study was to define obstacles for project scheduling, project readiness calculation and investigate methods for accurate project profit margin forecasting within specifically cruise ship outfitting projects. In recent years due to the several economic crisis, the competition

to sign a contract with the shipyard or directly with the cruise companies has been more challenging than ever and this has pushed many interior outfitting companies to reduce their installation costs and most importantly to understand the realistic profit margin forecasting during the project based on the project´s current situation (readiness, schedule) to take necessary financial actions already before the project ends. The research aimed to give the project managers a powerful tool to improve their forecasts and report to the stakeholders. This way, companies finance department and the stakeholders will have a realistic view already during the project before red flag is raised and get an opportunity to conduct necessary actions to balance their cash flow.

An intense theoretical background study has been conducted to define project scheduling, project readiness calculation and profit margin forecasting methods. In addition, qualitative and quantitative research took place specifically within the target group to bring up the current state challenges. Theoretical background and research have been combined, and valuable ideal state is defined. Earned value management with risk tool applications are seen as the best fitting implementation possible. However, several challenges have been documented to be tackled before or even during the launch of the suggested methods within the company for the best results.

8.2 Implementation suggestions in the shipbuilding industry

Due to the confidentiality agreement, this chapter of the thesis has been limited for full access. Confidentiality agreement duration is 6 years and will end on 01/06/2031.

8.3 Reliability of the study

Despite the study having brought important outcomes both theoretically and most importantly practically into life, it still contains a few limitations. One of the limitations is the research environment. The study has been conducted in Meyer Turku shipyard in Finland and aims a specific company to improve its operations. Thus, the study outcomes may not be applicable for another turnkey cruise ship interior outfitting company in the same shipyard or in another countries. Shipbuilding methods and culture vary depending on the country and in even cities. This unique topic should be considered for implementation in different circumstances.

The second limitation is the size of sampling took place for quantitative and qualitative research. Even though the sampling took place with direct professionals within the industry, it still contains a small % of error due to the sampling size. A total of twenty different people has responded to the survey, meanwhile five interviews have been conducted.

The third limitation is the lack of previously conducted similar scientific articles or documents. It has been realized that there is extremely limited or even nonexistent research conducted related to the research topic within shipbuilding industry. There have been found many sources available for land-based construction within the same topic. However, modern cruise ship building differs from land-based constructions. Due to this fact, there might be differences in theoretical background when it is compared to the actual implementation on the site.

8.4 Personal considerations

The research has provided broad theoretical information and most importantly concrete implementation suggestions. In the beginning of the thesis, I have always aimed to bring ideas which can be used realistically in the field. The whole research process has been conducted with this purpose and intention. Finding sources, filtering them into shipbuilding industry, evaluating the actual possibility to use on site brought many challenges. However, the research has also enabled me to learn many new topics and forced me to think differently which was eye opening in many cases. Constantly comparing the theoretical background to how I am tackling my daily tasks as an active project manager pushed me positively to change my point of view in many perspectives. In the end, I truly believe that the research has brought useful new aspects into project profit forecasting, scheduling and readiness calculation not only on the paper but in actual practice.

8.5 Suggestions for future research

The extended level of research in specific topics related to this thesis is highly recommended to deepen the knowledge and to create foundation for the lack of theoretical resources in shipbuilding sector. The first future research topic suggestion is conducting the same framework within different shipyards in other cities and countries to understand the general applicability of proposed concrete implementation results. This way, a generalization on correct forecasting would be possible in cruise ship building sector wise.

The second suggestion is related to internal communication and teamwork between different teams within the same organization and their effects on correct scheduling. As mentioned in chapter 7.3 under quantitative findings examination, external factors were proven to be one of the highest impacts towards correct scheduling. Correct information processing, teamwork, and correct internal communication are valuable sub-topics which are worth investigating the effect on scheduling.

The third suggestion is the possible usage and implementation of probability analysis and monte carlo method in shipbuilding industry. These methods have been found to be very valuable for-profit margin forecasting under theoretical background study. However, the same methods require detailed technical understanding of formulas and even implementing the formula in specific cases. A study where simplification of these methods are conducted to enable them to use in shipbuilding study is suggested and considered to be useful.

8.6 Data, ethics, GDPR

This thesis has been conducted with full consideration of proper citing, research ethics and plagiarism. All details of the citations are given under the references chapter with as much detail possible. ChatGPT, Gemini or other similar AI applications aren´t used at all for creating any contents. Only in extremely limited perspective, it is used to find further resources to extend the knowledge on the thesis topic. During the qualitative and quantitative research, all participants were asked to be a part of the study as voluntarily without any forcing. Personal information such as name, surname, birthdate, email address, company and other similar items haven´t been collected. All participants were informed that they can withdraw their statements and selections. In the end of each interview, the conversation and the notes were presented to the interviewee and asked if any changing is required. Data and presentation of the data have been presented transparently and accurately to ensure the results are objective and reflect reality.

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Appendices

Appendix 1. Survey questions

- What is your current position in your company or organization?
    - Project manager, are manager or category manager
    - Project engineer
    - Development manager
    - Planner, scheduler or its manager
    - Purchaser, purchasing engineer or manager
    - Site supervisor
- What industry you are working at?
    - Shipbuilding
    - Automative
    - IT
    - Construction
    - Energy
    - NGO
- How long is your experience in project management?
    - 0-1 Year
    - 1-3 Years
    - 3-5 Years
    - 5-10 years
    - More than 10 years
- What are the three biggest challenges in project scheduling which limits or prevents ideal project scheduling?
    - Time limitation in planning phase
    - Lack of human resources in the team
    - Lack of information from customer
    - Lack of information internally
    - Lack of technical knowledge
    - Workload, working in multiple projects
    - Lack of co-operation between different parties
    - Lack of project scheduling and IT software
    - Task duration estimations
    - Resource estimation for tasks
    - Lack of knowledge in project scope
- Which of the following project scheduling types you have used, at least once?
    - Gantt scheme, method
    - Critical path method
    - Programme evaluation and review technique
    - Last planner
- Do you think project readiness is calculated realistically? Scale 1 to 5)
    - 1
    - 2
    - 3
    - 4
    - 5
- What are the three biggest challenges in project readiness calculation?
    - Lack of tasks or WBS

    - Lack of reporting from the site on completed tasks
    - Lack of technical expertise to calculate the readiness
    - Wrongly calculated task weight/coefficient
    - Lack of control points or milestones
    - Wrongly made scheduling such as inaccurate total hours, duration
    - Unexpected extra tasks which are not planned in scheduling
    - Time and human resource limitations
    - Software limitations
    - Lack of lessons learned (red pen comments)
- Have you ever heard or used EVM "Earned Value Management" which is to compare the readiness to the planned readiness or compare the realized costs in comparison with received readiness and planned readiness?
    - No, I have not heard or not used EVM
    - I have heard but not used EVM yet
    - I have used EVM time to time
    - I have been actively using EVM
- How widely the risk tool is being used in your projects or organization? Select from 1 to 6.
    - Risk tool not used or risks are not monitored
    - Risk tool is used once in planning phase
    - Risk tool is being used throughout the project but not updated frequently
    - Risk tool is being used and mitigations followed up time to time
    - Risks tool is being used actively, each risk identified in Euros.
    - Risk tool is active, risks identified in euros and included into profit margin estimation
- What are the top three reasons in your opinion why installation costs go over the budget compared to the project manager estimation in the beginning of the project?
    - Unexpected costs during the project
    - Project scope complexity
    - Lack of WBS (Installation is not divided into enough small categories)
    - Project manager forecast is accurate but budged is not enough
    - Worker´s ability or efficiency
    - Lack of strict follow up of the used hours compared to the planned works
    - Poor planning phase
    - Design, drawings
    - Lack of information or co operation between different parties including customer
- What is the biggest challenge in your opinion when forecasting the project´s profit margin?
    - Time limitation to prepare and calculate
    - Lack of data on project readiness and needed hours to complete the remaining tasks
    - Hard to guess/estimate the worker´s efficiency on the site
    - Risks in the project
    - Not trustworthy schedule and readiness reporting
- Do you think is there a scientific way or a formula to calculate and forecast the project´s end result profit margin when project is ongoing?
    - Not possible
    - Up to an extend but very limited
    - Partially. However, I have doubts in practicality
    - Totally
- Do you have an automated software or tool in your organization to alert you for cost places where costs might go over the estimation or the budged based on the realized hours trends?
    - Not at all
    - Up to an extend (I need to do itmanually)
    - Fully automated
    - I am using my own implementation suchas separate excel sheet(s)

Appendix 2. Interview questions

Question-1: Project scheduling and project readiness are two of the basic fundaments of project management. Can you shortly describe how a perfect scheduling and readiness reporting looks like?

Follow up question: In your opinion what the blocking points are for creating a perfect scheduling in ship interior outfitting projects? And calculating and reporting perfect readiness in ship interior outfitting projects?

Question-2: Imagine that you have 6 workers as hourly base for piping installation.

- How do you follow-up the cost?
- How do you ensure that they spend the hours within the budged?
- How do you check that they perform within the schedule?

Question-3: Now imagine the question Nr1 but you have 10 different category similar to this such as electricity, interior, painting, AC, flooring, insulation. Does your company have a software to follow all together everything or do you conduct your own method, such as own excel? Can you give an example?

Question-4: In your periodical project finance review or even for your own evaluation, what are some critical key points you check to see if the project finance in healthy situation?

Question-5: In your opinion, what is the reason that generally project manager´s project profit forecasting tends to drop the more close the project delivery approaches? And is there a way or method to prevent this happening? Meaning the profit forecasting do not dramatically drop but remain the same with -/+ tolerances?

Question-6: Have you heard forecasting with earned value management? Monte carlo method? Scenario analysis methods?

- Do you think any of these methods can be used for profit margin forecasting?
- How do you see the practicality of these methods?
- What could be the possible challenges?