CHAPTER II

Theoretical Considerations

The art and science of Project Management have been around for several decades now. Their tools and techniques were created in response to the growing need for a new management style to handle the ever-more complex, sophisticated, and customised products and services systematically. Project Management can be practically applied to any size project, ranging from the building of a small bridge in a village, to the construction of skyscrapers, and the development of the highly sophisticated space programme. In this chapter, certain management tools and techniques, which are used to manage a job-shop manufacturing project, will be discussed.

2.1 Project Management

2.1.1 <u>Definition</u>

A project, as defined by the Project Management Institute (PMI), is a "temporary endeavour undertaken to create a unique product or service". It consists of several tasks and subtasks which must be achieved so as to reach the ultimate set objective. The main characteristics of these tasks are:-

i) A definite beginning and a definite end
ii) A well-defined objectives
iii) Done to achieve certain result
iv) Unique from one to another, and is non-repetative
v) Consumes time, resources, and costs

The word "Project Management", hence, can be referred to as the management of time, resources, and costs in order to promote the completion of the project activities in a timely, orderly, and economical manner, meeting or exceeding the project objectives.

2.1.2 Project Life Cycle

Because of their uniqueness, projects, by themselves, could be complex to handle due to high uncertainties involved. Therefore, in order to increase the success rate, a project could be divided into many phases for easier management and control. Each project phase is marked by one or more tangible and verifiable results, such as a completion of design, or a working prototype. At the end of each phase, a phase review is usually conducted to determine the status of the project, the justification of the project going into the next phase, and any improvement needed to be carried out. The project phases are collectively called the Project Life Cycle.

A project life cycle does not have a definite form, but varies from one business to another, depending on the nature of the project. However, they do have a couple of things in common: a definite beginning, and a definite end. An example of a project life cycle may contain phases like:

i) Conception - Goals, bidding and estimating, management/team selection

ii) Planning - Budgeting, Make-or-buy decisions, scheduling, Work Breakdown, Defined targets

iii) Implementation - Manage contracts, monitor, identification problems, re-plan, adjust targets

iv) Phase-out - Resolve operating problems, reward personnel, reassign personnel, review

The level of activities in each phase also varies from one to another, and can be represented in Figure 2.1.

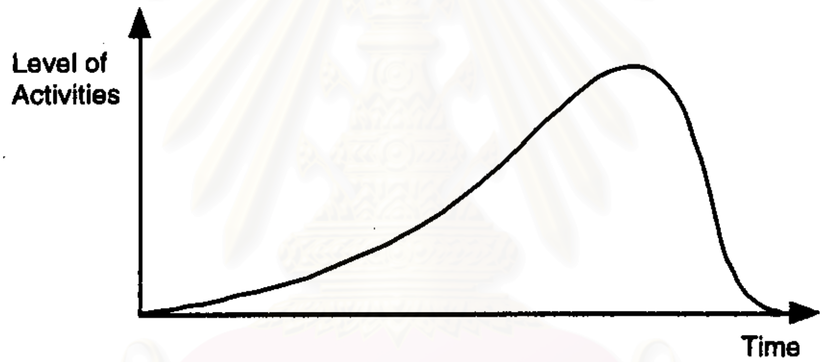


Figure 2.1: Project Life Cycle

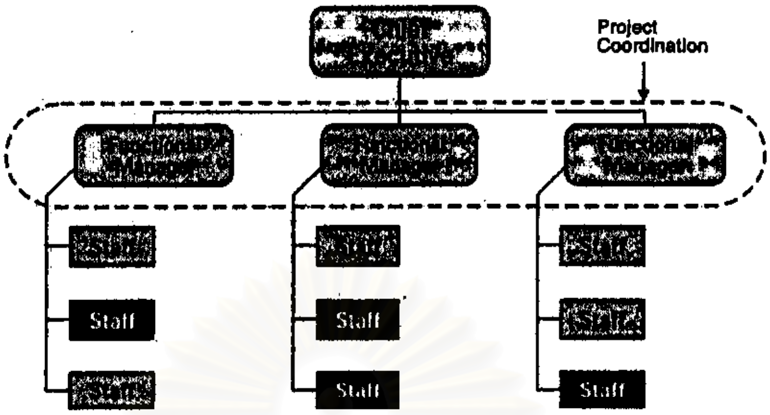
Projects are usually a part of organisation which carry out its activities. Whether it be a construction project, a product development project, or large acquisition project, the way an organisation is set up plays a crucial role in the project management and its success or failure. In certain company, its organisation could be described as functional, and seldom have any efficient and effective ways in dealing with projects. On the other hand, some company, like architectural firms, consultants, and construction contractors, operates their businesses solely by projects, and thus, have other ways to setup their organisation. Certain project characteristics which are affected by the type of organisation is shown in Figure 2.2.

Organisation Type / Project Characteristics					
Project Manager's Authority	Little or None	Limited	Low to Moderate	Moderate to High	High to Almost
Percent of Performing Organisation's Personnel Assigned Full-Time to Project Work	Virtually None	0 - 25%	15 - 60%	50 - 95%	65 - 100%
Project Manager's Role	Part-time	Part-time	Full-time	Full-time	Full-time
Common Titles for Project Manager's Role	Project Coordinator /Project Leader	Project Coordinator /Project Leader	Project Manager/Project Officer	Project Manager/Program Manager	Project Manager/Program Manager
Project Management Administrative Staff	Part-time	Part-time	Part-time	Full-time	Full-time

Figure 2.2: Organisational Structure Influences on Projects [1]

The function organisation (see Figure 2.3), as its name suggests, are grouped according to the functions they involve with, such as marketing, production, accounting, and engineering. Each employee in a group (department, division, or section) reports directly to the immediate supervisor. And, although the functional organisation do have projects, it tends to handle the related works within the confine of each function. Since they hardly work with other function at the same level, any project-related problems must be sent up the hierarchical chain to be coordinated and solved at the departmental level before the solutions are being sent down the chain of command to the appropriate staff.

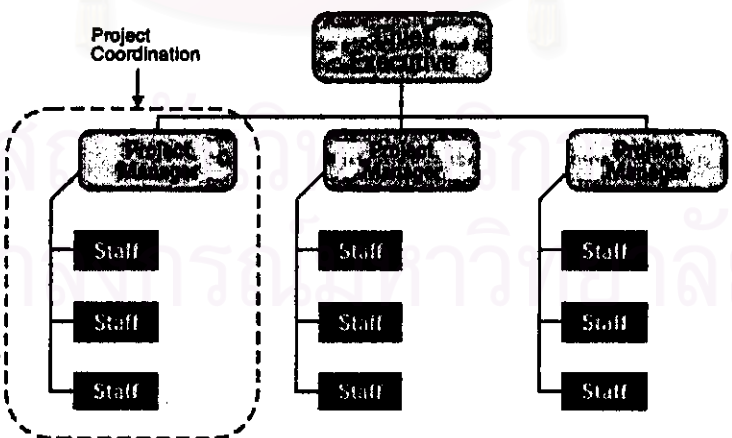
[1] A Guide to the Project Management Body of Knowledge (PA.: PMI, 1996), p. 18.



(Black boxes represent staff engaged in project activities.)

Figure 2.3: Functional Organisation[2]

On the other end, the projectised organisation does have a very strong setup for handling project works. Since their businesses are involved mainly with projects, the Project Managers in this type of organisation are very independent and do have high level of authorities. A typical organisational setup for highly projectised business is shown in Figure 2.4.

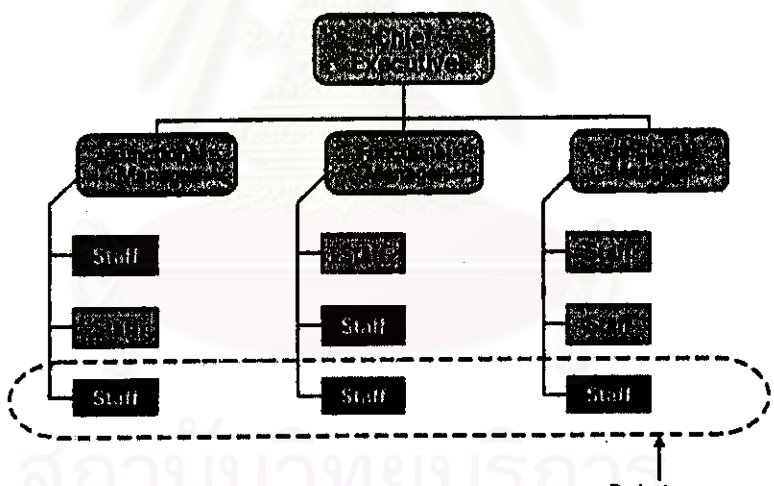


(Black boxes represent staff engaged in project activities.)

Figure 2.4: Projectised Organisation[3]

[2] Ibid., p. 19.
[3] Ibid.

If the previous 2 types of organisations represent the two extremes, the "blend" of their characteristics are displayed, with certain degree of variations, in the matrix organisation as shown in figure 2.5 - 2.7. Weak matrix organisation do possess many characteristics of the functional organisation, and thus, the Project Manager, or more correctly referred to as the Project Coordinator, still does not have that much authorities. In contrast, the Strong Matrix retains many characteristics which resemble that of a projectised organisation. Hence, the project manager with high level of authorities, together with his full-time administrative staffs, are able to cope with projects better than the other matrices counterpart.



(Black boxes represent staff engaged in project activities.)

Figure 2.5: Weak Matrix Organisation[4]

[4] Ibid., p. 21.

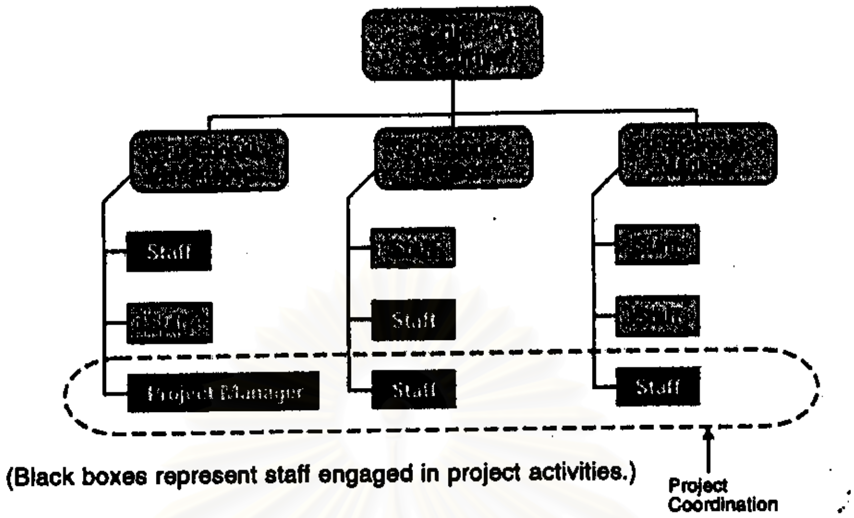


Figure 2.6: Balanced Matrix Organisation [5]

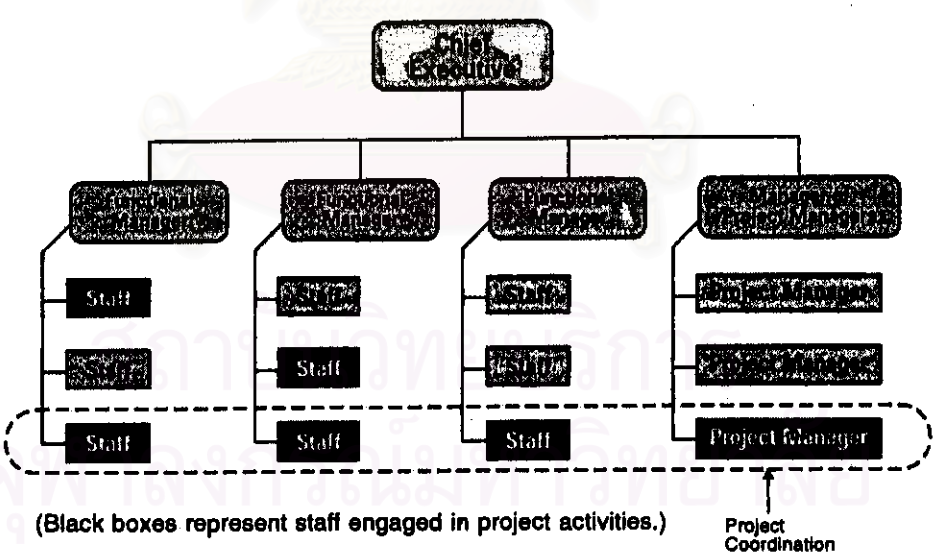


Figure 2.7: Strong Matrix Organisation [6]

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[5] Ibid.
[6] Ibid., p. 22.

The success of a project, regardless of its life cycle and organisational structure, rely a great deal, but not entirely dependent, on 3 stages of project management:

1) Project Planning
2) Project Scheduling
3) Project Controlling

2.1.4 Project Planning

Perhaps the most important of all stages in project management, project planning involves with determining what activities have to be done, and what resources are needed in order to successfully complete a project. Since it is dealing mostly with logical thoughts of how to go about in carrying out the project tasks before any actual work could begin, persons with experience and good knowledge in the field of work encompassing the project are needed in this stage. As it is said that "good planning is half the battle won".

Depending on the nature of the project, tasks that are carried out in the project planning stage may vary from one project to another. Among the more important ones is the creation of the Work Breakdown Structure (WBS). Since large projects are difficult or even impossible to be handled as one entity, the project must be systematically broken down (or decomposed) into several (usually 3 or 4) hierarchical levels of tasks. At each level, the tasks are further subdivided into even smaller activities until they are of manageable sizes for individual or department to handle without too much difficulties. These are called "work packages".

When breaking down a project into smaller tasks and subtasks, one has to do so in a logical manner so that the structure of activities are meaningful and representative of the entire project. There are 3 logical criteria which can be used to group these tasks together. These are:-

1) Function

Here the project is broken down into tasks which can be grouped by the technical skills which are required to carry them out. Figure 2.8 below shows how a WBS of a redecorating project might look like.

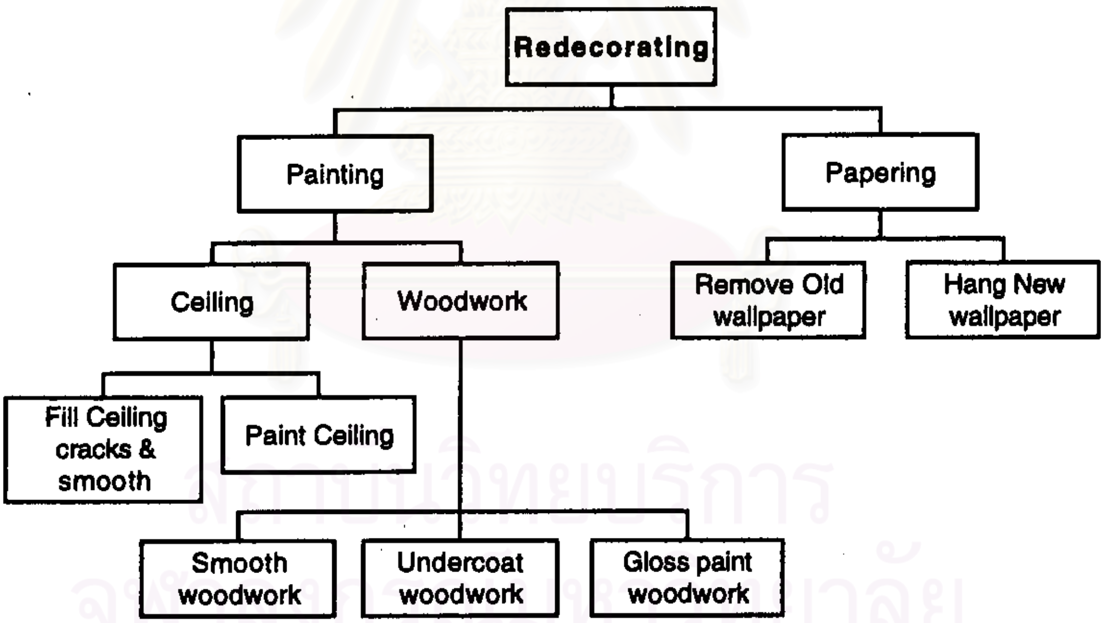

Figure 2.8: WBS by Functions[7]

[7] Project Planning, Management and Control, Warwick, 1997.

2) Time Phase

Another way to decompose a project is to group the tasks according to time phase or process structure needed to complete it. The phases given by the project life cycle falls into this category. Figure 2.9 illustrates an example of this type of WBS.

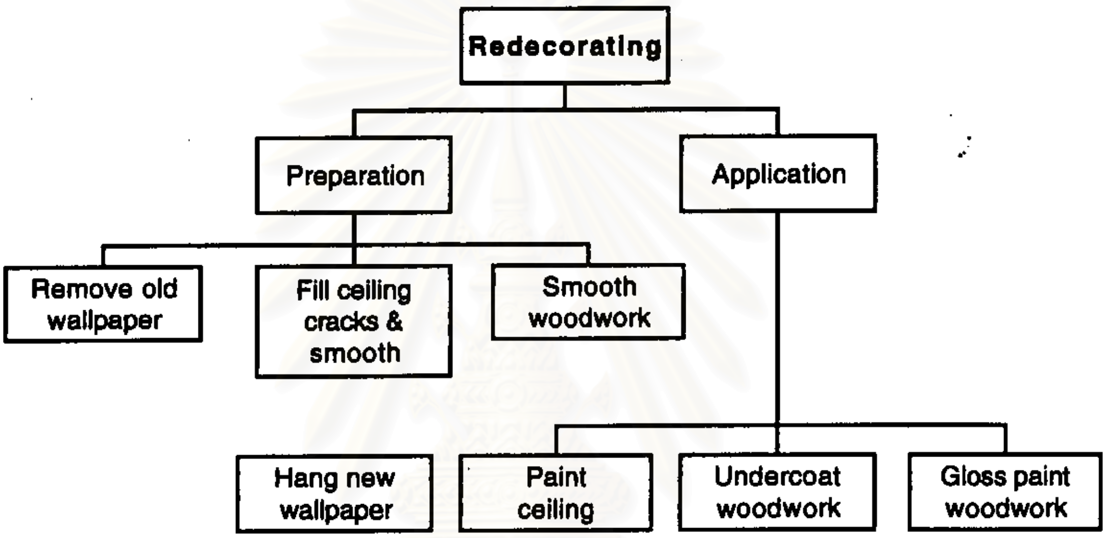

Figure 2.9: WBS by Phase [8]

3) Product Structure

Although this criteria breaks down a project based on the structure of the final product or work, it should not be confused with the breaking down of a product into Bill of Materials (BoMs). Figure 2.10 shows that the tasks and subtasks of the WBS are what needed to be done to the components of the final product, as opposed to what the product is composed of.

[8] Ibid.

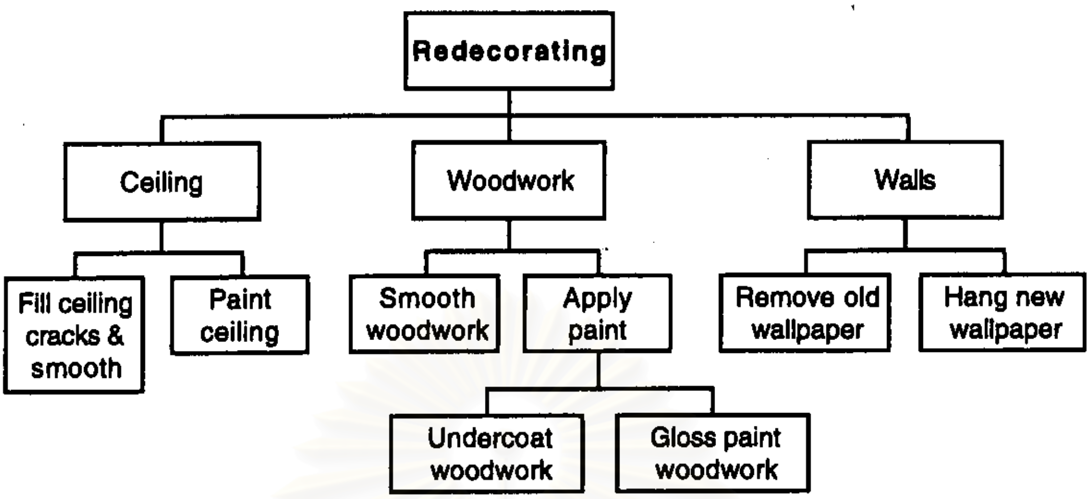

Figure 2.10: WBS by Product Structure[9]

In some cases, an organisation might not be able to choose the WBS criteria for the project on their own. Certain customers, like the US Department of Defence, do have their own preferred ways of doing things, and hence, would require the contractor to follow their methods. In any case, the WBS must be logically structured in an understandable way, so that it represents all the necessary task needed to complete the project.

2.1.5 Project Scheduling

A project plan, although very important, can not be implemented without a schedule to go with it. A schedule converts the project plan into an operating timetable for the project manager to use as a mean for monitoring and controlling project activities. In a project environment where many things are uncertain and there are problems of coordination, project schedules become even more important tool to help get things done. When allocating time slots for each project task and work packages, it is important to keep in mind that the dates and

[9] Ibid.

time do agree with that of the project master schedule, as the PM would use this as a control point for project management, and try to maintain the consistency in the project. Some of the well-known scheduling techniques are as follows:-

2.1.5.1 PERT/CPM

Perhaps the most common used technique in project scheduling, aside from the Gantt Charts, the Programme Evaluation and Review Technique (PERT), and the Critical Path Method (CPM) were both developed independently of each other in the late 1950's. The former, PERT, was codeveloped by the U.S. Navy, Booz-Allen Hamilton, and the Lockheed Corporation to plan and coordinate works among thousands of contractors who were working on the development of the Polaris submarine-launched intercontinental ballistic missile (ICBM). PERT uses a probabilistic time estimate to work out the schedule which the project would follow. The primary use of this technique has been in, but not restricted to, the area of research and development (R&D), which was its original objective. Meanwhile, E.I.duPont de Nemours and Remington-Rand teamed up to codevelop the CPM scheduling technique, using a deterministic system of best estimate time to complete a task, in an effort to help improve efficiencies, time, and costs of the company's engineering projects. While these two techniques are quite similar to each other and are often discussed as single PERT/CPM method, it should be noted that PERT strictly deals with the timing aspect of the project, while CPM can be used to control both the time and costs of project related activities. Some basic tools for these scheduling techniques are discussed below.

I) Activity-on-Arrow Diagram (AOA)

Also known as the i, j method, this is one of the earliest scheduling method developed. It uses arrows to represent project activities, and how they are related to one another (see Figure 2.11). The direction which the arrows point, customary left to right, indicate the flow of the project activities. The length of the arrows, however, does not have any relationship with the duration of activities they represent.

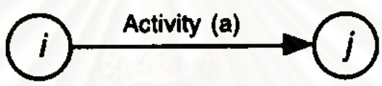

Figure 2.11: Activity-on-Arrow

Some activity may be preceded by more than one activity, all of which are required to be completed first before it is allowed to start. If the preceding activities are not linked directly with the activity, it is shown as a dummy activity, representing by a dashed arrow. Dummy activity is not an activity at all, and hence, does not have any time duration, and does not consume resources.

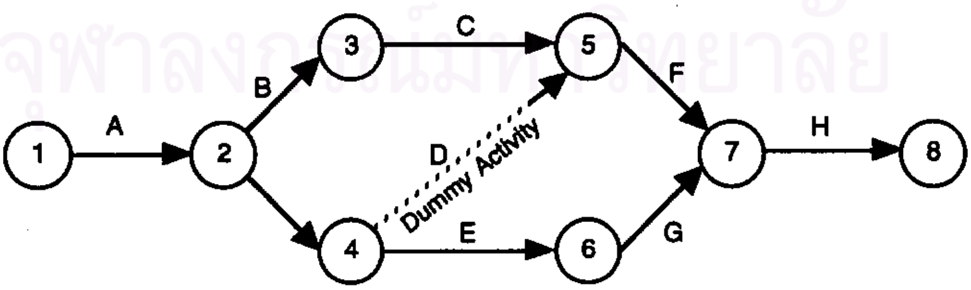

Figure 2.12: Sample AOA Network

Examples of the activities represented within Figure 2.12 may be explained as follows:-

1) Activity B & D can not start before A is completed.

2) Activity F can not start before C & D are completed.

3) Activity H can not start before F & G are completed.

II) Activity-on-Node (AON)

As opposed to indicating activities on arrows, the AON scheduling scheme puts the activities in rectangular boxes known as nodes, and link them up with arrows indicating logical dependencies each node have with respect to the other. The direction of activities flow, again, is represented by the arrow heads (see Figure 2.13).

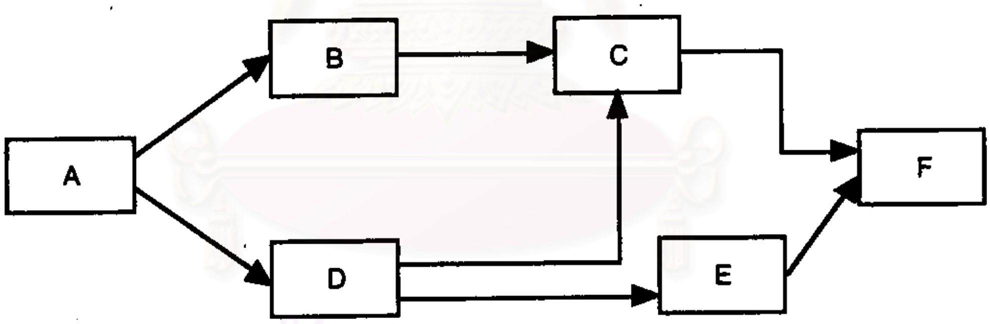

Figure 2.13: Activity-on-Nodes

The advantages of AON over AOA are that, first of all, there is no more need for dummy activities as each activities are now represented by the nodes. Secondly, it is easier and more natural to learn and practice this technique as all the required activities are drawn out first, and arrows indicating dependencies could join the nodes up later. This makes the AON method a much more efficient way to sequence the activities.

2.1.5.2 Precedence Diagramming Technique

The further development of the AON in the mid 1960's yielded a variant called the Precedence Diagramming Method (PDM). This technique has proven to be very popular for software publishers to develop upon, as it is easier to code and the PDM allows easy manipulation of graphics on the computer screen. Although it relies heavily on the AON technique, the PDM takes it a few steps further to cover more possible working scenarios. Unlike the AOA and AON which only have a finish-to-start relationship between the two adjacent activities, the PDM has four precedence relationships:

1) Finish-to-Start (FS) - This is the same relationship used in the AOA and AON technique, which puts a constrain on the successor activities that they can not start until their preceding activities have been completed. This, undoubtedly, is the most commonly used technique among the four relationships.

2) Start-to-Start (SS) - When an activity can not begin until its preceding activity has started, they are said to have a Start-to-Start relationship.

3) Finish-to-Finish (FF) - By the same token, if an activity can not be considered completed until its preceding activity has been finished, the two activities are said to have a Finish-to-Finish relationship.

4) Start-to-Finish (SF) - The least and rarest used of the four is the Start-to-Finish relationships. It restricts an activity from being completed until the preceding activity has started.

Figure 2.14 illustrate all four basic precedence relationships and the differences between them.

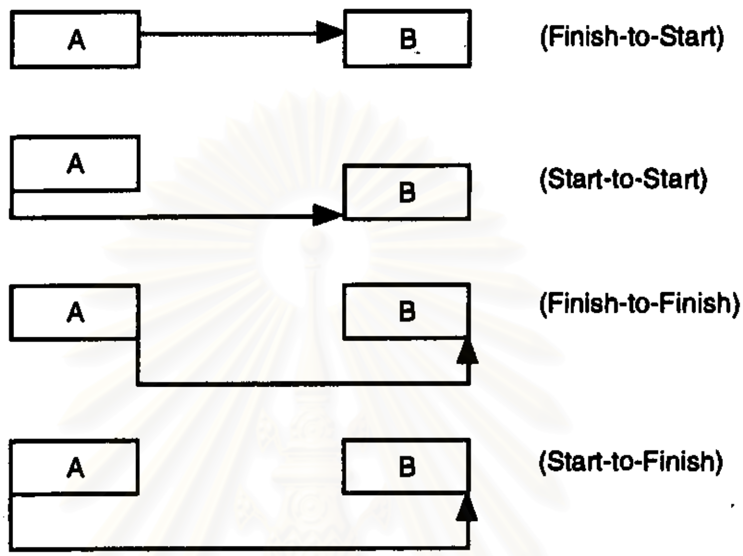

Figure 2.14: The Precedence Relationships

Since activities in each of the four precedence diagrams above are allowed to overlap, a lead-lag factor must also be taken into account when using PDM. The Project Management Institute (PMI) has given definitions for Lead and Lag to be:

Lead - A modification of a logical relationship which allows an acceleration of the successor task.

Lag - A modification of a logical relationship which directs a delay in the successor task.

The concept of lead and lag, when applied to the precedence relationship will look like Figure 2.15 below.

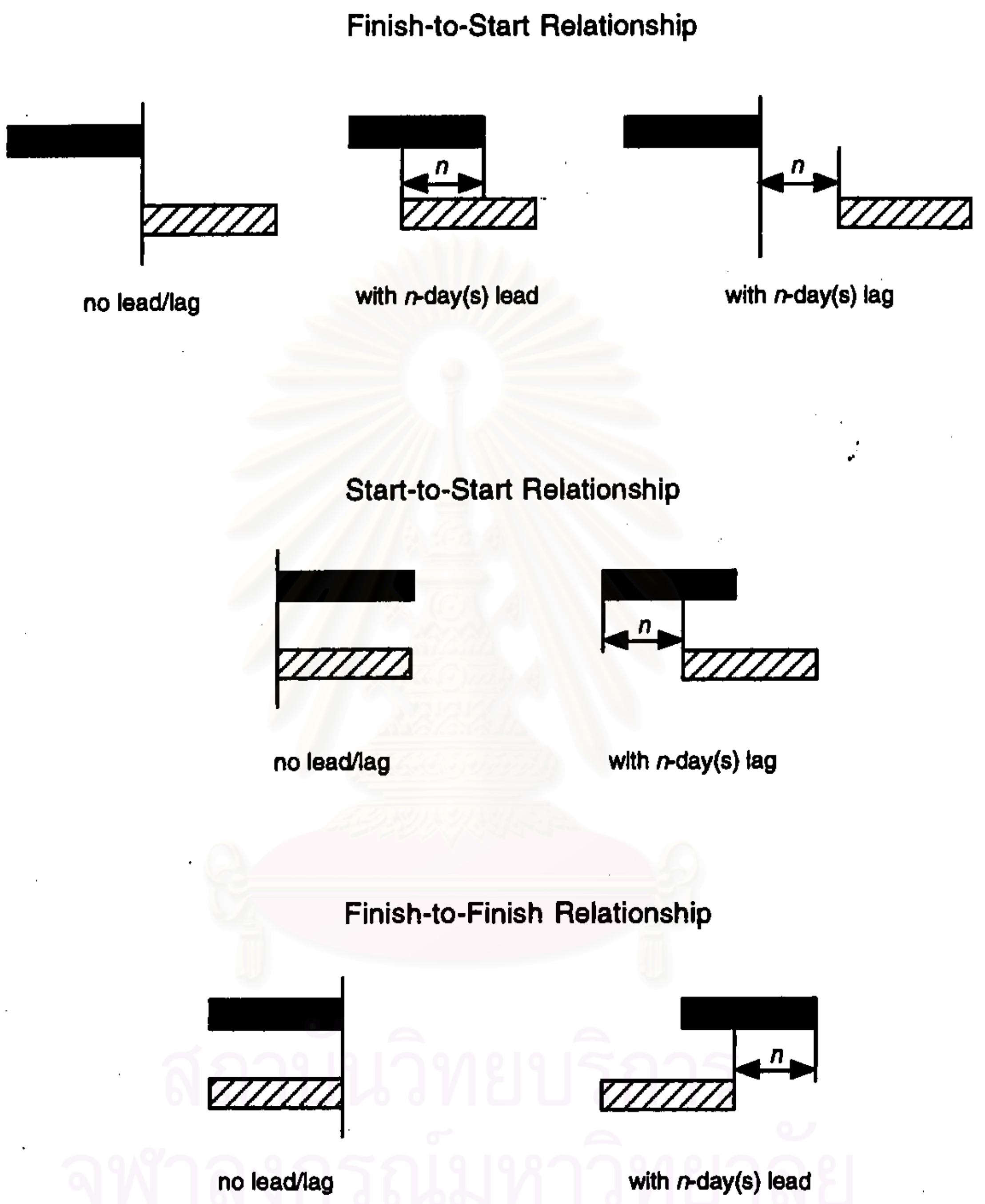

Figure 2.15: Dependency Relationships

As the length of time of the tasks in each level of activities are different from one, there are usually "spare time" or "float" left between the end of one activity and the beginning of the next one. Because some tasks have to wait for others to finish before it can begin, the "spare time" left could be used by the project manager to manipulate the project schedule for best result. PMI has defined a "float" to be "the amount of time that an activity may be delayed from its early start without delaying the project finish date". Also, a "free float" was defined as "the amount of time an activity can be delayed without delaying the early start of any immediate following activities".

Each node in the PDM may consist of several useful information on the activity it represents. The British Standard Activity Box is one of the many styles that can be used to describe a node (see Figure 2.16)

<table>
<tr><td>Earliest
Start</td><td>Duration</td><td>Earliest
Finish</td></tr>
<tr><td colspan="3">Activity Number
Activity Description
Resource</td></tr>
<tr><td>Latest
Start</td><td>Total Float</td><td>Latest
Finish</td></tr>
</table>

Figure 2.16: The British Standard Activity Box [10]

[10] Ibid.

2.1.5.3 Gantt Charts

Developed around 1917 by Henry L. Gantt, this is one of the oldest, most frequently used, and easy to understand way of presenting project schedule data. The gantt chart display the planned and actual progress of project tasks against a horizontal time scale. As such, the current status of each task can be easily read from it. Provided the task requirements are not frequently changed, or greatly altered from its original setup, the gantt chart has proven to be very easy to update and maintained by an individual. Figure 2.17 shows an example of a gantt chart, and the type of information it might contain.

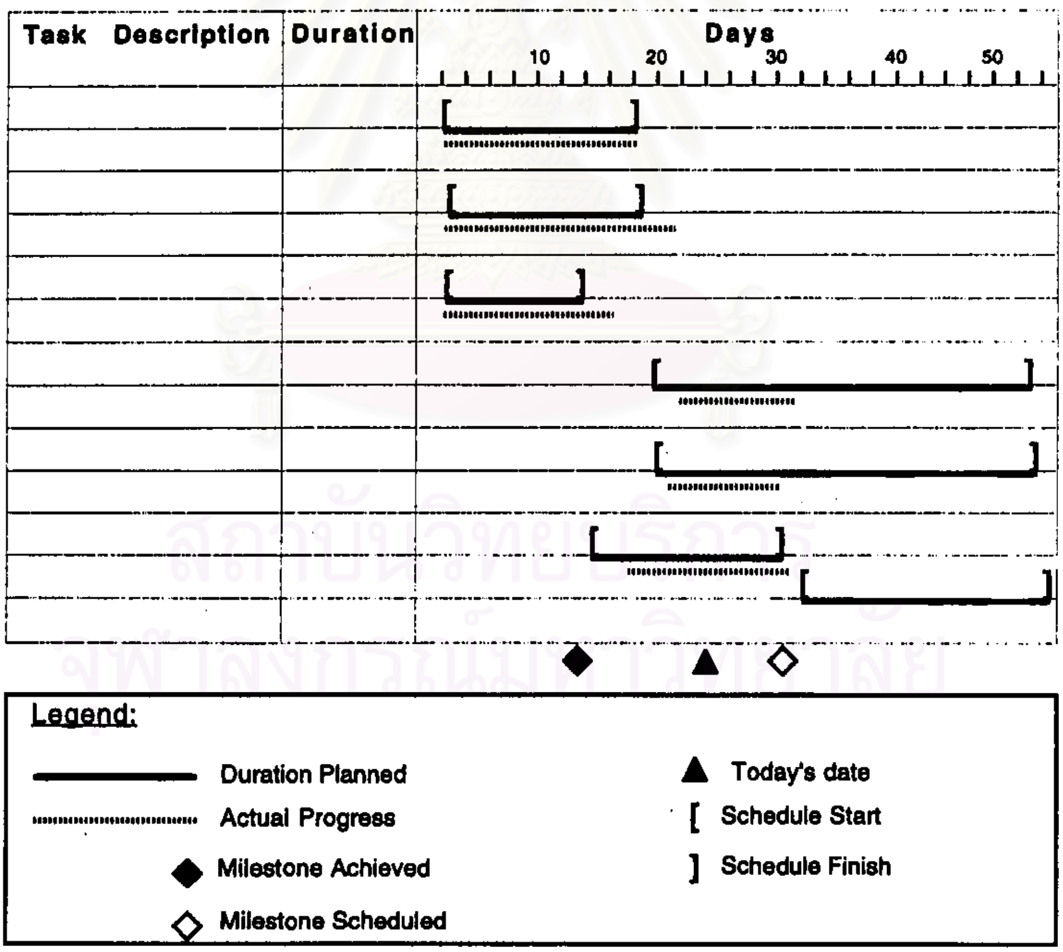

Figure 2.17: Sample Gantt Chart

2.1.6 Project Control

Project management would not be project management without its controlling aspects. In order to ensure, or at least increase the possibilities, that the project would be successfully executed and achieve its set objectives, its related tasks must be closely controlled. By doing so, problems that could result in the delays of the project could be detected, rectified, and prevented from happening again. Four steps to controlling a project are:

1) Monitoring

Monitoring is to continuously and systematically checking on the project performance. Data from the performed tasks are gathered and reported to the appropriate authority, usually the project manager, for further evaluation. The comparison between the original plan and the actual progress, for example, can be noted in the report.

2) Assessment

From the report on the project performance, assessment must be made to determine the impacts on the project schedule and costs which are resulted by the changes detected in the monitoring stage. In case a variation from the original plan is found in the project schedule, a revision of same must be made in order to see the total effect of the changes in the activities, and necessary correction could be implemented.

3) Resolving

Before trying to resolve the project problems, it is important to find out as much information as possible: which activities have been delay?, how many days would the project be delayed if the problems are not solved?, what caused the delay? what need to be done to put the project back on track?, etc.. Different question requires different measures to resolve. Severe problems, especially the one occurring near the project deadline, requires a more drastic measure to correct, while similar problem occurring in the beginning of the project might be dealt with using a more regular way. However, it should be noted that good project management does not only mean on-time delivery, but the cost of the project must be justifiable as well. Hence, one should not get carried away trying to rectify the schedule problems, and forgetting all about the cost-effectiveness of the project.

4) Communicating

The last, but not at all less important, stage of the control system is the communication stage. Because every project is a team effort, and not an individual quest for success, after having monitored, assessed, and resolved the project problems, it is vital that the findings are made known to all the parties concerned, for example the management, suppliers, subcontractors, and other project team members. Information can be transferred in forms of meetings, reports, memorandum, etc. In doing so, it creates the sense of awareness in all that involve in the project, making it possible to rectify and prevent the same problem from reoccurring.

2.1.6.1 Schedule Control

The control of project schedule requires a system to keep track of the changes made. This includes the paperwork, job tracking systems, and approval system. A gantt chart can be used to show the changes in the schedule for a manual tracking system.

However, for handling of greater information loads, a computerised project management information system would make a more efficient tracking and controlling tool.

2.1.6.2 Costs Control

Cost control is concerned with the factors which cause the variations from the budget allocated for the project, and how to manage them. It includes:

1) Monitoring the cost variance from plan
2) Recording of appropriate changes occurred
3) Prevent inappropriate and incorrect cost changes from being included
4) Inform proper authorities

Information gathered from the monitoring process can be used to evaluate the project performance using the following tools:

1) Variance Analysis

This involves a straight forward calculation of how much the actual costs have deviated from the budget.

$$\text{Cost variance} = \text{Estimated cost} - \text{Actual cost}$$

$$\%\ \text{Cost variance} = \frac{\text{Estimated cost} - \text{Actual cost}}{\text{Estimated Cost}} \times 100$$

A positive cost variance indicate underspending, while a negative cost variance means overspending of the budget.

2) Earned Value Analysis

As variance analysis tells very little about the project except whether the project is underspending or overspending its budget, another more informative technique is used to show both schedule and cost performance of the project. The earned value analysis relies on 3 factors for its calculations:

1) Budgeted Cost of Work Scheduled (BCWS) - This is the amount of money budgeted for the work which have been scheduled to be finished, plus the amount apportioned to the work in progress as of a specific date.

2) Budgeted Cost of Work Performed (BCWP) - This is the amount of money which is budgeted for the work and portion of work completed within a given time period.

3) Actual Cost of Work Performed (ACWP) - This is the amount of money which has actually been spent on the work and portion of work completed within a given time period.

From these factors, the schedule and costs performance of the project can be determined using the following calculations:

$$\text{Schedule variance (SV)} = \text{BCWP} - \text{BCWS}$$

$$\text{Schedule Performance Index (SPI)} = \frac{\text{BCWP}}{\text{BCWS}}$$

If SPI < 1 => The project is ahead of the schedule.

If SPI = 1 => The project is on schedule.

If SPI > 1 => The project is behind schedule.

Cost variance (CV) = BCWP - ACWP

$$\text{Cost Performance Index (CPI)} = \frac{\text{BCWP}}{\text{ACWP}}$$

If CPI < 1 => The project is under budget.

If CPI = 1 => The project is on budget.

If CPI > 1 => The project is over budget.

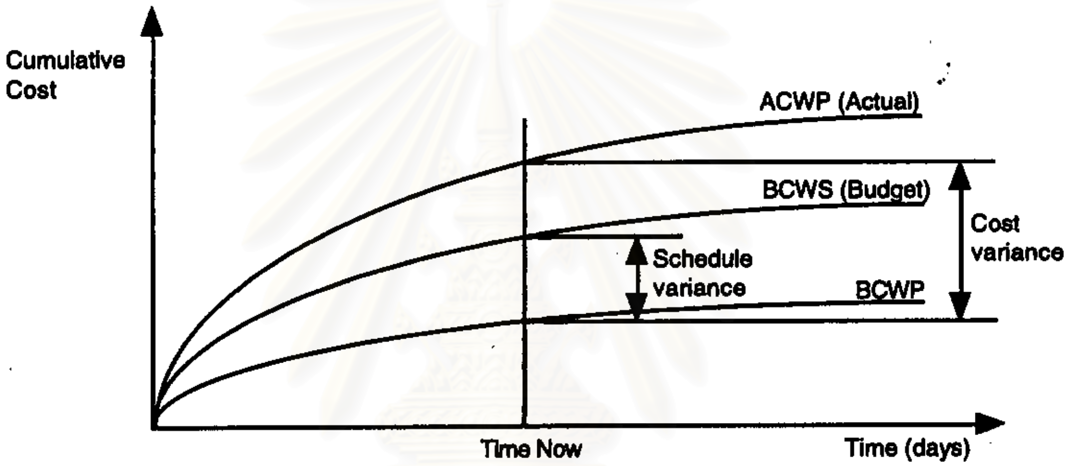

Figure 2.18: Schedule and Cost Performance from Earned Value Analysis Technique.

Earned value analysis is very much dependent on the accuracy of the original budget since everything else to be determined later on is compared against it. From the mathematical point of view, over padding of the project budget would result in a good cost performance as it would likely to yield a positive cost performance. However, if this is the case, the company would be facing an even more serious problem of opportunity lost. Although accurate budget estimate is required by the earned value analysis, inaccurate figures do not invalidate it, especially when the technique is used to demonstrate the relative improvement or deterioration of the activity performance.

2.2 Production Management

If the project planning was viewed as a macro picture of the project, the production management tools, on the other hand, could be viewed as the micro picture of the same project. In a manufacturing project, certain tools and techniques of production management can be appropriately applied to the project conception, execution, and control phases.

In a Job-shop, detail planning is important because it can lead to better quality products and lower production costs. Since a job-shop project almost always requires bidding, accurate estimates, which resulted from detailed planning, is important to the company success. This is because if the bid is too high, the company could lose the project to its competitor, and if the bid is too low, the company might lose money in performing the project due to the high degree of uncertainties and changes involve associate with a job-shop project. The detail planning includes: (1) studying the project requirements from the blue prints and specifications, (2) determining which products and/or components should be made by the company and which should be bought from the outside, (3) calculating the cost of products/project, and planning for capacity required, and (4) scheduling necessary works involve in the project. A schematic diagram of this procedure is shown in the Figure 2.19.

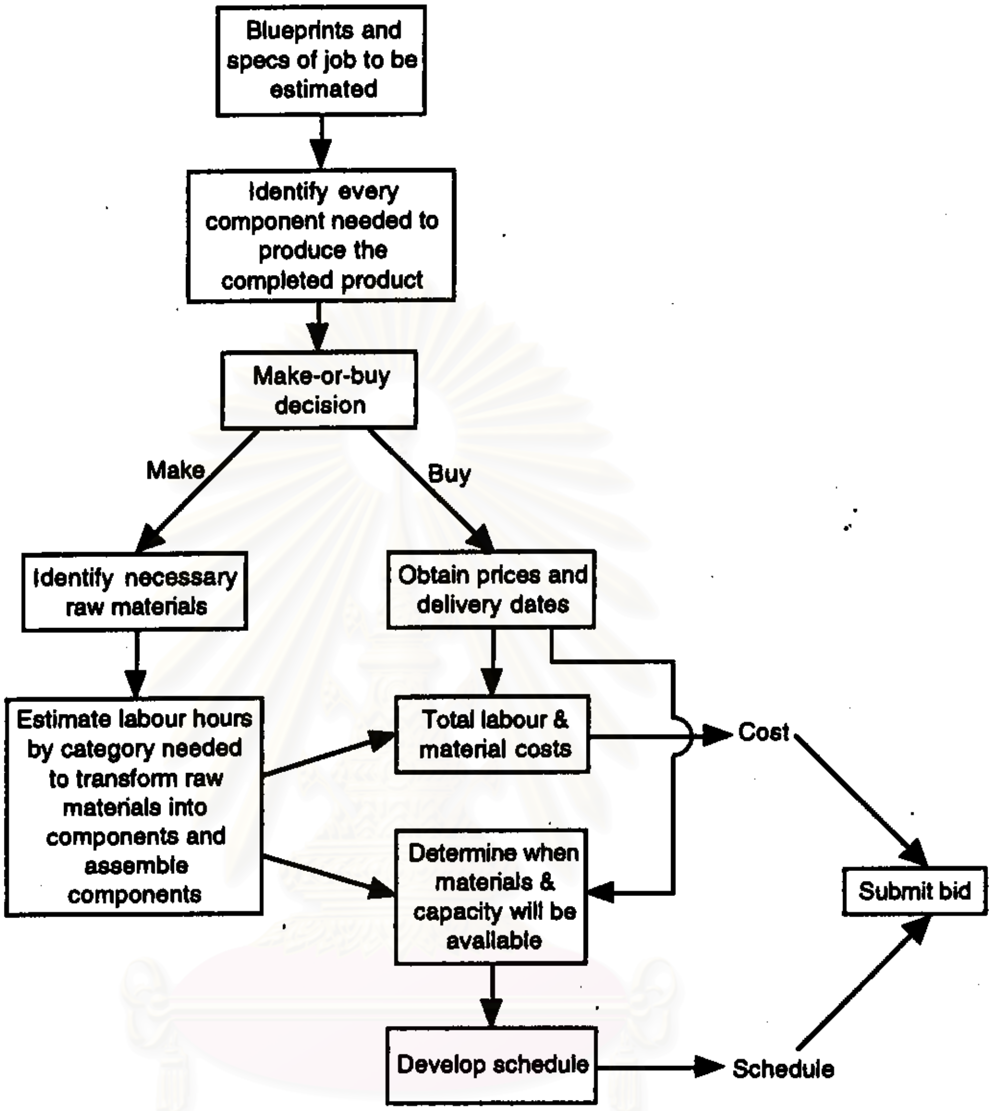

Figure 2.19: Schematic Diagram of the Pre-bid Estimating Procedure for a Job Shop [11]

2.2.1 Bill of Materials (BoM)

In the first phase of detail planning, blue prints and specifications of the products in the project are studied for engineering requirements. Just as a project can be broken down into tasks, subtasks, and work packages using any one of the WBS scheme, each product can also be broken down into assemblies, subassemblies, and components needed to fabricate it. This structured list of components is called the

[11] James B. Dilworth, Production and Operations Management (Singapore: McGraw-Hill, 1993), p. 310.

Bill of Materials (BoM). In order to enable accurate calculation of the product cost, and in turn, leading to accurate project cost, it is important that the BoMs themselves are made as accurate as possible. For a company that manufactures standard products, this is the only way to go. As for a job-shop company, whose products are rather unique, some minor errors in the BoMs might occur despite the fact that most of the major cost contributors have already been account for, due to unforeseen conditions. This is especially true for the more complicated and technically involved equipment. It is, therefore, important for everybody concerned, especially the Engineering Department, to ensure that all BoMs are made as complete as possible. An example of a BoM for a Double Sink Table is shown in Figure 2.20.

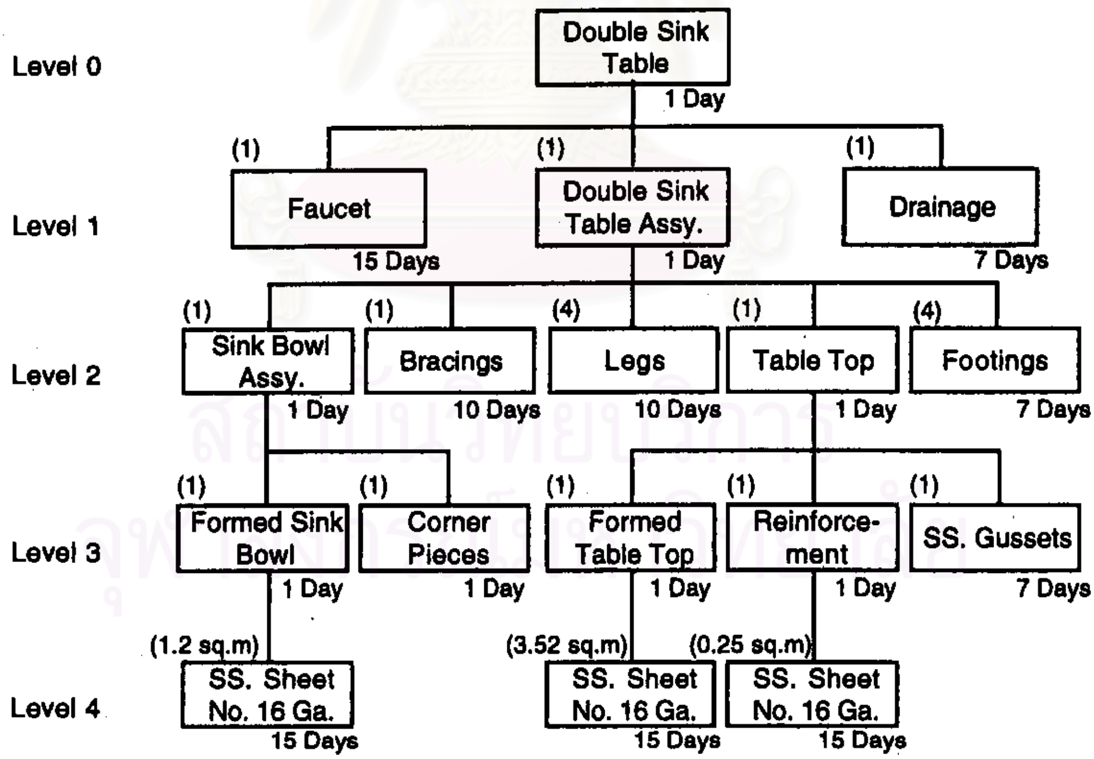

Figure 2.20: Sample Bill of Materials

In order to ease the task of the procurement, the list of material requirements can be summarised according to the types needed to make the equipment. In a project which consist of many equipment, leading to requirements for various types of materials, the net requirements for each material in the project can be obtained from these summarised BoMs (see Figure 2.21).

Bill of Materials (Summarised)					
Product: S.S. Table	Model No.: TB107000				
Direct Materials					
List	Description	Unit	Qty.	@/unit	Cost
1	Top plate: SS. 16 Ga.	sht	0.36		
2	Stiffener: SS. 16 Ga.	sht	0.14		
3	Shelf: SS. 20 Ga.	sht	0.22		
4	SS. Gusset	pc.	4		
5	Adj.Feet	pc.	4		
6	SS. rod	pc.	4		
7	Argon	inch	50		
8	SP #100	pc.	2		
9	SP #4	pc.	0.62		
10	SS. Pipe: Ø 1.5"	m.	3.42		
Direct Labour (Man-hour)					
1	Forming		6		
2	Assembly		4		
3	Finishing		2.9		
4	Installation		0		
				Total Cost	

Figure 2.21: A Summarised Bill of Materials for a stainless steel table.

2.2.2 Make-or-Buy Decisions

Although the make-or-buy decision is not a complicated thing to do when compare to other activities, such as scheduling and controlling project, however it can become strategically important for winning the bid. Depending on the customer's requirement: quality, price, or delivery time, a company could use the make-or-buy decision to offer exactly what the client needs to win the contract. Some key points that should be noted during a make-or-buy decision of products or components include:

1) Cost
2) Quality
3) Technical Involvement
4) Availability
5) Production Work Load, and Capability
6) Delivery Time

2.2.3 Cost Estimation

While the costs of the products and/or components to be bought for a project can be straightforwardly obtained from their suppliers, the costs of items which are to be manufactured by the company would have to be calculated from their cost elements.

1) Materials

The cost of materials are classified into 2 categories: direct materials and indirect materials.

i) Direct materials (DM) are the main ingredients which, when put together, make up the final product, such as sheet metals in the making of steel furniture. The cost estimation for DM can be obtained from the BoM of each products in the project.

ii) Indirect materials (IDM) are the miscellaneous materials which are used in the production of a product and not classified as direct materials. These parts often come delivered in such a way that one unit of same can be used on more than one final product. The examples of these are paints, rivets, and glue. The costs incurred by these materials are charged into the factory overheads.

2) Labour

Any contributors from the human resources, regardless of it being physical or metal effort, are included in the labour costs. Similarly, labour costs can also be classified into 2 categories:

i) Direct Labour (DL)

The direct labour constitutes all major human resources which have direct involvements in the making of the final product. The costs that incurred by their activities are considered the direct labour costs.

ii) Indirect Labour (IDL)

The rest of labour that does not fit into the direct labour category are called indirect labour. Typically, this include supervisor, managers, accounting department, and personnel department. The cost is charged into the factory as overheads.

3) Factory Overheads (FOH)

Factory overheads are the sum of indirect materials, indirect labour, plus other expenses which can not be directly attributed to any specific products. Besides the IDM and IDL, other factors which constitute the factory overheads include, rents, electric costs, and depreciation of the capital equipment. Furthermore, the factory overheads can be further categorised into: fixed costs, variable costs, and mixed (semivariable and step) costs. For simplicity of discussion relating to the project cost estimation, only the variable overhead would be discussed below.

Variable Costs

Since the variable overhead costs are very much dependent on the activities of the factory in a given period of time, it is, therefore, practically impossible to estimate them accurately with making certain assumptions. Since this type of factory overhead does often have some correlation with other costs variable, it can be estimated in form of factory overheads application rates, which can be a function of either:

1) Units of production
2) Direct Materials Cost
3) Direct Labour Cost
4) Direct Labour Hour
5) Machine Hour

Each type of overhead application rate depends on the nature of the factory, and should be chosen appropriately. The first two types of application rates (calculating by units of production, and by direct materials cost) require a definite amount of product type, and hence, is not suitable for job-shop. The application rate which bases on direct labour cost can be used if there is a direct relationship between the factory overhead costs and direct labour cost. However, it should be cautioned that if the wages within each department vary, it would make this method of calculation very difficult to calculate. Likewise, if there is a correlation between the factory overhead costs and the direct labour hour, a factory overhead application rate based on direct labour hour could be used, providing that the factory overhead costs does not compose of costs which are unrelated to the labour activities. Lastly, the FOH application rate can also be a function of machine hours used in the production. However, this would involve collecting and summarising data which would be time consuming and costly to obtain, especially if the machines are not of a fully automatic type.

2.3 Project Management Information System (PMIS)

Project management typically has a great deal of information associate with it, and to process these data manually into useful reports for effective management, decision making, and control, is practically impossible. With the invention of digital computer and subsequent development of personal computers (PCs) in the 1980's, tremendous data processing power are now available cheaply everywhere, thus, changing the face of the project management practices. Some important advantages of computerised project management include:

1. Ability to process large amount of data very quickly, so that more time can be spent on data analysing, and decision making as opposed to number crunching.
2. Ability to calculate and repeat calculations accurately every time.
3. Easy updating of project data.

4. Ability to do a "what-if" simulation rather effortlessly.
5. Ability to issue reports in various formats desired by the people concerned for easy readability and understanding.

Although a computer-based project management software have many desirable features for use in project planning tasks, it does not do everything automatically, and hence, can never replace the project manager. On the contrary, the PMIS is used to compliment the required good project management practices in making the life of the people involve with the project much more bearable. And since a computer only processes what it has been given to, the phrase "garbage in, garbage out" puts a more importance on the data gathering activities. Regardless of how many features a project management software package may offer, the quality of input data should be the primary concern in a good project management practices.