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PROJECT PORTFOLIO MANAGEMENT SYSTEM

MR. RUJANAN SATAWIN

A Thesis Submitted in Partial Fulfillment of the Requirements

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By	Mr. Rujanan Satawin
Field of Study	Engineering Management
Thesis Advisor	Associate Professor Suthas Ratanakuakangwan

Accepted by the Faculty of Engineering, Chulalongkorn University in Partial Fulfillment of the Requirements for the Master's Degree

………………………………….. Dean of the Faculty of Engineering

(Associate Professor Boonsom Lerdhirunwong, Dr.Ing.)

THESIS COMMITTEE

……………………………………….. Chairman

(Professor Sirichan Thongprasert, Ph.D.)

……………………………………….. Thesis Advisor

(Associate Professor Suthas Ratanakuakangwan)

……………………………………….. Examiner

(Assistant Professor Paveena Chaovalitwongse, Ph.D.)

……………………………………….. External Examiner

(Associate Professor James Wallbank, D.Eng.)

รุจนันท์ ศาตวินท์ : ระบบการบริหารพอร์ตโฟลิโอโครงการ (PROJECT PORTFOLIO MANAGEMENT SYSTEM) อ. ที่ปรึกษาวิทยานิพนธ์หลัก: รศ.สุทัศน์ รัตนเกื้อกังวาน, 150 หน้า.

วิทยานิพนธ์ฉบับนี้ได้นำบริษัทศึกษาซึ่งรับจ้างผลิตท่อเหล็กและอุปกรณ์ข้อต่อท่อขนาดใหญ่ โดยมีธรรมชาติของธุรกิจที่บีบบังคับคือ มีความจำเป็นที่จะต้องบริหารงานโครงการจำนวนมากในเวลาเดียวกันโดยมีลักษณะสินค้าที่ผ่านขบวนการผลิตที่คล้ายคลึง แต่มีความแตกต่างคือ ระยะเวลาส่งของ จำนวน และ ขนาดของสินค้า ที่กำหนดโดยลูกค้าในแต่ละโครงการ

เนื่องจากการลงทุนที่มีมูลค่าที่สูงเมื่อเปรียบเทียบกับมูลค่าของงานในแต่ละโครงการ และจำนวนทรัพยากรที่มีจำกัด บริษัทศึกษานั้นมีความจำเป็นที่จะต้องแบ่งปันทรัพยากรในขบวนการผลิตของแต่ละโครงการให้ลงตัวกับปริมาณงานโครงการทั้งหมดที่บริษัทได้ทำการตกลงรับงานจากลูกค้า ด้วยเหตุนี้ บริษัทในลักษณะนี้มักจะประสบปัญหาในการจัดสรรทรัพยากรเพราะการจัดสรรทรัพยากรนั้นจะต้องเชื่อมโยงความสัมพันธ์ของทรัพยากรระหว่างงานโครงการต่างๆ และไม่สามารถที่จะทำการจัดสรรทรัพยากรได้อย่างมีประสิทธิภาพหากทำการจัดสรรทรัพยากรโดยแยกเป็นแต่ละโครงการและไม่ทำการจัดสรรโดยนำความต้องการในทรัพยากรของทุกโครงการมาใช้ในการวางแผน สืบเนื่องจากการวางแผนและจัดสรรทรัพยากรที่ผิดพลาด บริษัทศึกษานั้นเผชิญกับปัญหาในการส่งสินค้าที่ล่าช้าเกินกำหนดที่ได้ตกลงไว้กับลูกค้า

ด้วยเหตุดังกล่าว วิจัยฉบับนี้ได้นำหลักการของการบริหารพอร์ตโฟลิโอโครงการเพื่อใช้ในการออกแบบโครงร่างแบบแผนให้เป็นระบบการบริหารพอร์ตโฟลิโอโครงการ โดยแบ่งเป็น 3 หัวข้อหลัก คือ แผนพอร์ตโฟลิโอ การควบคุมและตรวจติดตามงานโครงการต่างๆ และ การเลือกงานโครงการเข้ามาในพอร์ตโฟลิโอ โดยมีผลตอบแทนหลักเมื่อนำวิจัยนี้มาใช้ในเชิงปฏิบัติคือการเพิ่มประสิทธิภาพในการวางแผนและจัดสรรทรัพยากรซึ่งจะนำมาซึ่งการส่งสินค้าให้ตรงตามเวลาที่ลูกค้ากำหนด

ศูนย์ระดับภูมิภาคทางวิศวกรรมระบบผลิต ลายมือชื่อนิสิต...

สาขาวิชา การจัดการทางวิศวกรรม . ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก……...

ปีการศึกษา 2554 .

5171613921 : MAJOR ENGNEERING MANAGEMENT

KEYWORDS : PROJECT PORTFOLIO MANAGEMENT / MULTI-PROJECT MANAGEMENT / RESOURCE ALLOCATION

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The scope of this research is to develop a management framework through the adapted techniques of Project Portfolio Management. Specifically, the developed framework is designed for the resource allocation of the current projects and the resource planning for the future projects from a strategic viewpoint. As governed by the multi-projects nature of the business, Project Portfolio Management (PPM) is used in this research as a theoretical background in which the PPM techniques are applied and investigated in the context of the case study company. And finally, the suggestive system is to seek for a long-term solution over ad-hoc problem solving for the delay problem.

Moreover, the research introduces the rationale used to design the suggestive PPM framework. In this manner, the proposed framework is discussed in details of its application and logic in relation to the solution to the resource interdependency problem between projects. Mainly, the explanations of the PPM Framework are divided into three parts; Portfolio Plan (PP), Projects Monitor and Control, and Project Selection.

The main benefit following this research is for the case study company to be able to apply the developed framework in order to align the production's output to meet the delivery deadlines of the projects.

Regional Center for Manufacturing

System Engineering .... Student's Signature ....

Field of Study: Engineering Management ... Advisor's Signature ....

Academic Year: 2011 ....

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First of all, I would like to thank my family and loved ones for all their supports. I would not be who I am today if not because all of you. I would like to express my gratitude and respect to all my teachers and professors who had helped me to learn not to cease learning. I was very fortunate to have crossed paths with some of the greatest teachers that not only taught from textbooks but rather created beliefs of logic and imagination combined. Finally, I hope that this thesis finds its way to brilliant minds and to those who are connecting dots to develop their own methodology of PPM. With only a few words to say, I intend to do my best to pay it forward and hope that a series of insignificant acts can mount a significant difference.

Contents

Page

Page

List of Tables

Page

List of Figures

Page

CHAPTER I

INTRODUCTION

Time, cost, and scope are the three repetitive words that ring through the ears of every project managers. Managing a successful project exceeds the knowledge written in the textbooks and requires experiences, leadership, and even non-systematic approaches. Furthermore, the difficulty lies in the fact that each project is unique and is presented with a different set of problems changing from one project to another. Hence, a successful project manager from one project does not guarantee a success if he or she was to manage a different project with a different set of limitations, clients, and project environment. Let alone managing one project, many companies are undergoing multiple projects each year where these projects are operating in parallel and everybody involved are racing towards the completion of their assigned projects. In this way, it is important for the owner of the business to look after the best interest of the entire organization and not just one project alone. Unlike a single project management, the top management's responsibility is to manage a portfolio, consisting of multiple projects. For this purpose, this research is to develop a management system to enable the strategic planning in order to reduce the delay problem for the projects in the company's portfolio. As the focus of the research, Project Portfolio Management (PPM) framework will be developed in the business environment of the case study company. Unlike some of the management subjects, PPM is not a generic process and must be tailored to fit the context of the organization (Levine, 2006). Hence, the methodology applied, as well as the findings in this research, is reaching towards the improvements in the on-time delivery aspect of the projects in the company's portfolio.

1.1 Background of the research

At the case study company, BTEL, there are 3 main business units. The first business unit is the construction of Floating Production, Storage, and Offloading (FPSO) modules. Due to its specialty and heavy investment needed, there are only limited buyers such as Shell, Exxon, and Maersk, which are the global energy exploration and marine service companies. This type of project usually lasts over two years and the working team is a stand-alone unit and only focuses on the interest of one project. Similar to the FPSO team, the second type of BTEL's business unit is the site construction for infrastructures, industrial plants, and piping installations. Again, these types of projects usually last for more than a year and each project team is working entirely as a separate business subunit. Finally, the third business of the company is to manufacture large-diameter steel pipes and fittings (sizes range from 450mm up to 3500mm diameter) for selling to industries such as power plants, mining, infrastructure systems and oil and gas.

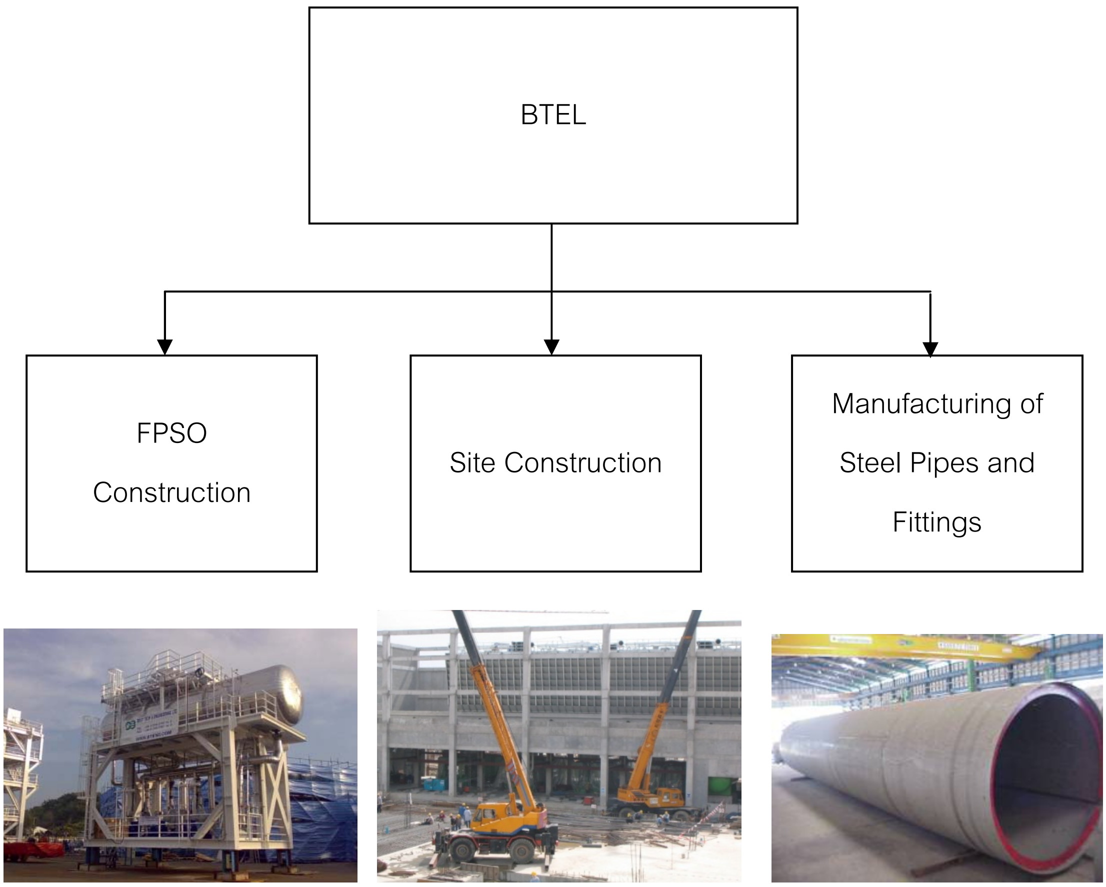

Figure 1.1 BTEL's business units

Unlike the construction business units, the manufacturing plant operates about 15 to 25 small-medium sized projects per year and oftentimes, in a parallel timeframe of one another. Some examples of the past projects include:

- Glow Phase 5 Combined Cycle / Cogen Project (Circulating Water Pipes)
- Staythrope Power Plant Project, UK (MCW pipes; Balance of Plant Pipes)
- Changi Water Reclamanation Plant (Liquid and Air Process Pipes)
- Ratchaburi Combined Cycle Power Plant (Main Cooling Water Pipes)
- Aghada Combined Cycle Power Plant, Ireland (Make-up Water Pipes)

Mainly, the customers for this business unit are the global EPC (engineering, procurement, and construction) contractors such as Alstom, EGAT, Mitsubishi Heavy Industries, and Siemens. Moreover, each project can last from a few weeks to several months depending on the contractual agreement set forth by the clients. The demands and the sizes of the products have a high variability and hence, it is uncertain to make a prediction and manufacture the pipes in advance. In another word, the products are make-to-order and delivered as per project basis. More so, there are even changes during the course of the project, such as the quantity of the products, and the company is required to engage in a highly flexible schedule in order to meet the demand of the customers. In this way, the company is challenged with a fluctuating demand whilst there are limited resources available.

With such characteristics, BTEL is categorized as a project company. Consequently, the company employs a *matrix* organization setup to endorse the project nature of the business (Kezner, 2006).

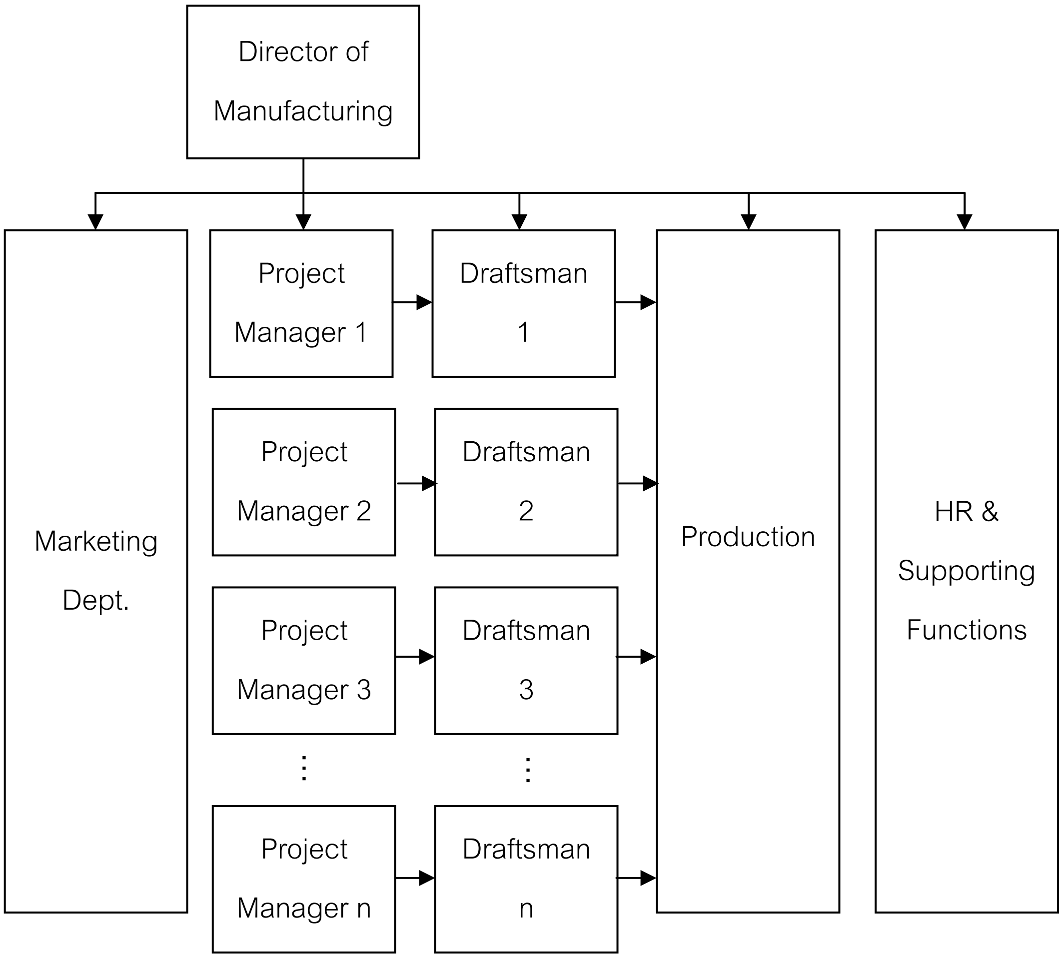

Figure 1.2 Pipes manufacturing organization chart

Despite the volatile demands, the bidding process for a project often takes a few weeks in advance prior to the order being placed by the customer. In this manner, the Marketing Department is the first to know about the potential incoming projects and the likely chance of being awarded. During the bidding weeks, the Marketing team will make several contacts with the customer to discuss the financial terms as well as the contractual conditions (e.g. delivery date, technical requirements, scope, and etc.). At this point, the Director of Manufacturing will make any necessary recommendations and coordinate with his subordinates if require by the Marketing Department. Once an order is placed, the project will be assigned an internal job reference as well as a project manager in charge. At this point, the project's information is distributed to the Production Department and all the people involved. Moreover, the project manager is to prepare a detailed technical specification and make contact to the customer as necessary. Consequently, the project manager is then to issue a work request to the Production Manager. The information in the work request includes the bill of quantities and the project deadline. As follows, the Production Manager will add the new project to the current production queue and report to the assigned project manager of his or her project progress on a weekly basis.

From the above overview, there are constant complaints from the Marketing Department and the project managers regarding the slow production progress.

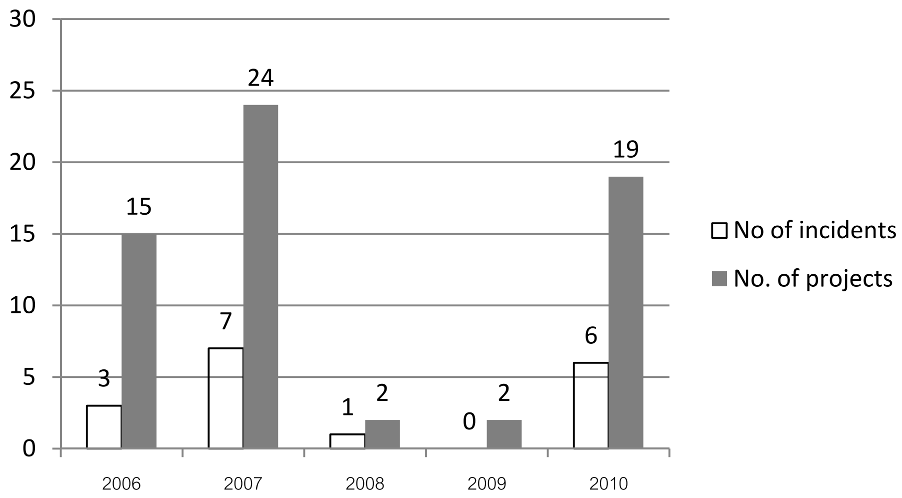

Figure 1.3 Delay record from year 2006 - 2010

In Figure 1.3 above, the two parameters shown are the number of incidents that a delay occurred per year and the number of projects each year. Convincingly, the number of incidents coincides with the number of projects executed each year. In another word, the number of incidents tends to increase as the number of projects increases, and vice-versa. Approximately, for every 10 projects executed, 2 to 3 projects are expected to be late. In the year 2008, however, there were 2 projects executed and one of the projects was late and therefore, this evidence shows that in the year 2008, the most delay per executed projects occurred considering there were only 2 projects and one was late. On the other hand, the company achieved a 100% on-time delivery in the year 2009. However, the above information is not entirely enough for a solid justification that year 2008 was the worst year in terms of the delivery record. Hence, the second piece of useful information is the delay record, collected by the company, which is measured in normalized days. A normalized day is calculated by taking the number of days delayed for a project divided by the total contractual duration of that project, and at the end of each year, the total normalized days per year are calculated.

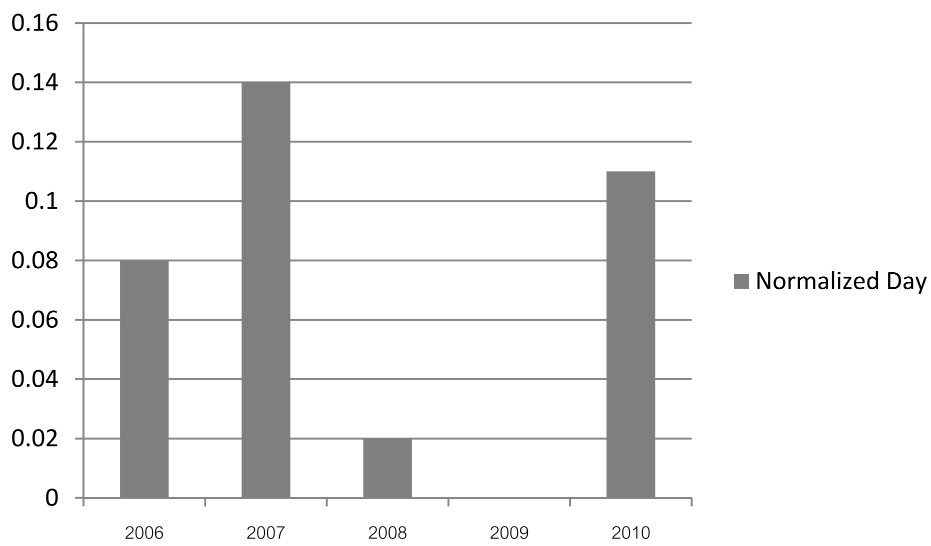

Figure 1.4 Delay Data

From the above figure, it shows that despite the highest ratio of incident in the year 2008, the normalized day is about 0.02 meaning that number of days late was only 2% of the total contractual duration of all the projects of that year. On the other hand, there were 8%, 14%, and 11% delays for year 2006, 2007, and 2010, respectively. Moreover, the total revenues of the few projects in the years 2008 and 2009 were more than the total revenues of the projects in all the other years combined. Despite the apparent delay problem, “There just isn’t enough time” seems to be a familiar response to the ongoing problem by the Production Department. Thus far, the solution is to produce as much as possible each day. As an everyday circumstance, the company runs about 1.5 shifts per day using the same group of workers and machines. Still, this problem is on-going and challenges the Production Manager to seek for further solutions.

In terms of quality, the products' attributes are required to meet the specifications given by the buyer. Moreover, these specifications are mostly common specifications, such as, American Society of Mechanical Engineers (ASME), American Society of Testing and Materials (ASTM), and American Water Works Association (AWWA). Failure to meet the given specifications will result in a corrective action and the products cannot be released until the specifications are satisfied. Nonetheless, quality issues are not BTEL's weaker areas. In fact, they are known for their high quality products and zero failure to comply rating.

1.2 Objectives

The objective of this research is to develop a management framework that enables a systematic approach for resource allocation in the production line. Specifically, the developed framework is designed to produce possible resource allocation choices for the company's executives from a strategic point of view. As governed by the multi-projects nature of the business, Project Portfolio Management (PPM) is used in this research as a theoretical background in which the PPM techniques are applied and investigated in the context of the case study company. And finally, the suggestive system is to seek for a long-term solution over ad-hoc problem solving for the delay problem.

1.3 Research Scope

The scope of this research is in the extent of developing a management framework through the adapted techniques of Portfolio Project Management (hereafter known as PPM) for the pipes manufacturing business unit at BTEL. Mainly, the PPM framework is useful for the resource allocation of the current projects and the resource planning for the future projects. Subjected to the business objectives, the goal of the

PPM can be to improve the net profitability, to reduce risks, to secure the future opportunities, and even for survivability in some cases (Wideman, 2004). Due to a finite number of resources, all the projects are often entitled to share the central resources provided by the organization, especially for a company like BTEL where there are many small projects going through the operation each year (Gruia, 2003). Hence, it is important to be able to set priorities or otherwise, the portfolio risks perplexity in resource allocation, and worse, a rippling obstruction which can result in a poor performance of all the projects in the portfolio.

Despite the classic emphasis on the financial aspects, the scope of this research is to design a management framework through PPM so that by applying the developed framework, the delay problem can be reduced. Ultimately, the goal is to have a 100% on-time delivery. As some might argue, managing projects require more experience than knowledge, and hence, the developed framework is tested under the real circumstances of the business environment through a parallel timeframe simulation. Therefore, the developed PPM framework does require a use of software technology in which, a simple program, like Microsoft Excel, is suitable. For future improvements, more complex software can surely be employed but for the scope of this study, the emphasis is placed on understanding the problem, the logic of the proposed solution, and the linkage of the two through the PPM framework.

At the case study company, BTEL is not only encountering with the delay problems; perhaps, as a side effect, there are also conflicts between several departments involved in the projects. Firstly, the screening process for selecting projects is carried out by the Marketing Department. Further, the Marketing team's main concern is that the price and the contractual conditions are fixed by the market (i.e. clients, competitors, and etc.) which cannot be altered. In another word, failure to promise these requirements will result in not getting the job. Therefore, it is the "get the job first, solve the problem later" concept that puts the Production team on the back foot. At the same time, the Production Department has a difficult time putting all the projects together to see the big picture, and therefore, reluctant to pinpoint what is wrong and how to fix it. On the other hand, the Manufacturing Director is trying to solve everybody's daily problems when he should be the person that brings together the key departments of the company. And so, it is very difficult to step back and reevaluate the problem while all this is happening. To make the matter worse, there are always unexpected cases happening, or the known unknowns as Donald Rumsfeld would have put it, which make all the plans unusable. The list of problems can go on and on, but looking on the bright side, this happening is not unusual for a multi-projects company like BTEL (Billows, 2010). Regardless, the framework offered in this research does not make all the problems go away or merely change the management's ability to push all the products through the production line and be able to deliver to the customers as planned. However, by following the logic used in the research and the implementation of the proposed PPM framework, the company will become a better projects management company and even gain an edge on their competitors who are running around putting out the fire from 8 to 5 and still not seeing any ash. While the ultimate goal for the proposed framework is to enable strategic resource planning in order to meet the promised deadlines, the basic rules of business still apply: increase profitability and satisfy the customers. By meeting these deadlines, it is obliged that the two purposes of the business's existence are kept intact.

1.4 Limitations and Assumptions

In order to provide a conclusive outcome of the research, there are several limitations and assumptions which must be taken into account. In simplification, most of the minor parameters are not included and taken into effects in analyzing the problem and determining the outcome. Moreover, the scope of this research is ranked on a strategic level and written for executives and that operational level adjustments must be made afterward for a maximized output. Additionally, the framework provided in this research must be subjected to periodic reviews and adjustments to fulfill the changing nature of a project company. In this way, the limitations and assumptions are categorized into three main groups;

Limitations and Assumptions in the Research Methodology

1. The case study organization, BTEL, is established in 1987 by a Thai family owner with three different business units. The only business unit within the scope of this research is the manufacturing plant for steel pipes business.

2. The data used for the company's production capacity is provided by the Production Department which had been recording the capacity over the years of operation. Hence, this research does not intend to collect further data to come up with its own production capacity. Nonetheless, the data is verified using an average comparison. Statistical methods are not applied in the verification.

3. The production capacity of the rolling machines is obtained from the given data by the machine's manufacturer. Any variation to the manufacturer's data is assumed as acceptable unless such variations have major impacts to the production schedule.

4. Although the company has other functions which involve in the projects, the two departments of the concern is the production and marketing departments. Any process(s) which can be easily outsourced are not included in the research.

5. The logistics issues are not included and the time for the movement of goods is assumed to be included in the time used for each process. Similarly, two main processes, packing and painting, are beyond the scope due to the fact that these two processes can easily be outsourced and the capacity can be increased within a 24-hour period.

6. In the calculation, the product's thickness is assumed to have no effect on the time requirement of each process. In reality, the thickness has a slight effect to the time variation in the process.

7. The effects of the suppliers are assumed that all activities do not have a major effect to the production time and therefore, they are not mentioned in the discussion unless a major event has taken placed which can affect the production schedule of 1 week or more, and then such matter is to be included in the research. All raw materials and consumables are off-the-shelf and readily available.

8. The market data, such as the bid which the company has already entered prior to the research and the future prediction of projects, is accepted as unpredictable and investment suggestions will not be made in regards to such projects. However, firmed projects will be taken into account in the discussion.

9. The research does not take into account the financial aspects of the case study company. Nonetheless, all the suggestions provided must be within acceptable cost in order to act on improvements.

10. In spite of the variable nature of each project, minor issues which do not have any major effects on the overall project's schedule will not be discussed.

11. Human Resource issues such as incentive systems, recruitment, and labor union are excluded from the research. The resources used in the strategic planning are assumed to be finite except for overtime which is limited by the number of shifts per day.

12. All the customers' and internal restricted information are considered as confidential and will not be revealed. Only referenced names and labels are used.

Limitations and Assumptions in the PPM Framework

1. The main objective which leads to the logic used for prioritization is to provide an on-time delivery for all projects. The research does not take into account the financial aspects of the case study company and hence, cost minimization is not considered for the optimum value and projects' sequence.

2. Although optimization is ideal, all mathematical concepts are simplified for the use of this research. Similarly, all technology implementations are basic functions using Microsoft Excel.

3. Unexpected events, such as Force Majeure, holidays, worker's leave, are not separated in detail. The lagged time of a project is provided using an umbrella method by deducting the number of weeks to the actual deadline for the delivery.

4. The production planning is from a strategic view in which minor aspects of the production activities are omitted.

5. The *produced goods* shown in the progress of the production plan are non-integer numbers, where in reality, the progress may only be applicable as to the process is either fully finished or not to be started unless it can be finished per one time basis. Hence, for actual implementation, the planning is needed to be refined by an experienced production manager.

Limitations and Assumptions in PPM Framework Evaluation

1. Risk assessment for project acceptance is not included in the scope of the research. Such arrays are expected to be evaluated by the Marketing team and the Risk Assessment team prior to the consideration of a project as acceptable. Only *go / no go* decision is given.

2. The developed *Portfolio Plan* only provides significance resource allocation tactics. Not all the possibilities are shown and discussed. Nonetheless, the evaluation method reveals satisfactory in-depth analysis and decision support for the option chosen.

3. Other requirements which can force the company into accepting the project are not taken into account. Examples include the “must-do”, top management influences, and etc.

1.5 Definitions

The following terms are defined by which these terms are used throughout the research as the followings;

1. PPM stands for Project Portfolio Management which is a subject area which is used for managing a multi-project business environment.

2. PP stands for Portfolio Plan which is a structural plan required to be achieved as a part of the PPM framework. The information in the Portfolio Plan includes projects’ information, demand forecast, resource allocation, and projects’ progress.

3. Pipe, and its plural, stands for a circular and hollow section made by steel plate rolling and welding process. The diameter of a pipe can ranged from 450mm to 3500mm with the maximum length up to 3 meter / piece. Any size smaller or larger is beyond the capability of the company.

4. PS360 is a model of a rolling machine which is capable of rolling pipe sizes 450mm to 3000mm. The term is used interchangeably referring to one or more machines of the same model and capabilities.

5. PS600 is a model of a rolling machine which is capable of rolling pipe sizes 1000mm to 3500mm. The term is used interchangeably referring to one or more machines of the same model and capabilities.

1.6 Expected Benefits

The main benefit following this research is for the case study company to be able to apply the developed framework in order to align the production's output to meet the delivery deadlines of the projects. Consequently, the PPM framework has the intention to bring about the people involved to make a joint decision and reduce the conflicts between different departments in the organization. Moreover, the techniques used for the development of this research can be applied to improve the effectiveness and overall productivity of the business unit. Furthermore, this research can help managers and directors to operate a proactive workforce and resource capacity planning. For the future, the proposed framework can be used as a decision support tool for decision making in forthcoming investments.

1.7 Research Presentation Methodology

In a logical format, this research is divided into six chapters.

- Chapter I in this research provides an introduction to the research as well as the main objectives, scope, limitations and assumptions, and the expected benefits.

- Chapter II is the summary of the literature survey conducted in order to carry out this research. As the backbone, PPM is defined and explained using the insights from textbooks, seminar papers, and researches related to the field. Afterward, different resource allocation methods and techniques are elaborated with the main focus on the strategic planning. Lastly, the link between the structure of an organization and its ability to execute project management is examined.

- Chapter III is designed to illustrate the problem that the case study company is facing. In order to depict the cause of the delaying problem, a 3 week observation at BTEL is conducted. Essentially, this chapter includes an analytical discussion on the current production strategy and the resource interdependency problem formation.

- Chapter IV introduces a suggestive management framework through the subject of Project Portfolio Management. Additionally, the proposed framework is discussed in details of its application and logic in relation to the solution to the problem described in the previous chapter. Mainly, the explanations of the PPM Framework are divided into three parts; Portfolio Plan (PP), Projects Monitoring and Control, and Project Selection.

- Chapter V is for the purpose of evaluating the proposed framework. Specifically, the PPM framework is tested by a walkthrough process, in a form of Microsoft Excel simulation, against the real situations happening at the organization. Moreover, the evaluation methodology is designed to test the effectiveness of the framework as well as to identify flaws and possible improvements.

- Chapter VI includes the conclusion of the research as well as further recommendations for future employment of the PPM framework.

CHAPTER II

LITERATURE REVIEW

In this chapter, the backgrounds, theories, and publications related to the topic of the research are presented. Mainly, there are 3 relevant subjects which are interrelated but contain their own distinctions worth discussing. The first topic which is directly related to the research scope is the subject of Project Portfolio Management (PPM). Secondly, as an integral part of the first topic, resource allocation and production planning are reviewed. And lastly, the relationship between organizational structure and project management is analyzed. Thus, the aim is to introduce the theoretical backgrounds of these subjects in order to be able to apply to the case study company by ways of adaptation and application of the real world situations. Therefore, the analytic interpretation of these publications is far more important than the ability to gather the information.

2.1 Project Portfolio Management

What is Project Portfolio Management? Is it a project management of more than one project? To answer the first question, Project Management Institute (as cited in The Enterprise Portfolio Management Council [EPMC], 2009, p.15) defines it as:

> The Centralized management of one or more portfolios, which includes identifying, prioritizing, authorizing, managing, and controlling projects, programs, and other related work to achieve specific strategic business objectives.

From another view, PPM is defined by Levine (2005, p.228) as “a set of business practices that brings the world of projects into tight integration with other business operations”. Certainly, PPM involves managing projects within the organization; however, it is not true to define PPM as a management of several individual projects as argued by Dye and Pennypacker (1999). For the people involved, managing a project is authorized to the project manager to carry out the necessary tasks and make the project's decisions to ensure that the assigned project is executed within the scope, budget, and time. On the other hand, PPM's authority is further up in the hierarchy where senior managers, CFO, and company's executives are involved. Therefore, it is rightly to claim that PPM lies in the strategic level of the organization and not at the operational level. However, its application and outcomes are beneficial to the whole organization from the shareholders to the shop floor employees.

2.1.1 Project Portfolio Management: Optimized Return of Investment

The classic goal of PPM is undoubtedly to maximize the return of investment. The concept of PPM is used by bankers, risk managers, CEOs, and investors. Sanwal (2007) has shown that the translation of data collection to decision factors to portfolio management gives the benefits to optimize the return of the organization's investments through logical and practical decision process. In conjunction, Gruia (2003) applies the Efficient Frontier in order to obtain the optimization in the portfolio and as the result, maximize the return under the condition of a finite resource. Here, Gruia (2003) suggests the leading role of technology as the must-have tool for a successful PPM. Adding to this claim, it is the understanding of the portfolio, its mathematical implication, and the ability to implement the software that construe a successful PPM. Moreover, PPM can be applied in investment decisions, for example, a selection of stocks to invest in. Given stocks A, B, C …n, investors often measure the two parameters: expected return and risks. However, having only one stock in the portfolio can introduce the highest risk if such stock does not perform as expected; and therefore, the concept is to create an investment portfolio which is balanced between risks and expected profits among the different stocks.

Similarly, PPM is widely used in the project selection process in order to filter the projects for the inclusion into the company's portfolio. As integrated between project screening, risk assessment, and profitability prediction, Gray and Larson (2011) outline the screening process into a framework as shown in Figure 2.1 in which the project selection process is a vital part of the PPM. As an incoming proposal enters the framework, Gray et al. (2011) propose several check points for evaluation between the strategic alignment of the incoming projects and the organization's strategy. Later, risk assessment is evaluated against the proposal. As mentioned throughout, risk assessment is the key process when selecting a project. However, risk assessment is limited in this research as it is a separate subject which requires an extensive discussion for the maximum benefit. And lastly, the emphasis is put on the fact that the resources must be reserved for the availability of the accepted project.

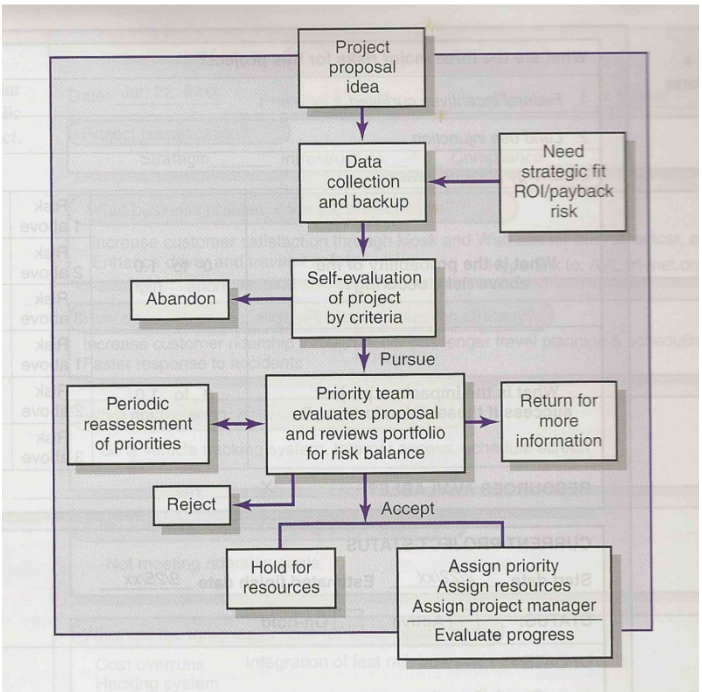

Figure 2.1 Project Screening Process (Gray et al., 2011, p.46)

Oftentimes, many companies fail to restrain the booked resources from being used especially when the accepted project has yet to start. Against some intuitions, it is a downfall for the top management to disapprove the fact that paid resources are not being used; and therefore, put themselves in a position that 'holding' resources are not allowed and everybody in the company is always expected to do something. This occurrence is also known as the Parkinson's syndrome in an organization; everybody, therefore, seems to always be busy and there is no clear determination of the resource availability (Latham & Locke, 1975). Arguably, this accusation is not always true for a company that does not experience a project nature type of business, such as, a mass assembly company. And so, for the resource planning to be successful, the resource being allocated to another time slot must be truly available; or otherwise, the manager must choose between projects given a finite number of resources from a common resource pool. In another word, each project needs to be prioritized if the resources are to be shared between two or more projects once the company has reached its full capacity for the shared resource. In alignment with the project selection process, the method of prioritization must reach towards achieving the company's objectives.

2.1.2 Project Portfolio Management: Strategic View

Now that PPM is defined, it is also important to know the people involved. In a way, PPM is a decision making authority for strategic decisions across the entire organization. The CEO is to acquire information such as the return on the project undertaking, the risks, and penalties if the projects are executed poorly (Wideman, 2004). Meanwhile, the corporate managers must look into the resource planning and capacity usages as well as prioritizing the projects in the company's portfolio (Wideman, 2004). Hence, PPM is a strategic management; and therefore, the people involved must be the influential leaders, managers, and authoritative figures at the company.

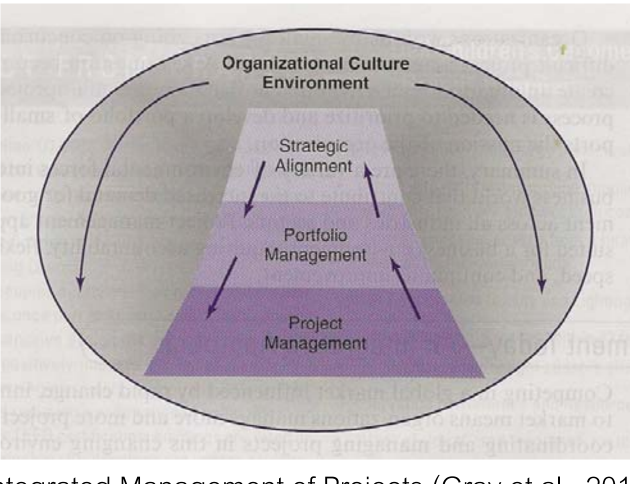

Figure 2.2 Integrated Management of Projects (Gray et al., 2011, p.14)

With this in mind, PPM is not about managing the details of the company. It is the big picture factor that is far more important. Hence, the PPM should be placed above project management and even several functions across an organization.

2.1.3 Project Portfolio Management: Art or Science

Thus far, PPM is certainly highly linked with hard numbers and profitable returns. As an opposing view, Moore (2010) puts the utmost emphasis on the soft skills in making PPM successful. In align with such technique, most texts offer a discussion framework and methodology instead of a downright scientific approach. Additionally, Moore (2010) believes that best practices and people's capabilities are the drivers for an organization to have a successful PPM. Similarly, Turner (2009) provides the change techniques to transform a company to a project-based management. Here, he characterizes the context of different projects, and in conjunction, supports the managing techniques to resolve the project-based nature of the business. Tracing back to the 'old' bureaucratic structure, Turner (2009) clarifies the importance and the need of the structural changes for improving a company's capabilities for project management. In line with the renowned works of Kotter (1996)'s 8-step Change Model, Moore (2010) offers the 'Ten Things to Do' for a successful strategic PPM process which includes defining business goals, prioritizing, using efficient decision making, and establishing communication frameworks.

2.2 Resource Allocation

As earlier defined, PPM is a strategic management. In reflection, the method of resource allocation for the top management is not entirely the same as the resource allocation useful by the operation level. In this manner, Leus, Wullink, Hans, and Herroelen (2003) rightly define the hierarchical structure using three levels of a business: strategic, tactical, and operational. It is worth noticing that throughout the research only 2 levels of organization are mainly mentioned: strategic level and operational level. As for the tactical level, it is considered to be included in the area of a strategic level rather than as the part of an operational level. The reason of this categorization is to align with the current case study company's organization setup where there are 2 apparent levels.

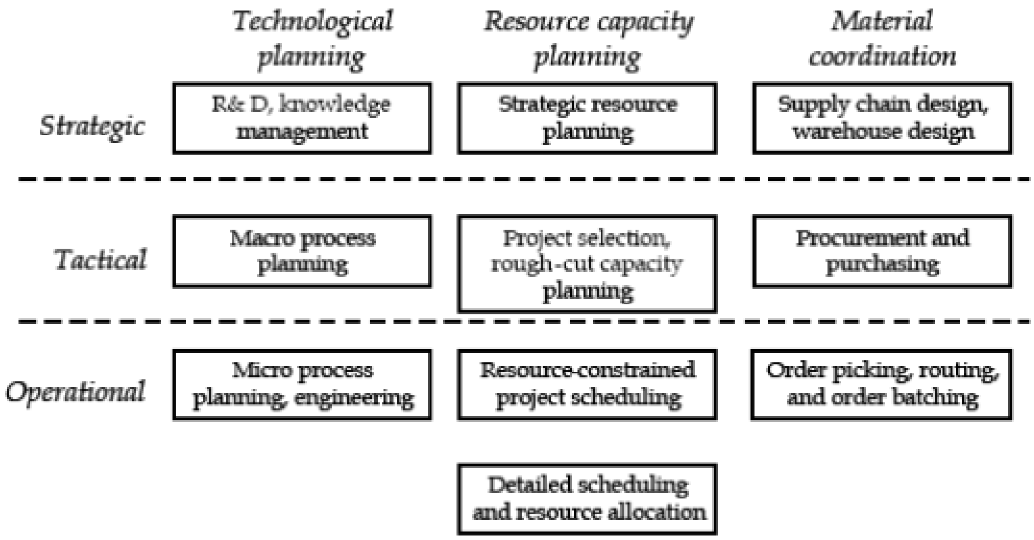

Figure 2.3 Hierarchical Framework (Leus et al., 2003, p.19)

The extent of resource planning at the strategic level proposed by Leus et al. (2003) is not necessary to be able to identify the resources for each process or for each of the operation, but rather, to view the resource planning as a group, for example, the number of total man hours for each project. Nevertheless, for the quantitative analysis of this research, the resource capacity planning applied is as proposed by Leus et al. (2003) at the tactical level which is the Rough-Cut Capacity Planning (RCCP). As the name suggested, RCCP is an overview of resources allocation only at a certain point, process, or milestone, which has a high significance to the overall cost, scope, and time relationships. Moreover, without all the details, RCCP has a high degree of flexibility which enables a competitive advantage in resource planning and overtime assignments (Leus et al., 2003). In reflection, not all processes in the company are included in the discussion of this research. The detailed schedule and planning must be under the scope of the operational level and the direct person-in-charge such as the production manager, who is responsible to carry out such tasks.

For the different classifications, a multi-project company can compose of many small projects, a few large projects, or a combination of both, in the company's portfolio. For categorization, the case study company is considered as a company with a portfolio consisting of many small projects. From time to time, this nature can change but during the scope of the research, this statement holds true. An unforeseen dilemma of such portfolio is that the impact on ineffective management of a small project is overlooked by many experienced senior managers until all the small problems add up to a large sum of deficits which is when all the managers jump in to attack the problems (Gray et al., 2011).Similarly, Levine (2005) identifies the continuous problem in a multi-project organization as that once a project starts to slip, other projects tend to follow the downward path. Hence, the case study company is not experiencing anything out of the ordinary for a multi-project company.

2.3 Organizational Structure and Project Management

As a part of the PPM, the ability to carry out successful project management as an individual project contributes to the overall success of the portfolio. Prior to going through and adding more to a company who is already in the hot water for delay, it is important to recognize the different compositions of the company that have influences on the company's processes. With different project requirements and characteristics, it is difficult to attempt to obtain a perfect set of processes. Nonetheless, it is required for a company to have the adequate company's processes for project management, which allow for:

- Project goal specificity (cost, scope, and time) (Wysocki, 2004)
- Flexibility to resolve changes and problems (Burke, 1999)
- Involvement of value added personals (Burke, 1999)

- Process maturity equals to practice maturity (Wysocki, 2004)
- Risks management (Barkley, 2004)

In addition to the above characteristics for the project management processes, there are influences and factors which contribute to the way the processes turn out. These contributions include processes, infrastructure, culture, capabilities, and strategy. Hence, it is vitally important to look at the organizational structure of the case study company. Moreover, the establishment of the PPM framework is required to have an effect on amending the current structure through the forming of the PPM Committee. Currently, the case study company employs a *matrix* organization structure. This organizational structure allows for a fast response and tailors to fit a specific project while maintaining an efficient use of the resources and technical knowledge (Kezner, 2006). Due to its make-to-order nature of the business, the batch size is small and there are high instability in terms of order sizes and the customer base. Therefore, the *functional* organizational structure is not the best fit due to its resistant to changes and the inability to optimize the delivery time in short term projects. Conclusively, the *matrix* organizational structure allows for a high flexibility and therefore, this setup fits the constantly changing nature of the business.

CHAPTER III

PROBLEM DESCRIPTION

Given the background of the case study company, the problem, evidently, is that the company cannot meet the delivery date as promised to the customers. In this manner, the immediate questions are raised;

- Is the current production strategy aligned to meet the project nature of the business?
- Is the production manager allocating the resources effectively?
- Are the resources providing the expected output?
- Is the capacity enough to meet the demand?

During a 3 weeks observation period, the above questions are investigated through a data collection and findings from the production department. At the end of this chapter, these findings throughout the observation are expected to provide a guideline for the analogy of further adjustments needed in order to meet the on-time objective.

3.1 Company's Products, Processes, and Projects

There are two main types of products at BTEL. The first one is the steel pipe and the second set of products, which are the bi-products of the first, are the steel fittings, such as miters, tees, and reducers. Figure 3.1 below illustrates the relationship between the products and processes required through a product-process matrix.

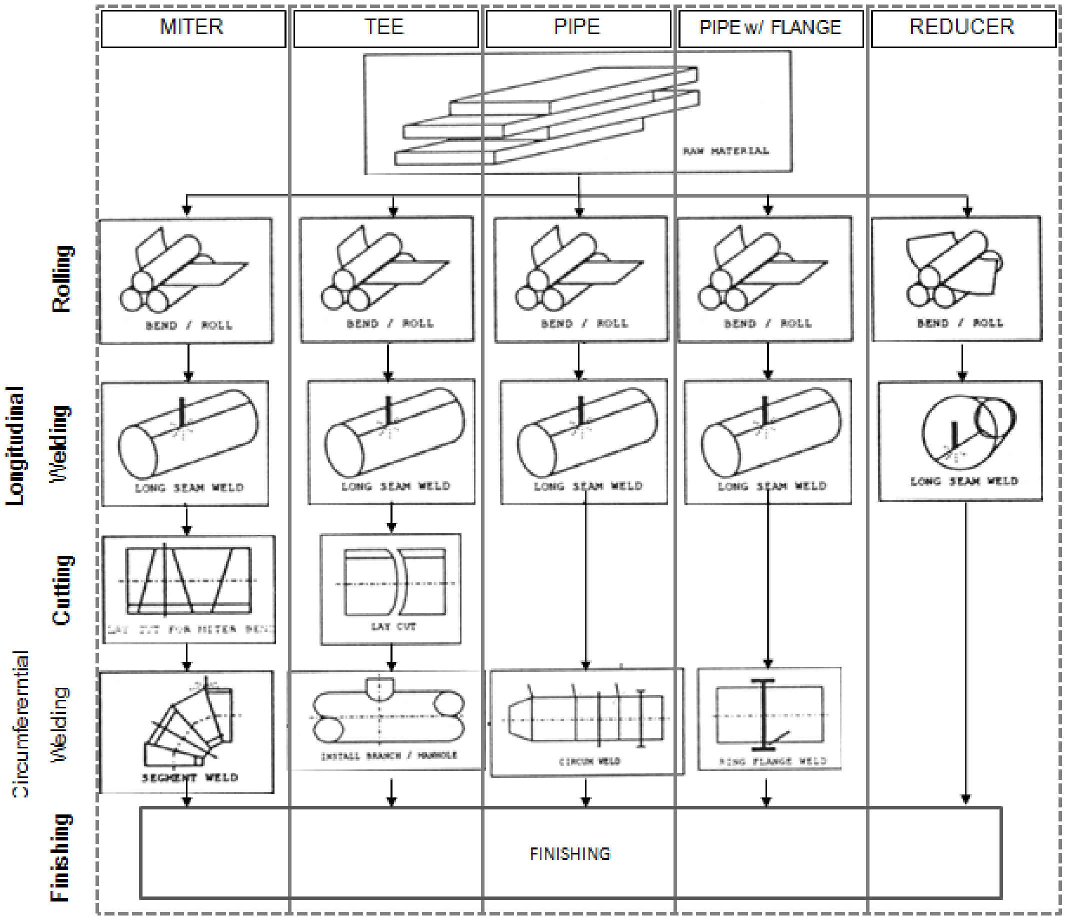

Figure 3.1 Product-Process Matrix

3.1.1 Company's Products

As a simplest form of product, a pipe is made by rolling a steel plate into a circular form (similar to a can), followed by a welding process along the length of the pipe (also refer to as *longitudinal welding*). Due to the raw materials' size limitation, the standard length of a pipe is 3 meter. However, circumferential welding, a welding process along the circumference at the opening or at the end of a pipe, allows for the extension of the pipe's total length. For example, if a 12-meter pipe is required, it requires four pieces of 3-meter pipe to be welded together.

Figure 3.2 Rolling Process

Using these pipes, they can also be turned into a second category of products which are known as *fittings*. The four main fitting types are miters, tees, reducers, and flanges. A miter, perhaps the most difficult to visualize, is an elbow connection which is used for turning the flow's direction to a specified degree in a pipeline. Further, a miter is made by cutting a straight pipe into the required sections. Using the cut sections, they can be re-assembled into an elbow shape and by circumferential welding of these sections with one another, a miter is made (see Figure 3.1 for schematic). As another type of fitting, a tee is simply, as its name represents, a T-shape fitting made by welding a pipe, also refer to as a *branch,* diagonally onto another pipe, which is also known as the *main*. Thirdly, a reducer is made the same way as a pipe, except that the rolling shape is in a shape of a cone instead of a shape of a can. Similar to a pipe, the rolled plate is longitudinal welded to join the loose ends. In all the above fittings mentioned thus far, the length can be extended by circumferential welding. Lastly, a type of fitting known as a flange, which is bought as a finished product from a supplier, can be welded circumferentially onto all other products at either ends. The purpose of a flange is used for connecting different pieces of pipes and fittings, through bolting joint, to form a pipeline. Figure 3.3 shows a finished product of each type.

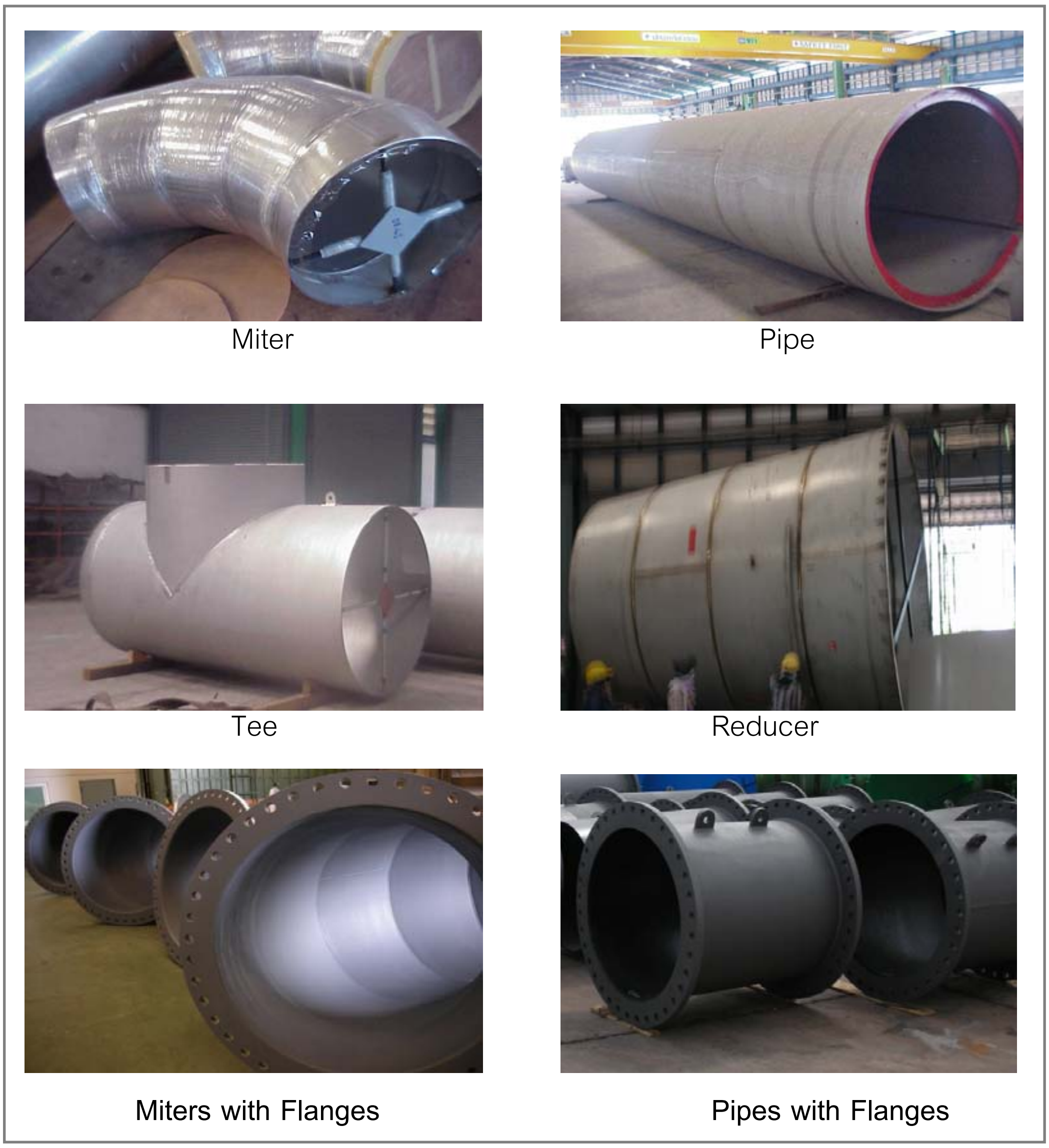

Figure 3.3 Sample Products

3.1.2 Company's Processes

Depending on the type of product, there are five main processes; rolling, longitudinal welding, cutting, circumferential welding, and finishing. For rolling, the essential factor is the capacity of the rolling machine. Currently, BTEL owns two pairs of identical machines or the total of four rolling machines. The first two machines are the model PS600 which have the capacity to roll pipe diameter sizes 1000mm up to 3500mm. The second pair of machines is the model PS360 which have the capacity to roll pipe diameter sizes 450mm up to 3000mm. Despite the wider range of sizes in the PS360 in comparison to the PS600, the PS360 are much slower than the PS600 when rolling the same diameter size. Appendix A gives the capacity of the two models; PS600 and PS360. By plotting the output (m/day) as a function of the diameter, the plot shown in Figure 3.4 can be obtained.

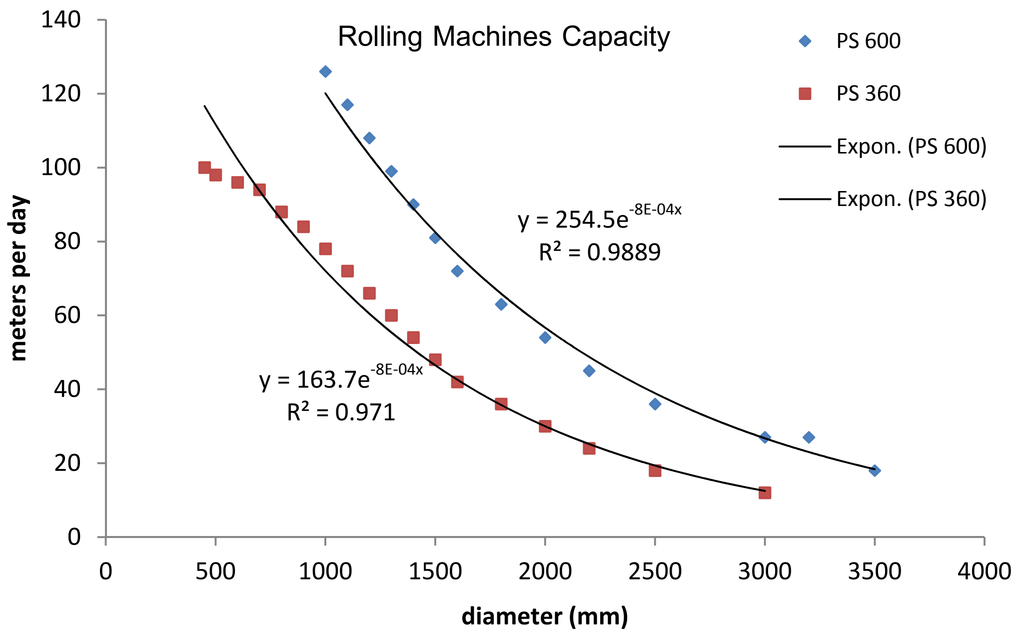

Figure 3.4 Capacity of PS600 and PS360

Using the scattered plots, a curve can be fitted as well as the determination of an equation relating the diameter to the output of each model. As the result, the relationship between output and diameter for PS600 model gives

Equation 3.1

$$output\ per\ day\ = 254.5 \times e^{-(8\times10^{-4})x}$$

Where;

x = the diameter of a pipe in millimeters

Similarly, the equation for PS360 model can be obtained as

Equation 3.2

$$output\ per\ day\ = 163.7 \times e^{-(8\times10^{-4})x}$$

Where;

x = the diameter of a pipe in millimeters.

In addition, the output is also a thickness dependent; however, for the ease of calculation, it is assumed that the effect of the pipe's thickness (usually in the range of 6-20mm) in this case is omitted in comparison to the length of the pipe which is in the range of 3000mm. From the above equations, it is now possible to determine the output in theory given the size of the pipe's diameter.

Once a steel plate is rolled into either a can or a cone shape, it is moved to a welding station for longitudinal welding. This is a process which all the products must undergo, similar to the preceding one. Figure 3.5 shows a longitudinal welding station.

Figure 3.5 Longitudinal Welding Station

For longitudinal welding, there are total of 8 stations with each station's output of 166.75 meters per day or a total 1134 meter per day for all stations.

For the products which need to be cut after rolling, the cutting technology uses plasma cutting and gas cutting in which both machine types are hand tools and can be easily purchased. The given capacity for the cutting process is 2100 meters per day. Due to its lower skill needed, almost all the workers at the plant have the knowledge to use the tools and perform this process without difficulty.

Similar to the longitudinal welding, the circumferential welding uses an Arc Welding technology, but unlike the earlier process, the welding direction is along the circumference of the pipe and fitting, rather than along the length of the pipe. Moreover, this process required more skill since the task is performed without using a semi-automatic machine. Therefore, each welder is required to be certified prior to be able to perform any welding. Currently, the company employs 16 welders of this type who can output approximately 224 meter per day in total.

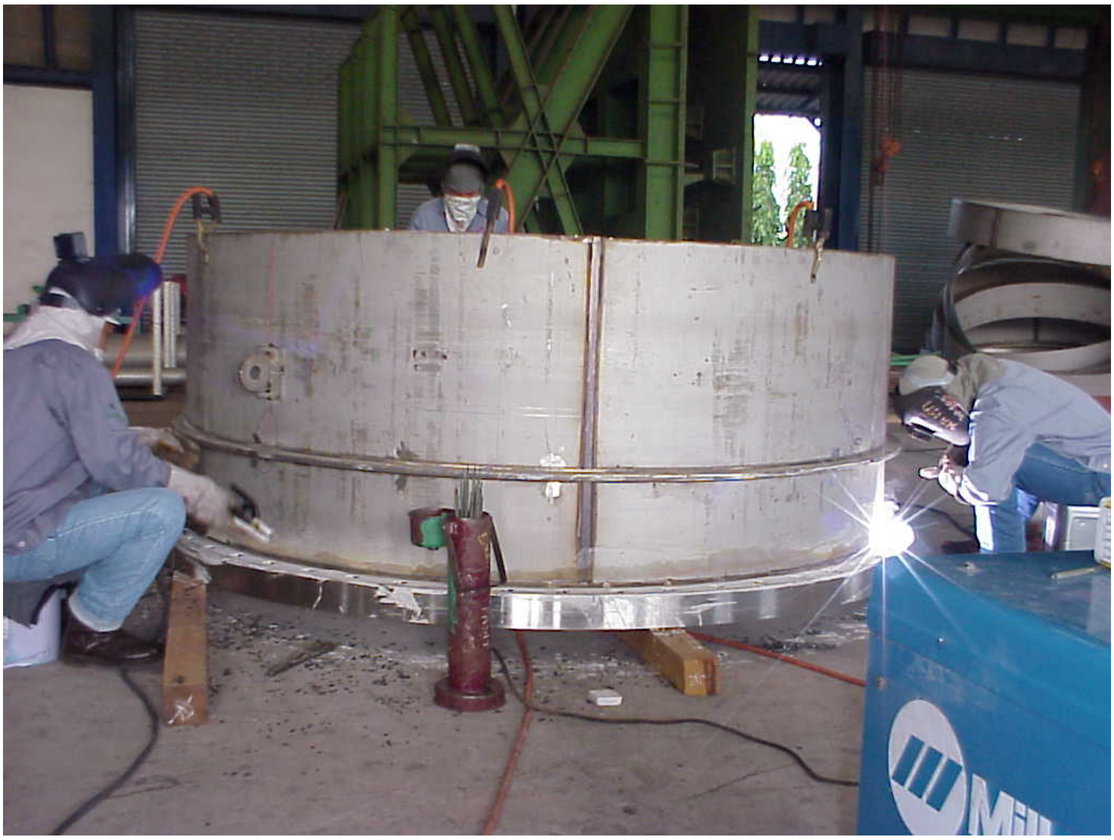

Figure 3.6 Circumferential Welding of Pipe and Flange

As the last process required for all the products, finishing is simply a grinding process, usually at the weld seams, to remove splatters, uneven surfaces, and sharp edges. This process has a high variation as to the capacity per day since some surfaces are easier to smoothen which can take a matter of seconds while other spots may take minutes to do. Nonetheless, this process is less critical and like cutting process, most of the workers can perform this task. As a given figure, the capacity for finishing process is 3675 meters per day. Moreover, the workers for cutting and finishing processes are also assigned multiple less skilled tasks such as packing, cleaning, and helping out the other working stations.

From the process description and given data by the production department, Table 3.1 below summarizes that capacity of each process per week, assuming an 8-hour working shift per man-day.

Process	Machine		Operators (persons)	Total Capacity (m/day)	Total Capacity (m/ 6day week)
	Capacity (m/day/machine)	Quantity (no.)			
*Rolling (PS600)	126	2	2	252	1512
*Rolling (PS360)	100	2	2	200	1200
Longitudinal	166.75	8	10	1334	8004
Cutting	420	5	5	2100	12600
**Circumferential	16	14	16	224	1344
Finishing	735	5	5	3675	22050
**assumed the maximum output pipe size*			***per diameter basis*		

Table 3.1 Production Capacity

At this point, the suspected bottlenecks are the rolling processes and circumferential welding. Specifically, the rolling machine PS360 has the capacity output per week of 1200 m/wk. Moreover, this approximation is assuming the optimal output size which is in the size range of 450mm diameter. Meanwhile, the circumferential welding process has the second smallest capacity of 224 m/day. Nonetheless, a bottleneck cannot be assumed to be fixed at one process entirely, since each project requires a different product mix, and in turn, the process time is dependent on the project mix. Hence, this is a wandering bottleneck problem and all the projects must be evaluated at the same time in order to determine a bottleneck at an instantaneous time period. The only useful analysis for the time being is that the given capacity can be used to calculate the output for each process.

3.1.3 Company's Projects

Thus far, the relationship of the products and the processes has been established. Hence, a project consists of one or more of the above product mix. Moreover, there are a variety of lengths and diameters which are subjected to the customer's specifications. With these characteristics, the company is considered as a *make-to-order* manufacturer and having an inventory of finished goods is not practical. Currently, BTEL is undertaking 6 projects. For the ease of referencing, each project will be arbitrary numbered starting from project 1 to project 6. In addition, the parameters needed about a project necessary for the case study are;

- Deadline
- Product Type
- Product Size
- Quantity

Gathering the information above, Table 3.2 illustrates an example of the information from Project 1 which is necessary for further analysis of the production plan.

Project Reference	No. of wks left	Product List	Diameter (mm)		Length (m/pc)	Total (pcs)
			size 1	Size 2		
Project 1	6	Pipe	2200		12	221
		Pipe	2200		6	4
		Pipe	1500		12	94
		Miter	2200		6	3
		Miter	1500		5	3
		Flange	2200			345
		Flange	1500			191

Table 3.2 Project's Information

From the above table, the first column is the project reference where each project is assigned a unique reference. For Project 1, there are 6 weeks left until the contractual deadline which is shown in the second column of the Table. As for the later columns, these are the information about the products in reference to the project. For example, the first row (excluding the heading) provides the information that the product type is pipe of diameter size 2200mm which has a length of 12 meter per piece and the total quantity needed for this size is 221 pieces. As for the second row, it reads that 4 pieces of pipe diameter size 2200mm with the length of 6 meter are needed, and so on. For flanges, the length is not necessary because the process requirement is not determined by the length of the flange (i.e. rolling and longitudinal welding are not required). Thus, the two important parameters for a flange are the diameter and the total quantity. Importantly, all the above information, except the project reference, is given by the customer at the beginning of a project. Repeating the same process, all six projects, currently at the company, can be listed using the same table format as shown in Table 3.3.

Project Reference	No. of wks left	Product List	Diameter (mm)		Length (m/pc)	Total (pcs)
			size 1	Size 2		
Project 1	6	Pipe	2200		12	221
		Pipe	2200		6	4
		Pipe	1500		12	94
		Miter	2200		6	3
		Miter	1500		5	3
		Flange	2200			345
		Flange	1500			191
Project 2	9	Pipe	500		12	330
		Pipe	500		3	22
		Pipe	550		12	45
		Pipe	550		3	3
		Pipe	600		12	210
		Pipe	600		3	6
		Pipe	700		12	4
		Pipe	750		12	286
Project 3	10	Pipe	3000		12	12
		Pipe	3000		11	1
		Miter	3000		8	2
Project 4	34	Pipe	3600		12	36
		Pipe	3600		3	1
		Pipe	1200		12	12
		Pipe	1200		1.5	1
		Pipe	450		12	6
		Miter	1200		6	6
Project 5	8	Pipe	1200		12	15
		Pipe	900		12	21
		Pipe	450		6	15
		Miter	1200		5.5	4
		Miter	900		5	2
		Miter	450		3.5	2
		Flange	1200			30
		Flange	900			46
		Flange	450			5
		Reducer	1200	900	5.5	1
		Reducer	900	450	4.5	1
		Tee	1200	450	7	1
Project 6	15	Pipe	750		12	10
		Pipe	500		12	4
		Pipe	500		4.5	1
		Miter	750		5	4
		Reducer	750	500	3	1
		Tee	750	750	4.5	1

Table 3.3 Current Projects' Information

From the above information, each product's given dimensions can be calculated to the production process needed in the unit of meter per piece. Using Table 3.4, the calculation matrix is shown for each type of product in alignment with the necessary process

	Rolling (R)	Longitudinal Welding (LW)	Cutting (C)	Circumferential Welding (CW)	Finishing (F)
Pipe	L	L	0	c x (n-1)	LW+CW
Miter	L	L	c x (n-1)	c x (n-1)	LW+CW
Reducer	L	L	0	c x (n-1)	LW+CW
Tee	L	L	$2c_b$	(c x (n-1))+ c_b	LW+CW
Flange	0	0	0	C	CW

Table 3.4 Product-Process Calculation Matrix

where,

L = length per piece; c = circumference; c_b = circumference of branch;

n = no. of sections; R = rolling; LW = longitudinal Weld; C = cutting;

CW = circumferential welding; F = finishing

Taking item 1 of Project 1 as an example, the pipe's length per piece is 12 meters which equals to L. The circumferential welding, CW, is equal to the circumference, π x diameter, multiply by the number of section, 4, since each section is 3 meter long and the total length is 12 meters, subtracted by 1. Plugging in numbers, CW equals to 20.73 meter / piece. And finally, the required meter per piece for finishing, F, is equaled to LW + CW which is 12+20.73 = 32.73 meter / piece. Using the given products' sizes, the required process for each item of the products can be obtained as summarized in Appendix B.

3.2 Data Collection

From an interview conducted with the Production Manager, the current strategy employed is to produce as much as possible each day and that the manager will try to limit the working hours for any of the process to 76 hours per week so that the workers are not overloaded. Moreover, the project's sequence is to tackle the project with the earliest deadline first, otherwise, if resources are left from the closest deadline, the project with the second nearest deadline is executed and so on. In order to illustrate how the strategy works, each week progress is collected as well as the man-day usages for each process on a weekly basis. Hence, in the first week, the production department's goal was to complete as much of the project 1 as possible since it is the project with the earliest deadline. But because the PS360 operators are not able to endure more than 76 hours per week, all other subsequent processes were limited by the output of the PS360 for this project. In the same week, the production department was also able to complete Project 5 and start on Project 2, since these two projects did not require the use of PS360 rolling machines. For tracking keeping, at the end of each week a production record is produced as shown in Appendix C. From the first week, it was visible that there was not a schedule and the resource allocation was done on a daily basis. In the same manner, the production strategy used in week 1 was employed for weeks 2 and 3. Nonetheless, the progress was often limited by the output of the rolling process; mainly, the operators were able to handle on average 9.5 man-day per week or about 76 hours per week. On the other hand, the welders were able to endure longer working hours because of the rotation system that was able to provide more rests time during the day in comparison to the other working groups. As of this point, the given capacity can be verified against the actual capacity for each of the working process as shown in Table 3.5.

ACTUAL PRODUCTION		Week 1	Week 2	Week 3	Meters / day
PS600	Meters Produced	840	840	1092	105.6
	Man-day usage	9.35	9.1	7.8	
PS360	Meters Produced	1760	2028	1779	204.6
	Man-day usage	9.68	9.1	8.42	
Longitudinal Welding	Meters Produced	2783	2968	2971	1203.7
	Man-day usage	2.29	2.49	2.76	
Cutting	Meters Produced	99.9	0	0	2172.7
	Man-day usage	0.05	0	0	
Circumferential Welding	Meters Produced	3052	2248	2043	238.2
	Man-day usage	12.252	9.22	9.35	
Finishing	Meters Produced	5651.6	2291.4	4932.1	3237.1
	Man-day usage	2.030	0.62	1.33	

Table 3.5 Data Collection of Output

Using the averaged output per day for each process except for the rolling process (see Equation 3.1 and 3.2), the given capacity by the production department is validated. Some variations are visible as shown in Table 3.4, where the maximum is 14% difference which is about 1.3 hours in one working day which is within an acceptable range for the purpose of this research. For the rolling capacity, the given data from the machine manufacturers will be used by plugging in the diameter in Equation 3.1 and 3.2 for PS600 and PS360, respectively.

Process	Given Capacity (m/day)	Actual Capacity (m/day)	% Difference
Longitudinal Welding	1334	1156.7	13%
Cutting	2100	2172.7	-3%
Circumferential Welding	224	238.2	-6%
Finishing	3675	3237.1	14%

Table 3.6 Capacity Comparison

Despite the delay problem that was to be resolved, the production progress seems to be even ahead of the deadline in some of the projects over the 3 weeks data collection period.

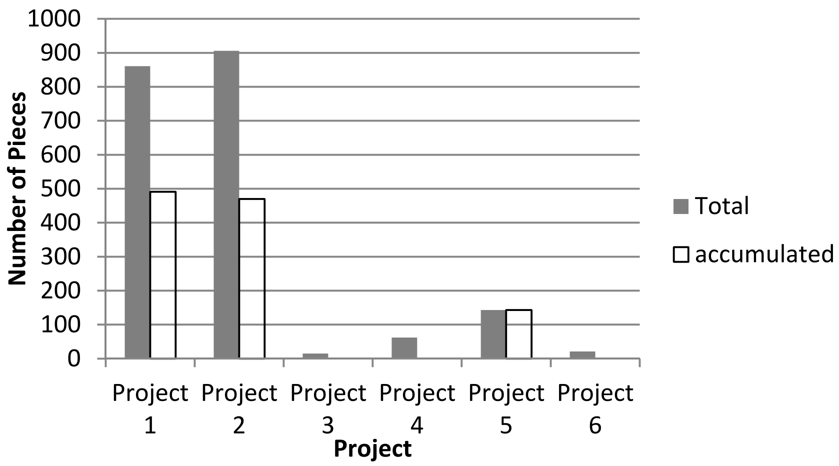

Figure 3.7 Work Progress for 3-Wk Period

The project with the earliest deadline is Project 1, which is to be due in 3 weeks time. Surely if they can complete over 50% progress in the past 3 weeks, they should be able to complete the project in the next 3 weeks without any problems. Likewise, they are way ahead of the deadline for Project 5, which was completed with nearly 7 weeks left. On the surface, the current production strategy seems to be working quite well.

3.3 Problem Analysis

Thus far, it is evident from the past records that the company is facing a delay problem. Nonetheless, there is a variety of possible causes which lead to the delay problem itself. While the suggestive solution methodology is to be a top-down approach, the methodology used for examining the problem is in the manner of a bottom-up analysis. In this way, the problem investigation is conducted on three main levels; the workers' level, the project management level, and the organization level. Specifically, four potential causes of the delay problem suspected are workers' capabilities, project management capability, resource interdependency, and unexpected events.

3.3.1 Workers' Capabilities

As the first potential cause, the delay problem could be created from the fact that the workers cannot perform the tasks as assigned due to the limitation in their capabilities, and therefore, resulting in the delay. Hence, it is important to investigate this possibility by looking at each working group of the operational level. The first group, the rolling process, is operated by 4 operators with the years of experience of 6 or more years. These operators have been highly praised by the Production manager for their ability to provide predictable outputs and it is conclusive to say that the workers' capability at this process is not in questioned. The next set of processes is the welding process. As the most critical process due to its highest risk factor if fault occurs, there is a very formal welder qualification process carried out by the company in which it is usually a must-do requirement for all the projects. Specifically, the company implements the qualification process according to ASME section IX standard with a verification by a third party such as ABS, Moody's International, and SGS, all of which are an international certified body. If a welder fails to pass the test, he or she is not allowed to perform the welding process at the company. Finally, the last groups of workers are the cutters and finishers. These two groups have similar commonality which is that the skills required are the lowest skill type in comparison to the preceding processes. Nonetheless, all the workers must be trained and tested by an internal examination, although much less stringent than the welding test, prior to be accepted as the worker for that position. Overall, workers' capability is not identified as a cause to the delay problem. Relating to the workers' issue, it is worth to investigate the behavior of the workers. From observation, most of the workers are diligent; only a few workers show signs of unenthusiastic work behavior. Moreover, the company has employed an 'early finisher' incentive which is an incentive in a form of small recognition given to the workers who were able to finish the assigned task earlier than the time given. On each day, all the early finishers will get a point which is to be accumulated overtime in order to use these points for an incentive exchange. Nonetheless, most of the workers are rather facing the problem of being overloaded with constant overtime rather than underworked.

3.3.2 Project Management Capability

At this point, the lack of capabilities from the worker's level has been ruled out. The next part to be investigated is the project management capability. The reason that this area is included in the assessment is because the business unit consists of many projects and if these projects are not managed properly, an assumption then can be made that altogether, the portfolio will have a poor result. In another word, if all the projects in the portfolio are successful, the portfolio will be successful. From the historical data, the company had undertaken 62 projects in the past 5 years from year 2006 – 2010. The number of project managers; however, is between 5-8 persons per year. From these figures, a conclusion can be drawn that each project manager is likely to handle more than one project at a time. In spite of this, the current responsibility of the project manager is only to coordinate with the customer in certain areas such as information updates and a few logistics issues and to get the information from the different departments in the company to pass on the customer, and vice versa. In this way, ‘project manager’ is merely for a title formality rather than an actual representation of the roles and responsibilities. The main reason of such a limited responsibility is because there is a repeating pattern in the scope of the projects and hence, the project’s complexity level is not entirely unique, which in turn, does not require a highly skilled project manager. Looking on the flip side, if a highly skilled project manager was to be in charged and carry out the customary project management process, a visible problem that he or she is to face is that the healthiness of his or her project is actually dependent on the wellness of the other projects. For example, Project A is running smoothly as planned, but on the other hand, Project B is late and needs more resources to catch up for the delay time. As the result, the resources from Project A are to be provided to Project B which then alters the current progress of Project A. Surely, this scenario can be solved by making the resources of Project A and Project B independent of one another. In reality, the business owner is not able to actually allow every project manager to possess his own resources, such as expensive machines, land, and etc., especially when the value of a project is considerably small in comparison to the central investment. Nonetheless, the company actually went through a period, particularly in year 2008 and 2009, where all the resources were allocated to only two projects each year. As the result shown in Figures 1.1 and 1.2 in Chapter 1, the company actually performed better in terms of delivery timeliness while the total contractual values were also higher. And hence, a conclusion can be drawn that despite the company being considered as a project company, a high capability of project management individually is actually not the key to success, particularly when there are many projects running at the same time.

3.3.3 Resource Interdependency

Referring back to the previous assumption, it is assumed that if all the projects in the portfolio are successful, the outcome of the portfolio itself should be successful; and therefore, the next investigation is to analyze the reason that causes the failure of each project. From the analysis above, the difficulty is evident in the fact that the required resources are interdependent between projects. By planning the resources of a project individually without taking all the other projects into the account, the planning is not as useful and not as practical in the real case situation. From this determination, it is logic to investigate the potential link between resource allocation and the delay problem, if exists.

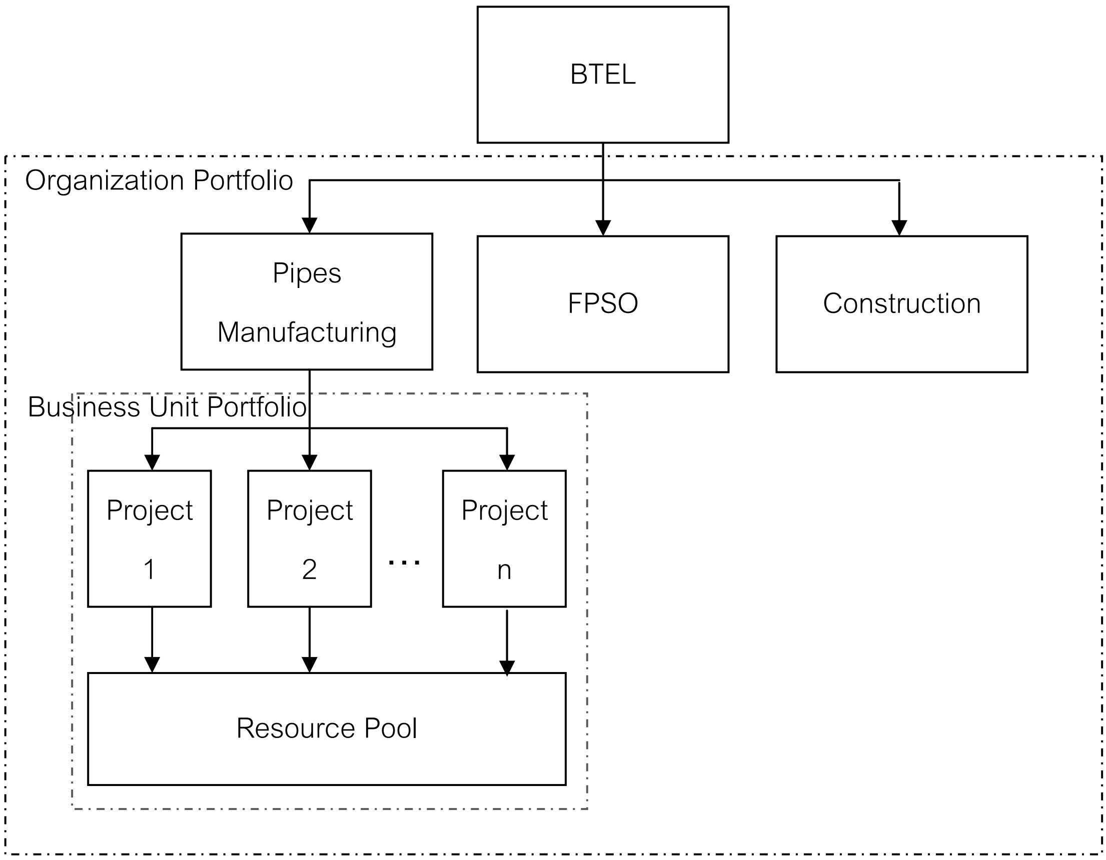

Figure 3.8 Portfolio Configuration

From the above figure, it shows the sharing of resources by different projects in the company. In order to link the three dimensions; capacity, demands, and resources allocation; five possibilities can be revealed:

- Portfolio Case 1: More capacity than demands and poor resource allocation

The above scenario can result in either delay or not delay, depending on how poor the resource allocation capability is and how much resources are available over the demand. If there are much more resources than the demands, it is possible that the company can meet the deadline despite a poor allocation technique.

- Portfolio Case 2: More capacity than demands and proficient resource allocation

  The company with the above situation is likely to achieve the target.

- Portfolio Case 3: Less capacity than demands and poor resource allocation

  In this case, the company is doomed for the delay to happen.

- Portfolio Case 4: Less capacity than demands and proficient resource allocation

  In this case, the company will not be able to deliver on-time if the current capacity is kept. However, the area of deficit in the resources can be detected.

- Portfolio Case 5: Capacity equals to the demands and proficient resource allocation

  This case is likely to result in an on-time delivery with a high efficiency, or Just-in-Time (JIT).

Due to the fluctuations in the demands, a company can experience more than one portfolio case, but limited to a different timeframe. For BTEL, they fit into the category of portfolio case 1 and case 3. Due to the lack of resource planning, the company can meet the deadlines when the demands are low and the delay problem emerges when the demands are high, but the common ground is that no actual values of resource usage and deficit are available. Under the conditions of fixed resources and the demands as unchangeable, the only possible change is the resource allocation. To further stress this point, it is not surprising that BTEL is able to meet the demands during the first 3 weeks of data collection. The main reason is because there were much more resources than needed or similar to Portfolio Case 1. However, it is determined that if the project mix requires any process to run more than 9.5 man-days per week for several weeks, the company will face a delay problem because this figure is the deciding factor that the production department had used to justify the resource usage. Therefore, this justification of 9.5 man-days is certainly arbitrary and not enough to support a strategic resource planning. To add more complexity, a project can also fail because of the resource pulling from one project to another as shown earlier. Hence, for the projects in the portfolio to be successful, the management of the portfolio itself must first be successful. Therefore, the problem formation to be solved is a resource interdependency problem between projects. The problem is identified at the organizational level and not at the level of each individual project.

3.3.4 Unexpected Events

In spite of a proficient resource allocation available, there are also unexpected events, such as machine breakdowns and electrical shortages, which can cause a delay in production. In reality, these problems are happening everyday with variable impacts. As most texts will suggest, the correct action is to fix the problem at the core such as if a machine breaks down, there must be a maintenance schedule, check-up list, spare parts inventory, operating analysis, and etc. Nonetheless, the present problem still exists where the production line is stopped due to this event. In the view of the Production Manager, he certainly needs to make up for the loss time and relocate the resources to a different working station. While fixing the problem at its root cause is important, the existing impact cannot be ignored. There is also another type of events which is considered as an unexpected event at this point. This occurrence is when more projects are added to the company. Currently, there is no communication framework which allows for planning to undertake the incoming projects. Hence, unexpected event is an umbrella category which can lead to the delay problem.

As the above analyses, the root cause of the problem is that BTEL does not have an established resource allocation plan and therefore, they cannot evaluate the interdependency issues of the resources which lead to the delay problems. Moreover, the production strategy does not take into account the demands (project mix) and the scheduler only focuses on the concern of the working hour limitation. While the demands are low, the company is expected to meet the deadlines as they have shown in week 1 through week 3 of the data collection. However, they are subjected to vulnerability during a high demand period with a possible slowdown due to the unexpected events occurring which can further amplify the delay problem.

CHAPTER IV

PROJECT PORTFOLIO MANAGEMENT FRAMEWORK

So far, the emphasis has been placed on the production department, when in fact, this dilemma is an enterprise wide responsibility. The sales and project managers are directly affected when their existing customers are not satisfied with the progress and the delivery of their projects. The director is clearly responsible for the poor delivery performances. Finally, the organization is impacted by the loss of expected profits and even long-term consequence such as the negative aspects on the company's reputation. Therefore, the problem solving requires participants from all key personals in the organization, and most importantly, the top management. Moreover, the delay problem poses rippling effects as the marketing team is hesitant to bid for future projects and there are always unexpected events occurring which can further put the delayed projects into further setback. Hence, the solution to the problem is to be a long-term and sustainable approach rather than just simply adding more resources here and there in the production line. On the other hand, overly complex solutions can have an adverse effect and actually add more problems to the organization. Therefore, practicality is an important quality to build buy-in from the key personals of the organization. In this way, the suggested solution is aimed for providing a sustainable problem solving as well as for the company to be able to have a repeatable process whilst maintaining the flexibility to align with the changing nature of the business.

In the sections of this chapter, the suggested PPM framework is described in detail starting with the rationale used for designing the PPM framework. Following the introduction of the framework, a managing body, refers to as the PPM Committee, is revealed which includes an overview of the roles and responsibilities of the people involved. Later, prioritization and resource allocation, by which the outcome of the two processes combined, is referred to as the *Portfolio Plan* is discussed. And finally, the latter part reveals the framework's function when applying to incoming projects.

4.1 Logic of the PPM Framework Design

From the previous chapter, the main cause of the delay problem is identified as the lack of a proficient resource planning. Importantly, the resource planning must include all of the projects in the portfolio due to the resource interdependency condition. Therefore, the main intention is to develop a system that can provide a resource planning so that the resources can be allocated proficiently. Similar to a strategy formulation, the proposed system has to link the current situation, the objective, and the process which enables the objective to be achieved.

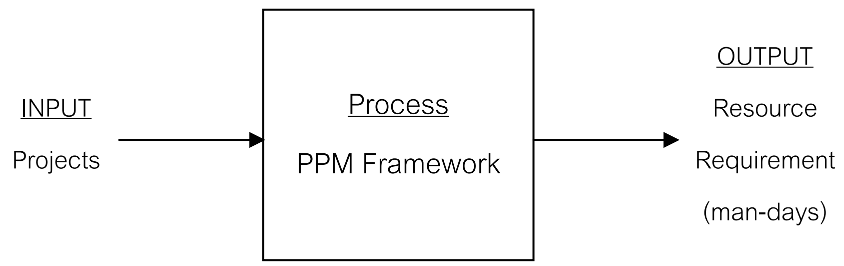

Figure 4.1 System schematic

From Figure 4.1 above, the input of the system is the known factors given when a project is awarded by the client. This information includes the deadlines, the type of products, and their sizes and quantities. Moreover, the inputs must include all the projects in the portfolio. Through the processes in the suggested framework, the expected output is the resource requirement in terms of the number of man-days required. With the determination of the resource requirement, the resources can be added or removed in order to produce the goods on-time. In spite of the simplified schematic, the actual situation is not static and there are constant changes in which the proposed PPM framework must take into the account.

Therefore, the first part in forming the PPM framework is to be able to establish a production plan, which is specifically refer to in this research as the Portfolio Plan. In essence, the Portfolio Plan is formed by matching the products to be produced with the available resources. With the resources requirement determined, two main instances are available. The first instance is that there are enough resources available; and therefore, the plan is to be executed and monitored. In contrast, if the resources are not enough, the second case requires a decision to be made whether more resources are to be added or work re-sequencing is necessary; whichever way, the second case requires an adjustment of the resource planning. To reflect the above rationale, the below schematic can be obtained as shown in Figure 4.2.

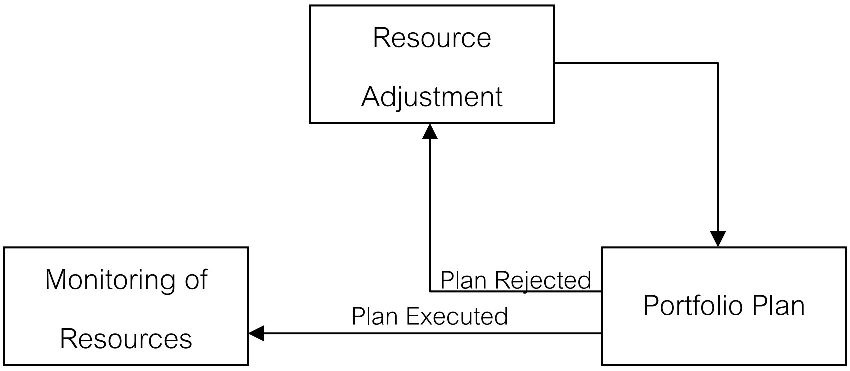

Figure 4.2 PPM Framework Logic Step-1

If the production line is static and there are no changes, the processes shown in Figure 4.2 can be done once and the Portfolio Plan can be easily executed once enough resources are provided. Realistically, there are unexpected events happening which are identified as one of the major causes of the delay problem. Despite its name, there are some events which can be forecasted of happening. The two major events, those can be predicted of happening through the lifetime of the company, are the additions of a new project and the close-outs of a finished project. In either case, both events must go through the resource adjustment box because a modification to the Portfolio Plan is needed. Likely, an incoming project means more resources are needed, and on the other hand, the resources from the completed project can be return to the resource pool. As for the other cases, such as machine breakdowns and weather conditions, these occurrences are less predictable but still require an adjustment of the resource allocation and therefore, must go through the resource adjustment box correspondingly.

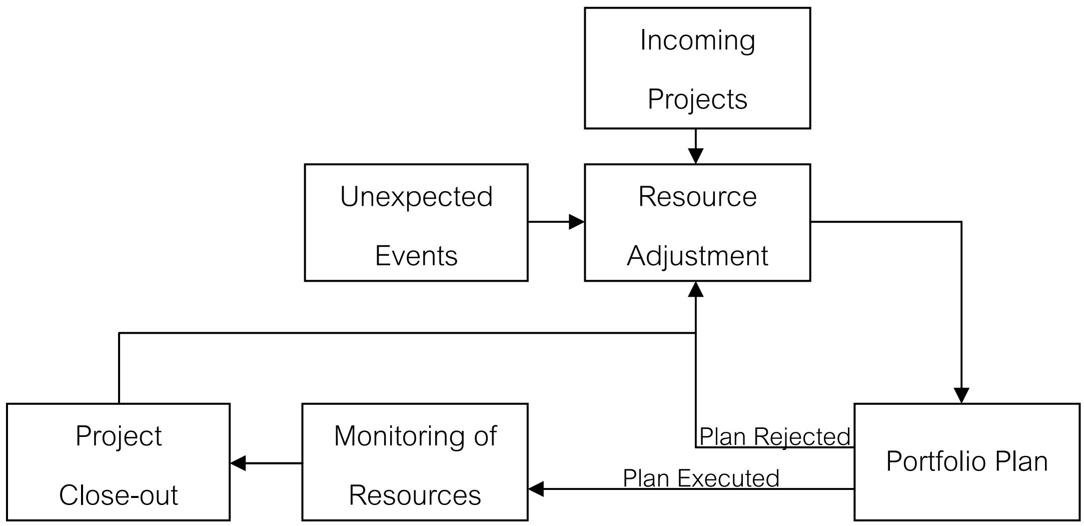

Figure 4.3 PPM Framework Logic Step-2

In a simplistic view, a rough PPM framework is shown in Figure 4.3 above. However, the above framework can be further improved by breaking up several key components. The first component is the 'incoming projects'. With the above setup, the production department has to reactively adjust the Portfolio Plan each time a new project becomes active; when in fact, the marketing team knows a few weeks prior during the bidding period, and therefore, more time can be provided to assess the necessary resource adjustment to undertake the new project. Therefore, the PPM framework needs to act as a communication framework to connect this missing link between the sales and the production departments. In this manner, the incoming projects can be evaluated further back even before the decision is made to accept or decline a project. As a major discussion itself, the Project Selection process becomes a part of the PPM framework as shown in the upper half of the final PPM framework (see Figure 4.4). Mainly, the logic is to take into account the production capacity as a deciding factor along with the financial aspects in the decision making.

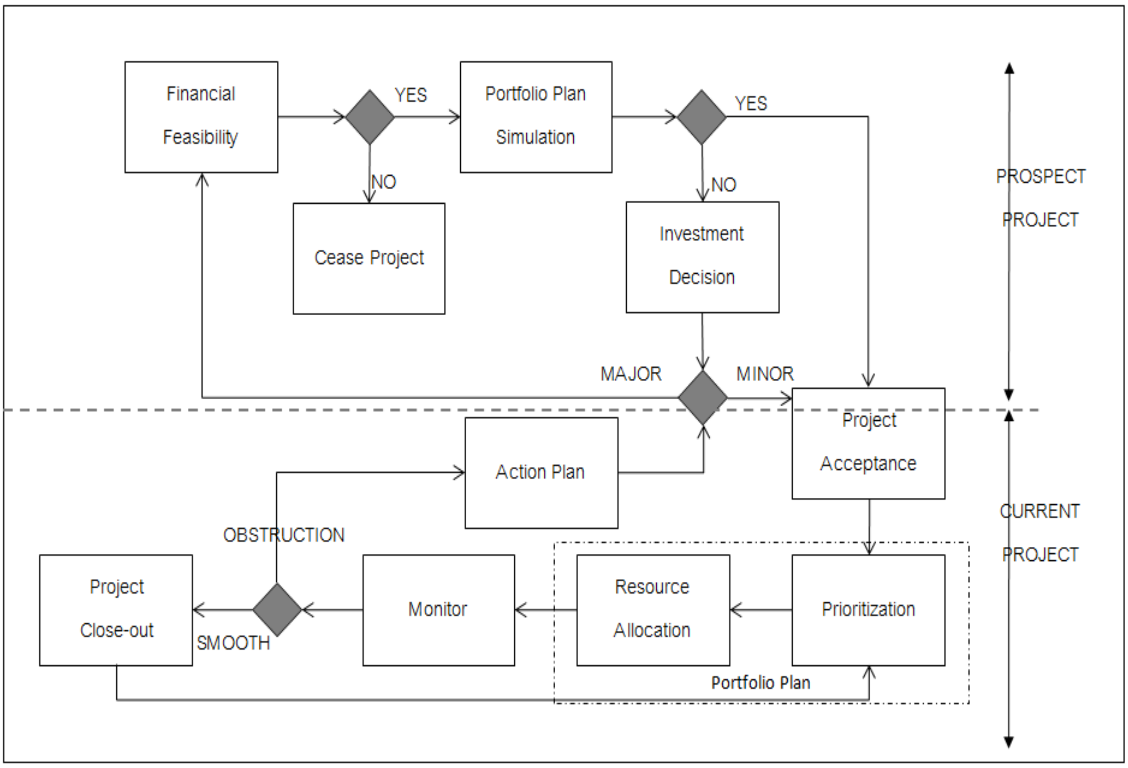

Figure 4.4 PPM Framework

Moreover, the Portfolio Plan in itself requires an integrated act of resource adjustment and prioritization and therefore, the rough framework in Figure 4.3 is misleading to view the forming of the Portfolio Plan and resource adjustment as two separated processes. Hence, contained within the Portfolio Plan, two main functions can be broken up as prioritization and resource allocation. As the lower half of the PPM framework, its purpose is for managing the current projects in the company's portfolio. Finally, the stage-gate (decision) boxes are added for the ease of users when applying the proposed PPM framework. Shown in Figure 4.4, the PPM framework is designed to enable resource forecast for adjustments through iterative process, what-ifs scenario, and automatic solver if using software technology (Gruia, 2003). Moreover, the PPM framework acts as a tool which helps for decision support across different functions in the organization, especially for managers and key functions (Pennypacker & Retna, 2003). Considerably, the PPM framework requires decision making and applies the technique of stage-gate as the decision making point. In the big picture, the framework is divided into two main parts. The first part is for the purpose of managing and monitoring the current projects. In relation, the second part is for the use of potential projects for project selection process. Despite the distinction, in reality, these two classes have interrelation and can exist within the same timeframe. In the later sections, each part of the framework is discussed in details.

4.2 PPM Committee

As the first step, a committee needs to be established and dedicated to PPM or also known as the PPM Committee. In some texts, this body is referred to as the Project Management Office (PMO); however, this function is identified as the PPM Committee in this research because the name, Project Management Office, can be misleading in several ways. Since this function is to affect the core characters of the business, the people involved must be the key personals in the organization. Hence, the PPM committee are put together to form a coalition with the key personals of the following qualifications;

- experiences and experts in the field of either management, production, project organizations, or finance
- authoritative figures for decision makings
- organization’s leaders and influential managers
- skilled Information Technology with the knowledge in production process
- coordinator who can create the *buy-in* factor across the organization

Moreover, the PPM Committee must be properly included in the organization structure which reports directly to the director of the business unit.

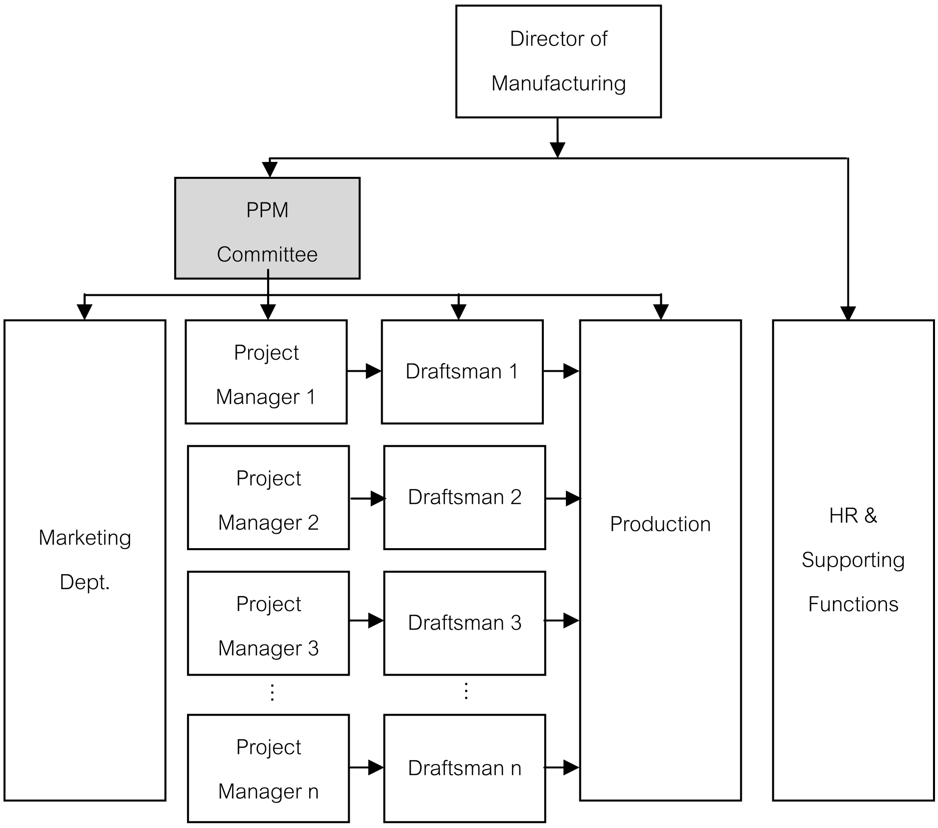

Figure 4.5 Organization Chart with PPM Committee

By placing the PPM committee above the marketing department, project management teams, and production department, it provides the authority to the committee. Moreover, it is the manufacturing director which is suggested to be the head of the PPM committee. And therefore, he is still the authoritative figure only now he is equipped with a powerful coalition dedicated to the organizational planning and improvements across several key functions of the business unit (Kotter, 1996). Moreover, the department heads are selected as the members of the committee. In this way, the PPM Committee has the internal members as shown in Figure 4.6.

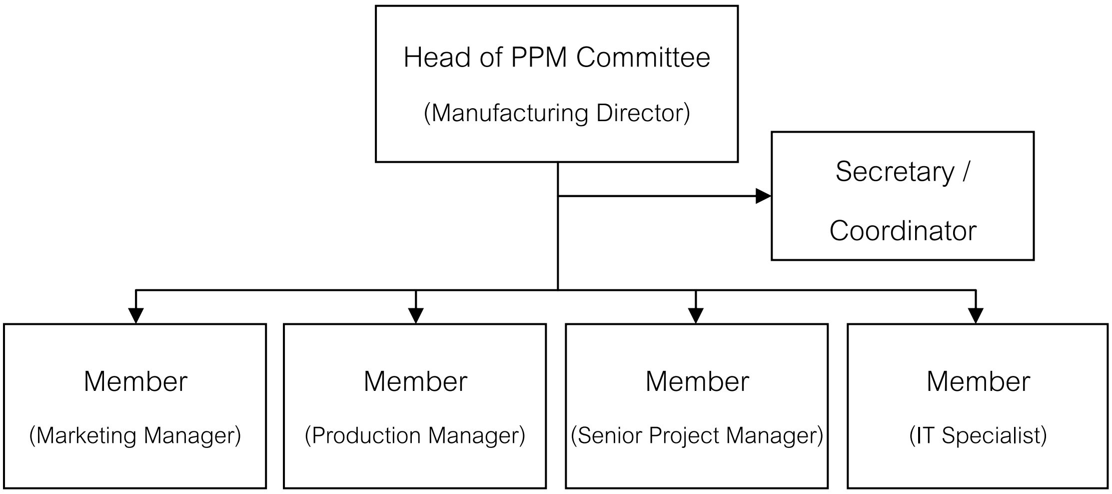

Figure 4.6 PPM Committee Board

As a startup, the committee is required to have the management representatives from each function which are the marketing manager, production manager, and a senior project manager who is to be selected by the Manufacturing Director. As an addition, the company should acquire an IT specialist to implement software technology to enable the ease of calculation and planning. And lastly, it is necessary to have a secretary and coordinators for the committee. There can be more than one coordinator and it is suggested that he or she is to only work for the PPM to ensure a full commitment and result oriented. As for the responsibilities of the PPM committee, they can be summarized as the followings;

1. Develop the Portfolio Plan for the organization
2. Implement the Portfolio Plan to the current production planning and resource allocation
3. Monitor, Control, and Evaluate the Portfolio Plan against the current productivity
4. Make major investment decisions and improvement plans
5. Select future projects through project selection process

6. Analyze lessoned learn and make further improvements to PPM

In order to further explain the roles of the PPM Committee, the following sections are integrated to describe the above provisions through the detailed description of the PPM framework.

4.3 Portfolio Plan

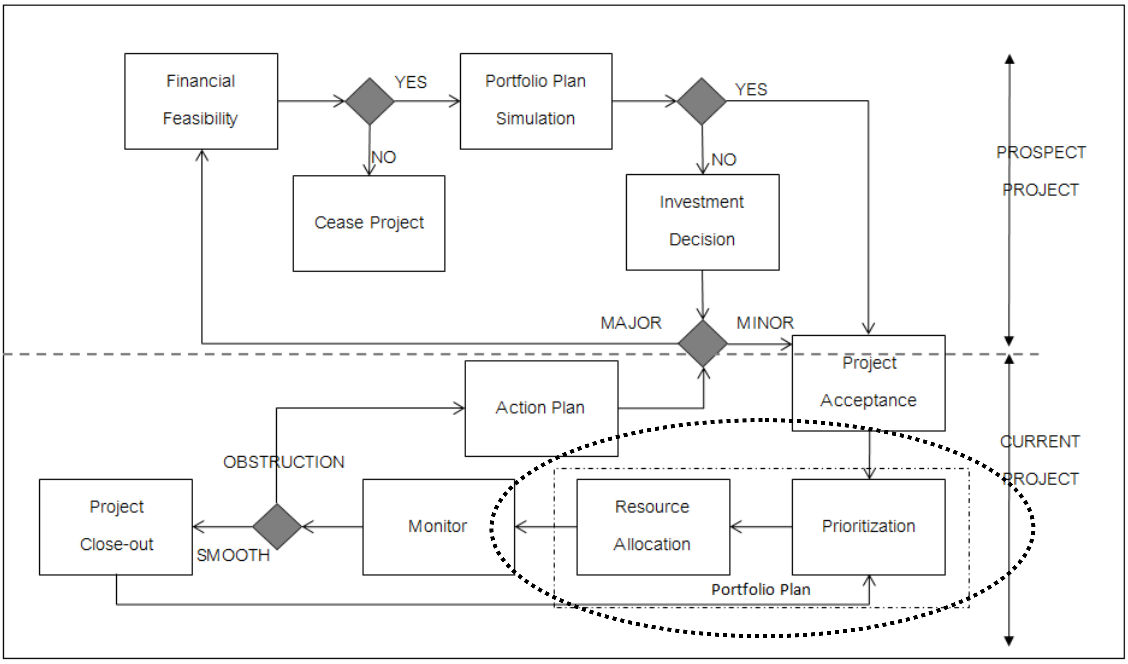

Figure 4.7 Portfolio Plan in the PPM Framework

The goal of this section is to define the Portfolio Plan and explains in details of its application using the example of the case study company. The Portfolio Plan, here after refer to as PP, is a summary of all projects which can provide the information such as the products' information for each project, the deadlines, the work status, resource usages, and production planning. Hence, the PP is the engine room of the framework. Moreover, the PP can be created using simple software such as Microsoft Excel, or a more complicated software such as Oracle's Primavera Enterprise PPM or Microsoft's Portfolio Server. Using an excel spreadsheet for this research, a PP can be formed and consists of four main parts; projects' register, prioritization, resource allocation, and progress track.

4.3.1 Projects' Register

Depending on the type of projects a company is dealing with, the PPM Committee needs to identify the important information about a project to be included in the PP. For this research, the significant parameters are the project's reference, contractual deadline, and product's information.

Project Reference	No. of wks left	Product List	Diameter (mm)		Total	meter
			Size 1	Size 2	(pcs)	per pc
Project 1	6	Pipe	2200		221	12
		Pipe	2200		4	6
		Pipe	1500		94	12
		Miter	2200		3	6
		Miter	1500		3	5
		Flange	2200		345	
		Flange	1500		191	
Project 2	9	Pipe	500		330	12
		Pipe	500		22	3
		Pipe	550		45	12
		Pipe	550		3	3
		Pipe	600		210	12
		Pipe	600		6	3
		Pipe	700		4	12
		Pipe	750		286	12
… Project 'n'						

Table 4.1 Projects' Register

The first column is the project reference in which each individual project must be assigned a unique reference. The second column is the deadline translated into the number of weeks left for this case. As for the later columns, this set of information is the products' information which belongs to each of the assigned project. For the case study, the important parameters are the product type, the sizes, and the quantity. All the above information, thus far, should be given at the beginning of the project.

4.3.2 Prioritization

Once all the projects' information is tabulated, the next step is to prioritize the projects in the portfolio. The key to prioritization is to be able to identify the level of importance among the projects in relation to the organization's objectives (Gray et. al, 2011). In many organizations, the project with the top priority can be the project with the highest expected profits, the highest volume, or even the ones with the most investment (Sanwal, 2007). Regardless of the different objectives, prioritization helps managers and stakeholders to be able to make decisions in which the outcomes will have effects on all the projects being prioritized (Levine, 2006). At BTEL, the production manager has obviously prioritized his production output according to the deadlines of the projects. Underneath the obvious priority, the production manager has put a great emphasis on the workers' hours to ensure that they will not exceed 9-9.5 working days per week. Seemingly, cost is not in the top priority in the view of the production manager which is shown through the daily use of overtime spending. Consistently, the delivery time is the improvement in the scope of this research; and therefore, meeting the deadline is the foremost objective and prioritization should reflect this goal accordingly. As in this case, numbers 1 through 6 are used for priority assignment, since there are currently six active projects, where 1 is ranked as the top priority and 6 is the project with the furthest deadline.

Project Reference	Wks to Deadline	Priority
Project 1	6	1
Project 2	9	3
Project 3	10	4
Project 4	34	6
Project 5	8	2
Project 6	15	5

Table 4.2 Prioritization of Current Projects

By doing so, Project 1 gets the highest priority due to its shortest time to the contractual deadline of 6 weeks while Project 4 receives the least priority of 6 due to its longest lead time until the due date.

Project Reference	No. of wks left	Priority	Product List	Diameter (mm)		Total	meter
				Size 1	Size 2	(pcs)	per pc
Project 1	6	1	Pipe	2200		221	12
			Pipe	2200		4	6
			Pipe	1500		94	12
			Miter	2200		3	6
			Miter	1500		3	5
			Flange	2200		345	
			Flange	1500		191	
Project 2	9	9	Pipe	500		330	12
			Pipe	500		22	3
			Pipe	550		45	12
			Pipe	550		3	3
			Pipe	600		210	12
			Pipe	600		6	3
			Pipe	700		4	12
			Pipe	750		286	12
… Project 'n'							

Table 4.3 Prioritization for Portfolio Plan

Notice that the 'priority' is located next to the 'number of weeks left' column, it is for the logic of placing the priority assignment next to the items being prioritized.

4.3.3 Resource Allocation

Once the projects' information and prioritization have been established, the next step is to allocate the resources. The main reason is to be able to assign resources to produce what is needed by the contractual deadline. But before anyone can know the amount of the resources needed, it is logical to identify the output demanded over a period of time. In the big picture, the production manager knows that he has to produce a certain number of units for each project by the contractual deadline. The problem is, though, this visualization is too long and too difficult to organize when the operation line is running in the matter of hours. The suggested demand forecast for the case study company is to determine the required output on a weekly basis. Subjected to the commonality of the projects' duration, this basis can be changed to months, days, or hours as long as the calculated output over time is consistent for all the projects in the portfolio. From a strategic view, having too short of a timeframe is not recommended. For operational practice, however, the resource planning can be as detailed as a daily schedule or even an hourly schedule if necessary (Leus et. al, 2003). By taking the total quantity for each product type in each project divided by the number of weeks left, an average of the number of units to be produced per week can be obtained.

Project Reference	No. of wks left	Priority	Product List	Diameter (mm)		Length (m/pc)	Total (pcs)	Balance Beginning of Week 1	Pieces Required per Week
				size 1	Size 2				
Project 1	6	1	Pipe	2200		12	221	143	23.83
		1	Pipe	2200		6	4	4	0.67
		1	Pipe	1500		12	94	86	14.33
		1	Miter	2200		6	3	3	0.5
		1	Miter	1500		5	3	3	0.5
		1	Flange	2200			345	189	31.5
		1	Flange	1500			191	175	29.17

Table 4.4 Units Required for Project 1 using Average per Week Method

As an example, Table 4.4 illustrates the result of using an average per week calculation for Project 1. Since the project was started prior to the timeframe of the research, the quantity shown in 'Balance Beginning of Week 1' column is used rather than the total units required. Moreover, it is less realistic that each piece can be produced in fraction; therefore, it is perhaps misleading to simply taking an average without considering the actuality. Nevertheless, for the ease of calculation, it is assumed that the rounding has a minor effect on the timeframe. Similar to the example shown, the unit requirements for all the projects in the portfolio are determined on a weekly basis. A complete list for all 6 projects can be found in Appendix D.

The next step is to determine the capacity usage required in order to meet the weekly demand. Using the tabulated process requirement for each project as summarized in Appendix B, the number of meters required for each process of each product type (meters per piece) specified to each project can be found. By multiplying the requirement for each process (meters per piece) to the number of the pieces required per week, the number of meters to be produced per calendar week can be determined. Lastly, these figures (meters per calendar week) are to be divided by the production capacity (meters per man-hour week) for each process to determine the number of resources (unit in man-hour week) required to produce the weekly demand. For example, if 100 units of goods are required each calendar week (7 days) while the production capacity can produce 200 units of goods per 6-days working week (assuming Monday-Saturday 8AM-5PM), then it will take 3 man-days to produce 100 units of goods. Using the calculated man-hours per week, each process is now determined as to the number of resources needed.

Equation 4.1

$$Resources\ required\ per\ week = \frac{Weekly\ Demand\ x\ Each\ Process\ Requirement}{Capacity\ for\ Each\ Process}$$

As a summary, Appendix D shows the resource allocation for all six projects in the beginning week. Using this method, the weekly output is constant each week until the project finishes, or unless there are changes to the deadline, the number of projects, the quantity of the products, or an unexpected occurrence which changes the production outputs. The sum of the man-days of each week for each process determines the amount of the resources required to be allocated.

	Resource Allocation by PP for Week 1											
	Rolling (PS600)		Rolling (PS360)		Longitudinal Welding		Cutting		Circumferential		Finishing	
	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)
Total	**522.0 meters**	**5.4 man-days**	**1199.2 meters**	**6.0 man-days**	**1719.0 meters**	**1.5 man-days**	**46.8 meters**	**0.0 man-days**	**1794.8 meters**	**8.0 man-days**	**3513.8 meters**	**0.96 man-days**

Figure 4.8 Print-screen for Summary of Resource Allocation of Week 1

Hiding the cells of each project, an example of a weekly summary for each process is shown in Figure 4.8 using week 1 data. In spite of the ease in calculation, there are downsides to the method used. Most importantly, this method does not allow for any disruptions which may not be realistic. Secondly, it is more difficult to implement in a real production line in comparison to the current production strategy to complete one project at a time. Starting all the projects concurrently is potentially difficult for tracking and switching from one project to another. However, the main concept is that a production target is available, which is the minimum quantity that should be produced per week in order to meet the deadline. Using the PP as the main frame, the detailed scheduling should be revised by an experienced production manager to maximize the work flow.

4.3.4 Progress Track

The progress tracking in the PP provides the information for the actual production against the PP's expected production output. At the end of each week, the actual production data is input into the PP. Furthermore, the data needed is similar to an inventory management where the basic information are the number of units at the beginning of the week, the number of units produced, and the balance of units at the end of the week. In a similar format, all information should be organized according to each product type in each project.

						Progress Track					
Project Reference	No. of wks left	Priority	Product List	Diameter (mm)		Balance Beginning of the wk		Produced this wk		Balance End of the wk	
				size 1	Size 2	PPM	Actual	PPM	Actual	PPM	Actual
Project 1	6	1	Pipe	2200		119.2	73	23.8	70	95.3	3
		1	Pipe	2200		3.3	4	0.7		2.7	4
		1	Pipe	1500		71.7	86	14.3		57.3	86
		1	Miter	2200		2.5	3	0.5		2.0	3
		1	Miter	1500		2.5	3	0.5		2.0	3
		1	Flange	2200		157.5	189	31.5		126.0	189
		1	Flange	1500		145.8	175	29.2		116.7	175

Table 4.5 Projects' Status

Using Project 1 as an example, each of the parameters is inserted in the PP. As the balance at the beginning of the week, the input is carried over from the balance of the previous week. For PPM columns, the values are constant over each week as long as the portfolio's conditions remain the same. On the other hand, the 'actual' data are the actual production's records each week. Hence, the same format as used in the resource allocation of the PP can be applied for the actual production. Figure 4.10 below shows a print screen for an example of a PP in Excel format.

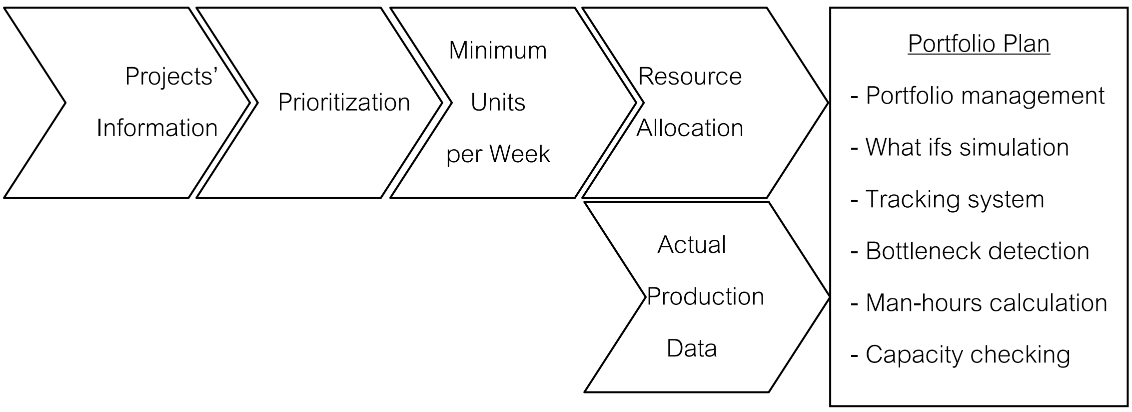

Figure 4.9 Benefits of the Portfolio Plan

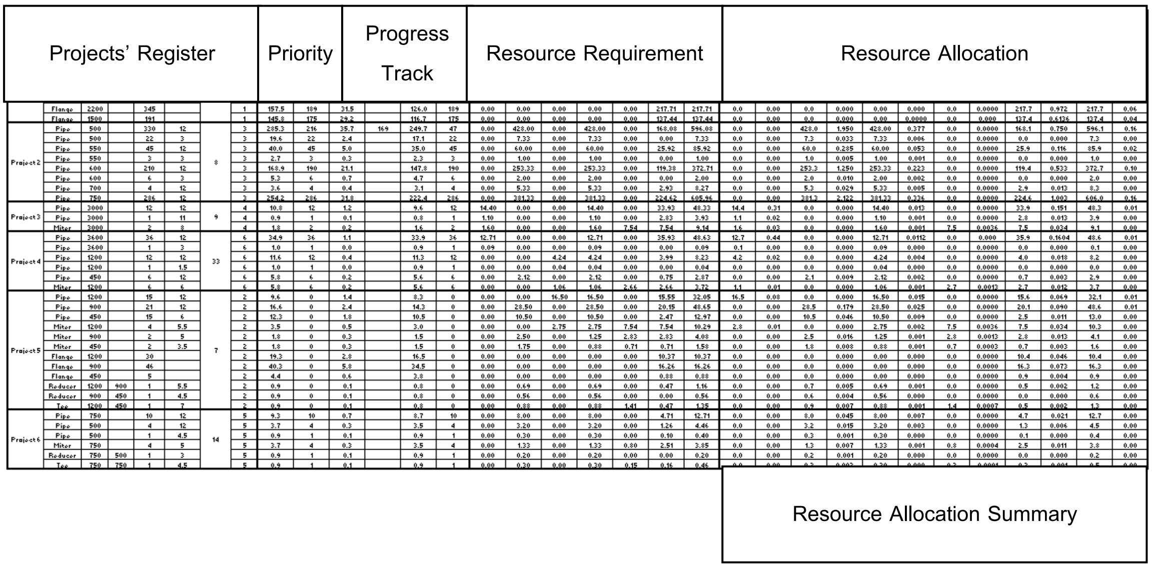

Figure 4.10 Print-screen of the Portfolio Plan

4.4 Portfolio Monitoring and Control

As each week progresses, the PP is required to be monitored and updated to ensure that the minimum demands each week are according to the plan. In reality, a project oftentimes does not always run as expected. Considered the difficulty of managing a project, managing a portfolio requires a timely decision making, and thus, the framework must anticipate changes throughout the course of the projects.

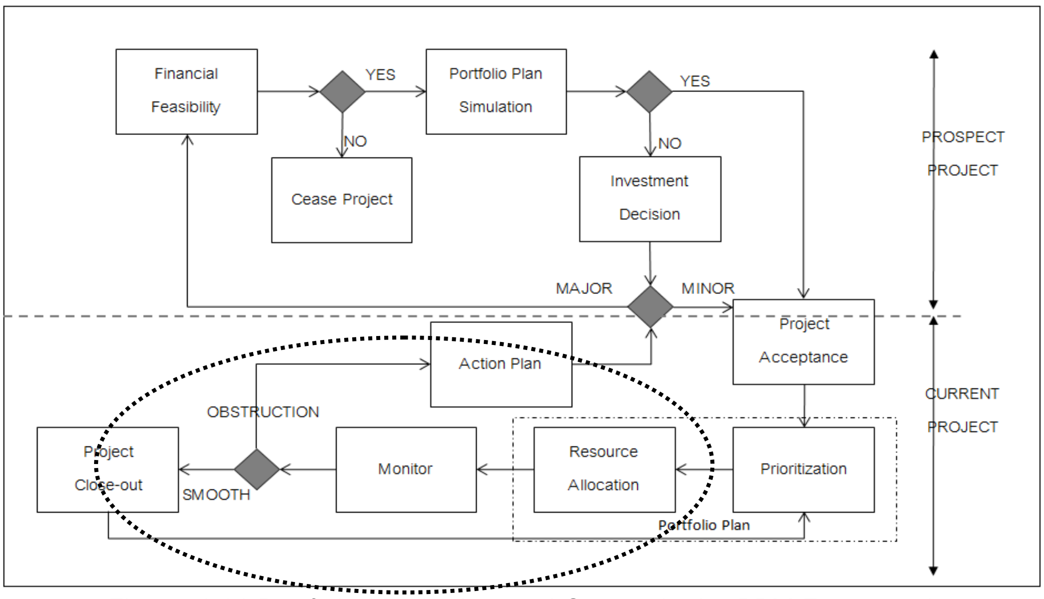

Figure 4.11 Portfolio Monitoring and Control in the PPM Framework

Once a disruption has been foreseen or occurred, the PPM Committee is required to make an action plan to counter the immediate problem and follow by an analysis of a long-term fixing. Nonetheless, if the action planned is not a major decision such as adding overtime or buying hand tools, these actions should be carried out straight away since maintaining the PP to be on track is more important so that the problem from one project does not stretch to affect the other projects in the portfolio. On the other hand, a problem can be a major decision which will require the approval from the top management or a further study to determine the feasibility and risks. In either case, the framework is looped so that adjustments are made to the PP in order to see the effects of the changes that will have on the portfolio. On the other hand, if a project goes as plan and finishes, the PP also requires an update to be made after each project close-out since more resources will be available.

4.5 Project Selection

As the final part of the framework, project selection is as important as managing the current projects. Referring to the PPM framework, project selection involves the work flow in the top half of the framework. Once a project is selected, through 'Project Acceptance', the selected project then gets included in the Portfolio Plan.

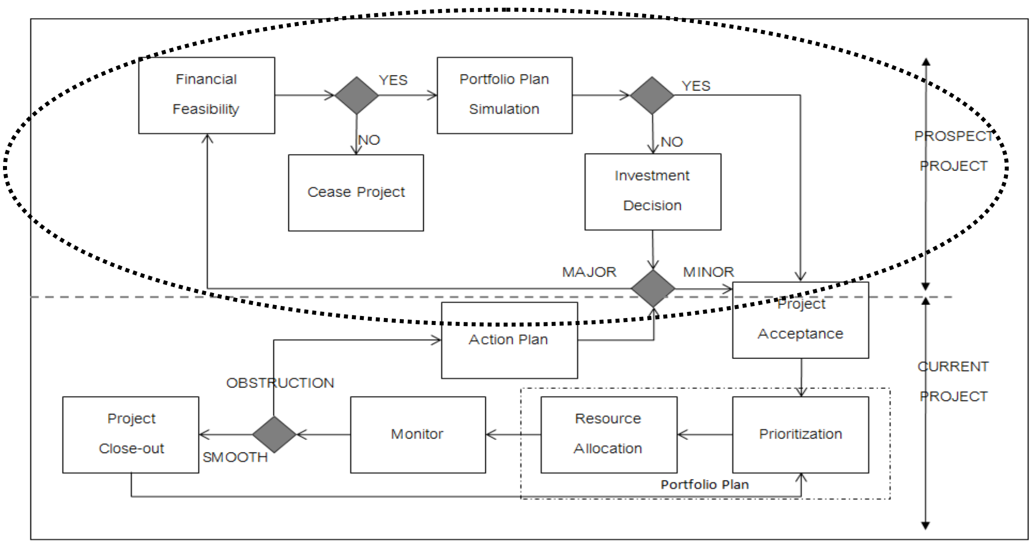

Figure 4.12 Project Selection in PPM Framework

As the first part of project selection, the marketing department is to undergo the project feasibility in terms of financial aspects and risks which coincides with the project screening process proposed by Gray et al (2011). If the prospect project is not feasible at this point, the project should be ceased. In the case that the project is financially viable, the marketing department is to propose the project to the PPM Committee in order for a PP simulation to be proceeded. Basically, a PP simulation is a test case scenario to check if the resources can be re-allocate to include the prospect project without undermining the delivery dates of the other projects in the portfolio. In case that the result from the PP simulation determines that more resources would be needed, the decision should be evaluated as a major or a minor decision. If a major decision is necessary, then the feasibility must be reassessed by the marketing team and the PPM Committee, to ensure that the investment is worth making. However, if a decision is considered as minor, the bidding for the project should be allowed while the necessary adjustments should be prepared in parallel so that the project can be smoothly executed once it is awarded. With the condition that a prospect project is required to undergo a PP simulation, the marketing department is linked with the production department early on through the PPM Committee, which results in more time allowance to make joint decisions and a proactive planning for the organization as a whole. This process, in turn, is expected to reduce the on-going conflicts between these two departments in the company. In summary, the PPM framework is in place for aligning the company's process with the business goals which allows for an efficient and participated decision making, and a systematic communication channel between functions. Reevaluating the system, the actual input of the system is not only the projects' demands but it also requires the actual production track, and what-if cases.

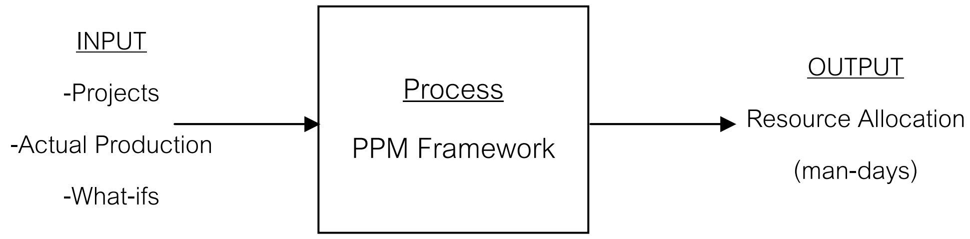

Figure 4.13 PPM System Schematic

By carrying out the processes in the PPM Framework, the production function can pinpoint the resources needed in order to meet the delivery demands and allocate such resources accordingly. By having these resources readily in advance, the proposed PPM framework can improve the delay problem in the company.

CHAPTER V

PPM FRAMEWORK EVALUATION

This chapter is for the purpose of evaluating the proposed PPM framework. The evaluation methodology is designed to test the effectiveness of the framework as well as to identify flaws and possible improvements. In this way, this chapter is divided into five main parts. The first part discusses the evaluation methodology and the expectations of the outcomes. In the latter parts, the evaluation is carried out in the testing timeframe of 12 weeks period to assess three main components of the PPM framework; the Portfolio Plan, the monitoring and control of projects, and the project selection process. Integrated in each section, suggestions and recommendations are made for future implementation. And lastly, a summary of the evaluation is provided.

5.1 Evaluation Methodology

The evaluation methodology used is a walkthrough process, by a mean of Excel simulation, against the real situations happening at the organization. In this manner, the test of the framework was carried out over a 12 weeks period in which over the specified period, all of the following steps in the framework were able to be tested. In order to organize the evaluation of the framework, each of the three process groups of the framework; Portfolio Plan, Portfolio Monitoring and Control, and Project Selection, are evaluated. Despite of a real test case, the missing factor is the establishment of the actual PPM Committee which was not carried out. Additionally, it is expected that the evaluation will allow for insightful findings of the framework's flaws and potential downsides. Due to the given nature of a multi-project company, it is anticipated changes and scenarios will occur, which in turn, the PPM framework will be used to support the decision makings to ensure an on-time delivery of all the projects in the portfolio. Each week Excel print out of the Portfolio Plan can be found in Appendix D.

5.2 Portfolio Plan Evaluation (Week 1 – 4)

As established, there are two main parts to the PP. The first part is the prioritization of projects which, in this case, each project was assigned a priority according to the perspective deadline where the highest priority was given to Project 1 and the lowest priority was given to Project 6 for the earliest and furthest deadline, respectively. This task was completed at the beginning of the evaluation period which is week no. 1.

Project Reference	Wks to Deadline	Priority
Project 1	6	1
Project 2	9	3
Project 3	10	4
Project 4	34	6
Project 5	8	2
Project 6	15	5

Table 5.1 Prioritization of Current Projects as of Week 1

Once the priority has been assigned, the next step is to calculate the minimum of units required per week for each project. In turn, this information can be used to calculate the weekly requirement for the working hours of each of the five major production processes. Similar to prioritization, the resource allocation is completed at the beginning of week 1. As the result, the actual production is compared with the PP in two parameters; the work progress and the resource consumption measured in man-week (equals to 6 man-days with 8 working hours per day).

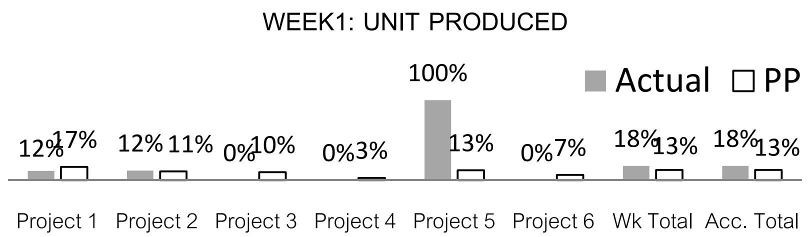

Figure 5.1 Percentage of Units Produced in Week 1

As shown in Figure 5.1, the actual production has completed Project 5 while started on Project 1 and Project 2 achieving 12% progress on both projects. Moreover, the progress is calculated by taking the number of units produced at the end of the week divided by the total number of the units needed. On the other hand, the PP started on all the projects, producing the minimum units required each week with the main condition that all deadlines are to be met. Overall, the actual production has achieved more than the PP with the total of 18% completion accumulated for all the projects. The problem with this summary is that it does not actually provide the information of which is doing better because the process is dependent on factors such as the length and the diameter of the products and therefore, producing more units of smaller size products will seem to be progressing faster (i.e. more number of units produced) than producing the units with a larger diameter and length which will require more time. However, the objective of the research is to focus on the project on-time delivery and therefore, as long as this goal is achieved, the success is to be measured at each due date rather than the work in progress. Further, it is also important to look at the man-hour usages to analyze the resource allocation in the two strategies.

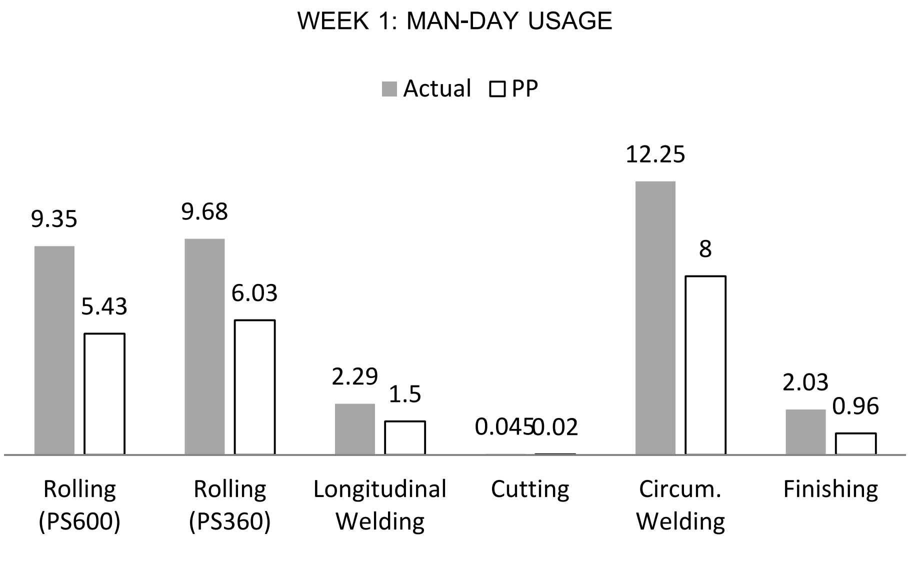

Figure 5.2 Man-day Usages for Week 1

Both the actual production's and PP's data show that circumferential welding is the most used capacity for the current project mix. Noticeably, the PP does not optimize the resource usage but only produces to the minimum units per week requirement. This identification detects the first flaw in the PP where the simulated production can actually make more units without have to use overtime but the PP does not take this logic into account. When the demand is lower than the capacity, the current PP is not the most efficient, but the effectiveness must remain. However, by adding a condition that the first process has to work at a minimum of 6 man-days (normal working days), the resource allocation for the subsequent processes will also change; hence, the time is spent efficiently at one process but overtime is needed for another process, unless if the demand is much less than the capacity then overtime may not be needed at all the consequential processes. In the real test case, if PS600 has to run for a minimum of 6 man-days, the circumferential welders will need more overtime to catch up for the work being done at the first station. Logically, this relationship is similar to a bottleneck problem in a production line where the least capacity determines the capacity of the entire production. However, a multi-projects environment is more complex where a bottleneck's existence is dependent on the project mix of the portfolio. With a different project mix, a bottleneck can shift to a different process, or also known as the wandering bottleneck (Leus et. al, 2003). And so, the condition is not only to require a minimum of 6 man-days for the first process but another condition, which is that all the subsequent process must not reach its capacity under normal working hours, must be satisfied in order to be truly optimized. But conclusively, the current PP is not logically formulated for a cost optimization.

Over the first three week evaluation period, another parameter which must be checked is the given capacity. This confirmation is important, because if the actual production can produce much more than the assumed capacity, then there will be a lot of time left because the PP has allowed for too much capacity. On the other hand, if the actual production is much smaller than the assumed capacity, this effect will cause a bigger problem that is the PP's schedule will always fall behind, when implemented in the real production, due to the fact that the PP has not allowed for enough capacity. For the rolling machines, the PP assumes that the data from the machine's manufacturer is valid which is also reconfirmed by an experienced production manager prior to the commitment of such assumption. Nonetheless, a set of random output was taken from the actual production data for the PS600 and PS360.

Pipe Size (x) (mm)	Actual Production		Manufacturer's Data			% Difference of Output
	Length Produced (m)	Man-Days Used	equation used	Output per day	Output Total (m)	
2200	420	9.5	$output/day = 254.5 \times e^{-(8\times10^{-4})x}$	43.8	416	1%
1500	516	7		76.65	536.6	-4%
2200	420	9.1	(see equation 3.1)	43.78	398.4	5%
900	114	1.4	$output/day = 163.7 \times e^{-(8\times10^{-4})x}$	79.68	111.5	2%
500	630	6		109.7	658.4	-5%
550	270	2.5	(see equation 3.2)	105.4	263.6	2%

Table 5.2 Actual vs. Theoretical Comparison for Rolling Machines Output

As shown above, the output figures given by the manufacturer are within an acceptable range of 5% difference to the actual production output. All other processes were verified in the chapter 3 and will be randomly re-verified at the end of the 6 weeks evaluation period.

During the first 3 weeks, there was not any major events occurred, and therefore, the PP only produces the weekly minimum at the end of each week. Figure 5.3 summarizes the accumulated units produced for each project by the end of week 3.

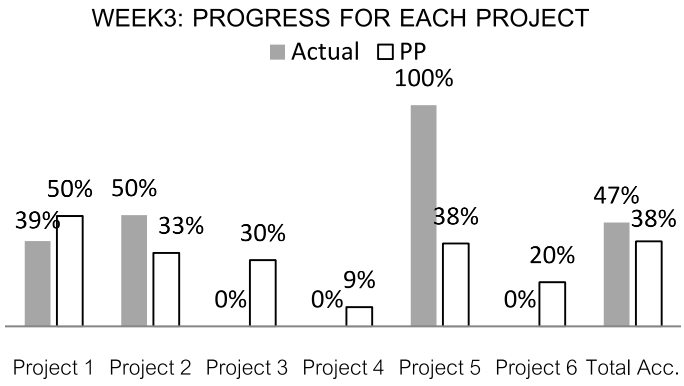

Figure 5.3 Work Progress at the End of Week 3

As the total work progress, the actual production is not too far ahead of the PP. Some noticeable differences are projects 3, 4, 5, and 6. The actual production has fully completed Project 5 whilst have not commerce on projects 3, 4, and 6. On the other hand, the PP has started on all projects with a constant gain each week but has not finished any project. For Project 1 which is the top priority, both methods are reaching the halfway line with approximately half of the time left. Despite the lack of a proper planning, the Production Manager is actually moving along according to the PP. Reasonably, this occurrence is not a coincidence, but it is because there are more resources available than the demands at this point. As long as the prioritization is aligned with the objective, there is more than one path to achieve the on-time goal. In this case, both the actual production and the PP have the same portfolio's prioritization and the demand is low; therefore, a highly proficient resource allocation has not yet shown its effect.

As the beginning of week 4, there was a new project added to the production line. Prior the research, this project was in the bidding process by the Marketing team who now has accepted the project. As the result, a new project starting in week 4 is assigned a project reference of Project 7. As suggested by the framework, this action would be an obstruction to the current PP. Therefore, the PP must be reconfigured which means re-prioritize and re-allocate of resources assuming the project is also accepted by the PPM Committee.

Project Reference	Wks to Deadline	Priority
Project 1	3	1
Project 2	6	3
Project 3	7	4
Project 4	31	7
Project 5	5	2
Project 6	13	6
Project 7	8	5

Table 5.3 Prioritization of Current Projects as of Week 4

As the given deadline of 8 weeks, the new project is ranked as the fifth priority, which means that all other previous projects with a later deadline must add 1 to the previous priority assignment. Unlike the actual production, the prioritization has not yet become too significantly important for the PP. The reason of this occurrence is because the PP has calculated that all the projects can be executed in parallel given the available resources. Moreover, prioritization becomes very important when a decision has to be made when the demand to produce the minimum units per week exceeds the production's capacity (Moore, 2010). So far, the production line is running as expected without any major setbacks. In addition to prioritization, the resource allocation in the PP must be adjusted due to the added project. Using the same technique as before, each of the items in Project 7 is calculated to determine the number of units required per week.

Project Reference	No. of wks left	Priority	Product List	size 1	Size 2	Total (pcs)	meter per pc	pcs required / wk
Project 7	8	5	Pipe	750		239	12	**29.88**
		5	Pipe	750		1	2.5	**0.13**
		5	Pipe	650		181	12	**22.63**

Table 5.4 Project 7 Information

Once the project is registered to the PP, the next step is to validate the process time required. The reason for this action is because if any of the working hour requirements exceed the allowable hours which were set by the Production Manager then it is necessary to evaluate for an alternative solution to protect the workers' condition.

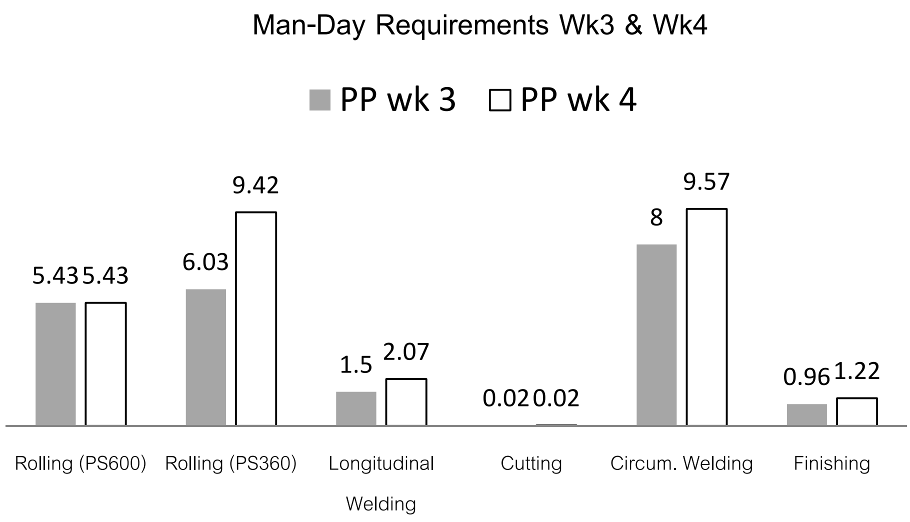

Figure 5.4 Man-day Requirements for PP Week 3 and Week 4

With the addition of Project 7, the two significant increases are the rolling process using PS360 machines and the circumferential welding which require a 9.42 and 9.57 man-days per week, respectively. Prior to this, the likely bottleneck was the circumferential welding process; as a benefit of the PP, PS360 rolling is now identifiable as a process to be cautious of. As shown through this case scenario, the company faces the challenge of a wandering bottleneck problem where the bottleneck has now changed according to the change in the project mix. As an effect, the wandering bottleneck baffles many managers and executives to be able to pinpoint where to invest. It then sets off the question if the investment should be made first to prevent ad-hoc reactions or it is too risky to invest knowing this dilemma. For the time being, the working hours of both processes are still acceptable, and therefore, the revised PP has accepted to carry out Project 7 to produce the previously calculated units per week. By doing so, all other outputs per week for the rest of the projects remain unchanged, but overtime hours are added to get more outputs. As for the actual production, the added project did not affect their current strategy as the new project is only considered to be queued until the earlier due date projects are completed. Nonetheless, by the end of week 4, the production department was able to fully completed projects 3 and 5.

From the first 4 weeks, the Portfolio Plan was able to give a tracking of the work in progress, a forecast of the tasks in the upcoming weeks, the capacity usage, and the resource allocation. Given a subtle situation of the past few weeks, the PP has not shown its what-ifs scenario capability and the advantages in times of difficulty. On the other hand, the Production Manager has not provided any breathing room for the workers and ran nearly 5 hours of overtime daily. From his experience, the 'as much as possible' strategy is found effective especially when he is hunching that something will go wrong and the hard work early on will pay off.

5.3 Portfolio Monitoring and Control Evaluation (Week 5 – 10)

Throughout the evaluation period, the task which is continuously performed is the monitoring and control; specifically, making sure that each project has achieved the minimum weekly units produced. In addition, it is sensible to periodically check the capacity for the processes. In this case, the circumferential welding process is randomly selected using the actual production outputs from weeks 4-6.

Welded Length	Man-day Usage	Meters per man-day	Assumed Capacity per day	% Difference
339.3	1.5	226.2	224	1.0%
559	2.5	223.6	224	-0.2%
706.9	3.14	225.13	224	0.5%
1003.7	4.5	223	224	-0,4%

Table 5.5 Circumferential Welding Capacity Verification

The above results are favorable as the actual values are very closely ranged to the values used in the PP. From monitoring the PP, the end of week 6 is the close-out of Project 1 which is the first completion out of all the projects. Therefore, the PP must be rechecked to ensure that no resources are still allocated for Project 6 which has finished. As for the actual production, they were also able to finish Project 1 by the end of week 6 as well.

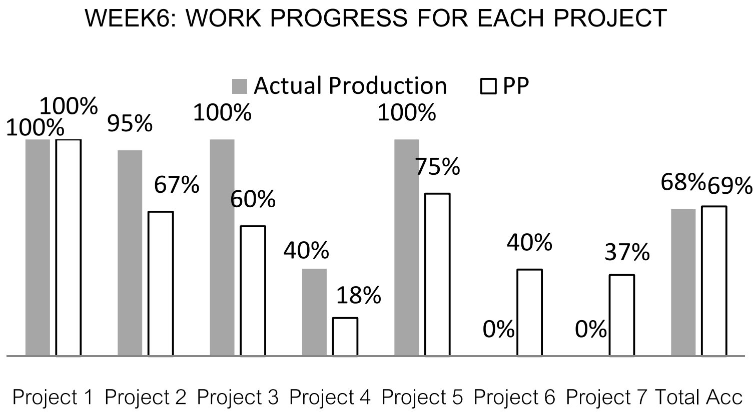

Figure 5.5 Work Progress at the End of Week 6

As a progress summary, the actual production has finished 3 projects which are projects 1, 3, and 5. In addition, Project 2 is nearly complete. However, they have not started on projects 6 and 7 which may become problematic in the later stages. To make the matter worse, one of the PS360 machines has broken down in the beginning of week 7. As a disruption emerges, an action plan is necessary as indicated in the PPM framework.

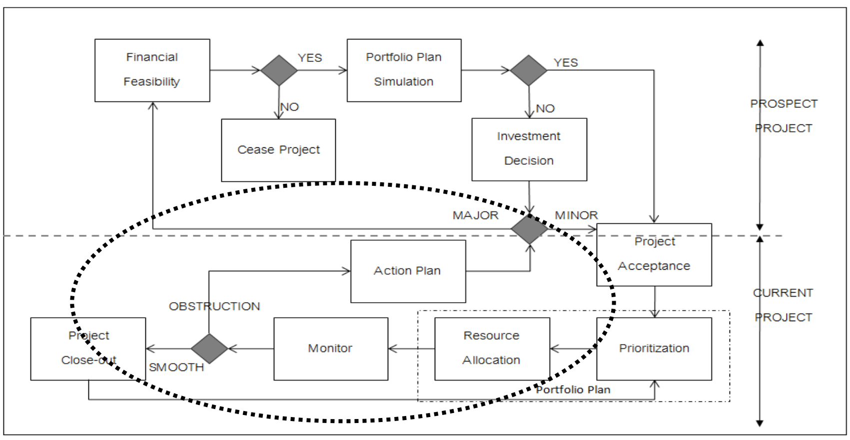

Figure 5.6 Monitoring and Control in PPM Framework

Having the PP available, several solutions can be proposed and since the main objective of the PPM is on-timeliness, not all the possibilities are discussed. Narrowing down to four options, the PP can be revised in several ways.

- Option 1: Run overtime so that all the weekly outputs remain constant

  Using this strategy, overtime is to be added for the other PS360 which is still available.

- Option 2: Halt all projects except Project 2

  Using this strategy, only the project with the highest priority will be operated. All resources are to be re-allocated to such project. In this case, the project which meets such conditions is Project 2.

- Option 3: Halt only projects with the requirement of PS360 except Project 2

  Using this strategy, projects 6 and 7 will be stopped in order to allow for the capacity of the remaining PS360 to be re-allocated to Project 2 which will be proceeded to obtain the minimum requirement per week.

- Option 4: Do nothing

  Using this strategy, all the outputs those required the process of PS360 will be reduced in half.

Intuitively, options 2 and 4 are less likely to be the way to handle the problem. However, the key benefit of the PPM framework is to provide a quantitative backup support for a decision making whilst the choices (options) are built on the foundation of intuitions and experiences. Hence, the PP can be simulated for the different case scenarios listed above. Moreover, all other processes can be shown as to their relationships to the breakdown event of the PS360.

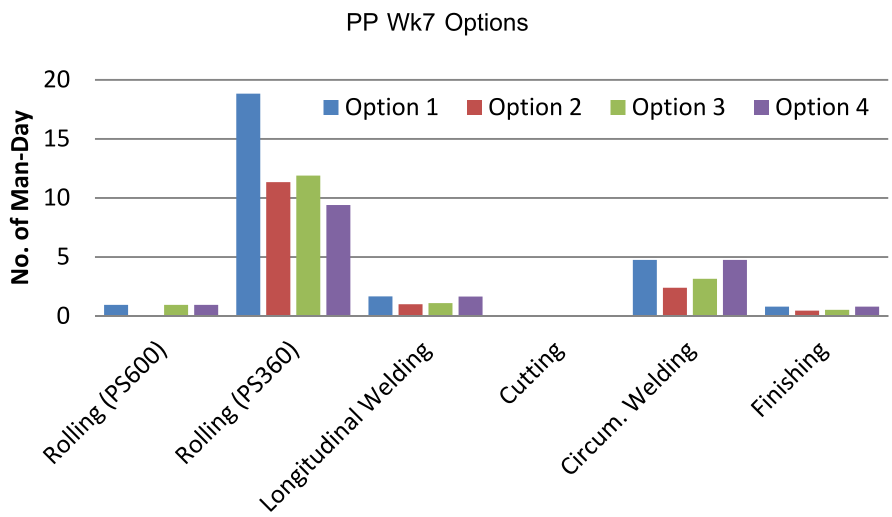

Figure 5.7 Week 7 Options for Portfolio Plan

If Option 1 is employed, the manufacturing plant will have to run the rolling process using the only PS360 left for over 20 hours per day for seven days a week. Obviously, the first option is certainly limited by the ability of the operators to endure such long hours. Even if there are operators available, running the only machine left for 22 hours per day is probably not the best idea since the machine cannot be easily replaced if there is another major damaged. Hence, the first option is an extreme case and ruled out. The second and the third options are then more realistic. The second option is to stop all other projects and put forth all resources towards Project 2 which is the highest prioritized project since Project 1 was completed at this point. By doing so, the hours needed for the rolling process are reduced tremendously, in comparison to Option 1, and the weekly outputs can be maintained. Nonetheless, the PP allows for further analysis as to that not all the projects will require to be stopped since not all the projects are impacted by the shutdown of the PS360 rolling machine. Hence, projects 2, 6, and 7 are the only three projects in the plant which significantly require the use of PS360 and should be halted. Finally, the last option is to do nothing. By choosing this option, an extra week will be needed (assuming the broken machine can be fixed by next week), where in the case of the PP, projects 2, 6, and 7 are likely to be delayed if this option is chosen. Using this case scenario, the PPM's problem solving becomes a logic process where possibilities are considered and weighted. Nonetheless, it is fair to say that the PP does not come up with the options, and it is the PPM Committee's responsibilities to input the what-ifs into the system and the PP acts as a tool to expedite the mathematical outcomes. In this way, the PP can provide substantial supports and options for the decision making. Intuitively, Option 3 is expected to be easily chosen looking at the outcome produced by the PP simulation as shown in Figure 5.7. Nevertheless, it is also important to confirm that the halted projects can be caught up to meet the deadlines. But since the time it takes to fix the broken PS360 is not known, perhaps, Option 1 should be chosen and the situation should be treated as a worst case scenario. If Option 3 is chosen and the machine is not soon fixed, then all the halted projects are basically waiting to be delayed. In order to solve this problem, the maintenance department was consulted. As the result, they had advised that a new part will be ready in 2 days and the machine can be fixed by next week. Hence, Option 3 is taken where projects 6 and 7 will be stopped while Project 2 will obtain the minimum weekly outputs. From this example, PPM is not just a management of the portfolio from a computer program. Efforts must be put in towards the real situations happening and promoting an effective communication across the company. The decision boxes are easily placed in the framework on paper, while in fact, decision making is one of the hardest requirements for the PPM Committee to do well. As for the actual production, Option 4 was chosen as they had kept on going with just one machine while working at the total amount of 8.5 man-days on the remaining PS360 machine for week 7. Expectedly, the broken PS360 was fixed at the end of week 7 as planned and was able to be used again by the beginning of week 8. Therefore, the PP must be readjusted with the availability of PS360 once more. Hence, the time required for PS360 will be added back in Week 8. Nonetheless, the required hours per week for PS360 is still more than week 6 (prior to the incident) because projects 6 and 7 which intensively require PS360 rolling must be caught up as an impact of the stoppage of these two projects in Week 7.

Project Reference	Product List	size 1	Size 2	Units To be Produced		
				Wk 6	Wk 7	Wk 8
Project 6	Pipe	750		0.67	0	1.1
	Pipe	500		0.27	0	0.4
	Pipe	500		0.07	0	0.1
	Miter	750		0.27	0	0.4
	Reducer	750	500	0.07	0	0.1
	Tee	750	750	0.07	0	0.1
Project 7	Pipe	750		29.88	0	37.3
	Pipe	750		0.13	0	0.2
	Pipe	650		22.63	0	28.3

Table 5.6 PP's Output Forecast for Project 6 and 7

In order to achieve this, PS360 must be operated at a minimum of 10 man-days per week until the end of week 9 when several projects are closed-out.

Throughout the evaluation period of 10 weeks, the Production Department has not missed any of the projects delivery schedule. In fact, they had been ahead of the PP in most of the projects in spite of the maximum use of the overtime spending. Moreover, they were able to choose to do nothing when one of the main machines was broken down.

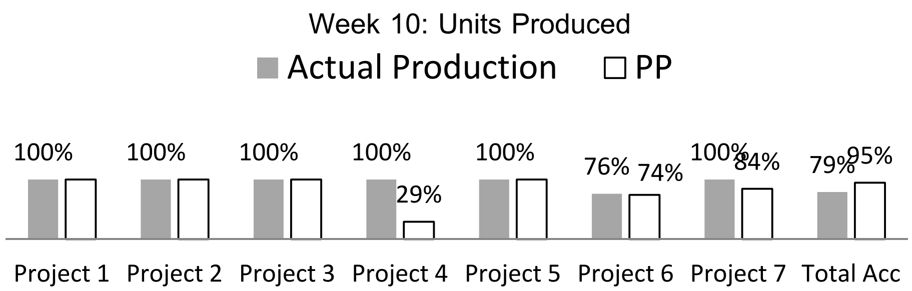

Figure 5.8 Week 10: Units Produced Comparison

As the result of 10-wks evaluation period, the PP is expected to provide enough support for running the actual production activities without undermining the delivery period. Interestingly, the amount of overtime and unused hours over the 10-week period coincide between the actual production and the PP.

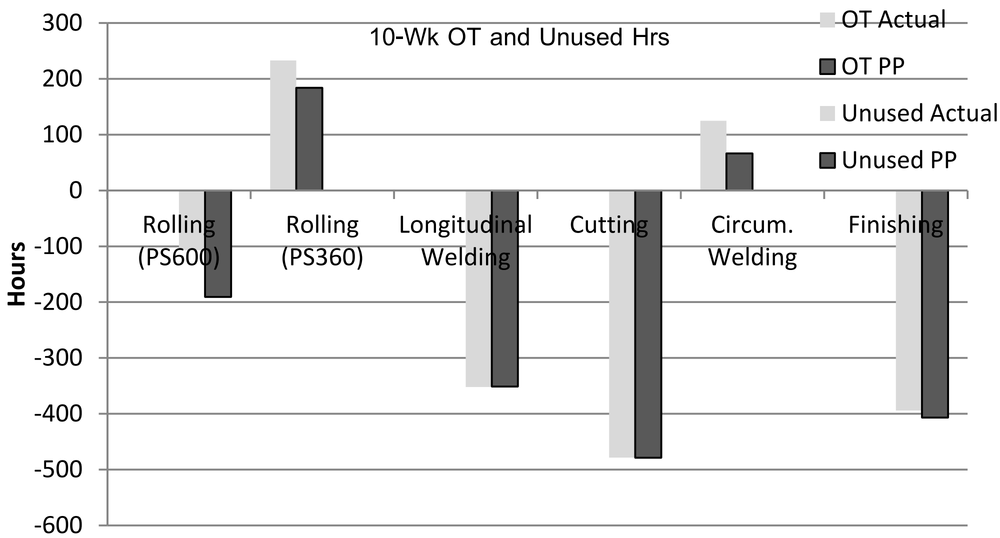

Figure 5.9 Summary of 10 weeks OT and Unused Hours

While the total accumulated progress of PP is much higher than the actual production as shown in Figure 5.8, the overtime usage over 10 weeks is about the same. As sounding as it seems, an opposing view is that the current PP does not allow for enough breathing room in case if something majorly goes wrongly. In another word, it is too 'just-in-time', which is arguably unrealistic for projects company. Evidently, if more lagged time was provided, the stoppage of PS360 would be less of a problem. Therefore, it is recommended that the PP should be improved so that it provides more lagged time if needed. A way which this can be employed is to reduce the 'number of weeks left' prior to the calculation of the required units per week, which in turn, will result in more weekly units required to be produced. Ironically, this finding opposes the lack of optimization as earlier claimed. The reason for this is because time has a higher priority than cost in the scope of this research. Nonetheless, by adapting the PPM's logic in this research, the cost factor can be prioritized or both cost and time can be weighted in the prioritization.

5.4 Project Selection Evaluation (Week 11-14)

During week 10, the customer of Project 7 wants to award a project similar to project 7 to the company. Hence, all the project parameters are to be the same as project 7. The only exception is that the company has to promise to deliver all the products of both projects within the deadline as set out for Project 7, so that the customer can save cost on the logistics. At the end of week 10, the production department has nearly finished all the projects on hand including Project 7 with only a few units left to be produced for Project 6 which can be finished within one day. Hence, the marketing team accepts the project.

Project Reference	No. of wks left	Priority	Product List	size 1	Size 2	Total (pcs)	meter per pc	Balance at the end of Wk 10 Actual
Project 6	7	6	Pipe	750		10	12	0
		6	Pipe	500		4	12	4
		6	Pipe	500		1	4.5	1
		6	Miter	750		4	5	0
		6	Reducer	750	500	1	3	0
		6	Tee	750	750	1	4.5	0
Project 7	2	5	Pipe	750		239	12	0
		5	Pipe	750		1	2.5	0
		5	Pipe	650		181	12	0

Table 5.7 Actual Production at the end of Week 10

So far, the production has not shown any sign of delay and that the employed strategy of producing as much as possible is working fantastically. In a way, this smooth going is a trap which makes everybody believes that this method is the way to maximize the output. Running a PP simulation, Project 8 (identical to Project 7 except with 2 weeks deadline) can be accepted if the production line can allow for 13.57 man-days per week which mean running both PS360 for 15.5 hours for the next two weeks.

Pcs per wk	Process Time Requirement for Project 8 in the Next Two Weeks											
	Rolling (PS600)		Rolling (PS360)		Longitudinal Welding		Cutting		Circumferential Welding		Finishing	
	(m)	(days)	(m)	(days)	(m)	(days)	(m)	(days)	(m)	(days)	(m)	(days)
119.5	0	0	1434	7.98	1434	1.26	0	0	845	3.77	2279	0.62
0.5	0	0	1.25	0.01	1	0.00	0	0	0	0.00	1	0.00
90.5	0	0	1086	5.58	1086	0.96	0	0	554	2.48	1640	0.45
Total	**0**	**0**	**2521.25**	**13.57**	**2521**	**2.22**	**0**	**0**	**1399**	**6.25**	**3920**	**1.07**

Table 5.8 Project 8 PP's Simulation

Simultaneously, the Marketing team is bidding for another project which they are likely to win and will be input into the portfolio in week 12.

Project Reference	No. of wks left	Product List	size 1	Size 2	Total (pcs)	meter per pc
Project 9	6	Pipe	2200		146	12
		Pipe	2200		3	3
		Pipe	700		320	12
		Pipe	700		1	3
		Flange	2200		292	
		Flange	700		640	

Table 5.9 Project 9's Information

Hence, the PP simulation can allocate the resources to investigate the possible route in order to complete both of the projects on-time. Again, there are several combinations which can be carried out. The first option is simply by taking an average for each product to be produced per week. As the result, there will need to be 211 units to be produced each week for Project 8 over the next two weeks. Additionally, 234 units will have to be produced for Project 9 starting the following week in order to meet both deadlines. More importantly, the assessment of the resource usage has to be investigated.

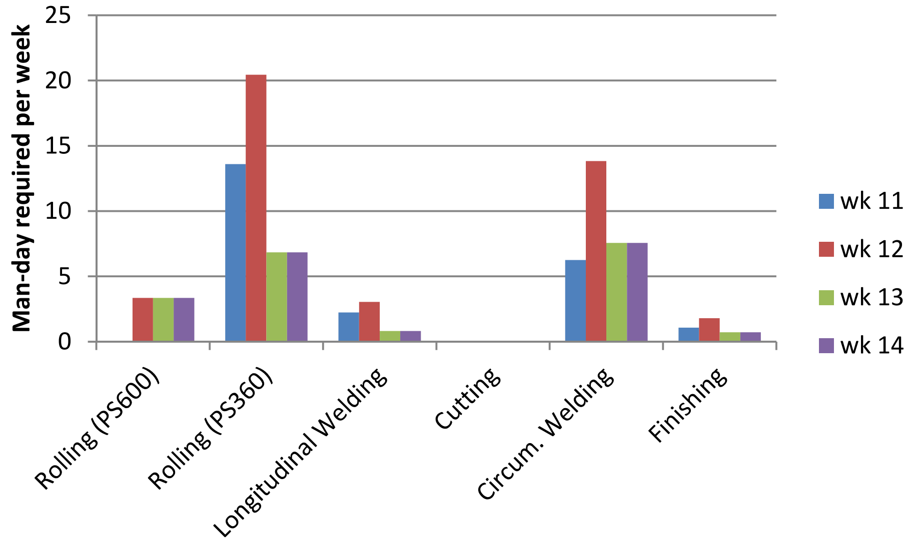

Figure 5.10 Projection for Resource Allocation from Week 11 - 14

As shown in Figure 5.10 above, the process which is problematic is the rolling process using the PS360. Specifically, in week 12 when both projects are executed, the machines will have to be used for approximately 23 hours per day for the whole week. Similar to the earlier studied problem, this option is not likely possible. Thus far, accepting both projects is assumed to be difficult especially for Project 8 which is due in 2 weeks. With the PP, the possible scenarios can be tested without much investment and time consumption. Due to a high variety of possibilities, it is recommended to first make some guesses as to the possible solutions. For this particular case, the obvious adjustment is needed for the PS360, and therefore, this process is the focus. Secondly, week 12 is the most loaded week, and so, from intuition, these two components are the ones to be lessened if possible. One of the possible solutions is then to reduce the load of PS360 by running lesser projects or producing lesser products for each or a partial of the projects. Hence, a possible solution is to stop Project 9, which has a lesser priority, and run solely Project 8 for Week 11 and 12.

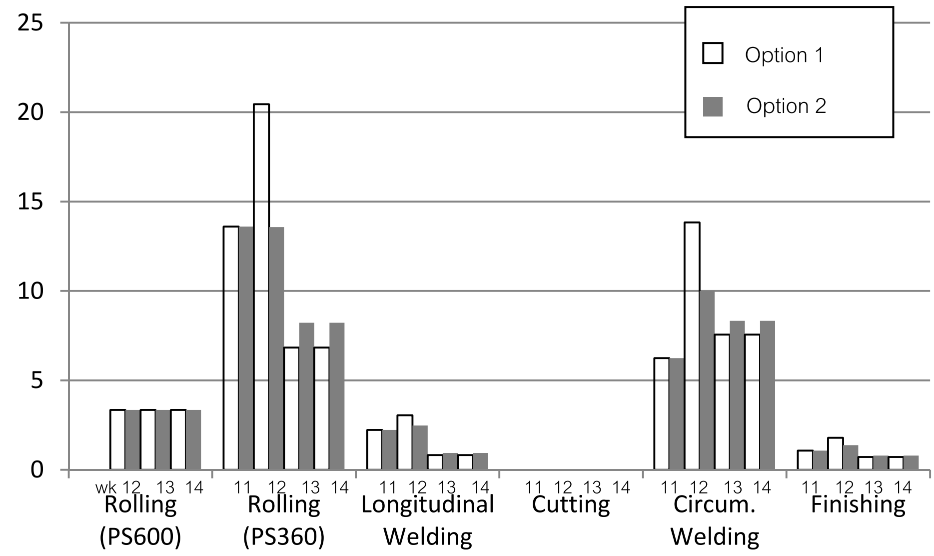

Figure 5.11 Resource Allocation for Options 1 & 2 (week 11 to 14)

Simulating option 2 in the PP, not running Project 9 for the products which need the use of the PS360 in week 12 reduces the resource requirement tremendously. Nonetheless, in the following weeks, option 2 must produce more units than option 1 for Project 9 in order to meet the 6 weeks deadline in week 17. Hence, it is possible to accept both projects under the conditions that Project 8 must finish first before Project 9 can use the PS360 and the machine must be used for 16 hours everyday (including Sunday) for the next two weeks (week 11 and 12).

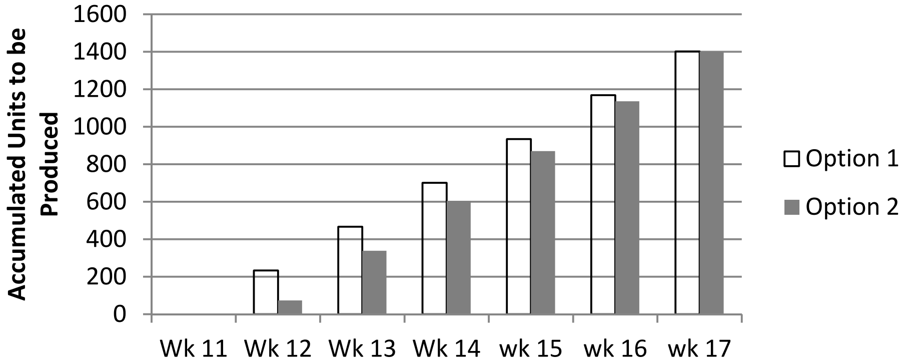

Figure 5.12 Project 9 Forecast

In reality, the production was able to complete a progress of 30% each week for Project 8, since they had limited the working man-days to 9.5 man-days per week, which caused them about 1.5 weeks delay. As Project 9 was initiated in week 14, two weeks later than the simulated PP, the delay problem further excavated. At this point, a suggestion was made to the production manager and that he must include a nightshift daily in order to catch up. Moreover, the rolling machine manufacturer was contacted to consult regarding the long hours usage per day since a machine's breakdown was an evident risk especially on the PS360 model. As the result, more time was needed because it was recommended to have a cool down time after every 8 hours of use for a 20 minutes session.

5.5 Evaluation Summary

Certainly, if the PPM framework was implemented for project selection, the PPM Committee will have to foresee the setback coming and will be able to proactively allocate the resources in order to keep the promise made to the customer and avoid the ad-hoc solutions. From the above evaluation of 12 weeks period, the PPM framework allows for an early detection of the resource deficit in undertaking incoming projects to the portfolio. Moreover, the PP provides case simulations for both current and prospect projects as well as a support for the development of action plans to counteract the unexpected event occurrences. In this way, the resources can be adjusted as soon as a potential delay is detected in order to achieve on-time deliveries. Additionally, the number of projects is no longer the difficulty in planning as the PP can be promptly evaluated in a repeatable and systematic logic. However, the difficulty still exists in formulating options where experiences as well as iterations of the plans are necessary. While numerous possibilities may be identifiable, one of the ways to narrow down the options is to add more conditions to the Portfolio Plan. As a brief example, the case of week 11 to 14 can be reevaluated with a cost parameter. Given the cost of the man resource of each position per day, Table 5.10 provides a cost input parameter which can be used to calculate the costs of different options.

	Rolling Operator	Longitudinal Welder	Cutter	Circumferential Welder	Finisher
Baht/day	620	700	240	780	220

Table 5.10 Wages per day

Taking the rate of overtime as 1.5 times the normal working day, Table 5.11 summarizes the man-day costs for each option.

	Wk 11		Wk 12		Wk 13		Wk 14		Total wk 11-14	
Option	1	2	1	2	1	2	1	2	1	2
Normal Time	10,196.40	10,196.40	13,005.80	12,516.60	11,209.40	11,311.00	11,209.40	11,311.00		
Overtime	7,360.50	7,360.50	22,599.60	11,720.10	2,606.40	4,790.70	2,606.40	4,790.70		
Total	17,556.90	17,556.90	35,605.40	24,236.70	13,815.80	16,101.70	13,815.80	16,101.70	80,793.90	73,997.00

Table 5.11 Man-day costs for option 1 & 2

Even if both options are possible, the cost constraint shows that the lower cost is to be selected using option 2 which is 73,997 baht in comparison to 80,793.90 baht for option 1. From this example, the PPM framework is more powerful by adding more conditions to support the decision making. Cautiously, a lower cost is not always a better option; and therefore, the constraints must be evaluated along with a risk assessment and by an experienced manager. Conclusively, the experience of the PPM Committee is an important factor which makes the PPM system effective. From the results of the evaluation, the PPM framework enables a proficient resource planning. The processes in the PPM framework counteract different scenarios for managing multi-projects company and measure against the resource interdependency problem which can improve the delivery time of the projects in the portfolio.

CHAPTER VI

CONCLUSION AND RECOMMENDATIONS

The problem of delay deliveries is certainly a classic and cyclical dilemma for many companies despite the differences in the business nature. For mass producers, such as commodity companies, solving the bottleneck means increasing the capacity, and therefore, increases the output of the total production line. On the other hand, construction companies are faced with a different set of challenges such as a delay in the critical path that puts them on turmoil of adding more resources to get to the finish line. Similarly, the objective of this research is to solve the on-going delay problem happening at the case study company. In this final chapter, the following sections summarize the findings and the outcomes of this research and provide further recommendations for future users and those readers interested in the subject of PPM.

6.1 Conclusion of the Research

The conclusion of the research is divided into four sections:

- Problem Analysis
- Theory Applied
- PPM Framework
- Framework Evaluation

6.1.1 Problem Analysis

The given problem is that the case study company cannot deliver their products to the customers on-time. From the nature of the business, BTEL is considered to be a project-based company. Nonetheless, there are characteristics that can differentiate two types of a project-based company. The first one is evident in a large construction company where each project team is working as a separate subunit towards the goals of the assigned project. All resources for this type are independent between projects, and its link to the home company is minimal. On the other hand, a project-based company can be a company who has many projects going through the company each year where the value of each project is considerably small in comparison to the investment made to establish the organization. Therefore, each project team is required to share the resources from a central pool; in another word, the resources are interdependent between the projects in the organization. Because of this resource pulling, all the projects must be taken into the account when developing the resource allocation plan. Looking from this view, the concern is no longer placed on each individual project but rather a combination of all the projects which is also known as the project portfolio. For BTEL, there are estimated 15-25 projects going through the company each year and without a proper resource planning and allocation, the delay problem manifests itself during the high demand period, which should be the period of profits. Instead, the high demand period is a burden period at the company where all the managers stop managing and spend their time tackling everyday's problems.

6.1.2 Theory Applied

From the problem analysis, it is clear that the management of the company's portfolio is far more important than managing each individual project itself. Hence, the Project Portfolio Management (PPM) techniques are adapted to fit the business context of the case study company. Correspondingly, PPM is widely used in the financial world of business. In such cases, the key measurement of success is undoubtedly the Return on Investment (ROI). For manufacturing business, however, PPM mainly focuses on Project Selection and Portfolio Prioritization, but similarly, PPM is applied to optimize risk-adjusted profits. Despite the business sector of applications, PPM focuses on the end results at the corporate level; and therefore, PPM is a strategic level management. In addition to PPM, the second theory of application is the method of resource allocation. Particularly, this research uses Rough-Cut Capacity Planning (RCCP) in order to minimize complexity and information which has less purpose for the strategic planning of the company.

6.1.3 PPM Framework

In the forth chapter, the PPM framework is introduced. The logic of the framework formulation is similar to a strategy formulation. The first step is simply to register the current capacity, available resources, and the current projects (demands). Secondly, the objective is to be able to deliver all the products by the given deadline; and moreover, the PPM framework breaks down each project's demand into a demand on a weekly basis in order to reduce the difficulty of visualizing the timeframe in months and to set a reachable weekly target for the Production Department. From the calculated weekly demands, the number of resources (in terms of man-days) can be obtained. If the number of the resources required exceeds the number of the resources available, the plan needs to be revised by adding more resources to match the demand or re-sequencing. Whichever way, this process requires what-ifs scenario and case simulation analyses. On the other hand, if the number of required resources does not exceed the resources available, the plan is accepted and to be executed by Production Department.

Despite of a painless task on paper, the reality is that there are constant changes and problems happening in the production line. In this way, the most difficult part of PPM is to be able to combine experience and the PPM techniques to perform the what-ifs scenarios and determine if such option is best for the current situation. Moreover, it is the understanding of the logic that is far more important, because in real life, no one can predict the future but experiences and knowledge along with the proper management tools can help to provide options and prepare for timely decision making. Hence, the proposed PPM framework is a feedback loop process where the portfolio needs to be monitor and adjustments must be made to counteract the constantly changing nature of the business.

6.1.4 PPM Framework Evaluation

Idealistically, the best way to test a methodology is to run 2 simultaneous processes under the exact same conditions and only apply the difference as the test subjects; over a lengthy period of time, the evaluation should be deterministic with confidence. However, it is not possible and not cost acceptable to run 2 production lines to test the framework in this research. Nonetheless, the framework evaluation method used is in attempt to simulate the actual production by having to react to the same scenarios as the Production Department faces for a 12-weeks period. In spite of a lesser degree in the realness, the findings are conclusive that the resource allocation by the PPM is practical and that the current production is to run into problems in the later weeks of the evaluation period. Another determination is that the reason that the current production strategy seems to be working from time to time is only because the demand did not exceed the allocated resources implemented by the Production Manager. When the demands exceed the available resources, the PP immediately shows the overloaded process and through a case simulation, a solution can be found by re-sequencing the work schedule of the later due project to be shifted to an earlier due project. Despite of its effectiveness, there are flaws which are discussed in the next section.

6.2 Recommendations

In this section, several flaws are identified in the aspect of the research itself and the proposed framework of the research. Integrating with such findings, potential improvements and further recommendations are suggested.

6.2.1 Limitation of the Research

The main flaw of this research is the lack of the financial aspects in the determination of the improvements. An assumption is made that by improving the delivery time, the company is expected to gain a higher profitability by not being penalized by the buyer and also, create more revenue through a higher customer satisfaction. Moreover, the research does not take into the account of the costs required in order to establish the PPM Committee to carry out the suggested improvements. In addition to the lack of the financial aspects, this research is limited on risks discussion which is undoubtedly cannot be overlooked when running a real business.

6.2.2 Future Recommendations

Certainly, several aspects are omitted in the proposed PPM framework, which requires a further examination of its practicality. The first area of improvement necessary is that the Portfolio Plan provides too little of a lagged time, where in reality, managing projects with the Just-in-Time ingredients is risky especially when the problem solving is directly linked to a time dependent factor. Secondly, the resource allocation method implemented in this research still lacks the refinement necessary for the Production Department to be able to further forward the developed plan without having to re-evaluate the practicality in an actual implementation. However, the refinement necessary is suggested to be performed by an experienced personal that is able to judge and make sound decisions. Specifically, several activities in the production line are excluded such as machines' setup time and the movement of goods. Moreover, the calculated weekly demand is shown in integer numbers where in reality the values are most likely to be whole numbers. And lastly, the resource allocation method applied does not allow for optimization and best fit solution is not provided. The current solution solver is done by an iterative method which is not convenient and the outcome is not optimized. For this case, an uplift of the technological know-how is necessary as well as a further logic formulation in order to optimize the output. Nevertheless, it is shown that a proficient resource planning is necessary regardless of the technology complexity; and the logic use in this research provides an in-depth analysis of PPM and applies its techniques to improve the delivery time of the projects in the company's portfolio.

REFERENCES

Barkley, B. (2004). Project Risk Management. New York: McGraw-Hill.

Billows, R. A. (2010). Program & Portfolio Management. Colorado: The Hampton Group.

Burke, R. (1999). Project Management: Planning and control techniques. New Jersey: John Wiley & Sons.

Dye, L. D., & Pennypacker, J. S. (Eds.). (1999). Project Portfolio Management: Selecting and prioritizing projects for competitive advantage. West Chester: Center of Business Practices.

Gray, C. F., & Larson, E. W. (2011). Project Manager: The managerial process. New York: McGraw-Hill.

Gruia, M. (2003). Efficient Frontier Technique for Analyzing Project Portfolio Management (UMT whitepaper). Available from UMT Portfolio Management.

Kezner, H. (2006). Project Management: A System Approach to Planning, Scheduling, and Control. New Jersey: John Wiley & Sons.

Kotter, J. P. (1996). Leading Change. Boston: Harvard Business School Press.

Latham, G. P., Locke, E. A. (1975). Increasing productivity and decreasing time limits: A field replication of Parkinson's law. Journal of Applied Psychology, Vol 60(4), 524-526.

Leus, R., Wullink, G., Hans, E. W., & Herroelen, W. (2003). A Hierarchical Approach to Multi-project Planning Under Uncertainty. Available from School of Business, Public Administration & Technology University Twenty.

Levine, H. A. (2006). Project Portfolio Management: A practical guide to selecting projects, managing portfolios, and maximizing benefits. San Francisco: Jossey-Bass.

Moore, S. (2010). Strategic Project Portfolio Management: Enabling a productive organization. New Jersey: John Wiley & Sons.

Pennypacker, J. S., & Retna, S. (Eds.). (2009). Project Portfolio Management: A view from the management trenches. New Jersey: John Wiley & Sons.

Sanwal, A. (2007). Optimizing Corporate Portfolio Management. New Jersey: John Wiley & Sons.

Turner, R. J. (2009). The Handbook of Project Based Management: Leading strategic change in organizations. New York: McGraw-Hill.

Wideman, M. R. (2004). A Management Frame for Project, Program and Portfolio Integration. Vancouver: Trafford.

Wysocki, R. (2004). Project Management Process Improvement. Boston: Artech House.

Appendices

Appendix A

Appendix A: Rolling Machine Capacity

Table A-1: PS600 Rolling Capacity

NOM.	WALL THICK.		MAX LENGTH	OUTPUT / DAY				OUTPUT / YEAR		
DIA	MIN.	MAX.	(EACH CAN)	LENGTH	LENGTH	MIN WALL	MAX WALL	LENGTH	MIN WALL	MAX WALL
MM	MM	MM	M	M / DAY	M / WK	MT / DAY	MT / DAY	M / YEAR	MT / YEAR	MT / YEAR
1000	6	32	4.5	126	756	18.65	99.48	37,800	5,595.48	29,842.56
1100	6	32	4.5	117	702	19.05	101.61	35,100	5,715.38	30,482.04
1200	6	37	4.5	108	648	19.18	118.30	32,400	5,755.35	35,491.33
1300	8	38	4.5	99	594	25.40	120.66	29,700	7,620.51	36,197.43
1400	8	40	4.5	90	540	24.87	124.34	27,000	7,460.64	37,303.20
1500	8	42	4.5	81	486	23.98	125.90	24,300	7,194.19	37,769.49
1600	8	42	4.5	72	432	22.74	119.37	21,600	6,821.16	35,811.07
1800	8	44	4.5	63	378	22.38	123.10	18,900	6,714.58	36,930.17
2000	10	46	4.5	54	324	26.65	122.57	16,200	7,993.54	36,770.30
2200	10	48	4.5	45	270	24.42	117.24	13,500	7,327.41	35,171.59
2500	10	51	4.5	36	216	22.20	113.24	10,800	6,661.29	33,972.56
3000	12	51	4.5	27	162	23.98	101.92	8,100	7,194.19	30,575.30
3200	12	52	4.5	27	162	25.58	110.84	8,100	7,673.80	33,253.14
3500	12	53	4.5	18	108	18.65	82.38	5,400	5,595.48	24,713.37

Table A-2: PS360 Rolling Capacity

NOM	WALL THICK.		MAX LENGTH	OUTPUT / DAY				OUTPUT / YEAR		
DIA	MIN.	MAX.	(EACH CAN)	LENGTH	LENGT	MIN WALL	MAX WALL	LENGTH	MIN WALL	MAX WALL
MM	MM	MM	M	M / DAY	M / WK	MT / DAY	MT / DAY	M / YEAR	MT / YEAR	MT / YEAR
450	6	15	3	100	600	5.60	13.99	25,200	1,678.64	4,196.61
500	6	15	3	98	588	6.22	15.54	25,200	1,865.16	4,662.90
600	6	15	3	96	576	7.46	18.65	25,200	2,238.19	5,595.48
700	6	15	3	94	564	8.70	21.76	25,200	2,611.22	6,528.06
800	6	15	3	88	520	9.95	24.87	25,200	2,984.26	7,460.64
900	6	15	3	84	504	11.19	27.98	25,200	3,357.29	8,393.22
1000	6	15	3	78	468	11.55	28.87	23,400	3,463.87	8,659.67
1100	6	22	3	72	432	11.72	42.99	21,600	3,517.16	12,896.25
1200	6	22	3	66	396	11.72	42.99	19,800	3,517.16	12,896.25
1300	8	23	3	60	360	15.39	44.26	18,000	4,618.49	13,278.16
1400	8	24	3	54	324	14.92	44.76	16,200	4,476.38	13,429.15
1500	8	25	3	48	288	14.21	44.41	14,400	4,263.22	13,322.57
1600	8	26	3	42	252	13.26	43.11	12,600	3,979.01	12,931.78
1800	8	27	3	36	216	12.79	43.17	10,800	3,836.90	12,949.54
2000	10	27	3	30	180	14.80	39.97	9,000	4,440.86	11,990.31
2200	10	27	3	24	144	13.03	35.17	7,200	3,907.95	10,551.48
2500	10	28	3	18	108	11.10	31.09	5,400	3,330.64	9,325.80
3000	10	30	3	12	72	8.88	26.65	3,600	2,664.51	7,993.54

Appendix B

Appendix B: Product-Process Calculation for Each Project

Table B-1: Product-Process Calculation Matrix

	Rolling (R)	Longitudinal Welding (LW)	Cutting (C)	Circumferential Welding (CW)	Finishing (F)
Pipe	L	L	0	c x (n-1)	LW+CW
Miter	L	L	c x (n-1)	c x (n-1)	LW+CW
Reducer	L	L	0	c x (n-1)	LW+CW
Tee	L	L	$2c_b$	(c x (n-1))+ c_b	LW+CW
Flange	0	0	0	C	CW

L = length per piece; c = circumference; c_b = circumference of branch; n = no. of sections; R = rolling; LW = longitudinal Weld; C = cutting;

CW = circumferential welding; F = finishing

Table B-2: Process Requirement for Project 1

Product Information								Process Requirement (meters / piece)						
Products	DN1 (mm)	DN2 (mm)	thickness (mm)	Length	q'ty (pcs)	Circumference (m)	Circumferential Welds per piece (no./pc)	Rolling (PS600)	Rolling (PS360)	Rolling (PS600 or PS360)	Longitudinal Welding	Cutting	Circumferential Welding	Finishing
				L		c	(n-1)							
Pipe	2200		16	12	143	6.91	3			12	12	0	20.73	32.73
Pipe	2200		16	6	4	6.91	1			6	6	0	6.91	12.91
Pipe	1500		12	12	86	4.71	3			12	12	0	14.14	26.14
Miter	2200		16	6	3	6.91	4			6	6	27.65	27.65	33.65
Miter	1500		12	5	3	4.71	4			5	5	18.85	18.85	23.85
Flange	2200				189	6.91	1					0	6.91	6.91
Flange	1500				175	4.71	1					0	4.71	4.71

Table B-3: Process Requirement for Project 2

Product Information								Process Required (meters / piece)						
Products	DN1 (mm)	DN2 (mm)	thickness (mm)	Length	q'ty (pcs)	Circumference (m)	Circumferential Welds per piece (no./pc)	Rolling (PS600)	Rolling (PS360)	Rolling (PS600 or PS360)	Longitudinal Welding	Cutting	Circumferential Welding	Finishing
				L		c	(n-1)							
Pipe	500		6	12	321	1.57	3		12		12	0	4.71	16.7
Pipe	500		6	3	22	1.57	0		3		3	0	0	3.0
Pipe	550		6	12	45	1.728	3		12		12	0	5.18	17.2
Pipe	550		6	3	3	1.728	0		3		3	0	0	3.0
Pipe	600		6	12	190	1.885	3		12		12	0	5.65	17.7
Pipe	600		6	3	6	1.885	0		3		3	0	0	3.0
Pipe	700		6	12	4	2.199	3		12		12	0	6.60	18.6
Pipe	750		12	12	286	2.356	3		12		12	0	7.07	19.1

Table B-4: Process Requirement for Project 3

Product Information								Process Required (meters / piece)						
Products	DN1 (mm)	DN2 (mm)	thickness (mm)	Length	q'ty (pcs)	Circumference (m)	Circumferential Welds per piece (no./pc)	Rolling (PS600)	Rolling (PS360)	Rolling (PS600 or PS360)	Longitudinal Welding	Cutting	Circumferential Welding	Finishing
				L		c	(n-1)							
Pipe	3000		19	12	12	9.42	3	12			12	0	28.27	40.27
Pipe	3000		19	11	1	9.42	3	11			11	0	28.27	39.27
Miter	3000		19	8	2	9.425	4	8			8	37.70	37.70	45.70

Table B-5: Process Requirement for Project 4

Product Information								Process Required (meters / piece)						
Products	DN1 (mm)	DN2 (mm)	thickness (mm)	Length	q'ty (pcs)	Circumference (m)	Circumferential Welds per piece (no./pc)	Rolling (PS600)	Rolling (PS360)	Rolling (PS600 or PS360)	Longitudinal Welding	Cutting	Circumferential Welding	Finishing
				L		c	(n-1)							
Pipe	3600		16	12	36	11.31	3	12			12	0	33.93	45.93
Pipe	3600		16	3	1	11.31	0	3			3	0	0	3
Pipe	1200		12.7	12	12	3.770	3			12	12	0	11.31	23.31
Pipe	1200		12.7	1.5	1	3.770	0			1.5	1.5	0	0	1.5
Pipe	450		8	12	6	1.414	3		12		12	0	4.24	16.24
Miter	1200		12.7	6	6	3.770	4			6	6	15.08	15.08	21.08

Table B-6: Process Requirement for Project 5

Product Information								Process Required (meters / piece)						
Products	DN1 (mm)	DN2 (mm)	thickness (mm)	Length	q'ty (pcs)	Circumference (m)	Circumferential Welds per piece (no./pc)	Rolling (PS600)	Rolling (PS360)	Rolling (PS600 or PS360)	Longitudinal Welding	Cutting	Circumferential Welding	Finishing
				L		c	(n-1)							
Pipe	1200		8	12	11	3.77	3			12	12	0	11.31	23.31
Pipe	900		8	12	19	2.83	3		12		12	0	8.48	20.48
Pipe	450		6	6	14	1.41	1		6		6	0	1.41	7.41
Miter	1200		8	5.5	4	3.77	4			5.5	5.5	15.08	15.08	20.58
Miter	900		8	5	2	2.83	4		10		5	11.31	11.31	16.31
Miter	450		6	3.5	2	1.41	2		7		3.5	2.83	2.83	6.33
Flange	1200		8		20	3.77	1				0	0	3.77	3.77
Flange	900		8		46	2.83	1				0	0	2.83	2.83
Flange	450		6		5	1.41	1				0	0	1.41	1.41
Reducer	1200	900	8	5.5	1	3.77	1		5.5		5.5	0	3.77	9.27
Reducer	900	450	8	4.5	1	2.83	0		4.5		4.5	0	0.00	4.50
Tee	1200	450	8	7	1	3.77	1		7		7	11.3097336	3.77	10.77

Table B-7: Process Requirement for Project 6

Product Information								Process Required (meters / piece)						
Products	DN1 (mm)	DN2 (mm)	thickness (mm)	Length	q'ty (pcs)	Circumference (m)	Circumferential Welds per piece (no./pc)	Rolling (PS600)	Rolling (PS360)	Rolling (PS600 or PS360)	Longitudinal Welding	Cutting	Circumferential Welding	Finishing
				L		c	(n-1)							
Pipe	750		6	12	10	2.36	3		12		12	0	7.07	19.07
Pipe	500		6	12	4	1.57	3		12		12	0	4.71	16.71
Pipe	500		6	4.5	1	1.57	1		4.5		4.5	0	1.57	6.07
Miter	750		6	5	4	2.36	4		5		5	9.42	9.42	14.42
Reducer	500	750	6	3	1	1.57	0		3		3	0	0.00	3
Tee	750	750	6	4.5	1	2.36	1		4.5		4.5	2.36	2.36	6.86

Table B-8: Process Requirement for Project 7

Product Information								Process Required (meters / piece)						
Products	DN1 (mm)	DN2 (mm)	thickness (mm)	Length	q'ty (pcs)	Circumference (m)	Circumferential Welds per piece (no./pc)	Rolling (PS600)	Rolling (PS360)	Rolling (PS600 or PS360)	Longitudinal Welding	Cutting	Circumferential Welding	Finishing
				L		c	(n-1)							
Pipe	750		10	12	239	2.36	3		12		12	0	7.07	19.07
Pipe	750		10	2.5	1	2.36			2.5		2.5	0	0	2.5
Pipe	650		10	12	181	2.04	3		12		12	0	6.13	18.13

Table B-9: Process Requirement for Project 8

Product Information								Process Required (meters / piece)						
Products	DN1 (mm)	DN2 (mm)	thickness (mm)	Length	q'ty (pcs)	Circumference (m)	Circumferential Welds per piece (no./pc)	Rolling (PS600)	Rolling (PS360)	Rolling (PS600 or PS360)	Longitudinal Welding	Cutting	Circumferential Welding	Finishing
				L		c	(n-1)							
Pipe	750		10	12	239	2.36	3		12		12	0	7.07	19.07
Pipe	750		10	2.5	1	2.36			2.5		2.5	0	0	2.5
Pipe	650		10	12	181	2.04	3		12		12	0	6.13	18.13

Table B-9: Process Requirement for Project 9

Product Information								Process Requirement (meters / piece)						
Products	DN1 (mm)	DN2 (mm)	thickness (mm)	Length	q'ty (pcs)	Circumference (m)	Circumferential Welds per piece (no./pc)	Rolling (PS600)	Rolling (PS360)	Rolling (PS600 or PS360)	Longitudinal Welding	Cutting	Circumferential Welding	Finishing
				L		c	(n-1)							
Pipe	2200		12	12	146	6.91	3	12			12		20.73	32.73
Pipe	2200		12	3	3	6.91	0	3			3		0.00	3.00
Pipe	700		8	12	320	2.20	3		12		12		6.60	18.60
Pipe	700		8	3	1	2.20	0		3		3		0.00	3.00
Flange	2200				292	6.91	1						6.91	6.91
Flange	1500				640	4.71	1						4.71	4.71

Appendix C

Appendix C: Actual Production Output on a Weekly Basis

Table C-1: Production Data for Week 1

Project Reference	No. of wks left	Product List	Diameter (mm)		Length (m/pc)	Beginning of the Week (pcs)	Actual Produced (pcs)	Balance End of the Week (pcs)
			size 1	Size 2				
Project 1	6	Pipe	2200		12	143	70	73
		Pipe	2200		6	4		4
		Pipe	1500		12	86		86
		Miter	2200		6	3		3
		Miter	1500		5	3		3
		Flange	2200			189		189
		Flange	1500			175		175
Project 2	9	Pipe	500		12	321	105	216
		Pipe	500		3	22		22
		Pipe	550		12	45		45
		Pipe	550		3	3		3
		Pipe	600		12	190		190
		Pipe	600		3	6		6
		Pipe	700		12	4		4
		Pipe	750		12	286		286
Project 3	10	Pipe	3000		12	12		12
		Pipe	3000		11	1		1
		Miter	3000		8	2		2
Project 4	34	Pipe	3600		12	36		36
		Pipe	3600		3	1		1
		Pipe	1200		12	12		12
		Pipe	1200		1.5	1		1
		Pipe	450		12	6		6
		Miter	1200		6	6		6
Project 5	8	Pipe	1200		12	11	11	0
		Pipe	900		12	19	19	0
		Pipe	450		6	14	14	0
		Miter	1200		5.5	4	4	0
		Miter	900		5	2	2	0
		Miter	450		3.5	2	2	0
		Flange	1200			22	22	0
		Flange	900			46	46	0
		Flange	450			5	5	0
		Reducer	1200	900	5.5	1	1	0
		Reducer	900	450	4.5	1	1	0
		Tee	1200	450	7	1	1	0
Project 6	15	Pipe	750		12	10		10
		Pipe	500		12	4		4
		Pipe	500		4.5	1		1
		Miter	750		5	4		4
		Reducer	750	500	3	1		1
		Tee	750	750	4.5	1		1

Table C-2: Production Data for Week 2

Project Reference	No. of wks left	Product List	Diameter (mm) size 1	Diameter (mm) Size 2	Length (m/pc)	Beginning of the Week (pcs)	Actual Produced (pcs)	Balance End of the Week
Project 1	5	Pipe	2200		12	73	70	3
		Pipe	2200		6	4		4
		Pipe	1500		12	86		86
		Miter	2200		6	3		3
		Miter	1500		5	3		3
		Flange	2200			189		189
		Flange	1500			175		175
Project 2	8	Pipe	500		12	216	169	47
		Pipe	500		3	22		22
		Pipe	550		12	45		45
		Pipe	550		3	3		3
		Pipe	600		12	190		190
		Pipe	600		3	6		6
		Pipe	700		12	4		4
		Pipe	750		12	286		286
Project 3	9	Pipe	3000		12	12		12
		Pipe	3000		11	1		1
		Miter	3000		8	2		2
Project 4	33	Pipe	3600		12	36		36
		Pipe	3600		3	1		1
		Pipe	1200		12	12		12
		Pipe	1200		1.5	1		1
		Pipe	450		12	6		6
		Miter	1200		6	6		6
Project 5	7	Pipe	1200		12	0		0
		Pipe	900		12	0		0
		Pipe	450		6	0		0
		Miter	1200		5.5	0		0
		Miter	900		5	0		0
		Miter	450		3.5	0		0
		Flange	1200			0		0
		Flange	900			0		0
		Flange	450			0		0
		Reducer	1200	900	5.5	0		0
		Reducer	900	450	4.5	0		0
		Tee	1200	450	7	0		0
Project 6	14	Pipe	750		12	10		10
		Pipe	500		12	4		4
		Pipe	500		4.5	1		1
		Miter	750		5	4		4
		Reducer	750	500	3	1		1
		Tee	750	750	4.5	1		1

Table C-3: Production Data for Week 3

Project Reference	No. of wks left	Product List	Diameter (mm) size 1	Diameter (mm) Size 2	Length (m/pc)	Beginning of the Week (pcs)	Actual Produced (pcs)	Balance End of the Week
Project 1	4	Pipe	2200		12	3	3	0
		Pipe	2200		6	4	4	0
		Pipe	1500		12	86	86	0
		Miter	2200		6	3		3
		Miter	1500		5	3		3
		Flange	2200			189		189
		Flange	1500			175		175
Project 2	7	Pipe	500		12	47	47	0
		Pipe	500		3	22	22	0
		Pipe	550		12	45	45	0
		Pipe	550		3	3	3	0
		Pipe	600		12	190	50	140
		Pipe	600		3	6		6
		Pipe	700		12	4		4
		Pipe	750		12	286		286
Project 3	8	Pipe	3000		12	12		12
		Pipe	3000		11	1		1
		Miter	3000		8	2		2
Project 4	32	Pipe	3600		12	36		36
		Pipe	3600		3	1		1
		Pipe	1200		12	12		12
		Pipe	1200		1.5	1		1
		Pipe	450		12	6		6
		Miter	1200		6	6		6
Project 5	6	Pipe	1200		12	0		0
		Pipe	900		12	0		0
		Pipe	450		6	0		0
		Miter	1200		5.5	0		0
		Miter	900		5	0		0
		Miter	450		3.5	0		0
		Flange	1200			0		0
		Flange	900			0		0
		Flange	450			0		0
		Reducer	1200	900	5.5	0		0
		Reducer	900	450	4.5	0		0
		Tee	1200	450	7	0		0
Project 6	13	Pipe	750		12	10		10
		Pipe	500		12	4		4
		Pipe	500		4.5	1		1
		Miter	750		5	4		4
		Reducer	750	500	3	1		1
		Tee	750	750	4.5	1		1

Table C-4: Production Data for Week 4

Project Reference	No. of wks left	Product List	Diameter (mm)		Length (m/pc)	Beginning of the Week (pcs)	Actual Produced (pcs)	Balance End of the Week
			size 1	Size 2				
Project 1	3	Pipe	2200		12	0		0
		Pipe	2200		6	0		0
		Pipe	1500		12	0		0
		Miter	2200		6	3	3	0
		Miter	1500		5	3	3	0
		Flange	2200			189	80	109
		Flange	1500			175		175
Project 2	6	Pipe	500		12	0		0
		Pipe	500		3	0		0
		Pipe	550		12	0		0
		Pipe	550		3	0		0
		Pipe	600		12	140	140	0
		Pipe	600		3	6		6
		Pipe	700		12	4		4
		Pipe	750		12	286		286
Project 3	7	Pipe	3000		12	12	12	0
		Pipe	3000		11	1	1	0
		Miter	3000		8	2	2	0
Project 4	31	Pipe	3600		12	36	7	29
		Pipe	3600		3	1		1
		Pipe	1200		12	12		12
		Pipe	1200		1.5	1		1
		Pipe	450		12	6		6
		Miter	1200		6	6		6
Project 5	5	Pipe	1200		12	0		0
		Pipe	900		12	0		0
		Pipe	450		6	0		0
		Miter	1200		5.5	0		0
		Miter	900		5	0		0
		Miter	450		3.5	0		0
		Flange	1200			0		0
		Flange	900			0		0
		Flange	450			0		0
		Reducer	1200	900	5.5	0		0
		Reducer	900	450	4.5	0		0
		Tee	1200	450	7	0		0
Project 6	12	Pipe	750		12	10		10
		Pipe	500		12	4		4
		Pipe	500		4.5	1		1
		Miter	750		5	4		4
		Reducer	750	500	3	1		1
		Tee	750	750	4.5	1		1
Project 7	8	Pipe	750		239	239		239
		Pipe	750		1	1		1
		Pipe	650		181	181		181

Table C-5: Production Data for Week 5

Project Reference	No. of wks left	Product List	Diameter (mm)		Length (m/pc)	Beginning of the Week (pcs)	Actual Produced (pcs)	Balance End of the Week (pcs)
			size 1	Size 2				
Project 1	2	Pipe	2200		12	0		0
		Pipe	2200		6	0		0
		Pipe	1500		12	0		0
		Miter	2200		6	0		0
		Miter	1500		5	0		0
		Flange	2200			109	109	0
		Flange	1500			175	175	0
Project 2	5	Pipe	500		12	0		0
		Pipe	500		3	0		0
		Pipe	550		12	0		0
		Pipe	550		3	0		0
		Pipe	600		12	0		0
		Pipe	600		3	6	6	0
		Pipe	700		12	4	4	0
		Pipe	750		12	286	100	186
Project 3	6	Pipe	3000		12	0		0
		Pipe	3000		11	0		0
		Miter	3000		8	0		0
Project 4	30	Pipe	3600		12	29		29
		Pipe	3600		3	1		1
		Pipe	1200		12	12		12
		Pipe	1200		1.5	1		1
		Pipe	450		12	6		6
		Miter	1200		6	6		6
Project 5	4	Pipe	1200		12	0		0
		Pipe	900		12	0		0
		Pipe	450		6	0		0
		Miter	1200		5.5	0		0
		Miter	900		5	0		0
		Miter	450		3.5	0		0
		Flange	1200			0		0
		Flange	900			0		0
		Flange	450			0		0
		Reducer	1200	900	5.5	0		0
		Reducer	900	450	4.5	0		0
		Tee	1200	450	7	0		0
Project 6	11	Pipe	750		12	10		10
		Pipe	500		12	4		4
		Pipe	500		4.5	1		1
		Miter	750		5	4		4
		Reducer	750	500	3	1		1
		Tee	750	750	4.5	1		1
Project 7	7	Pipe	750		239	239		239
		Pipe	750		1	1		1
		Pipe	650		181	181		181

Table C-6: Production Data for Week 6

Project Reference	No. of wks left	Product List	Diameter (mm) size 1	Diameter (mm) Size 2	Length (m/pc)	Beginning of the Week (pcs)	Actual Produced (pcs)	Balance End of the Week (pcs)
Project 1	1	Pipe	2200		12	0		0
		Pipe	2200		6	0		0
		Pipe	1500		12	0		0
		Miter	2200		6	0		0
		Miter	1500		5	0		0
		Flange	2200			0		0
		Flange	1500			0		0
Project 2	4	Pipe	500		12	0		0
		Pipe	500		3	0		0
		Pipe	550		12	0		0
		Pipe	550		3	0		0
		Pipe	600		12	0		0
		Pipe	600		3	0		0
		Pipe	700		12	0		0
		Pipe	750		12	186	142	44
Project 3	5	Pipe	3000		12	0		0
		Pipe	3000		11	0		0
		Miter	3000		8	0		0
Project 4	29	Pipe	3600		12	29	18	11
		Pipe	3600		3	1		1
		Pipe	1200		12	12		12
		Pipe	1200		1.5	1		1
		Pipe	450		12	6		6
		Miter	1200		6	6		6
Project 5	3	Pipe	1200		12	0		0
		Pipe	900		12	0		0
		Pipe	450		6	0		0
		Miter	1200		5.5	0		0
		Miter	900		5	0		0
		Miter	450		3.5	0		0
		Flange	1200			0		0
		Flange	900			0		0
		Flange	450			0		0
		Reducer	1200	900	5.5	0		0
		Reducer	900	450	4.5	0		0
		Tee	1200	450	7	0		0
Project 6	10	Pipe	750		12	10		10
		Pipe	500		12	4		4
		Pipe	500		4.5	1		1
		Miter	750		5	4		4
		Reducer	750	500	3	1		1
		Tee	750	750	4.5	1		1
Project 7	6	Pipe	750		239	239		239
		Pipe	750		1	1		1
		Pipe	650		181	181		181

Table C-7: Production Data for Week 7

Project Reference	No. of wks left	Product List	Diameter (mm)		Length (m/pc)	Beginning of the Week (pcs)	Actual Produced (pcs)	Balance End of the Week
			size 1	Size 2				
Project 1	0	Pipe	2200		12	0		0
		Pipe	2200		6	0		0
		Pipe	1500		12	0		0
		Miter	2200		6	0		0
		Miter	1500		5	0		0
		Flange	2200			0		0
		Flange	1500			0		0
Project 2	3	Pipe	500		12	0		0
		Pipe	500		3	0		0
		Pipe	550		12	0		0
		Pipe	550		3	0		0
		Pipe	600		12	0		0
		Pipe	600		3	0		0
		Pipe	700		12	0		0
		Pipe	750		12	44	44	0
Project 3	4	Pipe	3000		12	0		0
		Pipe	3000		11	0		0
		Miter	3000		8	0		0
Project 4	28	Pipe	3600		12	11		11
		Pipe	3600		3	1		1
		Pipe	1200		12	12		12
		Pipe	1200		1.5	1		1
		Pipe	450		12	6		6
		Miter	1200		6	6		6
Project 5	2	Pipe	1200		12	0		0
		Pipe	900		12	0		0
		Pipe	450		6	0		0
		Miter	1200		5.5	0		0
		Miter	900		5	0		0
		Miter	450		3.5	0		0
		Flange	1200			0		0
		Flange	900			0		0
		Flange	450			0		0
		Reducer	1200	900	5.5	0		0
		Reducer	900	450	4.5	0		0
		Tee	1200	450	7	0		0
Project 6	9	Pipe	750		12	10		10
		Pipe	500		12	4		4
		Pipe	500		4.5	1		1
		Miter	750		5	4		4
		Reducer	750	500	3	1		1
		Tee	750	750	4.5	1		1
Project 7	5	Pipe	750		239	239	20	219
		Pipe	750		1	1		1
		Pipe	650		181	181		181

Table C-8: Production Data for Week 8

Project Reference	No. of wks left	Product List	Diameter (mm)		Length (m/pc)	Beginning of the Week (pcs)	Actual Produced (pcs)	Balance End of the Week (pcs)
			size 1	Size 2				
Project 1	0	Pipe	2200		12	0		0
		Pipe	2200		6	0		0
		Pipe	1500		12	0		0
		Miter	2200		6	0		0
		Miter	1500		5	0		0
		Flange	2200			0		0
		Flange	1500			0		0
Project 2	2	Pipe	500		12	0		0
		Pipe	500		3	0		0
		Pipe	550		12	0		0
		Pipe	550		3	0		0
		Pipe	600		12	0		0
		Pipe	600		3	0		0
		Pipe	700		12	0		0
		Pipe	750		12	0		0
Project 3	3	Pipe	3000		12	0		0
		Pipe	3000		11	0		0
		Miter	3000		8	0		0
Project 4	27	Pipe	3600		12	11	11	0
		Pipe	3600		3	1	1	0
		Pipe	1200		12	12	12	0
		Pipe	1200		1.5	1	1	0
		Pipe	450		12	6		6
		Miter	1200		6	6	6	0
Project 5	1	Pipe	1200		12	0		0
		Pipe	900		12	0		0
		Pipe	450		6	0		0
		Miter	1200		5.5	0		0
		Miter	900		5	0		0
		Miter	450		3.5	0		0
		Flange	1200			0		0
		Flange	900			0		0
		Flange	450			0		0
		Reducer	1200	900	5.5	0		0
		Reducer	900	450	4.5	0		0
		Tee	1200	450	7	0		0
Project 6	8	Pipe	750		12	10		10
		Pipe	500		12	4		4
		Pipe	500		4.5	1		1
		Miter	750		5	4		4
		Reducer	750	500	3	1		1
		Tee	750	750	4.5	1		1
Project 7	4	Pipe	750		239	219	140	79
		Pipe	750		1	1		1
		Pipe	650		181	181		181

Table C-9: Production Data for Week 9

Project Reference	No. of wks left	Product List	Diameter (mm)		Length (m/pc)	Beginning of the Week (pcs)	Actual Produced (pcs)	Balance End of the Week (pcs)
			size 1	Size 2				
Project 1	0	Pipe	2200		12	0		0
		Pipe	2200		6	0		0
		Pipe	1500		12	0		0
		Miter	2200		6	0		0
		Miter	1500		5	0		0
		Flange	2200			0		0
		Flange	1500			0		0
Project 2	1	Pipe	500		12	0		0
		Pipe	500		3	0		0
		Pipe	550		12	0		0
		Pipe	550		3	0		0
		Pipe	600		12	0		0
		Pipe	600		3	0		0
		Pipe	700		12	0		0
		Pipe	750		12	0		0
Project 3	2	Pipe	3000		12	0		0
		Pipe	3000		11	0		0
		Miter	3000		8	0		0
Project 4	26	Pipe	3600		12	0		0
		Pipe	3600		3	0		0
		Pipe	1200		12	0		0
		Pipe	1200		1.5	0		0
		Pipe	450		12	6	6	0
		Miter	1200		6	0		0
Project 5	0	Pipe	1200		12	0		0
		Pipe	900		12	0		0
		Pipe	450		6	0		0
		Miter	1200		5.5	0		0
		Miter	900		5	0		0
		Miter	450		3.5	0		0
		Flange	1200			0		0
		Flange	900			0		0
		Flange	450			0		0
		Reducer	1200	900	5.5	0		0
		Reducer	900	450	4.5	0		0
		Tee	1200	450	7	0		0
Project 6	7	Pipe	750		12	10		10
		Pipe	500		12	4		4
		Pipe	500		4.5	1		1
		Miter	750		5	4		4
		Reducer	750	500	3	1		1
		Tee	750	750	4.5	1		1
Project 7	3	Pipe	750		239	79	79	0
		Pipe	750		1	1	1	0
		Pipe	650		181	181	65	116

Table C-10: Production Data for Week 10

Project Reference	No. of wks left	Product List	Diameter (mm)		Length (m/pc)	Beginning of the Week (pcs)	Actual Produced (pcs)	Balance End of the Week (pcs)
			size 1	Size 2				
Project 1	0	Pipe	2200		12	0		0
		Pipe	2200		6	0		0
		Pipe	1500		12	0		0
		Miter	2200		6	0		0
		Miter	1500		5	0		0
		Flange	2200			0		0
		Flange	1500			0		0
Project 2	0	Pipe	500		12	0		0
		Pipe	500		3	0		0
		Pipe	550		12	0		0
		Pipe	550		3	0		0
		Pipe	600		12	0		0
		Pipe	600		3	0		0
		Pipe	700		12	0		0
		Pipe	750		12	0		0
Project 3	1	Pipe	3000		12	0		0
		Pipe	3000		11	0		0
		Miter	3000		8	0		0
Project 4	23	Pipe	3600		12	0		0
		Pipe	3600		3	0		0
		Pipe	1200		12	0		0
		Pipe	1200		1.5	0		0
		Pipe	450		12	0		0
		Miter	1200		6	0		0
Project 5	0	Pipe	1200		12	0		0
		Pipe	900		12	0		0
		Pipe	450		6	0		0
		Miter	1200		5.5	0		0
		Miter	900		5	0		0
		Miter	450		3.5	0		0
		Flange	1200			0		0
		Flange	900			0		0
		Flange	450			0		0
		Reducer	1200	900	5.5	0		0
		Reducer	900	450	4.5	0		0
		Tee	1200	450	7	0		0
Project 6	6	Pipe	750		12	10	10	0
		Pipe	500		12	4		4
		Pipe	500		4.5	1		1
		Miter	750		5	4	4	0
		Reducer	750	500	3	1	1	0
		Tee	750	750	4.5	1	1	0
Project 7	2	Pipe	750		239	0		0
		Pipe	750		1	0		0
		Pipe	650		181	116	116	0

Appendix D

Appendix D: Portfolio Plan's Resource Allocation

Table D-1: Units Required per week using Average per Week Method for Week 1

Project Reference	No. of wks left	Priority	Product List	Diameter (mm) size 1	Size 2	Length (m/pc)	Total (pcs)	Balance Beginning of Week 1	Pieces Required per Week
Project 1	6	1	Pipe	2200		12	221	143	23.83
		1	Pipe	2200		6	4	4	0.67
		1	Pipe	1500		12	94	86	14.33
		1	Miter	2200		6	3	3	0.50
		1	Miter	1500		5	3	3	0.50
		1	Flange	2200			345	189	31.50
		1	Flange	1500			191	175	29.17
Project 2	9	3	Pipe	500		12	330	321	35.67
		3	Pipe	500		3	22	22	2.44
		3	Pipe	550		12	45	45	5.00
		3	Pipe	550		3	3	3	0.33
		3	Pipe	600		12	210	190	21.11
		3	Pipe	600		3	6	6	0.67
		3	Pipe	700		12	4	4	0.44
		3	Pipe	750		12	286	286	31.78
Project 3	10	4	Pipe	3000		12	12	12	1.20
		4	Pipe	3000		11	1	1	0.10
		4	Miter	3000		8	2	2	0.20
Project 4	34	6	Pipe	3600		12	36	36	1.06
		6	Pipe	3600		3	1	1	0.03
		6	Pipe	1200		12	12	12	0.35
		6	Pipe	1200		1.5	1	1	0.03
		6	Pipe	450		12	6	6	0.18
		6	Miter	1200		6	6	6	0.18
Project 5	8	2	Pipe	1200		12	15	11	1.38
		2	Pipe	900		12	21	19	2.38
		2	Pipe	450		6	15	14	1.75
		2	Miter	1200		5.5	4	4	0.50
		2	Miter	900		5	2	2	0.25
		2	Miter	450		3.5	2	2	0.25
		2	Flange	1200			30	22	2.75
		2	Flange	900			46	46	5.75
		2	Flange	450			5	5	0.63
		2	Reducer	1200	900	5.5	1	1	0.13
		2	Reducer	900	450	4.5	1	1	0.13
		2	Tee	1200	450	7	1	1	0.13
Project 6	15	5	Pipe	750		12	10	10	0.67
		5	Pipe	500		12	4	4	0.27
		5	Pipe	500		4.5	1	1	0.07
		5	Miter	750		5	4	4	0.27
		5	Reducer	750	500	3	1	1	0.07
		5	Tee	750	750	4.5	1	1	0.07

Table D-2: Portfolio Plan’s Resource Allocation for Week 1

Project Reference	Product List	Diameter (mm)		Pieces required per week	Resource Allocation by PP											
		size 1	Size 2		Rolling (PS600)		Rolling (PS360)		Longitudinal Welding		Cutting		Circumferential Welding		Finishing	
					Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)
Project 1	Pipe	2200		23.83	286.0	3.3	0.0	0.0	286.0	0.3	0.0	0.0	494.2	2.2	780.2	0.2
	Pipe	2200		0.67	4.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	4.6	0.0	8.6	0.0
	Pipe	1500		14.33	172.0	1.1	0.0	0.0	172.0	0.2	0.0	0.0	202.6	0.9	374.6	0.1
	Miter	2200		0.50	3.0	0.0	0.0	0.0	3.0	0.0	13.8	0.0	13.8	0.1	16.8	0.0
	Miter	1500		0.50	2.5	0.0	0.0	0.0	2.5	0.0	9.4	0.0	9.4	0.0	11.9	0.0
	Flange	2200		31.50	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	217.7	1.0	217.7	0.1
	Flange	1500		29.17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	137.4	0.6	137.4	0.0
Project 2	Pipe	500		35.67	0.0	0.00	428.0	1.95	428.00	0.38	0.0	0.000	168.1	0.75	596.1	0.16
	Pipe	500		2.44	0.0	0.00	7.3	0.03	7.33	0.01	0.0	0.000	0.0	0.00	7.3	0.00
	Pipe	550		5.00	0.0	0.00	60.0	0.28	60.00	0.05	0.0	0.000	25.9	0.12	85.9	0.02
	Pipe	550		0.33	0.0	0.00	1.0	0.00	1.00	0.00	0.0	0.000	0.0	0.00	1.0	0.00
	Pipe	600		21.11	0.0	0.00	253.3	1.25	253.33	0.22	0.0	0.000	119.4	0.53	372.7	0.10
	Pipe	600		0.67	0.0	0.00	2.0	0.01	2.00	0.00	0.0	0.000	0.0	0.00	2.0	0.00
	Pipe	700		0.44	0.0	0.00	5.3	0.03	5.33	0.00	0.0	0.000	2.9	0.01	8.3	0.00
	Pipe	750		31.78	0.0	0.00	381.3	2.12	381.33	0.34	0.0	0.000	224.6	1.00	606.0	0.16
Project 3	Pipe	3000		1.20	14.4	0.31	0.0	0.00	14.40	0.01	0.0	0.000	33.9	0.15	48.3	0.01
	Pipe	3000		0.10	1.1	0.02	0.0	0.00	1.10	0.00	0.0	0.000	2.8	0.01	3.9	0.00
	Miter	3000		0.20	1.6	0.03	0.0	0.00	1.60	0.00	7.5	0.004	7.5	0.03	9.1	0.00
Project 4	Pipe	3600		1.06	12.7	0.44	0.0	0.00	12.71	0.01	0.0	0.000	35.9	0.16	48.6	0.01
	Pipe	3600		0.03	0.1	0.00	0.0	0.00	0.09	0.00	0.0	0.000	0.0	0.00	0.1	0.00
	Pipe	1200		0.35	4.2	0.02	0.0	0.00	4.24	0.00	0.0	0.000	4.0	0.02	8.2	0.00

	Pipe	1200		0.03	0.0	0.00	0.0	0.00	0.04	0.00	0.0	0.000	0.0	0.00	0.0	0.00
	Pipe	450		0.18	0.0	0.00	2.1	0.01	2.12	0.00	0.0	0.000	0.7	0.00	2.9	0.00
	Miter	1200		0.18	1.1	0.01	0.0	0.00	1.06	0.00	2.7	0.001	2.7	0.01	3.7	0.00
Project 5	Pipe	1200		1.38	16.5	0.08	0.0	0.00	16.50	0.01	0.0	0.000	15.6	0.07	32.1	0.01
	Pipe	900		2.38	0.0	0.00	28.5	0.18	28.50	0.03	0.0	0.000	20.1	0.09	48.6	0.01
	Pipe	450		1.75	0.0	0.00	10.5	0.05	10.50	0.01	0.0	0.000	2.5	0.01	13.0	0.00
	Miter	1200		0.50	2.8	0.01	0.0	0.00	2.75	0.00	7.5	0.004	7.5	0.03	10.3	0.00
	Miter	900		0.25	0.0	0.00	2.5	0.02	1.25	0.00	2.8	0.001	2.8	0.01	4.1	0.00
	Miter	450		0.25	0.0	0.00	1.8	0.01	0.88	0.00	0.7	0.000	0.7	0.00	1.6	0.00
	Flange	1200		2.75	0.0	0.00	0.0	0.00	0.00	0.00	0.0	0.000	10.4	0.05	10.4	0.00
	Flange	900		5.75	0.0	0.00	0.0	0.00	0.00	0.00	0.0	0.000	16.3	0.07	16.3	0.00
	Flange	450		0.63	0.0	0.00	0.0	0.00	0.00	0.00	0.0	0.000	0.9	0.00	0.9	0.00
	Reducer	1200	900	0.13	0.0	0.00	0.7	0.01	0.69	0.00	0.0	0.000	0.5	0.00	1.2	0.00
	Reducer	900	450	0.13	0.0	0.00	0.6	0.00	0.56	0.00	0.0	0.000	0.0	0.00	0.6	0.00
	Tee	1200	450	0.13	0.0	0.00	0.9	0.01	0.88	0.00	1.4	0.001	0.5	0.00	1.3	0.00
Project 6	Pipe	750		0.67	0.0	0.00	8.0	0.04	8.00	0.01	0.0	0.000	4.7	0.02	12.7	0.00
	Pipe	500		0.27	0.0	0.00	3.2	0.01	3.20	0.00	0.0	0.000	1.3	0.01	4.5	0.00
	Pipe	500		0.07	0.0	0.00	0.3	0.00	0.30	0.00	0.0	0.000	0.1	0.00	0.4	0.00
	Miter	750		0.27	0.0	0.00	1.3	0.01	1.33	0.00	0.8	0.000	2.5	0.01	3.8	0.00
	Reducer	750	500	0.07	0.0	0.00	0.2	0.00	0.20	0.00	0.0	0.000	0.0	0.00	0.2	0.00
	Tee	750	750	0.07	0.0	0.00	0.3	0.00	0.30	0.00	0.2	0.000	0.2	0.00	0.5	0.00
				Total	522.0 meters	5.4 man-day	1199.2 meters	6.0 man-day	1719.0 meters	1.5 man-day	46.8 meters	0.02 man-day	1794.8 meters	8.0 man-day	3513.8 meters	0.956 man-day

Table D-3: Portfolio Plan's Resource Allocation for Week 2

Project Reference	Product List	Diameter (mm)		Pieces Required per Week	Resource Allocation by PP											
		size 1	Size 2		Rolling (PS600)		Rolling (PS360)		Longitudinal Welding		Cutting		Circumferential Welding		Finishing	
					Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)
Project 1	Pipe	2200		23.8	286.0	3.27	0.0	0.000	286.00	0.2522	0.0	0.000	494.2	2.2061	780.2	0.21
	Pipe	2200		0.7	4.0	0.05	0.0	0.000	4.00	0.004	0.0	0.0000	4.6	0.021	8.6	0.00
	Pipe	1500		14.3	172.0	1.12	0.0	0.000	172.00	0.152	0.0	0.0000	202.6	0.905	374.6	0.10
	Miter	2200		0.5	3.0	0.03	0.0	0.000	3.00	0.003	13.8	0.0066	13.8	0.062	16.8	0.00
	Miter	1500		0.5	2.5	0.02	0.0	0.000	2.50	0.002	9.4	0.0045	9.4	0.042	11.9	0.00
	Flange	2200		31.5	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	217.7	0.972	217.7	0.06
	Flange	1500		29.2	0.0	0.00	0.0	0.000	0.00	0.0000	0.0	0.000	137.4	0.6136	137.4	0.04
Project 2	Pipe	500		35.7	0.0	0.00	428.0	1.950	428.00	0.377	0.0	0.0000	168.1	0.750	596.1	0.16
	Pipe	500		2.4	0.0	0.00	7.3	0.033	7.33	0.006	0.0	0.0000	0.0	0.000	7.3	0.00
	Pipe	550		5.0	0.0	0.00	60.0	0.285	60.00	0.053	0.0	0.0000	25.9	0.116	85.9	0.02
	Pipe	550		0.3	0.0	0.00	1.0	0.005	1.00	0.001	0.0	0.0000	0.0	0.000	1.0	0.00
	Pipe	600		21.1	0.0	0.00	253.3	1.250	253.33	0.223	0.0	0.0000	119.4	0.533	372.7	0.10
	Pipe	600		0.7	0.0	0.00	2.0	0.010	2.00	0.002	0.0	0.0000	0.0	0.000	2.0	0.00
	Pipe	700		0.4	0.0	0.00	5.3	0.029	5.33	0.005	0.0	0.0000	2.9	0.013	8.3	0.00
	Pipe	750		31.8	0.0	0.00	381.3	2.122	381.33	0.336	0.0	0.0000	224.6	1.003	606.0	0.16
Project 3	Pipe	3000		1.2	14.4	0.31	0.0	0.000	14.40	0.013	0.0	0.0000	33.9	0.151	48.3	0.01
	Pipe	3000		0.1	1.1	0.02	0.0	0.000	1.10	0.001	0.0	0.0000	2.8	0.013	3.9	0.00
	Miter	3000		0.2	1.6	0.03	0.0	0.000	1.60	0.001	7.5	0.0036	7.5	0.034	9.1	0.00
Project 4	Pipe	3600		1.1	12.7	0.44	0.0	0.000	12.71	0.0112	0.0	0.000	35.9	0.1604	48.6	0.01
	Pipe	3600		0.0	0.1	0.00	0.0	0.000	0.09	0.000	0.0	0.0000	0.0	0.000	0.1	0.00
	Pipe	1200		0.4	4.2	0.02	0.0	0.000	4.24	0.004	0.0	0.0000	4.0	0.018	8.2	0.00
	Pipe	1200		0.0	0.0	0.00	0.0	0.000	0.04	0.000	0.0	0.0000	0.0	0.000	0.0	0.00
	Pipe	450		0.2	0.0	0.00	2.1	0.009	2.12	0.002	0.0	0.0000	0.7	0.003	2.9	0.00
	Miter	1200		0.2	1.1	0.01	0.0	0.000	1.06	0.001	2.7	0.0013	2.7	0.012	3.7	0.00
Project 5	Pipe	1200		1.4	16.5	0.08	0.0	0.000	16.50	0.015	0.0	0.0000	15.6	0.069	32.1	0.01

	Pipe	900		2.4	0.0	0.00	28.5	0.179	28.50	0.025	0.0	0.0000	20.1	0.090	48.6	0.01
	Pipe	450		1.8	0.0	0.00	10.5	0.046	10.50	0.009	0.0	0.0000	2.5	0.011	13.0	0.00
	Miter	1200		0.5	2.8	0.01	0.0	0.000	2.75	0.002	7.5	0.0036	7.5	0.034	10.3	0.00
	Miter	900		0.3	0.0	0.00	2.5	0.016	1.25	0.001	2.8	0.0013	2.8	0.013	4.1	0.00
	Miter	450		0.3	0.0	0.00	1.8	0.008	0.88	0.001	0.7	0.0003	0.7	0.003	1.6	0.00
	Flange	1200		2.8	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	10.4	0.046	10.4	0.00
	Flange	900		5.8	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	16.3	0.073	16.3	0.00
	Flange	450		0.6	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.9	0.004	0.9	0.00
	Reducer	1200	900	0.1	0.0	0.00	0.7	0.005	0.69	0.001	0.0	0.0000	0.5	0.002	1.2	0.00
	Reducer	900	450	0.1	0.0	0.00	0.6	0.004	0.56	0.000	0.0	0.0000	0.0	0.000	0.6	0.00
	Tee	1200	450	0.1	0.0	0.00	0.9	0.007	0.88	0.001	1.4	0.0007	0.5	0.002	1.3	0.00
Project 6	Pipe	750		0.7	0.0	0.00	8.0	0.045	8.00	0.007	0.0	0.0000	4.7	0.021	12.7	0.00
	Pipe	500		0.3	0.0	0.00	3.2	0.015	3.20	0.003	0.0	0.0000	1.3	0.006	4.5	0.00
	Pipe	500		0.1	0.0	0.00	0.3	0.001	0.30	0.000	0.0	0.0000	0.1	0.000	0.4	0.00
	Miter	750		0.3	0.0	0.00	1.3	0.007	1.33	0.001	0.8	0.0004	2.5	0.011	3.8	0.00
	Reducer	750	500	0.1	0.0	0.00	0.2	0.001	0.20	0.000	0.0	0.0000	0.0	0.000	0.2	0.00
	Tee	750	750	0.1	0.0	0.00	0.3	0.002	0.30	0.000	0.2	0.0001	0.2	0.001	0.5	0.00
				Total	522.0 meters	5.4 man-days	1199.2 meters	6.0 man-days	1719.0 meters	1.5 man-days	46.8 meters	0.0 man-days	1794.8 meters	8.0 man-days	3513.8 meters	0.96 man-days

Table D-4: Portfolio Plan's Resource Allocation for Week 3

Project Reference	Product List	Diameter (mm)		Pieces Required per Week	Resource Allocation by PP											
					Rolling (PS600)		Rolling (PS360)		Longitudinal Welding		Cutting		Circumferential Welding		Finishing	
		size 1	Size 2		Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)
Project 1	Pipe	2200		23.8	286.0	3.27	0.0	0.000	286.00	0.2522	0.0	0.000	494.2	2.2061	780.2	0.212
	Pipe	2200		0.7	4.0	0.05	0.0	0.000	4.00	0.004	0.0	0.0000	4.6	0.021	8.6	0.002
	Pipe	1500		14.3	172.0	1.12	0.0	0.000	172.00	0.152	0.0	0.0000	202.6	0.905	374.6	0.102
	Miter	2200		0.5	3.0	0.03	0.0	0.000	3.00	0.003	13.8	0.0066	13.8	0.062	16.8	0.005
	Miter	1500		0.5	2.5	0.02	0.0	0.000	2.50	0.002	9.4	0.0045	9.4	0.042	11.9	0.003
	Flange	2200		31.5	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	217.7	0.972	217.7	0.059
	Flange	1500		29.2	0.0	0.00	0.0	0.000	0.00	0.0000	0.0	0.000	137.4	0.6136	137.4	0.037
Project 2	Pipe	500		35.7	0.0	0.00	428.0	1.950	428.00	0.377	0.0	0.0000	168.1	0.750	596.1	0.162
	Pipe	500		2.4	0.0	0.00	7.3	0.033	7.33	0.006	0.0	0.0000	0.0	0.000	7.3	0.002
	Pipe	550		5.0	0.0	0.00	60.0	0.285	60.00	0.053	0.0	0.0000	25.9	0.116	85.9	0.023
	Pipe	550		0.3	0.0	0.00	1.0	0.005	1.00	0.001	0.0	0.0000	0.0	0.000	1.0	0.000
	Pipe	600		21.1	0.0	0.00	253.3	1.250	253.33	0.223	0.0	0.0000	119.4	0.533	372.7	0.101
	Pipe	600		0.7	0.0	0.00	2.0	0.010	2.00	0.002	0.0	0.0000	0.0	0.000	2.0	0.001
	Pipe	700		0.4	0.0	0.00	5.3	0.029	5.33	0.005	0.0	0.0000	2.9	0.013	8.3	0.002
	Pipe	750		31.8	0.0	0.00	381.3	2.122	381.33	0.336	0.0	0.0000	224.6	1.003	606.0	0.165
Project 3	Pipe	3000		1.2	14.4	0.31	0.0	0.000	14.40	0.013	0.0	0.0000	33.9	0.151	48.3	0.013
	Pipe	3000		0.1	1.1	0.02	0.0	0.000	1.10	0.001	0.0	0.0000	2.8	0.013	3.9	0.001
	Miter	3000		0.2	1.6	0.03	0.0	0.000	1.60	0.001	7.5	0.0036	7.5	0.034	9.1	0.002
Project 4	Pipe	3600		1.1	12.7	0.44	0.0	0.000	12.71	0.0112	0.0	0.000	35.9	0.1604	48.6	0.013
	Pipe	3600		0.0	0.1	0.00	0.0	0.000	0.09	0.000	0.0	0.0000	0.0	0.000	0.1	0.000
	Pipe	1200		0.4	4.2	0.02	0.0	0.000	4.24	0.004	0.0	0.0000	4.0	0.018	8.2	0.002
	Pipe	1200		0.03	0.0	0.00	0.0	0.000	0.04	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Pipe	450		0.2	0.0	0.00	2.1	0.009	2.12	0.002	0.0	0.0000	0.7	0.003	2.9	0.001
	Miter	1200		0.2	1.1	0.01	0.0	0.000	1.06	0.001	2.7	0.0013	2.7	0.012	3.7	0.001
Project 5	Pipe	1200		1.4	16.5	0.08	0.0	0.000	16.50	0.015	0.0	0.0000	15.6	0.069	32.1	0.009

	Pipe	900		2.4	0.0	0.00	28.5	0.179	28.50	0.025	0.0	0.0000	20.1	0.090	48.6	0.013
	Pipe	450		1.8	0.0	0.00	10.5	0.046	10.50	0.009	0.0	0.0000	2.5	0.011	13.0	0.004
	Miter	1200		0.5	2.8	0.01	0.0	0.000	2.75	0.002	7.5	0.0036	7.5	0.034	10.3	0.003
	Miter	900		0.3	0.0	0.00	2.5	0.016	1.25	0.001	2.8	0.0013	2.8	0.013	4.1	0.001
	Miter	450		0.3	0.0	0.00	1.8	0.008	0.88	0.001	0.7	0.0003	0.7	0.003	1.6	0.000
	Flange	1200		2.8	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	10.4	0.046	10.4	0.003
	Flange	900		5.8	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	16.3	0.073	16.3	0.004
	Flange	450		0.6	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.9	0.004	0.9	0.000
	Reducer	1200	900	0.1	0.0	0.00	0.7	0.005	0.69	0.001	0.0	0.0000	0.5	0.002	1.2	0.000
	Reducer	900	450	0.1	0.0	0.00	0.6	0.004	0.56	0.000	0.0	0.0000	0.0	0.000	0.6	0.000
	Tee	1200	450	0.1	0.0	0.00	0.9	0.007	0.88	0.001	1.4	0.0007	0.5	0.002	1.3	0.000
Project 6	Pipe	750		0.7	0.0	0.00	8.0	0.045	8.00	0.007	0.0	0.0000	4.7	0.021	12.7	0.003
	Pipe	500		0.3	0.0	0.00	3.2	0.015	3.20	0.003	0.0	0.0000	1.3	0.006	4.5	0.001
	Pipe	500		0.1	0.0	0.00	0.3	0.001	0.30	0.000	0.0	0.0000	0.1	0.000	0.4	0.000
	Miter	750		0.3	0.0	0.00	1.3	0.007	1.33	0.001	0.8	0.0004	2.5	0.011	3.8	0.001
	Reducer	750	500	0.1	0.0	0.00	0.2	0.001	0.20	0.000	0.0	0.0000	0.0	0.000	0.2	0.000
	Tee	750	750	0.1	0.0	0.00	0.3	0.002	0.30	0.000	0.2	0.0001	0.2	0.001	0.5	0.000
				Total	522.0	5.4	1199.2	6.0	1719.0	1.5	46.8	0.0	1794.8	8.0	3513.8	1.0
					meters	man-days	meters	man-days	meters	man-days	meters	man-days	meters	man-days	meters	man-days

Table D-5: Portfolio Plan's Resource Allocation for Week 4

Project Reference	Product List	Diameter (mm)		Pieces Required per Week	Resource Allocation by PP											
					Rolling (PS600)		Rolling (PS360)		Longitudinal Welding		Cutting		Circumferential Welding		Finishing	
		size 1	Size 2		Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)
Project 1	Pipe	2200		23.8	286.0	3.27	0.0	0.000	286.00	0.2522	0.0	0.000	494.2	2.2061	780.2	0.212
	Pipe	2200		0.7	4.0	0.05	0.0	0.000	4.00	0.004	0.0	0.0000	4.6	0.021	8.6	0.002
	Pipe	1500		14.3	172.0	1.12	0.0	0.000	172.00	0.152	0.0	0.0000	202.6	0.905	374.6	0.102
	Miter	2200		0.5	3.0	0.03	0.0	0.000	3.00	0.003	13.8	0.0066	13.8	0.062	16.8	0.005
	Miter	1500		0.5	2.5	0.02	0.0	0.000	2.50	0.002	9.4	0.0045	9.4	0.042	11.9	0.003
	Flange	2200		31.5	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	217.7	0.972	217.7	0.059
	Flange	1500		29.2	0.0	0.00	0.0	0.000	0.00	0.0000	0.0	0.000	137.4	0.6136	137.4	0.037
Project 2	Pipe	500		35.7	0.0	0.00	428.0	1.950	428.00	0.377	0.0	0.0000	168.1	0.750	596.1	0.162
	Pipe	500		2.4	0.0	0.00	7.3	0.033	7.33	0.006	0.0	0.0000	0.0	0.000	7.3	0.002
	Pipe	550		5.0	0.0	0.00	60.0	0.285	60.00	0.053	0.0	0.0000	25.9	0.116	85.9	0.023
	Pipe	550		0.3	0.0	0.00	1.0	0.005	1.00	0.001	0.0	0.0000	0.0	0.000	1.0	0.000
	Pipe	600		21.1	0.0	0.00	253.3	1.250	253.33	0.223	0.0	0.0000	119.4	0.533	372.7	0.101
	Pipe	600		0.7	0.0	0.00	2.0	0.010	2.00	0.002	0.0	0.0000	0.0	0.000	2.0	0.001
	Pipe	700		0.4	0.0	0.00	5.3	0.029	5.33	0.005	0.0	0.0000	2.9	0.013	8.3	0.002
	Pipe	750		31.8	0.0	0.00	381.3	2.122	381.33	0.336	0.0	0.0000	224.6	1.003	606.0	0.165
Project 3	Pipe	3000		1.2	14.4	0.31	0.0	0.000	14.40	0.013	0.0	0.0000	33.9	0.151	48.3	0.013
	Pipe	3000		0.1	1.1	0.02	0.0	0.000	1.10	0.001	0.0	0.0000	2.8	0.013	3.9	0.001
	Miter	3000		0.2	1.6	0.03	0.0	0.000	1.60	0.001	7.5	0.0036	7.5	0.034	9.1	0.002
Project 4	Pipe	3600		1.1	12.7	0.44	0.0	0.000	12.71	0.0112	0.0	0.000	35.9	0.1604	48.6	0.013
	Pipe	3600		0.0	0.1	0.00	0.0	0.000	0.09	0.000	0.0	0.0000	0.0	0.000	0.1	0.000
	Pipe	1200		0.4	4.2	0.02	0.0	0.000	4.24	0.004	0.0	0.0000	4.0	0.018	8.2	0.002
	Pipe	1200		0.03	0.0	0.00	0.0	0.000	0.04	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Pipe	450		0.2	0.0	0.00	2.1	0.009	2.12	0.002	0.0	0.0000	0.7	0.003	2.9	0.001
	Miter	1200		0.2	1.1	0.01	0.0	0.000	1.06	0.001	2.7	0.0013	2.7	0.012	3.7	0.001
Project 5	Pipe	1200		1.4	16.5	0.08	0.0	0.000	16.50	0.015	0.0	0.0000	15.6	0.069	32.1	0.009

	Pipe	900		2.4	0.0	0.00	28.5	0.179	28.50	0.025	0.0	0.0000	20.1	0.090	48.6	0.013
	Pipe	450		1.8	0.0	0.00	10.5	0.046	10.50	0.009	0.0	0.0000	2.5	0.011	13.0	0.004
	Miter	1200		0.5	2.8	0.01	0.0	0.000	2.75	0.002	7.5	0.0036	7.5	0.034	10.3	0.003
	Miter	900		0.3	0.0	0.00	2.5	0.016	1.25	0.001	2.8	0.0013	2.8	0.013	4.1	0.001
	Miter	450		0.3	0.0	0.00	1.8	0.008	0.88	0.001	0.7	0.0003	0.7	0.003	1.6	0.000
	Flange	1200		2.8	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	10.4	0.046	10.4	0.003
	Flange	900		5.8	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	16.3	0.073	16.3	0.004
	Flange	450		0.6	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.9	0.004	0.9	0.000
	Reducer	1200	900	0.1	0.0	0.00	0.7	0.005	0.69	0.001	0.0	0.0000	0.5	0.002	1.2	0.000
	Reducer	900	450	0.1	0.0	0.00	0.6	0.004	0.56	0.000	0.0	0.0000	0.0	0.000	0.6	0.000
	Tee	1200	450	0.1	0.0	0.00	0.9	0.007	0.88	0.001	1.4	0.0007	0.5	0.002	1.3	0.000
Project 6	Pipe	750		0.7	0.0	0.00	8.0	0.045	8.00	0.007	0.0	0.0000	4.7	0.021	12.7	0.003
	Pipe	500		0.3	0.0	0.00	3.2	0.015	3.20	0.003	0.0	0.0000	1.3	0.006	4.5	0.001
	Pipe	500		0.1	0.0	0.00	0.3	0.001	0.30	0.000	0.0	0.0000	0.1	0.000	0.4	0.000
	Miter	750		0.3	0.0	0.00	1.3	0.007	1.33	0.001	0.8	0.0004	2.5	0.011	3.8	0.001
	Reducer	750	500	0.1	0.0	0.00	0.2	0.001	0.20	0.000	0.0	0.0000	0.0	0.000	0.2	0.000
	Tee	750	750	0.1	0.0	0.00	0.3	0.002	0.30	0.000	0.2	0.0001	0.2	0.001	0.5	0.000
Project 7	Pipe	750		29.9	0.0	0.00	358.5	1.995	358.50	0.316	0.0	0.0000	211.2	0.943	569.7	0.155
	Pipe	750		0.1	0.0	0.00	0.3	0.002	0.31	0.000	0.0	0.0000	0.0	0.000	0.3	0.000
	Pipe	650		22.6	0.0	0.00	271.5	1.395	271.50	0.239	0.0	0.0000	138.6	0.619	410.1	0.112
				Total	**522.0** meters	**5.4** man-days	**1829.5** meters	**9.4** man-days	**2349.3** meters	**2.1** man-days	**46.8** meters	**0.0** man-days	**2144.6** meters	**9.6** man-days	**4493.9** meters	**1.2** man-days

Table D-6: Portfolio Plan's Resource Allocation for Week 5

Project Reference	Product List	Diameter (mm)		Pieces Required per Week	Resource Allocation by PP											
					Rolling (PS600)		Rolling (PS360)		Longitudinal Welding		Cutting		Circumferential Welding		Finishing	
		size 1	Size 2		Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)
Project 1	Pipe	2200		23.8	286.0	3.27	0.0	0.000	286.00	0.2522	0.0	0.000	494.2	2.2061	780.2	0.212
	Pipe	2200		0.7	4.0	0.05	0.0	0.000	4.00	0.004	0.0	0.0000	4.6	0.021	8.6	0.002
	Pipe	1500		14.3	172.0	1.12	0.0	0.000	172.00	0.152	0.0	0.0000	202.6	0.905	374.6	0.102
	Miter	2200		0.5	3.0	0.03	0.0	0.000	3.00	0.003	13.8	0.0066	13.8	0.062	16.8	0.005
	Miter	1500		0.5	2.5	0.02	0.0	0.000	2.50	0.002	9.4	0.0045	9.4	0.042	11.9	0.003
	Flange	2200		31.5	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	217.7	0.972	217.7	0.059
	Flange	1500		29.2	0.0	0.00	0.0	0.000	0.00	0.0000	0.0	0.000	137.4	0.6136	137.4	0.037
Project 2	Pipe	500		35.7	0.0	0.00	428.0	1.950	428.00	0.377	0.0	0.0000	168.1	0.750	596.1	0.162
	Pipe	500		2.4	0.0	0.00	7.3	0.033	7.33	0.006	0.0	0.0000	0.0	0.000	7.3	0.002
	Pipe	550		5.0	0.0	0.00	60.0	0.285	60.00	0.053	0.0	0.0000	25.9	0.116	85.9	0.023
	Pipe	550		0.3	0.0	0.00	1.0	0.005	1.00	0.001	0.0	0.0000	0.0	0.000	1.0	0.000
	Pipe	600		21.1	0.0	0.00	253.3	1.250	253.33	0.223	0.0	0.0000	119.4	0.533	372.7	0.101
	Pipe	600		0.7	0.0	0.00	2.0	0.010	2.00	0.002	0.0	0.0000	0.0	0.000	2.0	0.001
	Pipe	700		0.4	0.0	0.00	5.3	0.029	5.33	0.005	0.0	0.0000	2.9	0.013	8.3	0.002
	Pipe	750		31.8	0.0	0.00	381.3	2.122	381.33	0.336	0.0	0.0000	224.6	1.003	606.0	0.165
Project 3	Pipe	3000		1.2	14.4	0.31	0.0	0.000	14.40	0.013	0.0	0.0000	33.9	0.151	48.3	0.013
	Pipe	3000		0.1	1.1	0.02	0.0	0.000	1.10	0.001	0.0	0.0000	2.8	0.013	3.9	0.001
	Miter	3000		0.2	1.6	0.03	0.0	0.000	1.60	0.001	7.5	0.0036	7.5	0.034	9.1	0.002
Project 4	Pipe	3600		1.1	12.7	0.44	0.0	0.000	12.71	0.0112	0.0	0.000	35.9	0.1604	48.6	0.013
	Pipe	3600		0.0	0.1	0.00	0.0	0.000	0.09	0.000	0.0	0.0000	0.0	0.000	0.1	0.000
	Pipe	1200		0.4	4.2	0.02	0.0	0.000	4.24	0.004	0.0	0.0000	4.0	0.018	8.2	0.002
	Pipe	1200		0.03	0.0	0.00	0.0	0.000	0.04	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Pipe	450		0.2	0.0	0.00	2.1	0.009	2.12	0.002	0.0	0.0000	0.7	0.003	2.9	0.001
	Miter	1200		0.2	1.1	0.01	0.0	0.000	1.06	0.001	2.7	0.0013	2.7	0.012	3.7	0.001
Project 5	Pipe	1200		1.4	16.5	0.08	0.0	0.000	16.50	0.015	0.0	0.0000	15.6	0.069	32.1	0.009

	Pipe	900		2.4	0.0	0.00	28.5	0.179	28.50	0.025	0.0	0.0000	20.1	0.090	48.6	0.013
	Pipe	450		1.8	0.0	0.00	10.5	0.046	10.50	0.009	0.0	0.0000	2.5	0.011	13.0	0.004
	Miter	1200		0.5	2.8	0.01	0.0	0.000	2.75	0.002	7.5	0.0036	7.5	0.034	10.3	0.003
	Miter	900		0.3	0.0	0.00	2.5	0.016	1.25	0.001	2.8	0.0013	2.8	0.013	4.1	0.001
	Miter	450		0.3	0.0	0.00	1.8	0.008	0.88	0.001	0.7	0.0003	0.7	0.003	1.6	0.000
	Flange	1200		2.8	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	10.4	0.046	10.4	0.003
	Flange	900		5.8	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	16.3	0.073	16.3	0.004
	Flange	450		0.6	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.9	0.004	0.9	0.000
	Reducer	1200	900	0.1	0.0	0.00	0.7	0.005	0.69	0.001	0.0	0.0000	0.5	0.002	1.2	0.000
	Reducer	900	450	0.1	0.0	0.00	0.6	0.004	0.56	0.000	0.0	0.0000	0.0	0.000	0.6	0.000
	Tee	1200	450	0.1	0.0	0.00	0.9	0.007	0.88	0.001	1.4	0.0007	0.5	0.002	1.3	0.000
Project 6	Pipe	750		0.7	0.0	0.00	8.0	0.045	8.00	0.007	0.0	0.0000	4.7	0.021	12.7	0.003
	Pipe	500		0.3	0.0	0.00	3.2	0.015	3.20	0.003	0.0	0.0000	1.3	0.006	4.5	0.001
	Pipe	500		0.1	0.0	0.00	0.3	0.001	0.30	0.000	0.0	0.0000	0.1	0.000	0.4	0.000
	Miter	750		0.3	0.0	0.00	1.3	0.007	1.33	0.001	0.8	0.0004	2.5	0.011	3.8	0.001
	Reducer	750	500	0.1	0.0	0.00	0.2	0.001	0.20	0.000	0.0	0.0000	0.0	0.000	0.2	0.000
	Tee	750	750	0.1	0.0	0.00	0.3	0.002	0.30	0.000	0.2	0.0001	0.2	0.001	0.5	0.000
Project 7	Pipe	750		29.9	0.0	0.00	358.5	1.995	358.50	0.316	0.0	0.0000	211.2	0.943	569.7	0.155
	Pipe	750		0.1	0.0	0.00	0.3	0.002	0.31	0.000	0.0	0.0000	0.0	0.000	0.3	0.000
	Pipe	650		22.6	0.0	0.00	271.5	1.395	271.50	0.239	0.0	0.0000	138.6	0.619	410.1	0.112
				Total	522.0 meters	5.4 man-days	1829.5 meters	9.4 man-days	2349.3 meters	2.1 man-days	46.8 meters	0.0 man-days	2144.6 meters	9.6 man-days	4493.9 meters	1.2 man-days

Table D-7: Portfolio Plan's Resource Allocation for Week 6

Project Reference	Product List	Diameter (mm)		Pieces Required per Week	Resource Allocation by PP											
					Rolling (PS600)		Rolling (PS360)		Longitudinal Welding		Cutting		Circumferential Welding		Finishing	
		size 1	Size 2		Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)
Project 1	Pipe	2200		23.8	286.0	3.27	0.0	0.000	286.00	0.2522	0.0	0.000	494.2	2.2061	780.2	0.212
	Pipe	2200		0.7	4.0	0.05	0.0	0.000	4.00	0.004	0.0	0.0000	4.6	0.021	8.6	0.002
	Pipe	1500		14.3	172.0	1.12	0.0	0.000	172.00	0.152	0.0	0.0000	202.6	0.905	374.6	0.102
	Miter	2200		0.5	3.0	0.03	0.0	0.000	3.00	0.003	13.8	0.0066	13.8	0.062	16.8	0.005
	Miter	1500		0.5	2.5	0.02	0.0	0.000	2.50	0.002	9.4	0.0045	9.4	0.042	11.9	0.003
	Flange	2200		31.5	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	217.7	0.972	217.7	0.059
	Flange	1500		29.2	0.0	0.00	0.0	0.000	0.00	0.0000	0.0	0.000	137.4	0.6136	137.4	0.037
Project 2	Pipe	500		35.7	0.0	0.00	428.0	1.950	428.00	0.377	0.0	0.0000	168.1	0.750	596.1	0.162
	Pipe	500		2.4	0.0	0.00	7.3	0.033	7.33	0.006	0.0	0.0000	0.0	0.000	7.3	0.002
	Pipe	550		5.0	0.0	0.00	60.0	0.285	60.00	0.053	0.0	0.0000	25.9	0.116	85.9	0.023
	Pipe	550		0.3	0.0	0.00	1.0	0.005	1.00	0.001	0.0	0.0000	0.0	0.000	1.0	0.000
	Pipe	600		21.1	0.0	0.00	253.3	1.250	253.33	0.223	0.0	0.0000	119.4	0.533	372.7	0.101
	Pipe	600		0.7	0.0	0.00	2.0	0.010	2.00	0.002	0.0	0.0000	0.0	0.000	2.0	0.001
	Pipe	700		0.4	0.0	0.00	5.3	0.029	5.33	0.005	0.0	0.0000	2.9	0.013	8.3	0.002
	Pipe	750		31.8	0.0	0.00	381.3	2.122	381.33	0.336	0.0	0.0000	224.6	1.003	606.0	0.165
Project 3	Pipe	3000		1.2	14.4	0.31	0.0	0.000	14.40	0.013	0.0	0.0000	33.9	0.151	48.3	0.013
	Pipe	3000		0.1	1.1	0.02	0.0	0.000	1.10	0.001	0.0	0.0000	2.8	0.013	3.9	0.001
	Miter	3000		0.2	1.6	0.03	0.0	0.000	1.60	0.001	7.5	0.0036	7.5	0.034	9.1	0.002
Project 4	Pipe	3600		1.1	12.7	0.44	0.0	0.000	12.71	0.0112	0.0	0.000	35.9	0.1604	48.6	0.013
	Pipe	3600		0.0	0.1	0.00	0.0	0.000	0.09	0.000	0.0	0.0000	0.0	0.000	0.1	0.000
	Pipe	1200		0.4	4.2	0.02	0.0	0.000	4.24	0.004	0.0	0.0000	4.0	0.018	8.2	0.002
	Pipe	1200		0.03	0.0	0.00	0.0	0.000	0.04	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Pipe	450		0.2	0.0	0.00	2.1	0.009	2.12	0.002	0.0	0.0000	0.7	0.003	2.9	0.001
	Miter	1200		0.2	1.1	0.01	0.0	0.000	1.06	0.001	2.7	0.0013	2.7	0.012	3.7	0.001
Project 5	Pipe	1200		1.4	16.5	0.08	0.0	0.000	16.50	0.015	0.0	0.0000	15.6	0.069	32.1	0.009

	Pipe	900		2.4	0.0	0.00	28.5	0.179	28.50	0.025	0.0	0.0000	20.1	0.090	48.6	0.013
	Pipe	450		1.8	0.0	0.00	10.5	0.046	10.50	0.009	0.0	0.0000	2.5	0.011	13.0	0.004
	Miter	1200		0.5	2.8	0.01	0.0	0.000	2.75	0.002	7.5	0.0036	7.5	0.034	10.3	0.003
	Miter	900		0.3	0.0	0.00	2.5	0.016	1.25	0.001	2.8	0.0013	2.8	0.013	4.1	0.001
	Miter	450		0.3	0.0	0.00	1.8	0.008	0.88	0.001	0.7	0.0003	0.7	0.003	1.6	0.000
	Flange	1200		2.8	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	10.4	0.046	10.4	0.003
	Flange	900		5.8	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	16.3	0.073	16.3	0.004
	Flange	450		0.6	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.9	0.004	0.9	0.000
	Reducer	1200	900	0.1	0.0	0.00	0.7	0.005	0.69	0.001	0.0	0.0000	0.5	0.002	1.2	0.000
	Reducer	900	450	0.1	0.0	0.00	0.6	0.004	0.56	0.000	0.0	0.0000	0.0	0.000	0.6	0.000
	Tee	1200	450	0.1	0.0	0.00	0.9	0.007	0.88	0.001	1.4	0.0007	0.5	0.002	1.3	0.000
Project 6	Pipe	750		0.7	0.0	0.00	8.0	0.045	8.00	0.007	0.0	0.0000	4.7	0.021	12.7	0.003
	Pipe	500		0.3	0.0	0.00	3.2	0.015	3.20	0.003	0.0	0.0000	1.3	0.006	4.5	0.001
	Pipe	500		0.1	0.0	0.00	0.3	0.001	0.30	0.000	0.0	0.0000	0.1	0.000	0.4	0.000
	Miter	750		0.3	0.0	0.00	1.3	0.007	1.33	0.001	0.8	0.0004	2.5	0.011	3.8	0.001
	Reducer	750	500	0.1	0.0	0.00	0.2	0.001	0.20	0.000	0.0	0.0000	0.0	0.000	0.2	0.000
	Tee	750	750	0.1	0.0	0.00	0.3	0.002	0.30	0.000	0.2	0.0001	0.2	0.001	0.5	0.000
Project 7	Pipe	750		29.9	0.0	0.00	358.5	1.995	358.50	0.316	0.0	0.0000	211.2	0.943	569.7	0.155
	Pipe	750		0.1	0.0	0.00	0.3	0.002	0.31	0.000	0.0	0.0000	0.0	0.000	0.3	0.000
	Pipe	650		22.6	0.0	0.00	271.5	1.395	271.50	0.239	0.0	0.0000	138.6	0.619	410.1	0.112
				Total	522.0 meters	5.4 man-days	1829.5 meters	9.4 man-days	2349.3 meters	2.1 man-days	46.8 meters	0.0 man-days	2144.6 meters	9.6 man-days	4493.9 meters	1.2 man-days

Table D-8: Portfolio Plan's Resource Allocation for Week 7

Project Reference	Product List	Diameter (mm)		Pieces Required per Week	Resource Allocation by PP											
					Rolling (PS600)		Rolling (PS360)		Longitudinal Welding		Cutting		Circumferential Welding		Finishing	
		size 1	Size 2		Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)
Project 1	Pipe	2200		0.0												
	Pipe	2200		0.0												
	Pipe	1500		0.0												
	Miter	2200		0.0	FINISHED											
	Miter	1500		0.0												
	Flange	2200		0.0												
	Flange	1500		0.0												
Project 2	Pipe	500		35.7	0.0	0.00	428.0	3.900	428.00	0.377	0.0	0.0000	168.1	0.750	596.1	0.162
	Pipe	500		2.4	0.0	0.00	7.3	0.067	7.33	0.006	0.0	0.0000	0.0	0.000	7.3	0.002
	Pipe	550		5.0	0.0	0.00	60.0	0.569	60.00	0.053	0.0	0.0000	25.9	0.116	85.9	0.023
	Pipe	550		0.3	0.0	0.00	1.0	0.009	1.00	0.001	0.0	0.0000	0.0	0.000	1.0	0.000
	Pipe	600		21.1	0.0	0.00	253.3	2.501	253.33	0.223	0.0	0.0000	119.4	0.533	372.7	0.101
	Pipe	600		0.7	0.0	0.00	2.0	0.020	2.00	0.002	0.0	0.0000	0.0	0.000	2.0	0.001
	Pipe	700		0.4	0.0	0.00	5.3	0.057	5.33	0.005	0.0	0.0000	2.9	0.013	8.3	0.002
	Pipe	750		31.8	0.0	0.00	381.3	4.245	381.33	0.336	0.0	0.0000	224.6	1.003	606.0	0.165
Project 3	Pipe	3000		1.2	14.4	0.31	0.0	0.000	14.40	0.013	0.0	0.0000	33.9	0.151	48.3	0.013
	Pipe	3000		0.1	1.1	0.02	0.0	0.000	1.10	0.001	0.0	0.0000	2.8	0.013	3.9	0.001
	Miter	3000		0.2	1.6	0.03	0.0	0.000	1.60	0.001	7.5	0.0036	7.5	0.034	9.1	0.002
Project 4	Pipe	3600		1.1	12.7	0.44	0.0	0.000	12.71	0.0112	0.0	0.000	35.9	0.1604	48.6	0.013
	Pipe	3600		0.0	0.1	0.00	0.0	0.000	0.09	0.000	0.0	0.0000	0.0	0.000	0.1	0.000
	Pipe	1200		0.4	4.2	0.02	0.0	0.000	4.24	0.004	0.0	0.0000	4.0	0.018	8.2	0.002
	Pipe	1200		0.03	0.0	0.00	0.0	0.000	0.04	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Pipe	450		0.2	0.0	0.00	2.1	0.019	2.12	0.002	0.0	0.0000	0.7	0.003	2.9	0.001
	Miter	1200		0.2	1.1	0.01	0.0	0.000	1.06	0.001	2.7	0.0013	2.7	0.012	3.7	0.001
Project 5	Pipe	1200		1.4	16.5	0.08	0.0	0.000	16.50	0.015	0.0	0.0000	15.6	0.069	32.1	0.009

	Pipe	900		2.4	0.0	0.00	28.5	0.358	28.50	0.025	0.0	0.0000	20.1	0.090	48.6	0.013
	Pipe	450		1.8	0.0	0.00	10.5	0.092	10.50	0.009	0.0	0.0000	2.5	0.011	13.0	0.004
	Miter	1200		0.5	2.8	0.01	0.0	0.000	2.75	0.002	7.5	0.0036	7.5	0.034	10.3	0.003
	Miter	900		0.3	0.0	0.00	2.5	0.031	1.25	0.001	2.8	0.0013	2.8	0.013	4.1	0.001
	Miter	450		0.3	0.0	0.00	1.8	0.015	0.88	0.001	0.7	0.0003	0.7	0.003	1.6	0.000
	Flange	1200		2.8	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	10.4	0.046	10.4	0.003
	Flange	900		5.8	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	16.3	0.073	16.3	0.004
	Flange	450		0.6	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.9	0.004	0.9	0.000
	Reducer	1200	900	0.1	0.0	0.00	0.7	0.011	0.69	0.001	0.0	0.0000	0.5	0.002	1.2	0.000
	Reducer	900	450	0.1	0.0	0.00	0.6	0.007	0.56	0.000	0.0	0.0000	0.0	0.000	0.6	0.000
	Tee	1200	450	0.1	0.0	0.00	0.9	0.014	0.88	0.001	1.4	0.0007	0.5	0.002	1.3	0.000
Project 6	Pipe	750		0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Pipe	500		0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Pipe	500		0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Miter	750		0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Reducer	750	500	0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Tee	750	750	0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
Project 7	Pipe	750		0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Pipe	750		0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Pipe	650		0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
				Total	54.5 meters	0.9 man-days	1185.8 meters	11.9 man-days	1238.2 meters	1.1 man-days	22.7 meters	0.0 man-days	706.2 meters	3.2 man-days	1944.4 meters	0.5 man-days

Table D-9: Portfolio Plan's Resource Allocation for Week 8

Project Reference	Product List	Diameter (mm)		Pieces Required per Week	Resource Allocation by PP											
		size 1	Size 2		Rolling (PS600)		Rolling (PS360)		Longitudinal Welding		Cutting		Circumferential Welding		Finishing	
					Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)
Project 1	Pipe	2200		0.0												
	Pipe	2200		0.0												
	Pipe	1500		0.0												
	Miter	2200		0.0	FINISHED											
	Miter	1500		0.0												
	Flange	2200		0.0												
	Flange	1500		0.0												
Project 2	Pipe	500		35.7	0.0	0.00	428.0	3.900	428.00	0.377	0.0	0.0000	168.1	0.750	596.1	0.162
	Pipe	500		2.4	0.0	0.00	7.3	0.067	7.33	0.006	0.0	0.0000	0.0	0.000	7.3	0.002
	Pipe	550		5.0	0.0	0.00	60.0	0.569	60.00	0.053	0.0	0.0000	25.9	0.116	85.9	0.023
	Pipe	550		0.3	0.0	0.00	1.0	0.009	1.00	0.001	0.0	0.0000	0.0	0.000	1.0	0.000
	Pipe	600		21.1	0.0	0.00	253.3	2.501	253.33	0.223	0.0	0.0000	119.4	0.533	372.7	0.101
	Pipe	600		0.7	0.0	0.00	2.0	0.020	2.00	0.002	0.0	0.0000	0.0	0.000	2.0	0.001
	Pipe	700		0.4	0.0	0.00	5.3	0.057	5.33	0.005	0.0	0.0000	2.9	0.013	8.3	0.002
	Pipe	750		31.8	0.0	0.00	381.3	4.245	381.33	0.336	0.0	0.0000	224.6	1.003	606.0	0.165
Project 3	Pipe	3000		1.2	14.4	0.31	0.0	0.000	14.40	0.013	0.0	0.0000	33.9	0.151	48.3	0.013
	Pipe	3000		0.1	1.1	0.02	0.0	0.000	1.10	0.001	0.0	0.0000	2.8	0.013	3.9	0.001
	Miter	3000		0.2	1.6	0.03	0.0	0.000	1.60	0.001	7.5	0.0036	7.5	0.034	9.1	0.002
Project 4	Pipe	3600		1.1	12.7	0.44	0.0	0.000	12.71	0.0112	0.0	0.000	35.9	0.1604	48.6	0.013
	Pipe	3600		0.0	0.1	0.00	0.0	0.000	0.09	0.000	0.0	0.0000	0.0	0.000	0.1	0.000
	Pipe	1200		0.4	4.2	0.02	0.0	0.000	4.24	0.004	0.0	0.0000	4.0	0.018	8.2	0.002
	Pipe	1200		0.03	0.0	0.00	0.0	0.000	0.04	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Pipe	450		0.2	0.0	0.00	2.1	0.019	2.12	0.002	0.0	0.0000	0.7	0.003	2.9	0.001
	Miter	1200		0.2	1.1	0.01	0.0	0.000	1.06	0.001	2.7	0.0013	2.7	0.012	3.7	0.001
Project 5	Pipe	1200		1.4	16.5	0.08	0.0	0.000	16.50	0.015	0.0	0.0000	15.6	0.069	32.1	0.009

	Pipe	900		2.4	0.0	0.00	28.5	0.358	28.50	0.025	0.0	0.0000	20.1	0.090	48.6	0.013
	Pipe	450		1.8	0.0	0.00	10.5	0.092	10.50	0.009	0.0	0.0000	2.5	0.011	13.0	0.004
	Miter	1200		0.5	2.8	0.01	0.0	0.000	2.75	0.002	7.5	0.0036	7.5	0.034	10.3	0.003
	Miter	900		0.3	0.0	0.00	2.5	0.031	1.25	0.001	2.8	0.0013	2.8	0.013	4.1	0.001
	Miter	450		0.3	0.0	0.00	1.8	0.015	0.88	0.001	0.7	0.0003	0.7	0.003	1.6	0.000
	Flange	1200		2.8	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	10.4	0.046	10.4	0.003
	Flange	900		5.8	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	16.3	0.073	16.3	0.004
	Flange	450		0.6	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.9	0.004	0.9	0.000
	Reducer	1200	900	0.1	0.0	0.00	0.7	0.011	0.69	0.001	0.0	0.0000	0.5	0.002	1.2	0.000
	Reducer	900	450	0.1	0.0	0.00	0.6	0.007	0.56	0.000	0.0	0.0000	0.0	0.000	0.6	0.000
	Tee	1200	450	0.1	0.0	0.00	0.9	0.014	0.88	0.001	1.4	0.0007	0.5	0.002	1.3	0.000
Project 6	Pipe	750		0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Pipe	500		0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Pipe	500		0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Miter	750		0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Reducer	750	500	0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Tee	750	750	0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
Project 7	Pipe	750		0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Pipe	750		0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Pipe	650		0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
				Total	54.5 meters	0.9 man-days	1185.8 meters	11.9 man-days	1238.2 meters	1.1 man-days	22.7 meters	0.0 man-days	706.2 meters	3.2 man-days	1944.4 meters	0.5 man-days

Table D-10: Portfolio Plan's Resource Allocation for Week 9

Project Reference	Product List	Diameter (mm)		Pieces Required per Week	Resource Allocation by PP											
					Rolling (PS600)		Rolling (PS360)		Longitudinal Welding		Cutting		Circumferential Welding		Finishing	
		size 1	Size 2		Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)
Project 1	Pipe	2200		0.0	FINISHED											
	Pipe	2200		0.0												
	Pipe	1500		0.0												
	Miter	2200		0.0												
	Miter	1500		0.0												
	Flange	2200		0.0												
	Flange	1500		0.0												
Project 2	Pipe	500		35.7	0.0	0.00	428.0	1.950	428.00	0.377	0.0	0.0000	168.1	0.750	596.1	0.162
	Pipe	500		2.4	0.0	0.00	7.3	0.033	7.33	0.006	0.0	0.0000	0.0	0.000	7.3	0.002
	Pipe	550		5.0	0.0	0.00	60.0	0.285	60.00	0.053	0.0	0.0000	25.9	0.116	85.9	0.023
	Pipe	550		0.3	0.0	0.00	1.0	0.005	1.00	0.001	0.0	0.0000	0.0	0.000	1.0	0.000
	Pipe	600		21.1	0.0	0.00	253.3	1.250	253.33	0.223	0.0	0.0000	119.4	0.533	372.7	0.101
	Pipe	600		0.7	0.0	0.00	2.0	0.010	2.00	0.002	0.0	0.0000	0.0	0.000	2.0	0.001
	Pipe	700		0.4	0.0	0.00	5.3	0.029	5.33	0.005	0.0	0.0000	2.9	0.013	8.3	0.002
	Pipe	750		31.8	0.0	0.00	381.3	2.122	381.33	0.336	0.0	0.0000	224.6	1.003	606.0	0.165
Project 3	Pipe	3000		1.2	14.4	0.31	0.0	0.000	14.40	0.013	0.0	0.0000	33.9	0.151	48.3	0.013
	Pipe	3000		0.1	1.1	0.02	0.0	0.000	1.10	0.001	0.0	0.0000	2.8	0.013	3.9	0.001
	Miter	3000		0.2	1.6	0.03	0.0	0.000	1.60	0.001	7.5	0.0036	7.5	0.034	9.1	0.002
Project 4	Pipe	3600		1.1	12.7	0.44	0.0	0.000	12.71	0.0112	0.0	0.000	35.9	0.1604	48.6	0.013
	Pipe	3600		0.0	0.1	0.00	0.0	0.000	0.09	0.000	0.0	0.0000	0.0	0.000	0.1	0.000
	Pipe	1200		0.4	4.2	0.02	0.0	0.000	4.24	0.004	0.0	0.0000	4.0	0.018	8.2	0.002
	Pipe	1200		0.03	0.0	0.00	0.0	0.000	0.04	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Pipe	450		0.2	0.0	0.00	2.1	0.009	2.12	0.002	0.0	0.0000	0.7	0.003	2.9	0.001
	Miter	1200		0.2	1.1	0.01	0.0	0.000	1.06	0.001	2.7	0.0013	2.7	0.012	3.7	0.001
Project 5	Pipe	1200		0.0	FINISHED											

	Pipe	900		0.0												
	Pipe	450		0.0												
	Miter	1200		0.0												
	Miter	900		0.0												
	Miter	450		0.0												
	Flange	1200		0.0												
	Flange	900		0.0												
	Flange	450		0.0												
	Reducer	1200	900	0.0												
	Reducer	900	450	0.0												
	Tee	1200	450	0.0												
Project 6	Pipe	750		1.1	0.0	0.00	13.3	0.074	13.33	0.012	0.0	0.0000	7.9	0.035	21.2	0.006
	Pipe	500		0.4	0.0	0.00	5.3	0.024	5.33	0.005	0.0	0.0000	2.1	0.009	7.4	0.002
	Pipe	500		0.1	0.0	0.00	0.5	0.002	0.50	0.000	0.0	0.0000	0.2	0.001	0.7	0.000
	Miter	750		0.4	0.0	0.00	2.2	0.012	2.22	0.002	1.3	0.0006	4.2	0.019	6.4	0.002
	Reducer	750	500	0.1	0.0	0.00	0.3	0.002	0.33	0.000	0.0	0.0000	0.0	0.000	0.3	0.000
	Tee	750	750	0.1	0.0	0.00	0.5	0.003	0.50	0.000	0.3	0.0001	0.3	0.001	0.8	0.000
Project 7	Pipe	750		37.3	0.0	0.00	448.1	2.494	448.13	0.395	0.0	0.0000	264.0	1.178	712.1	0.194
	Pipe	750		0.2	0.0	0.00	0.4	0.002	0.39	0.000	0.0	0.0000	0.0	0.000	0.4	0.000
	Pipe	650		28.3	0.0	0.00	339.4	1.744	339.38	0.299	0.0	0.0000	173.3	0.773	512.6	0.139
				Total	35.2 meters	0.8 man-days	1950.6 meters	10.1 man-days	1985.8 meters	1.8 man-days	11.8 meters	0.0 man-days	1080.3 meters	4.8 man-days	3066.1 meters	0.8 man-days

Table D-11: Portfolio Plan's Resource Allocation for Week 10

Project Reference	Product List	Diameter (mm) size 1	Diameter (mm) Size 2	Pieces Required per Week	Resource Allocation by PP											
					Rolling (PS600)		Rolling (PS360)		Longitudinal Welding		Cutting		Circumferential Welding		Finishing	
					Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)
Project 1	Pipe	2200		0.0												
	Pipe	2200		0.0												
	Pipe	1500		0.0												
	Miter	2200		0.0	FINISHED											
	Miter	1500		0.0												
	Flange	2200		0.0												
	Flange	1500		0.0												
Project 2	Pipe	500		0.0												
	Pipe	500		0.0												
	Pipe	550		0.0												
	Pipe	550		0.0	FINISHED											
	Pipe	600		0.0												
	Pipe	600		0.0												
	Pipe	700		0.0												
	Pipe	750		0.0												
Project 3	Pipe	3000		1.2	14.4	0.31	0.0	0.000	14.40	0.013	0.0	0.0000	33.9	0.151	48.3	0.013
	Pipe	3000		0.1	1.1	0.02	0.0	0.000	1.10	0.001	0.0	0.0000	2.8	0.013	3.9	0.001
	Miter	3000		0.2	1.6	0.03	0.0	0.000	1.60	0.001	7.5	0.0036	7.5	0.034	9.1	0.002
Project 4	Pipe	3600		26.5	12.7	0.44	0.0	0.000	12.71	0.0112	0.0	0.000	35.9	0.1604	48.6	0.013
	Pipe	3600		0.7	0.1	0.00	0.0	0.000	0.09	0.000	0.0	0.0000	0.0	0.000	0.1	0.000
	Pipe	1200		8.8	4.2	0.02	0.0	0.000	4.24	0.004	0.0	0.0000	4.0	0.018	8.2	0.002
	Pipe	1200		0.7	0.0	0.00	0.0	0.000	0.04	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Pipe	450		4.4	0.0	0.00	2.1	0.009	2.12	0.002	0.0	0.0000	0.7	0.003	2.9	0.001
	Miter	1200		4.4	1.1	0.01	0.0	0.000	1.06	0.001	2.7	0.0013	2.7	0.012	3.7	0.001
Project 5	Pipe	1200		0.0	FINISHED											

	Pipe	900		0.0												
	Pipe	450		0.0												
	Miter	1200		0.0												
	Miter	900		0.0												
	Miter	450		0.0												
	Flange	1200		0.0												
	Flange	900		0.0												
	Flange	450		0.0												
	Reducer	1200	900	0.0												
	Reducer	900	450	0.0												
	Tee	1200	450	0.0												
Project 6	Pipe	750		3.8	0.0	0.00	15.0	0.083	15.00	0.013	0.0	0.0000	8.8	0.039	23.8	0.006
	Pipe	500		1.5	0.0	0.00	6.0	0.027	6.00	0.005	0.0	0.0000	2.4	0.011	8.4	0.002
	Pipe	500		0.4	0.0	0.00	0.6	0.003	0.56	0.000	0.0	0.0000	0.2	0.001	0.8	0.000
	Miter	750		1.5	0.0	0.00	2.5	0.014	2.50	0.002	1.5	0.0007	4.7	0.021	7.2	0.002
	Reducer	750	500	0.4	0.0	0.00	0.4	0.002	0.38	0.000	0.0	0.0000	0.0	0.000	0.4	0.000
	Tee	750	750	0.4	0.0	0.00	0.6	0.003	0.56	0.000	0.3	0.0001	0.3	0.001	0.9	0.000
Project 7	Pipe	750		74.7	0.0	0.00	448.1	2.494	448.13	0.395	0.0	0.0000	264.0	1.178	712.1	0.194
	Pipe	750		0.3	0.0	0.00	0.4	0.002	0.39	0.000	0.0	0.0000	0.0	0.000	0.4	0.000
	Pipe	650		56.6	0.0	0.00	339.4	1.744	339.38	0.299	0.0	0.0000	173.3	0.773	512.6	0.139
				Total	35.2 meters	0.8 man-days	815.0 meters	4.4 man-days	850.2 meters	0.7 man-days	12.0 meters	0.0 man-days	541.2 meters	2.4 man-days	1391.5 meters	0.4 man-days

Table D-12: Portfolio Plan's Resource Allocation for Week 11

Project Reference	Product List	Diameter (mm)		Pieces Required per Week	Resource Allocation by PP											
					Rolling (PS600)		Rolling (PS360)		Longitudinal Welding		Cutting		Circumferential Welding		Finishing	
		size 1	Size 2		Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)
Project 6	6	Pipe	750	0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	6	Pipe	500	0.6	0.0	0.00	6.9	0.031	6.86	0.006	0.0	0.0000	2.7	0.012	9.5	0.003
	6	Pipe	500	0.1	0.0	0.00	0.6	0.003	0.64	0.001	0.0	0.0000	0.2	0.001	0.9	0.000
	6	Miter	750	0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	6	Reducer	750	0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	6	Tee	750	0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
Project 7	5	Pipe	750	0.0	FINISHED											
	5	Pipe	750	0.0												
	5	Pipe	650	0.0												
Project 8	5	Pipe	750	119.5	0.0	0.00	1434.0	7.981	1434.00	1.265	0.0	0.0000	844.7	3.771	2278.7	0.620
	5	Pipe	750	0.5	0.0	0.00	1.3	0.007	1.25	0.001	0.0	0.0000	0.0	0.000	1.3	0.000
	5	Pipe	650	90.5	0.0	0.00	1086.0	5.579	1086.00	0.958	0.0	0.0000	554.4	2.475	1640.4	0.446
				Total	0.0 meters	0.0 man-days	2528.8 meters	13.6 man-days	2528.8 meters	2.2 man-days	0.0 meters	0.0 man-days	1402.0 meters	6.3 man-days	3930.8 meters	1.1 man-days

Table D-13: Portfolio Plan's Resource Allocation for Week 12 (Option 1)

Project Reference	Product List	Diameter (mm)		Pieces Required per Week	Resource Allocation by PP											
		size 1	Size 2		Rolling (PS600)		Rolling (PS360)		Longitudinal Welding		Cutting		Circumferential Welding		Finishing	
					Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)
Project 8	Pipe	750		119.5	0.0	0.00	1434.0	7.981	1434.00	1.265	0.0	0.0000	844.7	3.771	2278.7	0.620
	Pipe	750		0.5	0.0	0.00	1.3	0.007	1.25	0.001	0.0	0.0000	0.0	0.000	1.3	0.000
	Pipe	650		90.5	0.0	0.00	1086.0	5.579	1086.00	0.958	0.0	0.0000	554.4	2.475	1640.4	0.446
Project 9	Pipe	2200		24.3	292.0	3.33	0.0	0.000	292.00	0.2575	0.0	0.000	504.5	2.2524	796.5	0.217
	Pipe	2200		0.5	1.5	0.02	0.0	0.000	1.50	0.001	0.0	0.0000	0.0	0.000	1.5	0.000
	Pipe	700		53.3	0.0	0.00	640.0	6.844	640.00	0.564	0.0	0.0000	351.9	1.571	991.9	0.270
	Pipe	700		0.17	0.0	0.00	0.5	0.005	0.50	0.000	0.0	0.0000	0.0	0.000	0.5	0.000
	Flange	2200		48.7	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	336.4	1.502	336.4	0.092
	Flange	700		106.7	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	502.7	2.244	502.7	0.137
				Total	293.5 meters	3.4 man-days	3161.8 meters	20.4 man-days	3455.3 meters	3.0 man-days	0.0 meters	0.0 man-days	3094.5 meters	13.8 man-days	6549.8 meters	1.8 man-days

Table D-14: Portfolio Plan's Resource Allocation for Week 12 (Option 2)

Project Reference	Product List	Diameter (mm)		Pieces Required per Week	Resource Allocation by PP											
		size 1	Size 2		Rolling (PS600)		Rolling (PS360)		Longitudinal Welding		Cutting		Circumferential Welding		Finishing	
					Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)
Project 8	Pipe	750		119.5	0.0	0.00	1434.0	8.0	1434.0	1.3	0.0	0.0	844.7	3.8	2278.7	0.6
	Pipe	750		0.5	0.0	0.00	1.3	0.0	1.3	0.0	0.0	0.0	0.0	0.0	1.3	0.0
	Pipe	650		90.5	0.0	0.00	1086.0	5.6	1086.0	1.0	0.0	0.0	554.4	2.5	1640.4	0.4
Project 9	Pipe	2200		24.3	292.0	3.33	0.0	0.0	292.0	0.3	0.0	0.0	504.5	2.3	796.5	0.2
	Pipe	2200		0.5	1.5	0.02	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	1.5	0.0
	Pipe	700		0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pipe	700		0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Flange	2200		48.7	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	336.4	1.5	336.4	0.1
	Flange	700		0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
				Total	293.5 meters	3.4 man-days	2521.3 meters	13.6 man-days	2814.8 meters	2.5 man-days	0.0 meters	0.0 man-days	2240.0 meters	10.0 man-days	5054.8 meters	1.4 man-days

Table D-15: Portfolio Plan's Resource Allocation for Week 13 (Option 1)

Project Reference	Product List	Diameter (mm)		Pieces Required per Week	Resource Allocation by PP											
					Rolling (PS600)		Rolling (PS360)		Longitudinal Welding		Cutting		Circumferential Welding		Finishing	
		size 1	Size 2		Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)
Project 8	Pipe	750		0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pipe	750		0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pipe	650		0.0	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Project 9	Pipe	2200		24.3	292.0	3.33	0.0	0.0	292.0	0.3	0.0	0.0	504.5	2.3	796.5	0.2
	Pipe	2200		0.5	1.5	0.02	0.0	0.0	1.5	0.0	0.0	0.0	0.0	0.0	1.5	0.0
	Pipe	700		53	0.0	0.00	640.0	6.8	640.0	0.6	0.0	0.0	351.9	1.6	991.9	0.3
	Pipe	700		0	0.0	0.00	0.5	0.0	0.5	0.0	0.0	0.0	0.0	0.0	0.5	0.0
	Flange	2200		48.7	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	336.4	1.5	336.4	0.1
	Flange	700		107	0.0	0.00	0.0	0.0	0.0	0.0	0.0	0.0	502.7	2.2	502.7	0.1
				Total	293.5 meters	3.4 man-days	640.5 meters	6.8 man-days	934.0 meters	0.8 man-days	0.0 meters	0.0 man-days	1695.4 meters	7.6 man-days	2629.4 meters	0.7 man-days

Table D-16: Portfolio Plan's Resource Allocation for Week 13 (Option 2)

Project Reference	Product List	Diameter (mm)		Pieces Required per Week	Resource Allocation by PP											
					Rolling (PS600)		Rolling (PS360)		Longitudinal Welding		Cutting		Circumferential Welding		Finishing	
		size 1	Size 2		Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)
Project 8	Pipe	750		0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Pipe	750		0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
	Pipe	650		0.0	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	0.0	0.000	0.0	0.000
Project 9	Pipe	2200		24.3	292.0	3.33	0.0	0.000	292.00	0.2575	0.0	0.000	504.5	2.2524	796.5	0.217
	Pipe	2200		0.5	1.5	0.02	0.0	0.000	1.50	0.001	0.0	0.0000	0.0	0.000	1.5	0.000
	Pipe	700		64	0.0	0.00	768.0	8.213	768.00	0.677	0.0	0.0000	422.2	1.885	1190.2	0.324
	Pipe	700		0	0.0	0.00	0.6	0.006	0.60	0.001	0.0	0.0000	0.0	0.000	0.6	0.000
	Flange	2200		48.7	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	336.4	1.502	336.4	0.092
	Flange	700		128	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	603.2	2.693	603.2	0.164
				Total	293.5 meters	3.4 man-days	768.6 meters	8.2 man-days	1062.1 meters	0.9 man-days	0.0 meters	0.0 man-days	1866.3 meters	8.3 man-days	2928.4 meters	0.8 man-days

Table D-17: Portfolio Plan’s Resource Allocation for Week 14 (Option 1)

Project Reference	Product List	Diameter (mm)		Pieces Required per Week	Resource Allocation by PP											
		size 1	Size 2		Rolling (PS600)		Rolling (PS360)		Longitudinal Welding		Cutting		Circumferential Welding		Finishing	
					Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)
Project 9	Pipe	2200		24.3	292.0	3.33	0.0	0.000	292.00	0.2575	0.0	0.000	504.5	2.2524	796.5	0.217
	Pipe	2200		0.5	1.5	0.02	0.0	0.000	1.50	0.001	0.0	0.0000	0.0	0.000	1.5	0.000
	Pipe	700		53	0.0	0.00	640.0	6.844	640.00	0.564	0.0	0.0000	351.9	1.571	991.9	0.270
	Pipe	700		0	0.0	0.00	0.5	0.005	0.50	0.000	0.0	0.0000	0.0	0.000	0.5	0.000
	Flange	2200		48.7	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	336.4	1.502	336.4	0.092
	Flange	700		107	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	502.7	2.244	502.7	0.137
				Total	293.5 meters	3.4 man-days	640.5 meters	6.8 man-days	934.0 meters	0.8 man-days	0.0 meters	0.0 man-days	1695.4 meters	7.6 man-days	2629.4 meters	0.7 man-days

Table D-18: Portfolio Plan’s Resource Allocation for Week 14 (Option 2)

Project Reference	Product List	Diameter (mm)		Pieces Required per Week	Resource Allocation by PP											
					Rolling (PS600)		Rolling (PS360)		Longitudinal Welding		Cutting		Circumferential Welding		Finishing	
		size 1	Size 2		Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)	Planned (meters)	Capacity Usage (days)
Project 9	Pipe	2200		24.3	292.0	3.33	0.0	0.000	292.00	0.2575	0.0	0.000	504.5	2.2524	796.5	0.217
	Pipe	2200		0.5	1.5	0.02	0.0	0.000	1.50	0.001	0.0	0.0000	0.0	0.000	1.5	0.000
	Pipe	700		64	0.0	0.00	768.0	8.213	768.00	0.677	0.0	0.0000	422.2	1.885	1190.2	0.324
	Pipe	700		0	0.0	0.00	0.6	0.006	0.60	0.001	0.0	0.0000	0.0	0.000	0.6	0.000
	Flange	2200		48.7	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	336.4	1.502	336.4	0.092
	Flange	700		128	0.0	0.00	0.0	0.000	0.00	0.000	0.0	0.0000	603.2	2.693	603.2	0.164
				Total	293.5 meters	3.4 man-days	768.6 meters	8.2 man-days	1062.1 meters	0.9 man-days	0.0 meters	0.0 man-days	1866.3 meters	8.3 man-days	2928.4 meters	0.8 man-days

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Rujanan Satawin completed his undergraduate studies in 2004 with the Bachelor's Degree in Mechanical Engineering at the University of California, Santa Barbara. After graduated, he started his career at a steel fabrication company as a business development executive. In 2008, he enrolled in the dual Master's Degree Program at the Chulalongkorn University and University of Warwick to expand his knowledge in the engineering business management at the Regional Center for Manufacturing System Engineering at Chulalongkorn University.