Industrial Project Management: Methods, Issues And Strategies

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ABSTRACT

In an increasingly competitive market place, where the trend is to capture and retain growing market demand, number of investment strategies are to be identified, developed and implemented to achieve remarkable success in business growth. Expertise in project management is the needed know-how for achieving success in such rapidly growing business environment. From inception to operation, an industrial project must pass through three major fundamental phases, viz.: Development, Implementation and Operation. All these phases are to be planned, Scheduled and executed within the targets set for time, quality and cost. During these phases various issues are faced and various strategies are adopted to manage the project efficiently. This paper discusses some of the methods, issues and strategies relating to industrial project management.

Key Words: *Development-Implementation-Operation*
Planning-Scheduling-Execution:
Time-Quality-Cost

INTRODUCTION

Project, the term is widely used to define any capital expenditure scheme involving current outlay of funds in the expectation of stream of benefits extending far into the future. It may be development of an application software or installation of a green field industrial unit. The driving force for projects is the demand for various products and services. Demand for various products or services increases due to increase in population and the quest for better standard of living. Business units compete to capture this growing markets or strive to retain existing market. This leads to various investment strategies such as, replacement, renovation, modernization, Expansion, Vertical integration. diversification, etc. The critical factors which decide which strategy to adopt are market conditions resources available, profitability and needs of project fund providers.

For example, if we assume that capacity expansion is the selected strategy then it is necessary to determine the capacity of the new units to be installed. Size of the new unit is an important parameter in capacity expansion strategy in present competitive market. The importance of this project parameter can be better understood if we look into the sales of five top companies (Per Gundersby 1996) as a percentage of word industry total for the year 1992.

As can be seen in **Fig.1** in the year 1992, about 60% of cars and trucks in the world were produced by 5 top companies in that industry and 20% of the forest products were produced by 5 top companies in the world in the forest product industry. The reason for such consolidation is explained further.

Thirty years ago, size of industrial units built were smaller. But today, due to rapid development in technology, clusters of huge units are built to achieve lower operating cost. Each new project has production capacity greater than last project to enable the new project to compete with the lowest operating cost producers. Large size project have long term effects, they are irreversible and involve substantial outlays. As the size of the unit to be built increases, resources required also increases. For such projects to be successful the engineering, implementation and progress monitoring system should be well established. Hence careful planning of all project activities is vital to save time and cost as well as achieve highest quality. This paper sequentially, discusses methods, issues and strategies for efficient

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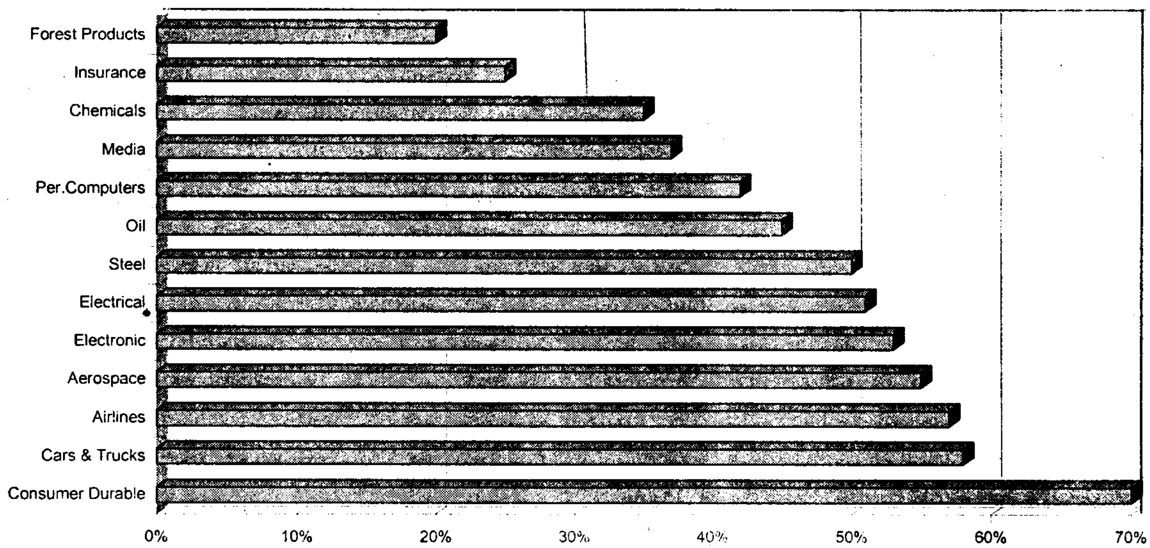
FIG.1 - CONSOLIDATION OF INDUSTRIES



management of large project relating to continuous process industry. However, the concepts are applicable for engineering & service industries.

METHODOLOGY

Project management has three fundamental phases, namely, development, implementation and operation. Each phase has several stages and these are discussed in this section.

DEVELOPMENT PHASE

Development phase involving, identification study, pre-feasibility and detailed feasibility analysis, decides whether to implement a project or not ? and whether a project is technically feasible, economically viable and commercially successful?. While an overview of development phase is discussed here, a detailed discussion can be found else where (Prasana Chandra, 1995).

Identification Study

Identification study, generates ideas by SWOT analysis. Strengths and weaknesses can be determined by evaluating marketing and distribution, production and operation, R & D, corporate resources and personnel, Raw material survey, finance & accounting aspects, etc. Opportunities and threats can be identified by analyzing economic aspects, available resources, government policies and regulations, technological developments, social and demographic aspects, competition, existing industry problems, and strategies and objectives, etc.

For example, the significant and sudden increase in newsprint and paper import (Asia Pacific Paper Maker, July 97) in India has ultimately resulted in increased idle capacity in Paper manufacturing to a level of 33% for printing and writing paper and 46% for newsprint (PPI This week, May 97). As this is a threat to the Indian Industry, the manufacturer has to look for opportunities for reducing the production cost so as to be competitive. Some such opportunities are (1) replacement of inefficient (high specific energy consuming equipment) process equipment and utility systems (low specific energy generating equipment) with modern efficient process equipment and utility systems. Typical example is higher cogenerated power by using 100 to 130 kg/sq.cm steam. (ii) renovation and modernization of pulping and paper making process with the new technology that has been developed to achieve increase in productivity. For example rebuilding of an existing paper machine with modern technology such as gap former, shoe press, optireel, power transmission equipment, etc. (Jyrki Mustaniemi, 1997) increases productivity.

Pre-feasibility Study

Pre-feasibility analysis involve preliminary screening of identified projects to assess whether a project is prima facie worth while to justify a detailed feasibility study and what aspects of the project are critical to its viability and hence warrant an in-depth investigation. For example, for a country like Singapore where waste paper recovery is high, installation of packaging and tissue paper producing mills

Table-1							
Computation of typical project rating index							
Factors	**Factor Weight**	**Rating-Very Good**	**Rating Good**	**Rating Average**	**Rating Poor**	**Rating Very Poor**	**Factor Score**
(Rating weight)⟶		5	4	3	2	1	
Raw material availability	0.20	5					1.00
Water availability	0.20				2		0.40
Power availability	0.15			3			0.45
Potential Market	0.20	5					1.00
Government support	0.15		4				0.60
Technology availability	0.10	5					0.50
Total of factor weight	1.00						
RATING INDEX							3.95

based on waste paper is highly feasible proposal and warrant an in depth study.

Factors relevant to projects such as raw material supply, market prospects, technology requirements, cost competitiveness, capital requirements, infrastructure, environmental considerations, profitability, compatibility with promoter, consistency with government priorities, risk level, etc., are then identified for each project. Weights are assigned to theses factors and these factors are rated on a 5 point scale for each project. Factor score is obtained by the product of weight and rating. Total of all factor scores give the rating index. Projects are selected based on this project rating index (e.g. shown in Table-1) for further detailed feasibility study.

Detailed Feasibility study

Detailed feasibility study is the detailed analysis of market, technical, financial, economic and ecological aspects of the projects.

Market Analysis

Market analysis is concerned with forecasting of market potential and market share of the project under appraisal by characterizing the market from primary as well as secondary information. Primary source of information is the information obtained through, the so called, Market survey or sample survey which ascertains consumer attitudes, preferences, behavior, etc. Typical sources of secondary information are census data, national sample survey reports, annual year reports of industries, stock exchange directory, journals and magazines, competitors' publications, middle men, etc. However, in today's competitive world, it is advantageous to avoid any middle men and have direct contact with customers and consumers for continuous survival in the market.

The information so collected is further refined to arrive at the demand for the product in the future, likely share of the market by the competitors and proposed share by the project under study. Also suitable marketing plan comprising strategy for pricing, distribution channels, promotions, brand strategy, after sales services, etc., should be suitably analyzed and concrete proposals should be established.

Technical Analysis

Technical analysis is the study of location, capacity, product-mix, process and technology, and inputs required so as to determine whether the project is technically viable and have sensible choices. For example, selection of a particular location is influenced by the factors such as proximity to raw materials, inputs and market, government concessions and regulations, etc. The capacity of the plant to be established depends upon the estimated market share, technological requirements, economical size, investment cost, input requirements, resources that can be mobilized by the firm, government approval requirement, economy of scale, etc. For example to be competitive in the pulp and paper market, in

Indonesia, capacity of a modern pulp mill is in the range of 2000 to 3000 tones per day and that of a modern paper machine is in the range of 800 to 1200 tons per day (Martin Bayliss, 1996). Obviously the advantage is the low cost of production.

The technology should be flexible to take care of fluctuation in market demand. For example, Tamilnadu newsprint and paper Ltd's (Prospectus, The TNPL issue, 1995), expansion project has the flexibility to shift product mix between Newsprint and Printing and writing paper depending upon market situation.

Financial Analysis

Financial analysis ascertains whether the proposed project will be financially viable in the sense of being able to meet the burden of servicing debt (risk) and whether proposed project will satisfy the expectations (return) of those who provide the capital.

To judge a project from financial angle, following data are estimated: Cost of project, means of financing, estimates of sales and production, cost of production, working capital requirement and its financing, working results such as profitability projections, break-even point, project cash flow statements and projected balance sheets.

Typical components of cost of project are cost of main machinery, auxiliary items, spares, electrical equipment, instrument items, automation items, civil work, equipment/items installation and overheads. The various sources of finance are the share capital, term loans, export credit, government incentives, public deposits, etc. Estimates of sales and production depends on the start-up and depends on the market acceptance and market reactions for subsequent years. The components of cost of production are the cost of raw material and other inputs such as utilities, chemicals etc., cost of labor and overheads. Working capital requirement consists of inputs, stock of goods in process, stock of finished goods, debtors and operating expenses. The sources of working capital are commercial banks, trade credit, long term sources of financing. Using above estimations, profitability projections, cash flow statements and break even point are computed and balance sheet is prepared.

Economic Analysis

Economic analysis refers to the social cost benefit analysis (shadow prices and other impacts). It is a methodology for evaluating projects from the social point of view. An example of social cost are deforestation costs due to setting up of an industrial unit in forest areas. The social benefit may be reduction in import of a particular product there by saving the foreign exchange.

In today's rapid industrialization in developing countries, there is an upper limit for importing plant and machinery for capital projects, for each year. Hence if a project requires capital imports, it is important to see that, the spending pattern and earning pattern related to the project does not affect the trade imbalance and there by devaluation of currency which is a social cost.

Ecological analysis

Ecological analysis deals with environmental concerns, like pollution of land, water and air, etc. Environmental damages due to the use of non renewable resources and restoration measures are dealt in this analysis. Regulation by local government with regard to environmental issues should be considered in this analysis. However in the international context, more severe environmental control concepts demand for embedding the environmental strength of a company in marketing of their products. For example in Europe (Heikki Manisto, et al, 1996) product labeling criteria is developed to inform consumers about environmental impact of the products produced by a particular mill. Typical factors considered for scoring of eco-labeling load points are use of non-renewable resources, use of renewable resources, CO_2 emissions, SO_2 discharges, COD doscharges, AOX discharges, waste generation, etc. Hence provisions should be considered for obtaining higher scoring of eco-labeling load points. This eco-labling concept is emerging because of the fact that the use of environmental strengths as marketing assets may lead the industry to adopt severe measures for lowering the environmental impacts even more rapidly than government regulation would achieve.

Selection of Projects

In selection of projects, appraisal criteria commonly used are NPV, B/C ratio, IRR and discounted pay back period. Of all these superior is NPV. However, social cost and benefits and environmental issues are to be taken care in the final selection of projects. In case of multiple project mathematical programming techniques are useful tools to select projects in view of various constraints.

A detailed feasibility report (also called as bankable report) is then prepared, with sufficient information to demonstrate the viability of the project to lending institutions. Once feasibility report is approved by fund providers, then the final go ahead decision is taken and the button is pressed for implementation of the project.

IMPLEMENTATION PHASE

Implementation phase consists of basic engineering, tendering of main machinery and equipment, receiving & evaluation of offers, preparing of time schedules and budget estimates, tender negotiation and awarding of contracts, detail engineering, procurement of bulk materials, civil construction, equipment erection, check-out, commissioning, training, start-up and test run. During implementation phase, a system for marketing and brand development is also implemented so that when products are produced they are absorbed in the market immediately.

Basic Engineering

The purpose of basic engineering is

- To determine the scope and extent of work required for the implementation.
- To define basic design criteria, engineering standards and project instructions for engineering disciplines.
- To prepare and issue tenders to pre-qualified vendors and evaluate offers.
- To prepare master time schedule and budget.
- To define a plan for operation of the mill.

The basic engineering design depends on the process complexity and can be extended or modified to include additional information depending on the requirement.

Basic Progress engineering

- Analysis and selection of suitable process technology considering future changes in input and output.
- Mill capacity philosophy based on present and future requirements.
- Design criteria for annual and daily production basis, the departmental design data, equipment sizes and capacities for each department including utility.
- Over all development plan and future expansion.
- Process flow diagrams and process description.
- Mass, head and energy balances.
- Basic process requirements for main machinery and process equipment.
- Utility and effluent summary.

Computer simulation greatly help in visualizing and evaluating different options in process design and selecting the most suitable and economical process design (e.g. Arivalagan A et al., 1993, 1995).

Basic Layout Engineering

- Main dimension of equipment in mill master layout with necessary sectional drawings of main equipment arrangement, storage yards, stores, warehouses, product loading and dispatch areas, etc.

Basic Civil Engineering

- Soil testing and foundation requirements
- Basic building frame design
- Basic structural and architectural requirements
- Painting and colour code for building

Basic Mechanical Engineering

- Master equipment list & equipment description with specification
- Specification for piping, Valves, tanks, material handling system, insulation, sprinkler and fire protection system, ventilation, paintings, etc.

Basic Electrical Engineering

- Estimation of power and energy requirements.
- Specification for power generation and distribution system.
- Single line diagram and capacity of transformers.
- Space requirements for electrical rooms in layout.
- Specifications for motors, variable speed drives, motor control center, lighting levels, grounding system, etc.
- Heat loads and air conditioning requirements for electrical rooms.

Basic Instrumentation and Automation Engineering

- Scope, purpose and degree of instrumentation and automation.
- Technical description of control system and degree of decentralization.
- Specification of instruments and control valves.
- Principles of selecting instruments and control valves, their installation and labeling.
- Requirements for control rooms and rack rooms in layout.
- Air and power requirements for instruments and Automation.
- Heat loads and air-conditioning requirements for control and rack rooms.
- Specification for connections between instruments, process equipment, electrical system and automation system.

Tendering & Evaluation of offers

Procurement activities start by floating bids for the major process equipment in the form of main packages as well as for standard auxiliary equipment such as cranes, material handling systems, electrical items, automation systems, etc. Design standard for various packages and standard equipment are incorporated in the bid document. Battery limit for scope of supply and scope of services such as engineering, supervision of erection, commissioning and start-up are clearly defined. Performance guarantee parameters, testing methods, equipment warranty requirements, standard general commercial terms and conditions of contract are included in the bid document. Time scheduling for the overall project completion, engineering document deliverables, equipment deliverables, supervisory services are also included.

The bidding procedure for project may be ICB (international competitive bidding) or LCB (local competitive bidding) or a combination of both depending upon availability of required technology in the local country or for searching an improved or innovative technology around the globe. In some cases financial institutions (for example World Bank) specify a condition that bidding should be an ICB while sanctioning the loans in order to have healthy competition.

In case of turnkey contracts for large complex plants and equipment, it is necessary to adopt two stage bidding procedure. The first stage bid consists of basic conceptual design inviting technical proposals with out price, which is subject to technical as well as clarifications and adjustments to be followed by amended bidding documents and submission of final technical proposals and priced bids in the second stage.

Offers from vendors are received in stipulated time and are evaluated and a detailed recommendation is made for starting negotiations with prospective vendors. The evaluation and selection of vendors for the supply of major packages is an important decision for the project. While there exists various methods for evaluation, one typical evaluation method is outlined in the **Table #2.**

Master Time Schedule

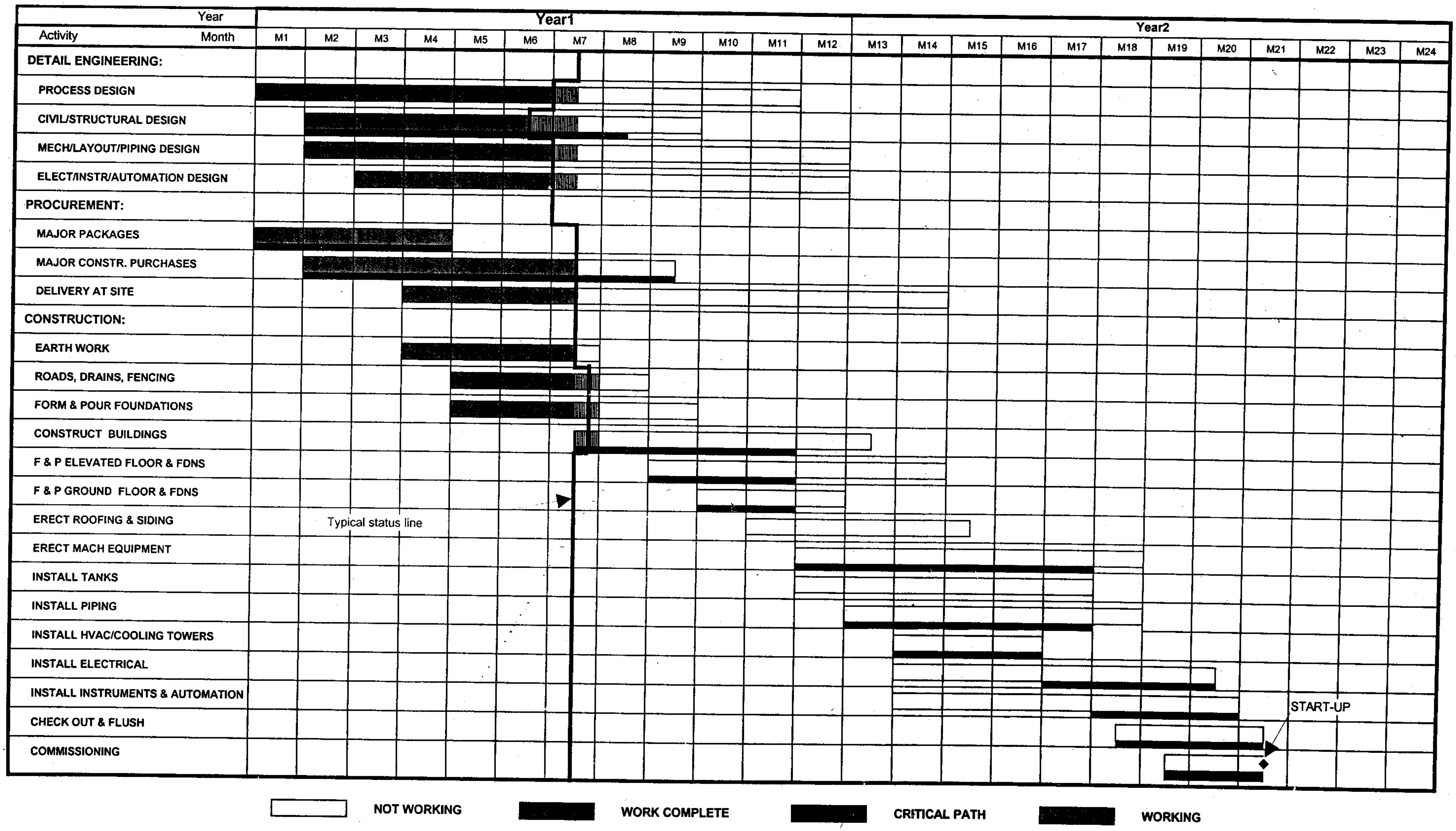
A master time schedule, also called as level-1 schedule, is a highly summarized schedule showing the major activities of the project such as details engineering, procurement and delivery of main equipment as well as bulk materials to site, civil construction, erection of equipment, fabrication and erection of tanks, installation of pipes, installation of electrical, instrumentation as well as automation systems. Also in the level 1 schedule, critical activities and key mile stones are high lighted and will be used for monitoring and control of total project. A typical master time schedule is shown in **Fig.2** It serves as a basis for rough estimates for various resources required over the period of time. It is most useful for the strategic planning and subsequently for progress monitoring during implementation by top management. Based on the master schedule and delivery time quoted by vendors in their offer, erection time required for each equipment and the sequential logic in integrating the multidiscipline engineering activities, a detailed procurement schedule is prepared for negotiating and finalizing contracts for detail engineering, main equipment packages, auxiliary items, bulk materials, civil work, MEI installation, etc.

Investment Budget

The pre-request for preparing the investment budget is the completion of evaluation of bids received from vendors for major packages. Also all the auxiliaries as well as scope of services excluded in the vendor's scope of supply but necessary for completion of project, are clearly identified and specified in cost estimation. The major components of project cost

Table # 2.				
Typical Evaluation method for International Competitive Bidding				
S.No	**Description**	**Unit**	**Vendor A**	**Vendor B**
1.	Description of package		Process Equipment	Process equipment
2.	CIF at domestic Port	US$	36 million	45 million
3.	Inclusion/Exclusion in Scope of supply			
	All electrical motors		included	excluded
	All Pumps		excluded	included
	All pipes and fittings		excluded	included
	Instruments & control		included	excluded
4.	Performance guarantee			
	Production	t/h	100+/-5%	100+/-5%
	Raw material consumption	t/h	115	110
	Power consumption	KWh/t	4000	3800
	Steam consumption	t/h	100	100
5.	Equated Price			
	Offered Price CIF	US$	35,000,000	45,000,000
	Cost of items excluded CIF	US$	4,500,000	3,500,000
	Total CIF equivalent	US$	39,500,000	48,500,000
	Freight to Site	US$	197,500	242,500
	Landed cost at Site	US$	39,697,500	48,742,500
	Installation cost @ 7.5%	US$	2,977,312	3,655,687
	Installed Cost	US$	42,674,812	52,398,187
	Extra raw material cost/year	US$	500,000	0
	Extra energy cost/year	US$	7,700,000	0
	Total extra Operating cost	US$	8,200,000	0
	NPV of extra Operating cost at (i=18%, n=20 years)	US$	47,948,434	0
	Total net present equated Cost	US$	90,623,247	52,398,187

FIG NO. 2 - MASTER PROJECT SCHEDULE (Typical)



are engineering cost, equipment cost, civil construction cost, installation cost, administration and support services cost, infrastructure cost, duty, freight, insurance, custom clearance and inland transport, pre-operating expenses and contingency. Using the offers received for bids and from past experience a detailed investment budget is prepared for the project. Assumptions made in budget are clearly indicated. Estimate are compared with industrial standard to make sure that they are correct to maximum possible extend.

Operations Plan

The operations plan include

- Development of production strategies.
- Organization structure, recruitment schedule & training.
- Predication of start-up curve.
- Estimation of pre start up costs and working capital.

For example, in a pulp mill expansion project a new recovery boiler can be started with existing mill black liquor even though there appears a delay in completion of other connected process plants. Similarly in a new paper mill project, converting equipment can be commissioned by using purchased paper rolls before the start of the connected new paper machine. In another example, when the paper machine started producing, roll can be sold in the market and later on sheet order can be taken up when the converting plant is ready for start-up. Also this will help in knowing the market reactions so that better strategies can be adopted.

The skilled manpower required for operating the plant are recruited much in advance, preferably at the time of signing major equipment package contracts or at the start of detail engineering, so that operation and maintenance aspects are taken care of during design stage.

Basic Engineering report

After the basic engineering work is completed the findings are compiled in the form of a engineering report covering main technical features, budget estimates, location and layout drawings, process flow diagrams, operational plan and strategy for production, etc.

Tender Negotiation and contracting

Contracts for Main Equipment and frame contract Bulk materials

Based on evaluation reports made during basic engineering phase, tender negotiation starts for finalizing the award of contracts for major packages and frame contracts for bulk materials by inviting the vendors in accordance with the procurement time schedule. The vendor is allowed to make a presentation of their offer highlighting their main technical features. Clarification required for various technical details and missing information, incorrect or incomplete information are obtained from vendors with regard to technical data and guarantee, technical specification and delivery limit with drawings, time schedule for delivery of drawings and documents as well as equipment, mill standards and quality assurance. After technical negotiations are completed, commercial terms and conditions are discussed, agreed and signed including contract documents, general contract conditions, general marking, packing and shipping instructions, monthly progress reporting, invoicing, financial agents, rate for additional supervision services, liaison agents, vendors weekly reporting at job site, delivery check list, etc. Contracts are finalized after completion of commercial negotiation and detailed engineering starts once contract is effective.

Detail Engineering

Detail engineering is an important multidiscipline design integration for construction involving engineering communication and document exchange among equipment vendors and construction contractors as well as the project team. Integrating their respective designs for construction is a complex task for the project management. This integration is hardly achieved in real world due to many reasons. The contractor is frequently left to integrate each discipline's and vendor's design during construction. Plant operability, easy of maintenance, energy integration, process hazards, plant buildability, etc., are all important in detail engineering. If these not taken care during detail engineering, changes may be required at a later date during construction or operation which will have higher cost effects. A typical example, called as "snow ball effect", is that in a process industry during construction stage, the process engineer called for adding a pump to a process tank which has resulted in additional cost of US$ 150,000 with a six weeks slippage in the mechanical installation schedule (William J Colt, 1997). Hence it is important that the scope of work should be well defined during detail engineering stage, so as to overcome barriers in project execution and meet project objectives.

The main items in detailed engineering for each discipline are listed below-

Detailed Process Engineering

- P & I Diagram & detailed process description.
- Process design data, mass, heat & power balance & dimensioning calculation.
- Master equipment list.
- Raw materials and other inputs required and procurement plan.

Detailed Civil Engineering

- Equipment Loads and their locations with foundation outline.
- Dynamic analysis for foundations of machines.
- Opening in walls, roofs, floors including pits & drains.
- Tolerance on deformation of building.
- Foundations separated from building.
- Embed steel dimensions, locations & Loads.
- Structural design of the building.
- Building layout & dimensions.
- Foundation layout for all equipment with x, y, z co-ordinates.
- Released for construction (RFC) drawings for concrete, structural, architectural and finishing works.
- Bill of quantities (BOQ) for construction materials.
- Design of electrical rooms, rack rooms and control rooms.

Detailed Mechanical layout and Piping Engineering

- Equipment layout with space requirements for auxiliary equipment, erection, maintenance, safety limit, material handling system, etc.
- Equipment position numbering and specification.
- General arrangement (GA) and sectional drawings of equipment.
- Dimensions and weight of equipment.
- Design of steel structures for equipment supports, platforms, etc.
- Type of mechanical drive arrangements.
- Specification of cranes, hoists, lifts.
- Engineering calculation of piping system.
- Piping routing, arrangement drawings and stress analysis.
- Piping isometric and support drawings.
- BOQ for pipes, fittings, valves, etc.
- Pumps sizing calculation and selection.
- Tanks sizing, GA and fabrication drawings.
- Design of ventilation systems, humidity control systems, air pressurization systems, air purification units, air conditioning units, cooling towers, insulation, etc.
- BOQ for installation materials for equipment such as shims, hardware, etc.

Detailed Electrical Engineering

- Final Motor ratings and power requirement for heating elements & control system.
- Electrical equipment list with position numbers and specification.
- Special requirements for electrical equipment and circuits.
- Selection of variable speed drives and controls.
- Interlocking, circuit, connection and grounding diagram.
- Cable tray routing and arrangement.
- Sizing, selection and quantity of motors, transformers, Motors Control Center, Cables, electrical panels, cable trays, etc.

- Dimensions of electrical items, foundation requirements and locations in plant layout and layout of electrical rooms.
- Lighting system design
- Heat and ventilation, pressurization, air purification, etc., requirements for electrical rooms.
- BOQ for installation materials.

Detailed Instrumentation Engineering

- Loop diagrams, loop foundation and logic interlocking diagrams.
- Instrument index and instrument data sheets.
- Master position list for instruments and location drawings.
- Instrument cable tray routing & layout.
- Dimensioning of panels, cabinets, and junction boxes.
- Sizing and selection of control valves, flow meters, and other instruments.
- Connections for field instruments on pipes or process equipment.
- Cable lists and tube lists.
- BOQ for. installation materials.

Detailed Automation Engineering

- DCS graphic displays, Proposal for reporting.
- DCS I/O lists, wiring & interconnect drawings with I/O channel.
- Alarm system and group start Programs.
- Hardware specification with cabinet layout and I/O.
- Software configuration and simulation drawings.
- Cabinet inter wiring & cable schematics.
- Drawings & documents for interface to foreign systems.
- Specification, dimensions and location of hardware equipment in control & rack rooms.
- Specifications of PLC or other control systems.
- Interface type and standard for data transmission between PLC or other system and DCS or MIS and Specification as well as amount of transmitted data.
- DCS or QCS system architecture schematic.
- Configuration parameters for instruments logic and motor logic.
- Control cabinets power usage and heat loads.
- Layout of control and rack rooms.
- MIS system configuration and software development.

During detail engineering, alternative concepts and designs should be considered to save cost and to suit to site conditions. For example, air cooling can be used in areas where cooling water is in short supply, construction materials can be based on available local supply, utility consumption can be reduced by adding heat integration if oil is to be imported, additional equipment can be installed to recover product from byproducts or waste effluents if the raw materials are expensive, etc.

Civil Constructions

The activities for civil construction are as follows-

- Mobilization of resources at site.
- Cutting and leveling of the earth.
- Casting of foundations.
- Casting columns, beams and floor slabs for building.
- Fabrication and erection of steel structures.
- Erection of roof truss, roofing, siding.
- Casting of foundations for equipment.
- Construction of electrical, control and rack rooms.
- Final finishing and architectural works.

Much of the barriers in progressing on civil work depends on how well the detail engineering has been done and job experience of the contractor, the methods adopted in the construction process, the skill of the labor executing the job, quality of materials used, delivery of right material at the right time, progress measurement system and controls adopted in directing the whole construction process.

MEI installation

Before starting the installation of mechanical, electrical, instrumentation and automation equipment (called MEI work), a detailed land use plan for site should be prepared. A proper planning of lay down areas is a pre-request for starting the erection work. The activities connected with MEI work are installation overhead cranes, embeds/base plates on equipment's foundation, tanks, equipment, piping system including on line instruments, lighting system, cable trays and cables, transformers and control panels, Distributed control system, quality control system as well as Management information systems. The major challenge during the construction is the logistic operation. Detailed time schedule is use for follow-up of the installation activities. However when the progress of installation reaches 75% to 80%, then punch lists are prepared for each major equipment and systems and followed up with the contractor for completion and smooth starting of pre-commissioning activities. Again it is the capability and experience of contractor and the delivery of materials and resources in time are critical aspect of MEI installation. Generally for complex systems and equipment, equipment supplier's erection specialist's knowledge is essential for guiding the contractor and determining the completeness of the MEI installation.

Training, Commissioning and Start-up

Training of operating personnel before actual starting of commissioning is essential for successful commissioning and subsequent operation of the unit built. The kind of training to be given depends upon the qualification and experience of operating personnel and complexity of the plant built. Generally main equipment suppliers, organize theoretical and practical training and provide adequate training materials. Theoretical classes are completed before starting commissioning. Theoretical classes are essential since the knowledge in technology is very helpful in solving operation problems. Practical training starts during commissioning and the operating team take responsibility in operating the plant at least after 3 to 6 months of practical training. The major package vendor's knowledge and experience during plant commissioning is critical. Check out and commissioning including mechanical test and water run are carried out under supervision of equipment supplier's commissioning engineer/specialist and in accordance with commissioning manual prepared earlier.

When equipment in a new unit has been installed and checked out as mechanically satisfactory, it is a desirable practice to carry out some form of simulated or mock operation. The plant can be checked out in segments or stages or system wise under this scheme, then integrated into total process (Troyan, 1960). Proving out a new plant or process is ordinarily a tough job than keeping an established operation on the line. Plant manuals and operating procedures contain many helpful techniques for commissioning operation.

Test Run

Test run are conducted to prove the performance guarantee parameters of the equipment by the vendors. It is done in accordance with already agreed and established procedures and for duration as per contract. Commercial operation start after evaluation of performance. If the desired guarantee parameters are not achieved then the vendor's operation specialist will identify the deficiencies in the technology or the equipment and then rectify. Again the test run is conducted and clear records and agreements are established for full filling the contractual obligations.

Marketing and Brand development

Proper planning for product marketing and brand development is to be done generally at the time of committing the first major contract for the supply of major plant and machinery. Product marketing involves establishing the sales offices, sales network, alliances, agents, etc. Brand development involves corporate identity, public relations and market information and research as well as comparison and evaluation of existing products in the market.

OPERATING PHASE

The operating phase start from commercial production and depending upon the "learning curve". Full production capacity is reached after removing the bottle-necks. For large size projects, the full capacity is reached within 1 to 2 years from start-up date.

During the life of the plant innovations occur in process technology and equipment resulting modernization and renovation of the plant to achieve lower consumption of inputs and higher quality of output so as to be competitive and to retain market share. When potential exists for increasing the market share, expansion of unit takes place to increase the production capacity.

ISSUES & STRATEGIES

There are many risks and pitfalls which may turn projects into failures, unless they are professionally planned and properly executed. In case of huge Investment cost projects, delay may cause insurmountable financial burdens. Despite fast-growing markets, there are also business risks. In certain projects, timing of investments is crucial to get good returns. In business, there will be ups and downs. So the strategy is to take benefit from the cyclical nature of the business, i.e. implement project when the prices are in lower range and produce and sell when price are in higher range and make profit as estimated.

When a company is planning to invest in a new project, the decision is very much dependent not only on the market assessment and business cycle, but also on the need to avoid clash with other project for same product (Sverker Martin, 1991). For this reason it is extremely important to move quickly from decision to implementation. This demand for an affective and efficient project management system. An efficient project management system is the one which achieve the above objective within the constraints set for time, quality and cost (TQC). TQC are the tracheotomy conflicting factors in project management. Pruden tradeoff between these factors are essential for successful project completion. Number of issues arise in project management which are to be resolved by adopting effective strategies. Some of the issues and strategies are discussed further in this section.

Time Factor

In order to complete the project within the targeted time, proper planning and realistic scheduling is essential. Planning and scheduling involves sequencing activities for execution. It finds answer to the question "Who has to do what, when and how?". The resources available for these activities are to be clearly specified. The resources are constrained by the cost allocated for each activity. Also the method of doing the activity is most important which determines the time. Fast track projects demands tight scheduling. Schedules should be tight, but achievable. The probability of achieving the scheduled dates directly depends and the probability of arranging the required resource at the required time.

Too optimistic or too perssimistic schedules are not feasible as they will provide poor base for control and performance. Personnel judgment, historical data, current trends, supplier's document delivery schedules, equipment delivery, erection supervision schedules are important in establishing a reasonably effective scheduling program. However following points are important for achieving targeted schedules.

- Solid basic engineering is a must to save time during implementation phase (matti neiminen, 1996).
- Routine expediting to deliver equipment committed by suppliers. Expediting to include quality and delivery control. Desk expediting has little control of delivery time than actual visit to supplier's or their sub-contractor's manufacturing unit.
- Major equipment vendors supply as much information and engineering as possible to minimize in house engineering.
- Continuous follow-up of time between readiness of bill of material and issue of PO.
- Design engineers should physically visit construction team and design team.
- Material selected should not only be standard items, but should also be available in the market.
- Use of modern communication methods such as inter-net, E-mail, courier, fax, facilities for faster exchange and engineering information.

To meet the challenge of shorter execution times, the efficiency in engineering and related activities has to be increased. This call for tight control over information flow, effective integration of engineering and site activities. To meet this challenge, the concept of computer aided engineering and the "Virtual Project Office" are emerging (Kalevi Keto, 1996).

Quality Factor

By far the most important aspect is the quality of engineering work in project management (Olof Andersson, 1996). If overlooked success can not be achieved. Quality of the project team, quality of engineering (in house, vendor's and consultants), quality of equipment and materials purchased as well as quality of civil and MEI contraction should be better.

Better quality does not always require high cost. The cost should be optimum. If quality of engineering is not proper, then it may need change of specifications. However, the further the project proceeds, the greater the cost of possible change.

Cost Factor

It is important to complete a project within allocated budget. The method of approach adopted has influence on the project cost. A project may be executed as vendor/consultant controlled or owner controlled engineer, procure and construct (EPC) approach. A typical example of consultant controlled EPC approach is the US$ 3.5 billion Refinery-Petrochemical Project awarded to BECTEL by India's Reliance Group (Julie Jordan, 1997). Modern practice is to adopt a modified version of owner EPC approach. In this new innovative approach (Jean-Pierre Lablanc, 1997) partnership between suppliers and contractors is advocated and a phased EPC approach integrating multiple design/build package contract is adopted. This approach gives owner maximum control over the project. If a project is totally given to a consultant as a EPC package then, the project cost will generally be the highest and such practice is adopted only for propriety intellectual technologies (Hassan, 1997). On the other hand, if main equipment and good amount of engineering relating to equipment are only purchased as main packages by proper tendering and all other items, called as Take-out items" are purchase separately and the engineering work for the same is included in the main packages, it is possible to achieve lowest possible cost. Thus piece-by-piece purchasing approach results in lowest cost and optimize equipment selection. In terms of efficiency and performance, this method of project implementation can be very successful and rewarding but clear contract definition for each package with very detailed scope and responsibility descriptions are a critical aspect of this project implementation method.

To control the project cost, two basic principles are generally followed before a proposal is submitted for approval during implementation.

Principle #1

Cost = Standard Quantity X Unit Price.

1	= 1 x 1	x 1	- Normal
1.44	= 1 x 1.2	x 1.2	- Over
0.64	= 1 x 0.80	x 08	- Efficient

Standards should be clear and high. If the quantity estimate is 20% more and unit price is also 20% more, then net increase in cost will be 40%. On the other hand, if the quantity is brought down by 20% by efficient methods and unit price is negotiated down by 20%, then the reduction in total cost achieved will be 36%. Quantity estimates should not be hypothetical and should be done only after design is at least 80% complete. Less quantity can be achieved though good engineering, better design, better layouts, and better method of doing the work. Unit price can be lowered by requesting right specification and quality of material, ordering at the right time (to reduce unnecessary last minute air freighting), in right quantity (to get discount) and by proper evaluation of offers and better negotiation skills.

A very high degree of negotiation skills are essential for controlling the project cost since almost all expenditure arise due to award of contract for engineering services, equipment supply, civil construction and MEI installation. Negotiation must be hard to go for lower range of pricing to which the vendor or contractor would agree. However, too much emphasis on price, without looking into technical as well as quality aspects has detrimental effect on project schedule. Further, having strategic information about the vendor as to their production capacity, volume of outstanding orders will help during negotiation. If buyer knows that the production capacity of the supplier's manufacturing unit is met then there is no way he could reduce the price with that vendor and buyer has to go to for another vendor. Another strategy for negotiation is to mention few items which have lowest of the offered by others. This will have a psychological effect on them their prices are higher than others.

Principle #2

Any budget estimate can be classified into any one of following three types: "nice to have" luxury items which do not add value to end product, "need to have" take out items and "must to have" items without which project cannot be completed. All the nice have to have items should be avoided. All need to have items are to be weighed properly so as to ascertain whether they are really needed and quantity and quality estimation is reasonably accurate. "Must to have" items are to be considered to control the budget. Standards established for engineering and construction and previous experience help in clearly classifying purpose of estimates.

Generally, a budget control sheet containing the total budget, commitment, cost expected to complete remaining work, final cost, over/under run is produced and frequently reviewed on a monthly basis by the project team and corrective actions are taken. The essential requirement for successful cost control is continuos monitoring of scope changes and variations and adopting a basic rule that no commitments are made without analyzing these factors in writing.

Quality of engineering is the most important factor to control the project cost. if engineering is not done properly not only the project cost will be on the higher side, but also the operating cost. One example is the over sizing of pumps and motors. Optimization of engineering design and construction methods are important for achieving reduced costs (Jukka Nyrola, 1994).

Another leverage to control cost, is the proper timing of receipt of equipment at site. If payment are made and equipment brought to site at an early date than required, than the holding cost and interest on payment will increase the project cost. On the other hand if there is a delay in delivery of critical equipment to site, then it will delay project completion time. Hence there exists a trade off which can be determined by simulating various scenarios using the time and cost schedules.

Procurement Procedures

Procurement policy and purchaser's procurement knowledge has definite and substantial impact on the success of the project. The important issues are-

- Listing and qualification of prospective vendors and contractors.
- Identification of items with longest delivery time.
- Availability of local supply of civil and structural material.
- Identification of goods and material with price inflation potential.
- Inspection of prospective local manufacturers to verify their capability, facilities and quality.
- Identifying construction materials and tools to be supplied by purchaser or contractor.
- Local purchase or fabrication at site with raw material supplied to contractor at site
- To take action in time for obtaining government approval for project imports.
- When offers received are not technically at par, proper price loading to technically inferior quote should be done.

Human Resource Factor

The organization structure for industrial project management depends upon the size and type of the project and matrix structure is generally adopted. The project head stimulates effective communication and coordination among, engineering, procurement and construction and commissioning teams. The project manager should posses business expertise (cost, planning and scheduling, economic and risk, procurement, contract administration and analytical skills), technical expertise, management skills (decision making, creative, realistic, follow up on delegation, effective communication), leader ship qualities (action, educating and guiding people). To achieve success, the level of technical knowledge of various groups participating in the project is also very important.

Vendors should have expertise in process technology & equipment manaufacturing, detail engineering, supervision of erection, training, check out, commissioning and post commissioning trouble shooting. Consultants should have back ground knowledge and previous experience is a must for consultants. Engineering team should have experience in detail engineering, construction, operation and maintenance and should look for better, faster and cheaper (also alternative) way to do job, introduce constructability in design and build operation and maintenance friendliness into design. Also, engineering team should have capability to check the completeness of vendor's engineering information and this has cascading effect on schedule. Lack of this knowledge, will result in changes at later date and increase cost and delay the project. The team members should be experienced in related engineering discipline as well as in the concerned industry field. Inexperienced engineers create problem in completing the job in time.

Construction team should have expertise in managing people, making things happen, manage by walking around, lead by directing and by example, anticipate and prevent problems, stamina to work long hours and long periods, safety conscious, and efficient use of construction resources, cheaper and faster construction methods and practices. Commissioning team should have previous experience, very systematic and methodical, calm under crisis situation, think on feet, problem solving attitude not fault finding attitude, cautious and scientific approach, good theoretical knowledge and safety conscious. Mill operation team should have previous operating experience in similar units and problem solving attitude.

Table-3

Typical example of engineering progress measurement	
• Complete preliminary site plan (building locations and site elevations)	10%
• Issue preliminary site plan for approval	25%
• Complete design calculation	30%
• Issue bill of material for procurement	45%
• Complete drawing	80%
• Issue for approval	85%
• Issue for construction	95%
• Issue for revisions	100%

Communication and coordination factor

Project is 70% communication and 25% work. Engineers should involve in project at early stages. Attitude between disciplines and coordinators should not be as 'Other people problem". It is important to ensure that issued project instructions are better understood and implemented. If communication is improper, it will result in delay of project. Every one in the project team should have access to needed data and information for his job. A very good communication and coordination can be achieved by establishing weekly meetings on subjects such as critical activities, area co-ordination, discipline co-ordination, budget, time schedule, civil work, MEI installation, commissioning, etc. Further vendor project meetings once in a month helps to review and resolve conflict and clarifications for all the parties involved.

Progress Monitoring and Control

Progress Measurement of Engineering

Measurement of progress of engineering is always a debatable issue. Though any standard procedure is not commonly available, a reasonably acceptable objective method of measuring engineering progress is established (James A bent, 1989). This yard stick is necessary to evaluate the engineering documents received from vendors as well as from consultants. Personal judgment have effects on the estimate of engineering progress. Typical example progress measurement in engineering is shown in **Table No. 3.**

Progress Measurement of Construction and MEI installation

The method used for measuring progress of civil construction and MEI installation is based on the proportionate quantity of work done. However, a proper analytical procedure to compute this progress should be established and agreed by all concerned. A typical example for progress measurement of mechanical installation is shown below:

Trends Curves or S curves

Trend curves (S curves), reflecting cumulative percentage of progress for plan as well as actual values, are prepared for engineering, civil construction, MEI installation, commissioning. The progress percentages are integrated for different disciplines by suitable weight factors based on cost or effort. The S curves are useful for identifying the deviations to plan and taking corrective actions to achieve target values in the remaining time. This type of progress monitoring is particularly beneficial to top manage-

Table-4

Typical progress measurement for Mechanical equipment installation	
Move equipment from lay down yard to foundation	20%
Lift and position on foundation	30%
Mount motors and fix the drive component	50%
Align and issue clearance certificate for grouting	80%
Grouting of the equipment and motor	90%
Punch list job completion after final inspection	100%

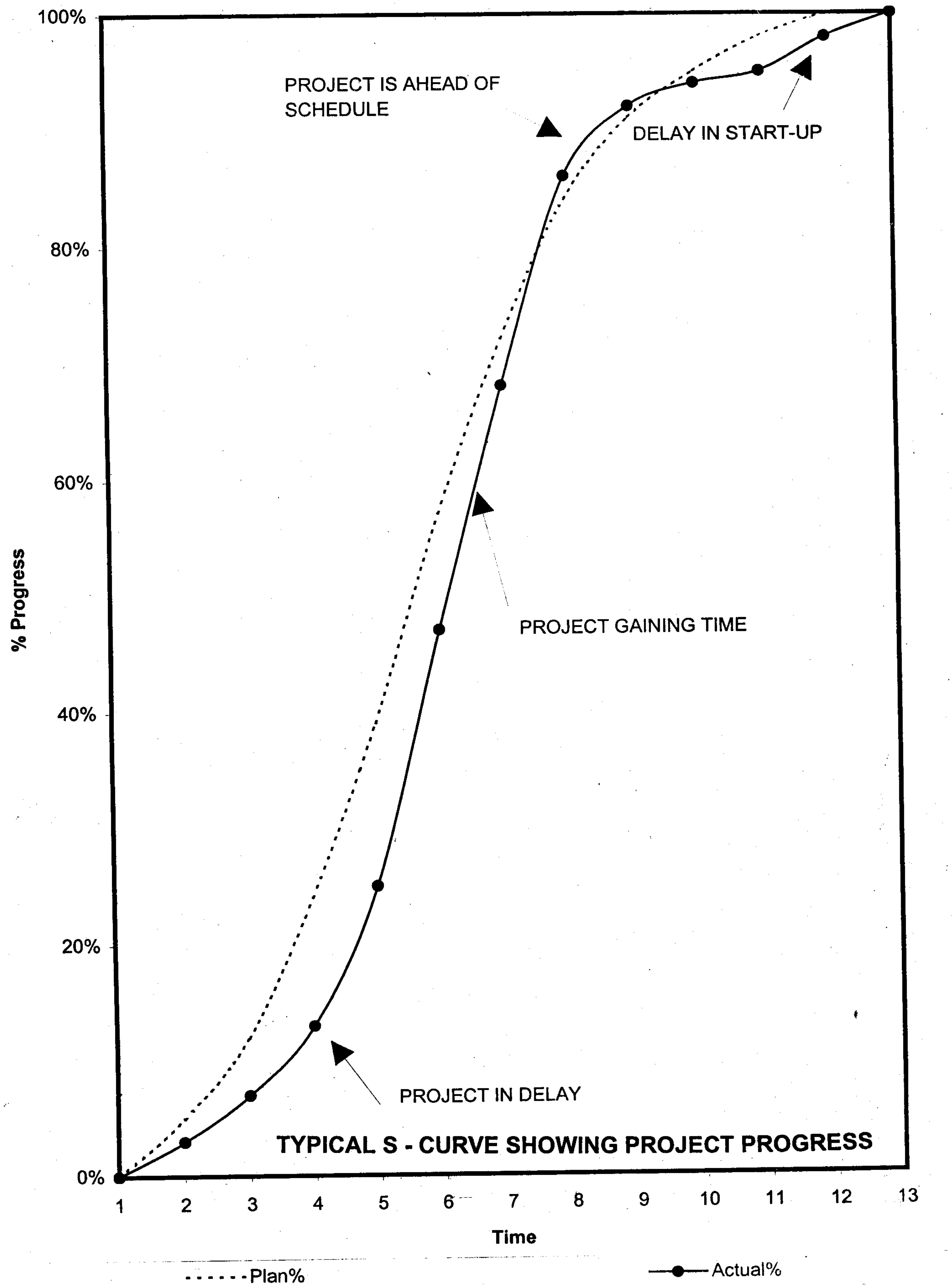

100%
80%
60%
40%
20%
0%
% Progress
PROJECT IS AHEAD OF SCHEDULE
DELAY IN START-UP
PROJECT GAINING TIME
PROJECT IN DELAY
TYPICAL S - CURVE SHOWING PROJECT PROGRESS
1
2
3
4
5
6
7
8
9
10
11
12
13
Time
Plan%
Actual%

FIG.3

ment to know quickly the areas of concern for taking corrective action. Typical S curve for a project is shown in **Fig.3.**

Decision making process

Decision making in project management involves the following procedure

- listen to problems
- find alternative solutions
- find what should have been done is not done
- prioritize the jobs and identify critical ones
- allocate jobs and decide targets on TQC
- monitor progress
- review and remind for correction to deviations

Civil Construction and Installations

Following factors are important in improving the efficiency in construction and installations-

- Intruduce constructability in design.
- Develop work simplifying methods and minimize labor intensive design.
- Ensure latest revised drawings are in the hands of construction and MEI installation teams.
- Maintain machinery and equipment used for construction and installations such as cranes, trucks, construction power units.
- Plan properly for heavy lifts.
- Plan lay down areas properly and easy movement to erection site.
- Coordinate movements of materials in site on a daily basis among different contractors and work groups.
- Ensure right delivery at right time to contractor.

CONCLUSIONS

Some methods, certain issues and some strategies for efficient project management were discussed. For a project to be successful economical and financial decisions play major role in development phase and quality of engineering, efficiency in procurement, methods of construction and installation plays an important role during implementation phase. Establishing sales network and brand development are key factors for achieving commercial success after commissioning.

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