CONSTRUCTION PLANNING & SCHEDULING

III YEAR

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CE601111604 CONSTRUCTION PLANNING & SCHEDULING

OBJECTIVE

At the end of this course the student is expected to have learnt how to plan construction projects, schedule the activities using network diagrams, determine the cost of the project, control the cost of the project by creating cash flows and budgeting and how to use the project information as an information and decision making tool.

UNIT I CONSTRUCTION PLANNING
Basic concepts in the development of construction plans-choice of Technology and Construction method-Defining Work Tasks- Definition- Precedence relationships among activities-Estimating Activity Durations-Estimating Resource Requirements for work activities-coding systems.

UNIT II SCHEDULING PROCEDURES AND TECHNIQUES Relevance of construction schedules-Bar charts - The critical path method-Calculations for critical path scheduling-Activity float and schedules-Presenting project schedules-Critical path scheduling for Activity-on-node and with leads, Lags and Windows-Calculations for scheduling with leads, lags and windows-Resource oriented scheduling-Scheduling with resource constraints and precedences -Use of Advanced Scheduling Techniques-Scheduling with uncertain durations-Crashing and time/cost trade offs -Improving the Scheduling process – Introduction to application software.

UNIT III COST CONTROL MONITORING AND ACCOUNTING
The cost control problem-The project Budget-Forecasting for Activity cost control - financial accounting systems and cost accounts-Control of project cash flows-Schedule control-Schedule and Budget updates-Relating cost and schedule information.

UNIT IV QUALITY CONTROL AND SAFETY DURING CONSTRUCTION
Quality and safety Concerns in Construction-Organizing for Quality and Safety-Work and Material Specifications-Total Quality control-Quality control by statistical methods -Statistical Quality control withSampling by Attributes-Statistical Quality control by Sampling and Variables-Safety.

UNIT V ORGANIZATION AND USE OF PROJECT INFORMATION Types of project information-Accuracy and Use of Information-Computerized organization and use of Information -Organizing information in databases-relational model of Data bases-Other conceptual Models of Databases-Centralized database Management systems-Databases and application programs-Information transfer and Flow.

TOTAL: 45 PERIODS

TEXT BOOKS

1. Chitkara, K.K. “Construction Project Management Planning”, Scheduling and Control, Tata McGraw-Hill Publishing Co., New Delhi, 1998.
2. Srinath,L.S., “PERT and CPM Priniples and Applications “, Affiliated East West Press, 2001

REFERENCES

1. Chris Hendrickson and Tung Au, “Project Management for Construction – Fundamentals Concepts for Owners”, Engineers, Architects and Builders, Prentice Hall, Pitsburgh, 2000.
2. Moder.J., C.Phillips and Davis, “Project Management with CPM”, PERT and Precedence Diagramming, Van Nostrand Reinhold Co., Third Edition, 1983.

3. Willis., E.M., “Scheduling Construction projects”, John Wiley and Sons 1986.
4. Halpin,D.W., “Financial and cost concepts for construction Management”, John Wiley and Sons, New York, 1985.

UNIT I CONSTRUCTION PLANNING

Basic concepts in the development of construction plans-choice of Technology and Construction method-Defining Work Tasks- Definition- Precedence relationships among activities-Estimating Activity Durations-Estimating Resource Requirements for work activities-coding systems.

Planning:

Planning aims at formulation of a time based plan of action for coordinatingvarious activities and resources to achieve specified objectives. Planning is theprocess of developing the project plan. The plan outlines how the project is to bedirected to achieve the assigned goals. It specifies a predetermined and committedfuture course of action, based on discussions and decisions made on the currentknowledge and estimation of future trends.

construction planning

The construction planning process is stimulated through a study of projectdocuments. These documents include but are not limited to the available technicaland commercial studies and investigations, designs and drawings, estimation ofquantities, construction method statements, project planning data, contractdocuments, site conditions, market survey, local resources, project environmentand the client's organization. The planning process takes in to account, thestrengths and weakness of the organizations.

Construction Planning and Explain the basic concepts in thedevelopment of Construction plans:

Construction planning is a fundamental and challenging activity in the management and execution of construction projects. It involves the choice of technology, the definition of work tasks, the estimation of the required resources and durations for individual tasks, and the identification of any interactions among the different work tasks. A good construction plan is the basis for developing the budget and the schedule for work. Developing the construction plan is a critical task in the management of construction, even if the plan is not written or otherwise formally recorded. In addition to these technical aspects of construction planning, it may also be necessary to make organizational decisions about the relationships between project participants and even which organizations to include in a project. For example, the extent to which subcontractors will be used on a project is often determined during construction planning.

A planner begins with a result (i.e. a facility design) and must synthesize the steps required to yield this result. Essential aspects of construction planning include the generation of required activities, analysis of the implications of these activities, and choice among the various alternative means of performing activities. In contrast to a detective discovering a single train of events, however, construction planners also face the normative problem of choosing the best among numerous alternative plans. A planner must imagine the final facility as described in the plans and specifications.

In developing a construction plan, it is common to adopt a primary emphasis on either cost control or on schedule control. Some projects are primarily divided into expense categories with associated costs. In these cases, construction planning is cost or expense oriented. Within the categories of expenditure, a distinction is made between costs incurred directly in the performance of an activity and indirectly for the accomplishment of the project. For example, borrowing expenses for project financing and overhead items are commonly treated as indirect costs. For other projects, scheduling of work activities over time is critical and is emphasized in the planning process. In this case, the planner insures that the proper precedences among activities are maintained and that efficient scheduling of the available resources prevails. Traditional scheduling procedures emphasize the maintenance of task precedences (resulting in critical path scheduling procedures) or efficient use of resources over time (resulting in job shop scheduling procedures). Finally, most complex projects require consideration of both cost and scheduling over time, so that planning, monitoring and record keeping must consider both dimensions. In these cases, the integration of schedule and budget information is a major concern.

Alternative Emphases in Construction Planning

Construction planning is not an activity which is restricted to the period after the award of a contract for construction. It should be an essential activity during the facility design. Also, if problems arise during construction, re-planning is required.

objectives of planning:

Proper design of each element of the project Proper selection of equipment and machinery in big projects, the use oflarge capacity plants are found economical Procurement of materials well in advance Proper arrangement of repair of equipment and machinery Employment of trained and experienced staff on the project To provide incentive for good workers To arrange constant flow of funds for the completion of project To provide proper safety measures and ventilation, proper arrangement oflight and water.

project plans:

Planning the entire project from its inception to completion requires a vastcoverage, varied skills and different types of plans. The nature of plansencountered in a typical construction project are ndicated belowTypes of project plansDevelopment stage nature of planInception stage project feasibility planEngineering stage project preliminary planImplementation stage project construction plan

work tasks

Work tasks represent the necessary frame work to permit scheduling ofconstruction activities, along with estimating the resources required by theindividual work tasks and a necessary precedence or required sequence amongthe tasks. The terms work tasks or activities are often used interchangeably inconstruction plans to refer to specific defined items of work.

Choice of Construction Technology and Construction method:

As in the development of appropriate alternatives for facility design, choices of appropriate technology and methods for construction are often ill-structured yet critical ingredients in the success of the project. For example, a decision whether to pump or to transport concrete in buckets will directly affect the cost and duration of tasks involved in building construction. A decision between these two alternatives should consider the relative costs, reliabilities, and availability of equipment for the two transport methods.

Unfortunately, the exact implications of different methods depend upon numerous considerations for which information may be sketchy during the planning phase, such as the experience and expertise of workers or the particular underground condition at a site. In selecting among alternative methods and technologies, it may be necessary to formulate a number of construction plans based on alternative methods or assumptions. Once the full plan is available, then the cost, time and reliability impacts of the alternative approaches can be reviewed. This examination of several alternatives is often made explicit in bidding competitions in which several alternative designs may be proposed or value engineering for alternative construction methods may be permitted. In this case, potential constructors may wish to prepare plans for each alternative design using the suggested construction method as well as to prepare plans for alternative construction methods which would be proposed as part of the value engineering process.

In forming a construction plan, a useful approach is to simulate the construction process either in the imagination of the planner or with a formal computer based simulation technique. By observing the result, comparisons among different plans or problems with the existing plan can be identified. For example, a decision to use a particular piece of equipment for an operation immediately leads to the question of whether or not there is sufficient access space for the equipment. Three dimensional geometric models in a computer aided design (CAD) system may be helpful in simulating space requirements for operations and for identifying any interferences. Similarly, problems in resource availability identified during the simulation of the construction process might be effectively forestalled by providing additional resources as part of the construction plan.

Example- Laser Leveling

An example of technology choice is the use of laser leveling equipment to improve the productivity of excavation and grading. In these systems, laser surveying equipment is erected on a site so that the relative height of mobile equipment is known exactly. This height measurement is accomplished by flashing a rotating laser light on a level plane across the construction site and observing exactly where the light shines on receptors on mobile equipment such as graders. Since laser light does not disperse appreciably, the height at which the laser shines anywhere on the construction site gives an accurate indication of the height of a receptor on a piece of mobile equipment. In turn, the receptor height can be used to measure the height of a blade, excavator bucket or other piece of equipment. Combined with electro-hydraulic control systems mounted on mobile equipment such as bulldozers, graders and scrapers, the height of excavation and grading blades can be precisely and automatically controlled in these systems. This automation of blade heights has reduced costs in some cases by over 80% and improved quality in the finished product, as measured by the desired amount of excavation or the extent to which a final grade achieves the desired angle. These systems also permit the use of smaller machines and less skilled operators. However, the use of these semi-automated systems require investments in the laser surveying equipment as well as modification to equipment to permit electronic feedback control units. Still, laser leveling appears to be an excellent technological choice in many instances.

project planning techniques:

Stages Planning process Techniques/methodsPlanning resourcesPlanning implementationBreaking down projectwork, developing timenetwork plansForecasting resourcerequirements, planningmanpower requirements,planning materialrequirements, budgetingcosts, designingorganizational structureFormulating monitoringmethodologyWork break down, networkanalysis, gnat chartMan power schedulingMaterial schedulingResource allocationCost planning & budgetingEquipment selection andschedulingResource productivitycontrol, time control,contribution control,budgetary control

The steps involved in planning:

a. defining the scope of work to be performed

b. preparing the logic or network diagram to establish a relationship among activities and integrating these diagrams to develop the network model

c. analyzing the project network or models to determine project duration, and identifying critical and non-critical activities

d. Exploring trade-off between time to cost to arrive at optimal time and costs for completing the project.

e. Establishing standards for planning and controlling men, materials, equipment, costs and income of each work package

f. Forecasting input resources, production costs and the value of the workdone

g. Forecasting the project budget allocations for achieving targets assigned to each organizational unit

h. Designing a control system for the organization

i. Developing the resources, time and cost control methodology

purpose of coding:

a. To identify the data connected with each work package, as work packagesfrom the database for managing various project functions.

b. To aid in the organization of data from the very detailed to the very broadlevels

c. To enable the processing, sorting, and extraction of information requiredat various levels of management and functional units.

d. To computerize the data processing system

Types of labeling approach

a. alphabet codes

b. numerical codes

c. alphanumeric codes

Alphabet codes:

Alphabet letters A to Z, single or combined, can be used to represent acode. An alphabet in a single character space can represent 26 variations ascompared to numerals 0 to 9, which can depict maximum of 10 variations

Numerical codes:

It is the most important form of coding in numerical codes, each charactercan be represented by a numerical varying from 0 to 9

Alpha numerical codes:

It is the combination of alphabets and numerals to develop a each code.

precedence relationship among activities:

Precedence relations between activities signify that the activities must takeplace in a particular sequence. Numerous natural sequences exist forconstruction activities due to requirements for structural integrity, regulationsand other technical requirements.

activity direct cost

This is the cost that can be traced in full with the execution of a specific

activity. It consists of costs of direct labour, direct equipment and other direct costs.

For example: in the activity of roof concreting, the following direct costs would beinvolved.

Types of costs item of costs

Direct materials cost of concrete and steel

Direct labour cost of labour employed

coding systems:

One objective in many construction planning efforts is to define the plan within the

constraints of a universal coding system for identifying activities. Each activity defined

for a project would be identified by a pre-defined code specific to that activity. The use of

a common nomenclature or identification system is basically motivated by the desire for better integration of organizational efforts and improved information flow. In particular, coding systems are adopted to provide a numbering system to replace verbal descriptions of items. These codes reduce the length or complexity of the information to be recorded. A common coding system within an organization also aids consistency in definitions and categories between projects and among the various parties involved in a project. Common coding systems also aid in the retrieval of historical records of cost, productivity and duration on particular activities. Finally, electronic data storage and retrieval operations are much more efficient with standard coding systems.

The most widely used standard coding system for constructed facilities is the MASTERFORMAT system developed by the Construction Specifications Institute (CSI) of the United States and Construction Specifications of Canada. After development of separate systems, this combined system was originally introduced as the Uniform Construction Index (UCI) in 1972 and was subsequently adopted for use by numerous firms, information providers, professional societies and trade organizations. The term MASTERFORMAT was introduced with the 1978 revision of the UCI codes. MASTERFORMAT provides a standard identification code for nearly all the elements associated with building construction.

MASTERFORMAT involves a hierarchical coding system with multiple levels plus keyword text descriptions of each item. In the numerical coding system, the first two digits represent one of the sixteen divisions for work; a seventeenth division is used to code conditions of the contract for a constructor. In the latest version of the MASTERFORMAT, a third digit is added to indicate a subdivision within each division. Each division is further specified by a three digit extension indicating another level of subdivisions. In many cases, these subdivisions are further divided with an additional three digits to identify more specific work items or materials. For example, the code 16-

950-960, "Electrical Equipment Testing" are defined as within Division 16 (Electrical) and Sub-Division 950 (Testing). The keywords "Electrical Equipment Testing" is a standard description of the activity.

While MASTERFORMAT provides a very useful means of organizing and communicating information, it has some obvious limitations as a complete project coding system. First, more specific information such as location of work or responsible organization might be required for project cost control. Code extensions are then added in addition to the digits in the basic MASTERFORMAT codes. For example, a typical extended code might have the following elements:

0534.02220.21.A.00.cf34

The first four digits indicate the project for this activity; this code refers to an activity on project number 0534. The next five digits refer to the MASTERFORMAT secondary division; referring to Table 9-7, this activity would be 02220 "Excavating, Backfilling and Compacting." The next two digits refer to specific activities defined within this MASTERFORMAT code; the digits 21 in this example might refer to excavation of column footings. The next character refers to the block or general area on the site that the activity will take place; in this case, block A is indicated. The digits 00 could be replaced by a code to indicate the responsible organization for the activity. Finally, the characters cf34 refer to the particular design element number for which this excavation is intended; in this case, column footing number 34 is intended. Thus, this activity is to perform the excavation for column footing number 34 in block A on the site.

activity indirect cost:

This is the cost that incurred while performing an activity, but cannot betraced directly to its execution. In other words, all costs other than the direct ones fallin this category. These represent the apportioned share of supervision; general andadministration costs are commonly refer to as overheads

UNIT II
SCHEDULING PROCEDURES AND TECHNIQUES

Relevance of construction schedules-Bar charts - The critical path method-Calculations for critical path scheduling-Activity float and schedules-Presenting project schedules-Critical path scheduling for Activity-on-node and with leads, Lags and Windows-Calculations for scheduling with leads, lags and windows-Resource oriented scheduling-Scheduling with resource constraints and precedences -Use of Advanced Scheduling Techniques-Scheduling with uncertain durations-Crashing and time/cost trade offs -Improving the Scheduling process – Introduction to application software.

object of scheduling:

Scheduling means putting the plan on calendar basis. A project network shows thesequence and inters dependencies of activities, their time and their earliest and latestcompletion time, but these needs to be scheduled to determine commencement andtermination dates of each activity. Using optimum resources or working within resourceconstraints, it is a time table of work. A basic distinction exists between resource orientedscheduling techniques. The project is divided into number of operations.

advantages of scheduling:

1. By studying of any work and the many alternative methods of execution, wecan choose the best one.

2. It gives a clear idea regarding the required men, materials and equipments atdifferent stages of work.

3. Resource utilization is optimized.

4. Actual progress of the work is monitored with the actual plan. If there is anydelay, proper remedial measures can be taken to avoid such delays.

purpose of work scheduling:

The bar – chart type work schedule provides a simplified version of the workplan, which can easily be understood by all concerned with planning, co – ordination,execution and control of the project.

The steps involved in schedule chart:

(a) Select the EST point of activity layout on the graph, and draw a line slopingequal to its rate of execution i.e., 1 unit per day.

(b) Plot the lowest rate slowing line and mark its intersection with the top tofoundation horizontal line.

(c) Starting from the point of intersection, move forward horizontally on the topline and identify latest completion point of subsequent activity as indicated by the setback.

Critical path method with neat sketches.:

The most widely used scheduling technique is the critical path method (CPM) for scheduling, often referred to as critical path scheduling. This method calculates the minimum completion time for a project along with the possible start and finish times for the project activities. Indeed, many texts and managers regard critical path scheduling as the only usable and practical scheduling procedure. Computer programs and algorithms for critical path scheduling are widely available and can efficiently handle projects with thousands of activities.

The critical path itself represents the set or sequence of predecessor/successor activities which will take the longest time to complete. The duration of the critical path is the sum of the activities' durations along the path. Thus, the critical path can be defined as the longest possible path through the "network" of project activities. The duration of the critical path represents the minimum time required to complete a project. Any delays along the critical path would imply that additional time would be required to complete the project.

There may be more than one critical path among all the project activities, so completion of the entire project could be delayed by delaying activities along any one of the critical paths. For example, a project consisting of two activities performed in parallel that each require three days would have each activity critical for a completion in three days.

Formally, critical path scheduling assumes that a project has been divided into activities of fixed duration and well defined predecessor relationships. A predecessor relationship implies that one activity must come before another in the schedule. No resource constraints other than those implied by precedence relationships are recognized in the simplest form of critical path scheduling.

An Activity-on-Branch Network for Critical Path Scheduling

An Activity-on-Node Network for Critical Path Scheduling

The factors affecting work scheduling:

(a) Time:

Most of the projects carry time constraints in the form of imposed dates, thesedates may include constraints on start and completion of activities.

(b) Manpower:

Man power is one of the main in the successful execution of projects. The idlelabour time is paid for and the strikes and breakdown of work are kept in view bymanpower.

(c) Materials:

Construction materials are increasingly becoming scarce and their procurement isa time consuming process. The schedule aids in forecasting of materials and their timelysupply determines the economics and progress work.

purpose of numbering events:

i. It simplifies the identification and description of a n activity in terms of event numbers.

ii. The activities are coded as i- j where i and j are the event numbers as commencementand termination of an activity.

iii. It helps in developing identification code for computer application.

iv. It systematizes the computations of critical path for each activity as far as possible, the number of the proceeding event it should be less than that of the succeeding event.

cash flow control:

Activity float and schedules:

A number of different activity schedules can be developed from the critical path scheduling procedure described in the previous section. An earliest time schedule would be developed by starting each activity as soon as possible, at ES(i,j). Similarly, a latest time schedule would delay the start of each activity as long as possible but still finish the project in the minimum possible time. This late schedule can be developed by setting each activity's start time to LS(i,j).

Activities that have different early and late start times (i.e., ES(i,j) < LS(i,j)) can be scheduled to start anytime between ES(i,j) and LS(i,j). The concept of float is to use part or all of this allowable range to schedule an activity without delaying the completion of the project. An activity that has the earliest time for its predecessor and successor nodes differing by more than its duration possesses a window in which it can be scheduled. That is, if $E(i) + Dij < L(j)$, then some float is available in which to schedule this activity.

Illustration of Activity Float

Float is a very valuable concept since it represents the scheduling flexibility or "maneuvering room" available to complete particular tasks. Activities on the critical path do not provide any flexibility for scheduling nor leeway in case of problems. For activities with some float, the actual starting time might be chosen to balance work loads over time, to correspond with material deliveries, or to improve the project's cash flow.

4. LFT (Latest Finish Time):

It is the latest time by which an activity must be completed to ensure the completion of project within the stipulated time.

The classification of networks

1. Skeleton network

2. Master network

3. Detail network

4. Summary network.

Define the following terms:

(a) Float:

The difference between the latest start time and earliest start time of an activity iscalled as float. Float is a measure of the amount of time by which the start of an activitycan be delayed consistent with the completion of the project on time.

(b) Total Float:

Total float of an activity is defined as the difference between the maximumduration of time available for the completion and duration required to carry out thatduration.

Resource leveling:

The aim is reduce the peak resource requirements and smooth out period to periodassignment within a constraint on the project duration.

Crashing:

Higher amounts of direct activity cost would be associated with smaller activityduration times, while longer duration time would involve comparatively lower directcost. Such deliberate reduction of activity times by putting in extra effort is calledCrashing.

various methods of presenting project schedules.

Communicating the project schedule is a vital ingredient in successful project management. A good presentation will greatly ease the manager's problem of understanding the multitude of activities and their inter-relationships. Moreover, numerous individuals and parties are involved in any project, and they have to understand their assignments. Graphical presentations of project schedules are particularly useful since it is much easier to comprehend a graphical display of numerous pieces of information than to sift through a large table of numbers. Early computer scheduling systems were particularly poor in this regard since they produced pages and pages of numbers without aids to the manager for understanding them. It is extremely tedious to read a table of activity numbers, durations, schedule times, and floats and thereby gain an understanding and appreciation of a project schedule. In practice, producing diagrams manually has been a common prescription to the lack of automated drafting facilities. Indeed, it has been common to use computer programs to perform critical path scheduling and then to produce bar charts of detailed activity schedules and resource assignments manually. With the availability of computer graphics, the cost and effort of producing graphical presentations has been significantly reduced and the production of presentation aids can be automated.

Network diagrams for projects have already been introduced. These diagrams provide a powerful visualization of the precedences and relationships among the various project activities. They are a basic means of communicating a project plan among the participating planners and project monitors. Project planning is often conducted by producing network representations of greater and greater refinement until the plan is satisfactory.

An Example Bar Chart for a Nine Activity Project

Bar charts are particularly helpful for communicating the current state and schedule of activities on a project. As such, they have found wide acceptance as a project representation tool in the field. For planning purposes, bar charts are not as useful since they do not indicate the precedence relationships among activities. Thus, a planner must remember or record separately that a change in one activity's schedule may require changes to successor activities. There have been various schemes for mechanically linking activity bars to represent precedences, but it is now easier to use computer based tools to represent such relationships.

1. Normal cost:

Normal cost is the lowest possible direct cost required to complete an activity.

2. Normal time:

Normal time is the maximum time required to complete an activity at normal cost.

3. Crash time:

Crash time is the minimum possible time in which an activity can be completedusing additional resources.

4. Crash cost:

Crash cost is the direct cost i.e., anticipated in completing an activity within thecrash time.

Define activity cost slope.

Activity cost slope is the rate of increase in the cost of activity per unit with adecrease in time. The cost slope indicates the additional cost incurred per unit of timesaved in reducing the duration of an activity.

Activity Cost slope =crash cost – Normal cost .Normal time – Crash time

UNIT III

COST CONTROL MONITORING AND ACCOUNTING

The cost control problem-The project Budget-Forecasting for Activity cost control - financial accounting systems and cost accounts-Control of project cash flows-Schedule control-Schedule and Budget updates-Relating cost and schedule information.

List out any 5 indirect cost:

Temporary utility

Cleaning

Unloading

Ware housing

Work shop

Contigencies:

Contigency is a cushion of cost to deal with uncertainities.Few factorsresulting in contigencies are minor design changes,under estimate of cost,lack ofexperience,unanticipated price changes,safety problems etc.

Budjet:

Budjet is an estimate of cost planned to be spent to complete a particularactivity.

Types of cost flow:

Cash Inflow

Cash outflow

Cost Forecasting:

Cost Forecasting is the requirement of cost to continue with the project atthe desired speed.

Cash Flow control:

Cash Flow control is the additional planning required to arrange for thecash to meet the demand for the funds.

Types of Accounting systems

The cost accounts described in the previous sections provide only one of the various components in a financial accounting system. Before further discussing the use of cost accounts in project control, the relationship of project and financial accounting deserves mention. Accounting information is generally used for three distinct purposes:

• Internal reporting to project managers for day-to-day planning, monitoring and control.

• Internal reporting to managers for aiding strategic planning.

• External reporting to owners, government, regulators and other outside parties.

External reports are constrained to particular forms and procedures by contractual reporting requirements or by generally accepted accounting practices. Preparation of such external reports is referred to as financial accounting. In contrast, cost or managerial accounting is intended to aid internal managers in their responsibilities of planning, monitoring and control.

Project costs are always included in the system of financial accounts associated with an organization. At the heart of this system, all expense transactions are recorded in a general ledger. The general ledger of accounts forms the basis for management reports on particular projects as well as the financial accounts for an entire organization. Other components of a financial accounting system include:

• The accounts payable journal is intended to provide records of bills received from vendors, material suppliers, subcontractors and other outside parties.

Invoices of charges are recorded in this system as are checks issued in payment.

Charges to individual cost accounts are relayed or posted to the General Ledger.

• Accounts receivable journals provide the opposite function to that of accounts payable. In this journal, billings to clients are recorded as well as receipts. Revenues received are relayed to the general ledger.

• Job cost ledgers summarize the charges associated with particular projects, arranged in the various cost accounts used for the project budget.

• Inventory records are maintained to identify the amount of materials available at any time.

In traditional bookkeeping systems, day to day transactions are first recorded in journals. With double-entry bookkeeping, each transaction is recorded as both a debit and a credit to particular accounts in the ledger. For example, payment of a supplier's bill represents a debit or increase to a project cost account and a credit or reduction to the company's cash account. Periodically, the transaction information is summarized and transferred to ledger accounts. This process is called posting, and may be done instantaneously or daily in computerized systems.

In reviewing accounting information, the concepts of flows and stocks should be kept in mind. Daily transactions typically reflect flows of dollar amounts entering or leaving the organization. Similarly, use or receipt of particular materials represent flows from or to inventory. An account balance represents the stock or cumulative amount of funds resulting from these daily flows. Information on both flows and stocks are needed to give an accurate view of an organization's state. In addition, forecasts of future changes are needed for effective management.

Types of Liabilities:

1) Current Liabilities

2) Fixed Liabilities

Types of Assets:

1) Current Assets

2) Liquid Assets

3) Fixed Assets

4) Intangible Assets

Forecasting for Activity Cost Control:

For the purpose of project management and control, it is not sufficient to consider only the past record of costs and revenues incurred in a project. Good managers should focus upon future revenues, future costs and technical problems. For this purpose, traditional financial accounting schemes are not adequate to reflect the dynamic nature of a project. Accounts typically focus on recording routine costs and past expenditures associated with activities.Generally, past expenditures represent sunk costs that cannot be altered in the future and may or may not be relevant in the future. For example, after the completion of some activity, it may be discovered that some quality flaw renders the work useless. Unfortunately, the resources expended on the flawed construction will generally be sunk and cannot be recovered for re-construction (although it may be possible to change the burden of who pays for these resources by financial withholding or charges; owners will typically attempt to have constructors or designers pay for changes due to quality flaws). Since financial accounts are historical in nature, some means of forecasting or projecting the future course of a project is essential for management control.

• Budgeted Cost

The budgeted cost is derived from the detailed cost estimate prepared at the start of the project. The factors of cost would be referenced by cost account and by a prose description.

• Estimated total cost

The estimated or forecast total cost in each category is the current best estimate of costs based on progress and any changes since the budget was formed. Estimated total costs are the sum of cost to date, commitments and exposure. Methods for estimating total costs are described below.

• Cost Committed and Cost Exposure!! Estimated cost to completion in each category in divided into firm commitments and estimated additional cost or exposure. Commitments may represent material orders or subcontracts for which firm dollar amounts have been committed.

• Cost to Date

The actual cost incurred to date is recorded in column 6 and can be derived from the financial record keeping accounts.

• Over or (Under)

A final column in Table 12-4 indicates the amount over or under the budget for each category. This column is an indicator of the extent of variance from the project budget; items with unusually large overruns would represent a particular managerial concern. Note that variance is used in the terminology of project control to indicate a difference between budgeted and actual expenditures. The term is defined and used quite differently in statistics or mathematical analysis.

methods of measuring progress of work:

Ratio method

Repetitive type of work progress

Non Repetitive complexwork progress

Start/Finish method

project cost budjet monitoring parameters:

Budjet cost of work Scheduled(BCWS)

Budjet cost of work Performed(BCWP)

Actual cost of work Performed (ACWP)

UNIT IV
QUALITY CONTROL AND SAFETY DURINGCONSTRUCTION

Quality and safety Concerns in Construction-Organizing for Quality and Safety-Work and Material Specifications-Total Quality control-Quality control by statistical methods -Statistical Quality control with Sampling by Attributes-Statistical Quality control by Sampling and Variables-Safety.

statistical sampling:

1) Sampling by attributes

2) Sampling by variables

standards measured in safety construction:

Provide Helmets for workers

Requiring Eye Protection

Requiring Hearing Protection

Supply Safety Shoes

Provide First Aid facility

Various temporary Safeguards in construction:

Guy lines

Barricades

Braces

Railings

Toe Boards

Types of Accounting systems.

The cost accounts described in the previous sections provide only one of the various components in a financial accounting system. Before further discussing the use of cost accounts in project control, the relationship of project and financial accounting deserves mention. Accounting information is generally used for three distinct purposes:

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• External reporting to owners, government, regulators and other outside parties.

External reports are constrained to particular forms and procedures by contractual reporting requirements or by generally accepted accounting practices. Preparation of such external reports is referred to as financial accounting. In contrast, cost or managerial accounting is intended to aid internal managers in their responsibilities of planning, monitoring and control.

Project costs are always included in the system of financial accounts associated with an organization. At the heart of this system, all expense transactions are recorded in a general ledger. The general ledger of accounts forms the basis for management reports on particular projects as well as the financial accounts for an entire organization. Other components of a financial accounting system include:

• The accounts payable journal is intended to provide records of bills received from vendors, material suppliers, subcontractors and other outside parties.

Invoices of charges are recorded in this system as are checks issued in payment.

Charges to individual cost accounts are relayed or posted to the General Ledger.

• Accounts receivable journals provide the opposite function to that of accounts payable. In this journal, billings to clients are recorded as well as receipts.

Revenues received are relayed to the general ledger.

• Job cost ledgers summarize the charges associated with particular projects, arranged in the various cost accounts used for the project budget.

• Inventory records are maintained to identify the amount of materials available at any time.

In traditional bookkeeping systems, day to day transactions are first recorded in journals. With double-entry bookkeeping, each transaction is recorded as both a debit and a credit to particular accounts in the ledger. For example, payment of a supplier's bill represents a debit or increase to a project cost account and a credit or reduction to the company's cash account. Periodically, the transaction information is summarized and transferred to ledger accounts. This process is called posting, and may be done instantaneously or daily in computerized systems.

In reviewing accounting information, the concepts of flows and stocks should be kept in mind. Daily transactions typically reflect flows of dollar amounts entering or leaving the organization. Similarly, use or receipt of particular materials represent flows from or to inventory. An account balance represents the stock or cumulative amount of funds resulting from these daily flows. Information on both flows and stocks are needed to give an accurate view of an organization's state. In addition, forecasts of future changes are needed for effective management.

improve the job site in construction:

Design

choice of technology

Educating workers

Pre-qualification of contractors

Sampling by attributes:

The acceptance and rejection of a lot is based on the number of defectiveor a non defective item in the sample.This is referred to as sampling by attribute.

cash flow control:

Project managers also are involved with assessment of the overall status of the project, including the status of activities, financing, payments and receipts. These components include costs incurred (as described above), billings and receipts for billings to owners (for contractors), payable amounts to suppliers and contractors, financing plan cash flows (for bonds or other financial instruments), etc.

. In this case, costs are not divided into functional categories , such as labor, material, or equipment. Thus, the aggregation of different kinds of cost exposure or cost commitment has not been performed. The elements include:

• Costs

This is a summary of charges as reflected by the job cost accounts, including expenditures and estimated costs.

• Billings

This row summarizes the state of cash flows with respect to the owner of the facility; this row would not be included for reports to owners.

• Payables

The Payables row summarizes the amount owed by the contractor to material suppliers, labor or sub-contractors.

• Receivables

This row summarizes the cash flow of receipts from the owner. Note that the actual receipts from the owner may differ from the amounts billed due to delayed payments or retainage on the part of the owner.

• Cash Position

This row summarizes the cash position of the project as if all expenses and receipts for the project were combined in a single account. Each of the rows shown in Table 12-8 would be derived from different sets of financial accounts. Additional reports could be prepared on the financing cash flows for bonds .

improve in total control:

1) To improve worker enthusiasm

2) To reduce the defective items

3) To increase the cost of items

4) To insure safe and effective construction

factorsaffecying Quality in construction:

1) Incorrect Design

2) Improper workmanship

3) Lack of attention in worksite

4) Lack of training in construction work

Mention the causes of Accident in a construction industry:

1) Physical Accident

2) Physiological Accident

3) Psychological Accident

Schedule control:

Construction typically involves a deadline for work completion, so contractual agreements will force attention to schedules. More generally, delays in construction represent additional costs due to late facility occupancy or other factors. Just as costs incurred are compared to budgeted costs, actual activity durations may be compared to expected durations. In this process, forecasting the time to complete particular activities may be required.

The methods used for forecasting completion times of activities are directly analogous to those used for cost forecasting. For example, a typical estimating formula might be:

whereDf is the forecast duration, W is the amount of work, and ht is the observed productivity to time t. As with cost control, it is important to devise efficient and cost effective methods for gathering information on actual project accomplishments. Generally, observations of work completed are made by inspectors and project managers and then work completed is estimated. Once estimates of work complete and time expended on particular activities is available, deviations from the original duration estimate can be estimated.

This figure is constructed by summing up the percentage of each activity which is complete at different points in time; this summation can be weighted by the magnitude of effort associated with each activity. In Figure, the project was ahead of the original schedule for a period including point A, but is now late at point B by an amount equal to the horizontal distance between the planned progress and the actual progress observed to date.Illustration of Planned versus Actual Progress over Time on a Project

schedule adherence and the current status of a project can also be represented on geometric models of a facility.

In evaluating schedule progress, it is important to bear in mind that some activities possess float or scheduling leeway, whereas delays in activities on the critical path will cause project delays. In particular, the delay in planned progress at time t may be soaked up in activities' float (thereby causing no overall delay in the project completion) or may cause a project delay. As a result of this ambiguity, it is preferable to update the project schedule to devise an accurate protrayal of the schedule adherence. After applying a scheduling algorithm, a new project schedule can be obtained.Illustration of Planned versus Actual Expenditures on a Project

functions of Inspection:

1) Material Inspection

2) Process Inspection

3) Equipment Inspection

4) Finished Job Inspection

Various Safety equipments:

Helmet

Gloves

Shoes

Goggles

Safety Belts

technical services required for inspection:

1) Engineers/Designers/Arghitect/Geologists

2) Supervisors

3) Scientists

4) Technicians

Project budget:

For cost control on a project, the construction plan and the associated cash flow estimates can provide the baseline reference for subsequent project monitoring and control. For schedules, progress on individual activities and the achievement of milestone completions can be compared with the project schedule to monitor the progress of activities. Contract and job specifications provide the criteria by which to assess and assure the required quality of construction. The final or detailed cost estimate provides a baseline for the assessment of financial performance during the project. To the extent that costs are within the detailed cost estimate, then the project is thought to be under financial control. Overruns in particular cost categories signal the possibility of problems and give an indication of exactly what problems are being encountered. Expense oriented construction planning and control focuses upon the categories included in the final cost estimation. This focus is particular relevant for projects with few activities and considerable repetition such as grading and paving roadways.

For control and monitoring purposes, the original detailed cost estimate is typically converted to a project budget, and the project budget is used subsequently as a guide for management. Specific items in the detailed cost estimate become job cost elements. Expenses incurred during the course of a project are recorded in specific job cost accounts to be compared with the original cost estimates in each category. Thus, individual job cost accounts generally represent the basic unit for cost control. Alternatively, job cost accounts may be disaggregated or divided into work elements which are related both to particular scheduled activities and to particular cost account. In addition to cost amounts, information on material quantities and labor inputs within each job account is also typically retained in the project budget. With this information, actual materials usage and labor employed can be compared to the expected requirements. As a result, cost overruns or savings on particular items can be identified as due to changes in unit prices, labor productivity or in the amount of material consumed. The number of cost accounts associated with a particular project can vary considerably. For constructors, on the order of four hundred separate cost accounts might be used on a small project. These accounts record all the transactions associated with a project. Thus, separate accounts might exist for different types of materials, equipment use, payroll, project office, etc. Both physical and non-physical resources are represented, including overhead items such as computer use or interest charges.

UNIT V
ORGANIZATION AND USE OF PROJECT INFORMATION

Types of project information-Accuracy and Use of Information-Computerized organization and use of Information -Organizing information in databases-relational model of Data bases-Other conceptual Models of Databases-Centralized database Management systems-Databases and application programs-Information transfer and Flow.

Types of project information:

Cash flow and procurement accounts for each organization

• Intermediate analysis resulting during planning and design

• Design document, including drawings and specifications

• Construction schedules and cost estimates

• Quality control and assurance records

• Construction field activity and inspection logs

• Legal contracts and regulatory documents

project information in construction:

To find out the overall growth of the project.

• An historical record may be important for use during operation, to assess responsibilities in case of facility failure or for planning similar projects.

• The control and flow of information also important for collaborative work environment may professionals are working on difference aspect of a project and sharing information.

• Information provided for sharing data files tracing decisions and communication via electronic mail or video conferencing.

• To understand the scope alternatives for organizing project information.

Centralized Database Management Systems:

A datafile consists of a set of records arranged and defined for a single application system. Relational information between items in a record or between records is not explicitly described or available to other application systems. For example, a file of project activity durations and scheduled times might be assembled and manipulated by a project scheduling system. This datafile would not necessarily be available to the accounting system or to corporate planners.

A centralized DBM has several advantages over such stand-alone systems:

• Reduced redundancy good planning can allow duplicate or similar data stored in different files for different applications to be combined and stored only once.

• Improved availability information may be made available to any application program through the use of the DBM

• Reduced inconsistency if the same data is stored in more than one place, then updating in one place and not everywhere can lead to inconsistencies in the database.

• Enforced data security authorization to use information can be centralized.

For the purpose of project management, the issue of improved availability is particularly important. Most application programs create and own particular datafiles in the sense that information is difficult to obtain directly for other applications. Common problems in attempting to transfer data between such special purpose files are missing data items, unusable formats, and unknown formats.

As an example, suppose that the Purchasing Department keeps records of equipment rental costs on each project underway. This data is arranged so that payment of invoices can be handled expeditiously and project accounts are properly debited. The records are arranged by individual suppliers for this purpose. These records might not be particularly useful for the purpose of preparing cost estimates since:

• Some suppliers might not exist in the historical record.

• Finding the lowest cost supplier for particular pieces of equipment would be exceedingly tedious since every record would have to be read to find the desired piece of equipment and the cost.

• No direct way of abstracting the equipment codes and prices might exist.

An alternative arrangement might be to separately record equipment rental costs in (1) the Purchasing Department Records, (2) the Cost Estimating Division, and (3) the Company warehouse. While these multiple databases might each be designed for the individual use, they represent considerable redundancy and could easily result in inconsistencies as prices change over time. With a central DBM, desired views for each of these three users could be developed from a single database of equipment costs.

A manager need not conclude from this discussion that initiating a formal database will be a panacea. Life is never so simple. Installing and maintaining databases is a costly and time consuming endeavor. A single database is particularly vulnerable to equipment failure. Moreover, a central database system may be so expensive and cumbersome that it becomes ineffective; we will discuss some possibilities for transferring information between databases in a later section. But lack of good information and manual information management can also be expensive.

One might also contrast the operation of a formal, computerized database with that of a manual filing system. For the equipment supplier example cited above, an experienced purchasing clerk might be able to immediately find the lowest cost supplier of a particular piece of equipment. Making this identification might well occur in spite of the formal organization of the records by supplier organization. The experienced clerk will have his (or her) own subjective, conceptual model of the available information. This subjective model can be remarkably powerful. Unfortunately, the mass of information required, the continuing introduction of new employees, and the need for consistency on large projects make such manual systems less effective and reliable.

Databases and Applications Programs

The usefulness of a database organization is particularly evident in integrated design or management environments. In these systems, numerous applications programs share a common store of information. Data is drawn from the central database as needed by individual programs. Information requests are typically performed by including predefined function calls to the database management system within an application program. Results from one program are stored in the database and can be used by subsequent programs without specialized translation routines. Additionally, a user interface usually exists by which a project manager can directly make queries to the database. Figure illustrates the role of an integrated database in this regard as the central data store.

Illustration of an Integrated Applications System

database and DBM:

Database: Database is a collection of stored operational information used by themanagement and application systems of some particular enterprise.

DBM:DBM is the software program that directors the storage, maintenance,manipulation and retrieval of data users retrieve or store data by issuing specificrequest to the DBM. The objective of introducing a DBM is to free the user from thedetail of exactly how data are stored and manipulated,

database administrator:

Database administrator is an individual or group charged with themaintenance and design of the database, including approving access to the storedinformation.In large organization with many users, the database administrator is vital tothe success of the database systems.For small projects, the database administrator might be an assistant projectmanager or ever the project manager.

advantages relational models of databases:

• Flexibility

• Efficiency

• Reduces the redundancy

• Manipulation is easy

• Alternatives views or external models of the information.

Information can be organized using computers.

Numerous formal methods and possible organizations exist for the information required for project management. Before discussing the details of computations and information representation, it will be useful to describe a record keeping implementation, including some of the practical concerns in design and implementation. In this section, we shall describe a computer based system to provide construction yard and warehousemanagement information from the point of view of the system users. In the process, theusefulness of computerized databases can be illustrated.

In typical construction warehouses, written records are kept by warehouse clerks to record transfer or return of equipment to job sites, dispatch of material to jobs, and maintenance histories of particular pieces of equipment. In turn, these records are used as the basis for billing projects for the use of equipment and materials. For example, a daily charge would be made to a project for using a concrete pump. During the course of a month, the concrete pump might spend several days at different job sites, so each project would be charged for its use. The record keeping system is also used to monitor materials and equipment movements between sites so that equipment can be located.

Equipment movements would have to be tracked individually, days at each site counted, and the daily charge accumulated for each project. This project would be charged a daily rental rate until the grinder was returned. Hundreds or thousands of individual item transfers would have to be examined, and the process of preparing bills could easily require a week or two of effort.

In addition to generating billing information, a variety of reports would be useful in the process of managing a company's equipment and individual projects. Records of the history of use of particular pieces of equipment are useful for planning maintenance and deciding on the sale or scrapping of equipment. Reports on the cumulative amount of materials and equipment delivered to a job site would be of obvious benefit to project managers. Composite reports on the amount, location, and use of pieces of equipment of particular types are also useful in making decisions about the purchase of new equipment, inventory control, or for project planning. Unfortunately, producing each of these reports requires manually sifting through a large number of transfer cards. Alternatively, record keeping for these specific projects could have to proceed by keeping multiple records of the same information. For example, equipment transfers might be recorded on (1) a file for a particular piece of equipment and (2) a file for a particular project, in addition to the basic transfer form. Even with these redundant records, producing the various desired reports would be time consuming.

Finally, flexibility of systems for changes is an important design and implementation concern. New reports or views of the data are a common requirement as the system is used. For example, the introduction of a new accounting system would require changes in the communications procedure from the warehouse inventory system to record changes and other cost items.

In sum, computerizing the warehouse inventory system could save considerable labor, speed up billing, and facilitate better management control. Against these advantages must be placed the cost of introducing computer hardware and software in the warehouse.

Advantages of centralized management systems:

(i) Reduced redundancy: Good planning can allow duplicate or similar data stored indifferent files for different applications to be combined and stored only once

(ii) Improved availability: Information may be made available to any applicationprogram through the use of the DBM

(iii) Reduced inconsistency: If the data is stored in more than one place, thenupdating in one place and not everywhere can lead to inconsistencies in the database.

(iii) Enforced data security: Authorization to use information can be centralized.

Application programs in DBM:

• Data is drawn from the central database as needed by individual programs

• Information request are typically performed by including predefined

function calls to the database management system within an applicationprogram.

• One program are stored in the database and can be used by subsequentprograms without specialized translation routines.

database management systems

With the advent of micro-computer database managers, it is possible to develop formal, computerized databases for even small organizations and projects. In this section, we will discuss the characteristics of such formal databases. Equivalent organization of information for manual manipulation is possible but tedious. Computer based information systems also have the significant advantage of rapid retrieval for immediate use and, in most instances, lower overall costs. For example, computerized specifications writing systems have resulted in well documented savings. These systems have records of common specification phrases or paragraphs which can be tailored to specific project applications.

Formally, a database is a collection of stored operational information used by the management and application systems of some particular enterprise. This stored information has explicit associations or relationships depending upon the content and definition of the stored data, and these associations may themselves be considered to be part of the database. Figure illustrates some of the typical elements of a database. The internal model is the actual location and representation of the stored data. At some level of detail, it consists of the strings of "bits" which are stored in a computer's memory, on the tracks of a recording disk, on a tape, or on some other storage device.

Figure Illustration of a Database Management System Architecture

A manager need not be concerned with the details of data storage since this internal representation and manipulation is regulated by the Database Manager Program (DBM). The DBM is the software program that directs the storage, maintenance, manipulation and retrieval of data. Users retrieve or store data by issuing specific requests to the DBM. The objective of introducing a DBM is to free the user from the detail of exactly how data are stored and manipulated. At the same time, many different users with a wide variety of needs can use the same database by calling on the DBM. Usually the DBM will be available to a user by means of a special query language. For example, a manager might ask a DBM to report on all project tasks which are scheduled to be underway on a particular date. The desirable properties of a DBM include the ability to provide the user with ready access to the stored data and to maintain the integrity and security of the data. Numerous commercial DBM exist which provide these capabilities and can be readily adopted to project management applications.

While the actual storage of the information in a database will depend upon the particular machine and storage media employed, a Conceptual Data Model exists which provides the user with an idea or abstract representation of the data organization. (More formally, the overall configuration of the information in the database is called the conceptual schema.) For example, a piece of data might be viewed as a particular value within a record of a datafile. In this conceptual model, a datafile for an application system consists of a series of records with pre-defined variables within each record. A record is simply a sequence of variable values, which may be text characters or numerals. This datafile model is one of the earliest and most important data organization structures. But other views of data organization exist and can be exceedingly useful. The next section describes one such general model, called the relational model.

Continuing with the elements in Figure, the data dictionary contains the definitions of the information in the database. In some systems, data dictionaries are limited to descriptions of the items in the database. More general systems employ the data dictionary as the information source for anything dealing with the database systems. It documents the design of the database: what data are stored, how the data is related, what are the allowable values for data items, etc. The data dictionary may also contain user authorizations specifying who may have access to particular pieces of information. Another important element of the data dictionary is a specification of allowable ranges for pieces of data; by prohibiting the input of erroneous data, the accuracy of the database improves.

External models are the means by which the users view the database. Of all the information in the database, one particular user's view may be just a subset of the total. A particular view may also require specific translation or manipulation of the information in the database. For example, the external model for a paycheck writing program might consist solely of a list of employee names and salary totals, even if the underlying database would include employee hours and hourly pay rates. As far as that program is concerned, no other data exists in the database. The DBM provides a means of translating particular external models or views into the overall data model. Different users can view the data in quite distinct fashions, yet the data itself can be centrally stored and need not be copied separately for each user. External models provide the format by which any specific information needed is retrieved. Database "users" can be human operators or other application programs such as the paycheck writing program mentioned above. Finally, the Database Administrator is an individual or group charged with the maintenance and design of the database, including approving access to the stored information. The assignment of the database administrator should not be taken lightly. Especially in large organizations with many users, the database administrator is vital to the success of the database system. For small projects, the database administrator might be an assistant project manager or even the project manager

data dictionary:

Data dictionary contains the definitions of the information in the database.Data dictionary are limited to descriptions as the information source for anythingdealing with the database systems. The data dictionary may be contain userauthorization specifying who may have access to particular pieces of information

main feature of database:

Database can serve the role of storing a library of information on standardarchitectural features and compound properties.

• These standard compounds can be called from the database library andinduced into a new design

• The database can also store the description of a new design, such asnumber, type and location of building components

disadvantages of centralized database management systems:

1. Central database systems may be expansive and cumbersome that it

becomes ineffective

2. Manual information management can also expansive

3. Installing and maintaining database costly

4. A single database is particularly vulnerable to equipment failure

Information transfer and flow:

In an overabundance of optimism or enthusiasm, it might be tempting to conclude that all information pertaining to a project might be stored in a single database. This has never been achieved and is both unlikely to occur and undesirable in itself. Among the difficulties of such excessive centralization are:

- Existence of multiple firms or agencies involved in any project. Each organization must retain its own records of activities, whether or not other information is centralized. Geographic dispersion of work even within the same firm can also be advantageous. With design offices around the globe, fast track projects can have work underway by different offices 24 hours a day.
- Advantages of distributed processing. Current computer technology suggests that using a number of computers at the various points that work is performed is more cost effective than using a single, centralized mainframe computer. Personal computers not only have cost and access advantages, they also provide a degree of desired redundancy and increased reliability.
- Dynamic changes in information needs. As a project evolves, the level of detail and the types of information required will vary greatly.
- Database diseconomies of scale. As any database gets larger, it becomes less and less efficient to find desired information.
- Incompatible user perspectives. Defining a single data organization involves trade-offs between different groups of users and application systems. A good organization for one group may be poor for another.

In addition to these problems, there will always be a set of untidy information which cannot be easily defined or formalized to the extent necessary for storage in a database.

While a single database may be undesirable, it is also apparent that it is desirable to structure independent application systems or databases so that measurement information need only be manually recorded once and communication between the database might exist. Consider the following examples illustrating the desirability of communication between independent application systems or databases. While some progress has occurred, the level of integration and existing mechanisms for information flow in project management is fairly primitive. By and large, information flow relies primarily on talking, written texts of reports and specifications and drawings.

Application of an Input Pre-processor

Final Cost Estimation, Scheduling and Monitoring

Many firms maintain essentially independent systems for final cost estimation and project activity scheduling and monitoring. As a result, the detailed breakdown of the project into specific job related activities must be completely re-done for scheduling and monitoring. By providing a means of rolling-over or transferring the final cost estimate, some of this expensive and time-consuming planning effort could be avoided.

Design Representation

In many areas of engineering design, the use of computer analysis tools applied to facility models has become prevalent and remarkably effective. However, these computer-based facility models are often separately developed or encoded by each firm involved in the design process. Thus, the architect, structural engineer, mechanical engineer, steel fabricator, construction manager and others might all have separate computer-based representations of a facility. Communication by means of reproduced facility plans and prose specifications is traditional among these groups. While transfer of this information in a form suitable for direct computer processing is difficult, it offers obvious advantages in avoiding repetition of work, delays and transcription errors.