ENGINEERING PROJECT MANAGEMENT:

LOOKING FROM THE CLIENT'S & CONTRACTOR'S PERSPECTIVES

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ABSTRACT

Engineering Project Management is the most crucial factor which determines whether a project can be successfully implemented, and this paper will aim at scrutinizing factors which mount up to good Engineering Project Management. As Engineering Project Management is a wide topic, project management in a Client organization is slightly different from project management in a Contractor organization. This paper will look at their similarities and differences.

In this report, I divided Engineering Project Management into seven fundamental aspects, and described techniques and skills which, from my interviewees viewpoint and in my opinion, are suitable for ensuring that the objectives of these seven aspects can be fully met. Next, I looked into the human side of project management, a vital part in project management. From my consolidated opinions from my interviewees, I reasoned that there are six essential skills that have to be acquired by the project manager in order to perform successful project management. In the last two chapters common real-life problems encountered by Client and Contractor project managers were discussed and plausible solutions were offered to resolve the problems. As engineering project management is an evolving process, the offered solutions are not supposed to be comprehensive, but suggestions which are useful in my opinion for project managers for reference.

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PREFACE

Engineering Project Management, a subject which demands an amalgamation of high technical skills and subtle management skills. Engineering Project Management, a skill which proves to be invaluable and which requires ample experience to become good at; Engineering Project Management, a skill when not adequately or properly acquired by a project manager, can lead to devastating consequences, and the recent opening of the Chek Lap Kok Airport is one of the recent notorious example of how bad engineering project management can result.

From a reliable source, the Chek Lap Kok Airport was two years behind schedule. How can this be possible? In short, such delays do not happen overnight, but it is the result of accumulation of small numerous short delays in the Critical Path of the project. Of course the scale and complexity of the project rendered the project difficult to handle, but these are not excuses for poor engineering project management. To meet the deadline of opening the airport on 6th July 1998, since the start of 1998, the project has been accelerated in an incredible speed, and the objective was then to "meet the target opening date at all expenses". As a result the airport suffered a month of eminent international embarrassment since its opening due to its ill-equipped facilities and dysfunctional operating systems, and the damage to Hong Kong's economy, as well as its reputation,

was for sure irreparable. This clearly demonstrates how serious are the consequences of poor engineering project management (not to mention the innumerable lawsuits to follow due to damages caused by the malfunctioning airport), and it is with this in mind I produced this research project, with the aim to foster my readers' understanding in the subject and to give practical solutions to real-life problems. Surely I do not claim to have solutions to all the problems, or that my offered solutions are the best, for project management is a vast subject and is evolving continuously, yet I would only want to stress that good project management is irrefutably the key which leads to every project success.

Afterall, is project management an arts or a science? Let's try to find an answer in the report.

ACKNOWLEDGEMENT

I would like to take this opportunity to sincerely thank the Project Managers of Mass Transit Railway Corporation (MTRC), the Civil Aviation Department (CAD), Hongkong Telecom CSL (HKTCSL), and the project director of Hsin Chong Construction (Asia) Ltd. for sharing with me their valuable project management experiences and sparing their time in completing my interview questionnaires. I would also like to thank Dr. Chua Bee Ling for providing me academic material, professional advices and directions for the project, and rendering me her full support and constant encouragement during the course of the project. Last but not the least, I would like to thank my brother Bill for assisting me in drawing the diagrammatic illustrations.

CHAPTER I

INTRODUCTION

In order to understand project management, one must begin with the definition of a project. A project can be considered to be any series of activities and tasks that:

- have a specific objective to be completed within certain specifications;
- have defined start and end dates;
- have funding limits; and
- consume resources (i.e. capital, people, equipment)

The project objectives of any project can be grouped under three headings:

- **Performance & Quality** – the project specifications must be satisfied
- **Budget** – the project must be completed without exceeding the authorized expenditure;
- **Time** – actual progress must meet planned progress, and the project must be completed on or before the planned project completion date.

Project Management is the application of knowledge, skills, tools, and techniques to project activities in order to meet or exceed stakeholder needs and expectation from a project.[1] The following diagram is a pictorial representation of project management:

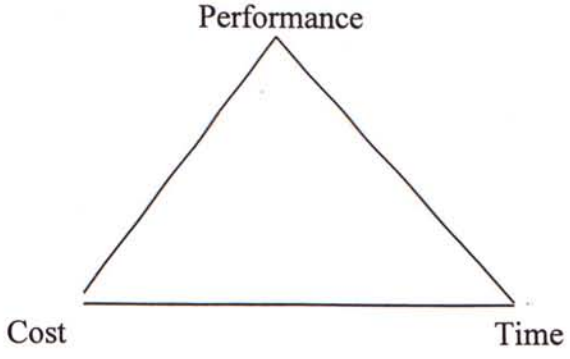

Figure 1-1. Overview of Project Management

The project management processes can be organized into main five categories:

1. **Project Definition**: defining the goal and scope of the project;
2. **Project Planning**: defining and maintaining a workable scheme to accomplish the goals and objectives of the project;
3. **Project Execution**: coordinating people and other resources to carry out the plan;
4. **Project Controlling**: ensuring that project objectives are met by monitoring and measuring progress and taking corrective action when necessary; and
5. **Project Closing**: formalizing acceptance of the project, evaluating the pros and cons of the project, and providing historical information for later project reference.

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[1] Duncan, William R. A guide to the project management body of knowledge, Project Management Institute

The following figures show how these processed inter-link with each other and their level of activity during the project life cycle:

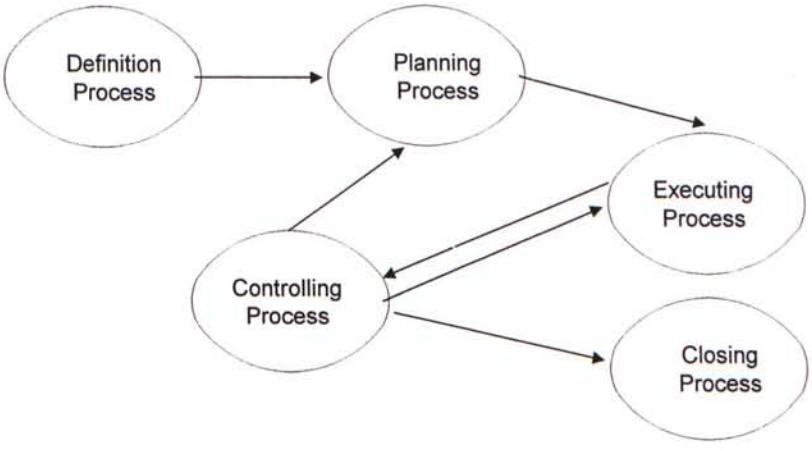


Figure 1-2 Links amongst Process Groups

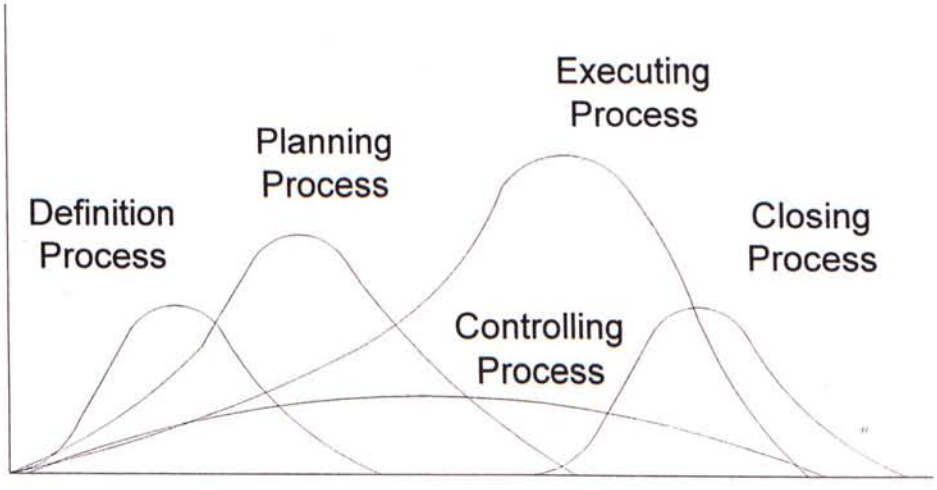


Figure 1-3. Overlap of Process Groups

From the five groups of project management processes I hereby categorized project management into seven fundamental aspects, and these aspects will be covered in detail in Chapter III.

CHAPTER II

METHODOLOGY

There are numerous literatures in the field which talks on project management. A sweep of the hand in the library shelf will probably get you a handful of project management related text books. I here thus will not attempt to replicate such academic material. I am hoping to look at it from a more practical point of view, a perspective which is not scrutinized closely by the general literature, and this is project management from a Client's viewpoint and from a Contractor's viewpoint. In this context "Client" refers to the organization which tenders out engineering projects for bidding, for example the Government is the Client in the Tsing Ma Bridge project; MTRC is the Client of the Airport Railway project, and KCRC is the Client of the West Rail project.

Chapter 3 of this report will go straight into the elements and various aspects of project management, and it will show that from a Client's perspective some of the aspects are more important whereas from a Contractor's viewpoint others will have more significance. Chapter IV will look at the human side of project management, which in fact to a very large extent determines whether a project can be successful. Chapter V will look at real-life situations and demonstrate how the theories mentioned in Chapters III and IV can apply. It will also summarize the opinions from my four interviewees, two of

them project managers working in Client organizations (MTRC & CAD) and two of them project managers working in Contractor organizations (HKTCSL & Hsin Chong). They will tell us the difficulties and problems encountered, how did they try to solve them, and from their experience what sort of issues have to pay extra attention to. Last but not the least, Chapter 6 will wrap up the lessons learnt from this research project and summarize the conclusions.

Throughout this report, I will use the materials I have read as a basis, and produce the contents with collaboration of the opinions of the four interviewed project managers, lectures from project management courses I have attended, and also my personal opinion and experience on project management. In Chapter III and IV, I will focus only on those techniques which my interviewees and I reckon are useful practically. As such, I am aiming to provide a practical but comprehensive presentation of good engineering project management practices. Attached in Appendix 1 are the invitation letters to the project managers for interviews (the one to HKTCSL was omitted as the project manager would like to be kept confidential) and Appendix 2, the actual questionnaire.

CHAPTER III

VARIOUS ASPECTS IN PROJECT MANAGEMENT

Project Management is a wide topic. Consolidating literature reviews and opinions from my interviews, I generalized project management into seven fundamental aspects, and they are:

- Project Scope Management
- Project Time Management
- Project Cost Management
- Project Quality Management
- Project Human Resources Management
- Project Communications Management
- Project Risk Management

The following sections will lead us into the details of each aspect.

Project Scope Management

Project scope management involves both project definition and project planning processes. Before starting up a project, one should evaluate if the project worths carrying out or worths bidding.

Project Evaluation

From a Client's viewpoint, this involves conducting preliminary risk analysis, preliminary feasibility studies cost/benefit analysis, break-even analysis, and evaluation on Return on Investment. From a Contractor's point of view, in addition to the above studies, it will also involve critically assessing the strength and weaknesses of other tenderers and formulating bidding strategies.

Define the Project Objectives

After confirming that the project worths carrying out (for the Client) or worths bidding (for the Contractor), a project goal shall be formulated. A project should commence with the definition of a Project Objective Statement (POS)/Project Mission Statement/Statement of Work (SOW). The SOW shall state clearly and concisely the work required for the project and defines the scope of the project. Going through the literatures, I was able to conclude that Doran's method would be a good and comprehensive approach for forming the objective statements:

Specific: be specific in targeting an objective;

Measurable: establish a measurable indicator(s) of progress

Assignable: Make the objective assignable to one person for completion

Realistic: state what can realistically be done with available resources

Time-related: state when can the objective be achieved.

Please refer to Appendix 3 for a sample SOW from the Client.

Defining the Project Scope

A Work Breakdown Structure (WBS) is a deliverable-oriented grouping of project elements that organizes and defines the total scope of the project, and the WBS is a very common tool in defining the project scope, regardless of Client or Contractor companies. The WBS is developed from the SOW and therefore work not in the WBS is outside the scope of the project. Like the SOW, the WBS is often used to develop or confirm a common understanding of project scope, and becomes the focal point for planning the project. Each descending level represents an increasingly detailed description of the project elements. The items at the lowest level of the WBS are often referred to as *work packages*. A few hints on developing a WBS:

- Break the total work down into manageable tasks;
- Ensure the structure suits how you want to manage the activities
- Ensure that the work packages are not too detailed or too general;
- Identify any project support activities.

Figures 3-1 and 3-2 illustrates typical Work Breakdown Structure frameworks:

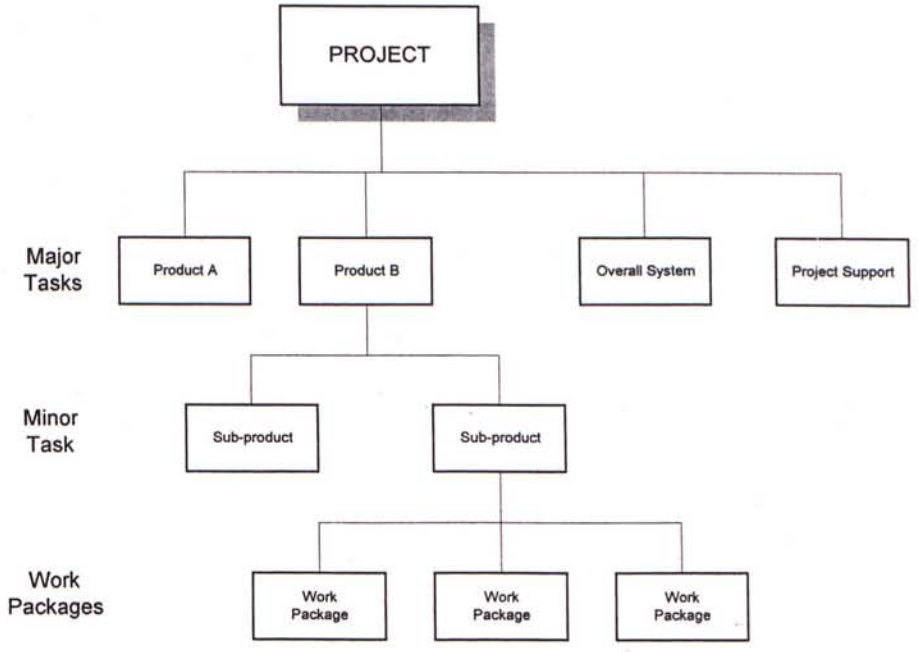


Figure 3-1. Typical Work Break Down Structure (Product Divided)

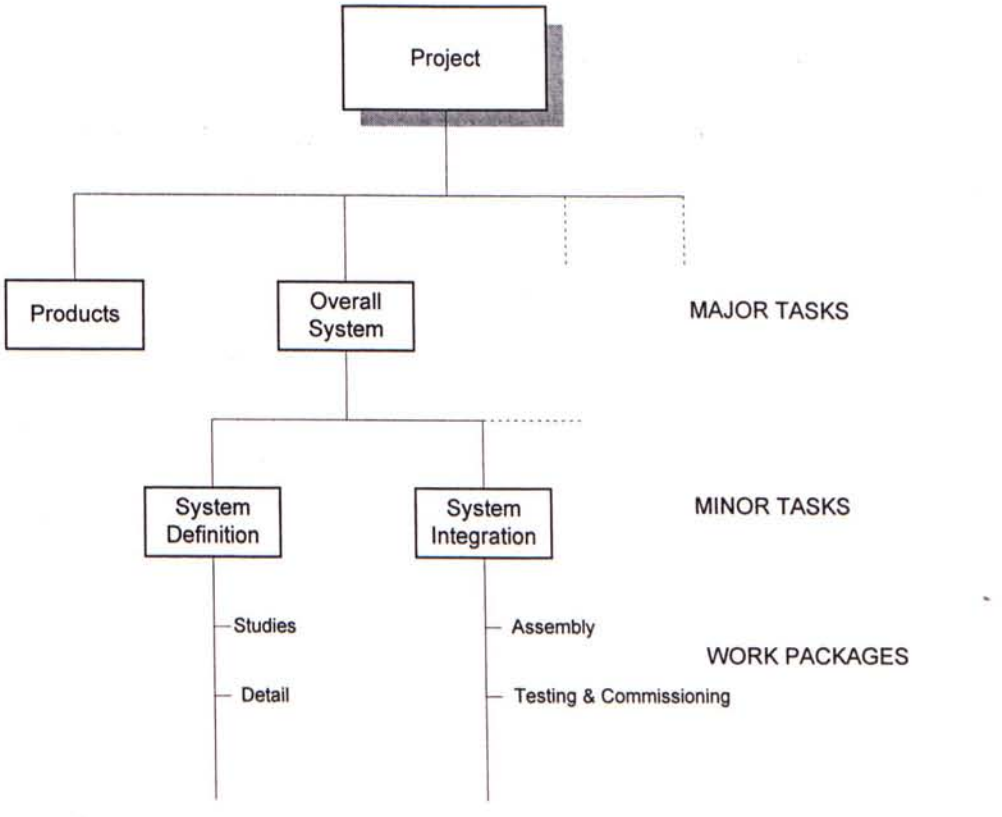


Figure 3-2. Typical Work Breakdown Structure (System Activities)

As it can be seen, the WBS can be built up by the project manager according to the nature and needs of the project. The tasks and work packages in the WBS can be broken down into categories using various approaches, e.g. by physical/functional components, by geographic location, by business functions, by departments, etc. The main theme to bear in mind is that the WBS should describe the project so that it can be managed. From the interviews, it was found that the WBS plays a much more significant role in large scale project, for example, in civil or construction projects.

Project Time Management

Project Time Management is vital in the project planning, project execution and project control processes. As projects are unique undertakings, they involve a degree of uncertainty . Client Organizations conducting projects usually divide each project into several ***project phases*** to provide better management control and appropriate links to the ongoing operations of the performing organization. Collectively, project phases are known as the ***project life*** cycle. Each project phase is marked by completion of one or more ***deliverables.*** A deliverable is a tangible , verified work product such as a feasibility study, a detailed design, or a working prototype. The deliverables, and hence the phases, are part of a generally sequential logic designed to ensure proper definition of the product of the project, and these deliverables are usually used by the Client organization as payment milestones. Figure 3-3 illustrates a typical project cycle:

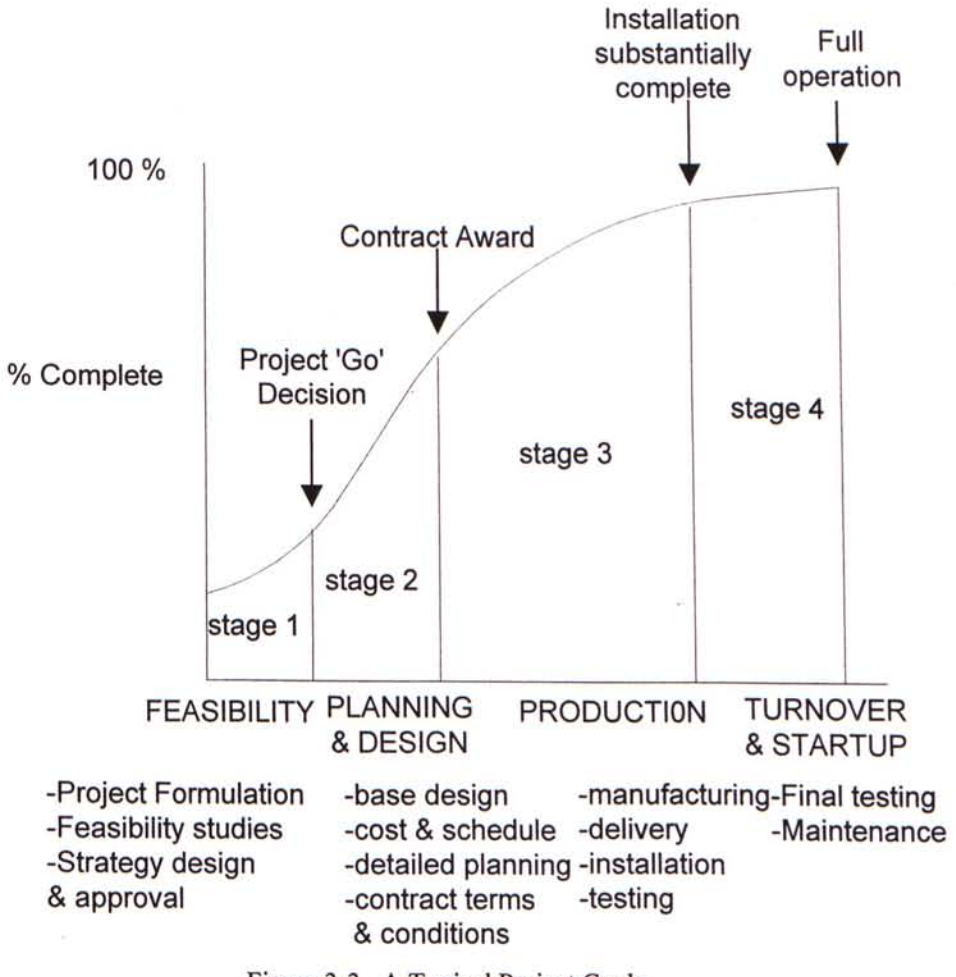


Figure 3-3. A Typical Project Cycle

Introduction to the S Curve

The S-Curve is a tool for helping us with a conceptual understanding of the project. As it can be seen from Figure 3-4 the S-Curve models progress against time. Early in the life of a project the team is forming and learning to work together (note the resemblance of *the learning curve*). Once the team has stabilized it can begin to work more effectively and the curve begins to accelerate rapidly. Towards the end of the project, work activity slows as the final touches are put on a successful project. Figure 3-5 depicts an aggressive S-curve and a common project failure S curve (which project managers should by all means avoid), in comparison with a normal S-curve.

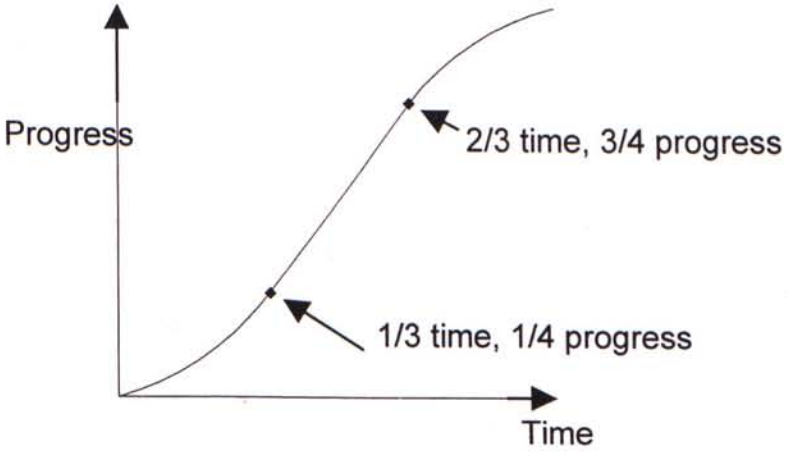


Figure 3-4. A Standard S-Curve

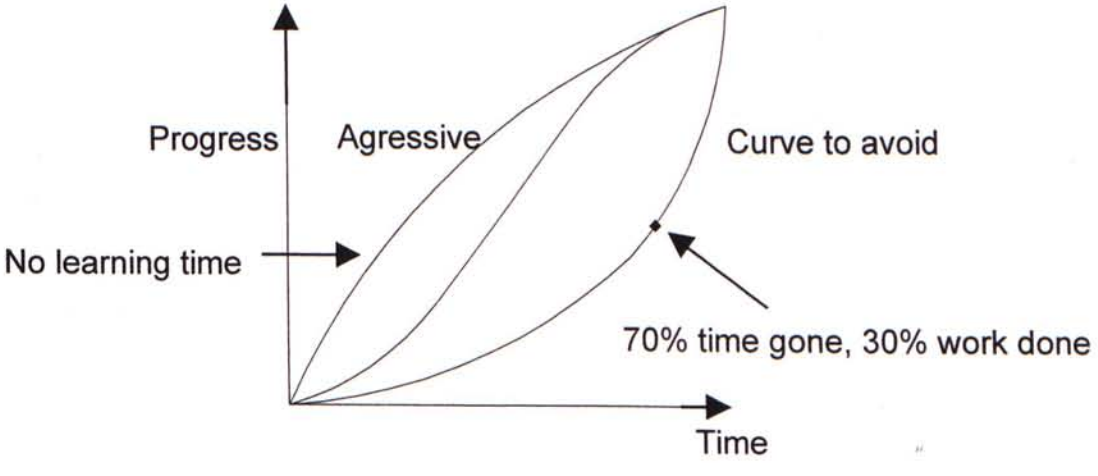


Figure 3-5. Aggressive S-Curve and the Project Failure S-Curve

The MTRC project manager uses the S-Curve to monitor the progress of the Contractor. Please refer to Appendix 4 for a detail illustration.

Planning & Scheduling with Gantt Charts

The Gantt chart is a popular tool for planning and scheduling simple projects or used in the initial planning of complex projects. It enables a project manager to initially schedule project activities and then to monitor progress over time by comparing planned progress to actual progress. The planned progress is often referred to as the *Baseline*. Figure 3-6 is an example of a Gantt chart:

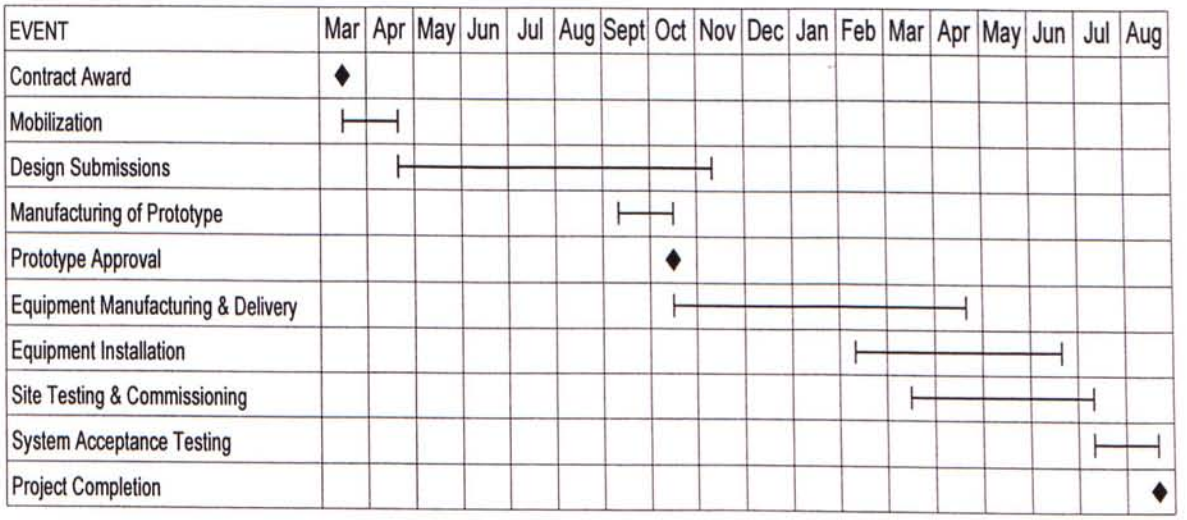


Figure 3-6. A typical Gantt Chart

Appendix 5 illustrates a Gantt Chart used by the Client and the Contractor organization.

The obvious advantage of a Gantt chart is its simplicity, and this accounts for its popularity. However, Gantt charts fail to reveal certain relationships among activities that can be crucial to effective project management, for instance whether a delay in an activity will affect the overall project schedule. For complex projects and more detail

planning, the Gantt chart gives way to the use of *networks*, and the most popular technique is the PERT or CPM.

Network Representation of a Project

A project is a sequence of interconnected activities. As such it can be represented by a diagram called a project network. There are two methods of representing the activities. The first is the Activity on the Arrow (AOA) method, where each activity is represented by an arrow and the nodes define the start and end of the activity. The second is the Activity on the Node (AON) method, and also known as the Precedence Diagramming Method (PDM), where each activity is represented by a node and the arrows represent the relationship between the activities. With the advent of the computer software packages, the AOA method lost its appeal and the AON method becomes more common. Figures 3-7 and 3-8 illustrates the AOA and AON methods, and Figure 3-9 illustrates how to transform a Gantt chart into a PERT/CPM .

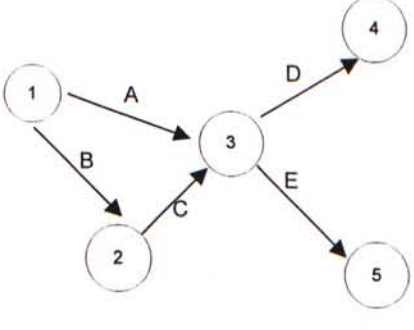


Figure 3-7. Activity On the Arrow

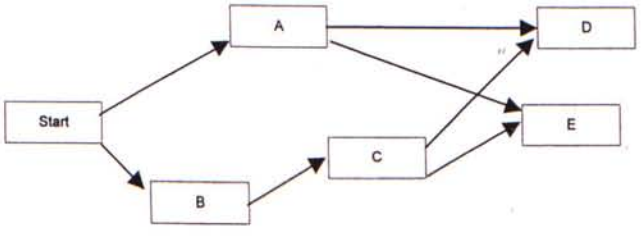


Figure 3-8. Activity On the Node

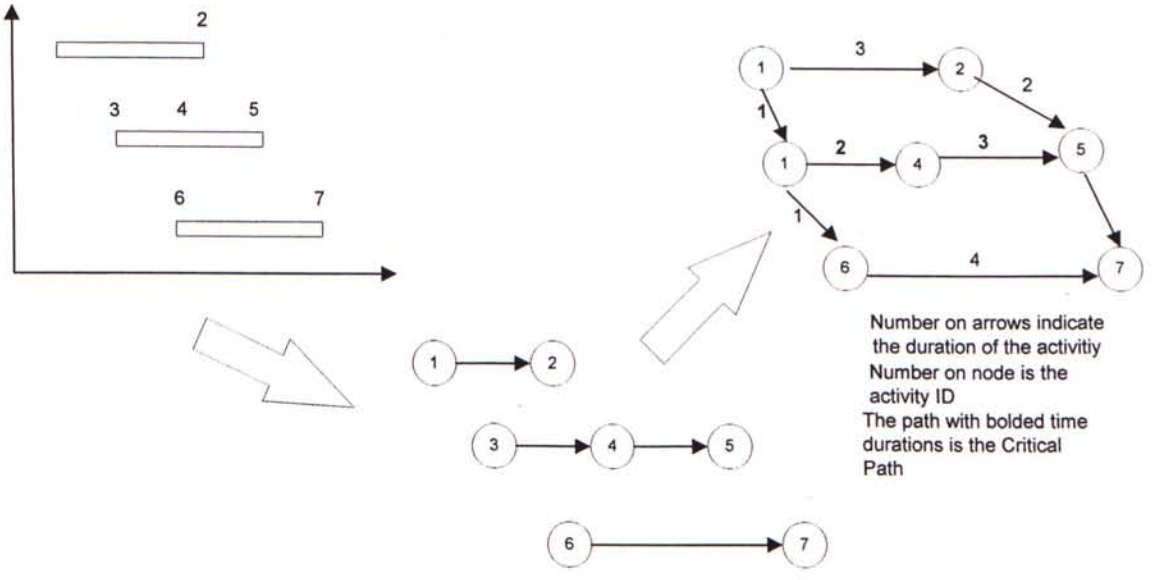


Figure 3-9. Conversion from Gantt chart to PERT/CPM

PERT and CPM

PERT (Program Evaluation and Review Technique) and CPM (Critical Path Method) allow project managers to obtain:

a) A graphical display of project activities.

b) An estimate of how long the project will take.

c) An indication of which activities are the most critical to timely project completion.

d) An indication of how long any activity can be delayed without lengthening the project.

PERT differs from CPM primarily in that it uses probabilistic activity time estimates (expected value) while CPM uses deterministic activity time estimates. The expected value in PERT is determined by the application of the following formula:

Expected Value for activity duration = (Optimistic + 4 X Most Likely + Pessimistic)

6

Figure 3-10 illustrates the rational of the PERT duration calculation:

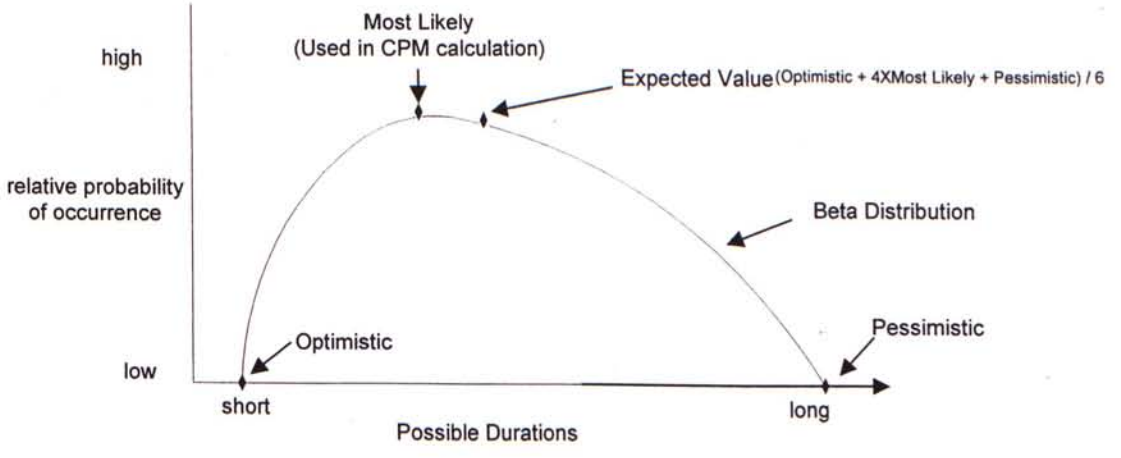
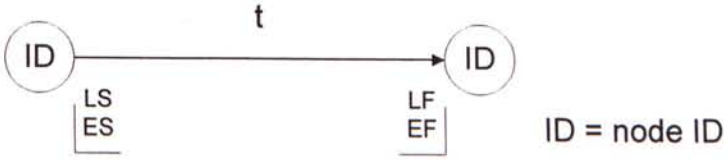


Figure 3-10. PERT Duration calculation

In practice, the CPM method is more commonly used as most activities can be estimated deterministically, and activities that are hard to estimate accurately will be done by the expected value method in PERT.

In a PERT/CPM (AOA method), the activity and its duration (t) is written on the arrow, and a *path* is formed by a sequence of activities that leads from the starting node to the finishing node. The ***critical path*** is the longest path and it determines the expected duration of the project. ***Slack*** or ***Float*** is the allowable slippage for a path; it is the difference between the length of a path and the length of the critical path. Parameters like *Early Start* (ES), *Early Finish*(EF), *Late Start*(LS) and *Late Finish* (LF) are illustrated on the PERT as follows:



Computation of these parameters are as follows:

EF = ES + t; **LS = LF - t;**

Slack = LS - ES or LF - EF

Below is an example of a PERT/CPM:

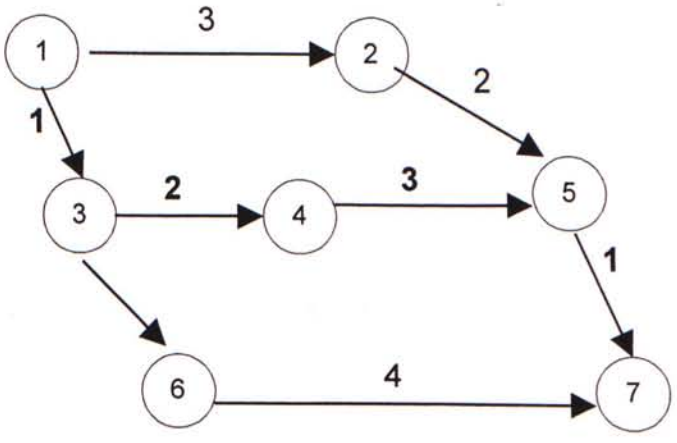


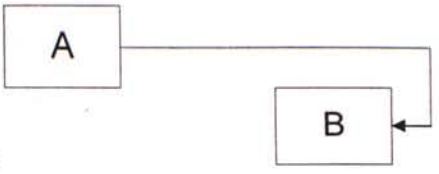
Figure 3-11. A typical PERT/CPM diagram

Precedence Diagramming Method

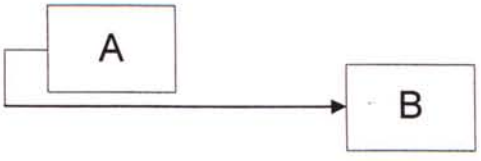
The PDM uses AON method, and has four types of activity dependencies:

FS: When A finishes, B may start;

FF: When A finishes, B may finish;

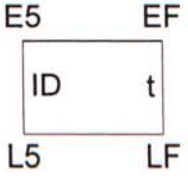


SS: When A starts, B may start;



SF: When A starts, B may finish.

An activity node is depicted thus:



The following diagram illustrates a typical PDM:

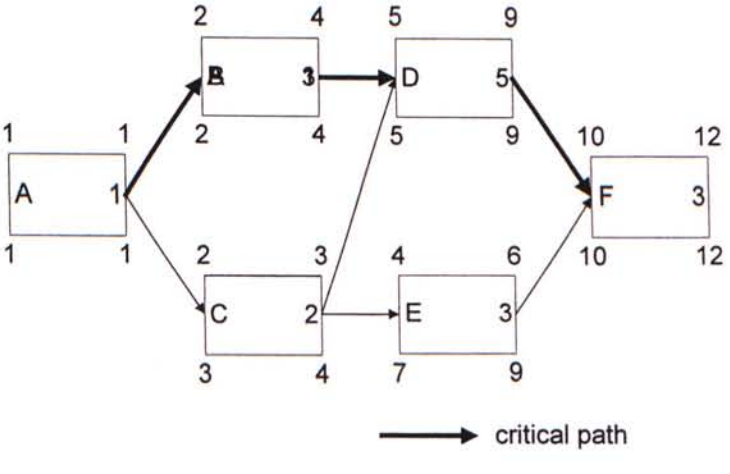


Figure 3-12. A typical PDM

Project Managers should always monitor the critical path, and if possible, move more resources from other paths to the critical path. Note that the above mentioned project planning techniques apply to both Clients and Contractors, and to summarize, the following diagrams demonstrates how to amalgamate all the above mentioned techniques to produce a hierarchy of plans.

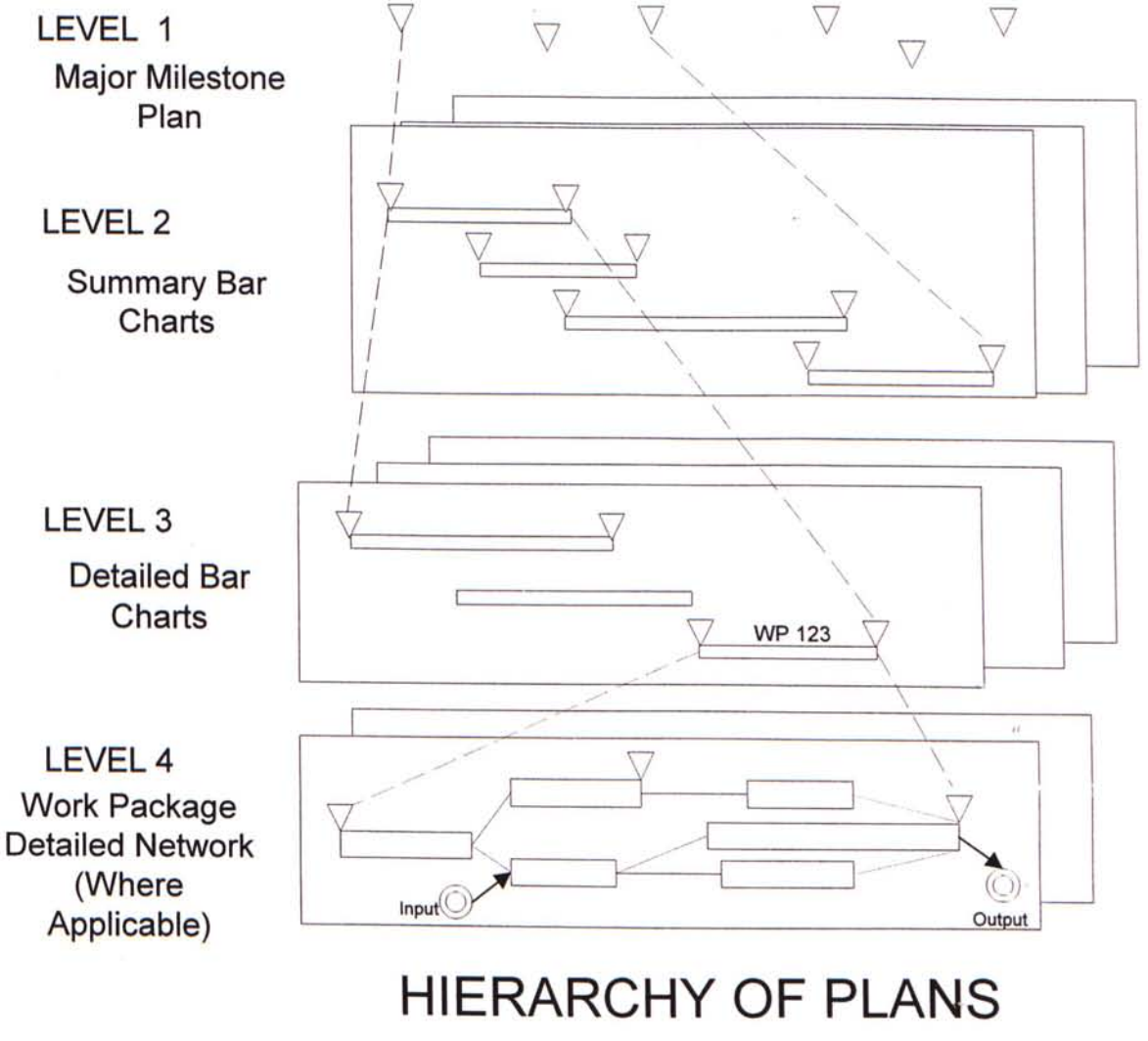


Figure 3-13. Hierarchy of Plans and Schedules

Project Cost Management

Project Cost Management plays an important role in the project planning, project execution and project control processes. It basically involves three activities: Cost Estimating , Cost Budgeting and Cost Control. For Contractors, Project Pricing is also a very important element in Project Cost Management.

Cost Estimating

Cost estimating involves developing an approximation (estimate) of the costs of the resources needed to complete the project activities. There are several techniques in Cost estimating:

1. **Analogous Estimating**: Also known as *Top-down Estimating*, involves using the actual cost of a previous, similar project as the basis for estimating the cost for the current project. It is used when there is limited detailed information and requires expert judgement. It is generally less accurate than other techniques, but it is also generally less costly.
2. **Parametric Modelling:** This involves using project characteristics (parameters) in a mathematical model to predict costs. Its accuracy will rely on the accuracy of the historical information used to develop the model and how readily quantifiable are the parameters.
3. **Grassroots/Engineering Buildup estimating**: Also known as *Bottom-up estimating*, and this technique involves estimating the cost of individual work items (by obtaining quotations, by historical database, or by expert judgment), then

summarizing or rolling up the individual estimates to get a project total. Such an approach is generally more accurate but at the time also more costly.

It should be noted that cost estimating is essential for both Clients and Contractors. For Contractors though, there is usually an extra step to work on, and that is project pricing, a business decision on how much should the product or service be charged.

Pricing Strategies for Contractors

In general, two situations prevails when one is pursuing project acquisition competitively. First, the new business opportunity may be a one-of-a-kind project with little or no follow-on potential. Second, the new business opportunity may be an entry point to a large follow-on or repeat business, or may represent a planned penetration into a new market. Contractors facing these two situations have different business objectives. The objective for the former will be to win the project and execute it profitably and satisfactorily according to contractual requirements. The objective for the latter is often to win the project and perform well, thereby gaining a foothold in a new market segment or a new customer community in place of making a profit. Accordingly, each situation has its own unique pricing strategy as summarized below:

One-of-a-kind Project:

1. Develop cost model and estimating guidelines; design proposed project/program baseline (refer to later section for cost baseline) for minimum cost to minimum customer requirements.
2. Estimate cost realistically for minimum requirements.
3. Scrub the baseline and squeeze out unnecessary costs.
4. Determine realistic minimum costs.
5. Adjust cost estimate for risks.
6. Add desired profit margins and determine the price.
7. Compare price to estimated Client's budget and competitive cost information.
8. Bid only if price is within competitive range.

Projects with Large Follow-On Business:

1. Design proposed project/program baseline compliant with customer requirements, with innovative features but minimum risks.
2. Estimate cost realistically.
3. Scrub the baseline and squeeze out unnecessary costs.
4. Determine realistic minimum cost.
5. Adjust cost estimate for risk.
6. Compare final cost estimate to estimated Client's budget and the "most likely" winning price.

7. Determine the gross profit margin necessary for winning the contract. Determine if this margin is acceptable according to the must-win desire (this margin could be negative!)
8. Depending on the strength of desire to win, bid the "most likely" winning price or lower.

Note that in competitive bidding, four elements are most crucial in determining the bidding price: the Contractor's own cost estimate, the estimated Client's budget, competitive cost information (or anticipated bidding price of competitors), and the strength of desire to win the contract.

Cost Budgeting

Cost budgeting involves allocating the overall cost estimates to individual work items in order to establish a cost baseline for measuring project performance. The ***cost baseline*** is a time-phased budget that will be used to measure and monitor cost performance on the project. It is developed in the form of an S-curve, as illustrated in the following diagram:

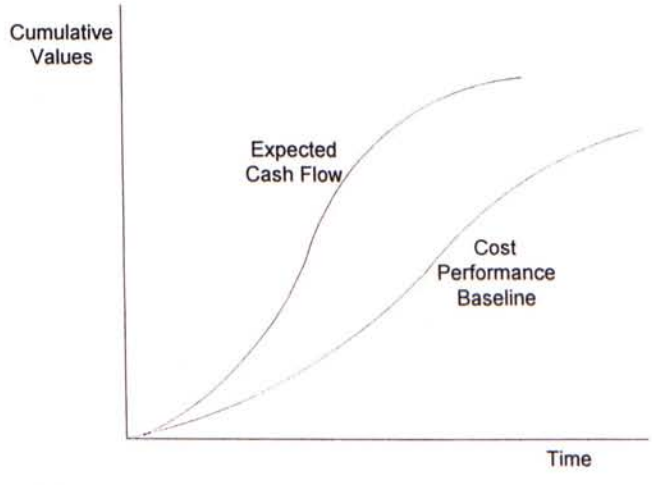


Fig. 3-14. Illustrative Cost Baseline Display

Several sub-structures are required in order to perform cost budgeting. Apparently, cost estimates are required; the work breakdown structure is also required to identify the project elements that costs will be allocated to; furthermore, the project schedule is required to order to assign costs to the time period when the cost will be incurred.

Cost Control

Cost control includes:

- monitoring cost performance to detect variances from plan;
- ensuring that all appropriate changes are recorded accurately in the cost baseline;
- preventing incorrect, inappropriate, or unauthorized changes from the being included in the cost baseline;
- informing appropriate stakeholders of authorized changes (for details please refer to Chapter 3.6, Project Communications Management)

Earned Value Analysis is the most commonly used method of cost and performance measurement. It integrates scope, cost, and schedule measures to help the project manager to assess project performance. Earned value involves calculating three key values for each activity:

- The budget, also called the ***budgeted cost of work scheduled*** **(BCWS)**, is that portion of the approved cost estimate planned to be spent on the activity during a given period;

- The actual cost, or the ***actual cost of work performed*** **(ACWP)**, is the total of direct and indirect costs incurred in accomplishing work on the activity during a given period;
- The ***earned value***, also known as the ***budgeted cost of work performed*** **(BCWP)**, is a percentage of the total budget equal to the percentage of the work actually completed. One difficulty in calculating the earned value is that the percentage complete is hard to determine. A technique, known as the 50/50 rule, is used to overcome this: *Half the budget for each element is recorded at the time that the work is scheduled to begin, and the other half at the time that the work is scheduled to be completed.* For a project with a large number of elements, the amount of distortion from such a procedure is minimal. Figure 3-15 illustrates this technique:

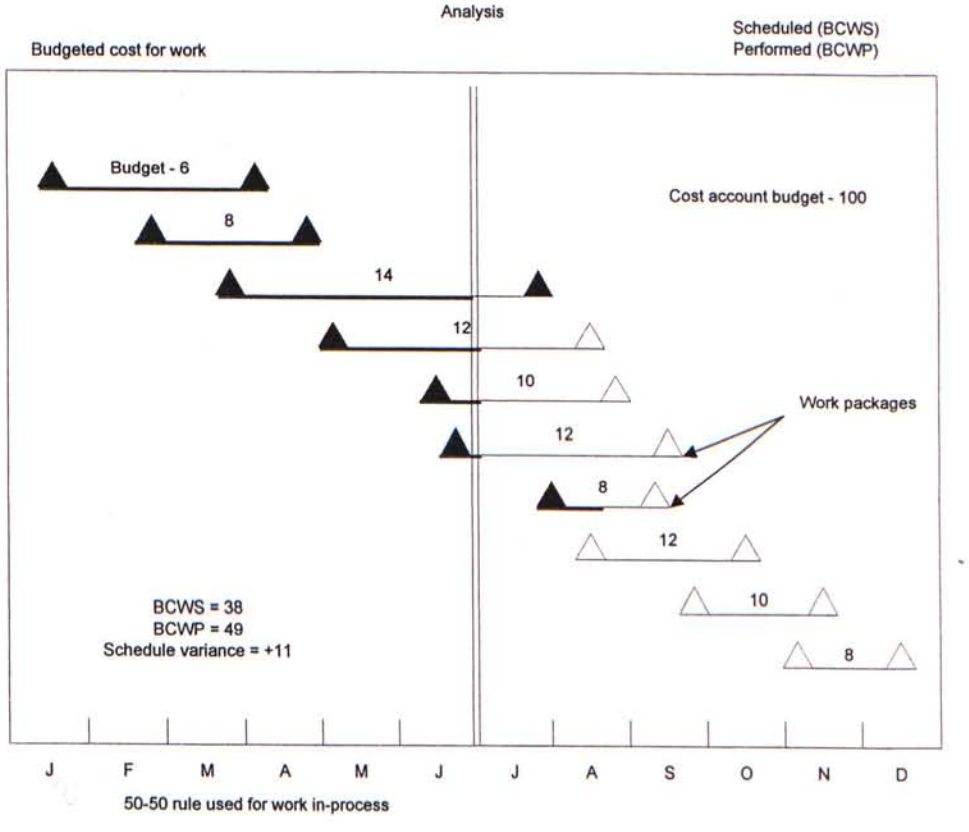


Fig. 3-15. Analysis showing the use of the 50/50 rule

The three values mentioned above are used to provide measures of whether or not work is being accomplished as planned. The most commonly used measures are:

Cost Variance (CV) = BCWP - ACWP,

Schedule Variance (SV) = BCWP - BCWS), and

Cost Performance Index (CPI) = BCWP/ACWP

For Cost Variance, a negative variance indicates a cost overrun, and for Schedule Variance, a negative variance indicates a behind schedule condition. Note that the Schedule Variance can be represented by hours, days, weeks, or even dollars. The following figure illustrates the relationship between BCWS, ACWP, BCWP, CV and SV:

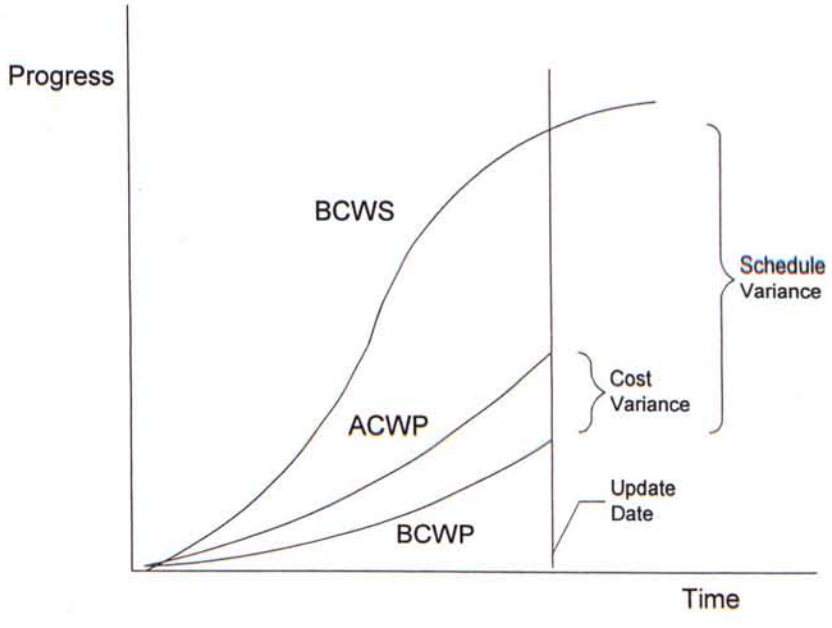


Fig. 3-16. BCWS, ACWP and BCWP curves

It should be noted that when reading performance reports, one should take care not to jump to conclusions by just comparing the estimated and actual expenditure:

Estimated Expenditure(HK$,M) (BCWS)	*Actual Expenditure(HK$,M) (ACWP)*	*Conclusion*
4	4	on cost
4	3	under cost
4	5	over cost
3	4	over cost
3	3	on cost
3	5	over cost
5	4	under cost
5	3	under cost
5	5	on cost

One should take into account the earned value as well to reflect the real situation. With data same as the above, and taking the earned value into account, we can arrive at the right conclusion:

BCWS (HK$,M)	*BCWP (HK$,M)*	*ACWP (HK$,M)*	*Conclusion*
4	4	4	on schedule, on cost
4	4	3	on schedule, under cost
4	4	5	on schedule, over cost
3	4	4	ahead of schedule, on cost
3	4	3	ahead of schedule, under cost
3	4	5	ahead of schedule, over cost
5	4	4	behind schedule, on cost
5	4	3	behind schedule, under cost
5	4	5	behind schedule, over cost

From the interviews, it was found that the Earn Value Analysis is more preferred on large scale projects like civil and structural projects, while for small projects (<HK$50M) project managers prefers to separate the program schedule with the cost schedule, as the administrative effort is considerable high in maintaining a schedule which aligns both cost and project schedule.

As well as the earn value analysis, an effective cost change control system is vital in cost control. A cost control system defines the procedures by which the cost baseline may be changed. It includes the paperwork, tracking systems, and approval levels necessary for authorizing changes. The cost change control system shall be integrated with the overall change control system, which will be detailed in the following Chapter.

Project Quality Management

Quality Management

Project Quality Management includes the processes required to ensure that the project will satisfy the needs for which it was undertaken. It is involved in the project planning, project execution and project closing processes. In a broad sense, it can be classified into three categories: Quality Planning, Quality Assurance, and Quality Control.

Quality Planning involves identifying which quality standards are relevant to the project and determining how to satisfy them. It is one of the key facilitating processes during project planning and should be performed regularly and in parallel with other project planning processes. To have good Quality Planning, a company must have a *Quality Policy*, a statement formally expressed by top management, the overall intentions and direction of an organization with regard to quality. In addition, there shall be a *Quality Management Plan* to describe how the project management team will implement its Quality Policy. In ISO 9000 terminology, it should describe the *project quality system*: "the organizational structure, responsibilities, procedures, processes, and resources needed to implement quality management".

A common tool for Quality Planning is flowcharting. The following figure shows a typical system or process flowchart for design reviews:

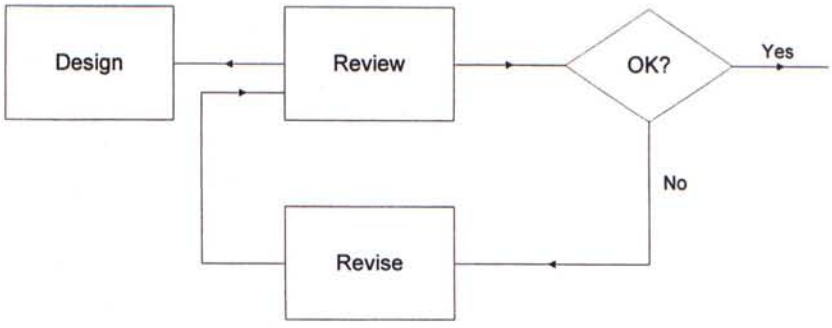


Fig. 3-17. Sample process flowchart

Another example of flowcharting is the Cause-and-Effect Diagram or Fishbone Diagram, which illustrates how various causes and sub-causes relate to create potential problems and effects:

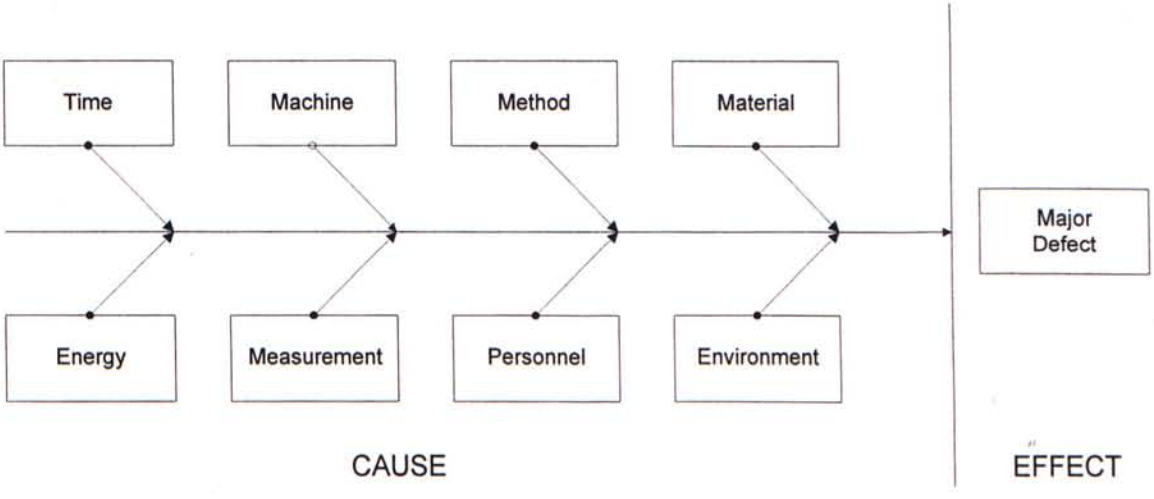


Fig. 3-18. Cause-and-Effect Diagram

Quality Assurance is all the planned and systematic activities implemented within the quality system to provide confidence that the project will satisfy the relevant quality standards. Quality Audits are the main tools in the implementation of Quality Assurance.

Quality Control involves monitoring specific project results to determine if they comply with relevant quality standards and identifying ways to eliminate causes of unsatisfactory results. This involves quality inspection, quality control charts/flowcharts and statistic sampling.

An important aspect in project quality control is *Change Control Management*. A *Change Control System* should be established for every project. It should define steps by which official project documents may be changed. It includes paperwork, tracking systems, and approval levels necessary for authorizing changes. Many change control systems include a *Change Control Board (CCB)* responsible for approving or rejecting change requests. The Change Control System for large projects also usually involves *Configuration Management*, a documented procedure used to apply technical and administrative direction to:

- identify and document the functional and physical characteristics of an item or system;
- control any changes to such characteristics;
- record and report the change and its implementation status;
- audit the items and system to verify conformance to requirements.

Contractor organizations have to pay special effort in maintaining good quality, for all the Client organizations require the Contractors to be ISO 9000 compliant, and this is one of the critical criterion in the tender assessment.

Project Human Resources Management

Project Human Resource Management is the art of making the most effective use of the people involved in the project. It is a key element in the project planning and the project execution processes, and involves all the project stakeholders - sponsors, customers, individual contributors, etc.

Organizational Planning

Nowadays a lot of companies are implementing the matrix organization structure in order to carry out projects. Amongst our interviewed companies, only the CAD maintains a functional organization structure, while the MTRC, HKTCSL, and Hsin Chong all implement the matrix organization structure, where there is a project manager which coordinates and leads the functional personnel with regards to the concerned project. In order to clarify the roles and responsibilities of the various parties in the project, a Roles & Responsibility (R&R) Matrix is usually drafted. Figure 3-19 is a typical R&R matrix:

Phase/Party Responsible	**A**	**B**	**C**	**D**	**E**	**.....**
Requirements	S	R	A	P	P	
Functional	S		A	P		
Design	S		R	A	I	P
Development		R	S	A		
Testing			S	P	I	P

P = participant A = Accountable R = Review required

S = Sign-of required I = Input required

Fig 3-19. Roles & responsibility Matrix

The project manager can also make use of a staffing management plan to detail when and how human resources will be brought onto and taken off the project team. A *Resource Histogram* is a good tool for monitoring the human resources of the project team, and can also be used by the Client's project manager to monitor the resource allocation of the Contractor.

Staff Acquisition

Staff acquisition involves getting the human resources needed to working on the project. In most environment, the best resources may not be available, and the project management team must take care to ensure that the resources which are available will meet the project requirements. When the project management team is able to influence or direct staff assignment, it must consider the characteristics of the potentially available staff:

- Previous Experience: have the individuals done similar or related work before?
- Personal Interest: are the individuals interested in working on the project?
- Personal Characteristics: are the individuals likely to work well together as a team?
- Availability: are the individuals available in the necessary time frame?

Some Contractor organizations have different teams to bid for the project before contract award and to implement the project after contract award. In such a case (as it is in the case of HKTCSL), the project manager of the implementation stage has to communicate well with the project leader and will have to mobilize his resources once the company won the contract.

Team Development

Team development on a project is often complicated when the individual team members are accountable to both a functional manager and to the project manager in a matrix organization structure. Effective management of this dual reporting relationship is often a critical success factor for the project. A way to overcome this kind of problem, as expressed by the HKTCSL project manager, is to have an overall project manager in which all the functional managers report to. This will give the project manager higher authority and in a lot of cases facilitate the decision making process.

Project Communications Management

Project Communications Management includes the processes required to ensure timely and appropriate generation, collection, dissemination, storage and ultimate disposition of project information. It is an important element in the project execution, project controlling and project closing processes and provides the critical links among people, ideas, and information that are necessary for success.

Information Dissemination

Throughout a project, information can be distributed via the following methods:

1. Informal oral communications: face to face, teleconversation, video conferencing;
2. Informal written communications: memos, fax, e-mails;
3. Formal written communications: reports, meeting minutes, correspondence, project documents.

In order to have effective communication, efficient communication channels should be established both horizontally and vertically in the project organization structure, as well as effective communications within the company and external to the company (e.g. Client-Contractor communications).

For Contractor organizations which have different teams to bid for the project before contract award and to implement the project after contract award, good communication between the pre-contract award team and post-contract award team is of utmost importance. The bidding team usually ask the implementation team the minimum cost to run the project, and based on such information will decide the pricing strategy. It

is not uncommon that the bidding team pressures the implementation team to come up with a unreasonably low cost, and at this instance the project manager of the implementation team will have to stand up for his team and negotiate with the bidding team. Negotiation skills and Conflict Management skills will be covered in Chapter IV.

Performance Reporting

Performance Reporting involves collecting and disseminating performance information in order to provide stakeholders with information about how resources are being used to achieve project objectives. This process includes:

- Status reporting - describing where the project now stands.
- Progress reporting - describing what the project team has accomplished.
- Forecasting - predicting future project status and progress.

Performance reporting should generally provide information on scope, schedule, cost and quality. Some projects also require information on risk and procurement. Reports may be prepared comprehensively or on an exception basis. Various techniques used in performance reporting includes variance analysis, trend analysis, S-curves, and earned value analysis.

Administrative Closure

The project or phase, after either achieving its objectives or being terminated for other reasons, require closure. Administrative closure consists of verifying and documenting project results to formalize acceptance of the product of the project by the

sponsor, client, or customer. It includes collection of project records, ensuring that they reflect final specifications, analysis of project success and effectiveness (lesson learnt), and archiving such information for future project reference. Appendix 6 shows a sample project closing report from a Client organization.

Project Risk Management

Project Risk Management includes the processes concerned with identifying , analyzing, and responding to project risks. It includes maximizing the results of positive events and minimizing the consequences of adverse events. It can be broken down into the following three elements:

Risk Identification

Risk identification consists of determining which risks are likely to affect the project and documenting the characteristics of each. Both internal and external risk should be taken into consideration.

Risk Evaluation

After identifying all the risks involved, a systematic way is required to evaluate and quantify risks. *Quantified Risk Analysis* is a common way to evaluate risk and risk interactions to assess the range of possible project outcomes. It basically look into two aspects of risk of a particular event: how likely is the risky/hazardous event to occur, and how profound is the consequence of the event. As such, a *Risk Contour Map* can be produced to illustrate the risk probability and severity:

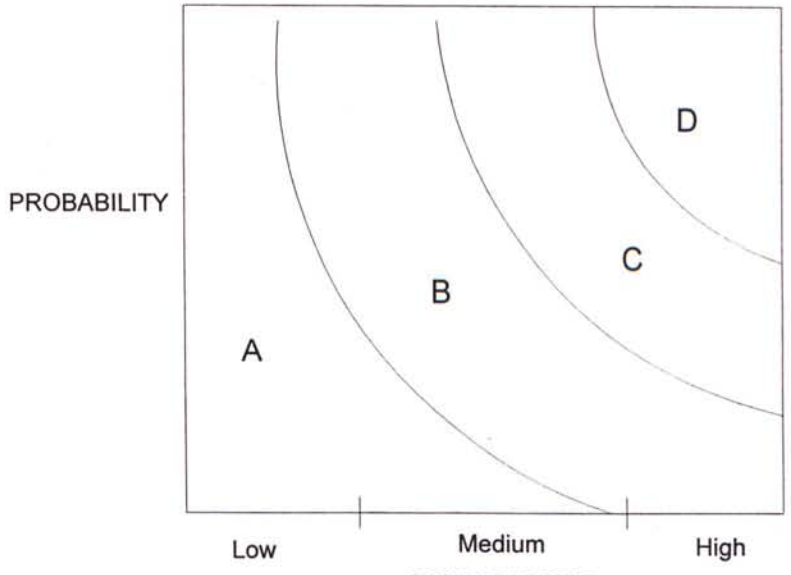


Fig 3-20. Risk Contour Map

In some cases, where detail calculation of the risk probability is required, a Fault Tree Analysis is used. Appendix 7 shows a Fault Tree Analysis undertaken by a Client Organization.

Risk Response Development

Risk Response Development involves defining enhancement steps for opportunities and response to threats. Responses to threats generally fall into one of the three categories:

1. Risk Avoidance: eliminating a specific threat, usually by eliminating the cause. This can also be done by contractual arrangements, for instance, for Client's to pass the risk to the Contractor.
2. Mitigation: reducing the probability of occurrence (e.g. by using more reliable components) or the severity of consequence (e.g. buying insurance).
3. Acceptance: accepting the consequence. Acceptance can be active (e.g. by developing a contingency plan) or passive (e.g. by accepting a lower profit if some activities overrun).

CHAPTER IV

THE HUMAN SIDE OF PROJECT MANAGEMENT

All the interviewed project managers agreed that the human side of project management accounts for half the success of the project, and the project manager himself is the key human element in a project. A project manager has to carry out the following responsibilities:

- **Interface Management**: product/project interfaces, customer liaison, management coordination (functional & upper level), material interfaces (inventory control), information flow and responsibility change management;
- **Resource Management**: time (schedule), manpower, money, facilities, equipment, material, information/technology;
- **Planning and Control Management**: increase equipment utilization and performance efficiency, reduce risks, identify alternatives to problems and resolutions to conflict.

In order to fulfill such responsibilities, the interviewees all agreed that a project manager should have the following personality and characteristics:

- Honesty and Integrity
- Understanding of personal problems

- Understanding of project technology
- Business management competencies
- Alertness, crisis awareness and quickness
- Versatility
- Energy and toughness
- Decision Making Ability

In a nutshell, the project manager shall have a high Emotion Quotient (EQ) and Adversity Quotient (AQ). Naturally, it is very rare to find a project manager with all the above inherent characteristics, but the following skills for sure should be acquired by the project manager (regardless whether he/she is in a Client or Contractor organization) to a certain degree:

- Leadership and Team Building skills
- Interpersonal Influencing and Negotiation skills
- Conflict Management skills
- Decision Making and Problem Solving skills
- Planning, Organizing, and Administrating skills
- Technical Expertise

The following sub-chapters will analyze and elaborate on each of the above mentioned skills.

Leadership and Team Building Skills

Building the project team is one of the prime responsibilities of the project manager. Team building involves a whole spectrum of management skills required to identify, commit, and integrate the various task groups from the traditional functional organization into a single project management system. To be effective, the project manager must provide an atmosphere conducive to teamwork. He must nurture a climate with the following characteristics:

- Team members committed to the program;
- Good interpersonal relations and team spirit;
- Clearly defined goals and program objectives;
- Involved and supportive top management;
- Open communication among team members and support organization.

The above characteristics all boils down to three fundamental factors:

1. Effective communication
2. Sincere interest in the professional growth of team members
3. Commitment to the project.

An absolutely essential prerequisite for a project success is the project manager's ability to lead the team within a relatively unstructured environment. It involves dealing effectively with managers and supporting personnel across functional lines with little or no formal authority. From literature review, it was found that perhaps the best model for analyzing leadership in a project management environment is the life cycle theory of

leadership developed by Hersey and Blanchard, where they contended that leadership style must change according to the maturity of the employees[2] Maturity here is defined as job-related experience, willingness to accept job responsibility, and desire to achieve.

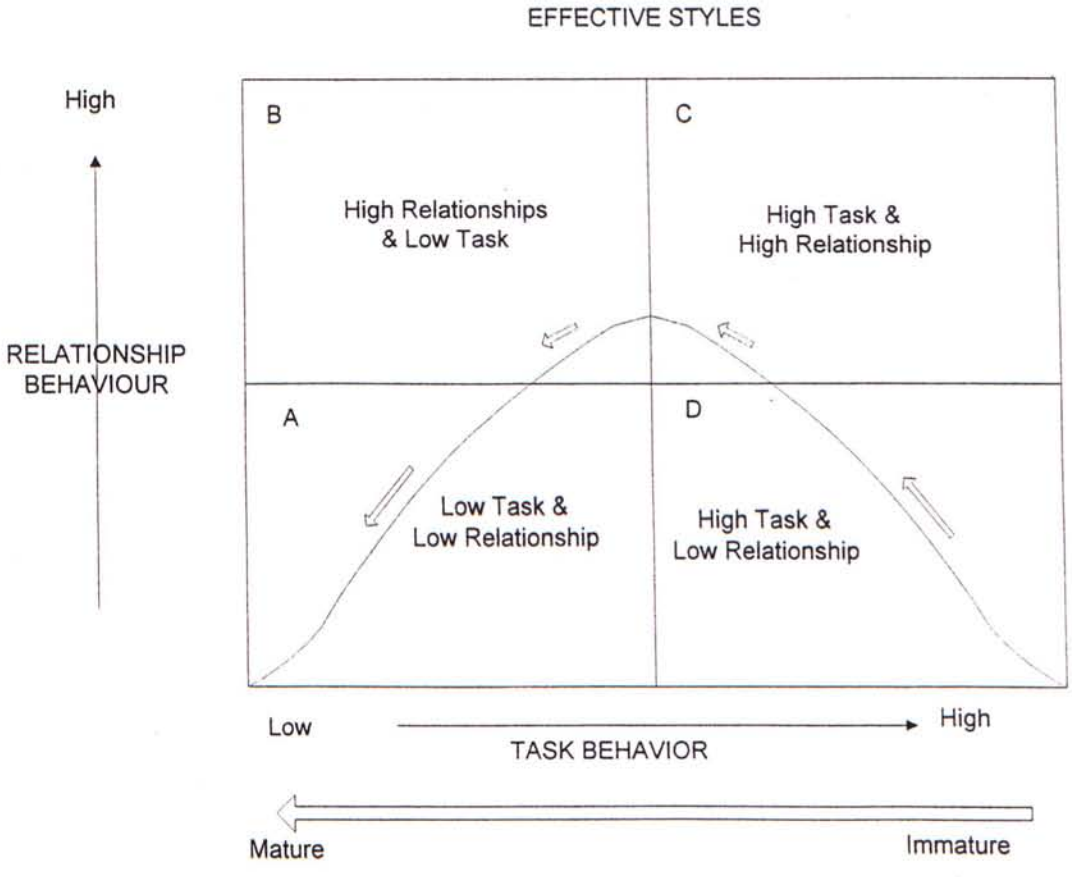


Fig 4-1. The life cycle theory of leadership

As shown in Figure 4-1, the subordinates enters the organization in quadrant D, which is high task and low relationships behavior. In this quadrant, the leadership style of the project manager shall be purely task-oriented behavior (Telling) and the project manager's main concern is the accomplishment of the objective, often with little concern for the employees or their feelings. Hersey and Blanchard assumed that in the initial stage, there is anxiety, tension, and confusion amongst new employees, therefore high

[2] Hersey, P, & Blanchard, K, Management of Organizational Behaviour. New Jersey: Prentice Hall, 1979

relationship behavior is inappropriate as high relationship behavior is relatively ineffective when the subordinate is new to the organization and is not familiar with the job he is doing.. In quadrant C, the subordinate begins to understand his tasks and the project manager shall try to develop strong behavioral relationship (Selling). There still exists a strong need for high task behavior since the employees may not have achieved the level of competency to assume full responsibility. Quadrant B is often regarded as pure relationship behavior (Participating), where the project manager is more interested in gaining the respect of the subordinates than in achieving objectives. Referent Power becomes extremely important. In this quadrant, subordinates no longer need directives and are knowledgeable enough about the job and self motivated to the extent that they are willing to assume more responsibility for the task. In quadrant A, subordinates are experienced in the job and confident about their own abilities. The project manager can thus exhibit low task and low relationship behavior (Delegating) as the subordinates mature.

As a respectful leader and an effective team builder, the project manager should:

- try to get to know team members and understand what motivates them
- manage expectations by ensuring that what is promised can be delivered
- involve project team members in the detail planning of the project so that they will have ownership of the plan
- initiate informal events to promote team work

- give team members assignments or training to provide opportunities for growth and development
- empower team members to create challenge and stretch their abilities
- keep team members focused on project goals and deliverables
- accept responsibility for resolving project issues, focusing on solutions and actions, and buffering criticism.

Interpersonal Influencing and Negotiation Skills

Interpersonal Influencing Skills

Project managers typically have a lot of delegated authority but very little formal power. He must therefore get jobs done through the use of interpersonal influences. There are five such interpersonal influences:

- **Formal Authority**: the ability to gain support because project personnel perceive the project manager as being officially empowered to issue orders.
- **Reward & Penalty Power**: the ability to gain support because project personnel perceive the project manager as capable of directly or indirectly dispensing penalties or valued rewards. However, project managers typically do not have much reward and penalty power since performance appraisals, which affect the project personnel's salary increase and promotion, are usually conducted by the functional line managers.
- **Expert Power**: the ability to gain support because project personnel perceive the project manager as possessing special knowledge or expertise.

- **Referent Power**: the ability to gain support because project personnel feel personally attracted to the project manager or his project.

Regardless of how much authority and power a project manager develops over the course of the project, the ultimate factor in his ability to get the job done is usually his leadership style. Project managers, because of the inherent authority gaps that develop at the project-functional interface, must rely heavily on supplementary techniques for getting the job done, such as development of bonds of trust, friendship, and respect with the functional employees.

Negotiation skills

As the interviewees believed that negotiation skills are vital in project management, I looked into several researches and came up with *Getting to Yes* (1986) by Roger Fisher and William Ury. They offered four basic principles in negotiation:

1. **Separate the people from the problem**:once people feel threatened or criticized, their energy goes into defending their self-esteem, not into solving the problem. Keep the focus on the problem, even if you feel that it is another person's fault.
2. **Focus on interests, not positions**: when we negotiate, we often take positions and defend them, but positions can be traps. Focus on the goals and principles behind your position, and separate those goals from your own ego.
3. **Generate other possibilities**: good negotiators try to think of options that are of low cost to them but of high benefit to the other party. This strategy is called

"dovetailing" or collaborating. We should try to uncover the other party's real needs, and such probing usually enables us to come up with alternatives.

4. **Insist on using objective criteria**: make negotiated decisions based on objective standards or criteria such that the negotiating parties can test the reasonableness of a position.

Consolidating the opinions of the interviews and of my own, practical actions to improve one's interpersonal influencing and negotiation skills include:

- try to get to know project team members
- understand the issues and concerns of other individuals and groups, and take time to understand the political dynamics among groups involved in the project
- Be aware of verbal and non-verbal behavior
- develop strategies that address other people's most important concerns or needs

Conflict Management Skills

In the project environment, conflicts are inevitable, and the most common types involve:

- conflict over schedules;
- conflict over priorities;
- conflict over manpower resources;
- conflict over technical issues and performance trade-offs;
- conflict over administrative procedures;
- personality conflicts (which is one of the most difficult to resolve), and

- conflict over cost.

Research from Blake and Mouton[3] have categorized five modes for handling conflicts. These include:

1. **Withdrawal**: Retreating from an actual disagreement.
2. **Smoothing**: De-emphasizing or avoiding areas of differences and emphasizing areas of agreement.
3. **Compromising:** bargaining and searching for solutions that bring some degree of satisfaction to the parties in dispute.
4. **Forcing**: Exerting one's viewpoint at the potential expense of another
5. **Confrontation**: Facing the conflict directly which involves a problem-solving approach whereby affected parties work through their disagreement.

There is no best mode of effective conflict management, despite the fact that all interviewees believed that confrontation is the most preferable mode. In fact, confrontation is the ideal approach under most circumstances, but in certain situations, for example, when a colleague reacts in a hostile manner, "withdrawal" can be used as a temporary measure to "cool off" the heat; in other cases, compromising and smoothing might be effective strategies if they do not affect the overall project objectives.

Project managers must recognize the potential sources of conflict and know when in the project life cycle they are most likely to occur. Conflict prevention is always better

than resolving conflicts when they occur. For example, clearly defined plans in the early stages of the project can prevent conflicts over manpower resources, priorities and schedules; detailed administrative procedures development can prevent conflict over procedures. In summary, project managers need to know the advantages and disadvantages of each resolution mode for effective conflict management. Conflict can be beneficial when disagreements result in the development of new information that can enhance the decision making process. In the next section we will look into the decision making and problem solving skills.

Decision Making and Problem Solving Skills

Decision making and problem solving skills are also reckoned by our interviewees as being necessary skills to be acquired by the project manager. There are three major types of decision making models:

1. **Directive**: the project manager makes the decision for all. While this is certainly expedient, it has obvious drawbacks. The only information available is the decision maker's information, which may or may not be correct or complete. An added danger is that those who disagree or were left out of the decision may not carry it out.
2. **Participative**: Everyone in the project team has something to contribute, so there will be a synergy created as the best decision is sought. As everybody participates, commitment will become much stronger, and such an atmosphere fosters team building. However, this approach is rather time consuming.

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[3] Blake, R. R., and Mouton, J. S., The Management Grid. Houston: Gulf Publishing, 1964

3. **Consultative**: mid-way approach which combines the best of the other two types. While the project manager makes the decision, it is done only after having consulted with everyone to get input and ideas. This approach is participative at the input stage but directive at the point of decision. I personally, and supported by all my interviewees, reckon that this is the best approach when it comes to decision making.

With regards to problem solving, as well as using conflict management skills, interpersonal influencing skills and negotiation skills, conducting a Brainstorming session will definitely be beneficial: assemble together those individuals that may have some knowledge on the problem area. Start the session with everyone throwing any idea out and listing them out on a board. No discussion (except clarification) is permitted. This continues until no new ideas are forthcoming. Then begin a discussion on the items listed. Look to combine ideas or revise ideas based on each member's perspective. Test each idea with an open mind and in time some solutions will for sure begin to emerge.[4]

Planning, Organizing and Administration Skills

As unanimously agreed by the interviewees, planning and organizing skills are essential for the successful management of large complex projects. Effective project planning requires communications and information processing skills to define actual resource requirements and administrative support necessary. It requires the ability to negotiate the necessary resources and commitment from key personnel in various support organizations with little or no formal authority, including the definition of measurable

[4] Wysocki, Beck, Crane, Effective Project Management, Chapter 13, p.188

milestones. Nonetheless, it must be borne in mind that the project manager should build in considerable flexibility in the plan since changes in project scope and depth are inevitable.

Administrative skills like planning, staffing, budgeting, scheduling, and other control techniques are also vital for project managers. Capable of using various software tools for scheduling and budgeting (eg. Open Plan, Microsoft Project, MS Excel), etc. is definitely a must for project managers.

A well-planned, systematically organized project manager should:

- plan ahead for meetings
- ensure a common understanding and agreement on the project scope and objectives and on any subsequent changes
- monitor the project status to ensure effective use of resources

Technical Expertise

Technical expertise is necessary for project managers to evaluate technical concepts and solutions, to communicate effectively in technical terms with the project team, and to assess risks and make trade-offs between cost, schedule and technical issues. Technical skills are essential because being the leader in an engineering project team which comprises technical experts from functional organizations, the project manager will require considerable technical knowledge to earn the respect from the line engineers.

This is why most of the project managers have an engineering background, and this applies to both Client and Contractor organizations.

CHAPTER V

PROJECT MANAGEMENT IN APPLICATION

One of the main theme of this project is to look into the real-life problems commonly encountered by the Client's project manager and the Contractor's project manager and attempt to seek plausible solutions. Naturally, in the dynamic project environment, there is no single best solution to tackle any one particular problem; nevertheless, the solutions provided here are consolidated opinions from my interviewees and are also in my opinion, good solutions of solving or mitigating the problems.

Real-Life Problems Encountered by Client Project Managers

One of the common initial problems encountered by Client's project managers starts right before contract award. In a lot of cases, tenderers with unreasonably low tender prices bid for the contract. Their low prices are either the result of poor quality, taking too much risk, or unaware of the complexity of the project. This phenomenon has always been a headache to project managers as it would be disastrous to allow a poorly qualified, inexperience contractor to win the tender bid and it is rather difficult to justify a tenderer which is not the lowest bid to win the contract.

As mentioned by the interviewees, in all Client organizations there will be a tender pre-qualification assessment to assess the financial status, previous experience and

technical expertise of the potential tenderers. In the pre-qualification questionnaire, the potential tenderers will also be asked to give a reference company which can comment on the tenderers' past performance with the company on a similar scale/nature project as the tendering project. Those not qualified will not be allowed to tender for the contract. This process will thus eliminate a batch of unqualified potential tenderers. As for those who are qualified and entered the tendering process, several rounds of Questions and Answers will be conducted to ensure that the tenderers fully understand the tender requirements and to question the tenderers' technical knowledge. For both MTRC and CAD, during the tender evaluation process, sometimes engineers will be sent to visit the tenderers' factory to inspect the equipment, material or workmanship quality. For MTRC, it is common to ask the potential tenderers during the pre-qualification stage to carry out an engineering design to test the tenderer's competency. For CAD, it once asked the tenderers to produce a prototype or small scale system of the tender at the tenderer's own cost to demonstrate that the system that the tenderer proposed actually works. With such measures, the Client will be able to scrutinize the technical competency of the tenderers and have stronger grounds to turn down tenderers with weak technical competencies.

Another commonly encountered problem is how to ensure that contractors can meet the project milestones and how to prevent contractors from slacking (or even giving up) near the end of the project since in many projects, a large portion of the contract sum is paid after equipment delivery and by the time when the project is coming to the end, most of the money has been paid to the contractor and the contractor will then tend to slacken. This could be a serious problem, especially for projects that require system

integration, since having the equipment attaining performance up to specifications do not guarantee that the entire system will function properly. There have been cases where contractors delivered the equipment but were not able to make the system work, and so they quitted the project as most of the money has been paid. Or even worse, in some cases the Clients have target completion dates that cannot be delayed (eg. the opening of the Airport, the opening of a new railway extension, the opening of the new extension of the Convention and Exhibition Centre), and contractors might see this as an opportunity to squeeze money out of the Client, claiming that in order to prevent slippage additional cost is required. How can Clients deal with such a situation?

For MTRC, a retention money scheme is implemented, where 10% of each payment to the contractor is retained until project completion. Upon successful project completion, the retained money will be credited to the contractor's account. However, such a scheme only have limited deterring effect as the sum retained is not too significant. In certain cases, contractors might find it more economical to quit the project than to drag on with the project and, especially when a solution to the problem(s) seems remote. Naturally the Client can pursue legal actions, but this is a lose-lose situation, an alternative which should not be taken until the last resort. As all project managers agreed, claiming for liquidated damages does not really work, because there are too many gray areas to argue upon.

For the CAD, at least 30% of the contract sum will be retained until successful project completion. This for sure will solve the problems mentioned above, but the

contractors will have to have a very strong financial support in order to finance the cashflow of the project.

Another way to prevent the above mentioned problems is through contractual arrangements, demand the contractor for a demand bond instead of the performance bond. The performance bond is a bond which the Client can draw when the Client can prove that the contractor does not perform up to standard; for a demand bond though, the Client can draw it without the need of any proofs and these bonds usually mount up to 10% of the contract sum.

Another plausible solution is for the Client's project managers to seek for a compromise. When it can be foreseen that the Contractor will definitely not be able to meet the target project completion date, the Client's project manager can categorize the outstanding items into high, medium and low priority and demand the high priority outstanding items to be rectified or completed before the target completion date, while allowing the other items to be resolved after the targeted project completion date.

As mentioned earlier, claiming for liquidated damages is not very effective, and might push the contractor to a corner which might lead to its winding up or quitting the project. This is undesirable because in many cases, especially in system integration or software system projects, the Contractor, which is responsible for developing the system, is the only company which has the technical know-how on the delivered system, and the winding up of the Contractor's company or the quitting of the company will be disastrous

to the project. A way to avoid such situations is to claim liquid damages in the form of claiming for additional spare parts or for an extension of the warranty period.

Unlike system projects, for construction or civil projects, since payment is made to the Contractor in terms of the progress of project, and partial completion of a project does not normally render the entire project dysfunctional, the above mentioned problem does not create too much of a problem.

Another commonly encountered problem comes from the interfaces between different contractors. In many cases, when several project are conducted in the same time period, clashes might occur, and delays might thus result. To overcome this problem, communication between various project managers within the Client organization is essential, and it is desirable to have monthly meeting for all relevant project managers to site down and discuss the project matters and to align their most update project statuses, and to try to anticipate possible forthcoming clashes.

Real-Life Problems encountered by Contractor's Project Manager

The first common decision to be made by project managers (or the project director) is to decide whether the company should bid for a project. This "go" or "no go" decision is very important since if one enters into the tendering process and lost, the sunk cost can be considerably high as the tendering period usually last for more than half a year and the company has to commit a lot of resources during this tendering period. As revealed by the CAD project manager, one Contractor claimed that he has spent $4

million during the tendering process to bid for a $240 million system integration project. For civil or construction projects, the sunk cost can be even greater as the contractor sum is much larger. So one must be sure that one has a rather high chance to win the contract before entering into the tendering, or even the pre-qualification process. So what are the evaluating criteria? After consolidating my interviewed Contractor project managers' opinion, I came up with the following criteria:

1. Consider whether one's company has sufficient resources, in terms of both staffing resources or financial resources, for the concerned project scale. Note that projects usually have very tight cash flows at the beginning, and the cash outflow can be very high in the first one or two years. In addition, a lot of contracts specify the Contractors to buy performance bonds or demand bonds which mount up to 10% of the contract sum. Other overhead costs at the start of the project include mobilization, insurance, and preliminary design costs, not to mention the sunk cost during the pre-qualification and tendering period.. If the company does not have a strong financial background in comparison with the scale of the project, serious consequences could result. As revealed by the Hsin Chong project director, they will only be interested in projects in the range $300 million to $3 billion. Projects with smaller contract sums inflict too high overhead cost for them and therefore reduce their profit margin while projects with larger contract sums will be on the risky side for them and might deplete their company's liquid cashflow. Naturally, the company's resources will also depend on how many other contracts the Contractor company will be having during the period of the tendering project and in what phases are those other contracts in.

2. Consider whether the company has the technical knowledge and experience in carrying out the project. Having expert technical know-how is very important, since as well as ensuring that the project can be smoothly implemented, a good technical solution can result in massive cost saving as compared with a mediocre technical solution.
3. Consider the strengths and weaknesses of the other competitive bidders. Bidding for a Contract is like fighting in a battlefield. To increase your chances of winning, as well as knowing your internal strength and weaknesses for the project (doing a SWOT analysis will be a good idea), you also have to understand the opponents' capabilities and how badly do they want to win the contract, for the latter can seriously affect their pricing strategy.
4. Last but not the least, is to understand the rules of the game. Different Client organizations can have different tender scoring criteria, and therefore knowing which aspects score high in the tender assessment will definitely be advantageous.

Another common problem encountered is how to come up with a low bidding price but remain significantly profitable? Following are four tricks offered for reference:

1. Manipulate the project cashflow such that most of the money will be spent in the last years of the project. As most client organizations use the Net Present Value (NPV) method to evaluate and compare the prices of a contract, as long as we are in an era of inflation, the discount in the last year will be the greatest, and moving the money to the last years will result in a smaller project NPV. Nevertheless, this will mean that the payback time from the Client will be longer.

2. Maintain relatively high unit prices of equipment and relatively high unit prices of labor, but reduce the other intangible prices, eg. mobilization price, design price, etc. The objective of such a strategy is in anticipation that there might be variation orders to come in the future, and having the unit price of equipment and labor high will make the variation order (VO) considerably profitable, as the price of the VOs are mainly based on these unit prices. The intangible prices in comparison do not affect significantly the VO prices. As revealed by the MTRC project manager, one of its tenderers in fact made the mobilization and design prices free; in addition, the first Section of Works was also given free to MTRC, but MTRC was charged a high equipment unit price and labor price for future VOs. This strategy lead us to the third trick:
3. Scrutinize the contract document and anticipate the number of potential VOs that will be awarded in the future. For contract documents that are not well written, Contractors can find loopholes in the document and claim for VOs. Note that this strategy's objective is not only to pick on the carelessness of the contract document author, but also an exercise to anticipate the future external environmental changes. Any future environmental changes which affects the project scope will give rise to potential VOs.
4. If it is a system project, make your system as proprietary as possible such that for any further system expansion or system change the Client organization will have to come back to you (of course in well written contract documents, there might be clauses to prevent the Contractors from offering proprietary systems, but the Contractor should try to persuade the Client the advantages of a proprietary system, eg. faster system

response time, more value-added functionalities, more flexible system configuration and larger system expansion capacity, etc.).

When bidding for a contract, another issue which requires scrutiny is how to bid for the tender. Should the company take up the entire project, or would a join venture or an alliance with other companies be preferable? What and how many sub-contractors should be sought?

In general, there are three situations where bidding as a join venture will be preferable. First is when the project involves too much risk, a join venture will be a good way to diversify the risk. Second is when the project sum is too large, and a join venture partner with strong financial support will give the company a high chance of winning the contract; third is when the join venture partner has the technical expertise which can complement areas which your company is technically weak on. Note however that project management will become even more complex in a joint venture situation. The following will have to be settled:

- who will lead the joint venture?
- how will be the reporting/project organization structure of the join venture?
- how will be the logistics of the join venture?
- in case of disputes, how should they be resolved?
- how will human resources allocation be conducted in the join venture?

- how will profits be shared? Mark up on net profit or gross profit? (a 7% mark up on net profit means with a cost of $10, the price will be $10 X 1.07 = $10.70, while a 7% mark up on gross is $10/0.93 = $10.75)

Normally, the above decisions will be made and negotiated between the project directors of the join venture companies.

Another common problem is that it is quite common the case that the project manager and his tendering team who bids for the project is different from the project manager and his implementation team who implements the project. In such a case, an effective communication channel is vital to prevent any accidental miscommunications. Once it is known that the company has won the contract, the tendering project manager will pass all the information to the implementing project manager (some of the information might be confidential and not yet disclosed to the implementing project manager) The challenge of the implementing project manager is, in several days time,

1. verify that the cost estimates of the tendering team are correct; any unreasonable assumptions have to be voiced out and negotiated with the tendering project manager before the project starts;
2. understand the scope of the project, read through all contract documents (usually several inches high) and align the project strategy with the tendering project team;
3. formally form the project team. In a matrix organization, the project manager will have to pull project team members from various functional line managers;

4. Mobilize the project team and sort out various administrative issues, eg. bonds, insurances, start up a cost centre for the project, establishing bank accounts, hatching the currency of the major equipment, etc.

Apparently, a lot of work has to be done by the project manager in a very short time, and therefore an advice is for the implementing project manager to plan ahead before contract award.

As for sub-contractors, the project manager should aim at recruiting experienced sub-contractors, or those who have good track records. Sub-contracting out non-core activities or activities which the sub-contractors are more specialized in than your own company usually means cost saving.

During the implementation of the project, one of the most common encountered problem by the Contractor project manager is that the there is a delay on the supplier's side (problem in placing manufacturing orders, shipping and delivery, etc.) which affects the project schedule. In this case, what should the project manager do?

One of the main task of the Contractor project manager is to negotiate with the Client project manager, try to buy time or try to shuffle the tasks in order to minimize project delay. The Contractor project manager will need to utilize his negotiation and interpersonal skills, on one hand press the supplier to expedite the equipment or material

delivery, and on the other hand lobby with the project manager in search for a solution which minimizes possible delays.

Problem Encountered by Project Managers In General

In a matrix organization, it is typical that the project manager find himself in a situation where he has delegated authority but does not have the actual power (this is the case of MTRC and HKTCSL). This is because although the project team members report to him in the project, they in fact directly report to their respective line managers, and it is the functional line manager who gives the appraisal to the project team member, and therefore the team members tend to act according to their respective line manager's instructions rather than the project manager's instruction. How can this dilemma be rectified?

This two boss problem in fact goes right into the heart of the matrix organization. If the organization is setup this way, there is little a project manager can do. It is therefore of utmost importance that a project manager is well equipped with interpersonal influencing skills, such that jobs can be done smoothly via informal communication channels. From an organization point of view, it is preferable to have the project team member appraised by both the project manager and the functional line manager (which is the case in Hsin Chong). Another suggestion is to have the functional line managers reporting to the project manager, as this will give the project manager both delegated authority and actual power. As such, the seniority of the project manager will be greatly escalated.

CHAPTER VI

CONCLUSION: LESSON LEARNT

From the interviews and literature reviews, it was found that in general, the key success factor for a successful project lies in the project manager and the company's top management. Project managers should:

- understand interaction of organizational and behavioral elements to build an effective team;
- show concern for team members, i.e. know their needs;
- provide work challenge;
- communicate objectives clearly;
- plan effectively and early in the project cycle;
- be committed to the project;

As for top management, they should:

- provide a good organizational climate, as this has a direct relationship with project performance;
- provide adequate support to the project manager (this is very important!)

- provide clearly defined decision channels and priorities, so to improve operating effectiveness with functional departments;
- smoothen project start-up and phase out procedures so as to ease personnel problems and power plays.

As well as being equipped with the skills mentioned in Chapter IV, the project manager should have a VERY CLEAR over picture of the project, and factors affecting the project, e.g. critical paths of the project, external environmental factors affecting the project, etc. As he is the ultimate decision maker, he should have a very broad knowledge, in terms of contractual, technical, financial matters and should also have a sound business sense. He should know how to ask the right questions in order to consolidate opinions from his subordinates in order to derive a decision and should have a high adversity quotient.

For Client project managers, the following points should be noted:

- ensure that the Contractor who wins the contract is experienced and competent;
- don't let delays accumulate; pressure the contractors to meet every milestone; and in cases where meeting the milestone becomes impossible, limited degree of compromise should be allowed; try to avoid delays which will trigger a domino effect on the entire project (i.e. delays in the critical path);
- implement a payment scheme which prevents the contractors from slacking at the end of the project or quitting the project;

- ensure that the interfaces between different contractors are well defined (by having clear interface requirement specifications and communication with other relevant project managers within the Client organization);
- always cultivate a cooperative environment with the contractors.

For Contractor project managers, the following points should be noted:

- consider the company's financial background, resources and technical competency before biding for a project; if the project is too big or too risky, looking for a join venture will be an appropriate move;
- analyze external environmental factors which might affect the project scope, as these would lead to possible variation orders, which translates to gaining extra profits;
- always closely monitor the material or equipment suppliers, as failure to deliver the material or equipment on time or within quality standards will have a severe impact on the project schedule;
- use the project management tools as mentioned in Chapter III to ensure that the project is delivered on time and within budget.

Coming back to the question in the Preface section, "Is project management an arts or a science? ". After the research, I would like to conclude that project management is the art of managing people and project events , with the assistance of scientific tools and techniques.

APPENDICES

Appendix 1

Invitation Letters to the Project Managers for Interview

THE CHINESE UNIVERSITY OF HONG KONG 香港中文大學

SHATIN · NT · HONG KONG · TEL.: 609 6000 609 7000 · TELEGRAM • SINOVERSITY TELEX • 50301 CUHK HX FAX • (852) 603 5544 · 香港新界沙田 · 電話：六〇九 六〇〇〇 六〇九 七〇〇〇

工商管理學院碩士課程
MBA Programmes
Faculty of Business Administration

~~Tel. 609 7703~~
~~722 5000 (Town centre)~~

學生碩士企劃用箋
Student MBA Projects

Mr. Joseph Poon,
Senior Electronic Engineer,
10/F, Commercial Building,
Air Flight Forwarding Centre,
2 Chun Wan Rd.
Chek Lap Kok,
Hong Kong.

11 March 1999

Dear Mr. Poon,

Re: Interview on Engineering Project Management

I am currently studying a part-time MBA course in the Chinese University of Hong Kong and researching on the topic *Engineering Project Management: Looking from a Client's and Contractor's Perspective.* I am recently arranging interviews with very experienced project managers in several renowned Client and Contractor organizations in order to obtain some insights in engineering project management. As such, I would hereby like to invite you for an interview on the captioned topic. I understand that with your hectic schedule and busy commitment, it will be impertinent for me to seek a meeting with you. However, should it be agreeable to you, I will be very grateful to attend a meeting at a time convenient to you. I shall follow-up on this letter by contacting your secretary in a few days time.

Please find attached the interview questionnaire for your reference. Certainly, the information that I obtain will be used strictly for research purposes. Should you have any queries regarding the interview, please do not hesitate to call me at 2993-8466 or to send me an e-mail at "johnkchan@hknet.com".

Thank you very much in anticipation of your kind assistance in this matter.

Yours sincerely,

John K. W. Chan

THE CHINESE UNIVERSITY OF HONG KONG 香港中文大學

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Faculty of Business Administration

~~Tel. 609 7793~~
~~722 5000 (Town centre)~~

學生碩士企劃用箋
Student MBA Projects

Mr. James K. F. Lee,
Project Director,
Hsin Chong Construction(Asia)Ltd.
4th floor, Devon House,
979 King's Road,
Quarry Bay,
Hong Kong.

11 March 1999

Dear Mr. Lee,

Re: Interview on Engineering Project Management

I am currently studying a part-time MBA course in the Chinese University of Hong Kong and researching on the topic *Engineering Project Management: Looking from a Client's and Contractor's Perspective.* I am recently arranging interviews with very experienced project managers in several renowned Client and Contractor organizations in order to obtain some insights in engineering project management. As such, I would hereby like to invite you for an interview on the captioned topic. I understand that with your hectic schedule and busy commitment, it will be impertinent for me to seek a meeting with you. However, should it be agreeable to you, I will be very grateful to attend a meeting at a time convenient to you. I shall follow-up on this letter by contacting your secretary in a few days time.

Please find attached the interview questionnaire for your reference. Certainly, the information that I obtain will be used strictly for research purposes. Should you have any queries regarding the interview, please do not hesitate to call me at 2993-8466 or to send me an e-mail at "johnkchan@hknet.com".

Thank you very much in anticipation of your kind assistance in this matter.

Yours sincerely,

John K. W. Chan

THE CHINESE UNIVERSITY OF HONG KONG 香港中文大學

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工商管理學院碩士課程
MBA Programmes
Faculty of Business Administration

學生碩士企劃用箋
Student MBA Projects

~~Tel. 609 7783~~
~~722 5808 (Town centre)~~

Mr. L. K. Yeung,
Assistant Project Controller,
MTR Tower, Telford Plaza,
Kowloon Bay,
Hong Kong.

11 March 1999

Dear Mr. Yeung,

Re: Interview on Engineering Project Management

I am currently studying a part-time MBA course in the Chinese University of Hong Kong and researching on the topic *Engineering Project Management: Looking from a Client's and Contractor's Perspective.* I am recently arranging interviews with very experienced project managers in several renowned Client and Contractor organizations in order to obtain some insights in engineering project management. As such, I would hereby like to invite you for an interview on the captioned topic. I understand that with your hectic schedule and busy commitment, it will be impertinent for me to seek a meeting with you. However, should it be agreeable to you, I will be very grateful to attend a meeting at a time convenient to you. I shall follow-up on this letter by contacting your secretary in a few days time.

Please find attached the interview questionnaire for your reference. Certainly, the information that I obtain will be used strictly for research purposes. Should you have any queries regarding the interview, please do not hesitate to call me at 2993-8466 or to send me an e-mail at "johnkchan@hknet.com".

Thank you very much in anticipation of your kind assistance in this matter.

Yours sincerely,

John K. W. Chan

Appendix 2

Interview Questionnaires

INTERVIEW QUESTIONNAIRE FOR CLIENT PROJECT MANAGERS

1. What are the important aspects in Engineering Project Management to ensure that projects can be carried out successfully?

   For the following questions, please use two typical projects as examples.

2. What is the project organization structure?
3. Do you have a formal Project Mission Statement/Statement of Work?
4. Any use of Work Breakdown Structure? Can you give an example?
5. What tools are used for Planning and Scheduling? What software? Any examples?
6. How do you estimate the project cost? Who does the cost estimating?
7. How do you pay Contractors? Any incentive or punitive schemes?
8. What tools and methods are used for cost control? What software?
9. How can the Quality of the Contractor/Sub-Contractor be controlled/monitored?
10. How do you estimate project risk?
11. How to prevent the Contractor with unreasonably low bids (due to poor quality or unawareness of complexity and demand of project) from winning the contract?
12. How to prevent Contractor's from slacking (or even giving up) near the end of the project (since most of the money has already been paid)?
13. A lot of Clients have target completion dates that cannot be delayed (eg. opening of the Airport, opening of a railway extension). Contractors might see this as an

opportunity to squeeze money out of the Client, claiming that in order to prevent slippage additional cost is required. How to do deal with such a situation?

14. How to manage conflicts, e.g. between functional managers and program managers?
15. Please illustrate a few real-life problems encountered by the Client's project manager and describe how to solve these problems.
16. What kinds of skills does a good project manager possess?
17. What is the difference between being the project manager in a Client organization and the project manager in a Contractor organization?

INTERVIEW QUESTIONNAIRE FOR CONTRACTOR PROJECT MANAGERS

1. What are the important aspects in Engineering Project Management to ensure that projects can be carried out successfully?
2. What are the considerations in evaluating whether a project worths bidding? How to evaluate? What are the elements that determine whether to bid as a main Contractor, a sub-contractor, or to be in alliance with other companies?

   For the following questions, please use two typical projects as examples.
3. What is the project organization structure?
4. Do you have a formal Project Mission Statement/Statement of Work?
5. Any use of Work Breakdown Structure? Can you give an example?
6. What tools are used for Planning and Scheduling? What software? Any examples?
7. How do you estimate project cost? How do you formulate the bidding price?
8. How are the costs for a project charged?
9. How do you negotiate with subcontractors when bidding a contract?
10. When bidding for a contract, what are the various strategies employed?
11. How do you use the Client's payment to finance the project?
12. What tools and methods are used for cost control? What software?
13. How can the quality of the subcontractors be controlled/monitored?
14. How do you form the project team for the project? Any difference before and after Contract Award?

15. How much resource is committed when bidding for a contract? How do you mobilize resources once you know you have won the Contract?
16. How to manage procurement in fulfillment of the Client's Project Master Program?
17. How to manage conflicts, e.g. between functional managers and program managers?
18. Please illustrate a few real-life problems encountered by the Contractor's project manager and describe how to solve these problems
19. What kinds of skills does a good project manager possess?
20. What is the difference between being the project manager in a Client organization and the project manager in a Contractor organization?

Appendix 3

Scope of Work/Project Mission Statement

PROJECT TEAM MISSION STATEMENT

Replacement of RHKP/FSD Radio Asset

Capital Works C4280 - A Customer Service Project

1. THE PROJECT TEAM MISSION:

This *MISSION STATEMENT* is prepared to document the commitment by all team members to contribute to successful implementation of Capital Work C4280. This project calls for the replacement of 88 sets of existing RHKP radio basestations, provision of radio basestations for FSD (at 800MHz) at MTR, and incorporating system enhancement such as central alarm monitoring to facilitate system maintenance. The works shall be carried out in a safe manner and in accordance with the quality standards as defined in the endorsed specifications.

2. PROJECT TEAM MEMBERS:

For Project success, it is essential that irrespective of rank or position within MTRC, full support and endorsement shall be given to a *Team Leader* who represents all members from within each departmental discipline. This is to ensure that the agreed Roles and Responsibilities are diligently carried out under the commitments made in this Mission Statement.

2.1 CUSTOMER [Team Leader - C.M. Shek]

Success Criteria - Operational Objectives/ Expectations

"To co-ordinate user input for a smooth implementation and user adaptation to the new system so as to avoid interruption on the day-to-day/ incident handling radio communication among the MTR Police and FSD Teams in MTR" - C.M. Shek

Supporting Team Members

PM(O)	L.W. Wong
APM(O-S)	F. Lam
SPO(O)	David Yam

2.2 DESIGNER [Team Leader - John Chan DSE(Comm)]

Success Criteria - Design Objectives/ Expectations

"To install a reliable conventional radio system with a basestation status monitoring network and to manage the design process such that all submittals shall fulfil the users' requirements with the defined specifications and quality standards of the project." - John Chan

Supporting Team Members

CSDM	H.W.Chan
DE(F&S)	Eric Cheung
SM(BD -Co)	Angus Li
DE(Comm)	M.K. Wong

PROJECT TEAM MISSION STATEMENT

Replacement of RHKP/FSD Radio Asset

Capital Works C4280 - A Customer Service Project

2.3 IMPLEMENTOR [Team Leader - H.S. Leung, IE(C&CS)]

Success Criteria - Objectives/ Expectations

"To collaborate with other task sections to ensure that all work will be carried out in accordance with the specifications, schedule and safety requirements. To ensure uninterrupted RHKP/FSD radio services can be maintained during transition period. Also to co-ordinate with maintainer to locate and resolve all defects during maintenance period." - H.S. Leung

Supporting Team Members

C&CSM	F. Mok
NWM(C&CS)	W.H. Woo
MM(Tel)	Alex Lo
TO(Tel)	Andy Wong

2.4 MAINTAINER [Team Leader - Alex Lo, MM(Tel)]

Success Criteria - Objectives/ Expectations

"To ensure that all defects are located and resolved. To monitor and evaluate the performance and reliability of the system introduced against defined performance standards. Also to continuously improve the standards of the services." - Alex Lo

Supporting Team Members

C&CSM	F. Mok
NWM(C&CS)	W.H. Woo
IE(C&CS)	H.S. Leung
SE(Tel)	C.C. Tsang

2.5 CONTRACTS [Team Leader - Ben So, CEII]

Success Criteria - Objectives/ Expectations

"To ensure a proper procedure for pre-qualification, tendering and tender assessment, leading to the award of the Contract to the most competitive and compliant tenderer. Thereafter, to provide a high level of contract administration service during the post contract period." - Ben So

Supporting Team Members

CAM(HQ)	B. Poynton
CEI(E&M)	R. Iu

2.6 PROJECT CONTROL [Team Leader - L.K. Yeung, APC(C&C)]

Success Criteria - Objectives/ Expectations

"To encourage and enlist commitments from all concerned parties, consolidate and co-ordinate their resources to complete the works within budget and the agreed time period; and as well in accordance with the defined safety requirements" - L.K. Yeung

Supporting Team Members

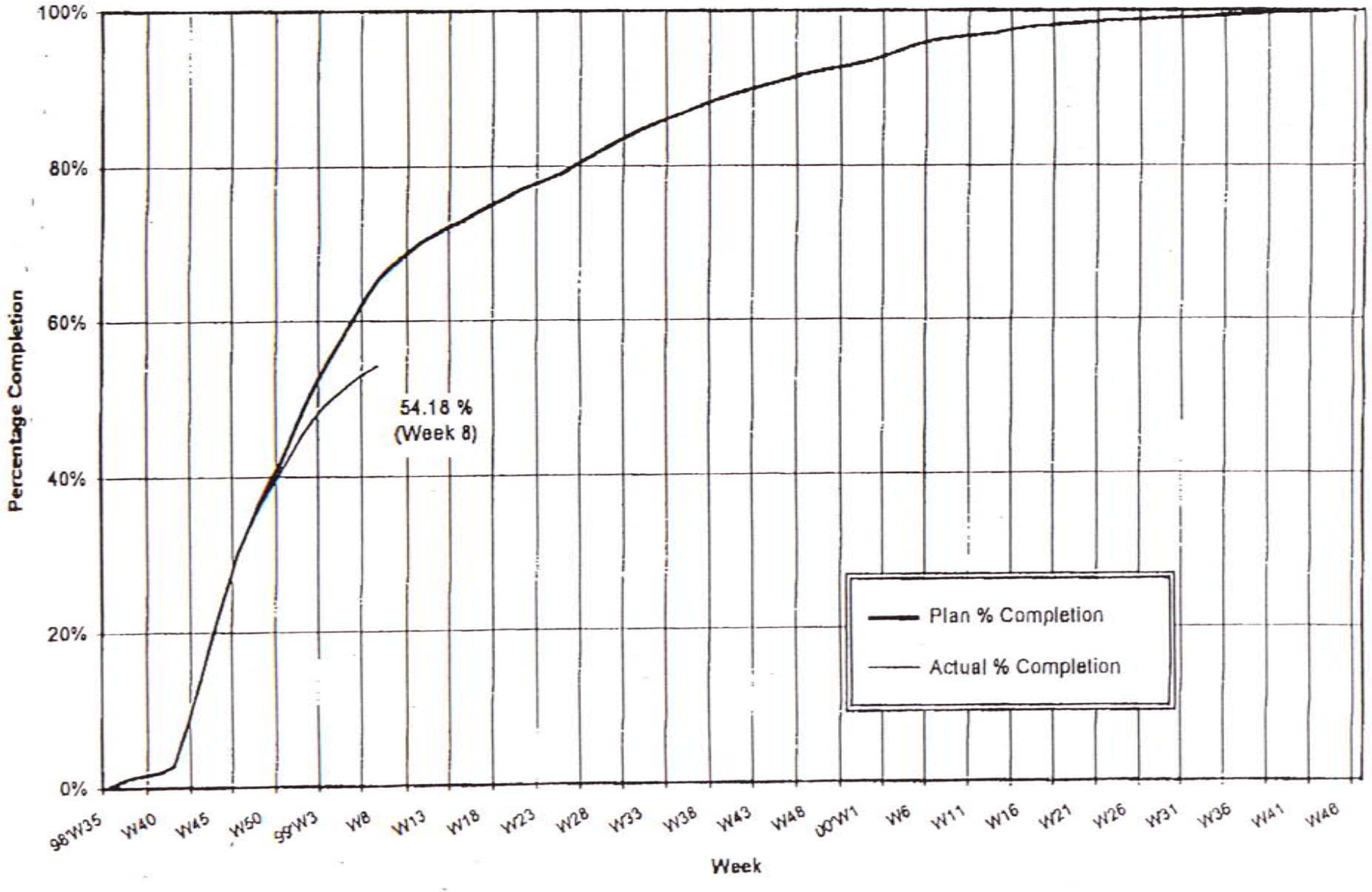
PCM	Dominic Au Yeung
PC(C&C)	Bill Beadling
P&PA	S. Tsang

WB/LKY/jl
Revision : 4
7 January 1999
File Ref : Mission\C4280\Rev4

Appendix 4

S-Curve

Project Progress (S-Curve)



Appendix 5

Gantt Chart

C4288.01 Replacement of HKP/FSD Radio Asset (Fix Repeater)

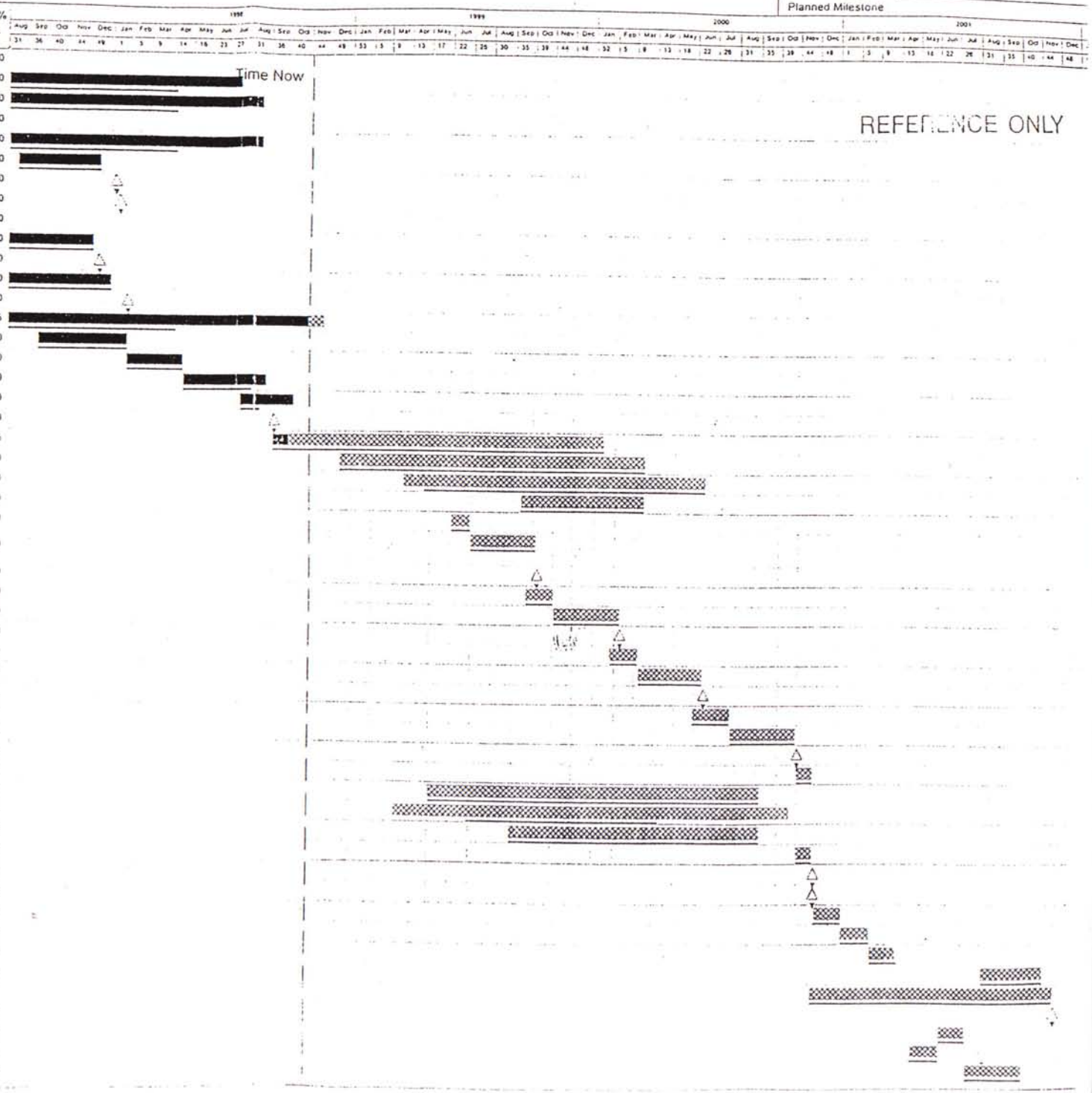
Detail Programme

Run: 23Nov01 05/11/98

Phy. % Comp. Milestone Baseline Planned Milestone

CLIENT ORGANIZATION's GANTT CHART SAMPLE

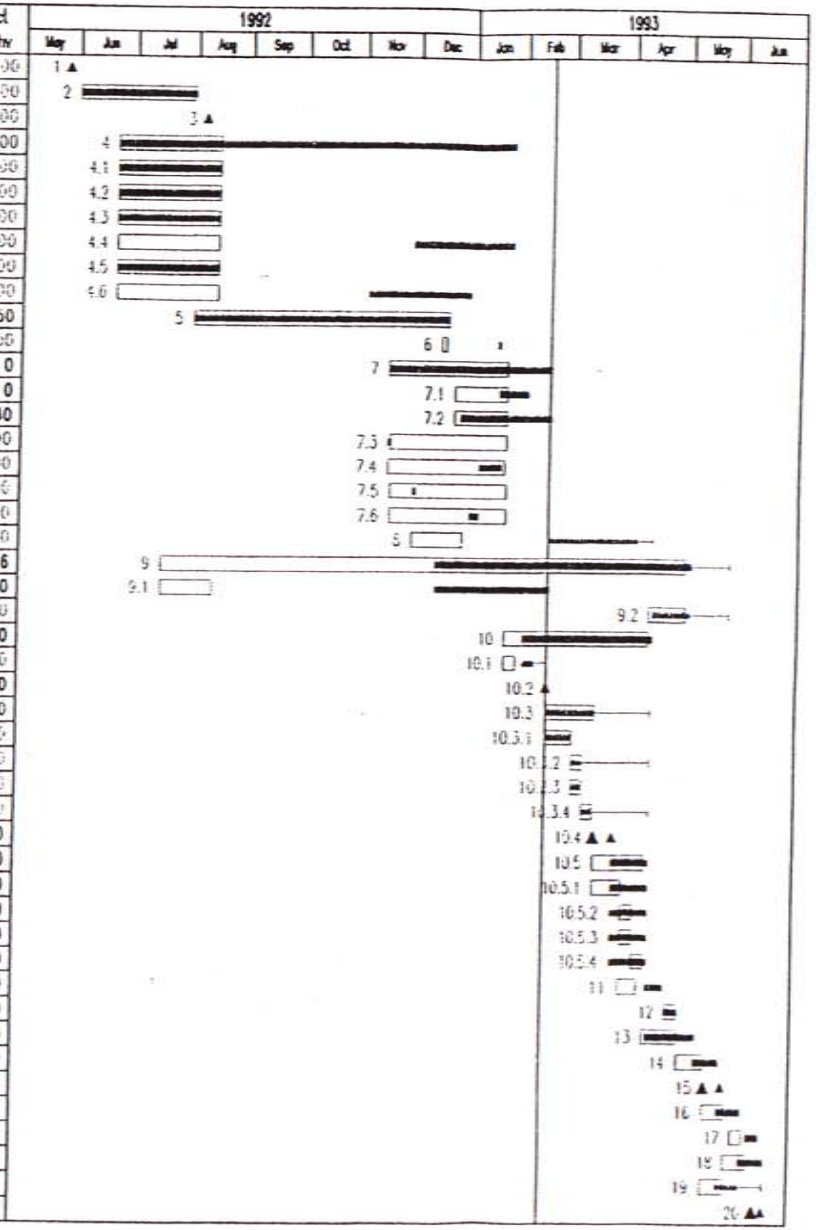
Activity ID	Activity Description	Early Start	Early Finish	Rem. Dur.	Phy. % Cmp.
11	Project Team Mission Statement	15Oct96	30Nov96	0	100
12	Detailed CRB	15Feb95	16Jul98	0	100
13	Preliminary Project Plan	01Dec96	18Aug98	0	100
14	PDP (RHKP)	01Jul96	31Aug96	0	100
15	PDP (FSD)	01Jul97	18Aug98	0	100
16	Pre-Qualification	14Aug97	12Dec97	0	100
17	Main Exec. Approval (Tdr'r List)	02Jan98	02Jan98	0	100
18	Board Approval (Tdr'r List)	08Jan98	08Jan98	0	100
19	MTRC Safety Plan	30Apr97	30Apr97	0	100
21	Project Approval (HKP E-Paper)	15Jul97	03Dec97	0	100
22	OEMC Approval (HKP E-Paper)	10Dec97	10Dec97	0	100
23	Project Appl (FSD & C4408 LCX) (Joint E-Paper)	15Jul97	29Dec97	0	100
25	OEMC Approval (FSD & C4408 LCX)	21Jan98	21Jan98	0	100
27	Proj. Safety & Quality Plan	15Jul97	20Nov98	15d	95
28	Tender Document Preparation	15Sep97	21Jan98	0	100
29	Tendering	21Jan98	15Apr98	0	100
31	Tender Assessment	15Apr98	26Aug98	0	100
32	F1 Application	16Jul98	08Oct98	0	100
33	Contract Award	04Sep98	04Sep98	0	100
34	Design Submission/Approval	04Sep98	14Jan00	302d	5
35	Manufacture	16Dec98	16Mar00	311d	0
37	Installation	22Mar99	15Jun00	388d	0
38	Safety Audit	13Sep99	14Mar00	126d	0
39A	Section 1 Comm'g. System Acceptance & Cut-Over	03Jun99	30Jun99	24d	0
39B	Section 1 Reliability Demo Test & C4348.01 TWL Migration	01Jul99	05Oct99	83d	0
39C	Section 1 Completion	05Oct99	05Oct99	0	0
41A	Section 2 Comm'g. System Acceptance & Cut-Over	22Sep99	02Nov99	36d	0
41B	Section 2 Reliability Demo Test & C4348.01 KTL Migration	03Nov99	08Feb00	84d	0
41C	Section 2 Completion	08Feb00	08Feb00	0	0
42A	Section 3 Comm'g. System Acceptance & Cut-Over	26Jan00	07Mar00	36d	0
42B	Section 3 Reliability Demo Test & C4348.01 KTL Migration	08Mar00	13Jun00	84d	0
42C	Section 3 Completion	13Jun00	13Jun00	0	0
43A	Section 4 Comm'g. System Acceptance & Cut-Over	30May00	24Jul00	48d	0
43B	Section 4 Reliability Demostration Test	25Jul00	30Oct00	84d	0
43C	Section 4 Completion	30Oct00	30Oct00	0	0
44	Decommissioning of HKP System	31Oct00	24Nov00	22d	0
45	Documentation	03May99	05Sep00	339d	0
46	Training	10Mar99	20Oct00	405d	0
47	Spares Delivery	30Aug99	05Sep00	256d	0
51	Final Inspection	31Oct00	24Nov00	19d	0
52	Whole of Works Completion	24Nov00	24Nov00	0	0
53	Completion Certificate	24Nov00	24Nov00	0	0
54	1st Ctr'r P/A Report (C42A)	28Nov00	08Jan01	27d	0
55	Project Comp'n Review Report	09Jan01	19Feb01	29d	0
56	Asset Capitalization	20Feb01	30Mar01	29d	0
58	Decommissioning of Existing FSD Cable and Accessories	08Aug01	07Nov01	79d	0
59	Maintenance Period	24Nov00	23Nov01	365d	0
61	Maintenance Certificate	23Nov01	23Nov01	0	0
62	Close F1	06Jun01	16Jul01	28d	0
63	Final Ctr'r P/A Form (C42B)	24Apr01	06Jun01	30d	0
64	Post Completion Evaluation	17Jul01	10Oct01	60d	0



CONTRACTOR ORGANIZATION GANIT CHART SAMPLE

TAMAR MICROWAVE LINK – MASTER PROGRAMME

WBS	Task Type	Task Name	Start Date	End Date	Durath (Days)	Reer	Pct Activ
1	FIXED	CONTRACT AWARD	20 May 1992	20 May 1992	0		100
2	ASAP	DETAILED DESIGN	1 Jun 1992	30 Jul 1992	49.5	SD	100
3	FIXED	DESIGN APPROVAL COMPLETED	6 Aug 1992	6 Aug 1992	0		100
4	SUMMARY	EQUIPMENT PURCHASING	22 Jun 1992	25 Jan 1993	172.3	SD	100
4.1	ASAP	SAT Microwave Equipment	22 Jun 1992	14 Aug 1992	44	SD	100
4.2	ASAP	Nokia PCM Equipment	22 Jun 1992	14 Aug 1992	44	SD	100
4.3	ASAP	Andrew Antenna, etc	22 Jun 1992	14 Aug 1992	44	SD	100
4.4	ASAP	Andrew Waveguide, etc	27 Nov 1992	25 Jan 1993	44	SD	100
4.5	ASAP	Harner & Simon Power Supply	22 Jun 1992	14 Aug 1992	44	SD	100
4.6	ASAP	Rechargerable Battery	4 Nov 1992	30 Dec 1992	44	SD	100
5	ASAP	EQUIPMENT MANUFACTURING	3 Aug 1992	16 Dec 1992	110		50
6	ASAP	FACTORY ACCPT TEST & INSPECTN	18 Jan 1993	18 Jan 1993	1	SD	100
7	SUMMARY	EQUIPMENT DELIVERY	16 Nov 1992	16 Feb 1993	71.5	SD	0
7.1	FIXED	SAT Microwave Equipment	18 Jan 1993	2 Feb 1993	12	SD	0
7.2	FIXED	Nokia PCM Equipment	24 Dec 1992	16 Feb 1993	40	SD	80
7.3	FIXED	Andrew Antenna, etc	16 Nov 1992	16 Nov 1992	1	SD	100
7.4	ASAP	Andrew Waveguide, etc	7 Jan 1993	19 Jan 1993	10	SD	100
7.5	FIXED	Harner & Simon Power Supply	30 Nov 1992	30 Nov 1992	1	SD	100
7.6	ASAP	Rechargerable Battery	31 Dec 1992	6 Jan 1993	4	SD	100
8	ASAP	TEST PLAN PREPARATION	16 Feb 1993	5 Apr 1993	39	SD	0
9	SUMMARY	EQUIPMENT TYPE APPROVAL	11 Dec 1992	4 May 1993	111.9	SD	6
9.1	FIXED	Documents Submission	11 Dec 1992	16 Feb 1993	50	SD	10
9.2	ASAP	Equipment Tests (for DPO)	14 Apr 1993	4 May 1993	16	SD	0
10	SUMMARY	INSTALLATION	2 Feb 1993	14 Apr 1993	56.5		0
10.1	ASAP	Internal Bench Test	2 Feb 1993	8 Feb 1993	5	OP	0
10.2	FIXED	TAMAR Ready For Access	16 Feb 1993	16 Feb 1993	0		0
10.3	SUMMARY	Installation At TAMAR	16 Feb 1993	15 Mar 1993	22	OP	0
10.3.1	ASAP	cabinets & equipment	16 Feb 1993	2 Mar 1993	12	OP	0
10.3.2	ASAP	battery charger	2 Mar 1993	9 Mar 1993	5	OP	0
10.3.3	ASAP	antenna & pressurization eqmt	2 Mar 1993	9 Mar 1993	5	OP	0
10.3.4	ASAP	waveguide cables	9 Mar 1993	15 Mar 1993	5	OP	0
10.4	FIXED	STONECUTTER Ready For Access	25 Mar 1993	25 Mar 1993	0		0
10.5	SUMMARY	Installation At STONECUTTER	25 Mar 1993	14 Apr 1993	16	OP	0
10.5.1	ASAP	cabinets & equipment	25 Mar 1993	14 Apr 1993	16	OP	0
10.5.2	ASAP	battery charger	25 Mar 1993	14 Apr 1993	16	OP	0
10.5.3	ASAP	antenna & pressurization eqmt	25 Mar 1993	14 Apr 1993	16	OP	0
10.5.4	ASAP	waveguide cables	25 Mar 1993	14 Apr 1993	16	OP	0
11	FIXED	ON-SITE TRAINING (SAT TO CSL)	14 Apr 1993	23 Apr 1993	8	SD	0
12	FIXED	O & M Training on SAT equip.	26 Apr 1993	30 Apr 1993	5	SD	0
13	ASAP	EQUIPMENT SITE TEST (for JSSS)	14 Apr 1993	10 May 1993	21	OP	0
14	ASAP	SYSTEM COMMISSIONING	10 May 1993	24 May 1993	11	OP	0
15	FIXED	SYSTEM SUBSTANIAL COMPLETION	26 May 1993	26 May 1993	0		0
16	ASAP	TRAINING MANUAL PREPARATION	24 May 1993	4 Jun 1993	10	SD	0
17	FIXED	O & M Training on PCM equip.	9 Jun 1993	15 Jun 1993	5	SD	0
18	ASAP	O&M MANUAL PREPARATN	4 Jun 1993	17 Jun 1993	10	SD	0
19	ASAP	AS-BUILT DRAWINGS PREPARATN	24 May 1993	4 Jun 1993	10	OP	0
20	FIXED	AS-BUILT, O&M MANUAL SUBMISSN	17 Jun 1993	17 Jun 1993	0	SD	0



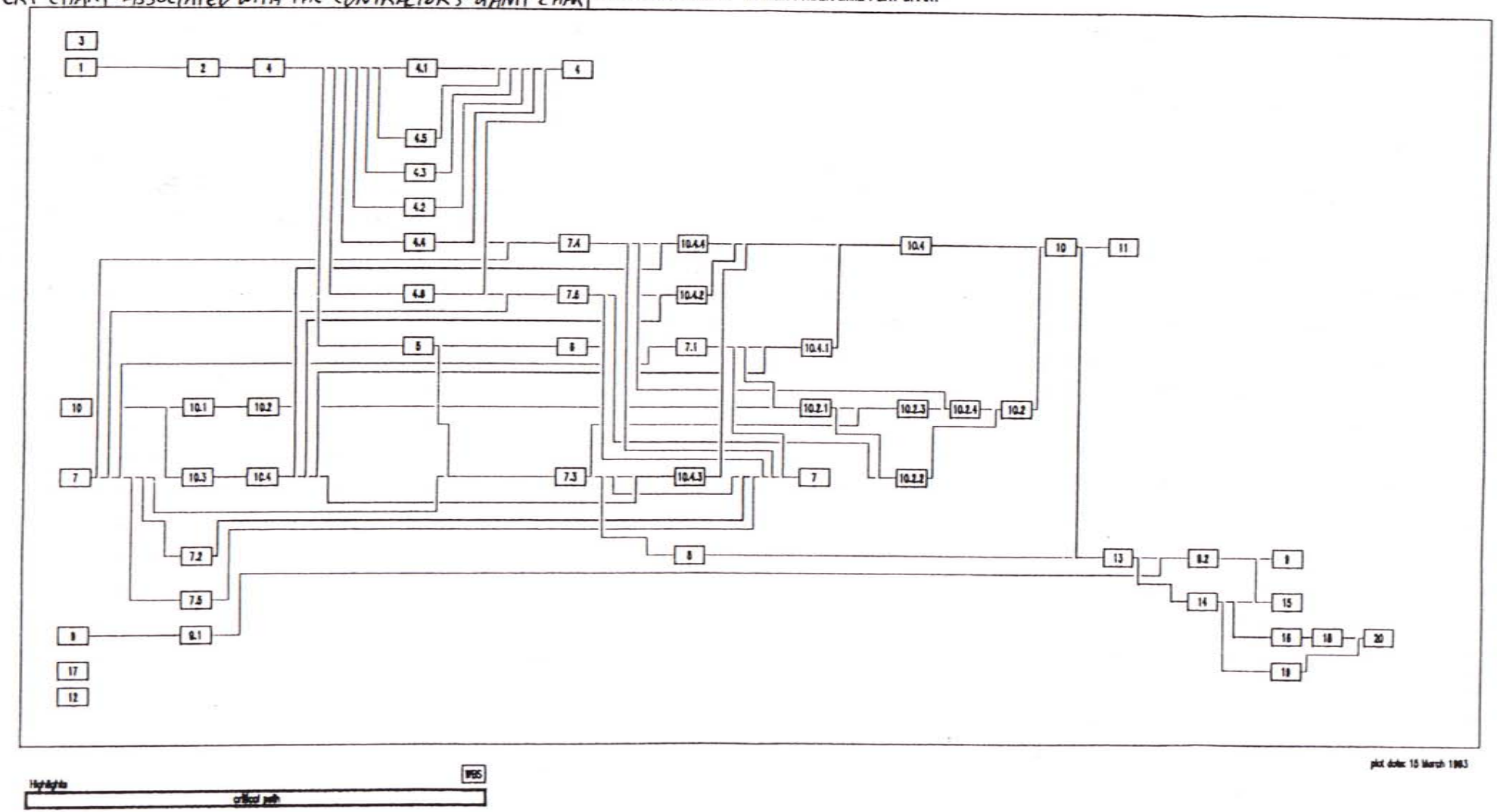
Highlights: Baseline | Actual | Milestone | Slack

critical path

Plot date : 15 February 1993

(Timeline 4.5)

PERT CHART ASSOCIATED WITH THE CONTRACTOR'S GANTT CHART



(Software
Timeline 4.0).

Appendix 6

Project Completion Review

Ref & Issue No: PRC 953 -Rev 0	Capital Work No.C4021.05	Date: 15th August 1997
Contract No : C953-91(E)	Contractor : MAPAL	

CONTENTS

Ref & Issue No: PRC 953 -Rev 0	Capital Work No.C4021.05	Date: 15th August 1997
Contract No : C953-91(E)	Contractor : MAPAL	

8. **Safety and Quality**

8.1 System Design Safety
8.2 Contractor/Industrial Safety
8.3 Risk Assessment
8.4 Safety Certification/Statutory Requirements
8.5 Inspecting Officer of Railways
8.6 System Design Quality
8.7 Quality Audit

9. **Overall Comments**

10. **Attachment**

10.1 Management Action List **(Not Applicable)**
10.2 Form 42a Assessment of Contractor Performance
10.3 Mission Statement
10.4 Summary of Form C/ Engineer's Instructions/ Variation Orders
10.5 Project Capitalization Matrix
10.6 Fault Trend during Reliability Monitoring Period

Ref & Issue No: PRC 953 -Rev 0	Capital Work No.C4021.05	Date: 15th August 1997
Contract No : C953-91(E)	Contractor : MAPAL	

II. PART B - For Submission After Maintenance Certificate is Issued

11. **Post Contract Review Report**

- 11.1 Completion of Outstanding Works
- 11.2 System Availability and Reliability/Fault Trend
- 11.3 Defect Rectification
- 11.4 Final Account of Project Costs
- 11.5 Summary and Recommendation

12. **Attachment**

- 12.1 Form 42b Assessment of Contractor Performance
- 12.2 Final Project Capitalization Matrix
- 12.3 Fault Trend
- 12.4 Master Programme (Baseline)

Note :

Part of the assessment is written to score system. The score is explained as follows :-

1. Poor and not acceptable
2. Below expectation but acceptable
3. Meeting expectation/ criteria
4. Above expectation
5. Excellent

Appendix 7

Fault Tee Analysis

	FSD are Informed of the MIK Incident	MCU Arrives at Station within Suitable Timescale	FSD Set up, Bring Down and Receive Equipment Within Required Timescale	Equipment Works Successfully	Communications are Clear and Legible With no confusion	Frequency	Fault Sequence	Fault Category	Minor Injuries	Major Injuries	Fatalities	Equivalent Fatalities	Risk
				9.00E-01 Y	9.00E-01 Y	1.80E-02	1 FSD provide assistance according to plan.	B	5	1	0	0.15	2.71E-03
			9.50E-01 Y		N 1.00E-01	2.01E-03	2 FSD provide assistance according to plan however, the communications are unclear.	C	10	2	0	0.3	6.02E-04
		7.50E-01 Y		N 1.00E-01	9.00E-01 Y	2.23E-03	3 FSD arrive to provide assistance, however the equipment fails.	E	50	10	3	4.5	1.00E-02
	9.99E-01 Y			9.00E-01 Y		9.50E-04	4 FSD arrive but do not set up equip. in required timescale, but equip. works and is clear.	E	10	2	1	1.3	1.23E-03
			N 5.00E-02		N 1.00E-01	1.06E-04	5 FSD arrive, but do not set up equip. in time. The equip. works, but the communications are unclear.	E	20	4	2	2.6	2.74E-04
3.13E-02 STATION FIRE				N 1.00E-01		1.17E-04	6 FSD arrive within the required time, but the equipment is not set up in time and it fails.	E	100	20	7	10	1.17E-03
				9.00E-01 Y	9.00E-01 Y	6.33E-03	7 The FSD do not arrive in time, but the equip. is set up in time and communications are clear.	E	35	4	2	2.55	1.61E-02
		N 2.50E-01			N 1.00E-01	7.04E-04	8 The FSD do not arrive in time. The equip. is set up in time, but communications are not clear.	E	30	8	4	5.1	3.59E-03
				N 1.00E-01		7.82E-04	9 The FSD do not arrive in time. The equip. is set up in time, but it fails.	E	200	40	15	21	1.64E-02
	N 1.00E-03					3.13E-05	10 MTRC deal with Incident without assistance	E	400	80	30	42	1.31E-03
												Total	5.35E-02

Node Justification:

1 - Same as for current situation. This will never change due to new equipment.
2 - Same as for current situation
3 - FSD are required to hand out correct radios from tenders. There may be the potential for human error in handing out radios, however no setting up is required.
as it has to be carried out in smoky conditions.
4 - More likely to work as the radios will new and there will be new fixed repeater
5 - Same as for the current situation

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