Universidad de Valladolid

Optimizing Project Portfolio Schedules Under Financial Constraints: A Practical Tool for Cash Flow Management

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GRATITUDE

First and foremost, I must give my deepest gratitude to God whose kindness is endless. He gave me the opportunity to write this thesis, and he also gave me strength and perseverance to complete this challenging journey. I also extend my most sincere thank you to my family for their unwavering prayer and spiritual encouragement, I believe that their quite prayer lights my way. To my friends, thank you for the never-ending support, for always believing in me and for being there. Importantly, my deepest thank you is for both of my professors – my tutors – for the guidance, insight and mentorship from the very beginning. My professors' presence and dedication reminded me that I am not doing this alone. Finally, to my new coworkers, sincerely thank you for your patience, generosity and understanding especially during my crucial times.

ABSTRACT

This master's degree thesis introduces a tool for managing portfolio schedule with financial constraints. The objective is to develop a model which helps organizations schedule their whole portfolio avoiding any negative cash flow balance while getting the highest profit possible. The tool operates within Excel and allows users to input the organization's financial data and gives a real time preview of their finance condition.

To better understand organization´s scheduling performance, this model lets users explore different scenarios and instantly see how each changes affect cash flow and profitability. Its intuitive design makes it easy to spot overhead costs and adjust project schedule. With its real-time adaptability, users can make explore schedules that help balance resources and reduce financial risks. The tool is designed to guide users and provide insights for making strategic decisions.

Keywords

Portfolio Management, Multi-Project Scheduling, Financial-Constraints, Optimization

RESUMEN

Este Trabajo Fin de Máster (TFM) presenta una herramienta para la gestión de la programación de portafolios con restricciones financieras. El objetivo es desarrollar un modelo que ayude a las organizaciones a planificar la totalidad de su portafolio evitando cualquier saldo de flujo de caja negativo y obteniendo el mayor beneficio posible. La herramienta funciona en Excel y permite a los usuarios ingresar los datos financieros de la organización, ofreciendo una vista previa en tiempo real de su situación económica.

Para comprender mejor el desempeño de la programación, este modelo permite a los usuarios explorar diferentes escenarios y ver al instante cómo cada cambio afecta el flujo de caja y la rentabilidad. Su diseño intuitivo facilita la identificación de los costos y el ajuste de los cronogramas de proyecto. Gracias a su adaptabilidad en tiempo real, los usuarios pueden explorar planes que ayuden a equilibrar recursos y reducir riesgos financieros.

Palabras Clave

Portafolio, Programación multi-proyecto, Restricciones Financieras, Optimización

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INTRODUCTION

Project Objective

The objective of this thesis is to develop a flexible and practical tool for scheduling a portfolio. The portfolio consists of projects. While each project contains several activities and each activity has an outcome and generates income. It specifically seeks to a offer workable tools for maximizing cash flow management in frequently occurring circumstances including inconsistent or delayed customer payments. By considering organization´s financial situation and analyzing project cash flow dynamics, the study seeks to offer an easily workable tool for mitigating financial risks and ensuring a maximum benefit possible.

Even though an interior design and built company was chosen to be the case study, this tool is to be flexible and practical, so it also serves for any organizations that must manage a number of overlapping projects under financial and operational boundaries. By analyzing the cash flow of each project, the study seeks to create a user-friendly solution that supports decision-making and reduces financial risk across the project portfolio.

The proposed solution focuses on optimizing cash flow management, one of the most common challenges in multi-project environments. This tool will enable companies to predict the timing of expenses and revenues more effectively. Thus, providing users with workable information to ensure that financial constraints are met without compromising project performance.

Project Scope

This study will focus on a portfolio consisting of several projects, which each of the project contains multiple activities. A simplified sample from an interior design company in Indonesia that manages both design and construction projects will later be studied and used as an example. The research will explore the unique challenges these types of projects face, particularly in managing cash flow and scheduling under financial constraints.

It will begin by analyzing available academic and commercial scheduling tools and methods. Based on recent studies, analyzing the positive aspects and advantages while also taking into consideration the lacking aspects. Then the company's current and past portfolio management tools and financial planning procedures will be studied. Special attention will be given to customer payment patterns and how they influence operational flow.

The study will then develop a workable model to help generate the most beneficial portfolio schedule. To do this, data on the company's resource performance and cash flow pattern will be collected and examined. Through this structured scope, the study aims to deliver a clear and flexible model that helps companies plan their projects with both flexibility and financial awareness.

Project Motivation

This thesis is motivated by the common financial challenges faced by interior design and construction companies, particularly in Indonesia, where there is a saying, *"Klien adalah raja"* which means *"the client is king"*. This mindset encourages professionals to give their best, but it also presents some challenges, such as delayed payments or resources overload that can disrupt cash flow and threaten the continuity of projects. In many cases, companies need to use funds from another ongoing projects to cover the expenses. This study aims to address and predict these types of challenges by providing a flexible tool that helps companies go through financial uncertainties and optimize the use of their resources. Ultimately, the goal is to contribute to the field of project management by analyzing and developing a scheduling model using a common program, Excel.

In line with the main motivation, as recent studies underline, there remains a demand for a practical and flexible scheduling tool that can operate in real-time, is easy to use and requires no special expertise to operate it. This study addresses it by developing the model in a common commercial application. The tool needs an intuitive Gantt-style interface with automated calculations and an easy adjustment. It is also important for the tool to be able to take into consideration the organization's current financial situation and their planned growth to make a more accurate simulation. Ultimately, the proposed model aims to bridge the gap between academic insights and real-world practica.

Document Structure

This thesis is structured as follows:

- **Chapter 1**:
  This chapter lays the foundation for the thesis by exploring the concept of Project Portfolio Management (PPM) and identifying gaps in current scheduling tools and methods. It begins with an overview of PPM, emphasizing its role in managing multiple projects while ensuring alignment with organizational goals. The discussion then moves to the strengths and limitations of existing scheduling tools, focusing on financial constraints implementation. We then trace scheduling's evolution, from early manual techniques to modern software, and introduce finance-based scheduling as a promising way to bridge these gaps. Finally, a case study of a mid-sized Indonesian interior design and construction firm illustrates the real-world challenges that inspired our proposed model.

- **Chapter 2**:
  This chapter introduces the crafted simulation-based model to bridge the gaps identified in Chapter 1. We start by highlighting why a scheduling approach that includes financial constraints is essential, then contrast traditional tools with a finance-based alternative. From there, we map out the model's standout features, such as flexibility, adaptability, and built-in financial integration, then finish off with a walk through its overall structure and mechanics. We will see how the planned schedule, financial projections, and control mechanisms work together to drive proactive planning and smarter decision-making. Finally, we dive into the tool's main sections, complete with visual guides and real-world examples to bring its capabilities to life.

- **Chapter 3**:
  This final chapter offers a theoretical demonstration of the tool, to deepen the understanding and show how it can be applied in real-world settings. We begin with step-by-step guidance on completing the data tables, then explore how each component connects and is arranged behind the scenes. Next, it will discuss custom modifications, so it fits the organization's needs. We then walk through the financial projections, explaining how to interpret the results for smarter decision-making. It wraps up by analyzing variations and scenarios to showcase the tool's flexibility under shifting conditions. By the end, users would have a better understanding of the tool and how it adapts to optimize portfolio performance.

Chapter 1. Base Context and Problem Identification

Managing several projects with their own budget, while scheduling their activities with limited resources are one of the main issues for most companies (Asgari et al., 2024). Since all projects are collectively managed through centralized coordination with standardized procedures, a portfolio-level approach is essential. As defined by Project Management Institute (2021), portfolio is a collection of programs and projects that are operated together to achieve a strategic goal.

This chapter will start by examining the idea of Project Portfolio Management (PPM) where multiple projects are managed at the same time under common operational and budget constraints. It will explore how organizations manage multiple projects under a shared resource, operational manager and budget constraints to optimize overall schedule performance.

Supporting theories from the previous topic, the next chapter will do a deeper study about available tools and methods. Mainly, academic and commercial tools and methods. Will be explored, the advantages, performance and adaptability of each tool and method. As we collect information and study each tool and method's effectiveness, we will also document restrictions, limitations and constraints for each tool and method if there is any.

Most scheduling tools and methods excel at mapping critical-paths, defining and linking activity dependencies and allocating resources, yet few incorporate a holistic finance-based perspective. Finance -based scheduling would consider all cash inflows, outflows and interproject financial interactions together, rather than treating each project's budget as an individual part. Hence, Asgari et al. (2024) suggested a collaborative finance-based scheduling approach that allows sharing financial resources across concurrent projects. This approach drastically lowers financing costs and increases profitability. In line with this, Fares et al. (2025) also emphasizes the importance of finance-based scheduling models considering both cash inflows and outflows in project portfolios.

Mentioned by Project Management Institute (2021), Microsoft project is the facto standard for detailed schedule development for every industry. Hence, a section will be dedicated to Microsoft Project. It will be explored their potential to reflect an optimal scheduling tool and its performance. In the end of the section, we will reflect the adaptability of Microsoft Project to reflect financial connections between projects or between activities.

To ground this debate in a real-world setting, this chapter will offer a case study of an Indonesian interior design and construction company. This firm is an adequate example because its sector faces interconnected uncertainties and an overlapping portfolio schedule. Especially in the management of several continuous projects, the firm regularly finds it challenging to match project timelines with available cash flow.

A subsection will be dedicated to reviewing the scheduling tools that the company has tried implementing. The company values current scheduling tools capability to track cashflow, allocate resources and visualize portfolio timeline. But the firm has identified a critical gap, which is the need of a real-time, finance-based scheduling tool that integrates portfolio schedule with cash-flow constraints. As project activities in this firm often require significant upfront spending with revenue only realized upon completion, or to put it in another word, the worst-case scenario. Thus, with this high risk, it's essential for the company, a tool to integrate these financial dynamics alongside portfolio schedule.

1.1 Project Portfolio Management (PPM)

Project Portfolio Management (PPM) as defined in A Guide to the Project Management Body of Knowledge (PMBOK® Guide) – Seventh Edition is a centralized management of one or more project portfolio to achieve strategic objectives. To maximize organizational resource and management, a portfolio is a collection of programs and projects. The objective of portfolio is to facilitate effective oversight and maximize organizational value. Each portfolio may contain one or more than one sub-portfolios, programs and projects. While program is a group of projects with the same objectives. Figure 1.1 gives preview about one example of a relationship between portfolio, program and projects.

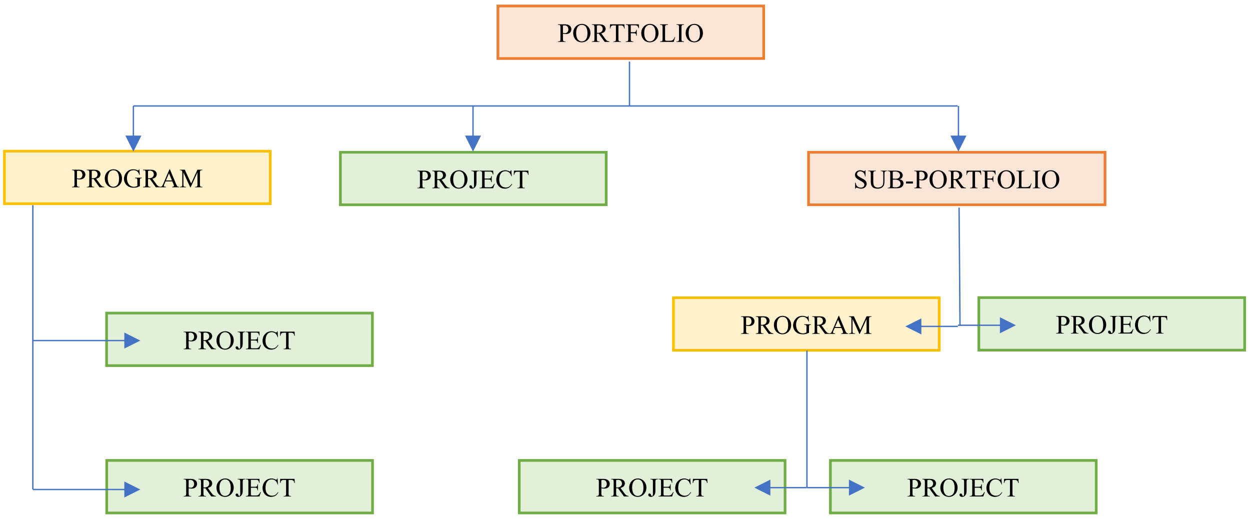


Figure 1.1: Relationships between portfolio, program and project. Source: Own elaboration

By treating portfolio, program and project as interrelated components rather than isolated components, PPM is meant to centralize them to organization's broader vision and goal (Institute, 2021). In today's fast-paced business development, organizations face evolving market demands while considering resource constraints and giving their best effort for client's satisfaction. For that reason, PPM provides a more structured framework for prioritizing initiatives based on expected benefits, risks and strategies. This balance helps decision-makers balance competing demands.

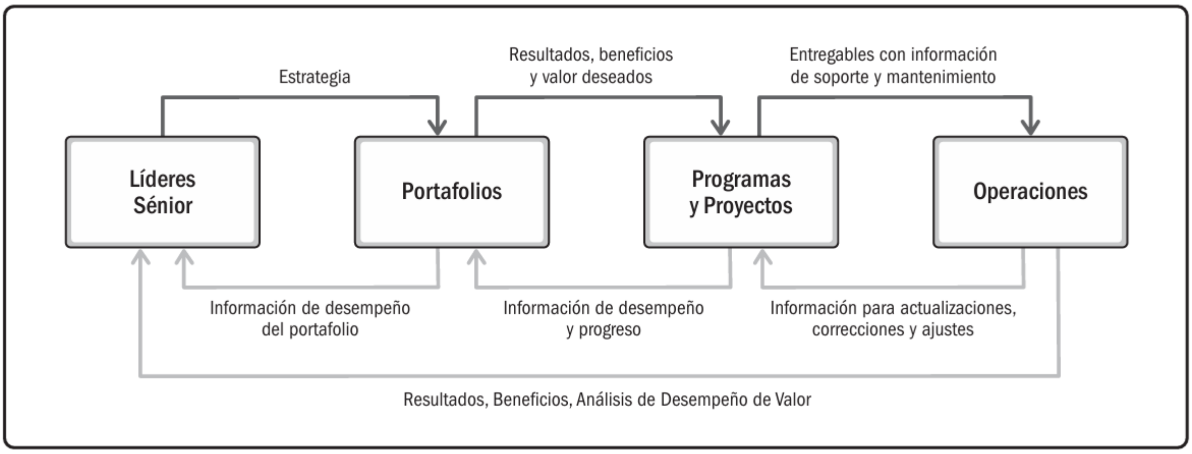


Figure 1.2: *Example of information flow in PPM. Source: Project Management Institute (2021)*

Visual guidance in figure 1.2 shows how information flows through this model. Direction and desired goal flows downward from senior leadership into portfolio decision which then affects program, projects plans and operational activities. At the same time, performance data and lessons learned travel the opposite direction from operations, to projects, programs and back to portfolio governance.

Main PPM focus as described in A Guide to the Project Management Body of Knowledge (PMBOK® Guide) – Seventh Edition are as follows:

- Use agreed-upon value criteria to define and prioritize portfolio components.
- Optimize resource allocation across concurrent projects.
- Monitor performance through metrics such as return on investment (ROI), schedule variance and risk exposure.
- Conduct portfolio reviews to adjust scope, budget and timeline to respond to data performance and strategic priorities.
- Prioritize transparent decision making and positive compliance with organizational policies through establishing governance structure.

Further, the PMBOK® Guide groups PPM within five performance domains and aligns it with eight guiding principles. For the importance of integrating strategic planning with continuous feedback loops, PPM bridges the gap between high-level corporate strategy to day-to-day project execution.

Another similar study refers to Project Portfolio Management (PPM) as an approach whereby current or proposed projects are analyzed and collectively managed by a centralized coordination of procedures, methodologies, and technology applied by project managers. The objectives are ensuring alignment with strategic objectives, optimal use of resources, and balance of risks and returns throughout the portfolio. (Dixit & Tiwari, 2020)

Kononenko & Kpodjedo (2022) claim that PPM offers a disciplined framework for assessing, choosing, and supervising a group of projects in a way that maximizes their combined worth. It stresses not only the technical performance of specific projects but also the strategic fit of the whole portfolio with the long-term objectives of the company. In sectors like construction and interior design, where businesses sometimes juggle several projects with overlapping timetables and shared resources, this is especially important.

Still, one of the difficulties companies encounter in actual settings is distributing resources among projects. The company must additionally change their internal structures—such as portfolios and programs—and control their resources in a way that satisfies contractual responsibilities relating to scope, schedule, cost, quality, and stakeholder satisfaction. Especially in cases of financial restrictions, this calls for a dynamic and flexible attitude to planning and execution.

Recent research underlines even more the need for strategy alignment and risk control in PPM. For building holding companies, for instance, Ghanbari et al. (2024) created a multi-objective optimization framework combining risk analysis and strategic alignment to enhance portfolio performance. Their results show the significance of having instruments for decision-making that not only maximize project choice but also consider financial and operational limitations over the portfolio.

Within the framework of this thesis, PPM provides the basis for comprehending how businesses handle several initiatives. Their difficulties, especially in matching project timelines with available resources, emphasize the need for a more finance-conscious method of scheduling.

According to Dixit & Tiwari, (2020), PPM is a powerful strategic approach to manage risk and evaluate schedule, economic and organizational part of a project. The study shows that PPM also helps evaluate and manage the risk across the portfolio, allocating resources and scheduling projects that balance risk and return. One of the important aspects that can be addressed by PPM is the portfolio scheduling which determines the optimal execution date for activities across multiple projects while sharing resources. But as the project gets more complex, the need also arises for a scheduling tool that can balance the scheduling, risk and project control to maintain alignment with organizational objectives.

Traditional PPM focuses on the alignment of strategic goals and resource and risk management. It also manages better the project selection and strategic alignment without integrating dynamic resource planning or real-time monitoring. While the modern PPM framework that has been studied recently is more finance aware. Hence, based on Project Management Institute (PMI), the modern framework is designed to strategically allocate resources, identify and manage risk and balance short-term execution with long-term strategic goals.

1.2 The Gap of the Current Scheduling Tools and Methods

1.2.1 History of Scheduling Tools and Methods

1.2.1.1 Evolution of the Standardization of Scheduling and Adoption Through the 20th Century

As time goes by, project scheduling methods and tools have evolved to adapt to the increasing difficulty in resource and time management. Starting with basic visual tools like bar charts, first presented by Karol Adamiecki in the late 19th century and then popularized by Henry Gantt in the early 20th century. The Gantt chart is built based on earlier innovations in visualizing time and work. The table below shows key milestones leading up to the Gantt chart's creation:

Table 1.1. Origins of earlier innovations in visualizing time and work. Source: Weaver (2021) and Gantt (1919)

Year	Key development in scheduling charts
1765	Joseph Priestley (England) publishes a *"Chart of Biography,"* plotting 2,000 famous lives on a time-scaled graph. This early timeline chart demonstrates the principle that time intervals can be represented by proportional bar lengths, laying groundwork for later schedule diagrams.
1896	Karol Adamiecki (Poland) devises the Harmonogram (or Harmonygraph), a work harmonization chart based on graphical analysis. Activities were represented by strips which positions and lengths showed timing and duration, with each strip labeled with the task name and its prerequisites. Adamiecki's Harmonygraph which has developed over a decade before Gantt's charts, has tabulated each activity's predecessors and successors, foreshadowing critical path analysis by 60 years. Due to language and limited dissemination, Adamiecki's innovations remained largely unknown in the West at the time.
1910	Henry L. Gantt (US), a mechanical engineer and management consultant, created his production scheduling charts. Gantt's charts were initially intended for managing factory workflows and tracking performance against time. He laid out work for machines and workers as horizontal bars on a time scale, comparing daily progress to planned output. This Gantt progress chart, which was developed around 1910–1915, has proved to be highly effective for planning and controlling production. The rate of work done was continuously compared against time elapsed, which stimulate management action to keep tasks on track.

Year	Key development in scheduling charts
	During World War I, General William Crozier of the U.S. Ordnance Department employed Gantt to implement these charts for coordinating arms and munitions production. At the time of speaking, traditional tabular reports had failed to convey progress on massive orders. Gantt's method provided a clear visual comparison between performances and promises; it helps on identify missed schedule and assign accountability for delays.
1923	Wallace Clark (US), a former associate of Gantt, published a book with the title "The Gantt Chart: A Working Tool of Management." This book is the first to formally name and describe the Gantt chart and it focuses on one of Gantt's later chart types for daily production control. Clark's 1923 publication codified Gantt's charting techniques and introduced them to a broad audience. Notably, the term "Gantt chart" was not used during Gantt's own lifetime. Instead, it gained its fame only after this publication. Clark's book was soon translated into multiple languages, firmly establishing the eponymous chart as a staple tool in management science.

The Gantt chart introduced by Henry L. Gantt in 1919 marked a turning point in scheduling by converting intricate project sequences into simple horizontal bars plotted against a time axis. This visualization enables user to see task durations, sequencing and progress at a glance. Gantt chart has evolved from a factory production aid into one of the most recognizable and widely used project management tools in the world. Unlike a simple timeline bar chart, Gantt's chart was designed as intensive production control tools as it did more than schedule tasks, but it also tracked how actual output measured up to the plan on day-by-day basis. As a result, Gantt's contribution was to unite task scheduling with performance monitoring in one intuitive diagram. (Weaver, 2021). At that time, this was a big shift from relying on written reports and tables as its visualization equipped managers with a "universal language" of time vs. work that doesn't need any specialization to understand it. Click or tap here to enter text..(*Understanding Gantt Charts: A Classic Tool for Project Scheduling*, 2024) Until today, this scheduling tool has yet extensively used today for their simplicity and clarity as Gantt charts offered a visual schedule of activities and their durations practically. (Bourne & Weaver, 2018)

More techniques emerged in the middle of the 20th century to address bar chart restrictions. Kelley and Walker at DuPont created the Critical Path Method (CPM) in 1956 to handle plant maintenance projects. CPM first proposed the idea of the critical path, that is, the longest sequence of dependent activities—which control the minimum project length (Bourne & Weaver, 2018). The U.S. Navy developed the Program Evaluation and Review Technique (PERT) concurrently for the Polaris missile project. Particularly helpful for research and development projects, PERT brought probabilistic time estimate to allow for variability in task durations. (Weaver, 2014).

The adaptation of these charts to general project management happened gradually after him. Nonetheless, because Henry Gantt's implementations were the first that many American industrial managers encountered, especially through wartime logistics. The technique became strongly associated with his name. By the early 1920s, the term "Gantt chart" came to signify any project schedule shown as a time-lined bar chart, even if Gantt's original charts were more nuanced than the simplified planning graphs we often see today.

The utility of Gantt charts for large scale projects was demonstrated in landmark infrastructure endeavors. A famous example is the Hoover Dam project (USA, 1931–1936), which relied on a Gantt chart to schedule and coordinate its complex construction phases (*The Gantt Chart and the Hoover Dam Project*, 2017). The project utilized Gantt chart for plotting thousands of tasks along a timeline. It was so central that a bronze reproduction of it is on display at the dam site today. (Figure 1.3).

By rendering the entire project plan in one chart, it allowed engineers, contractors, and stakeholders to visually grasp when each phase would occur and how they interrelated. The success of Hoover Dam firmly cemented the Gantt chart as a go-to planning instrument for major engineering works. Subsequent projects continued this trend; for instance, Gantt charts were used in constructing airports and the U.S. Interstate Highway System in the mid-20th century. By the 1940s, virtually every large construction or defense project was plotted on a Gantt timeline to monitor progress. (*The Gantt Chart and the Hoover Dam Project*, 2017).

Figure 1.3: Gantt chart for Hoover Dam Project in USA 1931 – 1936. Source: History of the Gantt Chart (n.d.)

Over a century after its establishment, the Gantt chart's impact on project management is profound and unmistakable. It has not only influenced how we schedule projects, but also how we think about planning, coordination, and time management. Key aspects of its enduring impact include:

- Standardization of Scheduling: Gantt chart introduced a standard way to represent project timelines that is now implemented across virtually all industries. Even with sophisticated planning software available, it is estimated that 80% of users utilize little beyond the basic Gantt chart features of tasks, durations, and progress bars – underscoring that Gantt's simple framework still underpins most project schedules. (Kerzner, 2017)
- Visualization and Communication: One of the greatest contributions of the Gantt chart is making the project plan a visual communication tool. By translating complex schedules into a graphical timeline, Gantt charts provide a common language that all stakeholders can understand. (*Understanding Gantt Charts: A Classic Tool for Project Scheduling*, 2024)
- Integration of Time and Work Management: Henry Gantt was one of the first to treat a schedule as a "living" document to both plan and record of what actually happens. He showed managers how to draw planned task bars on a timeline and then mark in the real start and finish dates, or percentage complete, right on the chart. This simple idea made it obvious who was responsible when things slipped. Today, we still use that same baseline-vs-actual comparison: updating our Gantt charts with real progress and letting software send reminders when tasks

fall behind. All modern projects tracking, keeping plans and reality side by side, traces back to Gantt's original approach.(*History of the Gantt Chart*, n.d.)

- Influence on Project Management Methodologies: Henry Gantt's simple idea turned what was once complicated plans into something user could actually see and manage. The clarity of the visual approach gave early project management leaders a powerful tool to order complex work. Gantt chart helped launch project management as a recognized discipline in the mid-20th century which lives in almost every modern method and tool. Even Agile teams use burndown charts and release timelines that borrow his visual style. Until now, terms like "milestone" and "critical path" are still commonly used because those concepts came from early Gantt timelines. In essence, Gantt taught that any project is just a series of tasks that are planned, monitored, and adjusted, and that remains the foundation of how projects are perceived today. (Petersen, 1991)

1.2.1.2 Evolution of Project Scheduling Methods and Tools Since the Gantt Chart

Ever since the introduction of the Gantt chart in the early 20th century, modern project scheduling has continually evolved. Each new methodology and tool were developed to answer newly emerging challenges from complex task dependencies and uncertainty to resource limitations, financial constraints, and managing multiple projects in parallel.

By the 1950s, projects had grown even larger and more complex, sounding the need for systematic scheduling techniques more than a simple Gantt chart. The critical path method (CPM) emerged in 1957 – 1959 through a collaboration between DuPont and Remington Rand engineers Morgan R. Walker and James E. Kelley Jr.(Weaver, 2006). CPM introduced the idea of modeling projects as networks of activities with defined dependencies. By identifying the longest path of the tasks, known as critical path, CPM can give a preview of the minimum project duration and the important task that couldn't slip without delaying the project. (Froud, 2025). CPM made it possible for managers to calculate precise schedule lengths for complex projects and focus on critical activities that determine the project critical path. It was first applied to refinery turnarounds and plant maintenance. CPM helped reduce downtime by optimizing task sequencing. Other than that, Kelley and Walker's method recognized that activities could sometimes be accelerated at additional cost while assuming a linear cost time curve between. This allowed managers to explore ways to shorten schedules by allocating extra resources or budget to effectively balance project duration against cost. Early CPM implementations required extensive data gathering and heavy computation. It was initially done on mainframe computers. Although it required heavy computation, the impact was significant: CPM provided a scientific, analytical approach to scheduling. The critical path concept remains important in modern project scheduling, and virtually most scheduling software today uses CPM or its variants to calculate task timelines and critical paths. (Weaver, 2006)

About the same time as CPM, the U.S. Navy was facing the uncertainty in their R&D projects. In 1958, the Navy's Special Projects Office, with consultants from Booz Allen Hamilton, developed the Program Evaluation and Review Technique (PERT) for the Polaris missile program. (Froud, 2025) PERT was initially created to handle the probabilistic nature of project durations in research and defense projects where activity times were not well known. Instead of single estimates, PERT introduced three-point duration estimates (optimistic, most likely, pessimistic) for each task. Using these, it computed an expected duration and variance, allowing managers to estimate the probability of meeting project deadlines. PERT also popularized the term "critical path" that is now adopted universally. In 1964, PERT gained a number of successful publicities. Later on, in the late 1960s, the distinction between PERT and CPM began to blur out as both are generalized to a network-based scheduling system. (Weaver, 2006). Extensions of PERT and early integration led to many variants but the early 1960s to explore its capabilities. These included:

- PERT/Cost : An extension to incorporate cost tracking to monitor budgets.
- PERT-RAMPS : Stands for Resource Allocation and Multi-Project Scheduling aimed to handle multiple projects with limited resources
- Other Systems (MAPS, SCANS, TOPS, PEP, TRACE, LESS, PAR, etc) : various organizations developed their own network scheduling acronyms in this era, each with unique features.

Early CPM and PERT models used Activity-on-Arrow (AOA) network diagrams. It represented tasks as arrows connected at nodes. But AOA networks had its own limitations, for example, dummy activities were needed to show certain relationships. Dr. John Fondahl then introduced the Precedence Diagramming Method (PDM) in 1961. It offers a more flexible non-computer-based substitute for CPM. (Neumann & Zhan, 1995). PDM is great for more complicated interactions between jobs—such as start-to-start or finish-to-finish dependencies. Also known as Activity-on-Node, PDM tasks are represented as nodes (boxes) and dependencies as arrows between them. Fondahl introduced PDM as a method that could be implemented manually without expensive computers. This was important because at the time, mainframe scheduling systems were costly and not widely accessible. PDM allowed construction managers to draw networks by hand and still apply critical path analysis effectively. Fondahl innovation allows complex dependencies and overlapping work phases. It enabled more realistic modeling of project sequences, for example, one task could start 10 days after another starts, allowing partial overlaps. European developments like the Metra Potential Method (MPM) in France (1958) similarly pioneered the use of lags and different relationship types. Particularly suited for projects with both minimum and maximum time lags between activities, MPM uses cyclic activity-on-node networks. (Neumann & Zhan, 1995). Such capabilities made network schedules more flexible. Thus, PDM became the base for modern precedence diagram

One critical problem of early CPM or PERT was the assumption of unlimited resources. CPM or PERT allow all tasks to start as soon as their predecessors were done, regardless of labor, equipment, or material availability. (Woodworth, 1976). To solve this challenging issue, researchers looked at Resource-Constrained Scheduling (RCS) approaches which aim to maximize project deadlines while considering constrained resource availability. Early attention to this problem can be seen in the work of Jerome D. Wiest. In 1963, he analyzed properties of schedules with limited resources which then later published one of the first heuristic algorithms in 1967 for scheduling large projects with resource constraints. A study by Russell in 1986 mentioned that by the mid-1970s hundreds of heuristic decision rules had been developed to tackle resource-constrained project scheduling. The rule is aimed at prioritizing which activities should get resources first. Some examples of these rules are, using priorities like shortest task first, minimum slack, and greatest resource demand. The typical objective was to minimize project duration under fixed resource limits, or sometimes to smooth resource usage without extending the project longer than necessary.(Russell, 1986).

Single project leveling and multi-project resource allocation were both continuously explored. In 1969, one of the first formulations of the multi-project scheduling problem was designed by Pritsker et al., extending CPM to schedules with multiple projects and shared resources. Researchers like Kurtulus and Davis (1982, 1985) also studied multi-project resource scheduling. By 1980, academic interest keeps growing. (Demeulemeester & Herroelen, 1992). in actual practice, resource conflicts are normally handled manually by the project managers by shifting non-critical activities to off-peak times. While software eventually incorporated resource leveling functions to automate it, the difficulty to minimize peaks that may delay the project still persist. The key challenge identified in this era was reconciling time and resource objectives: meeting deadlines while keeping resource usage feasible and efficient. Even now, this challenge keeps going in modern portfolio management. But the groundwork that has been laid in the 60s and the 70s has enabled today's tool to at least flag resource over-allocations and suggest leveling adjustments. However, resource-constrained project scheduling remains a complex area, especially when extended to multiple simultaneous projects, as it will be discussed next. (Woodworth, 1976).

For manufacturing and construction sectors, where resources including labor, tools, and materials are routinely shared over numerous projects. (Liu & Liu, 2019). Among the most studied techniques, Genetic Algorithms (GA) and Simulated Annealing (SA) are among a broader class of evolutionary and metaheuristic algorithms. These techniques are aimed at searching for general solutions and discovering almost optimal plans. Especially when traditional deterministic approaches fail because of the combinatorial complexity of scheduling problems (Shan et al., 2017).
For instance, adaptive genetic algorithms have been applied to resource-constrained project scheduling problems (RCPSP) in complex environments such aircraft assembly, where both demand-driven and resource-driven constraints must be balanced. (Shan et al., 2017). These algorithms respond to many constraints and goals since they replicate natural selection processes to iteratively enhance scheduling solutions. Like the physical process of annealing in metallurgy, simulated Annealing also searches the solution to find the best possible solution (general optima), not just settle for a good one (local optima). (Liu & Liu, 2019)

Even though GA and SA can optimize project's schedule better, their computational complexity and lack of real-time adaptation restrict their practical usage in dynamic, resource-limited situations. These methods are effective to maximize resource allocation, but as (Chaudhary & Meshram, 2025) said, these technologies are not ideal for responding to a rapid change in time and resources because it would demand a lot of computer processing capability. In a large scale or multi-project scenario, this would be very costly.

As methods and tools matured, integration of financial factors into scheduling came in naturally. The crashing concept of time-cost trade-off was already embedded in CPM. While tracking and controlling costs alongside schedule progress led to the field of earned value management (EVM). In the early 1960s, the US Department of Defense developed PERT/Cost. It essentially was the first attempt to unify schedule and cost control on projects. Though initially seen as paperwork-heavy and met with resistance, by the late 1980s EVM was recognized as a powerful project management methodology. Today, EVM (with metrics like BCWS, BCWP, ACWP) is a standard practice in large projects to monitor cost and schedule performance. (*Earned Value Management - History*, 2005).

Traditional scheduling tools like CPM and PERT are perfect for looking for critical paths, organizing tasks and a timeline. They also work well for finding a portfolio schedule with the shortest duration. They are simple and structured well, it would work super well for projects with stable conditions. But these methods do not account for the actual money available for the execution of the project activities. Now a more complex method has been studied and researched several times. They are more complex and integrate better financial constraints. Thus, a more flexible and easier-to-use tool for everyday use that can handle multiple projects, adjust to real-time changes and consider financial limits too would be the main goal.

1.2.2 Finance-Based Scheduling Model

Beyond tracking costs, one inquiry to tackle is how financial constraints and cash flow could be accounted for in scheduling decisions. A.H. Russell (1970) proposed an approach to schedule project activities with cash inflows/outflows to maximize Net Present Value (NVP), assuming unlimited resources. It was then followed by Grinold (1972) and Doersch & Patterson (1977), who formulated an integer programming model for project scheduling under capital rationing (limited funds per period). However, such optimization models could only solve very small projects, especially with the given computing power of the time. It has been proven impractical for larger projects. (Russell, 1986)

As a result, attention turned to heuristics for finance-based scheduling. A study by Robert A. Russell in 1986 noted that "development of techniques to maximize project net present value has lagged behind". At the time of speaking, it is quite true, while hundreds of algorithms tackled resource leveling, relatively fewer addressed cash flow optimization. His research concluded that sound cash management, especially in capital-intensive projects with high interest rates, warranted using NPV as an objective, yet the problem complexity required tailored heuristics for larger scope.

By the 1990s, some commercial software and research prototypes began offering features like cash flow reports, payment scheduling, or even schedule optimization with financial objectives. As an example, project scheduling models were crafted to maximize NPV or to minimize financing costs when projects have limited capital and must borrow money. This factor is what is sometimes called the finance-based project scheduling problem. However, even in recent years this area remains challenging and not fully solved by mainstream tools. A recent review by Wanlin et al. (2021) pointed out that "few studies have proposed exact or heuristic methods" for project scheduling with financing considerations. Organizations still often face cash shortages and must plan both schedule and financing, but the available method or tools for this combined problem are still limited. This underlines an ongoing gap that researchers are still continuously trying to address. In summary, for the period of 1960s – 1980s, the importance of linking project schedules with cost management and cash flow optimization has been in focus.

A more recent study about finance-based scheduling from Asgari et al. (2024) proposes a share financial resource across project portfolio, optimize the timing of expenses and improve internal cash flow management. Cash flow is divided into 2 parts; one is inflow and the other is outflow. Inflow refers to money coming in from external sources like client payments, milestone completions or installments based on contract terms, while outflows are the money going out as an expense, it includes and not limited to labor costs, material purchases, rentals and subcontractor payments. The idea is to align the schedule within the availability of funds to avoid negative cash flow. Finance-based scheduling is hoped to determine the availability of money in real-time at a certain point in time directly after a certain activity took place.

These challenges highlight a widespread issue in the sector: the need for scheduling tools that integrate financial restrictions into project scheduling. For example, every activity requires upfront funding but often only generates revenue upon completion, creating cash-flow gaps. When several projects overlap, these shortfalls become even harder to manage. Mentioned particular example is the issue faced by the chosen company that later will be discussed in the upcoming section.

Asgari et al. (2024) introduced a finance-based scheduling model that would optimize both cash flow and project timeline by sharing the financial resources across multiple-projects. The model that they introduced shows that integrating financial constraints to project scheduling would reduce the need for external financing and improve profitability. On the same page, Fares et al. (2025) emphasized the importance of considering both cash inflows and outflows in multi-project scheduling, especially for those who need to balance the financial demands. These studies show the potential of finance-constraint scheduling to improve decision-making and reduce the financial risk across project portfolio. It is because it considers budget limitations directly into the planning and execution phase, which ensure a positive cash flow. By doing so, it gives guidance for project managers to not start a project or activities that cannot be sustained financially. Negative cashflow in the middle of the execution would badly disrupt the progress and quality. Finance-based scheduling mitigates the risk by forecasting the available cashflow

However, these models are still theoretical and have not yet been adopted in commercial software. As Wanlin et al. (2021) and Chaudhary & Meshram (2025) concluded, there is a need for scheduling tool that can handle time, cost and financial constraints simultaneously with real-time changes. In line with these ideas, in this master's thesis we propose a flexible and practical finance-aware scheduling model that bridges the gap between academic theory and industry practice.

1.2.3 The Rise of Computerized Project Management Tools in 1970s – 1980s

The 1970s and 1980s saw the birth of project management software. One of the first general-purpose software packages was Artemis, developed in 1977 by Metier Management Systems. (Froud, 2025). Artemis ran on minicomputers and was used by large organizations for critical path scheduling and cost control. But even as these early systems emerged, many smaller projects were still scheduled manually or not at all, due to the expense and training required for computerized solutions. (Weaver, 2006).

Microsoft Project that was introduced in 1984 for MS-DOS was a revolution. (Froud, 2025)0. Finally, project managers could visualize Gantt charts, CPM and plan resource on their desktop computer. It offered a relatively user-friendly interface and integration with other MS Office tools. This put scheduling capabilities more at reach by general users.

Other notable tool included Primavera Project Planner that was first released in 1983 for DOS by Primavera Systems which was founded by Joel Koppelman and Dick Faris. (AKIM Engineering, n.d.). Primavera P3 targeted larger engineering and construction projects and became an industry standard for high-end scheduling needs. It eventually evolves into today's Primavera P6 enterprise system. By the end of the 1980s, several PM software emerges, focusing on different niches, from lightweight tools to manage small team projects, to robust systems for mega-projects. These tools incorporated not only basic scheduling algorithms, but they also incorporate new features: for example, resource leveling functions, cost tracking modules, and report generators.

However, the PC-based tools also had their downside. Without centralized control, project schedules just became data on individual desktop. Thus, organizations found it hard to maintain consistent standards or to get a unified view of all projects. The 1990s surge responses to this problem, the trend was shifted back towards enterprise level scheduling system by combining the accessibility of PCs with central databases and later, networked and web-based collaboration. In effect, the technology pendulum came in full circle: from centralized mainframes to decentralized PCs, and then towards integrated multi-user systems by the late 90s. The shift doesn't only reunite scattered schedules under one roof but also integrated Gantt charts and critical path analysis as core project management practices.

In the 2000s, corporate project management systems rose and introduced more centralized control and collaborative tools that let companies handle several projects across departments. Still, most commercial solutions view financial planning as a distinct activity separated from the scheduling basis even with these developments. This results in a gap, especially for businesses running multiple projects with limited resources, when the timing of income and expenses directly determines the viability of the plan.

But until recently, A study shows that, particularly in cash-sensitive contexts, cutting edge tools still lack the depth required for financial integration and multi-project coordination even if they are efficient for small to medium-sized projects. (Gayakwad & Prof. Attarde, 2025). Finally, it is worth noting that with globalization and fast-paced markets speed and flexibility is an important factor. As organizations have recognized that even the best schedule is not static, continuous monitoring and optimization is needed. Hence, current modern approaches demand flexible planning, frequent updates and cross-project visibility. This interest has always been alive in new research and development of scheduling methods. The fact that such research is ongoing confirms that there are still gaps in the available tools for integrating financial optimization in schedules. (Wanlin et al., 2021).

In Conclusion, each development had leveled up and added capabilities to deal with real world challenges. However, modern project portfolio management is still searching for the optimal way to align operational schedules to financial plans and strategic goals seamlessly. By learning from the historical evolution and leveraging the latest technologies, this master thesis is inspired to fill the remaining gaps. Optimizing not just timelines but also integrating cash flow management and resource allocation.

1.3 Case Study

1.3.1 Introduction to The Company

This section will present a case study of a mid-sized interior design and construction company from Indonesia to base this research on a real-world context. Founded in 2018, this interior design and built company which focused on residential projects has been experiencing steady growth. This company provides an end-to-end service, it has their own warehouse, so the whole process is a unity – from the conceptualization, design and construction. The warehouse is where all the manual labor and fabrication are carried out. It is considered a mid-sized company because according to BPS Indonesia, this is how a medium-sized enterprises are defined:

- Employ 20 – 99 workers
- Annual revenue between IDR 2,5 billion and IDR 50 billion.

As for this interior design company, it has 8 employees on the conceptualization and design team and 25 employees on the construction team and around IDR 8 billion – 10 billion. Leb by its founder and a managing partner, they both held the highest decision-making authority. The workflow starts with a consultation with the client to understand their needs, then the design team will be in charge to conceptualize the idea which will then be presented to the client. Once approved by the client, the design team will proceed with a more detailed 3D rendering to represent the client´s wants and needs. When the desired 3D rendering is reached, a contract between the client and the company will be assembled, outlining a detailed cost per item. Following up would normally be the most time-consuming and critical part, which is the production and construction, they both are normally handled in-house, unless the workload is too much to handle. During this process, clear scheduling is important, because here this company has to manage multiple stakeholders. It all concluded by a final touch up of the space, for example with decoration or loose furniture.

Given the scope of the operation, multiple stakeholders and scale of its workforce, maintaining a clear schedule is important because it requires coordination across various parts. Simultaneously, the company manages several projects, normally in different phases. Each one is also unique and different, as one could have a bigger scope, hence more sets of objectives and a bigger cashflow. Yearly, the company would have a set of projects, ongoing and new ones as their project portfolio.

Like most companies, their cashflow consists of inflow, which are received payments from clients and outflows, which are expenses needed during project execution. Outflow will be divided to 2:

- Fixed costs may include wages, office rental fees, and regular operating expenses. These are estimated at a certain percentage of the income objective for the upcoming year, which reflects an increase from the current year’s income.
- Variable costs will depend on how each activity is executed. If the activity is done in-house, expenses may include materials and transport, since employees belong to the company (and are part of fixed costs). If subcontracted, external workers will be hired, potentially increasing variable costs.

To mitigate financial risks, the company creates a contract with the client regarding payment. In most cases, the total payment will be divided into 3-4 parts which also reflect the milestones of the project. In the best-case scenario, the client must pay before the agreed phase / milestone. As Okereke (2020) stated, companies maintain a reserve fund to cover unexpected expenses or bridge gaps caused by delayed payments, the same goes for this company.

However, that method only helps up to a certain point. One of the most common disruptions is the unbalanced cashflow, which normally comes from delayed payments or a contract which allowed the client to pay later. This would be a serious problem when the project still must be executed as it has been scheduled, it results in the need to reallocate funds from another project or to pause the work – an action that can compromise project performance and the whole project portfolio. Normally, fund allocation is not a problem, as it is normally done in the company, but as the project gets more complicated, sometimes the company has a hard time prioritizing project without a clear scheduling plan. An unclear scheduling plan makes it harder to examine if it’s possible to do the fund allocation. Fun allocation is only possible when that month’s cashflow is still positive. According to (Johnson & and Babu, 2020), financial problems are the leading cause of project delays.

As Dorrah & McCabe (2023) explains, payment issues impact beyond individual projects as it can cause a ripple through the entire stakeholder chain. In some cases, the company includes “pay-when-paid” method, which delay payments to subcontractors. This method would save the company’s cash flow but would damage the stakeholders, which could cause a bad reputation and reduce the trust across project cooperation.

As for the case of this studied company, these challenges are more pressured by the cultural and market context because most local business operates under the principle of “the client is the king”. This principle forces a competing company to be highly flexible and smart to accommodate clients’ needs. As a result, often, reallocating funds between project and adjusting schedule to accommodate cash flow limitation is needed. From the company’s experience, this method can function well if the cashflow is never negative.

1.3.2 Experimented Method and Tools

The company has experimented with several commercial scheduling tools or academical scheduling tools that have been integrated into the commercial tool. This sub-section will be examined and evaluate how each tool handles multi-project scheduling, resource allocation, and cash flow management. We will also discuss the company’s opinions about each of the tools that they have tried (Table 1.2).

- Asana is a cloud-based work management platform that is well known for its user-friendly interface and team collaboration features. It works well at organizing tasks and deadlines visually, giving a clear preview for teams to see who is doing what and by when. For construction or interior design firms, Asana can serve as a central where project tasks, milestones and site activities are tracked across multiple projects. However, Asana is not specialized in construction PM Software, so its utility for complex scheduling and financial tracking has limits.
- Monday.com is another popular cloud work management tool. It is highly known for its customizable boards and visual interface. Its customizable feature allows teams to build their own workflow tables with custom columns, from task status and dates to budget numbers and formulas. In a construction setting, Monday.com can be configured to handle project schedules, budgets, and resource assignments all in one place, thanks to its flexible structure. It also offers features like Gantt chart timelines, workload views, and numerous integrations.

However, using Monday to its full potential might require careful setup and the right subscription tier, and some advanced project management functions like complex scheduling logic are limited.

- Atlassian's Jira was originally designed for software development. But as time went by, it is adaptable to other project types. Jira supports Agile methodologies which can be extended with plugins for Gantt charts or resource planning. It primarily serves as an issue and task tracking tool for its detailed task management.
- MS Project is a classic project management tool, very well known for its scheduling and planning capabilities. It can also handle multiple projects and shared resources. It offers great strength in creating a structured, date-driven plan for each project and forecasting timelines and costs. It is primarily a scheduler, rather than a team collaboration tool. Also, being a Microsoft product, it integrates well with Office suite with a proper license.

Table 1.2. Advantages and disadvantages from the company point of view. Source: Company from case study (2025)

Tools	Advantages	Disadvantages
Asana	Easy team adoption and collaboration for its intuitive UI and task-tracking format. Tasks can have assignees, due dates, attachments and comments. Real-time updates and notification help team members, and all stakeholders stay up to date. Within its portfolio feature, Asana supports multiple projects management. This feature is helpful especially for juggling resources between projects. Gantt style preview is useful for scheduling construction sequences. Custom fields for budget tracking allows inputting financial data directly into the project tasks. This feature is great for making a breakdown project's budget.	No cost management module tailored to projects as there is no automatic cash flow projection based on scheduled tasks. Hence, for a detailed tracking, Asana still relies on external spreadsheets and accounting software. Limited resource allocation will not automatically resolve overallocation by shifting task timelines. When two projects unknowingly scheduled the same contractor in the same week, Asana might show both tasks assigned, but it won't warn or fix the clash. The responsibility falls on the PM to catch and adjust these conflicts. Asana is completely cloud-based, while the mobile app and offline edits partially address this, the team still often face this issue especially in new building sites which still have internet connectivity issues. Reliance on premium features is key to having a good experience with Asana. To get multi-project portfolio dashboards and workload views, the company would incur significant subscription costs per user. For a mid-sized team, these recurring costs can add up, and not every team member may need all features.
Monday.com	Customizable project tracking boards provide a blank slate which gives the company full control to	Although feature packed, Monday.com, like Asana, doesn't compute cashflow or handle financial

Tools	Advantages	Disadvantages
	tailor columns to the user's needs. This flexibility can preview both schedule and financial information side by side. Visual Scheduling with Dependencies from Monday.com includes timeline and Gantt chart views which support task dependencies. Its basic functionality helps communicate timelines to stakeholders. Monday can automatically adjust the successor task's timeline accordingly. This automated ripple effect prevents the team from overlooking dependency impacts. The offered workload widget can add assignments across multiple projects boards. This feature helps highlight over capacity. Being a cloud-cased, it offers real-time communication updates. Team members can update task status and add comments. This feature is useful for managing remote project sites. Monday.com offers automatic integration with another tool like Excel or financial software to manage cash flow.	calculations without manual setup. It all relies on the team and creating necessary formulas. It also cannot alert delayed payment and still requires human analysis or external financial tools. Finance base, it remains a largely offline task. Overload capacity is not solved automatically. Hence, it depends on the team in updating timelines to reflect a resource reallocation decisions. Many of Monday.com's powerful features (time tracking, dependency automations, formula columns, advanced integrations, etc.) are locked behind the Pro or Enterprise plans. Also, the number of boards you can combine in a single dashboard (for multi-project overviews) is limited on lower plans. Additionally, training is needed to maximize these advanced capabilities.
Jira	The task and issue tracking is very efficient at capturing detailed tasks, issues, or defects and tracking their status through a workflow. It also allows filters for small tasks or issues. Customizable workflow and fields lets the company define custom workflows for different issue types and overtime Jira's setup is evolvable to better mirror project workflow. Agile-style task management supports backlog prioritization	Limited Gantt scheduling capabilities as Jira wasn't built as a traditional scheduling tool. Integrating Agile, tasks in Jira don't have start and end dates by default – typically just a single due date or sprint assignment. Without the plugins, it's complicated to create a detailed plan with task durations, dependencies, and get a calculated project end date. Jira has no built-in cost or budget tracking features. The company couldn't assign a cost to a task or track expenses without custom work. This lack of finance awareness is critical for the company's sensitive cash flow.

Tools	Advantages	Disadvantages
	which can help the team focus on the most critical deliverables. Cross-project tracking and portfolio in Jira premium software enables planning across multiple projects. This feature also lets the company create custom reports for multiple projects.	Extensive setup and plugins is needed for maximizing its full potential and the adaptation is not simple. Hence, to better operate Jira, the company needed a special consultant to set it up properly. This factory is mainly complicated at the time of speaking in Indonesia as it was not yet widely common. Even though it will inform you how many tasks a person has, it doesn't track team member workload or availability. Jira alone struggles with multi-project resource allocation, so the company needed to complement it with a specialized tool for resource management Jira's report is centered on Agile metrics, which is a good preview, but not essential to clients or high-level stakeholders from the company. The team members needed to invest a lot of time to generate a custom adequate report.
Microsoft Project	Created for detailed project schedules, it is possible to input all tasks with estimated durations, set dependencies and define milestones. It can well anticipate delays and critical paths. Resource allocation and leveling features allows assignment of resources to tasks with specified availability and work hours. The feature for leveling resources can automatically delay or split tasks to resolve conflicts ensuring no staff or crew is double-booked. Cash flow projection and cost tracking allow the company to assign costs to resources. This feature also can produce reports to manage the financial health of each project.	Steep learning curve and complexity is the biggest challenge for this mid-sized company. Its interface is dense with options and makes it easier to make mistakes. This slowed down integration and adoption. Lack of real-time collaboration as it is a desktop application, unless investing in Project Online / Project Server. But even those features still created confusion for the company's team members. Managing multi-project in MS Project is quite complicated as it requires combining files or using the enterprise features. Additionally, it leaves a big gap for error as broken links is the common enemy for project managers to share their resource pool updates with each other periodically.

Tools	Advantages	Disadvantages
	Multi-project management options by integrating them into a master project file or via online for enterprise features lets the company visualize portfolio timeline while still controlling each project. Resources can also be shared among projects. With adequate skill, MS Project gives full flexibility and control over the schedule detail. This feature lets project manager schedule to a high degree of accuracy for real-world conditions.	MS Project has minimal support for mobile use. While MS project online has a web interface, it is not convenient to navigate on phone.

Each scheduling tool offers distinct strengths and prioritization methods. This thesis will build on their best features while minimizing drawbacks. Above all, the company needs a solution that automatically tracks each activity's cash outflows when it begins and cash inflows when it's completed.

Chapter 2. Simulation-Based Financial and Operational Planning Model

Developing a new tool requires a deep understanding of where the previous scheduling approaches did well and fell short. This chapter will start by outlining the key gaps of traditional scheduling tools and methods and identifies the valuable features from past solutions that should be carried into the new model. In exchange for clarifying these limitations and advantages, it would be clearer to see exactly what the new model should address and which proven practices the tool should incorporate.

Other than motivated by the evolution and gaps in available methods and tools, the case study gives more foundation of what is needed in real-world scenario. While the case study focuses on the interior design and construction company, in many industries, especially small and medium-sized businesses, every task involves incurring costs upfront and only brings in revenue and/or profit once it is finished. Most project planning software doesn't account for this worst scenario reality. Companies might have a solid plan on paper but will struggle with cash flow issues in real practice if they fail to consider the funding dimension. As a result, there's a real need for a more flexible, practical tool—something simple to use, yet capable of mapping out both the timing and financial impact of each project variable. This model is designed specifically to support multiple project planning—balancing schedule, resource capacity, cost management, and income forecasting within a single, user-friendly platform. This tool is flexible, easily modified and accessible, so it would benefit a wide range of sectors.

2.1 Key Shortcomings and Identification of Valuable Features

2.1.1 Limitations of Past Tools and Methods

Manual, error – prone processes: Most legacy scheduling methods from paper timeline to basic spreadsheets rely on intensive manual effort to create and to update schedules. Not only that this practice is time-consuming, but it is also very prone to human error. In practice, this process might evoke conflicts and mistakes, thus requiring multiple revisions.

Limited flexibility in adapting to change: In line with the first point, traditional scheduling tools also struggle to accommodate quick changes. This could arise because of several reasons, one being manual and the other because it may require a special team member's ability to change and update it. Adjusting, for example, Gantt chart, can be a daunting manual task. Hence, schedules that are built on rigid methods may not adapt well to unexpected events.

Communication and accessibility gaps: One of the key objectives of having a scheduling tool or method is also to have better communication of it for the whole team or might be also for the stakeholders. This way, all people involved can have the same understanding and common ground. Thus, this point is an important aspect to have in a scheduling tool. Collected information from the previous chapter shows that some tools are still lacking this aspect, even the modern version of scheduling tools. If the schedule isn't instantly shared, team members may operate on outdated information. This lack of real-time communication can result in a miss-communication.

Over allocation of resources: Without real-time insight into resource usage, it is hard to spot when a person or equipment is overbooked or sitting idle, resulting in suboptimal allocations and productivity losses. In complex, resource-constrained projects, these traditional techniques often fail short since they fail to dynamically adjust to resource availability.

Lack of Integration and Automation: This lack of automation means updates are slow and inconsistencies can occur if one part of the plan is changed but not others. Overall, older methods cannot seamlessly connect with the broader project ecosystem, causing duplicate work and mistakes.
Steep learning curve and cost barriers: While basic tools are easy to pick up, more advanced scheduling software notably comes with high cost and complexity. Although some companies might need a more advanced scheduling tool which is to be used with a dedicated project manager with specialization, other organizations find the complexity to be unnecessary. Hence, some tools are not inclusive due to their complexity. In some cases, organizations stuck with manual methods simply because the available advanced tools were too complex or costly for practical use. This gap left many projects in a position to either use a simple but limited tool or face the overhead of a sophisticated system.

Inadequate schedule representation: There is still a lack for a complete preview of project's timeline and logic together, especially one that is finance-based. In some cases, this representational trade-off meant project managers had to choose between intuitive timelines versus explicit logic, or maintain two separate views, which was inefficient.

Limitations in financial planning: Traditional and modern available scheduling tools focus more on time, scope and resource management. But they struggle to incorporate financial constraints. With that in mind, research has proposed finance-based scheduling (FBS). The following examines the limitation of available commercial tools in handling financial requirements:

- Inability to enforce financial constraints on schedule: Available software doesn't consider whether the necessary cash is available at given time. It will schedule tasks as early as possible based on dependencies and resource availability. As a result, default schedules can be financially unrealistic.
- No option for cash-flow based task sequencing: Cannot delay or prioritize task based on availability of funds. For example, payment due at a task's start must be tracked manually. The software won't ensure that preceding activities or financing arrangements provide that cash.
- No representation of income-generating activities: In available tools, tasks cannot produce funds that feed back into the project's budget in real time. Milestones for client payments or stage completions are not linked to resource availability for future work. Any revenue events are external to the schedule's calculations. It is often managed in external finance systems or spreadsheets.
- Stating budgeting vs dynamic financing: Modern tools like MS Project allows setting a budget or cost limit, but it doesn't model periodic cash inflows and outflows to enforce that the project never exceeds a working capital limit. Thus, a cash crisis may not be detected by the software.
- Separated financial analysis: To have better financial-based scheduling, project managers opted to resort to external cash flow forecasts and financing plans. This approach may be error prone as time and resource schedules are made in a software while the detailed financial plans live in another software.

2.1.2 Differences between Available Scheduling Tools and Finance-Based Scheduling

Standard scheduling focuses on meeting deadlines and some also focus on minimizing total cost. But it doesn't account for the timing of costs and financial charges. For example, if a project requires borrowing money or outsourcing because of an overload internal labor, the overhead cost or interests' payments due to schedule decisions are not considered. Along the way, these overheads reduce profit margins or even jeopardize the entire portfolio.

To better clarify the distinction between traditional scheduling and finance-based scheduling, the following table provides a side-by-side comparison of their features.

Table 2.1. Side-by-side comparison of finance-based scheduling and available scheduling tools. Source: Own elaboration.

Aspect	Traditional Scheduling	Finance-Based Scheduling
Primary focus	Time and resource. Financial considerations are tracked but do not affect task sequencing.	Time, resources and cash constraints. Tasks are scheduled only, if necessary, funds are available.
Cost handling	Costs are a static attribute without concept of income from tasks.	Cost and revenues are tied to activities; each can have cash outflows and inflows at specific times.
Cash flow constraints	Not modeled as all tasks will be scheduled as soon as possible. Because most cash flow analysis must be done externally.	The schedule is to be adjusted or delayed (or advancing another task) to respect cash flow limits at each stage.
Scheduling objective	Minimize total duration or meet a fixed deadline, while keeping it within total budget.	Multi-dimensional objectives. Example: minimize project financing cost, maximize NPV or profit, in addition to meeting deadline or minimizing duration. Users might accept a slightly longer duration if it greatly reduces interest payments on loans, for example.
Financial metrics	EVM metrics can be calculated (planned value, actual cost, etc.), but those are for monitoring. The scheduling won't change based on cash flow status. Total cost is considered, but cash flow timing is not.	Cash flow metrics are part of the model. A feasible solution ensures all payment can be made. Often the objective function directly or indirectly optimizes a financial metric like profit, aligning schedule decisions with financial performance.
Tool support	Very widely available in PM software like MS Project and Primavera. Integration with the financial system mostly is limited to exchanging data with another tool.	Currently, it exists mostly in academic research and specialized solutions. Models are implemented in optimization software or custom programs using linear programing and heuristics. (Elazouni & Gab-Allah, 2004). Some solutions or custom integration attempt to address parts of it, like portfolio level cost constraints, but full finance-based scheduling is not yet a standard feature of commercial schedulers. The concept is already emerging as researchers develop algorithms, with the expectation that future tools will incorporate these capabilities.

Consequently, a paradigm shift may be needed. Project scheduling should not only answer if the project can be finished with the available resources, but also if it can be afforded to execute the plan as scheduled.

2.1.3 Identification of Valuable Features to Incorporate

- **Ease of use and familiarity:**
  A big strength of traditional spreadsheet-based scheduling is its ease of use. This familiarity lowers the barrier to adoption. Likewise, Gantt chart visuals are intuitive, making team members with no formal project management training able to understand a bar-chart timeline at a glance.

- **Clear timeline visualization:**
  From Gantt chart point of view, the evolution proved the value of a graphical timeline for communicating plans. The classic Gantt chart strength is presenting tasks along a calendar timeline, making start and finish dates obvious.

- **Automation and dynamic updates:**
  One basic advantage of dedicated scheduling software is automation; changes are real time without manual recalculation. This capability reduces human error and speeds up re-planning. The new Excel-based model aims to replicate this benefit by using formulas or macros to auto-update related cells and charts whenever schedule data changes. This automated consistency is crucial for easily evaluating “what-if” scenarios and addressing changes in real time.

- **Integrated data with other systems:**
  Another positive aspect of state-of-the-art tools is their integration with other project control areas. For example, the integration between Microsoft project and other Microsoft applications.

- **Collaboration and Accessibility:**
  Modern scheduling tool, for instance cloud-cased project tools allow everyone simultaneously view updates and collaboration. This improves transparency and team coordination.

- **Flexibility and customization:**
  One reason users favored Excel or similar simple tools is the flexibility to customize them to specific project needs. Unlike rigid software, a spreadsheet can be adapted with custom formulas, columns or views for certain requirements. This adaptability encourages wider adoption because the tool can bend to fit the process, not the other way around.

2.2 Introduction of Financial-Based Scheduling Model

With the key limitations and values in mind, the simulation tool developed in this study is implemented via an Excel workbook. Excel has been chosen because of its broad popularity and versatility in business applications. In 1996, Microsoft reported 30 million Excel users. As of 2023, an estimated of 1.1 to 1.5 billion people worldwide use excel. (17 Excel Statistics to Know, 2025).

A majority of organizations rely on Excel as a fundamental tool. A study from 2019 found that approximately 54% of organizations worldwide use Excel for data tasks. (17 Excel Statistics to Know, 2025). It is also mentioned that 99.99% of the world’s businesses use Microsoft Excel in some capacity. While the figure is informal estimate, it highlights that almost every enterprise from small forms to big corporations includes Excel in their standard software toolkit. Hence, it has been called the “universal language” of business data analysis. This is also supported by the fact that Excel is typically already installed on most business computers. Proficiency in Excel is universal among professionals. Over 75 million LinkedIn profiles list Excel or Microsoft Office as a skill. Which is more than 10% of all LinkedIn users. This number shows that Excel skills are common in the workplace. (What Percentage of Businesses Use Microsoft Excel, 2025).

Another practical advantage of Excel is its cost-effectiveness for most organizations. Excel comes as part of the universal Microsoft Office suite or Microsoft 365 that most companies already use for email and documents. So, using Excel-based tool usually doesn’t need additional cost. Today, Excel is also highly accessible across platforms and hardware, like Windows PC, Mac computers, through the web and mobile devices. Additionally, its real-time collaborative capabilities favor teamwork.

Scheduling is common use for Excel for its intuitive visual for laying out dates, tasks and responsibilities. Many professionals even generate Gantt charts and project trackers in Excel. For all the reasons above, the model developed in this master’s thesis has been implemented as an Excel worksheet.

The tool is designed to simulate portfolio scheduling. With the base of finance-based scheduling, this model is intended to help organizations improve their portfolio schedules and decision making. The tool is a combination of key values researched from the past sections and integrating the idea of Finance-based scheduling. The model is also intended to diminish the limitations of existing scheduling methods and tools. The overall preview of the tool is as follows (Figure 2.1). The tool is divided into 3 big sections: Planned schedule; Financial projection and Control. These features will be discussed in the upcoming sub-chapters.

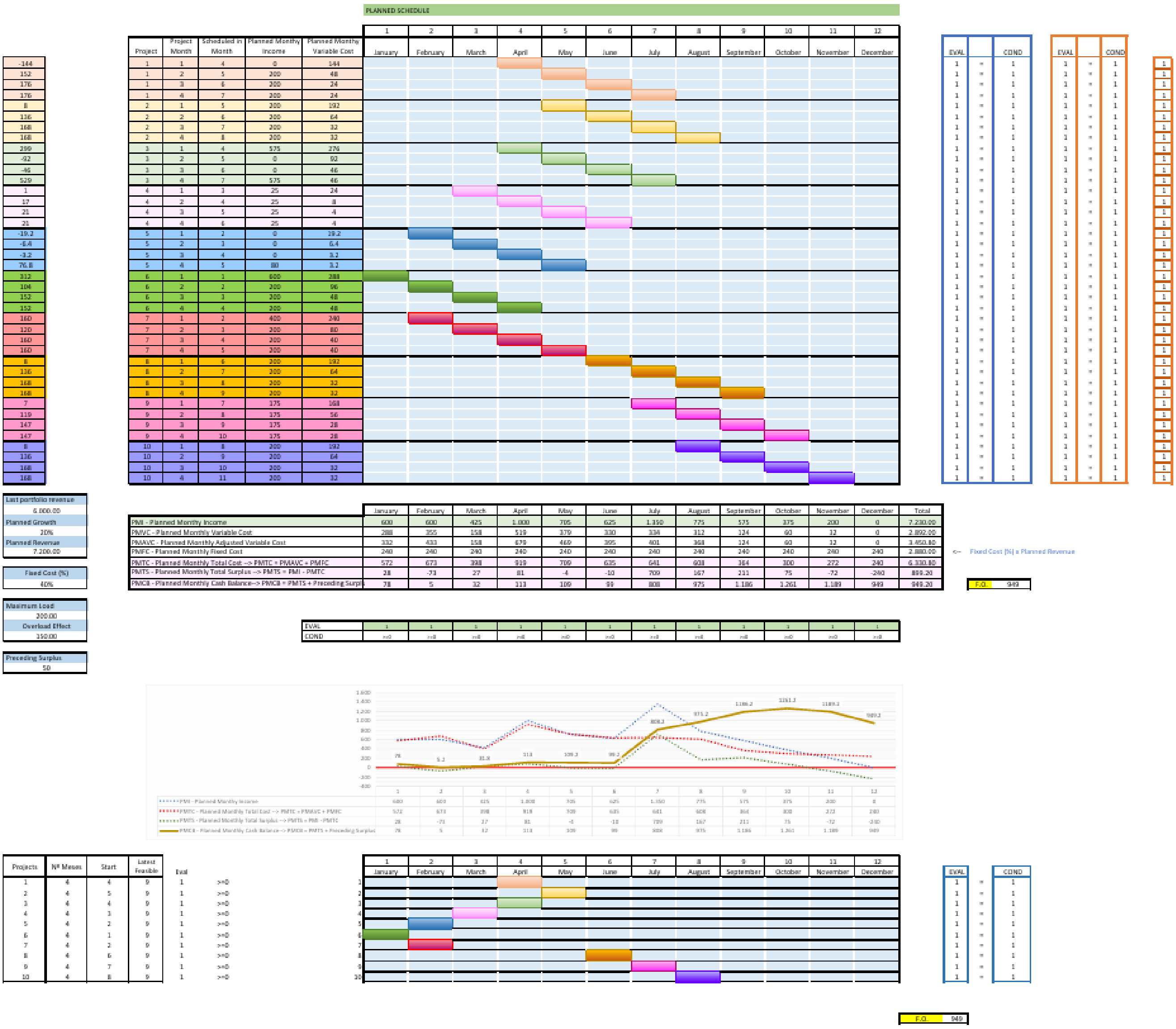


Figure 2.1: *Full complete preview of the model. Source: Attachment 1*

2.2.1 Planned Schedule

On the first part of the tool, we named the section as Planned Schedule. Each project is put in a specific time frame within a monthly planning simulation. Sections in this tool that are categorized as Planned Scheduling can be seen in figure 2.2, marked with a red box:

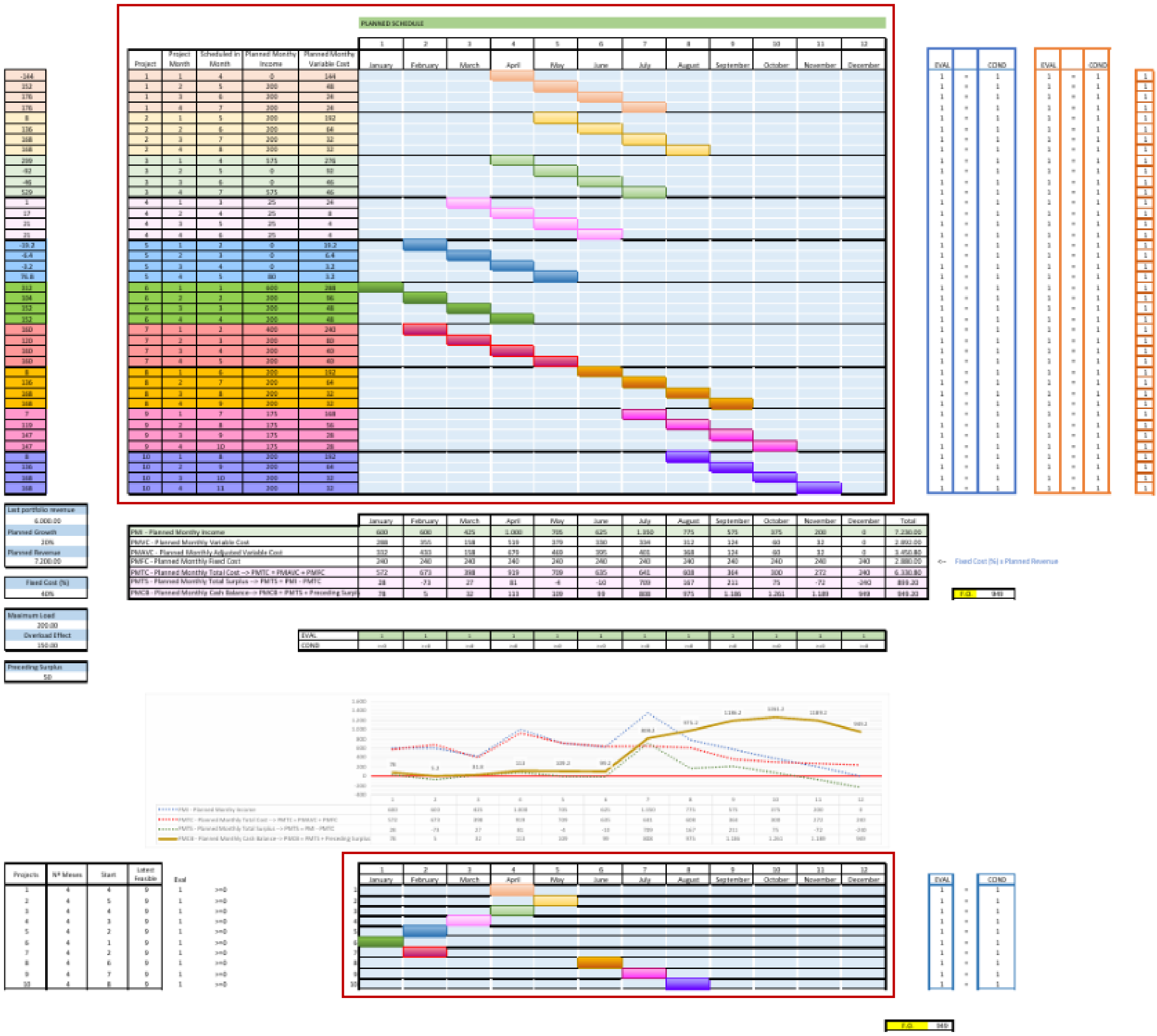


Figure 2.2: *Boundary of the first section, Planned Schedule. Source: Attachment 1*

The first part of this section shows a monthly preview of the project. As the evolutions of scheduling tools and methods have been studied in the chapters before, Gantt Chart preview is still common and widely used until now. Hence, we adapted this type of visualization into the most visually important part of the model. The bottom of this section shows the starting month of every project. The objective of this Planned Schedule section is to visualize a clear portfolio schedule with integrated financial information.

For this model, we will simulate a yearly portfolio where each project is divided into 4 milestones or activities. For its flexibility and customizability, in later use, additional activities or milestones can be added depending on the actual project to be scheduled. This model is adapted to accommodate the challenge faced by the company that was discussed in the previous chapter.

This section of the tool is meant to preview a clear breakdown of each project's monthly timeline and cash movement. Since this tool is already completely formulated, in the first part of the section, monthly income and monthly variable cost are the only parts of this section that must be filled in manually by the user, while all other parts of this section are already formula embedded, so for regular use, it is not suggested to edit them. Detailed explanations of Figure 2.3 starting from leftmost are as follows.

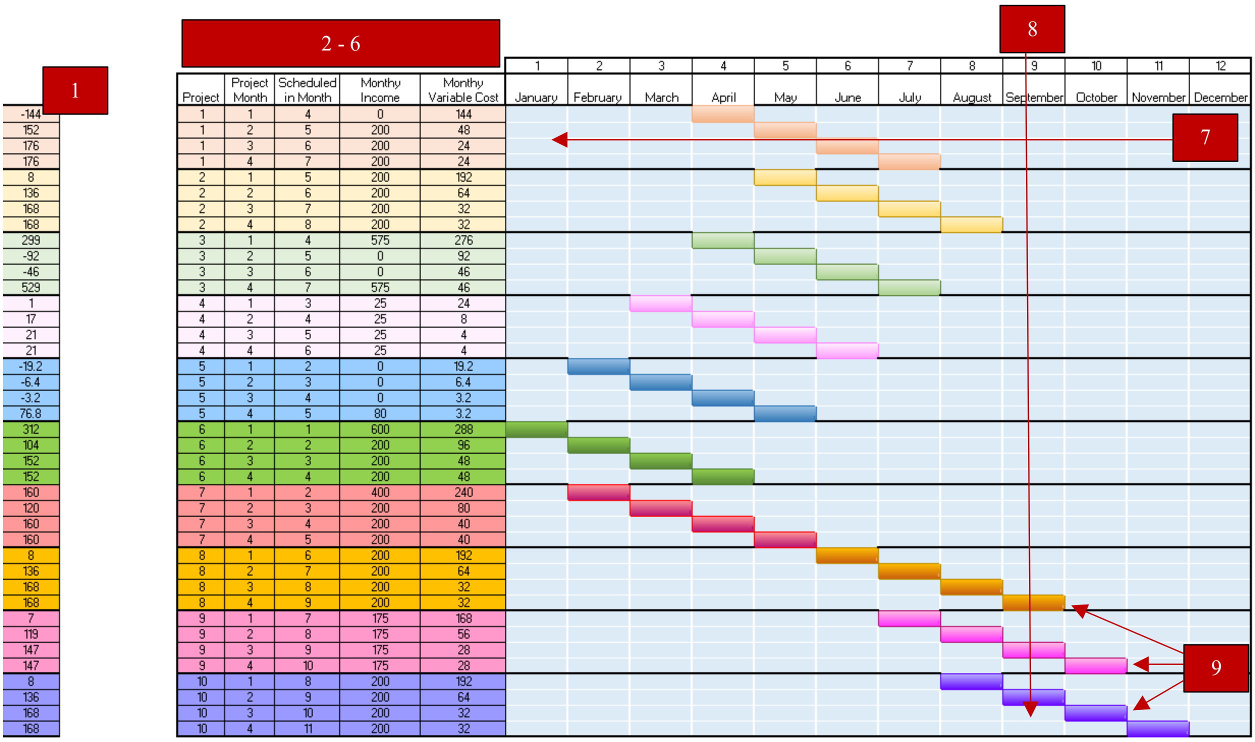


Figure 2.3: *Preview of first part in first section, Planned Schedule. Source: Attachment 1*

The first part of this Planned Schedule section is broken down in table 2.2 below. Two components to be defined manually by the user are marked in colored row, for example number 5 – 6. This section is identified with an orange-colored table.

Table 2.2. Description of the first part in the first section of the tool. Source: Own elaboration.

Identifier	Name	To be edited for normal use?	Function	Direct Connection
1	No name	No	Previews the difference between monthly income and monthly variable cost. This part is automatically calculated.	5, 6
2	Project	No, it must be edited in another section	A guide to identify each project by number. This initial model supports a maximum of 10 projects with 4 activities. A more customizable number is to be expected for future development.	All in general

Identifier	Name	To be edited for normal use?	Function	Direct Connection
3	Project Month	No, it must be edited in another section	The sequence within the project's duration.	All in general
4	Scheduled in Month	No, it must be edited in another section	To identify when the activity is scheduled in the yearly portfolio.	2nd Part in Planned Schedule section.
5	Monthly Income	Yes	User defined amount. Represents the amount of revenue upon activity completion.	1, 17
6	Monthly Variable Cost	Yes	User defined amount. Represents the amount of direct cost needed to execute the activity. The amount is directly corelated with the activity, hence, user should define the amount according to the milestone's necessity.	1, 18
7	No name	No, it must be edited in another section	Rows: Each one corresponds to different projects which have 4 activities inside of each. This component is directly connected to the second part of this Planned Schedule section.	2nd Part in Planned Schedule section.
8	No name	No, it must be edited in another section	Columns: Represents calendar months from January to December. This component is directly connected to the second part of this Planned Schedule section.	2nd Part in Planned Schedule section.
9	No name	No, it must be edited in another section	Individual cells: Shows when the activity is planned across the portfolio. Different colors help to differentiate projects. This component is directly connected to the second part of this Planned Schedule section. As mentioned before, in this model, every project has a maximum of 4 activities. Even though this model wasn't developed to be used for less than or more than 4 activities, it may occur to users to delete 1 to 3 consecutive cells to plan less than 4 activities. Although not recommended, this option does let user plan 3 to 1 activity. But the tool will inform it as an anomaly. Yet, the calculation will still work. This option will delete the formulated component, hence makes it complicated for future schedule. Instead, to outmaneuver the model for it to plan 1 to 3 activities in a safer way,	2nd Part in Planned Schedule section.

Identifier	Name	To be edited for normal use?	Function	Direct Connection
			users can put a 0 value in Monthly Income (identifier number 5) and Monthly Variable Cost (identifier number 6). Even though the preview will not be optimal (it will still preview 4 activities), this is a better shortcut for keeping the formula intact.	

The second part of this Planned Schedule section is as seen in figure 2.4 below.

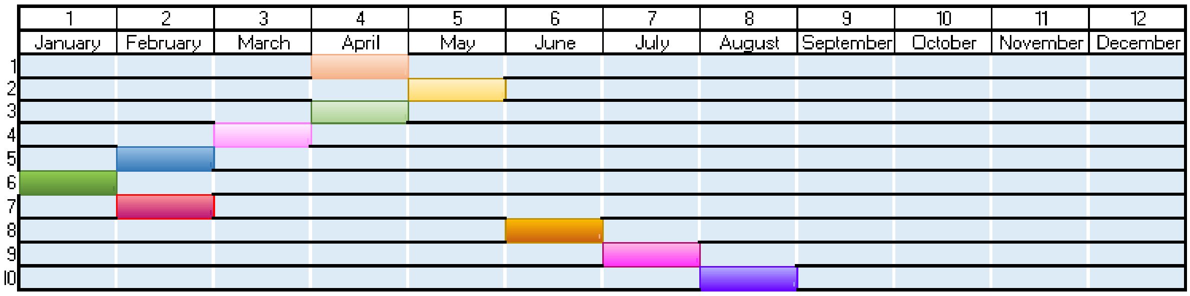


Figure 2.4: Preview of the second part in the first section, Planned Schedule. Source: Attachment 1

This last part of the section (Figure 2.4) lets the user adjust the project starting month. This part is a simplified preview of the first part as it only informs project starting points. Just as the previous part, each row corresponds to different projects, each column corresponds calendar months and the individual cells show when the project is going to start.

By moving the starting point, it also changes total portfolio benefit, which is identified by final objective (F.O.) in this model. This interactive table position allows us to adjust the starting month of each project in real-time. By clicking on any cell, the starting point is moved to that month. This concludes the end of the portfolio scheduling section.

2.2.2 Financial Projection

The second section of the tool is identified as the financial projection. By comparing given data on the first section, the model can help detect potential deficits or over-utilized resources. This section lets users define their company's finance situation to make the schedule more accurate to real-world scenario. Value imported will be the baseline for the financial projection. Parts of the financial projection section can be seen, marked with red box in the figure 2.5 below.

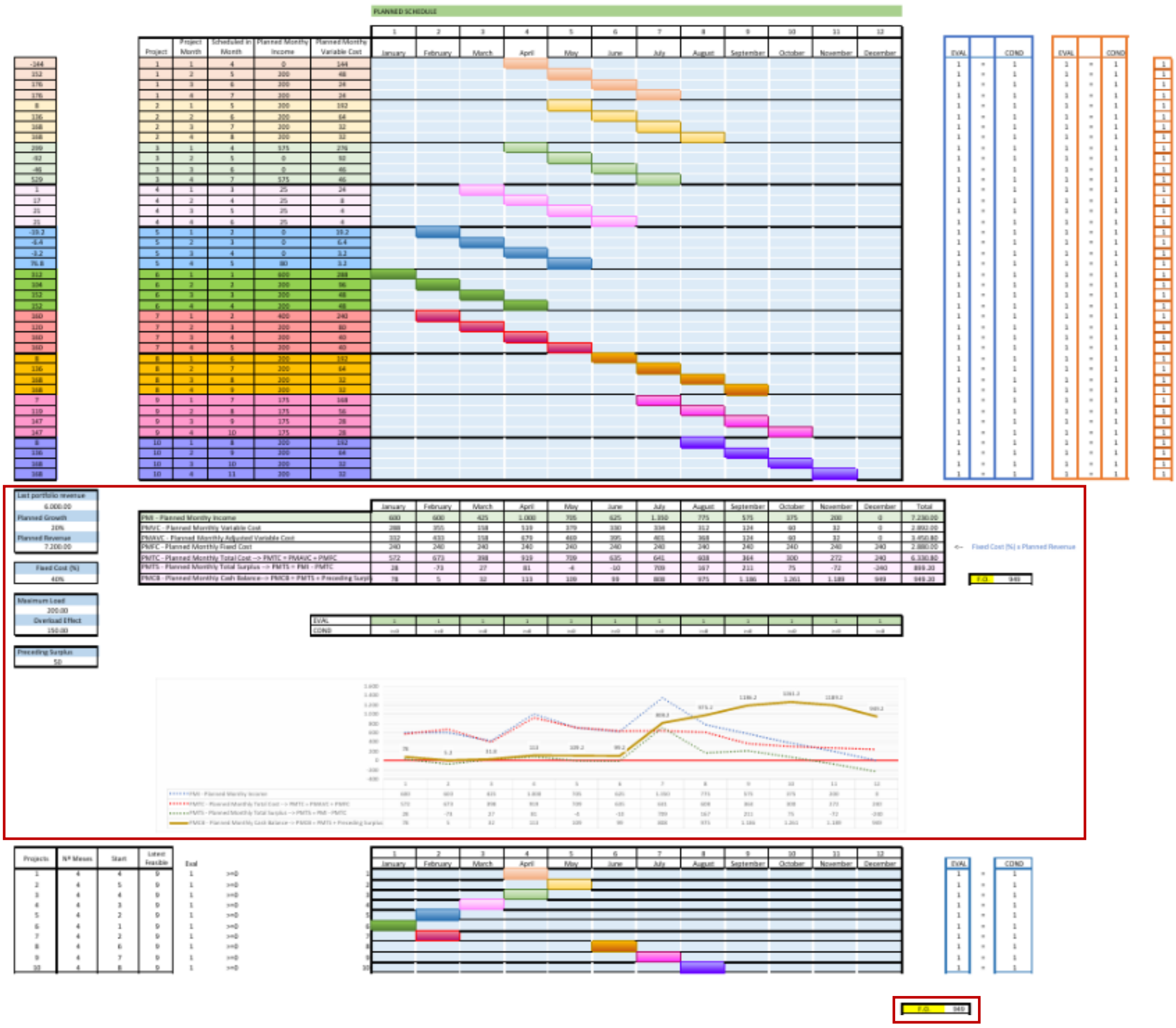


Figure 2.5: *Boundary of the second section, Financial Projection. Source: Attachment 1*

In this section, users can consult the analysis of the project financial dynamics based on their organization's financial situation. The projection helps to spot when the organization runs short on funds and gives user the ability to plan ahead. Additionally, the graphic serves as visual guidance to help identify at a glance.

To further align financial planning with portfolio schedules, this projection acts as a decision-making compass to guide the prioritization of projects. It also helps identify periods of potential financial risk such as negative cash flow or resource overload which can impact portfolio performance if not anticipated early. In this context, the financial projection functions not only for budgeting, but also as an integrated strategy for optimizing maximum benefit possible. In this tool, we identify portfolio final benefit as final objective, in the tool it is identified with F.O. with yellow-colored cells.

Except for planned revenue, it is the last part requiring manual input from user. The explanations start from the left part, which is shown in figure 2.6 for a clearer preview. Similar with the previous section, components to be modified are also identified by a colored row. This section is identified with a yellow-colored table.

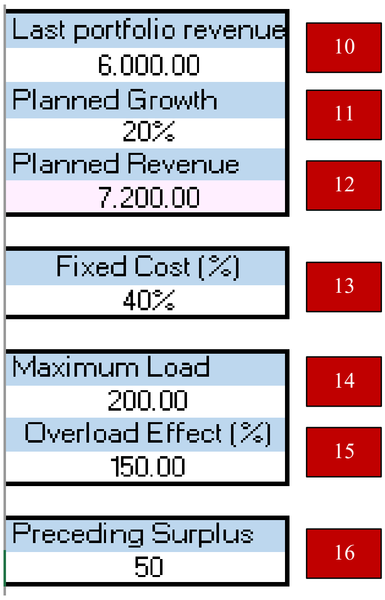


Figure 2.6: Preview of the first part in the second section, financial projection. Source: Attachment 1

Table 2.3. Description of the first part in the first section of the tool. Source: Own elaboration.

Identifier	Name	To be edited for normal use?	Function	Direct Connection
10	Last portfolio revenue	Yes, enter monetary value	Total revenue for the previous period, for example, last year. Revenue only counts for income, without expenses. Baseline for future reference. Directly connected to identifier number 12, planned revenue.	12
11	Planned Growth	Yes, enter percentage value	Expected projection of improved revenue performance in percentage for the upcoming period. Directly connected to identifier number 12, planned revenue.	12
12	Planned Revenue	No	Automatically calculated as Last portfolio revenue x (1 + Planned Growth). Hence, it is directly connected to identifier numbers 10 and 11. It shows the revenue target for the upcoming period. A percentage of this part will go into the fixed cost. Thus, it is also directly connected to Planned Monthly Fixed Cost (PMFC) in another part of this section.	10, 11, 20
13	Fixed Cost (%)	Yes, enter percentage value	A percentage from the planned revenue that will be allocated to fixed costs (example: rent and salaries). A percentage of 40% is used as an example	20

Identifier	Name	To be edited for normal use?	Function	Direct Connection
			in the model. Thus, it is also directly connected to Planned Monthly Fixed Cost (PMFC) in another part of this section.	
14	Maximum Load	Yes, enter monetary value	Maximum workload of monthly variable cost determined by the user. This means that any amount more than the inserted amount will be outsourced work. Usually, this number can be forecasted according to the company's experience. The workload is calculated by monetary value as variable cost value mirrors workload. The example used is 200 for the capacity. So, if the monthly cost is more than 200, it's assumed that the company must outsource the rest of the work.	19
15	Overload Effect	Yes, enter percentage value	Cost effect when maximum workload is exceeded. Putting in example is 150%, which means that once variable cost is more than 200, the rest of the cost apart from 200 will be 150% more expensive. Normally, outsourcing costs more than when work is done in-house. But if in user's case outsourced work costs the same, inputting a percentage of 100% will represent the same cost.	6, 19
16	Preceding Surplus	Yes, enter monetary value	Starting available cash or surplus balance from the portfolio prior.	23

The explanations continue, which is shown in figure 2.7 for a clearer preview. Similar with the previous section, components to be modified are also identified by a colored row. Main Table: Each row represents a monthly financial metric with a portfolio total on the right. This part is not to be modified at all, as all of them are already formula-driven.

17 - 23

	January	February	March	April	May	June	July	August	September	October	November	December	Total	
PMI - Planned Monthy Income	600	600	425	1.000	705	625	1.350	775	575	375	200	0	7.230.00	
PMVC - Planned Monthly Variable Cost	288	355	158	519	379	330	334	312	124	60	32	0	2.892.00	
PMAVC - Planned Monthly Adjusted Variable Cost	332	433	158	679	469	395	401	368	124	60	32	0	3.450.80	
PMFC - Planned Monthly Fixed Cost	240	240	240	240	240	240	240	240	240	240	240	240	2.880.00	<-- Fixed Cost (%) x Planned Revenue
PMTC - Planned Monthly Total Cost	572	673	398	919	709	635	641	608	364	300	272	240	6.330.80	<-- PMTC = PMAVC + PMFC
PMTS - Planned Monthly Total Surplus	28	-73	27	81	-4	-10	709	167	211	75	-72	-240	899.20	<-- PMTS = PMI - PMTC
PMCB - Planned Monthly Cash Balance	78	5	32	113	109	99	808	975	1.186	1.261	1.189	949	949.20	<-- PMCB = PMTS + Preceding Surplus

Figure 2.7: Preview of the second part in the second section, financial projection. Source: Attachment 1

Table 2.4. Description of the second part in the second section of the tool. Source: Own elaboration.

Identifier	Name	To be edited for normal use?	Function	Direct Connection
17	PMI – Planned	No	Represents the planned revenue generated by each project in a month. Use to reflect cash inflow and to	5

Identifier	Name	To be edited for normal use?	Function	Direct Connection
	Monthly Income		estimate profitability. In this model, according to different contract types and agreements with the client, payment can vary and not be limited to 4 instalments or 1 instalment.	
18	PMVC – Planned Monthly Variable Cost	No	Reflects the direct costs that vary based on the project activity for that month such as material quantity and expected risk for the project.	6, 14, 19
19	PMAVC – Planned Monthly Adjusted Variable Cost	No	This metric totals the variable costs over time per project and reflects the direct costs that vary based on the project activity for that month such sudden increase in price materials, outsourced labor, and other unexpected risk factors.	15, 18, 21
20	PMFC – Planned Monthly Fixed Cost	No	Reflects the recurring cost that doesn't change according to any factor of the ongoing projects, such as rent or salary. The total amount is a percentage of the planned revenue. Total is calculated by = Fixed Cost (%) x Planned Revenue, so each cell is the total divided by 12 (from January to December).	12, 13, 21
21	PMTC - Planned Monthly Total Cost	No	The sum of adjusted variable and fixed costs for a project in a specific month, including total costs and possibly penalty fees or contingencies. PMTC = PMAVC + PMFC	19, 20, 22
22	PMTS – Planned Monthly Total Surplus	No	Reflects the monthly surplus amount after all expenses have been taken out from the income. The actual monthly profit or loss. PMTS = PMI – PMTC	21, 22
23	PMCB - Planned Monthly Cash Balance	No	Available fund after calculating the preceding surplus. PMCB = PMTS + Surplus	16, 22
24 (Yellow-colored cell)	F.O. – Final Output	No	Represents the total benefit of the project portfolio. It serves as one of the final objectives, which is to come to the highest total benefit.	2nd Part in Planned Schedule section, 24

To support a fast evaluation of the financial performance, PMI, PMTC, PMTS and PMCB are also previewed as a line graph as it can be seen in figure 2.8. The line graph also represents the third part and all at once, also the last part in the second section, financial projections. Since it is a visual representation of the data anterior, it is identified on table 2.5 with the same number.

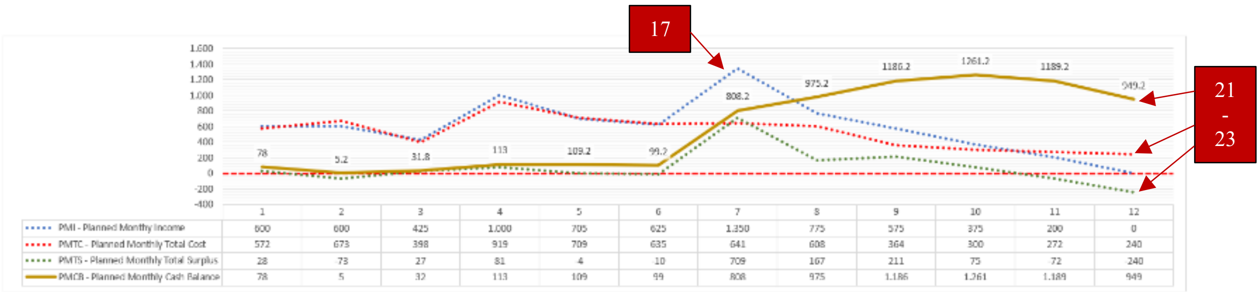


Figure 2.8: Preview of the third part in the second section, financial projection. Source: Attachment 1

Table 2.5. Description of the last part in the second section of the tool. Source: Own elaboration.

Identifier	Name	To be edited for normal use?	Function	Direct Connection
17	PMI – Planned Monthly Income	No	Blue dotted line (PMI): Gives preview of the revenue or allowance money user gets every month.	5
21	PMTC - Planned Monthly Total Cost	No	Red dotted line (PMTC): Gives preview of the monthly spending. If this line gets higher than the blue dotted line, it means that outflow is bigger than inflow.	19, 20, 22
22	PMTS – Planned Monthly Total Surplus	No	Green line (PMTS): Gives preview of how much money users have left after spending it. It can go up or down depending on whether the revenue or the cost is higher.	21, 22
23	PMCB - Planned Monthly Cash Balance	No	Yellow line (PMCB): Gives preview of money users have left. It adds up leftover money each month, so users know how much money they saved or lost altogether.	16, 22

The goal of the line graph is to help evaluate the pattern – dips in income or months with tight margins. Graph point below 0 means a negative cash balance at that specific time.

2.2.3 Control

EVAL and COND tables are a component that support the internal calculation behind the tool. As it sits quietly behind the scenes, it is not suggested to be edited during normal use. It is part of the programing that helps to check and inform anomaly to keep portfolio data accurate and workable. In detail, EVAL table verifies criteria against predefined rules across the portfolio while COND table verifies that no field is left blank. It informs the user if all necessary components have been filled in or not. Figure 2.9 will give preview of all EVAL and COND table in the tool's complete preview.

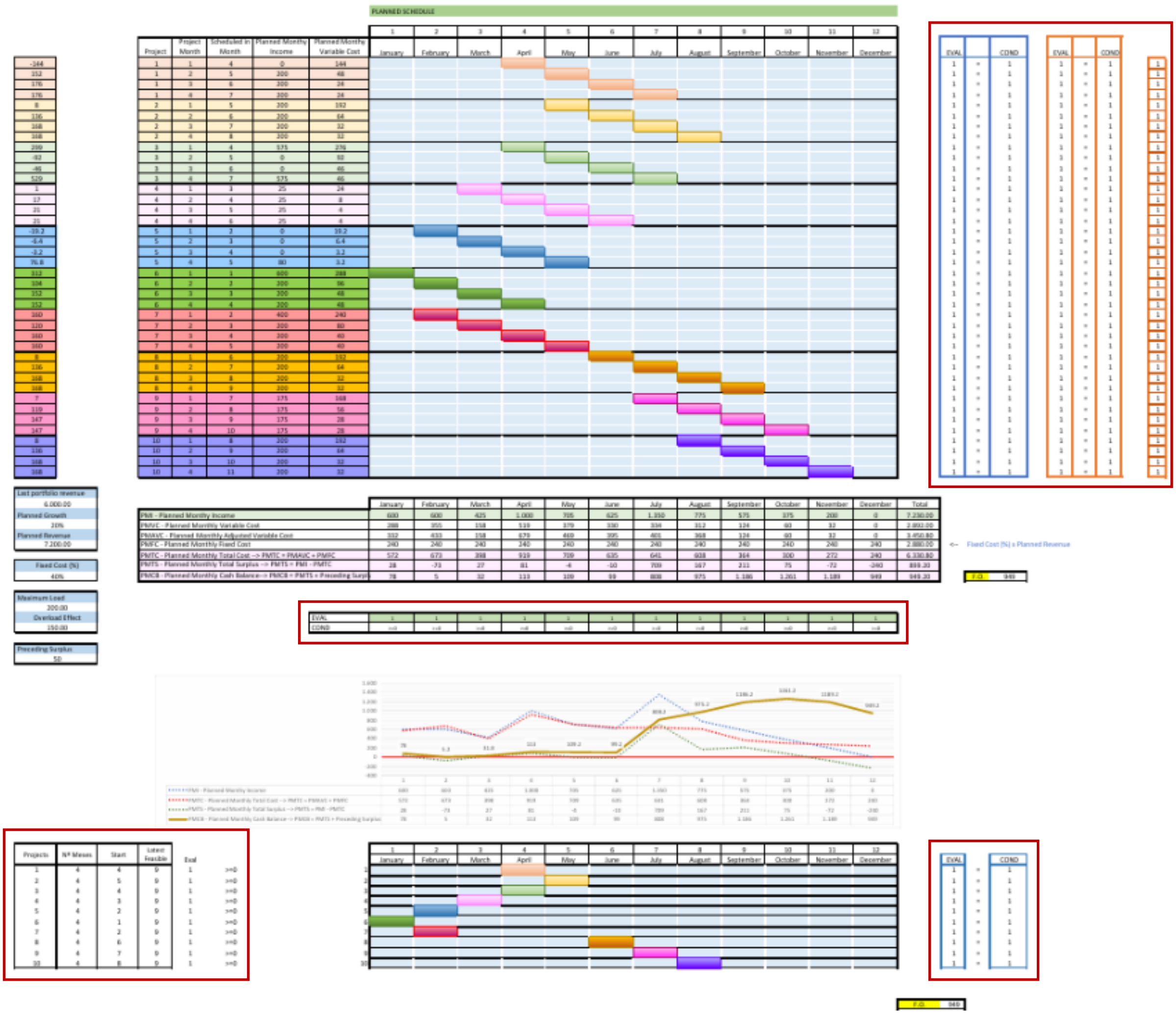


Figure 2.9: Boundary of the last section, Control. Source: Attachment 1

By running validation and completeness checks, EVAL and COND help diminish the common unintentional human-error. It detects uncompleted data or accidentally deleted formulas as anomalies. In this model, EVAL and COND flag anomalies help catch issues before it becomes a problem without solving it. In future development, an automated problem solving may be expected. Hence, any detected anomalies wouldn't stop the automated calculation of the tool.

This sub-section will give a description of the last section of this tool. Working from leftmost and from top to bottom, figure 2.10 is the first part in this section. Detailed descriptions are as follows:

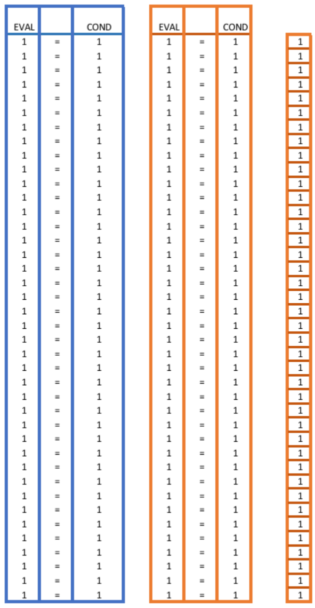
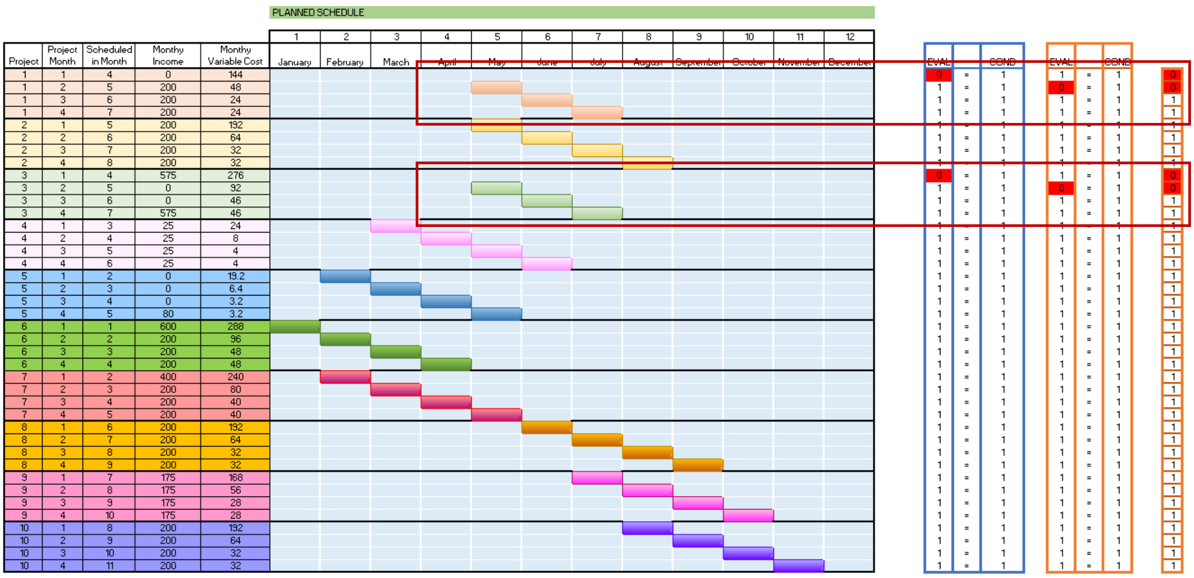


Figure 2.10: Preview of the first EVAL and COND table. Source: Attachment 1

This evaluation and condition table located on the top rightmost inform an anomaly. An anomaly would be shown as "0" in the evaluation part and generate a red colored cell (figure 2.11). This anomaly would not generate any problem later in the financial projection, but it shows that the first activity for projects 1 and 3 have not yet been scheduled. This may happen if users deleted a cell. Although it doesn't impact on the financial projection, it gives an alert to review the completeness.



Project	Project Month	Scheduled in Month	Monthy Income	Monthy Variable Cost
1	1	4	0	144
1	2	5	200	48
1	3	6	200	24
1	4	7	200	24
2	1	5	200	192
2	2	6	200	64
2	3	7	200	32
2	4	8	200	32
3	1	4	575	276
3	2	5	0	92
3	3	6	0	46
3	4	7	575	46
4	1	3	25	24
4	2	4	25	8
4	3	5	25	4
4	4	6	25	4
5	1	2	0	19.2
5	2	3	0	6.4
5	3	4	0	3.2
5	4	5	80	3.2
6	1	1	600	288
6	2	2	200	96
6	3	3	200	48
6	4	4	200	48
7	1	2	400	240
7	2	3	200	80
7	3	4	200	40
7	4	5	200	40
8	1	6	200	192
8	2	7	200	64
8	3	8	200	32
8	4	9	200	32
9	1	7	175	168
9	2	8	175	56
9	3	9	175	28
9	4	10	175	28
10	1	8	200	192
10	2	9	200	64
10	3	10	200	32
10	4	11	200	32

Figure 2.11: Preview of the first EVAL and COND table with anomaly. Source: Attachment 1

The second EVAL and COND table is the simplest control table with an important function. It is directly corelated to the monthly cashflow of the financial projection. This EVAL and COND table will inform with a pink cell when a month has a negative cashflow. A completely positive cash flow will be shown as figure 2.12 below.

EVAL	1	1	1	1	1	1	1	1	1	1	1	1
COND	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0

Figure 2.12: Preview of the second EVAL and COND table. Source: Attachment 1

While a negative monthly cash flow is shown in this second scenario, as shown in figure 2.13. It predicts negative cash flow in the first and second month because of a bigger expense than the income. This happens when PMI is smaller than a combination of PMAVC and PMFC. This results in a negative value for PMTS and PMCB. EVAL and COND table in this scenario will give users financial alerts to adjust their expenses to stay operational.

Last portfolio revenue	6.000.00
Planned Growth	20%
Planned Revenue	7.200.00
Fixed Cost (%)	40%
Maximum Load	200.00
Overload Effect (%)	150.00
Preceding Surplus	50

	January	February	March	April	May	June	July	August	September	October	November	December	Total	
PMI - Planned Monthy Income	600	800	625	1.200	505	425	1.150	775	575	375	200	0	7.230.00	
PMVC - Planned Monthly Variable Cost	432	403	182	399	331	306	310	312	124	60	32	0	2.892.00	
PMAVC - Planned Monthly Adjusted Variable Cost	548	505	182	499	397	359	365	368	124	60	32	0	3.438.80	
PMFC - Planned Monthly Fixed Cost	240	240	240	240	240	240	240	240	240	240	240	240	2.880.00	<-- Fixed Cost (%) x Planned Revenue
PMTC - Planned Monthly Total Cost	788	745	422	739	637	599	605	608	364	300	272	240	6.318.80	<-- PMTC = PMAVC + PMFC
PMTS - Planned Monthly Total Surplus	-188	55	203	461	-132	-174	545	167	211	75	-72	-240	911.20	<-- PMTS = PMI - PMTC
PMCB - Planned Monthly Cash Balance	-138	-83	120	581	449	275	820	987	1.198	1.273	1.201	961	961.20	<-- PMCB = PMTS + Preceding Surplus

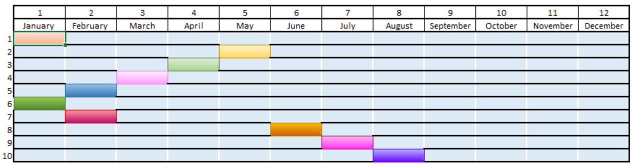
EVAL	0	0	1	1	1	1	1	1	1	1	1	1
COND	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0

F.O.	961

Figure 2.13: Preview of the second EVAL and COND table with negative cash flow. Source: Attachment 1

The last control table is located on bottommost, and just like the others, it is not to be modified as it is integrated into the programming. (Figure 2.14). This control table is located on the right side and the left side of the starting time scheduling table. This part of the tool helps make sure that every project is correctly scheduled and that nothing gets missed.

Projects	Nº Meses	Start	Latest Feasible	Eval	
1	4	1	9	1	>=0
2	4	5	9	1	>=0
3	4	4	9	1	>=0
4	4	3	9	1	>=0
5	4	2	9	1	>=0
6	4	1	9	1	>=0
7	4	2	9	1	>=0
8	4	6	9	1	>=0
9	4	7	9	1	>=0
10	4	8	9	1	>=0

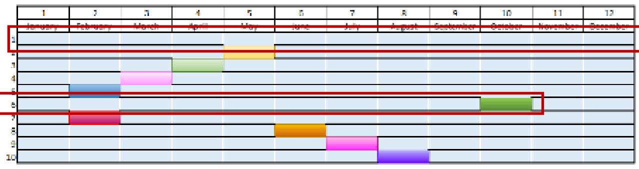


EVAL		COND
1	=	1
1	=	1
1	=	1
1	=	1
1	=	1
1	=	1
1	=	1
1	=	1
1	=	1
1	=	1

Figure 2.14: Preview of the last EVAL and COND table. Source: Attachment 1

EVAL and COND table on the left side shows that each project is set to take 4 months with each of their own starting point. The "start" column tells the starting month while the "last feasible" column represents the latest month a project can start without overstepping to the upcoming portfolio year. Projects that started after the 9th month will generate a number 0 on the "Eval" column, example is shown on figure 2.15.

Projects	Nº Meses	Start	Latest Feasible	Eval	
1	4	0	9	1	>=0
2	4	5	9	1	>=0
3	4	4	9	1	>=0
4	4	3	9	1	>=0
5	4	[illegible]	9	1	>=0
6	4	10	9	0	>=0
7	4	2	9	1	>=0
8	4	6	9	1	>=0
9	4	7	9	1	>=0
10	4	8	9	1	>=0



EVAL		COND
0	=	1
1	=	1
1	=	1
1	=	1
1	=	1
1	=	1
1	=	1
1	=	1
1	=	1
1	=	1

Figure 2.15: Preview of the last EVAL and COND table with anomaly. Source: Attachment 1

While the control table on the rightmost section is also an additional programming to ensure that every project is going to be executed. If a project is not scheduled in the starting time scheduling table, a corresponding cell will be red as it is shown in figure 2.15. It is, like the other control table, is also not to be modified as its function is only to inform that a project will be executed.

Chapter 3. Practical Example of the Simulation-Based Financial and Operational Portfolio Planning Model

In this chapter, a practical example will be presented to give a preview of the simulation model. This scenario will be based on the company which was featured in the case study from the previous chapter 1.3. All data used in this example have been extracted and simplified from the company's most recent project portfolio cycle. The description of this practical example is aimed at illustrating the potential of the model for real world scenario.

3.1 Data Completion

As for this model, the maximum projects are 10, the maximum length is 1 year, and each project will have 4 activities that will be divided into 4 months. As for this practical example, we will use this limit to show the model's full potential.

3.1.1 Completion of the project schedule table

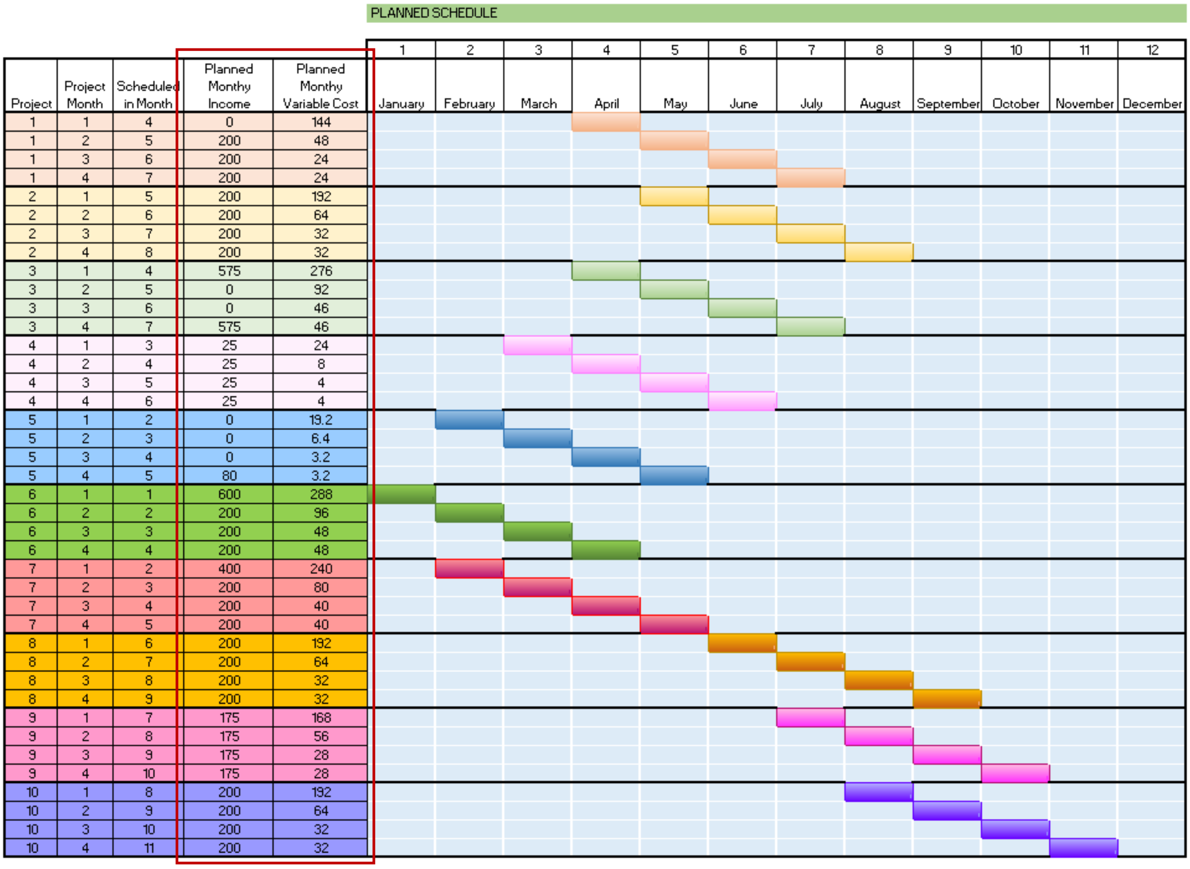
In this section, users need to complete the table with the organization's monthly income and monthly variable cost for each project and their breakdown activity as shown in figure 3.1, marked with a red box.

The columns "Project", "Project Month" and "Scheduled in Month" are not to be modified, as it is generated automatically, while "Scheduled in Month" will be automatically generated from the interactive table on portfolio scheduling timetable. Refer to table 2.2 for a complete explanation of each component and guideline.

The leftmost table, as shown on figure 3.2, marked with a red box, will give a preview if the revenue or spending is bigger or equal for that activity. If by accident, the activity schedule is deleted, the tool will give a warning by the EVAL and COND table on the right side as shown below or as it is also shown on figure 2.8.

The warning is shown as a red-colored cell. Although the tool will still work, it may not be optimal for future modifications. For that reason, users should pay attention to these warning anomalies as it informs incomplete data.

It is not recommended, but it may occur to users to delete individual cells to schedule less than 10 projects or less than 4 activities for each project. Additional information about this topic will be discussed in the next section 3.2.



Project	Project Month	Scheduled in Month	Planned Monthy Income	Planned Monthy Variable Cost
1	1	4	0	144
1	2	5	200	48
1	3	6	200	24
1	4	7	200	24
2	1	5	200	192
2	2	6	200	64
2	3	7	200	32
2	4	8	200	32
3	1	4	575	276
3	2	5	0	92
3	3	6	0	46
3	4	7	575	46
4	1	3	25	24
4	2	4	25	8
4	3	5	25	4
4	4	6	25	4
5	1	2	0	19.2
5	2	3	0	6.4
5	3	4	0	3.2
5	4	5	80	3.2
6	1	1	600	288
6	2	2	200	96
6	3	3	200	48
6	4	4	200	48
7	1	2	400	240
7	2	3	200	80
7	3	4	200	40
7	4	5	200	40
8	1	6	200	192
8	2	7	200	64
8	3	8	200	32
8	4	9	200	32
9	1	7	175	168
9	2	8	175	56
9	3	9	175	28
9	4	10	175	28
10	1	8	200	192
10	2	9	200	64
10	3	10	200	32
10	4	11	200	32

Figure 3.1: Section from the project schedule table to be completed. Source: Attachment 1

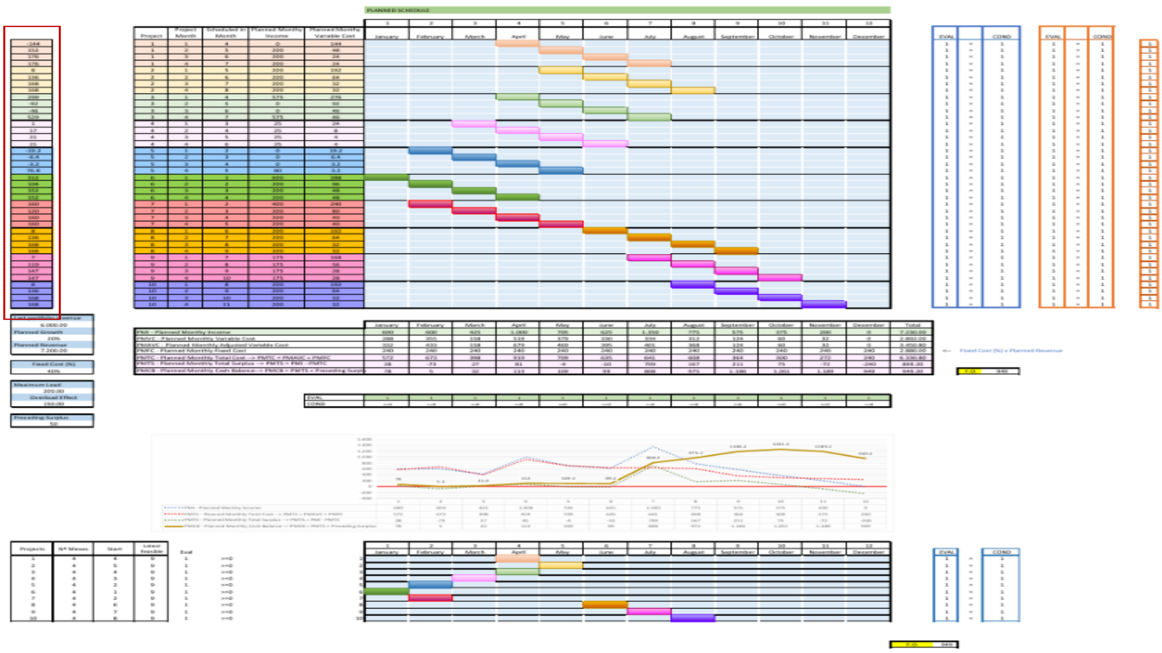
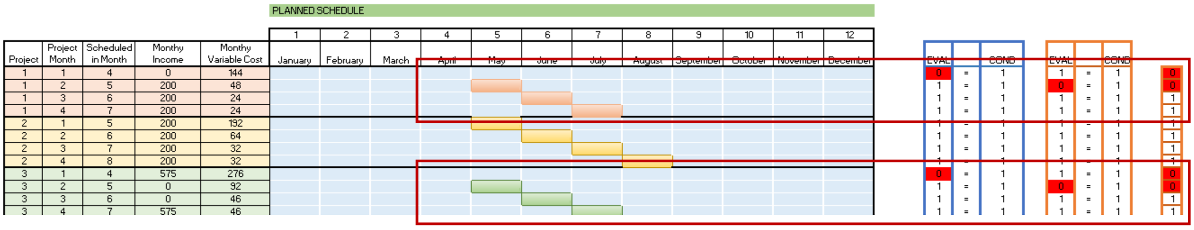


Figure 3.2: Section from the project schedule table to be completed. Source: Attachment 1



					PLANNED SCHEDULE																		
					1	2	3	4	5	6	7	8	9	10	11	12							
Project	Project Month	Scheduled in Month	Monthy Income	Monthy Variable Cost	January	February	March	April	May	June	July	August	September	October	November	December	EVAL		COND	EVAL		COND	
1	1	4	0	144													0	=	1	1	=	1	0
1	2	5	200	48													1	=	1	0	=	1	0
1	3	6	200	24													1	=	1	1	=	1	1
1	4	7	200	24													1	=	1	1	=	1	1
2	1	5	200	192													1	=	1	1	=	1	1
2	2	6	200	64													1	=	1	1	=	1	1
2	3	7	200	32													1	=	1	1	=	1	1
2	4	8	200	32													1	=	1	1	=	1	1
3	1	4	575	276													0	=	1	1	=	1	0
3	2	5	0	92													1	=	1	0	=	1	0
3	3	6	0	46													1	=	1	1	=	1	1
3	4	7	575	46													1	=	1	1	=	1	1

Figure 3.3: Section from the project schedule table with uncomplete example. Source: Attachment 1

3.1.2 Completion of the financial setup table

This is the last part from the tool that requires manual input from the user, as seen in figure 3.4 below.

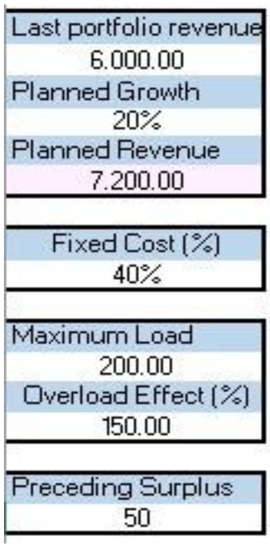


Figure 3.4: Section from the financial setup table to be completed. Source: Attachment 1

All part except the pink cell, which is marked as “Planned Revenue” must be completed manually as this part of the tool will reflect the financial condition and situation of the company. Data included will then be used to create the financial projection.

First part of the table is “Last portfolio revenue”, “Planned growth” and “Planed revenue”. As described on the previous chapter, “Last portfolio revenue” means organization’s last portfolio cycle’s revenue while “Planned growth” is their planned growth for the upcoming portfolio cycle. “Planned revenue” will automatically be calculated from the value and percentage inputted in those cells.

Next, user must fill in a table marked as ¨Fixed Cost (%) ¨. Here users need to input their proportioned percentage of planned revenue that will be allocated for their fixed cost. Monthly wages and rent are examples of fixed cost.

“Maximum load” refers to the highest monthly operational capacity in monetary terms that the organization can handle. While the effect of overload will be reflected in percentage in the cell ¨Overload Effect (%) ¨.

“Preceding Surplus” represents initial capital at the start of the new portfolio period. This value, depends on every organization, may come from leftover funds from the receding portfolio cycle or any other financial reserves.

It is recommended to refer to table 2.3 in chapter 2 to have a better understanding of each component.

3.1.3 Portfolio schedule starting time arrangement

This project scheduling starting time is an interactive table, as seen in figure 3.5 below.

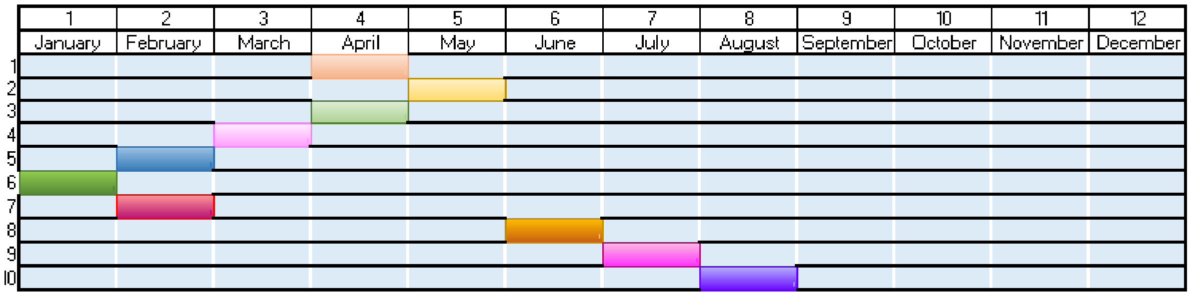


Figure 3.5: Section from the portfolio schedule starting time arrangement. Source: Attachment 1

The top part shows monthly portfolio period of the whole portfolio cycle, in this case, is monthly from January to December. On the left, number 1 – 10 refers to different projects, so each row will also represent different projects.

For every project row, the user must decide on a starting month and click the corresponding cell in the corresponding column. In this model, each project will last exactly 4 consecutive months. As users do this, users need to take into consideration that projects starting from October, November and December will finish in the next period, or in this case, next year. Here, users can also consider overlapping projects while keeping in mind the maximum load the team can handle.

Once all projects have a starting point, users can consult on the EVAL and COND table located on the left and right side of the portfolio scheduling starting timetable as shown below to check for anomalies. EVAL and COND table will flag missing start date or project overstepping to the next portfolio cycle. Figure 3.6 previews a complete table while figure 3.7 previews an incomplete data, hence the red cells. More than warning incomplete data, EVAL and COND table on the left side informs a project overstepping to the next portfolio period.

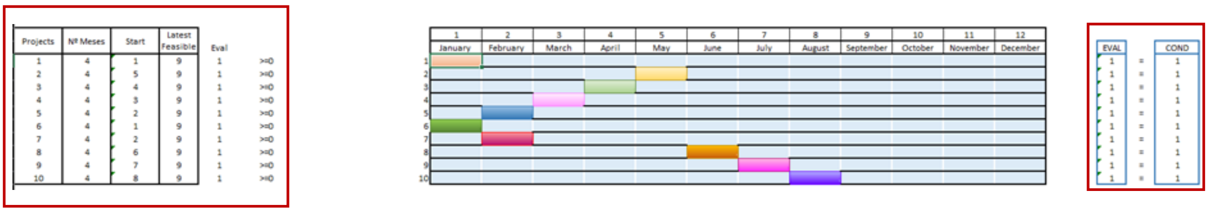


Figure 3.6: Section from the portfolio schedule starting time arrangement, no anomaly. Source: Attachment 1

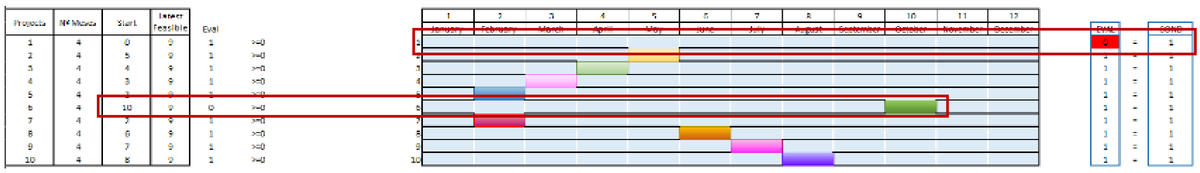


Figure 3.7: Section from the portfolio schedule starting time arrangement with anomaly. Source: Attachment 1

Adjusting the start time will also automatically update the preview of the visual representation of the overall project schedule as shown on figure 3.8. Each project, from 1 – 10 have a dedicated color, and adjustment will shift the same color cells in the overall project schedule. Thus, users can consult immediately the balance of the entire portfolio cycle and see how the timing of each project overlaps or affects one another.

Project	Project Month	Scheduled in Month	Planned Monthy Income	Planned Monthy Variable Cost
1	1	4	0	144
1	2	5	200	48
1	3	6	200	24
1	4	7	200	24
2	1	5	200	192
2	2	6	200	64
2	3	7	200	32
2	4	8	200	32
3	1	4	575	276
3	2	5	0	92
3	3	6	0	46
3	4	7	575	46
4	1	3	25	24
4	2	4	25	8
4	3	5	25	4
4	4	6	25	4
5	1	2	0	19.2
5	2	3	0	6.4
5	3	4	0	3.2
5	4	5	80	3.2
6	1	1	600	288
6	2	2	200	96
6	3	3	200	48
6	4	4	200	48
7	1	2	400	240
7	2	3	200	80
7	3	4	200	40
7	4	5	200	40
8	1	6	200	192
8	2	7	200	64
8	3	8	200	32
8	4	9	200	32
9	1	7	175	168
9	2	8	175	56
9	3	9	175	28
9	4	10	175	28
10	1	8	200	192
10	2	9	200	64
10	3	10	200	32
10	4	11	200	32

Figure 3.8: Section from the visual representation of the overall project schedule. Source: Attachment 1

3.2 Custom Modification

To ensure flexibility, this tool can - and should - be modified to organization´s necessity to be a better adaptation of the actual portfolio being scheduled. Thus, the tool doesn't only benefit certain organizations, but for universal use, offering a practical, easy and low-cost tool. However, it should be taken into consideration that the first model did in fact was developed hand-in-hand with the company discussed in the previous chapter. Thus, this first model of a finance-based scheduling tool is crafted especially with a specific need. So, some features might be a limitation for other organizations. Nevertheless, being programmed in Excel, no problem will be dead-end. There will always be a workaround for every problem.

The common difference for another organization might be the number of activities and projects to be executed. For a maximum use, this model lets the user schedule 10 projects and 4 activities. But an alternative to schedule less than 10 projects and 4 activities is available.

3.2.1 Alternative for Scheduling Less than 10 Projects

The workaround to schedule less than 10 projects is as simple as leaving a blank cell in the project starting timetable, example is shown below in figure 3.9. This approach differs from – and not applicable to – deleting a cell in the first part of the planned schedule section. Deleting cells in the first part of the planned schedule section removes the formula itself. But because the portfolio schedule starting timetable uses its own distinct formula, a blank cell simply skips that project without touching the underlying calculation. The formula stays intact for when users add a project later for future use.

Leaving a blank cell in this table will provoke the EVAL table on the right side. Thus, the corresponding cell on the EVAL table will be red-colored. For future use, user can change the project count back to 10 by clicking the cell corresponding to a desired project and month.

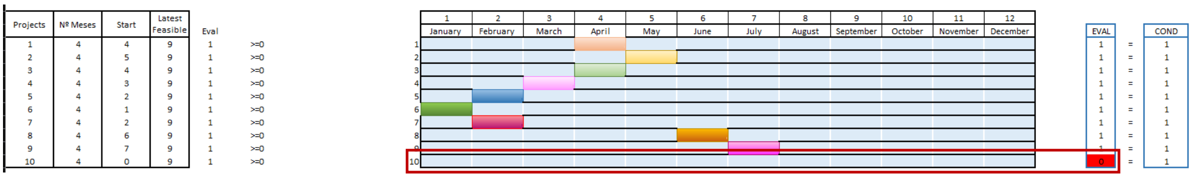


Figure 3.9: Alternative for scheduling less than 10 projects in portfolio schedule starting time arrangement. Source: Attachment 1

3.2.2 Alternative for Scheduling 1 to 3 Activities per Project

As mentioned in table 2.2, last row for identifier number 9, even though this model wasn't developed to be use for less than or more than 4 activities, it may occur to users to delete 1 – 3 consecutive cells. The calculation will still work even though the EVAL and COND table will inform them as an anomaly as shown on figure 3.10.

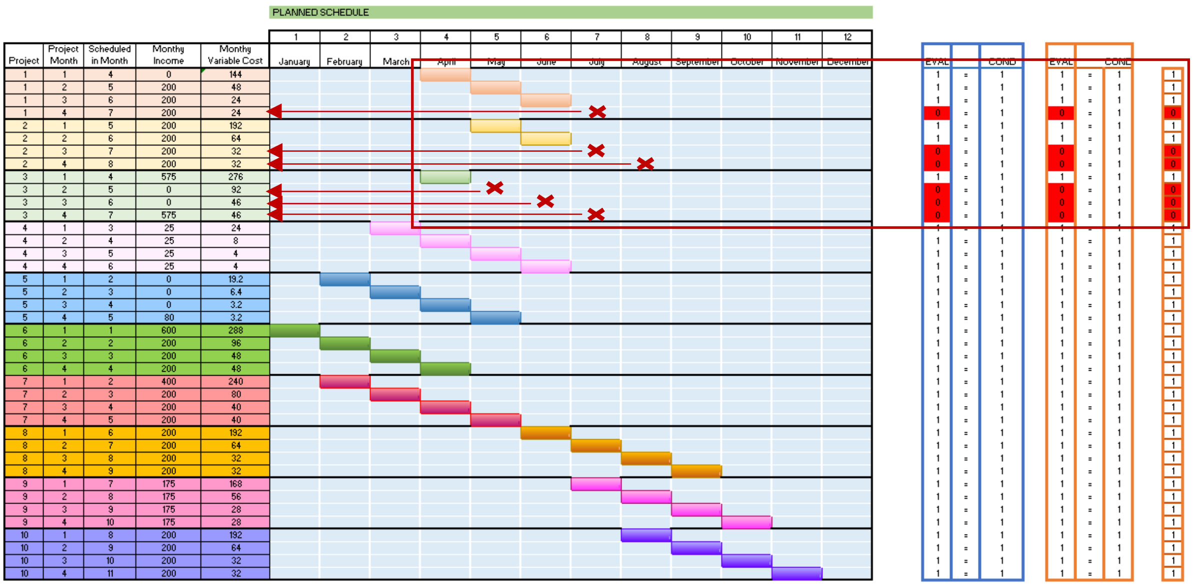


Figure 3.10: Preview of the first EVAL and COND table with anomalies because of an unrecommendable modification for scheduling 1 – 3 activities. Source: Attachment 1

However, it is important to note that this alternative, although it can be calculated perfectly, is not recommended as all individual cells are formulated. Unlike the alternative to schedule less than 10 projects, deleted cells in this section will stay deleted for further use as it uses a different formula. If it is necessary to schedule a preview of 1 to 3 activities in a project, refer to the figure 3.11 below for an example of a safer alternative.

In the example above, refer to the red box to see that projects 1, 2 and 3 do not have the normal activities count, hence the model informs an anomaly as the model sees it as incomplete. Marked with a bold X is the deleted activities flagged by the model. As previewed, project 1 has 3 activities, project 2 has 2 activities and project 3 has only 1. As EVAL and COND table only informs anomaly and incompleteness, this model can still work and will give calculation and projection as well. The following Monthly Income and Monthly Variable Cost of the deleted activities will not be calculated. As mentioned before, this modification is not recommended to be made, nor is it required for normal use for projects with 4 activities. This is because deleting the cell will also delete the embedded formula.

Only if the Gantt Chart is not the main dilemma for scheduling 1 to 3 activities in a project, refer to figure 3.11 for an example of safer alternative. This alternative does not delete individual cells like it was done in figure 3.10. Although it will give the same calculation as the first alternative shown in figure 3.10, the EVAL and COND table doesn't notify any anomaly because embedded formula is still intact. As this model was designed with the consideration of data from the company mentioned in the previous chapter, understandably, this workaround doesn't provide an optimal preview in the first part of the planned schedule section.

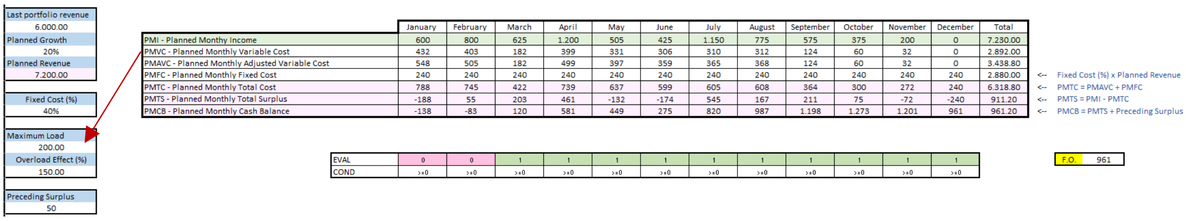
Figure 3.11: Preview of the first EVAL and COND table with a preferred alternative on scheduling 1 – 3 activities. Source: Attachment 1

3.3 Evaluation and Financial Projection

3.3.1 Core Interactions between Elements

All components are directly or indirectly corelate to each other. This section will dig deeper into the inner mechanics of how each core part of this tool is interacting with each other. Refer to chapter 2 to see the direct connections of each component. Every nominal such as surplus, cost and balance figure are parts of the portfolio scheduling financial system where one can ripple through multiple areas. Understanding how the variables connect will give the user a more strategic view of the operational decision and understanding the interconnected components.

- **Planned monthly variable cost (PMVC) directly linked to Project load.**
  Higher nominals will also mean a greater load, which leads to a higher variable cost. For example, materials and production tasks). This also means that it will occupy more fixed resources like machinery and human resources.



Last portfolio revenue	6.000.00
Planned Growth	20%
Planned Revenue	7.200.00
Fixed Cost (%)	40%
Maximum Load	200.00
Overload Effect (%)	150.00
Preceding Surplus	50

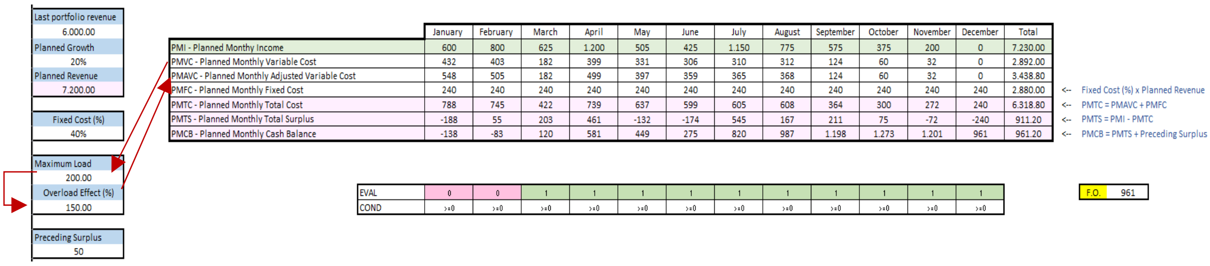
	January	February	March	April	May	June	July	August	September	October	November	December	Total	
PMI - Planned Monthy Income	600	800	625	1.200	505	425	1.150	775	575	375	200	0	7.230.00	
PMVC - Planned Monthly Variable Cost	432	403	182	399	331	306	310	312	124	60	32	0	2.892.00	
PMAVC - Planned Monthly Adjusted Variable Cost	548	505	182	499	397	359	365	368	124	60	32	0	3.438.80	
PMFC - Planned Monthly Fixed Cost	240	240	240	240	240	240	240	240	240	240	240	240	2.880.00	<-- Fixed Cost (%) x Planned Revenue
PMTC - Planned Monthly Total Cost	788	745	422	739	637	599	605	608	364	300	272	240	6.318.80	<-- PMTC = PMAVC + PMFC
PMTS - Planned Monthly Total Surplus	-188	55	203	461	-132	-174	545	167	211	75	-72	-240	911.20	<-- PMTS = PMI - PMTC
PMCB - Planned Monthly Cash Balance	-138	-83	120	581	449	275	820	987	1.198	1.273	1.201	961	961.20	<-- PMCB = PMTS + Preceding Surplus

EVAL	0	0	1	1	1	1	1	1	1	1	1	1
COND	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0

F.O.	961

Figure 3.12: Interaction between PMVC and Maximum Load. Source: Attachment 1

- **Planned monthly adjusted variable cost (PMAVC) is indirectly linked to Project load via PMVC.**
  If PMVC exceeds the maximum load defined by the user, cost spikes. Hence, cost will be adjusted using the overload effect (%). This would mean that even if PMVC seems acceptable at first, a big workload can push PMAVC higher if the resource thresholds are breached. This means that just by moving the project starting dates can lead to a higher or a lower final cash balance as a good schedule doesn't overlap too many projects with a big load at the same time.



Last portfolio revenue	6.000.00
Planned Growth	20%
Planned Revenue	7.200.00
Fixed Cost (%)	40%
Maximum Load	200.00
Overload Effect (%)	150.00
Preceding Surplus	50

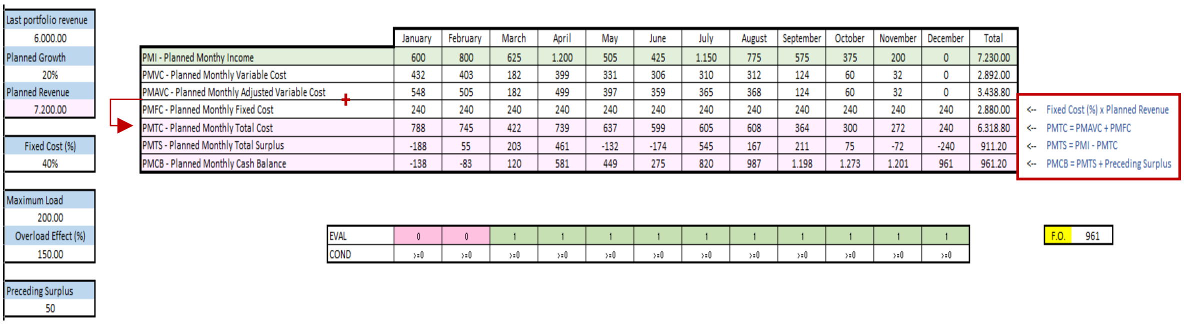
	January	February	March	April	May	June	July	August	September	October	November	December	Total	
PMI - Planned Monthy Income	600	800	625	1.200	505	425	1.150	775	575	375	200	0	7.230.00	
PMVC - Planned Monthly Variable Cost	432	403	182	399	331	306	310	312	124	60	32	0	2.892.00	
PMAVC - Planned Monthly Adjusted Variable Cost	548	505	182	499	397	359	365	368	124	60	32	0	3.438.80	
PMFC - Planned Monthly Fixed Cost	240	240	240	240	240	240	240	240	240	240	240	240	2.880.00	<-- Fixed Cost (%) x Planned Revenue
PMTC - Planned Monthly Total Cost	788	745	422	739	637	599	605	608	364	300	272	240	6.318.80	<-- PMTC = PMAVC + PMFC
PMTS - Planned Monthly Total Surplus	-188	55	203	461	-132	-174	545	167	211	75	-72	-240	911.20	<-- PMTS = PMI - PMTC
PMCB - Planned Monthly Cash Balance	-138	-83	120	581	449	275	820	987	1.198	1.273	1.201	961	961.20	<-- PMCB = PMTS + Preceding Surplus

EVAL	0	0	1	1	1	1	1	1	1	1	1	1
COND	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0

F.O.	961

Figure 3.13: Interaction between PMAVC and Maximum Load. Source: Attachment 1

- **Planned monthly total cost (PMTC) is composed of Fixed cost + Adjustable variable cost.** Just as it is written on the blue text description, monthly total cost will vary depending on overlapping project loads.



	January	February	March	April	May	June	July	August	September	October	November	December	Total
PMI - Planned Monthy Income	600	800	625	1.200	505	425	1.150	775	575	375	200	0	7.230.00
PMVC - Planned Monthly Variable Cost	432	403	182	399	331	306	310	312	124	60	32	0	2.892.00
PMAVC - Planned Monthly Adjusted Variable Cost	548	505	182	499	397	359	365	368	124	60	32	0	3.438.80
PMFC - Planned Monthly Fixed Cost	240	240	240	240	240	240	240	240	240	240	240	240	2.880.00
PMTC - Planned Monthly Total Cost	788	745	422	739	637	599	605	608	364	300	272	240	6.318.80
PMTS - Planned Monthly Total Surplus	-188	55	203	461	-132	-174	545	167	211	75	-72	-240	911.20
PMCB - Planned Monthly Cash Balance	-138	-83	120	581	449	275	820	987	1.198	1.273	1.201	961	961.20

EVAL	0	0	1	1	1	1	1	1	1	1	1	1
COND	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0

Figure 3.14: Interaction between costs. Source: Attachment 1

- **Planned monthly surplus (PMTS) is calculated by PMI – PMTC.** Also, as we can see this calculation in the blue text description as shown on figure 3.7. This shows whether each month has more spending or income. A positive value means a surplus while a negative value warns of a deficit.
- **Planned monthly cash balance (PMCB) is calculated by PMTS + Preceding surplus.** Also, as shown in the blue text description on figure 3.7, PMCB held important information about the available cash balance or liquidity in real time. If it shows a nominal below 0, user may need extra funding or adjustments.
- **Portfolio schedule starting time directly impacts project timeline**, determining monthly project load which can also inflate PMAVC, shift monthly income and ultimately determine the final output (F.O.).

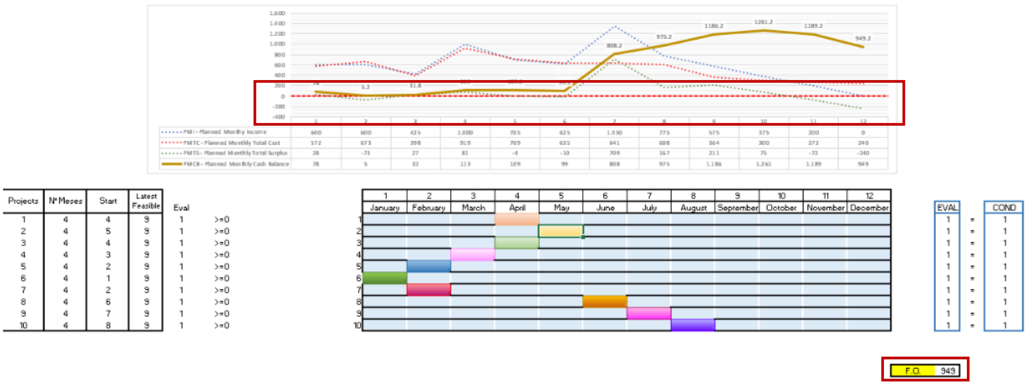


Figure 3.15: Interaction for portfolio schedule starting time example. Source: Attachment 1

It plays a big role in the overall tool because rearranging even just one project can make a big difference in terms of the finance balance. Figure 3.15 is an example of a schedule without any negative cashflow. The table is right below the graphic so the user can directly consult the graphic if there is any negative balance. Final output (F.O.) marked with a yellow cell is also directly under the portfolio schedule starting timetable. Hence, it would facilitate user with the consultation, which is to avoid negative dips in cashflow balance while maintaining the best possible final output or benefit possible.

Figure 3.16 previews that a change in just a project, in this case is project 1, can immediately change the available cash balance during January and February while also affecting the final output (final cash balance). This happens because project 1 requires a bigger upfront cost than the inflow from payments just as shown in figure 3.17 below

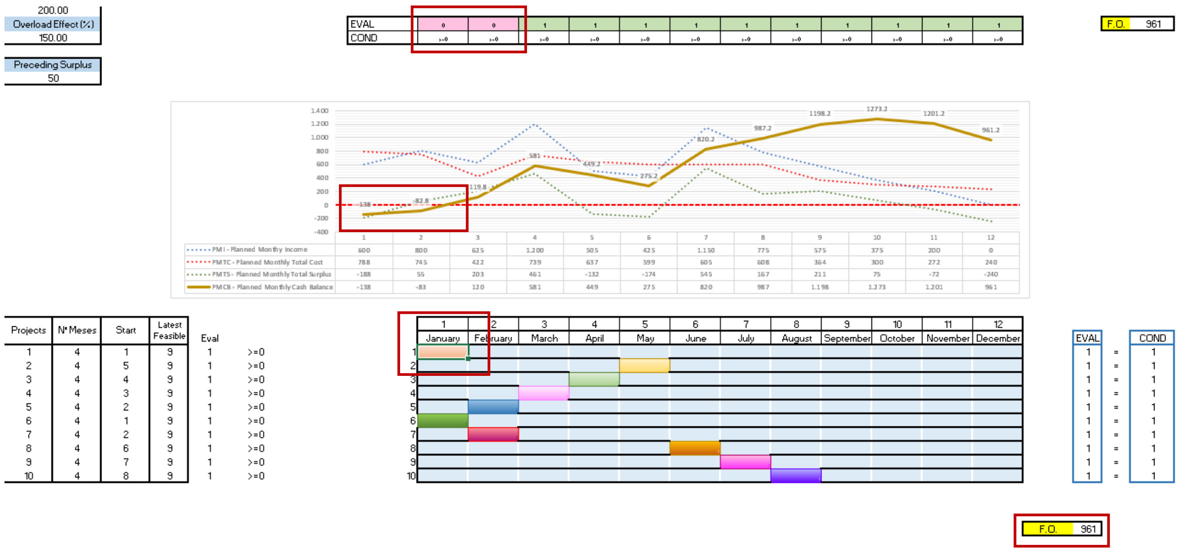


Figure 3.16: Interaction for portfolio schedule starting time example. Source: Attachment 1

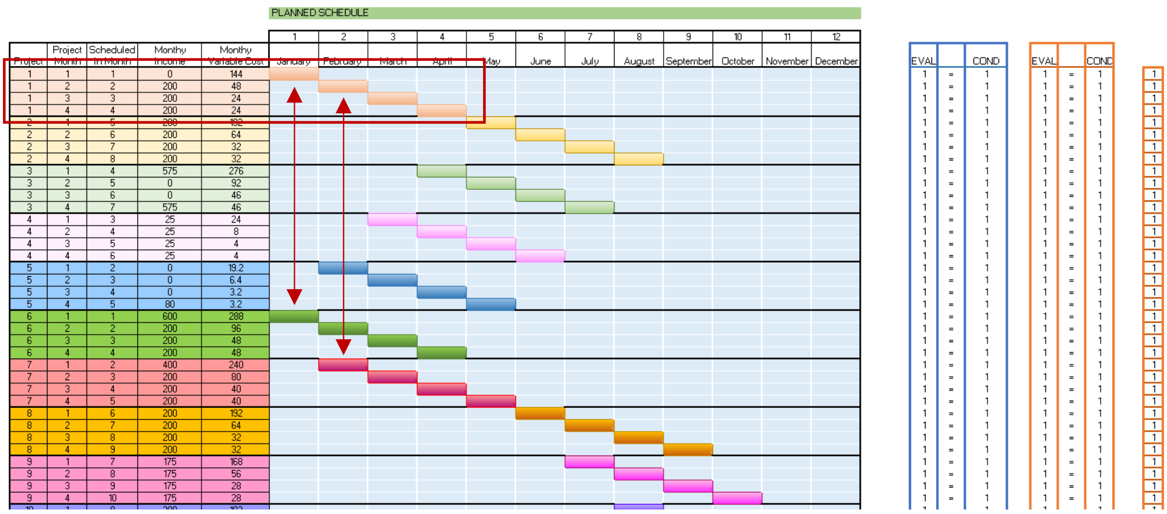


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Figure 3.17: A close-up chart of planned schedule section. Source: Attachment 1

Additionally, January and February have some overlaps of projects with big variable cost. As a result, the company could not handle the load, as the maximum load is just 200 as shown in figure 3.18 below. On top of that, outsourcing the workload in this case presents a 50% increase in price.

Last portfolio revenue	6.000.00
Planned Growth	20%
Planned Revenue	7.200.00
Fixed Cost (%)	40%
Maximum Load	200.00
Overload Effect (%)	150.00
Preceding Surplus	50

	January	February	March	April	May	June	July	August	September	October	November	December	Total	
PMI - Planned Monthy Income	600	800	625	1.200	505	425	1.150	775	575	375	200	0	7.230.00	
PMVC - Planned Monthly Variable Cost	432	403	182	399	331	306	310	312	124	60	32	0	2.892.00	
PMAVC - Planned Monthly Adjusted Variable Cost	548	505	182	499	397	359	365	368	124	60	32	0	3.438.80	
PMFC - Planned Monthly Fixed Cost	240	240	240	240	240	240	240	240	240	240	240	240	2.880.00	<-- Fixed Cost (%) x Planned Revenue
PMTC - Planned Monthly Total Cost	788	745	422	739	637	599	605	608	364	300	272	240	6.318.80	<-- PMTC = PMAVC + PMFC
PMTS - Planned Monthly Total Surplus	-188	55	203	461	-132	-174	545	167	211	75	-72	-240	911.20	<-- PMTS = PMI - PMTC
PMCB - Planned Monthly Cash Balance	-138	-83	120	581	449	275	820	987	1.198	1.273	1.201	961	961.20	<-- PMCB = PMTS + Preceding Surplus

EVAL	0	0	1	1	1	1	1	1	1	1	1	1
COND	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0

F.O.	961

Figure 3.18: Financial projection highlighting costs in January and February. Source: Attachment 1

Ultimately, all components and sections in this simulation tool are directly or indirectly connected to the Final Output (F.O.). Final output represents the cash balance at the end of the portfolio period. The value contains the benefits and surplus for the upcoming portfolio period. Changing nominals throughout the tool will directly or indirectly change the final output nominal. This way, by optimizing a schedule, this model also helps users to seek for maximum benefit possible.

3.3.2 Evaluation and Variations

After completing all the data, the tool will calculate and give an overview of the finance-based portfolio scheduling. The overview is shown in the financial projection part or as shown as in figure 3.19.

	January	February	March	April	May	June	July	August	September	October	November	December	Total	
PMI - Planned Monthy Income	600	600	425	1.000	705	625	1.350	775	575	375	200	0	7.230.00	
PMVC - Planned Monthly Variable Cost	288	355	158	519	379	330	334	312	124	60	32	0	2.892.00	
PMAVC - Planned Monthly Adjusted Variable Cost	332	433	158	679	469	395	401	368	124	60	32	0	3.450.80	
PMFC - Planned Monthly Fixed Cost	240	240	240	240	240	240	240	240	240	240	240	240	2.880.00	<-- Fixed Cost (%) x Planned Revenue
PMTC - Planned Monthly Total Cost	572	673	398	919	709	635	641	608	364	300	272	240	6.330.80	<-- PMTC = PMAVC + PMFC
PMTS - Planned Monthly Total Surplus	28	-73	27	81	-4	-10	709	167	211	75	-72	-240	899.20	<-- PMTS = PMI - PMTC
PMCB - Planned Monthly Cash Balance	78	5	32	113	109	99	808	975	1.186	1.261	1.189	949	949.20	<-- PMCB = PMTS + Preceding Surplus

EVAL	1	1	1	1	1	1	1	1	1	1	1	1
COND	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0	>=0

F.O.	949

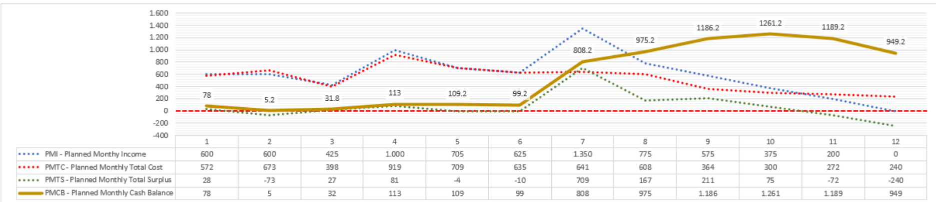

Figure 3.19: Section from the financial projection. Source: Attachment 1

It is recommended that the first thing users should consult on the financial projection section is the monthly surplus (PMTS) and the cumulative cash balance (PMCB). The surplus line shows when revenue falls below 0, it signals the user when they need to secure their short-term financing. While the cumulative cash balance puts each month's surplus on the cashflow. If it ever turns negative, it's warning the user that the current schedule isn't self-funding and requires adjustment. See figure 2.10 for a negative cashflow example.

Next, users can consult on planned income (PMI) curve and total cost (PMTC) to check cost spikes. It could mean a cluster of projects which can lead to unexpected outsourcing. This insight can inform users whether starting dates needed to be rearranged or negotiate better supplier teams to cut down on variable cost or to grow the team to also grow maximum overload threshold.

Beyond the month-to-month figures, users can consult the users can consult the year end summary revenue as organization's performance barometer. If the projected next balance meets or exceeds user´s strategic targets, then the portfolio schedule is financially sound. If not, this tool makes it easy to explore better alternatives, whether by tweaking some factors in the current portfolio cycle or by running better simulation for the upcoming portfolio.

User can run some "what-if" variations for a dynamic decision-making guide that keeps the organization agile. Examples of variations include adjusting:

- Planned monthly variable cost by finding for a new supplier that offers cheaper materials would result in a more economically planned monthly variable cost total.
- Planned growth means adjusting the revenue growth rate assumption.
    - A more conservative assumption means a smaller growth rate assumption will lower the planned revenue. A smaller plan revenue will also lower the planned monthly fixed cost. But if human resources are included in fixed costs, then a lower human resource will also lower maximum load. Hence, a bad situation will skyrocket the planned monthly adjusted variable cost (PMAVC) for the overload effects.
    - While an aggressive assumption will raise the revenue forecast, hence a bigger fixed cost. This assumption will give organizations more space to move and take in more projects with a bigger limitation for the maximum load. Technically, this would lower the risk of overload. While this looks promising, it also highlights a new risk such as a higher fixed cost.
- Fixed cost (%) variable like to simulate staffing shifts or rent renegotiation will lower the fixed cost. This variation would lower the maximum load and could be a problem if the projects are not scheduled cautiously.
- Maximum load to a higher variable will give the organization more flexibility to accept more projects and organize it freely without having to worry about the overhead cost for the overload effect. While technically a higher maximum load also links to a higher fixed cost, industry that doesn't require a big number of human resources can scale up the machinery to bump up maximum load.
- The overload effect will help with the unexpected overhead cost caused by the load limitations. To achieve a smaller figure, a change in supplier or a better partnership may be necessary. Start dates can smooth out resource overload and a better scheduling variation will help benefit the overall cash balance at the end of a portfolio period.

CONCLUSIONS

This project arises from a problem that we encountered in a real-world context. We started from highlighting the challenges that this mid-sized interior design and construction company in Indonesia was facing. Traditional scheduling tools, although they had advanced and revolutionized significantly, still have some shortcomings, especially in the financial context. Tools that the company had tried fell short in accommodating several aspects that the organization needed, like integrating cash flow consideration into project timelines. This gap underscored the need for a more practical and finance-aware solution.

For that, we introduced a finance-based scheduling tool. It is not just an algorithm, instead, it represents a foundational step towards a scheduling tool that fully incorporates finance-based scheduling principles. Ideas from the available academic research about finance-based scheduling are deeply implemented to support the shortcomings faced by the company. With the main objective of flexibility and practicality, the model was built on the Excel platform. By factoring in upfront costs, income generation, and financial feasibility, this tool empowers users to make informed decisions throughout the portfolio lifecycle. Whether managing current portfolios or planning future ones, it serves as a practical companion for organizations navigating complex scheduling and financial challenges.

RESOURCES

17 Excel Statistics to Know. (2025). https://scottmax.com/excel-statistics/

AKIM Engineering. (n.d.). *What is Primavera*. Retrieved July 9, 2025, from https://www.akimeng.com/what-is-primavera.html

Asgari, S., Chalhoub, J., Dezfouli, K. M., & Asgari, F. (2024). Joint finance-based scheduling in construction: Internal interest rate approach. *Journal of Infrastructure, Policy and Development*, *8*(5). https://doi.org/10.24294/jipd.v8i5.3822

Bourne, L. M., & Weaver, P. (2018). The origins of schedule management: the concepts used in planning, allocating, visualizing and managing time in a project. *Frontiers of Engineering Management*, *0*(0), 0. https://doi.org/10.15302/j-fem-2018012

Chaudhary, A., & Meshram, S. (2025). Comparison of Various Techniques for Project Scheduling under Resource Constraints. In *International Journal of Engineering Trends and Technology* (Vol. 73, Issue 2, pp. 57–72). Seventh Sense Research Group. https://doi.org/10.14445/22315381/IJETT-V73I2P106

Demeulemeester, E., & Herroelen, W. (1992). A Branch-and-Bound Procedure for the Multiple Resource-Constrained Project Scheduling Problem. *Management Science*, *38*(12), 1803–1818. http://www.jstor.org/stable/2632711

Dixit, V., & Tiwari, M. K. (2020). Project portfolio selection and scheduling optimization based on risk measure: a conditional value at risk approach. *Annals of Operations Research*, *285*(1), 9–33. https://doi.org/10.1007/s10479-019-03214-1

Dorrah, D. H., & McCabe, B. Y. (2023). Construction Payment Problems: A Critical Review of Payment Problems, Prompt Payment Legislation, and Challenges. In R. Gupta, M. Sun, S. Brzev, M. S. Alam, K. T. W. Ng, J. Li, A. El Damatty, & C. Lim (Eds.), *Proceedings of the Canadian Society of Civil Engineering Annual Conference 2022* (pp. 333–345). Springer International Publishing.

Earned Value Management - History. (2005). https://www.liquisearch.com/earned_value_management/history

Elazouni, A. M., & Gab-Allah, A. A. (2004). *Finance-Based Scheduling of Construction Projects Using Integer Programming*. https://doi.org/10.1061/ASCE0733-93642004130:115

Fares, A., Elazouni, A., Al-Shihabi, S., & Al-Alawi, M. (2025). Finance-based scheduling for projects in owners' portfolios: MILP versus improved GA and PSO. *Engineering, Construction and Architectural Management*, *ahead-of-print*(ahead-of-print). https://doi.org/10.1108/ECAM-07-2024-0960

Froud, E. (2025). *The Rise of Project Management Software: A History*. https://thedigitalprojectmanager.com/topics/history-of-project-management-software/

Gantt, H. L. (1919). *Work, Wages, and Profits* (2nd ed.). New York : The Engineering magazine co.

Gayakwad, H. V., & Prof. Attarde, P. (2025). Project Scheduling and Cost Estimation Using Advanced Software Tools (MS Project & Primavera P6). *International Journal of Research Publication and Reviews*, *6*(1).

Ghanbari, M., Olaikhan, A. A. J., & Skitmore, M. (2024). Enhancing project portfolio selection for construction holding firms: a multi-objective optimization framework with risk analysis. *Engineering, Construction and Architectural Management*, *ahead-of-print*(ahead-of-print). https://doi.org/10.1108/ECAM-05-2023-0532

History of the Gantt Chart. (n.d.). Retrieved July 9, 2025, from https://ganttchart.com/history_of_the_gantt_chart/

Institute, Project. (2021). *A Guide to the Project Management Body of Knowledge (PMBOK® Guide) - Seventh Edition and the Standard for Project Management (ENGLISH)*. Project Management Institute.

Johnson, R. M., & and Babu, R. I. I. (2020). Time and cost overruns in the UAE construction industry: a critical analysis. *International Journal of Construction Management*, *20*(5), 402–411. https://doi.org/10.1080/15623599.2018.1484864

Kerzner, H. D. (2017). *Project Management: A Systems Approach to Planning, Scheduling, and Controlling* (12th ed.). NJ: John Wiley & Sons.

Kononenko, I., & Kpodjedo, M. (2022). *The Basics of the Project Portfolio Management Generalized Body of Knowledge*.

Liu, M., & Liu, X. (2019). Distributionally robust resource constrained single machine scheduling. *International Conference on Industrial Engineering and Systems Management (IESM)*, 1–6. https://doi.org/10.1109/IESM45758.2019.8948219

Neumann, K., & Zhan, J. (1995). Heuristics for the minimum project-duration problem with minimal and maximal time lags under fixed resource constraints. In *Journal of Intelligent Manufacturing* (Vol. 6).

Okereke, R. A. (2020). The Effect of Delayed Payments and Retention on Contractors Cash Flow 1. In *PM World Journal: Vol. IX*. www.pmworldjournal.com

Petersen, P. B. (1991). The Evolution Of The Gantt Chart And Its Relevance Today. *Journal of Managerial Issues*, *3*(2), 131–155. http://www.jstor.org/stable/40603907

Russell, R. A. (1986). A Comparison of Heuristics for Scheduling Projects with Cash Flows and Resource Restrictions. *Management Science*, *32*(10), 1291–1300. http://www.jstor.org/stable/2631701

Shan, S., Hu, Z., Liu, Z., Shi, J., Wang, L., & Bi, Z. (2017). An adaptive genetic algorithm for demand-driven and resource-constrained project scheduling in aircraft assembly. *Information Technology and Management*, *18*(1), 41–53. https://doi.org/10.1007/s10799-015-0223-7

The Gantt chart and the Hoover Dam project. (2017). https://www.iapm.net/en/service/blog-archive/!/show/246/the-gantt-chart-and-the-hoover-dam-project/

Understanding Gantt Charts: A Classic Tool for Project Scheduling. (2024, June 27). https://ngo.management/management-functions/gantt-charts-project-scheduling-tool/

Wanlin, L., Jingwen, Z., & Wanjun, L. (2021). Heuristic Methods for Finance-Based and Resource-Constrained Project Scheduling Problem. *Journal of Construction Engineering and Management*, *147*(11), 04021141. https://doi.org/10.1061/(ASCE)CO.1943-7862.0002174

Weaver, P. (2006). *A BRIEF HISTORY OF SCHEDULING BACK TO THE FUTURE*. Mosaic Project Servies Pty Ltd. https://mosaicprojects.com.au/PDF_Papers/P182_The_origins_of_bar_charting.pdf

Weaver, P. (2014). A Brief History of Scheduling - Back to the Future. *PM World Journal*, *3*(8). http://en.wikipedia.org/wiki/Micrographia

Weaver, P. (2021). Henry L Gantt, A retrospective view of his work. *PM World Journal*. https://mosaicprojects.com.au/PMKI-ZSY-020.php#Barchart

What percentage of businesses use Microsoft Excel. (2025).

Woodworth, B. M. (1976). A time constrained approach to resource leveling in multi-project scheduling. *Project Management Quarterly*, *7*(2), 26–33. https://www.pmi.org/learning/library/2019/04/07/15/02/time-constrained-approach-resource-leveling-1737

ATTACHMENTS

Finance-Based Project Portfolio Scheduler.xlsm