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THESIS

DEVELOPMENT OF DECISION SUPPORT TOOLS FOR RESOURCE MANAGEMENT IN CONSTRUCTION INDUSTRY

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A Thesis Submitted in Partial Fulfillment of
the Requirements for the Degree of
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Most construction companies encounter the difficulties of addressing resource conflicts as they usually perform multiple projects at once. This leads to the delay, cost overrun, and poor quality. The study is conducted based from a case study on a small-scale construction company where members have difficulties maximizing the utilization of project management software. By this, the time has been consumed unreasonably on software complexities and the performance is not monitored properly due to the lack of information. The conflicts are not detected, notifies, and addressed in timely manner.

The main objective of this study is to help company members, project managers, or even the owner to avoid those undesirable outcomes. A decision support tool is developed on a project management software called "Microsoft Project" using Visual Basic Applications (VBA), for the purpose of solving resource conflicts. It supports the decision with selected only relevant information, analyze from all input data in different aspects for instance time, cost, and significance of each task. The extension supports the decision of prioritizing the tasks by applying the concept of Ranked Positional Weight (RPW). It also facilitates function of viewing multiple project performance at once with a more user friendly interface and a customization of report generator.

Therefore, the amount of time wasted in detecting resource conflicts and generate such reports has been reduced and the project performance can be monitored more closely and accurately. As a result, this leads to less possibilities of cost overrun and delay, which are the most undesirable outcome for all projects.

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Student's signature Thesis Advisor's signature

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INTRODUCTION

At the present, project management has taken a significant role in many different aspects, including the construction industry. The application of project management can be beneficial and useful for all types of project, either in a big or in a small scale. The concept of balancing the triangle constraint which is comprised of cost, time, and quality, has been applied in several contexts. These three constraints are the key for the project management. The purpose of project management is to avoid cost overrun, delay, and unsatisfying quality which occurs in most projects. When applying the concept of project management to the construction project management, the main focus remains the same. However, there are a lot more details involving in the construction industry. There are several tasks within a single project and all projects are unique. As a result, the level of complication and uncertainty is potentially higher than projects in other industries.

The most complication in construction management is the resource which, most of the time, is the cause of conflicts. In a small scale construction business, resource is shared among several projects, especially the human resource which is considered to be quite scarce in terms of quantity. For the reason that in construction project, many skills are required and all of the skills are rarely found in a person. Therefore, the human resource is very difficult to manage.

Apart from human resource conflict, there is also the problems arising from a poor monitoring system. The loss of control in most processes and inability of the project manager to analyse and monitor the project efficiently have decrease the change of a successful project. Even though construction industry prioritise cost as the first rank of concern, time is also valuable. As the saying “time is money”, having a complete project delivered as it has been scheduled is another way to help guarantee the satisfaction of customer. The delay is found as the most common problem in most

project. Therefore, to be able to deliver the project on time, every task must be on the same track with the schedule. As construction projects involve a high level of complexities, unexpected problems should always be aware at all time. Due to the number of unexpected problems, the schedule and other little details will always be changing and this makes the construction project so dynamic. In order to make changes in the project, an adequate decision making is highly required. Sufficient information will help enhance the decision as all significant data is gathered and take into consideration.

Since there are so much information available in a project, project manager sometimes might have overlooked some important details that actually contribute to the decision, without it, the decision could possibly be worse than it could have been. Therefore, this is when the complementation of Information technology (IT) has played its part. Technology is known for its supporting functions as it helps to manage project easier. The information system becomes more systematic and more comprehensive when monitor. The process of monitoring a project will take less time to request for an information that is needed for the decision making. The faster and accurate decision is made, the better for the project. If there is an unexpected problem, it is best to solve it as soon as possible so that all process would not have to stop. The project can run smoothly if the decision is made by a professional that understands the project nature well. However, there is a saying says even the best swimmer can drown. It is possible that an experienced project manager can make a bad decision if the information is not there for consideration. Hence, the chance of not making the best decision might be from the information deprivation which can be improved by the Project management information system (PMIS).

The extension of Microsoft Project is written to serve the purpose of generating the report of multiple project performance. The focus is at the customisation of report. There are two main functions for the customisation. The first one is the presentation of task overallocated resource. When resource conflicts occur, portfolio manager has to make the decision to address this conflict. This particular extension will assist the manager to make the decision more easily and accurately.

However, this does not mean the software will solve the entire conflict but the manager himself must analyse and consider the best solution, considering from the important relevant information that the software provides.

OBJECTIVES

1. To develop decision model for purpose of solving resource conflicts.

2. To facilitate the process of generating multiple project report with customized report generator.

3. To enhance the process of monitoring and tracking for project managers in order to analyse the project performance easier.

4. To develop a user friendly interface for the convenience of analyzing, monitoring and tracking to avoid the delay, cost overrun, and poor quality which are the most undesirable outcome for all projects.

Research Problems

1. Project manager is only interested in the project they are in charge of, usually one manager per a project. Therefore, conflicts that occur from the interdependencies among projects are difficult to solve as each manager only understands the project they are currently supervised.

2. It is difficult and time consuming to detect overallocated resource in Microsoft Project. The manager needs to scroll throughout the project timeline to find the conflicts manually.

3. In construction industry, projects are very dynamic in terms of internal and external constrains which is the reason that project managers constantly encounter with unexpected problems.

LITERATURE REVIEW

1. Project Management

According to Project Management Institute (1996), project management can be defined as "an organizational approach to the management of ongoing operations" in which it applies the combination of knowledge, skills, tools, and technique to execute a certain project in order to fulfill the need or expectation of a certain group of people. This certain group of people can be clients or stakeholders.

When managing a project, there are three main constraints that must be concerned at all times. These constraints are scope – what needs to be done and the specifications, time – how much time available to complete the project, and cost – how much money or resources available for such project. They are also known as the 'Project Management Triangle'. As seen in figure below, the scope, cost, and time are interdependent. That is, the impact is unavoidable for the rest of constraints when one of them has been altered or re-planned. For instance, a smaller budget most likely to cause a longer length of time to finish and the specification might have to be reduced. Similarly, these conditions can also be applied to the case of shorter duration and more specifications. (DeMacro, 2008).

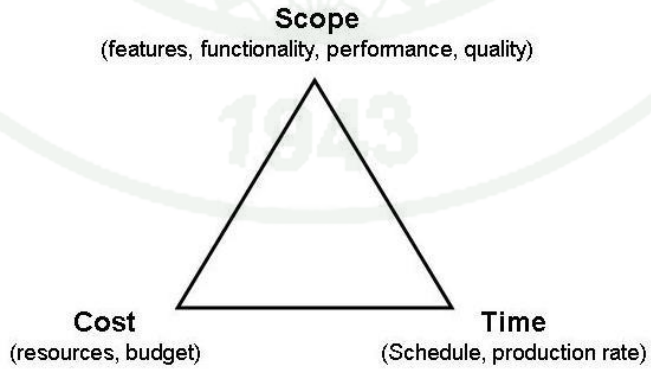


Figure 1 Project Management Triangle Constraints

In order to measure the success of a certain project, there are three major criteria must be taken to consideration which are the deadline, the budget, and the satisfaction of clients (JNC Solutions, n.d.). These criteria are considered to be equally significant. However, sometimes the prioritization can occur, depending on the situation. In simple words, the client might want to give priority to one of the three which can be the deadline, the scope, or the cost. This is entirely up to them if they have a fixed amount of a certain thing. For example, if the budget is fixed, the project manager have to reorganize and rebalance the project-management triangle. This is to make sure that time and scope are adjusted accordingly to the fixed budget.

All in all, the project that is overdue or over budget is not necessary always be a fail project. Rather, a successful project is judged from an ability to reach an agreed requirements between the project manager and the client, under the circumstance of different clients prioritizing these criteria differently.

According to Patanakul and Milosevic (2006), the interview demonstrates that task complexity is one of the most important factors in project requirements. "In projects with high task complexity, coordination is a key challenge…" (Meyer *et al.*, 2001). The project manager needs to make sure that the tasks are identified and scheduled, the resources are correctly allocated, the critical path is determined and the progress is monitored in order to accomplish the project objectives by taking time, budget, and design quality as the primary responsibility (Meyer *et al.*, 2001).

Due to the difference in client needs, cost-time-scope constraints, and the complexities occurred in each task, the project manager has to encounter several unexpected problems. Therefore, a fast decision making, an efficient resources allocation, and a clear focus is what the manager needs to achieve (Caniels and Bakens, 2012).

In order to be successful in making decisions when encounter unexpected challenges, a good project management process is required as it would lead to an effective and efficient decision making. There are five process groups according to PMI (1996). They are 1) initiating process, 2) planning process, 3) executing process, 4) controlling process, and 5) closing process. If the project management is competent

and well managed, there would be sufficient information to make a certain decision in the best way possible. The more information there is, the better decision can be made as there would be more alternatives available and less room for uncertainty or mistakes.

2. Tracking & Monitoring

According to Chandler (n.d.), project management consists of 20 % of planning and 80% of tracking and control. This really indicates the importance of the process of tracking and controlling in project management. The project manager's job is to be a surveillance person, looking out for errors and checking if the performance matches the plan. For this reason, the process of monitoring must be active continuously throughout the project because the unexpected should always be expected, especially for the projects that involve a high level of complexity. Due to the three constraints – time, cost, and scope – it would be better if the problems are solved as soon as they are detected as there is no time to lose. Encountering problems causes the possibilities of the delay and over budget which are the undesirable result for both the clients and the project manager. Therefore, to have the monitoring process active at all times will reduce possibilities of those unwanted outcomes and also to be able to keep the project performance up to the original objectives.

Due to a number of unexpected problems during the project, the original plan is not going to be exactly the same and there would be changes to make all the time. This is the reason why tracking is very necessary.

Project monitoring refers to the process of "collecting, recording, and reporting of project information that is important to project manager and other relevant stakeholders". The purpose of monitoring is to have a well-designed system which provides necessary information for project manager in order to make a 'timely decision' but to accomplish such thing is definitely not an easy task (Portny *et al.*, 2008). The essential task of setting up the monitoring system is that project manager ought to identify characteristics of performance, cost, and time. In short, the

circumstance and certain requirement for each constraint must be stated clearly. This is to guarantee a satisfactory deliverable to the clients.

There are a few forms of monitoring according to Portny *et al.* (2008), including Gantt chart and Earned valued chart. Gantt chart tracks progress regarding the time. As most tasks are dependent, some certain tasks cannot start if the previous one is not finished. The dependencies among project tasks could be the cause of loss and delay if there is a change. That is, when a task has been altered, other dependent task must be adjusted accordingly. Moreover, Earned Value Analysis is the process of examining the project efficiency and potential risk area regarding time-cost relation by integrating 3 values; BCWS (Budgeted Cost of Work Scheduled), ACWP (Actual Cost of Work Performed), and BCWP (Budgeted Cost of Work Performed). It also allows the manager to track the overall current project performance and recognise its positioning, whether it is on schedule or delay and whether it is on budget or over budget. The earned value analysis provides information for the project manager of where to be more cautious or which performance should be looked at more attentively. It should be ideal for all project to control and solve an issue at the early stage rather than try to solve when it has become 'insurmountable' which would probably cause more damages and be more difficult to deal with. This is to retrieve the project performance back on schedule as soon as possible. Other than tracking the macro picture of the project, the earned value analysis also forecasts the final outcome by measuring from the actual situation. By looking at the current performance, this analysis notifies the amount of money that 'was planned' to spend and the actual spending amount which will indicate the potential of project accomplishment (Nagrecha 2002; Brienza and Hildreth 2007; Sears *et al.* 2008; PierDesign n.d.; Jessop n.d.; Microsoft n.d.).

There are so much details to be analysed and collected during the process of project monitoring which project manager often makes either by overlooking some important information or sometimes collecting information that is less useful for the analysis. As a result of these mentioned mistakes, the forecast of project outcome might be inaccurate. (Portny *et al.*, 2008).

The most frequent project monitoring mistakes project manager makes are the fact that easily collected piece of information is gathered before the one that is more important but also more difficult to assemble. In addition, the “data that don’t change” is often collected by project manager. However it would not contribute significantly to the analysis for monitoring and control. Portny *et al.* (2008) have stated that “with no significant change there is no significant control activity”.

As mentioned previously that project monitoring and control is the majority of the project management, project manager should be able to identify problems quickly and should have a good understanding of the project performance. This is for the best possible accuracy of addressing an issue because by monitoring the performance, the actual problem does not just show up. Rather, it hints the manager with a trail of signal which should be interpreted further. Therefore, an ability to identify and address the issue depends on how well the project manager interpret those problematic signal and applies a suitable solution to a certain issue.

After the data collection and the analysis, reporting necessary information to the right person is essential. The report should be customised to ensure the stability of a quality management. Most of the times, there is information that should only be exposed and informed to a specific group of people. Not only for the security of confidential data but also for the sake of speed when the people involved have to process information. Over-reporting violates the privacy parameter of confidential information which can affect negatively to the overall project management. Similarly, underreporting would also undermines a good management as people who are involved in the project, especially ones who are entitled of making decision, require sufficient information to make the right decision. Therefore, a well-designed reporting system is suggested for all project.

3. Project Management Software

It is undeniable that technology has played such a significant role in the lifestyle of people nowadays. It facilitates and grants us a more convenient lifestyle in many aspects, unavoidably including in the aspect of project management. Technologies have taken a large portion in managing a project, particularly in terms of software applications. Since there are so much information and complication involved in a project, a systematic project-managing software is very much interested by project managers. With an overwhelming information and the difficulties of processing such data, "Meredith and Mantel (2006) found that utilizing Information technology (IT) has major impact in solving all difficulties, which may appear during project life-cycle phases, by presenting a crucial computer application, project management software such as, which may help in decreasing the time and cost that are required to use precise clarifications for project planning, scheduling, monitoring, and controlling" (Karim, 2011).There will always be some problems, regardless the size of the organization. The frequent problems found in most organization is that the project often fails to achieve the planned objectives of project duration, cost, and quality. As there is no analytic system that could actually integrates all of them efficiently. For the case of having a system, the project manager and team members are incapable of reporting adequately which leads to the loss of control of such system.

Due to the inaccuracy of recording and reporting system in most organizations, project manager is potentially deprived of useful information needed to make a good and timely decision. The project has been put at risk either by overlooking the data or by an incompetent system. Additionally, the data deprivation also decreases the possibility of project success. Hence, the application of Project Management Information System (PMIS) would be beneficial as it provides information needed for the decision making in which it enhances the success rate for

the project. At present, there are several PMIS software, for example Microsoft project and Primavera which specifically function to facilitate most processes in project management which gradually leads to the maximisation of project success.

4. Microsoft Project

Microsoft has developed a software called "Microsoft Project" which is known and widely used specifically to manage a project (Haughey, n.d.). It was first released in 1984. The software is available in two editions which are Microsoft Project Standard and Microsoft Project Professional. It offers integration with other Microsoft Products such as Microsoft Word, Microsoft Excel, and Microsoft Outlook. Microsoft Project "helps you document project tasks, build a schedule, assign resources, track progress, and make changes until your project is complete" (Biafore, 2013).

The software can creates schedules for critical path which can also be resource levelled. The resource can be separated into 3 types; people, equipment, and materials. They can be allocated to several tasks by pulling from a single origin or known as a resource pool. Each resource can be individually scheduled and recorded on its own calendar. Resource rate can be determined by project manager to set the specific cost for each resource. The manager can estimate the cost for each task by multiplying resource rate and amount of work needed to be accomplished. The resource can be utilised in multiple tasks and in multiple project. Moreover, there can be multiple resource being utilised in a single task as well. Microsoft Project schedules the tasks by considering on resource availability based. It can customise and assign different level of authority to access specific information to different people (Haughey, n.d.).

5. Construction Management

In construction industry, project management is very popular among project managers and stakeholders as it makes the management more systematic.

Construction project is difficult to manage as there are many detailed tasks which need to be accomplished within a certain time limit (Zoho, 2014). Moreover, each task is consisted of its unique conditions, complexity and uncertainty which also contribute to the overall project complexity (Mota *et al.*, 2009). A high level of complexity and uncertainty often put the project at risk and has become the cause of loss within the industry.

The nature of operation in this industry is a project-based operation and there would be a project manager in charge of each project. Realistically, construction companies would usually handle several projects at the same time. That is, there are many ongoing projects operating simultaneously or can also be called the multi-project management. Managing a single project is already complicated but not as much as the multi-project management. The difficulty in managing multiple projects in construction industry is the fact that each project is already full of details. All project is unique, in this case could be the uniqueness in size, budget, scope, or time duration. There are different types of constructions such as a house, a condominium or a factory which means it could involve from small to large scale constructions and such difference occurs in time, cost, and also quality. It is quite challenging to manage a project that costs a few million and the one that costs up to hundred millions simultaneously. This example also applies to the range in time duration and quality (Howell, 1968).

One thing that most project managers find really problematic about multi-project management in construction industry is the resource management. "Resources consist of materials, equipment, and labours" (Hendrickson and Au, 2008). Resource management for a single project is simple as all available resource is allocated directly to a certain ongoing project. As the number of projects increase, the more complex it gets to manage and allocate effectively. "Because there are multiple ongoing projects all the time therefore it is typical for the overlapping time in different projects to occur" (Hendrickson and Au, 2008). Conflict frequently occurs when many different ongoing projects need the same resource at the same time. This is when an efficient resource management and adequate allocation is required.

In a small scale construction business, the materials and equipment are not really complicate to manage as it can be hired or purchased when needed. However, for the labours, it is almost impossible to request more labours on the spot as the skilled labours are highly wanted in this industry. It can be said that resource management, especially the human resource, is the most problematic point for the multi-project management.

Patanakul and Milosevic (2008) point out that it is crucial to understand the interdependencies and interactions between projects which is the focus of multiple projects management as well as how to manage an individual project. That is, project manager must be able to manage individual project as well as looking at the whole picture, trying to reduce conflicts as all projects are interdependent from using the same resource pool. Despite the complexities and difficulties of requiring and allocating resources from the central pool, there is still advantage about it. Resource pool, looking from human resource management perspective, is full of skilled project managers and staffs. Skilled and experienced labours can be considered as a valuable asset of the business. The expertise can be rotated to several projects which would facilitate some difficult processes or share knowledge and experience to other members. (Zika-Viktorsson *et al.*, 2006) As it is said good things become even more valuable when it is shared. The more expertise have been rotated, the more skill they improve as all projects are different and it definitely helps to multiply and spread the skills to the rest of the labours more or less.

In construction industry, the most concerned factor is the cost. The cost has been used to set as a baseline to determine how successful the project is. It is done by comparing the planned cost and the actual spending and how much spending has been put to accomplish a certain task.

6. Ranked Positional Weight (RPW)

Ranked Positional Weight, developed by Helgeson and Brinie is one of the best-known heuristics for assembly line balancing in manufacturing industry (Quinn and Stockton, 1995). Chow (1990) points out that each assembly line may consist of one or more operations with different processing time, which varying by complexity of each operation. Thus, the manager makes an effort to determine the level of complexity at each operation by using ranked Positional Weight Method. Reikek and Delchambre (2006) declare that the strategy of this method is to firstly assign tasks that have longest chains of succeeding tasks. The length of the chain is known as positional weight. The weight of an operation is defined as the processing time of the operation itself plus the sum of the processing time of all succeeding operations (Mahapatra, 2010; Panneerselvam, 2012). Then, the tasks are ranked by their positional weight in descending order (Nof *et al.*, 1997). Stockton and Wainwright (1995) states "the ranked positional weight technique does not guarantee optimality."

Tam and Dissanayake (1998) applied the ranked positional weight method to the construction industry for the reason that the resemblance between construction process on site and assembly line manufacturing is very close. When conflicts in "resource-constraint allocation" occur, the method of RPW would be applied (Ng *et al*., 2013). This is to make sure that the importance of all tasks is being ranked, regarding its severity that would eventually contribute to the overall project delay.

The general procedure of RPW method is as follows:

1. List all activities and its precedence task
2. Identify the duration of all activities
3. Calculate the Positional Weight by adding duration of the task itself and duration of all successor task together
4. Rank all Positional Weight in descending order

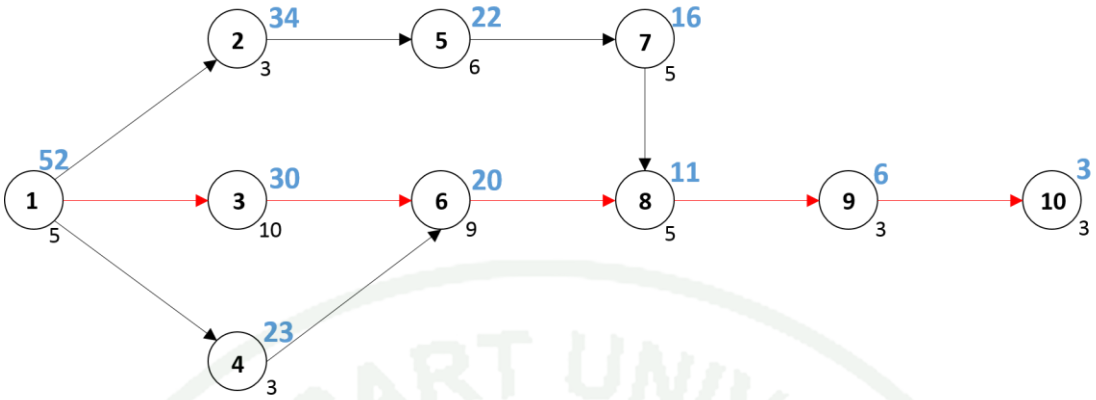


Figure 2 Precedence network diagram

Illustrative explanation of ranked positional weight method

Step 1: According to the figure, the nodes from 1-10 represent the activities, and the arrows represent the relationship among the tasks. Thus, precedence tasks can be identified.

Step 2: List the duration of each task as the number was given by the side of each node.

Step 3: Calculate positional weight of each task by adding itself duration and its successor' duration. It is easier to start calculating from the last activity, activity 10 which it has no successor task. So, positional weight of activity 10 is just the duration of itself or equal to 3. For activity 9, the successor of it is activity 10, so positional weight is 3 + 3 = 6. Next, the successors of activity 8 are activity 9 and 10, so its positional weight is 3 + 3 + 5 = 11. The successors of activity 7 are activity 8, 9 and 10, thus its positional weight is 5 + 5 + 3 + 3 = 16. Then continues with the rest of the table with the same pattern.

Step 4: Ranks all the positional weight in ascending order. Thus, the result is ranked as activity 1, 2, 3, 4, 5, 6, 7, 8, 9, and 10.

The outcome is presented in Table 1.

Table 1 Unranked positional weight

Activity	Predecessor	Duration (days)	Positional Weight
1	-	5	52
2	1	3	34
3	1	10	30
4	1	3	23
5	2	6	22
6	2,3,4	9	20
7	5	5	16
8	6,7	5	11
9	8	3	6
10	9	3	3

MATERIALS AND METHODS

Materials

The materials used to conduct this research can be classified into three groups as following:

1. Hardware

A personal computer, MacBook Air, Mid 2013, Intel Core i7 1.7 GHZ, RAM 8 GB, with OS X Yosemite 10.10.1 and Microsoft Windows 7 operating system, is used for coding the program, running and testing the experiments, gathering literatures, and writing the research documents.

2. Software

1.1 Microsoft Project 2013 is used to code the extension by using Visual Basic for Application (VBA). It is also used to input the data, run and test the code.

1.2 Microsoft Excel 2013 is used to view the reports generated from Microsoft's Project extension.

1.3 Microsoft Word 2013 is used to construct the research documents.

1.4 Microsoft Visio 2013 is used to illustrate the flowchart.

1.5 Parallels Desktop 10.0.1 for Mac is used to run Microsoft Windows 7 on OS X operating systems.

3. Literatures

Literatures and related papers are accessed online via Virtual Private Network (VPN) through the main library database of Kasetsart University, Chulalongkorn University, and University of Bath. Some textbooks are borrowed from the main library of Kasetsart University and Chulalongkorn Univeristy, some are bought from Amazon.com by personal funding.

Methods

1. Resource Workload

As the resources are very limited, they need to be shared in multiple construction projects. We are required achieve a good project management therefore a sufficient and efficient resources allocation is very significant. That is, the resources should be allocate to the right project at the right time, and balanced cost.

Workload-leveling is the process of addressing the resource conflict by schedule resource considering from different aspects such as resource capability, importance of task or slack time of each task. For this project, the project manager is strongly suggested to record a following list of essential data by Cicala (2013)

1. "The amount of work a resource can do in a time period (e.g. Hours per day),
2. The sequence of tasks in the project as defined by dependencies,
3. The skills required to perform particular tasks,
4. The expected timeline for the project,
5. The utilization rate for the resources."

2. Free Slack and Total Slack

Free Slack is the time period that an activity can have before it starts delaying the next (successor) activity. Free slack is the Early Start (ES) of the task's successors minus the Early Finish (EF) of the task itself. Moreover, Total Slack is amount of time that activity can delay before it affects the whole project. Total Slack = Late Finish (LF) – Early Finish (EF) of a task (Ambriz and White, 2011).

3. Ranked Positional Weight (RPW)

The author implements RPW method to Microsoft Project's extension and develops the code. The algorithm of the procedure of RPW has been altered. The instructions is clarified below, and Figure 3 is illustrated the flowchart of the algorithm. Additional information for the flowchart is Notes, which is a built in field in Microsoft Project, holding string of successor name, and Number 1, which is also a built in field in Microsoft Project, holding string of RPW.

The procedure of altered RPW method can be divided into three sub-procedure as follow:

Sub-procedure 1: Aiming to get all successors id

1. Start getting direct successor id from first task to the last in ascending order (Microsoft Projects can only retrieve direct successors)

2. Store the direct successor id into notes of each task (Alternatively, we can use available default text field (Text 1 - 30) in Microsoft Project to store the data but the length is limited. So, storing data in the notes field is preferred)

3. Start looking for all successor id from the last activity and run up to the first in descending order

4. Identify the predecessor id of each task

5. Record successor id of that task into the note of identified predecessor

The procedure in step 4 - 5 can be illustrated as following:

Let, Task 5, 6, and 7 are the successors of Task 4 (Result from step 1 and 2). And, Task 2 and 3 are the predecessors of Task 4.
Therefore, add task 5, 6 and 7 into the note of Task 2 and 3

Sub-procedure 2: Aiming to delete duplicate successor's id

As a result from sub-procedure 1, there might be some duplicated successor id in the notes of each task. For example, Task 4 (successors are Task 5, 7, and 8) and Task 6 (successors are Task 7 and 8) are the direct successor of Task 3. Then, successor id of Task 3 can be arranged as 5, 7, 8, 7, 8. It can be seen that successor's id 7 and 8 is duplicated. Hence, they should be deleted.

1. Convert data type in Notes field of each task from Integer to String (no specific format, can be anything for instance, number with decimal point, or normal text or combined.

2. Split the String of successor's id into Array of String ("An array is a set of values that are logically related to each other" (Microsoft Developer Network, n.d.a))

3. Create Dictionary object (According to Microsoft Developer Network (n.d.b), "A **Dictionary** object is the equivalent of a PERL associative array. Items can be any form of data, and are stored in the array. Each item is associated with a unique key. The key is used to retrieve an individual item and is usually an integer or a string, but can be anything except an array.")

4. Put data from each index in Array of String into dictionary. In simple word, if compares to a regular dictionary, vocabulary represents key and meaning represents value. Similar to the fact that there is no duplicated vocabulary in a dictionary, the duplicated successor id would be automatically ignored. That is, only the unique successor id will be stored.

5. Assign the value of each key equals to 1. (In this case, the value can be any number because it is irrelevant information to calculate the positional weight.)

6. Put the successor's id in dictionary back into notes of each task

Sub-procedure 3: Aiming to calculate positional weight (duration of a task plus duration of all of its successor)

1. Split successor's id in notes of each task into Array

2. Retrieve duration of each task and put into Number 1 (Number 1 is a built-in field with empty data in Microsoft Project)

3. Retrieve duration of successor in each task shown in notes and add to existing value of Number 1. Then, divides by 60 x 8 to get a unit in day(s).

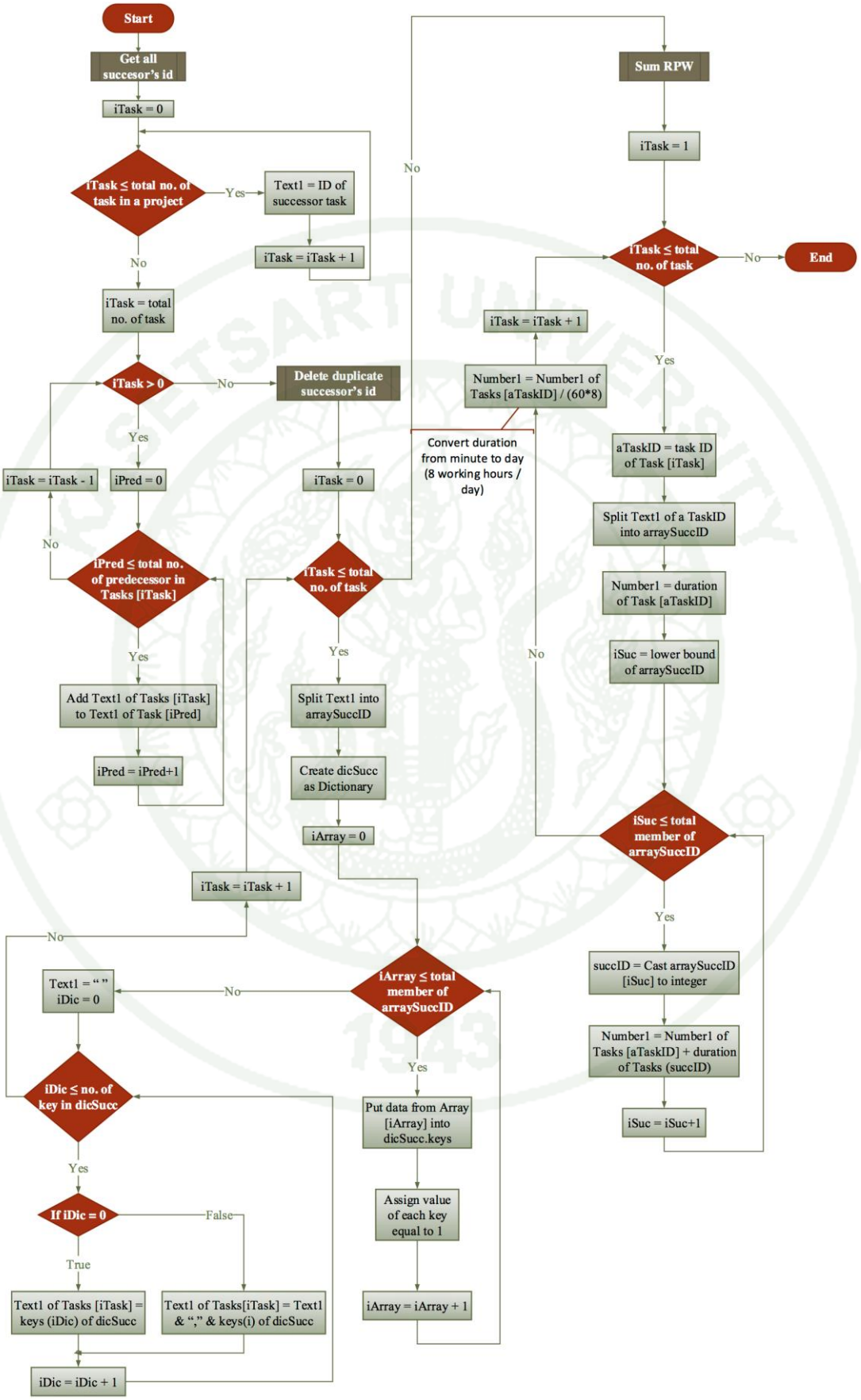


Figure 3 Ranked positional weight flowchart

4. Earned Value Analysis

Budgeted Cost of Work Scheduled (BCWS) or recorded as Baseline cost in Microsoft Project, represents how much the budgeted cost of work scheduled should be cumulatively spent up to the status date.

Budgeted Cost of Work Performed (BCWP) or known as earned value, represents the portion of the budgeted cost that should have been spent for work actually performed up to the status date. BCWP could be calculated from either each task's percentage complete or physical percentage complete depending on the project manager decision. The different between two values can be explained by the following example. A project of building stonewall of 5 stacked level consisting 20 stones each. The first level can be done in 10 minutes while the second take 5 minutes longer because you need to lift the stone up one row higher. The third level takes 20 minutes, the fourth 25 minutes, and the last row takes 30 minutes to complete. In total, a project takes 100 minutes to build stonewall. If we said that the project is 60 percent completed, it could be interpreted that the first three levels are physically completed. However, in terms of duration, we just only spent 75 out of 150 minutes or it can be concluded that the job is 50 percent complete. In this case, we should prefer physical percent complete as it reflects the actual work that we performed. Callan (2009) said "physical percentage complete is designed for human operators to insert their own subjective opinion of the relative degree of completion."

Actual Cost of Work Performed (ACWP) represents the amount of money actually spent for work already performed up to the status date.

Estimated at Completion (EAC) represents the total cost of the work predicted at the specific date. After the project's progress has been updated and the project performance indicator has been analyzed, According to Nathan (2012), there are four approaches to calculate EAC which will give various results. The scenario and situation of the project are the key indicators which lead to the method that the project

manager should apply. As each formula is calculated from different variables. The four scenarios are described below.

Scenario 1: Original estimate value is no longer valid

This scenario assumes that the circumstances or requirements of the projects have been altered very far away from the original. Moreover, if the project manager could ascertain that the original estimates are fundamentally floored. The original estimates will be no longer valid.

The bottom-up estimate to complete is the prediction of the remaining cost of the work, there is no certain formula for predicting this value. In conclusion, the EAC could be calculated by using the following formula:

EAC = ACWP + Bottom-up Estimate to Complete

Scenario 2: Cost Performance Index (CPI) will remain the same for the rest of the project

It is assuming that the cost variance of the project measured at the status date will persistently continue for the rest of the project. Sometimes, this scenario can be called as realistic case for the reason that it uses performance index that the project previously performed. For instance, the project with negative cost variance will continue its performance as over budgeted along the project. Hence, EAC could be calculated by using the following formula:

EAC = ACWP + (Baseline Cost – BCWP) / Cost Performance Index

Scenario 3: Current Cost Performance Index (CPI) is unusual

This scenario assumes that the unexpected problem has occurred and it is solved. The problems might cause the CPI to be worst at the specific time period. The current CPI does not reflect how the rest of the project will progress. Moreover, the project manager is also confident that the problem will not occur again that's why the calculation ignores the CPI. This scenario can be categorized as optimistic case or best case. For example, the company is required to install four power generators. During the installation of the first generator, it is accidentally damaged and the company has to spend extra money to repair it. As the result of the problems, the company enhances the risk mitigation plan and also believes that the original estimates for installing the remaining generators are still appropriate. The formula can be shown as following:

$$EAC = ACWP + (Baseline\ Cost - BCWP)$$

Scenario 4: Project has to meet a deadline

The company is insisted to finish the project on time while the project's performance is poor. It is over budget and behind schedule, this is the worst case. In this case, the cost and the schedule are needed to take into account. The formula to calculate the EAC is

$$EAC = ACWP + (Baseline\ Cost - BCWP) / (CPI \times SPI)$$

In this research, only three methods are taken into consideration as the first method, original estimate is no longer valid, requires the manager to predict the new cost for the remaining part of the project. Kendrick (2010) identifies scenario 2, 3 and 4 as realistic, worst, and best, respectively.

Illustrative explanation of earned value

Assuming that we are expected to construct 4 foundation piles within 4 weeks, each unit cost 20,000 THB. After one week passed, project manager records a percentage of completion of the first foundation tile progress as 80%. Therefore, BCWS = 20,000 THB up to week 1

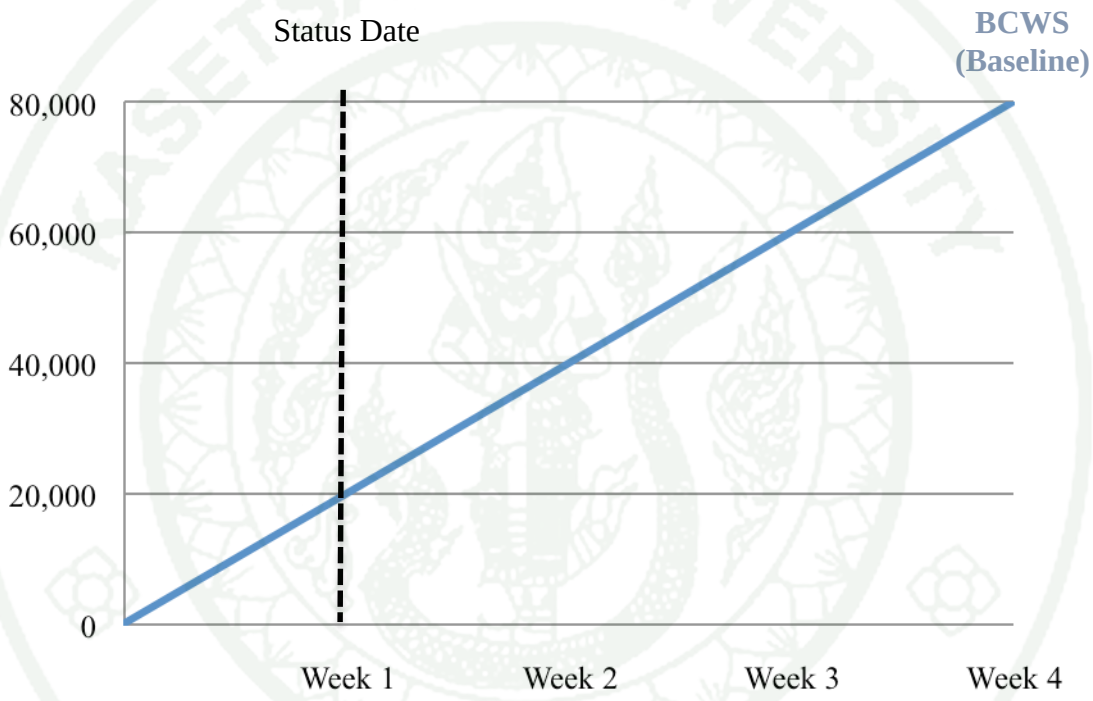


Figure 4 Earned Value Analysis (BCWS)

In this example, we use physical percent complete to calculate earned value analysis BCWP = 20,000 x 80% = 16,000 THB. Actual work done is 80% which equals to 16,000 THB

Therefore, the difference between BCWP and BCWS at the status date could determine whether the project is behind or ahead schedule. It can also be called Schedule Variance (SV).

In this case SV = BCWP – BCWS = 16,000 – 20,000 = – 4,000 THB

The negative SV indicates that the actual work performed is behind the work scheduled, and vice versa for the positive.

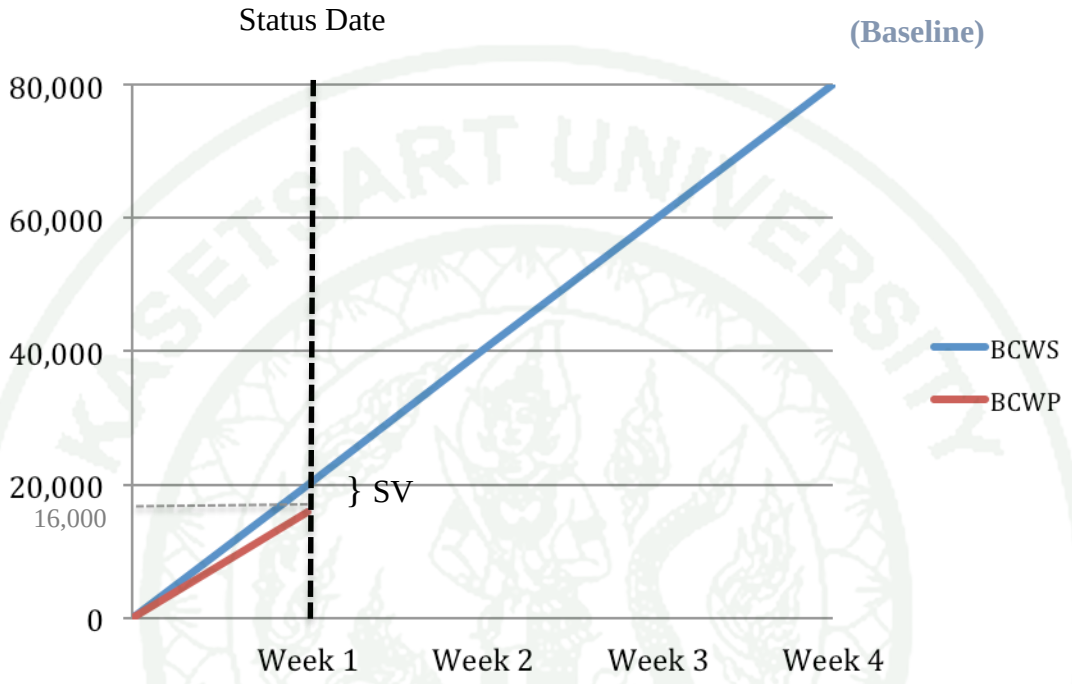


Figure 5 Earned value analysis (SV)

The ACWP or actual cost incurred for the work or the money we actually spent is 22,000 THB. Comparing to the planned value of work performed, we have spent more money than (comparing the value of actual work performed, we have spent more than we have planned which means the project is overbudget. The difference between these 2 variables can be called cost variance (CV))

CV = BCWP – ACWP = 16,000 – 22,000 = – 6,000 THB means the project is 6000 THB over budget. So if CV is negative (-), the project is over budget. If CV is positive (+), the project is under budget.

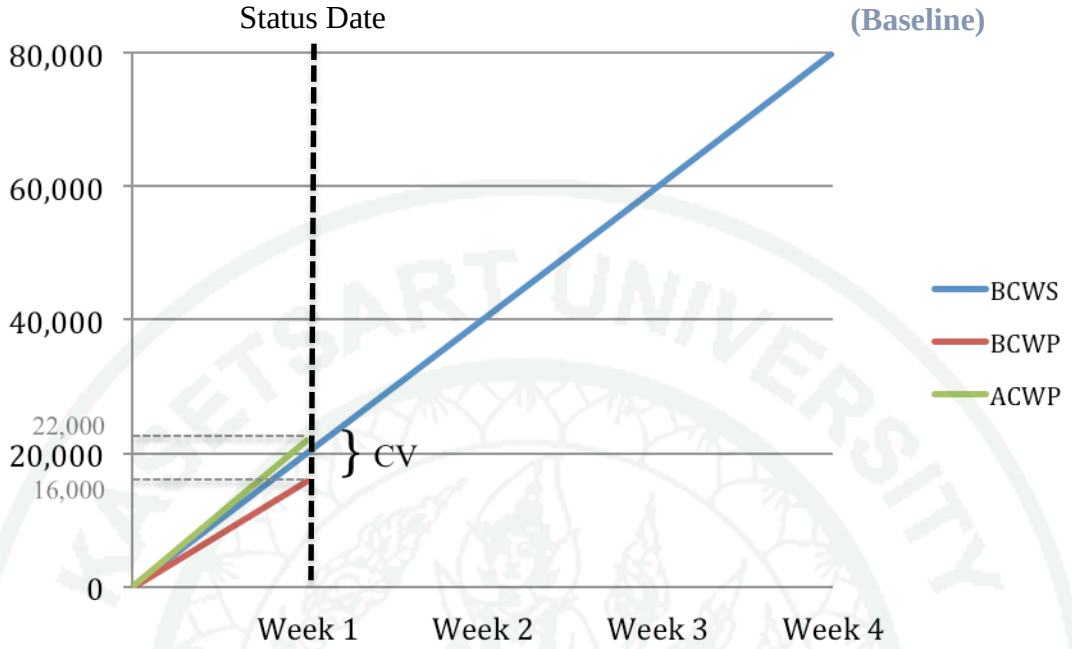


Figure 6 Earned value analysis (CV)

Nonetheless, the value of actual work accomplished is always changing (time changes-value changed). Therefore, the values of SV and CV that equal to -4000 and -6000 respectively, cannot indicate the severity of the delay or over-budgeting as there is no benchmarking. It is difficult to conclude the degree of severity of -6000. For example, BCWS for the first week is 10,000, we've got the values of SV as -4000 and CV as -6000 and BCWS in the 10th week is 1,000,000 with SV and CV of -100,000. Therefore, we can calculate the percentage as following:

For week 1,

$$\%SV = \frac{SV \times 100}{BCWS} = \frac{-4{,}000 \times 100}{20{,}000} = 20\% \text{ and } \%CV = \frac{CV \times 100}{BCWP} = \frac{-6{,}000 \times 100}{16{,}000} = 37.5\%$$

For week 10,

$\%SV = \frac{-100{,}000 \times 100}{1{,}000{,}000} = 10\%$ and $\%CV = \frac{-100{,}000 \times 100}{900{,}000} = 11.1\%$

Here, we improve the over buget percentage by decreasing from 20% to 10%. Similarly, we also improve the percentage of the delay from 37.5% down to 11.1%. Therefore, it is better to compare these values by using percentage.

Another alternative is to calculate the cost performance index (CPI) which is the ratio of budgeted cost of work performed to actual cost.

CPI = BCWP / ACWP

If the value of CPI is greater than 1.0, it shows that the cost spending to accomplish is less than what we had planned. On the other hand, if it is less than 1.0 signify that the cost is overrun. Another alternative is to calculate the Schedule performance index (SPI) which is the ratio of work performed to work schedule.

SPI = BCWP / BCWS

It can be concluded that

If BCWS = BCWP means the project is on target with the baseline scheduled
If BCWP > BCWS means the project is ahead of schedule
If BCWP < BCWS means the project is behind schedule
If BCWP > ACWP means the project is under budget
If BCWP > ACWP means the project is over budget

Earned Value Analysis method is considered to be very significant for the process of monitoring and tracking. By looking at a specific time interval, it can indicate the status of overall project whether the performance is at the satisfying level or not. The project manager is required to update progress frequently and set a baseline cost in order to apply Earned Value method proficiently (Brienza Jr and Hildreth, 2007).

5. Experiments

This research uses construction project as a case study. The author has an opportunity to interview the owner and also a few project managers of the construction company, Chalitpong Engineering. This company is a small-scale construction company that has approximate revenues of 200 million baht per year. In this company, the owner is also in charge of the portfolio management. He is the only one who looks at every project in every aspects, including time, cost, scope at the same time. The company members including the owner himself have difficulties to use hidden features of Microsoft Project in timely manner and potentially overlook some of them that might be beneficial.

Normally, the company uses Microsoft Project only for planning and scheduling and the information will not be updated after the process of planning while Microsoft Project offers such varieties of feature facilitating throughout the projects including the process of tracking and monitoring. The company usually communicates over the phone and email in order to track the progress or notify the occurred problems. This means that the owner needs to recognize and analyze all the issues by himself without any records or supporting tools. This leads to the lack of information when certain problems needed to be addressed. The lack of information puts the company at risk when there are decisions waiting to be made.

Hence, this experiment concentrates on managing multiple projects and solving resource conflicts by develops the extension from Microsoft Project using Visual Basic for Applications (VBA). The extension adapts subprojects in Microsoft to be able to load desired projects within one click and also improves the file management system to be more organized. Furthermore, the extension uses the inputted data more effectively by interpreting the information into different perspective and calculating additional variables to support the decision making

process of the manager. The author conducts a case study on construction industry and uses the data from Chalitpong Engineering Company. There are few assumptions for the experiment as following:

1. In this case study, material and equipment resources are unlimited resource. The only limited resource is human resources or known as resource type "work" in Microsoft Project such as skilled labor, management officer. As in small-scale construction industry, if there is shortage in equipment such as a crane, whether it would be least possible to buy it, they can immediately rent it.

2. Normal working hours is 08.00 – 17.00, 8 hours per day, 56 hours per week, 30 days per month

3. Each resource is able to do only one job in a day. The resource cannot be split to do one job in the morning and one in the afternoon.

4. All task's relationship is finish-to-start.

5. For the case the author observed, each project manager looks at one single project at a time, so the responsibility to look at the overall projects in company belongs to portfolio manager. In this case it is the owner that monitors all the project performance.

6. Ranked Positional Weight (RPW) value is static, even the project has greater percentage completed, RPW value remains the same. It is a predetermined value. Moreover, it can only be calculated in a separate project which means the RPW would only consider the task in its own project.

5.1 File Management System for managing multiple projects

According to Figure 7, portfolio manager can easily manage multiple projects as all the project managers are required to create the project file,

update the progress and upload to folder “Current Projects” shown as Label 1. Inside the folder, it contains a Microsoft Project File for each individual project as shown in Figure 8. This folder targets to store the project that the company currently operating.

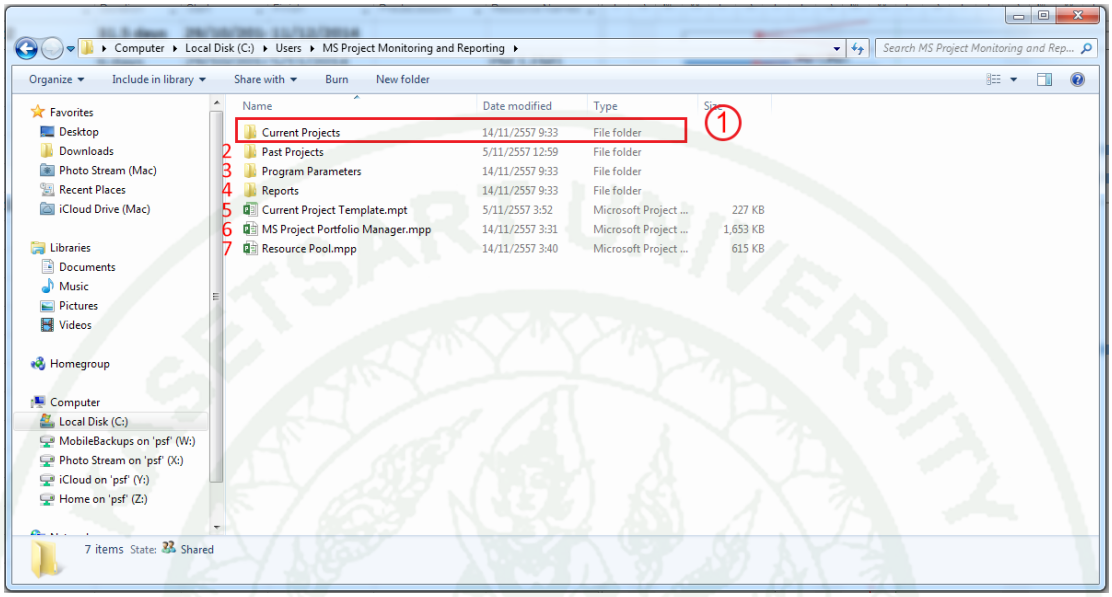


Figure 7 File management system – managing multiple projects

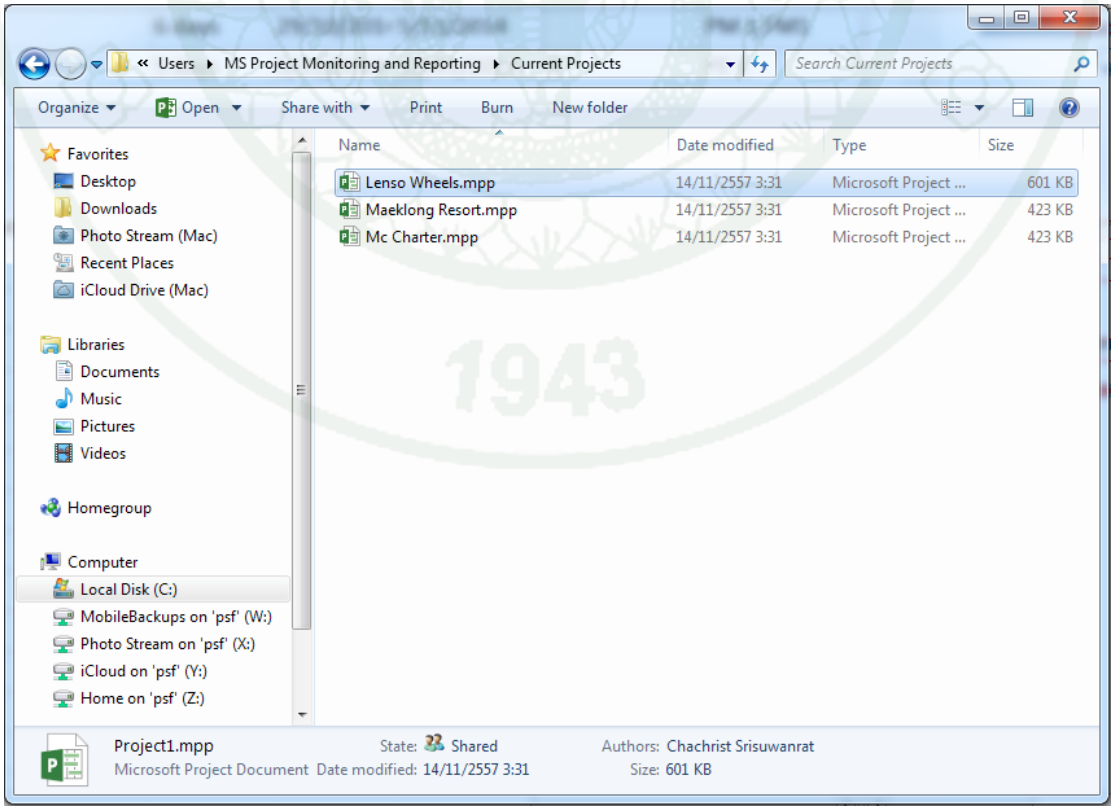


Figure 8 Inside Curent Projects folder

In addition, label 2 in Figure 7 represents the “Past Projects” folder, which is for the case that portfolio manager needs to manually move the finished projects from “Current Projects” folder into this folder. “Program Parameters” folder as shown as Label 3, stores the collection of default parameters that is set specifically by the portfolio manager for regular use. The “Reports” folder is for keeping the reports generated by the manager in Microsoft Excel format as seen in label 4. Also, the name of the report is set automatically due to the date and time that generated the reports. The format is in “yyyymmdd-hhmmss-Report.xlsx” as shown in Figure 9.

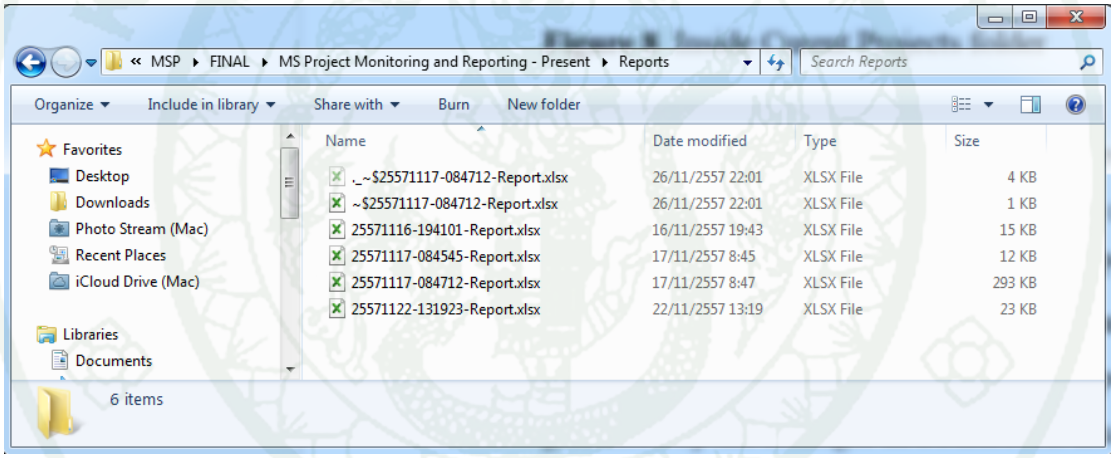


Figure 9 Reports Folder

Moreover, label 5 shown in Figure 7 is a Microsoft Project template file named “Current Project Template.mpt”. It is the file that project manager required to use when creating the new project instead of a blank project and also when updating the progress. Therefore, this will create the standard of tracking, it could be more confident that all project managers would input the relevant information needed and also the setting of all projects will be equivalent in order to avoid problems when portfolio manager combines all the projects. For example, if one project manager use different date format when comparing to others, this will create an error when portfolio manager tries to load all the projects.

Additionally, label 6 indicates the most significance elements, which is the "MS Project Portfolio Manager.mpp" file. It is the master file for portfolio manager and also the owner to combine all the projects in order to track and analyze every project in one place. The portfolio manager should navigate to "EXTRA" tab in Microsoft Project's Extension, and there will be 3 additional commands in the Macro ribbon which are calculate RPW, show Microsoft Project Portfolio Manager Control Panel and update the field name that the extension has incremented, represented by Figure 10. After the manager click the "Main Control Panel" button, Figure 11 will appear. There are two tabs consisting of "Current Projects" and "Custom Reports". In addition, the active project must be "MS Project Portfolio Manager" only in order to use the main control panel.

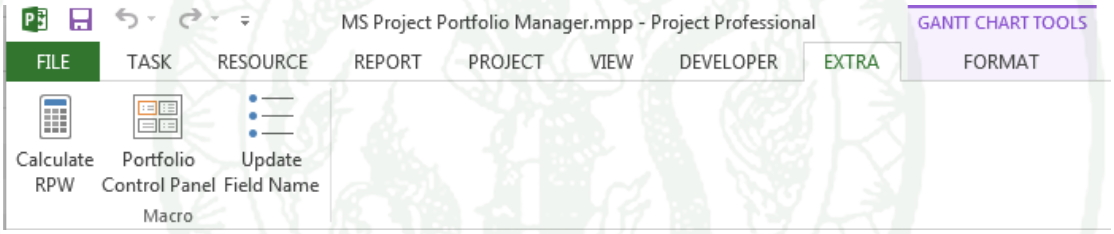


Figure 10 Microsoft Project customize ribbon

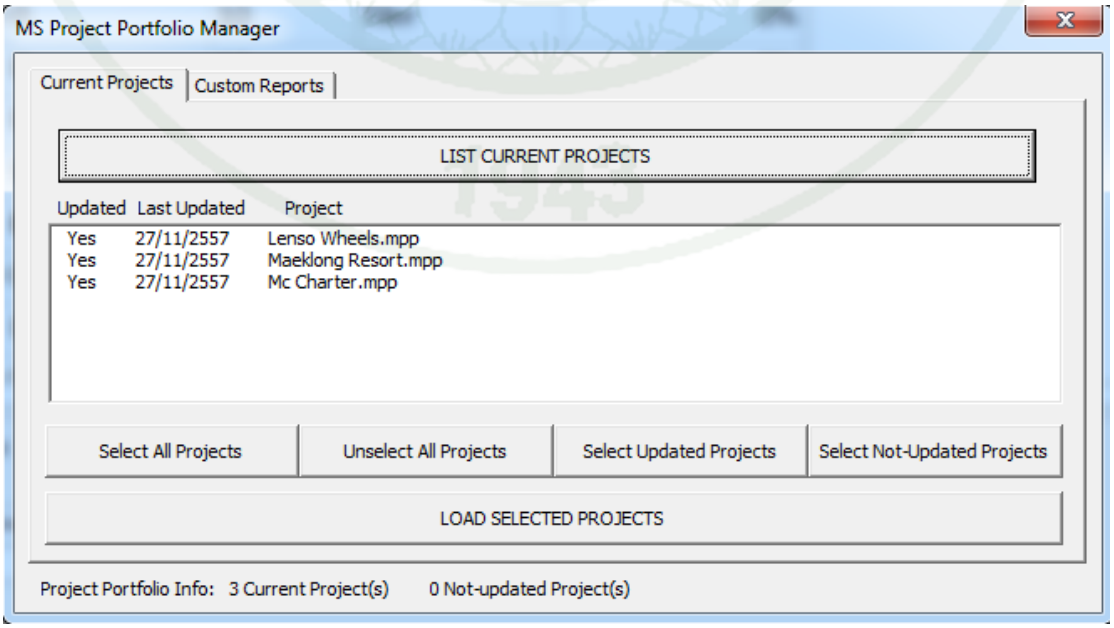


Figure 11 Microsoft Project Portfolio Manager Control Panel (Current Projects Tab)

In “Current Projects” tab, the portfolio manager could list all the project that have been saved in “Current Projects” folder. Also, some information for each project is provided in the list box. The manager could see the name of each project, the date of project’s latest update and the updated status (yes or no). Moreover, the information about project portfolio is also provided at the bottom of the control panel. The manager could see total number of folder in “current projects” folder and see how many projects have not been updated yet. Firstly, the manager required to press “List Current Projects” to view all project in “Current Projects” folder. Then choose the desire project file. Furthermore, the extension also has the shortcuts for manager to select all projects, unselect all projects, select only updated projects, or select not-updated projects as shown in Figure 11. Then the manager should press “Load Selected Projects” to load those selected projects. In most situations, the initial Microsoft Project screen contains previous loaded project, the program will request to confirm delete those view. All the action and edition in “MS Project Portfolio Manager” file will affect and write over all projects that the manager have loaded. Moreover, the manager will be pop-up automatically to load the resource file associated with all the loaded projects. Figure 12 shows the loaded projects when using portfolio control panel.

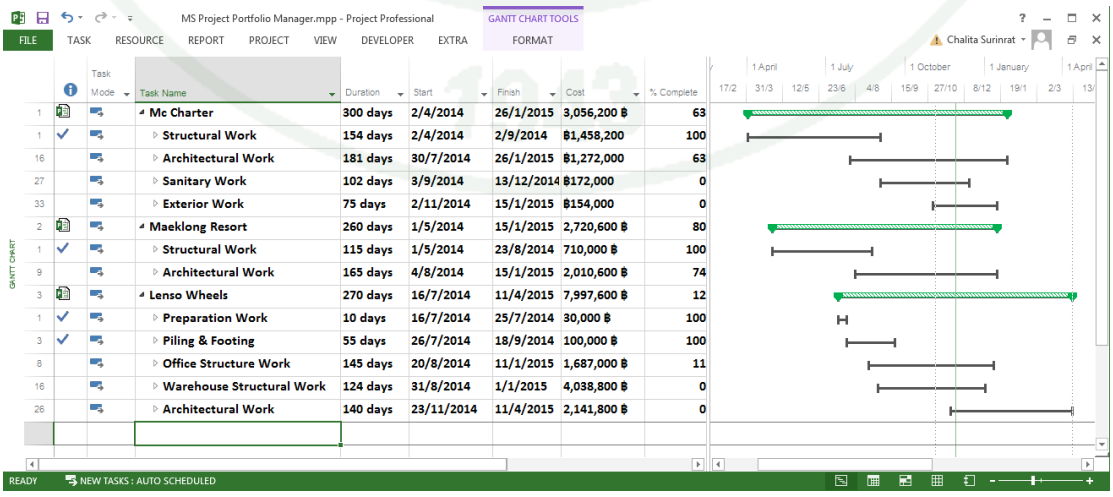


Figure 12 Loaded Projects by using portfolio control panel

After loaded the desire project, the manager can decided to generate any reports by navigating back to main control panel and choose the "Custom Reports" tab. The manager would see interface as shown in Figure 13. The reports are divided into five groups which are projects, cost, resources, tasks, and extra. In the extra group containing Gantt Chart, Current Tasks with Cost Parameters, Upcoming Tasks within Days, Task with Overallocated Resources and Customized Earned Value Report. The manager can choose to create any reports by ticking the check box and pressing create reports – all the reports generated by this command are in Microsoft Excel format.

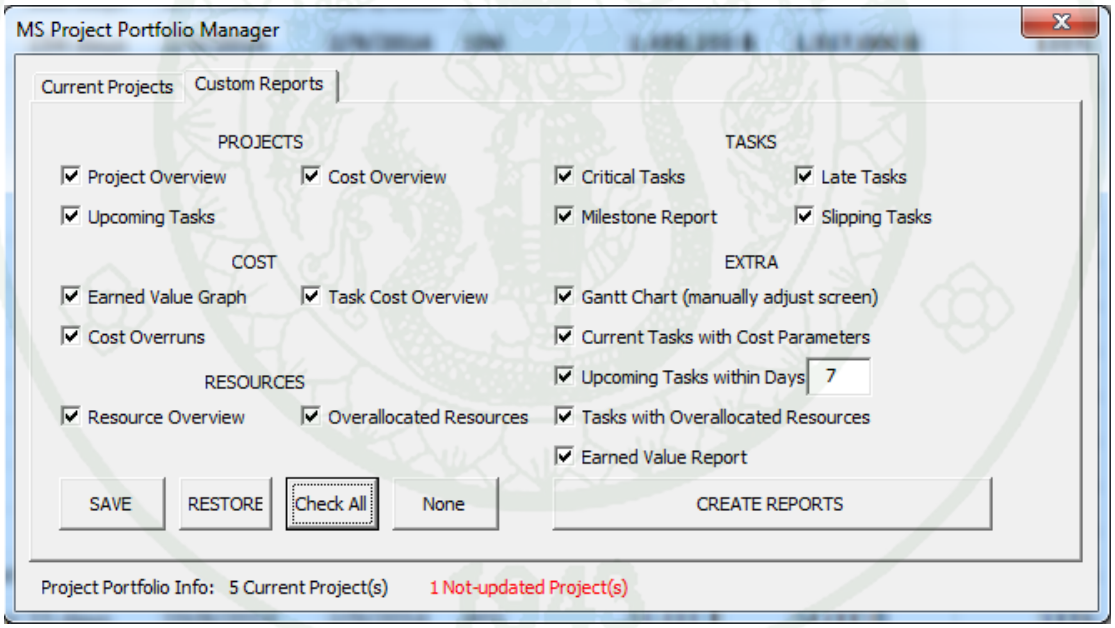
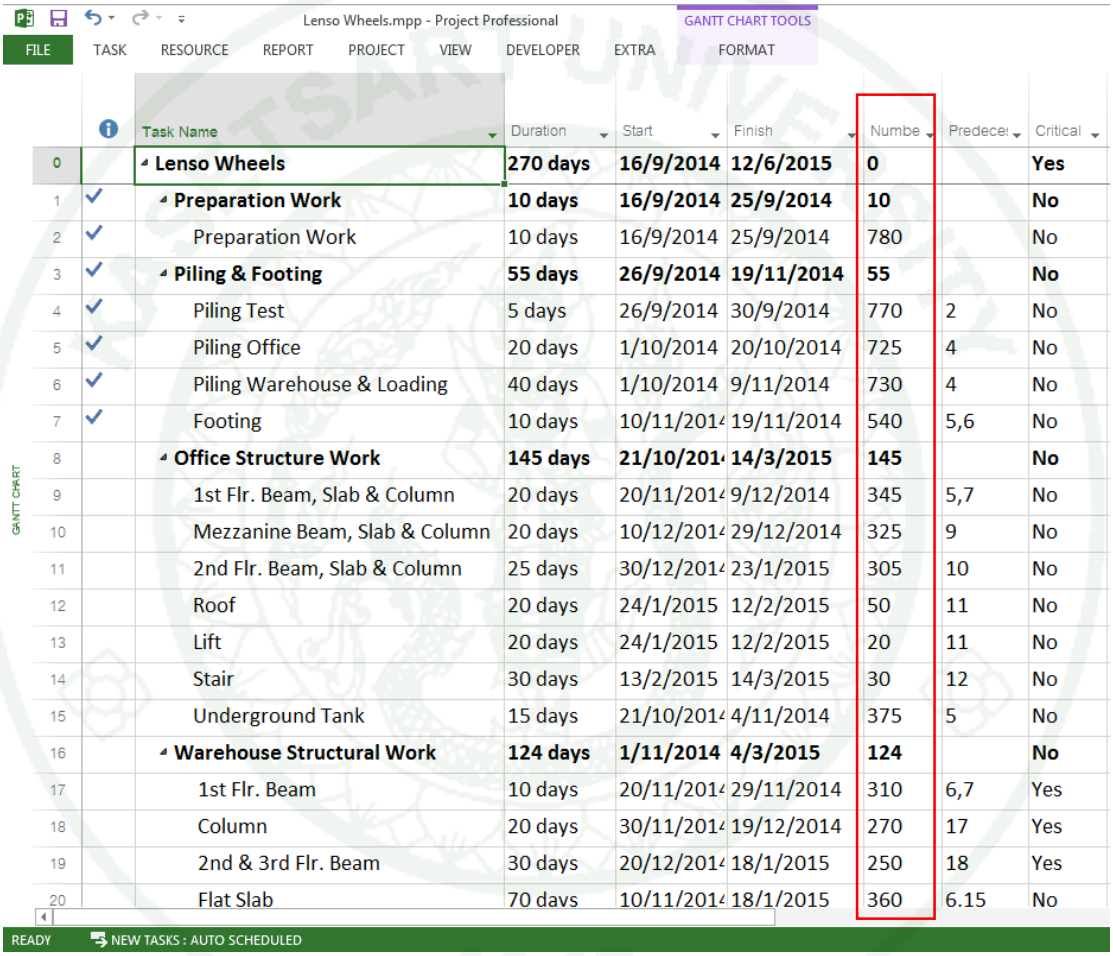


Figure 13 Microsoft Project Portfolio Manager Control Panel (Custom Reports Tab)

Finally, another command in customize ribbon is ranked positional weight (RPW) calculation. The condition for RPW calculation is that it can only be used for individual project by opening from its original file separately. Even loading a single project in overall Portfolio Manager file, the calculation will be incorrect due to independencies between tasks across projects and also some programming limitations.

The manager just click the “Calculate RPW” button as shown in Figure 10 then the outcome will be presented in “Number1” column. Sometimes, the manager is required to manually insert the column. Moreover, those positional weight in bold text shown in Figure 14 can be ignored because they are summary task, they are not the task that actually performed.



		Task Name	Duration	Start	Finish	Numbe	Predece	Critical
0		**Lenso Wheels**	**270 days**	**16/9/2014**	**12/6/2015**	**0**		**Yes**
1	✓	**Preparation Work**	**10 days**	**16/9/2014**	**25/9/2014**	**10**		**No**
2	✓	Preparation Work	10 days	16/9/2014	25/9/2014	780		No
3	✓	**Piling & Footing**	**55 days**	**26/9/2014**	**19/11/2014**	**55**		**No**
4	✓	Piling Test	5 days	26/9/2014	30/9/2014	770	2	No
5	✓	Piling Office	20 days	1/10/2014	20/10/2014	725	4	No
6	✓	Piling Warehouse & Loading	40 days	1/10/2014	9/11/2014	730	4	No
7	✓	Footing	10 days	10/11/201	19/11/2014	540	5,6	No
8		**Office Structure Work**	**145 days**	**21/10/201**	**14/3/2015**	**145**		**No**
9		1st Flr. Beam, Slab & Column	20 days	20/11/201	9/12/2014	345	5,7	No
10		Mezzanine Beam, Slab & Column	20 days	10/12/201	29/12/2014	325	9	No
11		2nd Flr. Beam, Slab & Column	25 days	30/12/201	23/1/2015	305	10	No
12		Roof	20 days	24/1/2015	12/2/2015	50	11	No
13		Lift	20 days	24/1/2015	12/2/2015	20	11	No
14		Stair	30 days	13/2/2015	14/3/2015	30	12	No
15		Underground Tank	15 days	21/10/201	4/11/2014	375	5	No
16		**Warehouse Structural Work**	**124 days**	**1/11/2014**	**4/3/2015**	**124**		**No**
17		1st Flr. Beam	10 days	20/11/201	29/11/2014	310	6,7	Yes
18		Column	20 days	30/11/201	19/12/2014	270	17	Yes
19		2nd & 3rd Flr. Beam	30 days	20/12/201	18/1/2015	250	18	Yes
20		Flat Slab	70 days	10/11/201	18/1/2015	360	6.15	No

Figure 14 Calculating ranked positional weight

5.2 Resource Conflicts Detection in Multi Project Management

As the resources of the company are share in a resource pool. This research demonstrates two situations of the resource conflicts that have different causes. Firstly, the most common situation that project manager is going to confront is resources overallocated that occur when new projects or new activities are added or

the changes in schedule where the conflicts mostly occurred in planning phase. Secondly, resource conflicts from the delay of projects.

5.2.1 Resource over-allocation in managing multiple projects caused by adding new activities and new projects

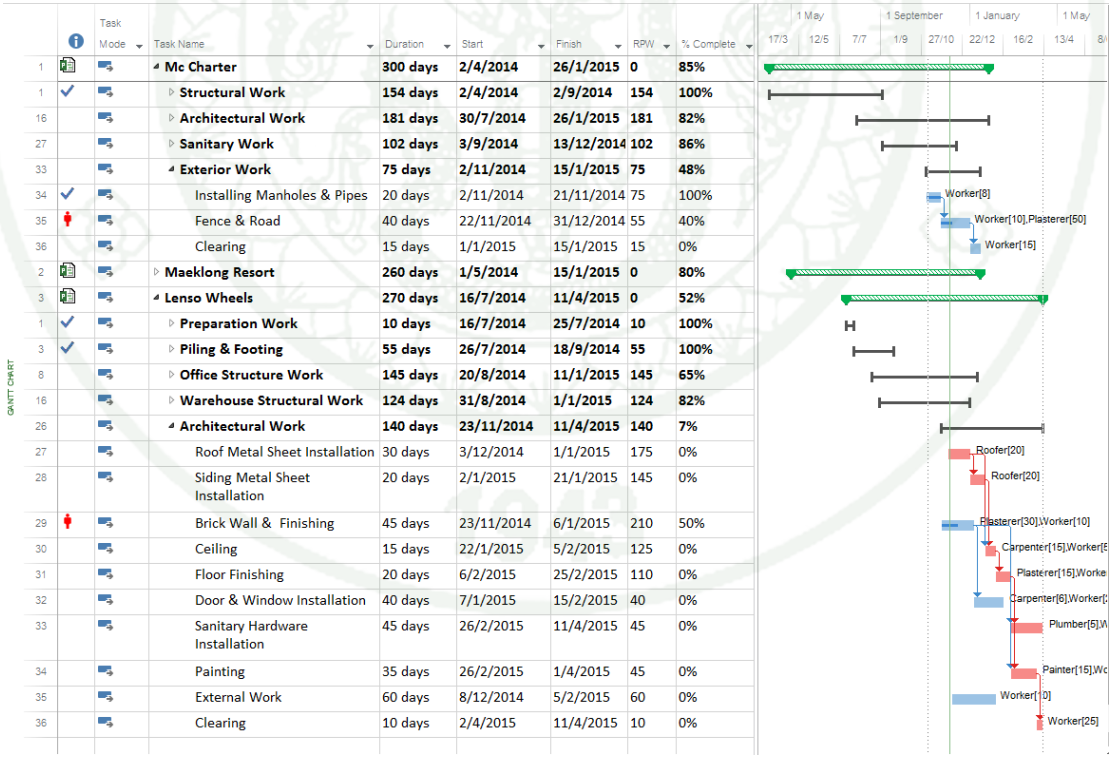
Assuming that the company has two ongoing projects namely Mc Charter, and Maeklong Resort. Later on, Lenso Wheels project has been added. In this case, each project manager is individually responsible for one project. So the portfolio manager is the one who looks after all projects. The resources are share for all project as a resource pool. In Microsoft Project, there are 3 resource types, which are “work”, “material”, and “cost”. The resource type “work” refers to human resource. In this company, the human resources can be segregated into 14 unique expertise. All human resources has different specialties and cannot be replaced by one another. This expertise can be divided into 4 groups based on their roles and responsibilities, consisting of skilled labor, general worker, management, and subcontractor. The resource sheet is shown in Figure 15.

RESOURCE SHEET

	Resource Name	Type	Initials	Max.	Std. Rate	Accrue	Base
1	Carpenter	Work	C	130	฿45.00/hr	Prorated	Standard
2	Plasterer	Work	P	50	฿50.00/hr	Prorated	Standard
3	Ironsmith	Work	I	40	฿45.00/hr	Prorated	Standard
4	Welder	Work	W	30	฿60.00/hr	Prorated	Standard
5	Roofer	Work	R	20	฿50.00/hr	Prorated	Standard
6	Painter	Work	P	15	฿50.00/hr	Prorated	Standard
7	Tiler	Work	T	20	฿60.00/hr	Prorated	Standard
8	Electrician	Work	E	6	฿70.00/hr	Prorated	Standard
9	Plumber	Work	P	10	฿50.00/hr	Prorated	Standard
10	Worker	Work	W	70	฿40.00/hr	Prorated	Standard
11	Foreman	Work	F	10	฿100.00/hr	Prorated	Standard
12	Site Engineer	Work	S	5	฿150.00/hr	Prorated	Standard
13	Project Engineer	Work	P	3	฿350.00/hr	Prorated	Standard
14	Subcontractor	Cost	S			Prorated	

Figure 15 Resource sheet view for resource pool (using Microsoft Project)

Project Mc Charter starts at April 1, 2014 and ends at January 26, 2015 with the duration of 300 days. While project Maeklong Resort starts at May 1, 2014 and ends at January 15, 2015 with the duration of 260 days. And Project Lenso starts at July 16, 2014 and ends at April 11, 2015 with the duration of 270 days. Each project has different sub-task shown in Figure 16. Mc Charter and Lenso Wheels projects are the warehouse construction, so the sub-task for each project is quite similar. For Mc Charter, the work can be divided into 4 phases including structural, architectural, sanitary, and exterior work. And for Lenso Wheels, the work can be divided into 5 phases, including preparation work, piling footing, office structural work, warehouse structural work, and architectural work. Apart from these two projects, Maeklong Resort has only 2 phases, which are structural and architectural work.



	Task Mode	Task Name	Duration	Start	Finish	RPW	% Complete
1		**Mc Charter**	**300 days**	**2/4/2014**	**26/1/2015**	**0**	**85%**
1		**Structural Work**	**154 days**	**2/4/2014**	**2/9/2014**	**154**	**100%**
16		**Architectural Work**	**181 days**	**30/7/2014**	**26/1/2015**	**181**	**82%**
27		**Sanitary Work**	**102 days**	**3/9/2014**	**13/12/2014**	**102**	**86%**
33		**Exterior Work**	**75 days**	**2/11/2014**	**15/1/2015**	**75**	**48%**
34		Installing Manholes & Pipes	20 days	2/11/2014	21/11/2014	75	100%
35		Fence & Road	40 days	22/11/2014	31/12/2014	55	40%
36		Clearing	15 days	1/1/2015	15/1/2015	15	0%
2		**Maeklong Resort**	**260 days**	**1/5/2014**	**15/1/2015**	**0**	**80%**
3		**Lenso Wheels**	**270 days**	**16/7/2014**	**11/4/2015**	**0**	**52%**
1		**Preparation Work**	**10 days**	**16/7/2014**	**25/7/2014**	**10**	**100%**
3		**Piling & Footing**	**55 days**	**26/7/2014**	**18/9/2014**	**55**	**100%**
8		**Office Structure Work**	**145 days**	**20/8/2014**	**11/1/2015**	**145**	**65%**
16		**Warehouse Structural Work**	**124 days**	**31/8/2014**	**1/1/2015**	**124**	**82%**
26		**Architectural Work**	**140 days**	**23/11/2014**	**11/4/2015**	**140**	**7%**
27		Roof Metal Sheet Installation	30 days	3/12/2014	1/1/2015	175	0%
28		Siding Metal Sheet Installation	20 days	2/1/2015	21/1/2015	145	0%
29		Brick Wall & Finishing	45 days	23/11/2014	6/1/2015	210	50%
30		Ceiling	15 days	22/1/2015	5/2/2015	125	0%
31		Floor Finishing	20 days	6/2/2015	25/2/2015	110	0%
32		Door & Window Installation	40 days	7/1/2015	15/2/2015	40	0%
33		Sanitary Hardware Installation	45 days	26/2/2015	11/4/2015	45	0%
34		Painting	35 days	26/2/2015	1/4/2015	45	0%
35		External Work	60 days	8/12/2014	5/2/2015	60	0%
36		Clearing	10 days	2/4/2015	11/4/2015	10	0%

Figure 16 Multi project view in Microsoft Project

Usually, the project manager identifies the resource conflicts by looking at the Resource Sheet and Resource Usage. As a result, the conflicts are easy to recognize as they are shown in red with the exclamation mark in front. According to Figure 15, it can be seen that there is resource conflict for plasterer. Furthermore, if the manager wants to know which task such conflicts occur, it would be easier and faster to use the extension the author has developed.

Thus, the extension will be used to detect the conflicts by generating the report named “Task with overallocated resources” that presents the resource conflicts and to sum up the information that is relevant to the decision making regarding such conflicts. According to the information given in the report, the manager would be able to make more precise decision in timely manner, in order to avoid delays and cost overruns.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Resource	Over-allocated	Project	Task	RPV	Critical	Total Slack	Free Slack	%Complete	Detail	Start	Finish	Resources	Max Units	Cumulative Units
24	Plasterer	TRUE	Mc Charter	Floor Finishing	20	FALSE	0 d	0 d	100	Current	22/11/2014	11/12/2014	Plasterer[10],Worker[5]	50	40
25	Plasterer	TRUE	Mc Charter	Fence & Road	55	FALSE	86 d	0 d	40	Current	22/11/2014	31/12/2014	Worker[10],Plasterer[50]	50	-10
26	Plasterer	TRUE	Lenso Wheels	Brick Wall & Finishing	210	FALSE	15 d	0 d	50	Current	23/11/2014	6/1/2015	Plasterer[30],Worker[10]	50	-40
27	Plasterer	TRUE	Lenso Wheels	Floor Finishing	110	TRUE	0 d	0 d	0	Future	6/2/2015	25/2/2015	Plasterer[15],Worker[10]	50	-55

Figure 17 Resource conflicts detected from "Tasks with Overallocated Resources" report using Microsoft Project’s extension

Report in Figure 17, which is cropped from Appendix A, indicates that plasterer has conflicts in Task floor finishing and fence & road in Mc Charter project, and in Task brick wall & finishing and floor finishing in Lenso Wheels project. Project manager also perceive the information associated with the overallocated tasks such as start and finish date of such task, all resource name and quantity that has been used for each task, percent complete, free slack and total slack.

Moreover, it can also identify whether it is a critical task or not. In the real world, the manager could be able to recognize the critical task but if the case that there are more than one critical task needed to be concerned at the same time. How the managers would prioritized those tasks. In most circumstance, they just use their sense, experience, surrounding environment, and project situation as the

factors to judge which task is required to get done first. They don't have enough information to substantiate their decision. Occasionally, the uncritical tasks need more attention than the critical one. For the reason that those tasks are very significant, many other tasks can't get start if this task does not finish.

The extension has applied the Ranked Positional Weight (RPW) method to solve this problem. The calculation of RPW will give the value that could make the manager know the total duration of the task itself along with all successor task. Therefore, if the manager has to choose between two critical tasks, it is recommended that the manager would give the priority to the task with the higher Ranked Positional Weight value. The higher RPW value indicates the higher severity of the damage towards the whole project.

Furthermore, the manager can also choose the dimension of data represented such as sorting by start date or finish date or free slack or total slack, and filtering only critical tasks or delayed tasks or upcoming tasks or delayed tasks or future tasks. The extension also provides the number of days that each task has been delayed. The upcoming tasks can be distinguished from future tasks. Upcoming task is the task, which the project manager can manually filter from all future tasks by looking for tasks that are planned to start with specific time period. The manager could choose a desired time period and change at any time.

5.2.2 Resource over-allocation in managing multiple projects caused by delay of tasks

In this scenario, it is assuming that all the resource conflicts or any other issues in planning phase are solved. After executing in the construction phase for a period of time, some tasks are delayed. In perspective of resource, this may lead to a shortage for the task that use the same resource. As in resource planning, each task gets different time slot but when the tasks are delayed, it can be overlapping. Only Microsoft Project Server that able to review the availability for

resource pool in order to find overallocated or underallocated resources either within a project or across projects.

However, using the Microsoft Project's Extension could help the manager to be aware of those conflicts by generating "Tasks with overallocated resources" report resulted in Figure 18. The report provides an extra information other than Microsoft Project which is "Cumulative Units". First of all, the author sorts the report in ascending order, sorting by setting resource in column A as the first key, start date as the second key and finish date as the last key. Then, identifies the maximum units for each resource and subtracts from the maximum unit if the resources have been used and the tasks are not one hundred percent complete, and displays in bold text.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Resour	Overallocated	Project	Task	RPW	Critic	Total Slac	Free Slac	%Complet	Detail	Start	Finish	Resources	Max Unit	Cumulative Units
2	Carpenter	FALSE	Maeklong Resort	Roof	20	FALSE	241 d	241 d	95	Delayed (102 d)	4/8/2014	23/8/2014	Carpenter[15],Ironsmith[8],Worker[6]	130	115
3	Carpenter	FALSE	Lenso Wheels	1st Flr. Beam	310	FALSE	14 d	0 d	90	Delayed (66 d)	19/9/2014	28/9/2014	Carpenter[25],Ironsmith[5],Worker[3]	130	90
4	Carpenter	FALSE	Lenso Wheels	Column	270	FALSE	24 d	0 d	70	Delayed (46 d)	29/9/2014	18/10/2014	Carpenter[15],Ironsmith[3],Worker[2]	130	75
5	Carpenter	FALSE	Lenso Wheels	2nd & 3rd Flr. Beam	250	FALSE	10.5 d	0 d	80	Delayed (16 d)	19/10/2014	17/11/2014	Carpenter[20],Ironsmith[2],Worker[2]	130	55
6	Carpenter	FALSE	Lenso Wheels	Loading	80	FALSE	75 d	0 d	40	Current	18/11/2014	7/12/2014	Carpenter[10],Ironsmith[10],Worker[10]	130	45
7	Carpenter	FALSE	Lenso Wheels	Roof	50	FALSE	100 d	0 d	45	Current	23/11/2014	12/12/2014	Carpenter[15],Ironsmith[7],Worker[5]	130	30
8	Carpenter	FALSE	Lenso Wheels	Lift	20	FALSE	130 d	130 d	30	Current	23/11/2014	12/12/2014	Carpenter[20],Ironsmith[4],Worker[2]	130	10
9	Carpenter	FALSE	Lenso Wheels	Stair	30	FALSE	100 d	100 d	0	Future	13/12/2014	11/1/2015	Carpenter[5],Ironsmith[2],Worker[2]	130	5
10	**Carpenter**	**FALSE**	**Lenso Wheels**	**Door & Window Installation**	**40**	**FALSE**	**65 d**	**65 d**	**0**	**Future**	**7/1/2015**	**15/2/2015**	**Carpenter[6],Worker[2]**	**130**	**-1**
11	**Carpenter**	**FALSE**	**Lenso Wheels**	**Ceiling**	**125**	**FALSE**	**10 d**	**10 d**	**0**	**Future**	**22/1/2015**	**5/2/2015**	**Carpenter[15],Worker[5]**	**130**	**-16**
12	Electrician	FALSE	Maeklong Resort	Electrical Work	90	FALSE	116 d	116 d	68	Current	28/9/2014	26/12/2014	Electrician[6]	6	0
13	Ironsmith	FALSE	Maeklong Resort	Roof	20	FALSE	241 d	241 d	95	Delayed (102 d)	4/8/2014	23/8/2014	Carpenter[15],Ironsmith[8],Worker[6]	40	32
14	Ironsmith	FALSE	Lenso Wheels	1st Flr. Beam	310	FALSE	14 d	0 d	90	Delayed (66 d)	19/9/2014	28/9/2014	Carpenter[25],Ironsmith[5],Worker[3]	40	27
15	Ironsmith	FALSE	Lenso Wheels	Column	270	FALSE	24 d	0 d	70	Delayed (46 d)	29/9/2014	18/10/2014	Carpenter[15],Ironsmith[3],Worker[2]	40	24
16	Ironsmith	FALSE	Lenso Wheels	2nd & 3rd Flr. Beam	250	FALSE	10.5 d	0 d	80	Delayed (16 d)	19/10/2014	17/11/2014	Carpenter[20],Ironsmith[2],Worker[2]	40	22
17	Ironsmith	FALSE	Lenso Wheels	Loading	80	FALSE	75 d	0 d	40	Current	18/11/2014	7/12/2014	Carpenter[10],Ironsmith[10],Worker[10]	40	12
18	Ironsmith	FALSE	Lenso Wheels	Roof	50	FALSE	100 d	0 d	45	Current	23/11/2014	12/12/2014	Carpenter[15],Ironsmith[7],Worker[5]	40	5
19	Ironsmith	FALSE	Lenso Wheels	Lift	20	FALSE	130 d	130 d	30	Current	23/11/2014	12/12/2014	Carpenter[20],Ironsmith[4],Worker[2]	40	1
20	**Ironsmith**	**FALSE**	**Lenso Wheels**	**Stair**	**30**	**FALSE**	**100 d**	**100 d**	**0**	**Future**	**13/12/2014**	**11/1/2015**	**Carpenter[5],Ironsmith[2],Worker[2]**	**40**	**-1**
21	Painter	FALSE	Maeklong Resort	Painting	55	FALSE	96 d	0 d	15	Current	22/11/2014	31/12/2014	Painter[8],Worker[2]	15	7
22	Painter	FALSE	Mc Charter	Painting	66	FALSE	85 d	0 d	20	Current	22/11/2014	20/1/2015	Painter[6],Worker[2]	15	1
23	**Painter**	**FALSE**	**Lenso Wheels**	**Painting**	**45**	**TRUE**	**0 d**	**0 d**	**0**	**Future**	**8/3/2015**	**11/4/2015**	**Painter[15],Worker[5]**	**15**	**-14**
24	Plasterer	FALSE	Mc Charter	Floor Finishing	20	FALSE	131 d	131 d	40	Current	22/11/2014	11/12/2014	Plasterer[10],Worker[5]	50	40
25	Plasterer	FALSE	Lenso Wheels	Brick Wall & Finishing	210	FALSE	25 d	0 d	20	Current	23/11/2014	6/1/2015	Plasterer[30],Worker[10]	50	10
26	**Plasterer**	**FALSE**	**Mc Charter**	**Fence & Road**	**55**	**FALSE**	**50 d**	**0 d**	**40**	**Future**	**7/1/2015**	**15/2/2015**	**Worker[10],Plasterer[50]**	**50**	**-40**
27	**Plasterer**	**FALSE**	**Lenso Wheels**	**Floor Finishing**	**110**	**TRUE**	**0 d**	**0 d**	**0**	**Future**	**16/2/2015**	**7/3/2015**	**Plasterer[15],Worker[10]**	**50**	**-55**
28	Plumber	FALSE	Maeklong Resort	Sanitary Hardware Installation	30	FALSE	121 d	121 d	20	Current	22/11/2014	21/12/2014	Plumber[5],Worker[2]	10	5
29	Plumber	FALSE	Mc Charter	Installing Sanitary Hardware	12	FALSE	129 d	0 d	20	Current	2/12/2014	8/12/2014	Plumber[5],Worker[20]	10	0
30	**Plumber**	**FALSE**	**Mc Charter**	**Installing water tank & pump**	**5**	**FALSE**	**129 d**	**129 d**	**0**	**Upcoming**	**9/12/2014**	**13/12/2014**	**Plumber[2],Worker[20]**	**10**	**-2**
31	**Plumber**	**FALSE**	**Lenso Wheels**	**Sanitary Hardware Installation**	**45**	**TRUE**	**0 d**	**0 d**	**0**	**Future**	**8/3/2015**	**21/4/2015**	**Plumber[5],Worker[2]**	**10**	**-7**
32	Roofer	FALSE	Lenso Wheels	Roof Metal Sheet Installation	175	FALSE	10 d	0 d	0	Current	3/12/2014	1/1/2015	Roofer[20]	20	0
33	**Roofer**	**FALSE**	**Lenso Wheels**	**Siding Metal Sheet Installation**	**145**	**FALSE**	**10 d**	**0 d**	**0**	**Future**	**2/1/2015**	**21/1/2015**	**Roofer[20]**	**20**	**-20**
34	Welder	FALSE	Lenso Wheels	Roof Structure Installation	220	FALSE	10 d	0 d	70	Delayed (1 d)	18/11/2014	2/12/2014	Welder[15]	30	15
35	**Welder**	**FALSE**	**Lenso Wheels**	**Siding & Ceiling Structure**	**175**	**FALSE**	**10 d**	**0 d**	**0**	**Current**	**3/12/2014**	**1/1/2015**	**Welder[20]**	**30**	**-5**

Figure 18 Task with overallocated resources partial report (using Microsoft Project's Extension)

5.3 Tracking and Monitoring Multiproject

The extension could facilitate the process of tracking and monitoring and offer three kind of reports to analyze the project status and mind out the potential problems. The purpose of report could be divided into two objectives – short term and long term tracking. The portfolio manager can generate “Current Task with Cost Parameters” and “Upcoming Tasks within specific days” report for the intention of short term tracking. Otherwise, the manager should generate “Customized Earned Value Report” to track the project in perspective of time and money. The project performance prior the status date are used to forecast the approximate estimate cost required until completion. The three approaches is described as following:

5.3.1 Current Task with Cost Parameters

This report would help the manager filter out only ongoing task, the extension prints out the tasks that have finish date after the status date and the tasks that are not 100% complete along with some cost parameters. So the manager knows how each task performed like behind or before schedule, over or under budget. The tasks show in red mean that they are delayed, manager should aware about these tasks.

5.3.2 Upcoming Task within specific days

The main purpose of this report is to warn the manager that some tasks needed to start within any specific days. Hence, the manager should ensure that the task prior the upcoming task will finish on time, so there would not cause a delay which also lead to cost overrun. The manager can input number of days in the box shown in Figure 19. In this case, the author sets the status date as December 1, 2014. The report gives the information of the task that will start within 7 days or December 8, 2014 and the details about their predecessors.

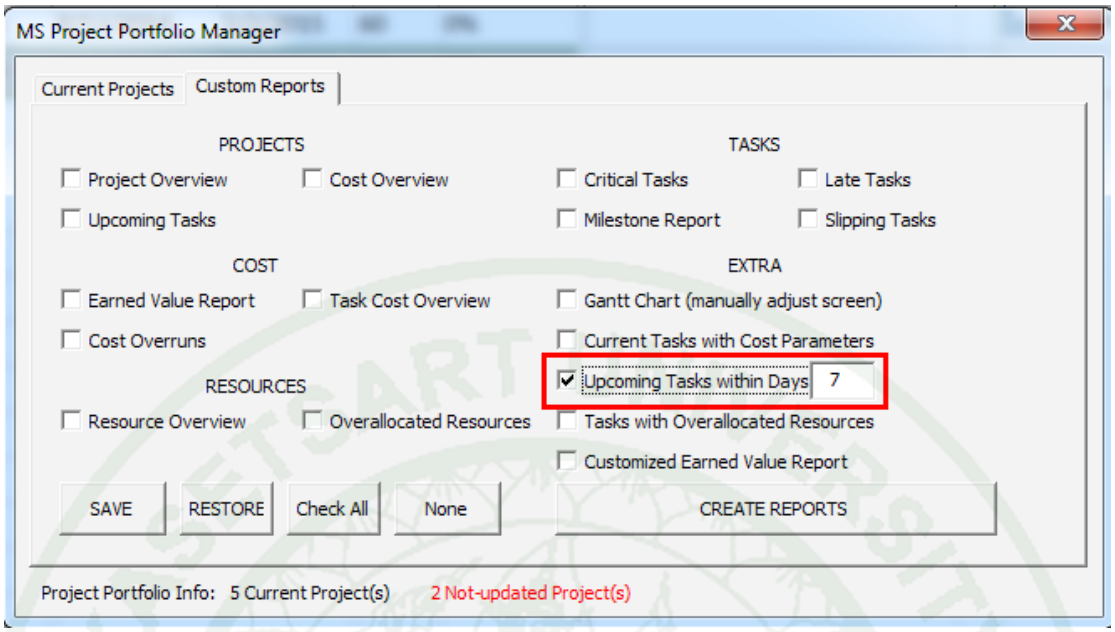


Figure 19 Portfolio manager control panel - underscore upcoming task within specific days

5.3.3 Customized Earned Value Report

The default Earned Value report in Microsoft Project shows only the graph while the extension expresses the detailed information of each task. The reason why this report suits long term tracking is that it forecast the cost at completion. The forecast is based on current performance at the status date. Some projects will continue perform like earlier. Problems accidentally occur in some projects. While some projects are in worst situation – over budget and behind schedule. The different situations can happen to any project at any time. Last but not least, knowing the estimate cost at completion for every scenario is better. If there is a problem occurred later, the company would be ready for the worst scenario and be prepared to handle it.

RESULTS AND DISCUSSION

In this section, the author deliberates the results in accordance with the three main features of the extension which are managing multiple projects, detecting resource conflicts, and monitoring and tracking project performance.

1. Management of Multiple Projects

Refers to the experiment demonstrated, the extension has a user friendly interface for every users as shown in **Figure 20**. The extension can be used by people who are not familiar to or don't know that much about Microsoft Project. It facilitates the users to analyze multiple number of projects simultaneously under just few clicks. As portfolio manager is the one who could gain most benefits from this, they can choose to analyze each project alone or any number of projects or even all the projects operated by the whole company.

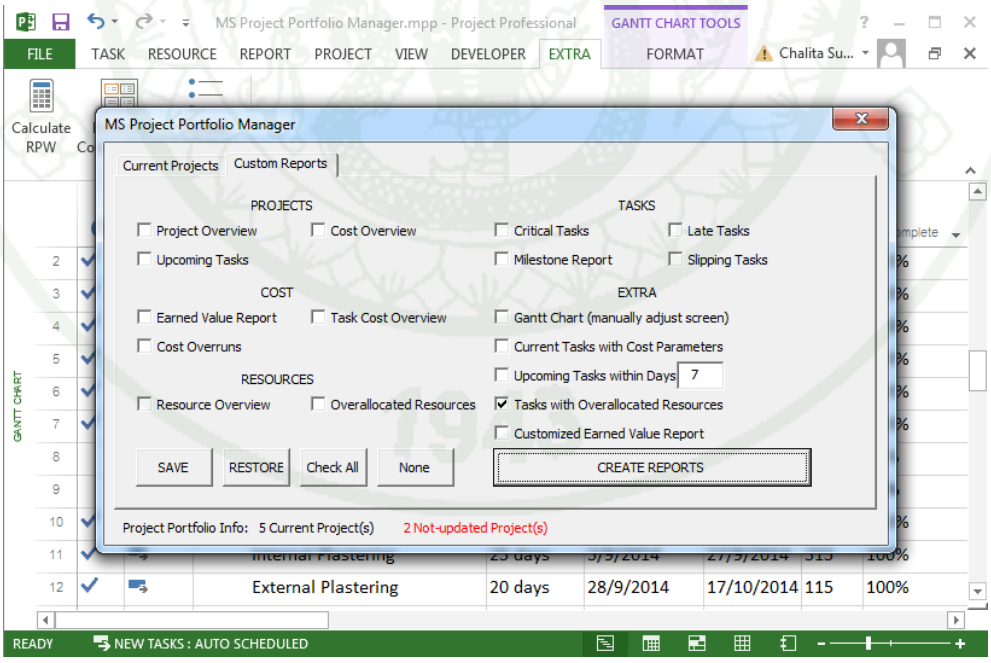


Figure 20 Microsoft Project's Extension user interface

The extension also provides the structural file management system to keep all files in the same place as shown in Figure 21. Furthermore, the user better upload the folder to any cloud service, such as Dropbox, One Drive, Google Drive or Box, for a more convenient use. Project manager at each construction site can update the progress and easily upload to the cloud service. So this is convenient to portfolio manager, they could be more confident that the file they are viewing is the latest one.

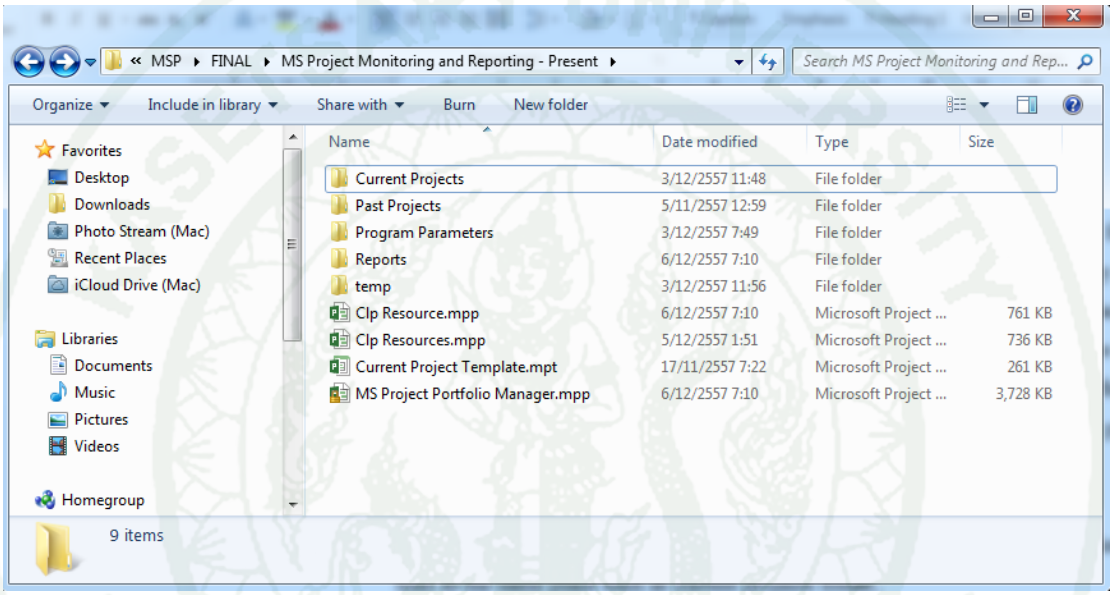


Figure 21 File management system for Microsoft Project's extension

2. Resource Conflicts Detection

Initially, the author will compare the results between resources levelling in Microsoft Project and manually handle conflicts by using information in “Tasks with overallocated resources” report, generating from Microsoft Project’s extension.

Figure 22 illustrates the report generated from the first scenario where resource conflicts in managing multiple projects are caused by adding new projects. Firstly, the author categorizes the task by their status. In this case, fence & road task in Mc Charter and brick wall & finishing task in Lenso Wheels project are the current task, and floor finishing task is the future task. If we look at the start date of both

current tasks, we can see that they are very close. We also see that both tasks are non-critical task.

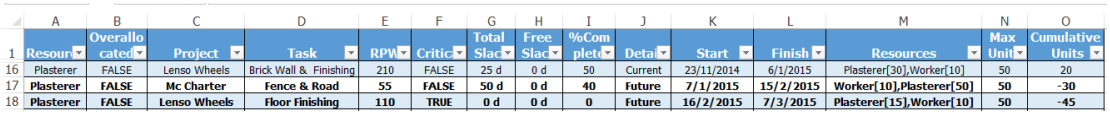
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Resource	Over-allocate	Project	Task	RPW	Critical	Total Slack	Free Slack	%Complete	Detail	Start	Finish	Resources	Max Units	Cumulative Units
25	Plasterer	TRUE	Mc Charter	Fence & Road	55	FALSE	86 d	0 d	40	Current	22/11/2014	31/12/2014	Worker[10],Plasterer[50]	50	-10
26	Plasterer	TRUE	Lenso Wheels	Brick Wall & Finishing	210	FALSE	15 d	0 d	50	Current	23/11/2014	6/1/2015	Plasterer[30],Worker[10]	50	-40
27	Plasterer	TRUE	Lenso Wheels	Floor Finishing	110	TRUE	0 d	0 d	0	Future	6/2/2015	25/2/2015	Plasterer[15],Worker[10]	50	-55

Figure 22 Partial "Tasks with overallocated resources" report to detect resource conflicts (using Microsoft Project's Extension)

Thus, we rather consider the ranked positional weight (RPW) as it is the indicator for level of significance of each task. We could recognize that brick wall & finishing task has the highest positional weight of 210. Floor finishing task and fence & road task have a positional weight of 110 and 55, respectively. Moreover, considering slack time could help us affirm that our decision will have less effects to the company.

From the above analysis, we can conclude that brick wall & finishing task in Lenso Wheels project is the first priority. We should allocate 30 plasters for that task and the possible earliest start date is November 23, 2014. Then, we are required to shift any other task so that the time slot from Nov 23, 2014 to Jan 6, 2015 would be available.

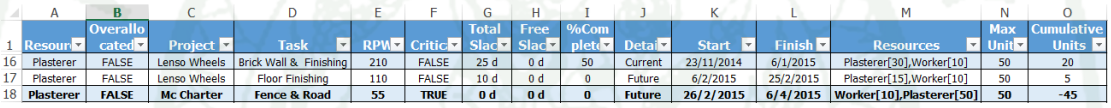
Whether floor finishing task in Lenso Wheels has second highest RPW value and it is also critical, its earliest start date is February 2, 2015, which is almost a month later than the finish date of brick wall & finishing task. We rather allocate the plasterer to fence & road task in Mc Charter first. Thus, we allocate 50 plasterers to floor finishing task. In this case, we will shift the entire task start date so the new start date of this task will become January 7, 2015 and finish at February 15, 2015. Finally, the only task left is floor finishing. We allocate 15 plasterer from February 16, 2015 to March 7, 2015 for floor finishing task in Lenso Wheels project. The report generates after solving all the conflicts can be seen in Figure 23.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Resour	Overallocated	Project	Task	RPW	Critic	Total Slac	Free Slac	%Complet	Detai	Start	Finish	Resources	Max Unit	Cumulative Units
16	Plasterer	FALSE	Lenso Wheels	Brick Wall & Finishing	210	FALSE	25 d	0 d	50	Current	23/11/2014	6/1/2015	Plasterer[30],Worker[10]	50	20
17	**Plasterer**	**FALSE**	**Mc Charter**	**Fence & Road**	**55**	**FALSE**	**50 d**	**0 d**	**40**	**Future**	**7/1/2015**	**15/2/2015**	**Worker[10],Plasterer[50]**	**50**	**-30**
18	**Plasterer**	**FALSE**	**Lenso Wheels**	**Floor Finishing**	**110**	**TRUE**	**0 d**	**0 d**	**0**	**Future**	**16/2/2015**	**7/3/2015**	**Plasterer[15],Worker[10]**	**50**	**-45**

Figure 23 Task with overallocated resources partial report after solving the conflicts manually

On the other hand, the author uses the same scenario and solves the conflict by using resource levelling in Microsoft Project. In this case, assuming that the task cannot be split, it will shift the task to the next available date. As a result in Figure 24, Microsoft project allocates the plasterer to brick wall & finishing task first, then prefer floor finishing than fence & road activity.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Resour	Overallocated	Project	Task	RPW	Critic	Total Slac	Free Slac	%Complet	Detai	Start	Finish	Resources	Max Unit	Cumulative Units
16	Plasterer	FALSE	Lenso Wheels	Brick Wall & Finishing	210	FALSE	25 d	0 d	50	Current	23/11/2014	6/1/2015	Plasterer[30],Worker[10]	50	20
17	Plasterer	FALSE	Lenso Wheels	Floor Finishing	110	FALSE	10 d	0 d	0	Future	6/2/2015	25/2/2015	Plasterer[15],Worker[10]	50	5
18	**Plasterer**	**FALSE**	**Mc Charter**	**Fence & Road**	**55**	**TRUE**	**0 d**	**0 d**	**0**	**Future**	**26/2/2015**	**6/4/2015**	**Worker[10],Plasterer[50]**	**50**	**-45**

Figure 24 Task with overallocated resources partial report after solving the conflicts by auto resource levelling in Microsoft Project

Therefore, the manager solves the resource conflicts by considering several factors including RPW, free slack, total slack, critical task, start and finish date. In this case, using information generated from the extension will cause less delays than resource leveling in Microsoft Project, the result is shown in Table 2.

Table 2 Comparing solutions solved by Microsoft Project and data from extension

	Mc Charter	Maeklong Resort	Lenso Wheels	Total
Old finish	26/01/15	15/01/15	11/04/15	
Extension - New finish	02/03/15	15/01/15	21/04/15	
Delayed (days)	35	0	10	**45**
MSP - New finish	21/04/15	15/01/15	11/04/15	
Delayed (days)	85	0	0	**85**

In Microsoft Project, the alerts for overallocated resources would show only if the resources are assigned to the tasks simultaneously for more than their maximum capacity. Hence, if any tasks are delayed, it means that the resource would continue occupying the following time slots. In reality, the resources are not available whether they were assigned to different time slots.

3. Tracking and Monitoring Project Performance

From the extension, there are three reports that would be useful for the process of tracking and monitoring. Firstly, the current tasks with cost parameter report, it is a collection of ongoing tasks including tasks that are delayed. According to Figure 25, we can see the list of task under each project summary. Taking Maeklong Resort for a discussion, row no. 8 is the summary for all tasks including future and past. The Cost Performance Index (CPI) is 0.97 which indicates that the project is over budget. However, the project does not perform that bad because the value is really close to 1. The bigger CPI, the better performance in terms of cost. If you look at the Cost Variance (CV), the value is just negative 62,518 THB for the whole project. It is an acceptable loss. On the other hand, the Schedule Performance Index (SPI) is 1.04 which is greater than 1. This means that the project is ahead schedule. Overall, the project performance is not quite bad based on the plan.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Detai	Project	Task	Critic	RPW	%Compl	Start	Finish	BL Star	BL Finis	CP	CV	SPI	SV	BCWS	ACWP	BCWP
2	**Current**	**MS Project Portfolio Manager**	**Mc Charter**	**FALSE**	**0**	**84**	**2/4/2014**	**2/3/2015**	**1/1/2014**	**27/10/2014**	**0.98**	**-45,800 ฿**	**0.79**	**-682,880 ฿**	**3,308,280 ฿**	**2,671,200 ฿**	**2,625,400 ฿**
3	Current	Mc Charter	Architectural Work	FALSE	181	78	30/7/2014	26/1/2015	30/4/2014	27/10/2014	0.97	-29,480 ฿	0.74	-337,680 ฿	1,323,200 ฿	1,015,000 ฿	985,520 ฿
4	Current	Mc Charter	Floor Finishing	FALSE	20	40	22/11/2014	11/12/2014	23/8/2014	11/9/2014	0	-48,000 ฿	0	-112,000 ฿	112,000 ฿	48,000 ฿	0 ฿
5	Current	Mc Charter	Painting	FALSE	66	20	22/11/2014	20/1/2015	23/8/2014	21/10/2014	0	-25,000 ฿	0	-182,400 ฿	182,400 ฿	25,000 ฿	0 ฿
6	Current	Mc Charter	Sanitary Work	FALSE	102	86	3/9/2014	13/12/2014	4/6/2014	13/9/2014	0.19	-119,200 ฿	0.16	-156,080 ฿	184,880 ฿	148,000 ฿	28,800 ฿
7	Current	Mc Charter	Exterior Work	FALSE	75	48	2/11/2014	2/3/2015	3/8/2014	16/10/2014	1.88	44,080 ฿	0.33	-189,120 ฿	283,200 ฿	50,000 ฿	94,080 ฿
8	Current	MS Project Portfolio Manager	Maeklong Resort	FALSE	0	80	1/5/2014	15/1/2015	5/5/2014	19/1/2015	0.97	-62,518 ฿	1.04	86,760 ฿	2,186,840 ฿	2,336,118 ฿	2,273,600 ฿
9	**Delayed**	**Maeklong Resort**	**Structural Work**	**FALSE**	**95**	**99**	**1/5/2014**	**23/8/2014**	**5/5/2014**	**7/8/2014**	**1.08**	**55,750 ฿**	**1.33**	**189,600 ฿**	**567,400 ฿**	**701,250 ฿**	**757,000 ฿**
10	Delayed	Maeklong Resort	Roof	FALSE	20	95	4/8/2014	23/8/2014	8/8/2014	27/8/2014	1.14	23,350 ฿	1	0 ฿	189,600 ฿	166,250 ฿	189,600 ฿
11	Current	Maeklong Resort	Architectural Work	FALSE	165	74	4/8/2014	15/1/2015	8/8/2014	19/1/2015	0.93	-118,268 ฿	0.94	-102,840 ฿	1,619,440 ฿	1,634,868 ฿	1,516,600 ฿
12	Current	Maeklong Resort	Painting	FALSE	55	15	22/11/2014	31/12/2014	26/11/2014	4/1/2015	0.63	-9,180 ฿	0.67	-7,680 ฿	23,040 ฿	24,540 ฿	15,360 ฿
13	Current	Maeklong Resort	Sanitary Work	FALSE	115	72	3/9/2014	26/12/2014	7/9/2014	30/12/2014	0.91	-41,728 ฿	0.91	-41,400 ฿	480,000 ฿	480,328 ฿	438,600 ฿
14	Current	Maeklong Resort	Sanitary Hardware Installation	FALSE	30	20	22/11/2014	21/12/2014	26/11/2014	25/12/2014	0.3	-9,040 ฿	0.25	-11,880 ฿	15,840 ฿	13,000 ฿	3,960 ฿
15	Delayed	Maeklong Resort	Septic Tank Installaiton	FALSE	40	90	18/10/2014	26/11/2014	22/10/2014	30/11/2014	0.75	-36,480 ฿	0.7	-46,080 ฿	153,600 ฿	144,000 ฿	107,520 ฿
16	Current	Maeklong Resort	Electrical Work	FALSE	90	68	28/9/2014	26/12/2014	2/10/2014	30/12/2014	1.12	23,472 ฿	1.11	21,840 ฿	204,960 ฿	203,328 ฿	226,800 ฿
17	Current	Maeklong Resort	Electrical Work	FALSE	90	68	28/9/2014	26/12/2014	2/10/2014	30/12/2014	1.12	23,472 ฿	1.11	21,840 ฿	204,960 ฿	203,328 ฿	226,800 ฿
18	Current	MS Project Portfolio Manager	Lenso Wheels	TRUE	0	49	16/7/2014	21/4/2015	16/7/2014	11/4/2015	0.97	-122,880 ฿	0.89	-591,953 ฿	5,171,773 ฿	4,702,700 ฿	4,579,820 ฿
19	**Current**	**Lenso Wheels**	**Office Structure Work**	**FALSE**	**145**	**63**	**20/8/2014**	**11/1/2015**	**20/8/2014**	**11/1/2015**	**0.84**	**-234,280 ฿**	**0.82**	**-260,820 ฿**	**1,462,440 ฿**	**1,435,900 ฿**	**1,201,620 ฿**
20	Current	Lenso Wheels	Roof	FALSE	50	45	23/11/2014	12/12/2014	23/11/2014	12/12/2014	0.22	-63,000 ฿	0.22	-63,000 ฿	81,000 ฿	81,000 ฿	18,000 ฿
21	Current	Lenso Wheels	Lift	FALSE	20	30	23/11/2014	12/12/2014	23/11/2014	12/12/2014	0.65	-6,860 ฿	0.44	-15,800 ฿	28,440 ฿	19,500 ฿	12,640 ฿
22	Current	Lenso Wheels	Warehouse Structural Work	FALSE	124	79	31/8/2014	1/1/2015	31/8/2014	1/1/2015	1.06	189,800 ฿	0.93	-252,733 ฿	3,442,533 ฿	3,000,000 ฿	3,189,800 ฿
23	Delayed	Lenso Wheels	1st Flr. Beam	FALSE	310	90	19/9/2014	28/9/2014	19/9/2014	28/9/2014	0.89	-10,000 ฿	1	0 ฿	80,000 ฿	90,000 ฿	80,000 ฿
24	Delayed	Lenso Wheels	Column	FALSE	270	70	29/9/2014	18/10/2014	29/9/2014	18/10/2014	1.71	50,000 ฿	1	0 ฿	120,000 ฿	70,000 ฿	120,000 ฿
25	Delayed	Lenso Wheels	2nd & 3rd Flr. Beam	FALSE	250	80	19/10/2014	17/11/2014	19/10/2014	17/11/2014	1.31	20,000 ฿	1	0 ฿	84,000 ฿	64,000 ฿	84,000 ฿
26	Current	Lenso Wheels	Loading	FALSE	80	40	18/11/2014	7/12/2014	18/11/2014	7/12/2014	1.19	14,000 ฿	0.71	-34,400 ฿	120,400 ฿	72,000 ฿	86,000 ฿
27	Current	Lenso Wheels	Roof Structure Installation	FALSE	220	70	18/11/2014	2/12/2014	18/11/2014	2/12/2014	1.01	1,000 ฿	0.91	-8,333 ฿	93,333 ฿	84,000 ฿	85,000 ฿
28	Current	Lenso Wheels	Architectural Work	TRUE	140	3	23/11/2014	21/4/2015	23/11/2014	11/4/2015	0.5	-68,400 ฿	0.5	-68,400 ฿	136,800 ฿	136,800 ฿	68,400 ฿
29	Current	Lenso Wheels	Brick Wall & Finishing	FALSE	210	20	23/11/2014	6/1/2015	23/11/2014	6/1/2015	0.5	-68,400 ฿	0.5	-68,400 ฿	136,800 ฿	136,800 ฿	68,400 ฿

Figure 25 Current tasks with cost parameter report (generating from Microsoft Project's extension)

Secondly, the upcoming task within a specific days report, it acts like a warning report as it filters the task that needed to start soon. In this case, the author sets the day's parameter as 7 days and the status date of December 2, 2014. As a result from Figure 26, there are 3 activities that will start on the status date. All of the predecessors of these tasks are already 100% completed, so this is a good signal. In contrast, the two other tasks that will start in 2 days look like they cannot be start on time because their predecessor, the roof structure installation, is delayed. From this information, the manager should be cautious of the roof structure installation and loading. They need to find out what's the problem that causes the delay.

	A	B	C	D	E	F	G	H	I	J	K	L
1	Project	Name	Start within days	Start	Finish	Duration	Resources	# of Predecess	Predecessors	Pred %Complete	Pred Finish	Pred Resources
2	Mc Charter	Installing Sanitary Hardware	0	2/12/2014	8/12/2014	7	Plumber[5], Worker[20]	3	Restroom Piping	100	11/11/2014	Plumber[5],Worker[2]
3	Mc Charter	Installing Sanitary Hardware							Restroom Tiling work	100	11/11/2014	Tiler[8],Worker[4]
4	Mc Charter	Installing Sanitary Hardware							Raiser	100	1/12/2014	Plumber[5],Worker[2]
5	Lenso Wheels	Siding & Ceiling Structure	1	3/12/2014	1/1/2015	30	Welder[20]	1	Roof Structure Installation	70	2/12/2014	Welder[15]
6	Lenso Wheels	Roof Metal Sheet Installation	1	3/12/2014	1/1/2015	30	Roofer[20]	1	Roof Structure Installation	70	2/12/2014	Welder[15]
7	Lenso Wheels	External Work	6	8/12/2014	5/2/2015	60	Worker[10]	1	Loading	40	7/12/2014	Carpenter[10],Ironsmith [10],Worker[10]

Figure 26 Upcoming task within specific days report (generating from extension)

Finally, the customized earned value report shown in Figure 27, it is used to track the project performance in terms of both time and money. The full report can be seen in Appendix B. Further from Microsoft Project, the extension calculates the estimate at completion (EAC) by using three methods. Those three methods are calculated using different formulas depending on the scenario. For the realistic EAC, we assumes that the project performance will continue with the same CPI measured at the status date. For example, if the project is under budget, it is going to be under budget for the rest of the project. In addition, the extension also demonstrates the value of best and worst EAC. Knowing how well the project perform would be a good information to help the company along with the project manager to keep its on track.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Project	Task	Cost	Baseline Cost	BCWS	Physical %Comple	BCWP	%Com plet	ACWP	EAC (realisti	EAC (bes	EAC (worst	CPI	CV	SPI	SV
39	Portfolio Manager	Maeklong Resort	2,731,560 ฿	2,531,000 ฿	2,186,840 ฿	90	2,273,600 ฿	80	2,336,118 ฿	2,600,598 ฿	2,593,518 ฿	2,620,146 ฿	0.97	-62,518 ฿	1.04	86,760 ฿
48	Maeklong Resort	Architectural Work	2,020,840 ฿	1,982,800 ฿	1,619,440 ฿	76	1,516,600 ฿	74	1,634,868 ฿	2,137,428 ฿	2,101,068 ฿	1,871,940 ฿	0.93	-118,268 ฿	0.94	-102,840 ฿
49	Maeklong Resort	Brick Wall	300,000 ฿	288,000 ฿	288,000 ฿	100	288,000 ฿	100	300,000 ฿	300,000 ฿	300,000 ฿	288,000 ฿	0.96	-12,000 ฿	1	0 ฿
50	Maeklong Resort	Internal Plastering	200,000 ฿	190,000 ฿	190,000 ฿	100	190,000 ฿	100	200,000 ฿	200,000 ฿	200,000 ฿	190,000 ฿	0.95	-10,000 ฿	1	0 ฿
51	Maeklong Resort	External Plastering	100,000 ฿	112,000 ฿	112,000 ฿	100	112,000 ฿	100	100,000 ฿	100,000 ฿	100,000 ฿	112,000 ฿	1.12	12,000 ฿	1	0 ฿
52	Maeklong Resort	Ceiling	120,000 ฿	104,000 ฿	104,000 ฿	100	104,000 ฿	100	120,000 ฿	120,000 ฿	120,000 ฿	104,000 ฿	0.87	-16,000 ฿	1	0 ฿
53	Maeklong Resort	Restroom Tiling	160,000 ฿	153,600 ฿	153,600 ฿	100	153,600 ฿	100	160,000 ฿	160,000 ฿	160,000 ฿	153,600 ฿	0.96	-6,400 ฿	1	0 ฿
54	Maeklong Resort	Floor Finishing	250,000 ฿	268,800 ฿	268,800 ฿	80	215,040 ฿	100	250,000 ฿	312,500 ฿	303,760 ฿	206,300 ฿	0.86	-34,960 ฿	0.8	-53,760 ฿
55	Maeklong Resort	Painting	163,600 ฿	153,600 ฿	23,040 ฿	10	15,360 ฿	15	24,540 ฿	245,402 ฿	162,780 ฿	141,330 ฿	0.63	-9,180 ฿	0.67	-7,680 ฿
56	Maeklong Resort	Clearing	72,000 ฿	72,000 ฿	0 ฿	0	0 ฿	0	0 ฿	72,000 ฿	72,000 ฿	72,000 ฿	0	0 ฿	0	0 ฿
57	Maeklong Resort	Sanitary Work	655,240 ฿	640,800 ฿	480,000 ฿	68	438,600 ฿	72	480,328 ฿	701,767 ฿	682,528 ฿	595,461 ฿	0.91	-41,728 ฿	0.91	-41,400 ฿
58	Maeklong Resort	Plumbing	120,000 ฿	105,600 ฿	105,600 ฿	95	100,320 ฿	100	120,000 ฿	126,316 ฿	125,280 ฿	99,284 ฿	0.84	-19,680 ฿	0.95	-5,280 ฿
59	Maeklong Resort	Sanitary Hardware Installation	65,000 ฿	79,200 ฿	15,840 ฿	5	3,960 ฿	20	13,000 ฿	260,004 ฿	88,240 ฿	40,200 ฿	0.3	-9,040 ฿	0.25	-11,880 ฿
60	Maeklong Resort	Septic Tank Installaiton	170,240 ฿	153,600 ฿	153,600 ฿	70	107,520 ฿	90	144,000 ฿	205,715 ฿	190,080 ฿	91,886 ฿	0.75	-36,480 ฿	0.7	-46,080 ฿
61	Maeklong Resort	Electrical Work	300,000 ฿	302,400 ฿	204,960 ฿	75	226,800 ฿	68	203,328 ฿	271,105 ฿	278,928 ฿	321,980 ฿	1.12	23,472 ฿	1.11	21,840 ฿
62	Maeklong Resort	Electrical Work	300,000 ฿	302,400 ฿	204,960 ฿	75	226,800 ฿	68	203,328 ฿	271,105 ฿	278,928 ฿	321,980 ฿	1.12	23,472 ฿	1.11	21,840 ฿

Figure 27 Partial customized earned value report

In monitoring and tracking process, it requires project manager to frequently and accurately update the progress. If the project managers fail to update the progress, all the tools created would be useless. Moreover, Construction process is different from assembly line in manufacturing for the reason that both the percentage of work complete and the physical percentage complete cannot be determine accurately, it depends on oneself judgment. For instance, one project manager updates the physical percentage complete of a piling work as 50% while another manager thinks that it is just 40%. This will lead to fluctuation in computation of earned value analysis.

CONCLUSION AND RECOMMENDATION

Conclusion

The tool is developed for the purpose of detecting resource conflicts, tracking and monitoring, and managing multiple projects. We demonstrate 2 scenarios for resource conflicts. The first one is the conflict that occur in planning phase when new task or new projects are added. The second scenario is occurred from project delay in construction phase, given that the conflict in planning phase is solved. The extension could help the project manager to detect resource conflicts faster and more accurate. The results show that Ranked Positional Weight is the factor that should be most concerned proven from the comparison between the extension and the leveling resource in Microsoft Project. The result from extension specifies the delay at 45 days while Microsoft Project specifies at 85 days which can be conclude that the manual scheduling is more efficient than the auto leveling by Microsoft Project. However, Ranked Positional Weight is not guarantee for the optimum solutions or minimum delays.

The extension generates report that will facilitate the process of tracking and monitoring project performance, along with warning report that concentrate on potential of cost overrun or delay. The Estimate at Completion (EAC) for worst case, best case, and realistic case, along with alert for not updated project progress are the additional function which will guarantee the increase of awareness toward project delay and cost overrun for project manager.

Additionally, for multiple project management, the project manager can manage and analyse overall performance of several projects at once which will reduce time from the usual report generation from Microsoft Project.

Recommendation

From this research, the further study of Ranked Positional Weight (RPW) is recommended as it can be applied in other parameters to calculate its effectiveness. Other technique that can also be used to address the resource conflict can be linear programming. Though, material and equipment are considered to be unlimited resource, cost should be more concern.

Additionally, the extension might be applied to construction company with larger-scale or any other industry to affirm that the extension could help the company to detect conflicts earlier and make an accurate decision.

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APPENDICES

Appendix A

Resource conflicts detected from "Tasks with Overallocated Resources" report using Microsoft Project's extension

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Resourc	Over-allocate	Project	Task	RPW	Critic	Total Slack	Free Slack	%Com plet	Detail	Start	Finish	Resources	Max Unit	Cumulative Units
2	Carpenter	FALSE	Maeklong Resort	Roof	20	FALSE	231 d	231 d	95	Delayed (100 d)	4/8/2014	23/8/2014	Carpenter[15],Ironsmith[6],Worker[6]	130	115
3	Carpenter	FALSE	Lenso Wheels	1st Flr. Beam	310	FALSE	14 d	0 d	90	Delayed (64 d)	19/9/2014	28/9/2014	Carpenter[15],Ironsmith[5],Worker[3]	130	100
4	Carpenter	FALSE	Lenso Wheels	Column	270	FALSE	24 d	0 d	70	Delayed (44 d)	29/9/2014	18/10/2014	Carpenter[10],Ironsmith[3],Worker[2]	130	90
5	Carpenter	FALSE	Lenso Wheels	2nd & 3rd Flr. Beam	250	FALSE	14 d	0 d	80	Delayed (14 d)	19/10/2014	17/11/2014	Carpenter[4],Ironsmith[2],Worker[2]	130	86
6	Carpenter	FALSE	Lenso Wheels	Loading	80	FALSE	65 d	0 d	70	Current	18/11/2014	7/12/2014	Carpenter[5],Ironsmith[10],Worker[10]	130	81
7	Carpenter	FALSE	Lenso Wheels	Roof	50	FALSE	90 d	0 d	45	Current	23/11/2014	12/12/2014	Carpenter[15],Ironsmith[5],Worker[5]	130	66
8	Carpenter	FALSE	Lenso Wheels	Lift	20	FALSE	120 d	120 d	45	Current	23/11/2014	12/12/2014	Carpenter[5],Ironsmith[2],Worker[2]	130	61
9	Carpenter	FALSE	Lenso Wheels	Stair	30	FALSE	90 d	90 d	0	Future	13/12/2014	11/1/2015	Carpenter[5],Ironsmith[2],Worker[2]	130	56
10	Carpenter	FALSE	Lenso Wheels	Door & Window Installation	40	FALSE	55 d	55 d	0	Future	7/1/2015	15/2/2015	Carpenter[6],Worker[2]	130	50
11	Carpenter	FALSE	Lenso Wheels	Ceiling	125	TRUE	0 d	0 d	0	Future	22/1/2015	5/2/2015	Carpenter[15],Worker[5]	130	35
12	Electrician	FALSE	Maeklong Resort	Electrical Work	90	FALSE	106 d	106 d	68	Current	28/9/2014	26/12/2014	Electrician[6]	6	0
13	Ironsmith	FALSE	Maeklong Resort	Roof	20	FALSE	231 d	231 d	95	Delayed (100 d)	4/8/2014	23/8/2014	Carpenter[15],Ironsmith[6],Worker[6]	40	34
14	Ironsmith	FALSE	Lenso Wheels	1st Flr. Beam	310	FALSE	14 d	0 d	90	Delayed (64 d)	19/9/2014	28/9/2014	Carpenter[15],Ironsmith[5],Worker[3]	40	29
15	Ironsmith	FALSE	Lenso Wheels	Column	270	FALSE	24 d	0 d	70	Delayed (44 d)	29/9/2014	18/10/2014	Carpenter[10],Ironsmith[3],Worker[2]	40	26
16	Ironsmith	FALSE	Lenso Wheels	2nd & 3rd Flr. Beam	250	FALSE	14 d	0 d	80	Delayed (14 d)	19/10/2014	17/11/2014	Carpenter[4],Ironsmith[2],Worker[2]	40	24
17	Ironsmith	FALSE	Lenso Wheels	Loading	80	FALSE	65 d	0 d	70	Current	18/11/2014	7/12/2014	Carpenter[5],Ironsmith[10],Worker[10]	40	14
18	Ironsmith	FALSE	Lenso Wheels	Roof	50	FALSE	90 d	0 d	45	Current	23/11/2014	12/12/2014	Carpenter[15],Ironsmith[5],Worker[5]	40	9
19	Ironsmith	FALSE	Lenso Wheels	Lift	20	FALSE	120 d	120 d	45	Current	23/11/2014	12/12/2014	Carpenter[5],Ironsmith[2],Worker[2]	40	7
20	Ironsmith	FALSE	Lenso Wheels	Stair	30	FALSE	90 d	90 d	0	Future	13/12/2014	11/1/2015	Carpenter[5],Ironsmith[2],Worker[2]	40	5
21	Painter	FALSE	Maeklong Resort	Painting	55	TRUE	86 d	0 d	15	Current	22/11/2014	31/12/2014	Painter[8],Worker[2]	15	7
22	Painter	FALSE	Mc Charter	Painting	66	FALSE	75 d	0 d	20	Current	22/11/2014	20/1/2015	Painter[6],Worker[2]	15	1
23	**Painter**	**FALSE**	**Lenso Wheels**	**Painting**	**45**	**TRUE**	**0 d**	**0 d**	**0**	**Future**	**26/2/2015**	**1/4/2015**	**Painter[15],Worker[5]**	**15**	**-14**
24	Plasterer	TRUE	Mc Charter	Floor Finishing	20	FALSE	0 d	0 d	100	Current	22/11/2014	11/12/2014	Plasterer[10],Worker[5]	50	40
25	**Plasterer**	**TRUE**	**Mc Charter**	**Fence & Road**	**55**	**FALSE**	**86 d**	**0 d**	**40**	**Current**	**22/11/2014**	**31/12/2014**	**Worker[10],Plasterer[50]**	**50**	**-10**
26	**Plasterer**	**TRUE**	**Lenso Wheels**	**Brick Wall & Finishing**	**210**	**FALSE**	**15 d**	**0 d**	**50**	**Current**	**23/11/2014**	**6/1/2015**	**Plasterer[30],Worker[10]**	**50**	**-40**
27	**Plasterer**	**TRUE**	**Lenso Wheels**	**Floor Finishing**	**110**	**TRUE**	**0 d**	**0 d**	**0**	**Future**	**6/2/2015**	**25/2/2015**	**Plasterer[15],Worker[10]**	**50**	**-55**
28	Plumber	FALSE	Mc Charter	Raiser	32	FALSE	0 d	0 d	100	Current	12/11/2014	1/12/2014	Plumber[5],Worker[2]	10	5
29	Plumber	FALSE	Maeklong Resort	Sanitary Hardware Installation	30	FALSE	111 d	111 d	20	Current	22/11/2014	21/12/2014	Plumber[5],Worker[2]	10	0
30	**Plumber**	**FALSE**	**Mc Charter**	**Installing Sanitary Hardware**	**12**	**FALSE**	**119 d**	**0 d**	**20**	**Upcoming**	**2/12/2014**	**8/12/2014**	**Plumber[5],Worker[20]**	**10**	**-5**
31	**Plumber**	**FALSE**	**Mc Charter**	**Installing water tank & pump**	**5**	**FALSE**	**119 d**	**119 d**	**0**	**Future**	**9/12/2014**	**13/12/2014**	**Plumber[2],Worker[20]**	**10**	**-7**
32	**Plumber**	**FALSE**	**Lenso Wheels**	**Sanitary Hardware Installation**	**45**	**TRUE**	**0 d**	**0 d**	**0**	**Future**	**26/2/2015**	**11/4/2015**	**Plumber[5],Worker[2]**	**10**	**-12**
33	Roofer	FALSE	Lenso Wheels	Roof Metal Sheet Installation	175	TRUE	0 d	0 d	0	Upcoming	3/12/2014	1/1/2015	Roofer[20]	20	0

	Resource	Over-all	Project	Task	RPW	Critical	Total Sl	Free Sla	%Cor	Detail	Start	Finish	Resources	Max U	Cumulative
34	**Roofer**	**FALSE**	**Lenso Wheels**	**Siding Metal Sheet Installation**	**145**	**TRUE**	**0 d**	**0 d**	**0**	**Future**	**2/1/2015**	**21/1/2015**	**Roofer[20]**	**20**	**-20**
35	Welder	FALSE	Lenso Wheels	Roof Structure Installation	220	TRUE	0 d	0 d	93	Current	18/11/2014	2/12/2014	Welder[15]	30	15
36	**Welder**	**FALSE**	**Lenso Wheels**	**Siding & Ceiling Structure**	**175**	**TRUE**	**0 d**	**0 d**	**0**	**Upcoming**	**3/12/2014**	**1/1/2015**	**Welder[20]**	**30**	**-5**
37	Worker	FALSE	Maeklong Resort	Roof	20	FALSE	231 d	231 d	95	Delayed (100 d)	4/8/2014	23/8/2014	Carpenter[15],Ironsmith[6],Worker[6]	70	64
38	Worker	FALSE	Lenso Wheels	1st Flr. Beam	310	FALSE	14 d	0 d	90	Delayed (64 d)	19/9/2014	28/9/2014	Carpenter[15],Ironsmith[5],Worker[3]	70	61
39	Worker	FALSE	Lenso Wheels	Column	270	FALSE	24 d	0 d	70	Delayed (44 d)	29/9/2014	18/10/2014	Carpenter[10],Ironsmith[3],Worker[2]	70	59
40	Worker	FALSE	Maeklong Resort	Septic Tank Installaiton	40	FALSE	136 d	136 d	90	Delayed (5 d)	18/10/2014	26/11/2014	Worker[20]	70	39
41	Worker	FALSE	Lenso Wheels	2nd & 3rd Flr. Beam	250	FALSE	14 d	0 d	80	Delayed (14 d)	19/10/2014	17/11/2014	Carpenter[4],Ironsmith[2],Worker[2]	70	37
42	Worker	FALSE	Mc Charter	Raiser	32	FALSE	0 d	0 d	100	Current	12/11/2014	1/12/2014	Plumber[5],Worker[2]	70	35
43	Worker	FALSE	Lenso Wheels	Loading	80	FALSE	65 d	0 d	70	Current	18/11/2014	7/12/2014	Carpenter[5],Ironsmith[10],Worker[10]	70	25
44	Worker	FALSE	Mc Charter	Floor Finishing	20	FALSE	0 d	0 d	100	Current	22/11/2014	11/12/2014	Plasterer[10],Worker[5]	70	20
45	Worker	FALSE	Maeklong Resort	Sanitary Hardware Installation	30	FALSE	111 d	111 d	20	Current	22/11/2014	21/12/2014	Plumber[5],Worker[2]	70	18
46	Worker	FALSE	Mc Charter	Fence & Road	55	FALSE	86 d	0 d	40	Current	22/11/2014	31/12/2014	Worker[10],Plasterer[50]	70	8
47	Worker	FALSE	Maeklong Resort	Painting	55	TRUE	86 d	0 d	15	Current	22/11/2014	31/12/2014	Painter[8],Worker[2]	70	6
48	Worker	FALSE	Mc Charter	Painting	66	FALSE	75 d	0 d	20	Current	22/11/2014	20/1/2015	Painter[6],Worker[2]	70	4
49	**Worker**	**FALSE**	**Lenso Wheels**	**Roof**	**50**	**FALSE**	**90 d**	**0 d**	**45**	**Current**	**23/11/2014**	**12/12/2014**	**Carpenter[15],Ironsmith[5],Worker[5]**	**70**	**-1**
50	**Worker**	**FALSE**	**Lenso Wheels**	**Lift**	**20**	**FALSE**	**120 d**	**120 d**	**45**	**Current**	**23/11/2014**	**12/12/2014**	**Carpenter[5],Ironsmith[2],Worker[2]**	**70**	**-3**
51	**Worker**	**FALSE**	**Lenso Wheels**	**Brick Wall & Finishing**	**210**	**FALSE**	**15 d**	**0 d**	**50**	**Current**	**23/11/2014**	**6/1/2015**	**Plasterer[30],Worker[10]**	**70**	**-13**
52	**Worker**	**FALSE**	**Mc Charter**	**Installing Sanitary Hardware**	**12**	**FALSE**	**119 d**	**0 d**	**20**	**Upcoming**	**2/12/2014**	**8/12/2014**	**Plumber[5],Worker[20]**	**70**	**-33**
53	**Worker**	**FALSE**	**Lenso Wheels**	**External Work**	**60**	**FALSE**	**65 d**	**65 d**	**0**	**Upcoming**	**8/12/2014**	**5/2/2015**	**Worker[10]**	**70**	**-43**
54	**Worker**	**FALSE**	**Mc Charter**	**Installing water tank & pump**	**5**	**FALSE**	**119 d**	**119 d**	**0**	**Future**	**9/12/2014**	**13/12/2014**	**Plumber[2],Worker[20]**	**70**	**-63**
55	**Worker**	**FALSE**	**Lenso Wheels**	**Stair**	**30**	**FALSE**	**90 d**	**90 d**	**0**	**Future**	**13/12/2014**	**11/1/2015**	**Carpenter[5],Ironsmith[2],Worker[2]**	**70**	**-65**
56	**Worker**	**FALSE**	**Mc Charter**	**Clearing**	**15**	**FALSE**	**86 d**	**86 d**	**0**	**Future**	**1/1/2015**	**15/1/2015**	**Worker[15]**	**70**	**-80**
57	**Worker**	**FALSE**	**Maeklong Resort**	**Clearing**	**15**	**TRUE**	**86 d**	**86 d**	**0**	**Future**	**1/1/2015**	**15/1/2015**	**Worker[15]**	**70**	**-95**
58	**Worker**	**FALSE**	**Lenso Wheels**	**Door & Window Installation**	**40**	**FALSE**	**55 d**	**55 d**	**0**	**Future**	**7/1/2015**	**15/2/2015**	**Carpenter[6],Worker[2]**	**70**	**-97**
59	**Worker**	**FALSE**	**Mc Charter**	**Miscellenous**	**6**	**FALSE**	**75 d**	**75 d**	**0**	**Future**	**21/1/2015**	**26/1/2015**	**Worker[20]**	**70**	**-117**
60	**Worker**	**FALSE**	**Lenso Wheels**	**Ceiling**	**125**	**TRUE**	**0 d**	**0 d**	**0**	**Future**	**22/1/2015**	**5/2/2015**	**Carpenter[15],Worker[5]**	**70**	**-122**
61	**Worker**	**FALSE**	**Lenso Wheels**	**Floor Finishing**	**110**	**TRUE**	**0 d**	**0 d**	**0**	**Future**	**6/2/2015**	**25/2/2015**	**Plasterer[15],Worker[10]**	**70**	**-132**
62	**Worker**	**FALSE**	**Lenso Wheels**	**Painting**	**45**	**TRUE**	**0 d**	**0 d**	**0**	**Future**	**26/2/2015**	**1/4/2015**	**Painter[15],Worker[5]**	**70**	**-137**
63	**Worker**	**FALSE**	**Lenso Wheels**	**Sanitary Hardware Installation**	**45**	**TRUE**	**0 d**	**0 d**	**0**	**Future**	**26/2/2015**	**11/4/2015**	**Plumber[5],Worker[2]**	**70**	**-139**
64	**Worker**	**FALSE**	**Lenso Wheels**	**Clearing**	**10**	**TRUE**	**0 d**	**0 d**	**0**	**Future**	**2/4/2015**	**11/4/2015**	**Worker[25]**	**70**	**-164**

Appendix B

Customized Earned Value Report

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Project	Task	Cost	Baseline Cost	BCWS	Physical %Comple	BCWP	%Com plet	ACWP	EAC (realisti	EAC (bes	EAC (worst	CPI	CV	SPI	SV
2	Portfolio Manager	Mc Charter	3,702,920 ฿	3,308,280 ฿	3,308,280 ฿	79	2,625,400 ฿	84	2,671,200 ฿	3,365,996 ฿	3,354,080 ฿	2,613,487 ฿	0.98	-45,800 ฿	0.79	-682,880 ฿
3	Mc Charter	Structural Work	1,458,200 ฿	1,517,000 ฿	1,517,000 ฿	100	1,517,000 ฿	100	1,458,200 ฿	1,458,200 ฿	1,458,200 ฿	1,517,000 ฿	1.04	58,800 ฿	1	0 ฿
4	Mc Charter	Preparation work	48,000 ฿	48,000 ฿	48,000 ฿	100	48,000 ฿	100	48,000 ฿	48,000 ฿	48,000 ฿	48,000 ฿	1	0 ฿	1	0 ฿
5	Mc Charter	Piling	0 ฿	0 ฿	0 ฿	100	0 ฿	100	0 ฿	0 ฿	0 ฿	0 ฿	0	0 ฿	0	0 ฿
6	Mc Charter	Footing & Pier	125,000 ฿	132,000 ฿	132,000 ฿	100	132,000 ฿	100	125,000 ฿	125,000 ฿	125,000 ฿	132,000 ฿	1.06	7,000 ฿	1	0 ฿
7	Mc Charter	1st Flr. Beam & Slab	222,000 ฿	244,000 ฿	244,000 ฿	100	244,000 ฿	100	222,000 ฿	222,000 ฿	222,000 ฿	244,000 ฿	1.1	22,000 ฿	1	0 ฿
8	Mc Charter	Precast & Topping	43,500 ฿	47,600 ฿	47,600 ฿	100	47,600 ฿	100	43,500 ฿	43,500 ฿	43,500 ฿	47,600 ฿	1.09	4,100 ฿	1	0 ฿
9	Mc Charter	Column	15,400 ฿	19,200 ฿	19,200 ฿	100	19,200 ฿	100	15,400 ฿	15,400 ฿	15,400 ฿	19,200 ฿	1.25	3,800 ฿	1	0 ฿
10	Mc Charter	2nd Flr. Beam & Slab	308,700 ฿	305,000 ฿	305,000 ฿	100	305,000 ฿	100	308,700 ฿	308,700 ฿	308,700 ฿	305,000 ฿	0.99	-3,700 ฿	1	0 ฿
11	Mc Charter	Precast & Topping	49,600 ฿	47,600 ฿	47,600 ฿	100	47,600 ฿	100	49,600 ฿	49,600 ฿	49,600 ฿	47,600 ฿	0.96	-2,000 ฿	1	0 ฿
12	Mc Charter	Column	20,000 ฿	19,200 ฿	19,200 ฿	100	19,200 ฿	100	20,000 ฿	20,000 ฿	20,000 ฿	19,200 ฿	0.96	-800 ฿	1	0 ฿
13	Mc Charter	Roof Fabricate Steel	300,000 ฿	326,400 ฿	326,400 ฿	100	326,400 ฿	100	300,000 ฿	300,000 ฿	300,000 ฿	326,400 ฿	1.09	26,400 ฿	1	0 ฿
14	Mc Charter	Steel Structure Installation	55,000 ฿	60,000 ฿	60,000 ฿	100	60,000 ฿	100	55,000 ฿	55,000 ฿	55,000 ฿	60,000 ฿	1.09	5,000 ฿	1	0 ฿
15	Mc Charter	Metal Sheet Installation	50,000 ฿	54,000 ฿	54,000 ฿	100	54,000 ฿	100	50,000 ฿	50,000 ฿	50,000 ฿	54,000 ฿	1.08	4,000 ฿	1	0 ฿
16	Mc Charter	Swimming Pool	165,000 ฿	158,000 ฿	158,000 ฿	100	158,000 ฿	100	165,000 ฿	165,000 ฿	165,000 ฿	158,000 ฿	0.96	-7,000 ฿	1	0 ฿
17	Mc Charter	Stair	56,000 ฿	56,000 ฿	56,000 ฿	100	56,000 ฿	100	56,000 ฿	56,000 ฿	56,000 ฿	56,000 ฿	1	0 ฿	1	0 ฿
18	Mc Charter	Architectural Work	1,272,000 ฿	1,323,200 ฿	1,323,200 ฿	74	985,520 ฿	78	1,015,000 ฿	1,362,783 ฿	1,352,680 ฿	975,419 ฿	0.97	-29,480 ฿	0.74	-337,680 ฿
19	Mc Charter	1st Flr. Brick & Pastering	221,000 ฿	224,000 ฿	224,000 ฿	100	224,000 ฿	100	221,000 ฿	221,000 ฿	221,000 ฿	224,000 ฿	1.01	3,000 ฿	1	0 ฿
20	Mc Charter	2nd Flr. Brick & Pastering	250,000 ฿	268,800 ฿	268,800 ฿	100	268,800 ฿	100	250,000 ฿	250,000 ฿	250,000 ฿	268,800 ฿	1.08	18,800 ฿	1	0 ฿
21	Mc Charter	Swimming Pool Ceramic Tiling work	80,000 ฿	88,000 ฿	88,000 ฿	100	88,000 ฿	100	80,000 ฿	80,000 ฿	80,000 ฿	88,000 ฿	1.1	8,000 ฿	1	0 ฿
22	Mc Charter	Restroom Tiling work	140,000 ฿	153,600 ฿	153,600 ฿	100	153,600 ฿	100	140,000 ฿	140,000 ฿	140,000 ฿	153,600 ฿	1.1	13,600 ฿	1	0 ฿
23	Mc Charter	Exterior Plastering	105,000 ฿	96,000 ฿	96,000 ฿	100	96,000 ฿	100	105,000 ฿	105,000 ฿	105,000 ฿	96,000 ฿	0.91	-9,000 ฿	1	0 ฿
24	Mc Charter	Ceiling	86,000 ฿	97,600 ฿	97,600 ฿	95	92,720 ฿	100	86,000 ฿	90,526 ฿	90,880 ฿	93,074 ฿	1.08	6,720 ฿	0.95	-4,880 ฿
25	Mc Charter	Door & Window	60,000 ฿	62,400 ฿	62,400 ฿	100	62,400 ฿	100	60,000 ฿	60,000 ฿	60,000 ฿	62,400 ฿	1.04	2,400 ฿	1	0 ฿
26	Mc Charter	Floor Finishing	120,000 ฿	112,000 ฿	112,000 ฿	0	0 ฿	40	48,000 ฿	120,000 ฿	160,000 ฿	160,000 ฿	0	-48,000 ฿	0	-112,000 ฿
27	Mc Charter	Painting	150,000 ฿	182,400 ฿	182,400 ฿	0	0 ฿	20	25,000 ฿	150,000 ฿	207,400 ฿	207,400 ฿	0	-25,000 ฿	0	-182,400 ฿
28	Mc Charter	Miscellenous	60,000 ฿	38,400 ฿	38,400 ฿	0	0 ฿	0	0 ฿	60,000 ฿	38,400 ฿	38,400 ฿	0	0 ฿	0	-38,400 ฿
29	Mc Charter	Sanitary Work	242,720 ฿	184,880 ฿	184,880 ฿	16	28,800 ฿	86	148,000 ฿	950,097 ฿	304,080 ฿	-617,198 ฿	0.19	-119,200 ฿	0.16	-156,080 ฿
30	Mc Charter	Restroom Piping	70,000 ฿	79,200 ฿	79,200 ฿	0	0 ฿	100	70,000 ฿	70,000 ฿	149,200 ฿	149,200 ฿	0	-70,000 ฿	0	-79,200 ฿
31	Mc Charter	Raiser	48,000 ฿	52,800 ฿	52,800 ฿	0	0 ฿	100	48,000 ฿	48,000 ฿	100,800 ฿	100,800 ฿	0	-48,000 ฿	0	-52,800 ฿
32	Mc Charter	Installing Sanitary Hardware	58,320 ฿	18,480 ฿	18,480 ฿	0	0 ฿	20	0 ฿	58,320 ฿	18,480 ฿	18,480 ฿	0	0 ฿	0	-18,480 ฿
33	Mc Charter	Installing water tank & pump	36,400 ฿	5,600 ฿	5,600 ฿	0	0 ฿	0	0 ฿	36,400 ฿	5,600 ฿	5,600 ฿	0	0 ฿	0	-5,600 ฿
34	Mc Charter	Installing Septic Tank	30,000 ฿	28,800 ฿	28,800 ฿	100	28,800 ฿	100	30,000 ฿	30,000 ฿	30,000 ฿	28,800 ฿	0.96	-1,200 ฿	1	0 ฿
35	Mc Charter	Exterior Work	730,000 ฿	283,200 ฿	283,200 ฿	33	94,080 ฿	48	50,000 ฿	150,510 ฿	239,120 ฿	182,690 ฿	1.88	44,080 ฿	0.33	-189,120 ฿

	Project	Task	Cost	Baseline	BCWS	Physical %	BCWP	%Co	ACWP	EAC (rea	EAC (bes	EAC (wor	CPI	CV	SPI	SV
36	Mc Charter	Installing Manholes & Pipes	50,000 ฿	51,200 ฿	51,200 ฿	90	46,080 ฿	100	50,000 ฿	55,556 ฿	55,120 ฿	45,644 ฿	0.92	-3,920 ฿	0.9	-5,120 ฿
37	Mc Charter	Fence & Road	590,000 ฿	160,000 ฿	160,000 ฿	30	48,000 ฿	40	0 ฿	590,000 ฿	112,000 ฿	112,000 ฿	0	48,000 ฿	0.3	-112,000 ฿
38	Mc Charter	Clearing	90,000 ฿	72,000 ฿	72,000 ฿	0	0 ฿	0	0 ฿	90,000 ฿	72,000 ฿	72,000 ฿	0	0 ฿	0	-72,000 ฿
39	Portfolio Manager	Maeklong Resort	2,731,560 ฿	2,531,000 ฿	2,186,840 ฿	90	2,273,600 ฿	80	2,336,118 ฿	2,600,598 ฿	2,593,518 ฿	2,620,146 ฿	0.97	-62,518 ฿	1.04	86,760 ฿
40	Maeklong Resort	Structural Work	710,720 ฿	567,400 ฿	567,400 ฿	100	757,000 ฿	99	701,250 ฿	525,613 ฿	511,650 ฿	743,037 ฿	1.08	55,750 ฿	1.33	189,600 ฿
41	Maeklong Resort	Piling	0 ฿	0 ฿	0 ฿	100	0 ฿	100	0 ฿	0 ฿	0 ฿	0 ฿	0	0 ฿	0	0 ฿
42	Maeklong Resort	Footing	60,000 ฿	63,200 ฿	63,200 ฿	100	63,200 ฿	100	60,000 ฿	60,000 ฿	60,000 ฿	63,200 ฿	1.05	3,200 ฿	1	0 ฿
43	Maeklong Resort	1st Flr. Beam & Slab	180,000 ฿	189,600 ฿	189,600 ฿	100	189,600 ฿	100	180,000 ฿	180,000 ฿	180,000 ฿	189,600 ฿	1.05	9,600 ฿	1	0 ฿
44	Maeklong Resort	Column	35,000 ฿	38,800 ฿	38,800 ฿	100	38,800 ฿	100	35,000 ฿	35,000 ฿	35,000 ฿	38,800 ฿	1.11	3,800 ฿	1	0 ฿
45	Maeklong Resort	2nd Flr. Beam & Slab	220,000 ฿	237,000 ฿	237,000 ฿	100	237,000 ฿	100	220,000 ฿	220,000 ฿	220,000 ฿	237,000 ฿	1.08	17,000 ฿	1	0 ฿
46	Maeklong Resort	Column	40,000 ฿	38,800 ฿	38,800 ฿	100	38,800 ฿	100	40,000 ฿	40,000 ฿	40,000 ฿	38,800 ฿	0.97	-1,200 ฿	1	0 ฿
47	Maeklong Resort	Roof	175,720 ฿	189,600 ฿	189,600 ฿	100	189,600 ฿	95	166,250 ฿	166,250 ฿	166,250 ฿	189,600 ฿	1.14	23,350 ฿	1	0 ฿
48	Maeklong Resort	Architectural Work	2,020,840 ฿	1,982,800 ฿	1,619,440 ฿	76	1,516,600 ฿	74	1,634,868 ฿	2,137,428 ฿	2,101,068 ฿	1,871,940 ฿	0.93	-118,268 ฿	0.94	-102,840 ฿
49	Maeklong Resort	Brick Wall	300,000 ฿	288,000 ฿	288,000 ฿	100	288,000 ฿	100	300,000 ฿	300,000 ฿	300,000 ฿	288,000 ฿	0.96	-12,000 ฿	1	0 ฿
50	Maeklong Resort	Internal Plastering	200,000 ฿	190,000 ฿	190,000 ฿	100	190,000 ฿	100	200,000 ฿	200,000 ฿	200,000 ฿	190,000 ฿	0.95	-10,000 ฿	1	0 ฿
51	Maeklong Resort	External Plastering	100,000 ฿	112,000 ฿	112,000 ฿	100	112,000 ฿	100	100,000 ฿	100,000 ฿	100,000 ฿	112,000 ฿	1.12	12,000 ฿	1	0 ฿
52	Maeklong Resort	Ceiling	120,000 ฿	104,000 ฿	104,000 ฿	100	104,000 ฿	100	120,000 ฿	120,000 ฿	120,000 ฿	104,000 ฿	0.87	-16,000 ฿	1	0 ฿
53	Maeklong Resort	Restroom Tiling	160,000 ฿	153,600 ฿	153,600 ฿	100	153,600 ฿	100	160,000 ฿	160,000 ฿	160,000 ฿	153,600 ฿	0.96	-6,400 ฿	1	0 ฿
54	Maeklong Resort	Floor Finishing	250,000 ฿	268,800 ฿	268,800 ฿	80	215,040 ฿	100	250,000 ฿	312,500 ฿	303,760 ฿	206,300 ฿	0.86	-34,960 ฿	0.8	-53,760 ฿
55	Maeklong Resort	Painting	163,600 ฿	153,600 ฿	23,040 ฿	10	15,360 ฿	15	24,540 ฿	245,402 ฿	162,780 ฿	141,330 ฿	0.63	-9,180 ฿	0.67	-7,680 ฿
56	Maeklong Resort	Clearing	72,000 ฿	72,000 ฿	0 ฿	0	0 ฿	0	0 ฿	72,000 ฿	72,000 ฿	72,000 ฿	0	0 ฿	0	0 ฿
57	Maeklong Resort	Sanitary Work	655,240 ฿	640,800 ฿	480,000 ฿	68	438,600 ฿	72	480,328 ฿	701,767 ฿	682,528 ฿	595,461 ฿	0.91	-41,728 ฿	0.91	-41,400 ฿
58	Maeklong Resort	Plumbing	120,000 ฿	105,600 ฿	105,600 ฿	95	100,320 ฿	100	120,000 ฿	126,316 ฿	125,280 ฿	99,284 ฿	0.84	-19,680 ฿	0.95	-5,280 ฿
59	Maeklong Resort	Sanitary Hardware Installation	65,000 ฿	79,200 ฿	15,840 ฿	5	3,960 ฿	20	13,000 ฿	260,004 ฿	88,240 ฿	40,200 ฿	0.3	-9,040 ฿	0.25	-11,880 ฿
60	Maeklong Resort	Septic Tank Installaiton	170,240 ฿	153,600 ฿	153,600 ฿	70	107,520 ฿	90	144,000 ฿	205,715 ฿	190,080 ฿	91,886 ฿	0.75	-36,480 ฿	0.7	-46,080 ฿
61	Maeklong Resort	Electrical Work	300,000 ฿	302,400 ฿	204,960 ฿	75	226,800 ฿	68	203,328 ฿	271,105 ฿	278,928 ฿	321,980 ฿	1.12	23,472 ฿	1.11	21,840 ฿
62	Maeklong Resort	Electrical Work	300,000 ฿	302,400 ฿	204,960 ฿	75	226,800 ฿	68	203,328 ฿	271,105 ฿	278,928 ฿	321,980 ฿	1.12	23,472 ฿	1.11	21,840 ฿
63	Portfolio Manager	Lenso Wheels	7,599,160 ฿	7,751,600 ฿	5,171,773 ฿	59	4,579,820 ฿	49	4,702,700 ฿	7,959,582 ฿	7,874,480 ฿	7,143,764 ฿	0.97	-122,880 ฿	0.89	-591,953 ฿
64	Lenso Wheels	Preparation Work	30,000 ฿	30,000 ฿	30,000 ฿	100	30,000 ฿	100	30,000 ฿	30,000 ฿	30,000 ฿	30,000 ฿	1	0 ฿	1	0 ฿
65	Lenso Wheels	Preparation Work	30,000 ฿	30,000 ฿	30,000 ฿	100	30,000 ฿	100	30,000 ฿	30,000 ฿	30,000 ฿	30,000 ฿	1	0 ฿	1	0 ฿
66	Lenso Wheels	Piling & Footing	100,000 ฿	100,000 ฿	100,000 ฿	90	90,000 ฿	100	100,000 ฿	111,111 ฿	110,000 ฿	88,889 ฿	0.9	-10,000 ฿	0.9	-10,000 ฿
67	Lenso Wheels	Piling Test	0 ฿	0 ฿	0 ฿	100	0 ฿	100	0 ฿	0 ฿	0 ฿	0 ฿	0	0 ฿	0	0 ฿
68	Lenso Wheels	Piling Office	0 ฿	0 ฿	0 ฿	100	0 ฿	100	0 ฿	0 ฿	0 ฿	0 ฿	0	0 ฿	0	0 ฿
69	Lenso Wheels	Piling Warehouse & Loading	0 ฿	0 ฿	0 ฿	100	0 ฿	100	0 ฿	0 ฿	0 ฿	0 ฿	0	0 ฿	0	0 ฿
70	Lenso Wheels	Footing	100,000 ฿	100,000 ฿	100,000 ฿	90	90,000 ฿	100	100,000 ฿	111,111 ฿	110,000 ฿	88,889 ฿	0.9	-10,000 ฿	0.9	-10,000 ฿

	Project	Task	Cost	Baseline	BCWS	Physical %	BCWP	%Co	ACWP	EAC (rea	EAC (bes	EAC (wor	CPI	CV	SPI	SV
71	Lenso Wheels	Office Structure Work	1,768,800 ฿	1,691,000 ฿	1,462,440 ฿	71	1,201,620 ฿	63	1,435,900 ฿	2,020,695 ฿	1,925,280 ฿	1,379,328 ฿	0.84	-234,280 ฿	0.82	-260,820 ฿
72	Lenso Wheels	1st Flr. Beam, Slab & Column	350,000 ฿	350,000 ฿	350,000 ฿	80	280,000 ฿	100	350,000 ฿	437,500 ฿	420,000 ฿	262,500 ฿	0.8	-70,000 ฿	0.8	-70,000 ฿
73	Lenso Wheels	Mezzanine Beam, Slab & Column	300,000 ฿	317,600 ฿	317,600 ฿	80	254,080 ฿	100	300,000 ฿	375,000 ฿	363,520 ฿	242,600 ฿	0.85	-45,920 ฿	0.8	-63,520 ฿
74	Lenso Wheels	2nd Flr. Beam, Slab & Column	485,000 ฿	485,000 ฿	485,000 ฿	90	436,500 ฿	100	485,000 ฿	538,889 ฿	533,500 ฿	431,111 ฿	0.9	-48,500 ฿	0.9	-48,500 ฿
75	Lenso Wheels	Roof	187,920 ฿	180,000 ฿	81,000 ฿	10	18,000 ฿	45	81,000 ฿	810,007 ฿	243,000 ฿	-103,500 ฿	0.22	-63,000 ฿	0.22	-63,000 ฿
76	Lenso Wheels	Lift	150,680 ฿	63,200 ฿	28,440 ฿	20	12,640 ฿	30	19,500 ฿	97,501 ฿	70,060 ฿	38,825 ฿	0.65	-6,860 ฿	0.44	-15,800 ฿
77	Lenso Wheels	Stair	94,800 ฿	94,800 ฿	0 ฿	0	0 ฿	0	0 ฿	94,800 ฿	94,800 ฿	94,800 ฿	0	0 ฿	0	0 ฿
78	Lenso Wheels	Underground Tank	200,400 ฿	200,400 ฿	200,400 ฿	100	200,400 ฿	100	200,400 ฿	200,400 ฿	200,400 ฿	200,400 ฿	1	0 ฿	1	0 ฿
79	Lenso Wheels	Warehouse Structural Work	3,558,560 ฿	3,788,800 ฿	3,442,533 ฿	84	3,189,800 ฿	79	3,000,000 ฿	3,563,362 ฿	3,599,000 ฿	3,551,105 ฿	1.06	189,800 ฿	0.93	-252,733 ฿
80	Lenso Wheels	1st Flr. Beam	103,600 ฿	80,000 ฿	80,000 ฿	100	80,000 ฿	90	90,000 ฿	90,000 ฿	90,000 ฿	80,000 ฿	0.89	-10,000 ฿	1	0 ฿
81	Lenso Wheels	Column	110,800 ฿	120,000 ฿	120,000 ฿	100	120,000 ฿	70	70,000 ฿	70,000 ฿	70,000 ฿	120,000 ฿	1.71	50,000 ฿	1	0 ฿
82	Lenso Wheels	2nd & 3rd Flr. Beam	114,560 ฿	84,000 ฿	84,000 ฿	100	84,000 ฿	80	64,000 ฿	64,000 ฿	64,000 ฿	84,000 ฿	1.31	20,000 ฿	1	0 ฿
83	Lenso Wheels	Flat Slab	1,800,000 ฿	2,100,000 ฿	2,100,000 ฿	90	1,890,000 ฿	100	1,800,000 ฿	2,000,000 ฿	2,010,000 ฿	1,900,000 ฿	1.05	90,000 ฿	0.9	-210,000 ฿
84	Lenso Wheels	Retaining Wall	100,000 ฿	94,800 ฿	94,800 ฿	100	94,800 ฿	100	100,000 ฿	100,000 ฿	100,000 ฿	94,800 ฿	0.95	-5,200 ฿	1	0 ฿
85	Lenso Wheels	Loading	201,600 ฿	172,000 ฿	120,400 ฿	50	86,000 ฿	40	72,000 ฿	144,000 ฿	158,000 ฿	143,200 ฿	1.19	14,000 ฿	0.71	-34,400 ฿
86	Lenso Wheels	Fabricate Roof Structure	720,000 ฿	750,000 ฿	750,000 ฿	100	750,000 ฿	100	720,000 ฿	720,000 ฿	720,000 ฿	750,000 ฿	1.04	30,000 ฿	1	0 ฿
87	Lenso Wheels	Roof Structure Installation	120,000 ฿	100,000 ฿	93,333 ฿	85	85,000 ฿	70	84,000 ฿	98,824 ฿	99,000 ฿	91,765 ฿	1.01	1,000 ฿	0.91	-8,333 ฿
88	Lenso Wheels	Siding & Ceiling Structure	288,000 ฿	288,000 ฿	0 ฿	0	0 ฿	0	0 ฿	288,000 ฿	288,000 ฿	288,000 ฿	0	0 ฿	0	0 ฿
89	Lenso Wheels	Architectural Work	2,141,800 ฿	2,141,800 ฿	136,800 ฿	3	68,400 ฿	3	136,800 ฿	4,283,600 ฿	2,210,200 ฿	2,005,000 ฿	0.5	-68,400 ฿	0.5	-68,400 ฿
90	Lenso Wheels	Roof Metal Sheet Installation	240,000 ฿	240,000 ฿	0 ฿	0	0 ฿	0	0 ฿	240,000 ฿	240,000 ฿	240,000 ฿	0	0 ฿	0	0 ฿
91	Lenso Wheels	Siding Metal Sheet Installation	160,000 ฿	160,000 ฿	0 ฿	0	0 ฿	0	0 ฿	160,000 ฿	160,000 ฿	160,000 ฿	0	0 ฿	0	0 ฿
92	Lenso Wheels	Brick Wall & Finishing	684,000 ฿	684,000 ฿	136,800 ฿	10	68,400 ฿	20	136,800 ฿	1,368,000 ฿	752,400 ฿	547,200 ฿	0.5	-68,400 ฿	0.5	-68,400 ฿
93	Lenso Wheels	Ceiling	105,000 ฿	105,000 ฿	0 ฿	0	0 ฿	0	0 ฿	105,000 ฿	105,000 ฿	105,000 ฿	0	0 ฿	0	0 ฿
94	Lenso Wheels	Floor Finishing	184,000 ฿	184,000 ฿	0 ฿	0	0 ฿	0	0 ฿	184,000 ฿	184,000 ฿	184,000 ฿	0	0 ฿	0	0 ฿
95	Lenso Wheels	Door & Window Installation	112,000 ฿	112,000 ฿	0 ฿	0	0 ฿	0	0 ฿	112,000 ฿	112,000 ฿	112,000 ฿	0	0 ฿	0	0 ฿
96	Lenso Wheels	Sanitary Hardware Installation	118,800 ฿	118,800 ฿	0 ฿	0	0 ฿	0	0 ฿	118,800 ฿	118,800 ฿	118,800 ฿	0	0 ฿	0	0 ฿
97	Lenso Wheels	Painting	266,000 ฿	266,000 ฿	0 ฿	0	0 ฿	0	0 ฿	266,000 ฿	266,000 ฿	266,000 ฿	0	0 ฿	0	0 ฿
98	Lenso Wheels	External Work	192,000 ฿	192,000 ฿	0 ฿	0	0 ฿	0	0 ฿	192,000 ฿	192,000 ฿	192,000 ฿	0	0 ฿	0	0 ฿
99	Lenso Wheels	Clearing	80,000 ฿	80,000 ฿	0 ฿	0	0 ฿	0	0 ฿	80,000 ฿	80,000 ฿	80,000 ฿	0	0 ฿	0	0 ฿

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