REQUIREMENTS AND PROPOSALS FOR A MANAGEMENT INFORMATION SYSTEM FOR CONTRACTOR PROJECT CONTROL

MAMDOUH RIAD BEKHIT

A Dissertation

in

The Centre for

Building Studies

Faculty of

Engineering

Presented in Partial Fulfillment of the Requirements
for the degree of Master of Engineering (Building)
Centre for Building Studies
Concordia University
Montreal, Quebec, Canada

April, 1980

ABSTRACT

REQUIREMENTS AND PROPOSALS FOR A MANAGEMENT INFORMATION SYSTEM FOR CONTRACTOR PROJECT CONTROL

MAMDOUH RIAD BEKHIT

A need exists for improved management information systems to be used by medium size building contractors which possess different properties and have different requirements when compared to large size, more sophisticated civil engineering contractors.

A preliminary study for developing such an information system has been undertaken and the basic features and requirements to be met by the system for project control by building contractors are identified.

The main hypothesis of this dissertation is that success in designing a management information system that will be used by contractors can only be achieved if the system reflects the types of problems encountered by the firm, the corrective actions open to it, and its organizational structure and personnel capabilities.

Deficiencies and problems are identified in accordance with their effects on time and cost factors only. Problems arising due to quality and quality control are treated in the same manner.

Construction as a whole is treated as a system composed of two major subsystems:

i) Resources

ii) Processes

Consequently, the work has concentrated on:

a) Definition and description of resources, processes, and their components.

b) Identification of problem areas and deficiencies based on above assumptions.

c) Proposals on possible corrective measures.

It is expected that the concepts put forward will provide a basis for the formulation of a management information system design brief which is responsive to the project control needs of the building contractor.

ACKNOWLEDGEMENT

I wish to extend my thanks to the individuals whose assistance and encouragement were instrumental in the realization of this dissertation.

First, and foremost I would like to express my gratitude and sincere appreciation to my supervisor Dr. Alan D. Russell, for his perceptive guidance, critical insight, dedication and encouragement throughout my research.

I would like also to thank Mr. Stephan Revay of Revay and Associates Ltd., Montreal, for his careful review of drafts of the questionnaire and his important comments and proposals in this regard.

I am also indebted to those contractors who responded to the questionnaire. Their response was of great help to me.

I am grateful to Dr. Nihat Taner whose advice and valuable criticisms are clearly reflected in the final version of this dissertation.

I am thankful to Carol Barton for her patience, reliability and professional ability in typing this dissertation.

TABLE OF CONTENTS

LIST OF FIGURES

CHAPTER 1

DESCRIPTION AND OBJECTIVES OF THE STUDY

1.1 INTRODUCTION

This dissertation represents one phase of a multiphase research program directed at developing minicomputer based project control and financial management information systems for use by medium-sized contractors. The term medium-sized contractors refers to those firms whose annual work volume lies between $5 million - $50 million. This group is responsible for the majority of construction work in Canada.

1.2 MANAGEMENT INFORMATION SYSTEM FOR PROJECT CONTROL

A management information system for project control is an aid for converting certain data about the efforts exerted and the physical work accomplished for the activities comprising a project, at specified time intervals during the project's duration, into useful information for management about the extent to which the various aspects of performance are in conformance with the firm's objectives. Key information required includes:

1. the productivity of labour and equipment,
2. the expected overall cost, profitability and completion time both at the activity and project level;
3. the presence of any deficiencies affecting the cost, time or quality of project activities along with their root causes; and
4. assessment of various courses of actions for rectifying deficiencies.

A fundamental criterion for success of any management information system (MIS) is the extent to which it is used. For the contractor, his willingness to use a computerized MIS will be governed by how well any proposed system interfaces with the present practices and personnel capabilities of the firm. Consequently, the designers of a MIS must consider the following requirements:

1. The developed system should reflect the realities of the contracting industry as opposed to the often idealized characteristics and conditions adopted in many academic studies. This is essential if the system is to achieve a high level of use.

   For instance, in spite of all the theoretically perceived virtues of the C.P.M. and PERT techniques, limited use of these techniques by medium-sized contractors, is being experienced. The manner in which firms plan and control has been investigated in a previous phase of this research program by way of detailed case studies of three Montreal based general contractors (17). An attempt was also made to document the information systems used by these firms as well as the attributes of the users of these systems.

2. The system should be capable of providing the user with three main types of information:

   i) It should be able to highlight key sources of deficiencies or weaknesses in performance. The system should possess the capability of revealing the presence of any such deficiencies as soon as possible after they start to exist. This is essential if the system

is to play an effective role in assisting management in correcting such deficiencies.

ii) The system should be able to provide the users with information as tightly confined as possible about the potential causes of the deficiencies. The causes suggested by the system should be at a level of detail that allows the user to initiate the necessary corrective action without further excessive investigations. In other words, a statement made by the system, for instance, that there exists a cost overrun in labour cost, is less useful than indicating that the labour productivity is below standard. This will save the user's efforts and time spent in concluding whether the cost overrun is due to higher wages (possibly because of unexpected market conditions), or due to lower productivity. It also would be more useful if the system can attribute this lower productivity to one specific root cause such as: insufficient supervision, overstaffing, inadequate labour skill or low morale among labour.

iii) The system should be able to function as an evaluation procedure that can help predict the implications on project time, cost and quality of proposed corrective actions. For instance, suppose the control system has forecasted a serious delay in a critical activity which is being carried out by the contractor's own equipment. The expected delay can be lessened or avoided by award-

ing the activity to a sub-contractor whose equipment resources are more advanced. Considering the extra cost involved, would such a decision be of an overall benefit to the general contractor? The control system is expected to be capable of forecasting the project's total cost and time, given the corrective action proposed.

3. The developed system should be able to present different types of output formats for the various levels of management. This is an important feature for the following reasons:

   i) Scope of Responsibility

   Various levels of management have different concerns which are proportionate with their scope of responsibility. Consequently, the nature and degree of details of the required information are substantially different. Moreover, different measures or terms could be required to express the same area of concern. For example, as a cost performance measure the group productivity is an appropriate measure for the first level supervisor, whereas, the comparable measure for top management could be the project's cost to complete.

   ii) Personnel's Education and Skills

   Considering the differences among the various levels of management in terms of their capabilities, skills and education, the use of different output formats for different levels of management becomes a must. The use of the same format for all management levels

might preclude the use of more advanced techniques for planning and control for those personnel capable of using them. For example, while the project manager might be comfortable with the use of CPM or precedence diagrams, a field superintendent may only be capable of using a bar chart. Thus, rather than foregoing the use of networking techniques for planning and control, the MIS should be able to produce output reports in formats which are matched to personnel capabilities.

1.3 SPECIFIC OBJECTIVES OF DISSERTATION

The role of this phase of study is to provide the basic input data required for the preparation of a design brief which will serve as the frame of reference for the designers of management information systems for project control for the medium-sized contractor, as defined previously.

Based on the discussion in section 1.2, the design brief should provide the designer with the following information:

i) Detailed information about the sorts of deficiencies that should be revealed by the system along with their relative importance. For example, consideration should be given to whether the rate of labour turnover should be included as a basic component of the system or instead, should be included as an optional component since it might be required only under certain circumstances, such as for projects in remote areas.

ii) The system's basic structure, especially with respect to

whether the system should be made up of independent components, which are capable of only acting alone or whether they should be designed so as to be capable of being assembled into a totally integrated system.

iii) Information about the quantity and quality of the resources which can be allocated, by the firm, for development of a control system. This includes the human and monetary resources, computing facilities, etc.

iv) Information about the system users as to classifications of management levels, information needed for each level, and knowledge of the skills and characteristics of the managers at each level.

From the above description, the basic input data needed for the task of preparing the design brief and the role of this dissertation in assisting in the related data collection task are as follows:

i) To accomplish the first task, all the controllable problems that might be encountered in a project, from the contractor's viewpoint, should be identified. This task will be assigned to the second chapter of this study. Problems are first divided into two main categories - Resource and Process problems and then analyzed in detail.

ii) A survey of the user's needs, characteristics and attitudes towards control, their present practices, as well as the potential resources they are willing to allocate to the control function, seems the basic data required to carry out the second and third tasks above. The third chapter will present a methodology directed at obtaining this

information.

iii) The last type of information required for the design brief will involve identifying the full range of actions which can be taken by various levels of management, in order to correct or to avoid the recurrence of controllable problems. Identifying the range of actions which a certain level of mangement is empowered to initiate, will help determine the information required for this level of management for the purpose of evaluating the appropriateness of alternative corrective actions. Chapter 4 examines the types of corrective actions possible and a format for associating these actions with performance measures, information required from the MIS and level of management responsible for initiating corrective action.

1.4 METHODOLOGY OF THE STUDY

The means generally available for tackling a study of the nature proposed herein are:

i) An analysis and synthesis of previous research work and literature in the particular area;

ii) The collection of data by means of questionnaires and interviews, and their analysis by accepted statistical techniques; and

iii) Synthesis of available information and experience and reasoned extension of existing knowledge based on the postulation of some analytic model.

Unfortunately, very little work has been carried out on the

information system needs for the medium-sized contractor. Consequently, items (ii) and (iii) above will form the basis of the methodology for this dissertation.

1.5 SUMMARY

It is the firm conviction of the author that the control system should be designed to reflect the real characteristics, actual problems and current practices of contracting firms. Dramatic changes are very unlikely to be effected by the firm for the sake of tailoring their practices and interrelationships to the requirements of a control system which is based on some normative model of the firm developed by management theorists.

The central hypothesis of the work described herein is that success in designing a management information system that will be used by contractors can only be achieved if the system reflects the types of problems encountered by the firm, the corrective actions open to it, and its organizational structure and personnel capabilities. This dissertation sets out to identify and structure such information. It can then be augmented further by future researchers so that a useful descriptive model of the firm can be developed. It is this model which will form the basis for the design of a management information system for project control for the medium sized contractor.

CHAPTER 2
CONSTRUCTION PROBLEMS, THEIR DETECTION AND CAUSES

2.1 THE SCOPE

This chapter will examine the problems encountered by the building general contractor with respect to control of project cost, time and quality.

The study will proceed as follows:

(i) The various types of problems will be systematically classified;

(ii) Using this classification, a scheme for an integrated set of performance measures for detecting of deficiencies in performance, will be presented. These performance measures provide the basis for assessing the input data, output information and its structure, and the processing algorithms required for the control system;

(iii) The potential causes for performance deficiencies will be identified.

It is important to point out that the problems which will be dealt with in this chapter are those which fall within a specific time span of the project life cycle. This period extends from the date of awarding the project to the contractor, until the final completion of work in its physical, financial and legal sense. Also it should be noted that quality control and measures will be treated as a factor influencing the cost and the duration of the project. That is, for

example if a specific item is rejected by the supervising engineer because of low quality, it would influence both the total time and introduce additional costs due to rework.

2.2 DETECTING PROBLEMS

Looking at construction as a PROCESS applied to some RESOURCES to yield a product (the facility), will help to identify two basic problem types encountered in maintaining control over time, cost and quality. These types are: 1) Resource Problems and 2) Process Problems.

Resource problems are associated with the procurement of resources of specific characteristics on the basis of a predetermined time schedule, and include the problems related to making these resources physically available at the site (if required).

Process problems are associated with all methods and procedures of utilizing and maintaining the delivered resources from the time of receiving them until converting them into the end product, including the handling (such as storage, transportation and distribution, etc.) of the resources at site.

An important difference between the two categories of problems, that has a considerable impact on the choice of the appropriate controlling technique is that the problems of the first category usually do not require complicated or sophisticated devices to detect their existence. This is because of their noticeable and direct impact on the physical progress of the works, which in extreme cases may result in the complete stoppage of the project. The other category of problems requires, usually, more complicated and sophisticated devices for detecting its presence, since in many cases there are usually no physical or conspicuous

signs that flag such presence or help in their detection. However, it should be emphasized that the two categories of problems are closely linked, for instance a process problem like low labour productivity can be caused by a resource deficiency like inexperienced labour, or by a process deficiency like inadequate safety precautions on site which may divert the labour attention to their safety rather than production.

The methodology used will consist of the analysis of each of the two main problem categories independently.

For each resource type, generally used in a construction operation, a set of performance measures will be proposed for the purpose of detecting any possible deficiencies in either the procurement of the resource (in case of resource problems) or in the utilization of the resource (in case of process problems).

The resources usually required for a construction project are identified in Figure 2.1 and described below. They have been broken down in a way which facilitates the succeeding analysis, grouping those which are expected to be handled in a similar fashion by the contractor's control procedures, and separating those which are thought to be handled differently. Five main resource categories have been identified. They are:

[1] HUMAN RESOURCES:

which can be subdivided into three groups:

a. Contractor's own direct labour

b. Contractor's management personnel

c. Subcontractors

[2] MATERIALS

which can be classified as follows:

a. Direct Materials; which make up the proposed building including any machinery and equipment.

b. Indirect Materials: Materials for temporary works such as scaffolding or form work. These materials can be used more than once.

c. Operating Materials: These are miscellaneous materials needed for the day-to-day operations such as fuel, lubricating oil, etc.

[3] MACHINERY AND EQUIPMENT

which include the machinerey used in the construction process (eg. mixers, buldozers, cranes). This category excludes the machinery or the equipment which will be permanently affixed in the building.

[4] MONETARY RESOURCES

Monetary resources refer to the working capital requirements of a job, credit from suppliers and equipment dealers, equity inputs, etc.

[5] DRAWINGS AND DESIGNS

of concern here are two types of drawings:

a. Working or shop drawings for specific items set by the contract as a part of the contractor's responsibilities. These drawings are usually made to meet the specifications set by the owner's Architect/ Engineer.

b. Drawings needed by the contractor's staff for the purpose of detailing certain processes or methods of construction.

2.3 RESOURCE PROBLEMS

PERFORMANCE MEASURES AND PROBLEMS CAUSES:

2.3.1 CONSTRUCTION MATERIALS PROCUREMENT

Definition

The procurement of construction materials includes all the activities necessary for the acquisition of the requried materials and making them available to the site use. These activities can be classified into the following major functions:

1. Purchasing: which includes the activities starting from the preparation of material specifications and contract conditions (or the bid package), selection of potential suppliers (or tenderers), execution of the order or contract which includes issuing letter of credits, manufacturing orders, etc.

2. Expediting: the follow up of fabrication schedules and/or delivery dates.

3. Inspection: check and approval of vendor's drawings and the quality assurance of the manufactured or the delivered materials.

4. Logistics: Packaging, custom clearance, selection of carrier (if applicable) or using the firm's own transportation means and delivery to site store.

Basic Planning Required

1. Fig. 2.2 shows a typical time schedule planning for the procurement activities. The various activities are plotted

against time. Interval checks will reveal delays in the procurement activities.

2. An estimate breakdown of the direct cost of the procured material which includes the initial cost, insurance, packaging; letter of credits, custom duties loading, unloading and transportation costs.

Performance Measures

1. Current Status and Time to Deliver at Site

A two fold performance measure is chosen to reflect a clear idea of the material procurement status. In Fig. (2.2), suppose point A represents the current procurement status of a certain material or piece of equipment. Point B represents the forecasted date of delivering the material at site according to the updated information about the future procurement activities. For instance in the example illustrated the duration of the manufacturing activity, according to the supplier's offer, is longer than the duration estimated in the original plan. Point A and B should be compared respectively with points A' and B' on the original planning curve. A delay should be highlighted by the control system if A is below A' and/or B is to the right of B'. The two measures are independent and can collectively pinpoint deficiencies that result in project delay. Note also that some problems can result from an early delivery of materials, for instance, because of the earlier than expected payment to the supplier which may upset the cash flow arrangement of the contractor. The proposed measure can detect such a problem as well.

The causes of a deficiency detected by this performance measure

are identified as follows:

1. Errors in purchasing orders either in items description or quantities;
2. Inefficient expediting efforts;
3. Inefficient logistics organization or procedures;
4. Uncontrollable transportation problems such as strikes in ports, accidents, etc.;
5. Shortages due to mismatch of supply capacity and demand in the market;
6. Defective planning as to the underestimation of the time requirement for any of the procurement stages (preparing specifications, shop drawings, approval of owner's agent, manufacturing, shipping, etc.);
7. Inadequate inventory policy (as to the minimum level of inventory or materials on site);
8. Monetary problems that might delay the delivery because of late payment to the supplier.

2. Partial Cost-to-Date and Projected Total (Direct) Cost of Material

Comparing the following two sets of figures is suggested here for detecting cost deficiencies in the procurement of a certain material:

A. The budgeted and the actual cost of executed commitments.

B. The budgeted and projected total direct cost of each

material.

A deficiency, indicated by one or both of the above measures, can be attributed to any of the following causes:

1. Inappropriate purchasing procedures (for instance, using direct negotiation rather than competitive bidding system, or vice versa, as a means of getting the best offer;
2. Unexpected escalation in material price due to mismatch of supply and demand in the market or delays in procurement;
3. Material cost underestimated;
4. Inadequate attention or underestimation of conditions of vendor's offer;
5. Incompetent purchasing agent as to the scope of his knowledge of sources of supply, or his negotiation capabilities.
6. Incompetent logistics officer as to the choice of the appropriate carrier, means of transportation, etc.

3. Quality of Procured Material

The quality of the indirect materials required for temporary works (eg. form work) are sometimes left by the specifications, to the contractor's discretion. A low quality material could probably affect some areas of site performance which might result in complaints by the site management and request to modify performance standards. A

procedure for controlling quality (among other aspects), can be effected, if the system is made capable of reporting the initially estimated standards and to highlight any changes in these standards.

The causes of procurement of low quality materials are:

1. Shortages due to the mismatch of the demand and supply in the market;
2. Inexperienced or incompetent purchasing officer;
3. Insufficient or defective description of the required items in the purchasing order.
4. Inadequate purchasing procedures as to the allocation of the responsibility of preparation and verification of the purchasing orders;
5. Underestimation of cost of materials coupled with rigid budget policy that force procurement of lower quality materials.

2.3.2 HUMAN RESOURCES PROCUREMENT

As pointed out earlier, the human resources can be classifed into three main categories:

A. The contractor's own labour force

B. The contractor's management personnel

C. The subcontractors (which can also be subdivided into labor force and management personnel).

2.3.2.1 Contractor's Own Labour Force

Definition

This catefory of human resources includes the direct labour required for activities carried out directly by the general contractor.

Basic Planning Required:

1. From the master schedule of activities, the requirement of each labour trade can be concluded. Efforts are exerted to minimize the fluctuations of needs. The procurement department is to be furnished with a final schedule for labour requirement. Fig. 2.3 illustrates a typical labour requirement schedule for a single craft. The lag time is used as a precaution against late detection of the problem. A commitment of labour availability has to be arrived at before that date, otherwise a deficiency should be signaled by the control system.

2. An estimate of the labour cost to the firm, for each craft.

Procurement Procedure

The sources options open to the firm are:

1. Unionized labour through trade unions.

2. Non-unionized labour through labour agencies or direct recruitment. This option is open to limited number of projects.

The Procurement Measures

1. Timely Procurement

The failure to procure the required resourses at the required time may be attributed to any of the following causes:

1. Incompetent procurement officer;
2. Unfavorable relations with trade unions;
3. Shortages in the labour market due to mismatch of demand and supply;
4. Inappropriate labour policy, as to the employment of unionized versus non-unionized labour.

2. Within Budget Procurement

The potential causes of an over-budget procurement are:

1. Unexpected escalation of labour's wages for certain trades;
2. Inappropriate labour policy as to the employment of unionized versus non-unionized labour.
3. Labour's wages underestimated in the original plan;
4. Labour's benefits or indirect cost underestimated. This includes transportation and accomodation plan in case of projects in remote areas.

2.3.2.2 Contractor's Project Management Personnel

Definition

This category of personnel covers all individuals working on the project other than direct labour. It includes office staff (supporting staff) as well as site staff.

Basic Planning Requirements

A list of requirements has to be prepared immediately after the project has been awarded. Some of the positions may be filled by personnel transferred from other projects of the firm. An estimate of the total cost of each individual to the firm should be established.

Procedure Description

The recruitment is accomplished through either employment agencies or direct hiring.

Performance Measures

1. Timely Recruitment

A delay in recruitment of the required personnel could be caused by any of the following reasons:

1. Inappropriate recruitment procedures (employment agency versus direct hiring);
2. Incompetent recruitment officer;
3. Market shortages in some professions due to mismatch of demand and supply;
4. The firm's reputation as to certain management procedures or policies which are not attractive to the management

personnel. These policies include:

a. The firm's trends of keeping its staff permanently employed,

b. Personal advancement opportunities,

c. Training policy,

d. Degree of formalization of work relationships,

e. Degree of structuring of tasks,

f. Authoritarian versus participative styles of management.

5. A delay in another project from which some individuals are expected to be transferred to the project under consideration.

2. Within Budget Recruitment

The potential causes of an over budget recruitment could be:

1. Unexpected escalation in the wages of certain professions due to mismatch of demand and supply in the market;
2. Inappropriate recruitment procedures (advertisement channels, using employment agencies versus direct hiring, etc.);
3. Defective estimate of the resources cost to the firm (in the initial plan);
4. Being forced to hire overqualified personnel in case of low supply.

2.3.2.3 Procurement of Subcontractors

Basic Planning Requirements

1. A list of activities that are intended to be subcontracted should be prepared immediately after the project has been

awarded to the general contractor. The list should include the expected commencement date of the respective activity.

2. An estimate of the total cost of each activity.

Procedures:

The procurement department can employ any of the following procedures for procurement of various subcontracts:

A. Direct negotiation with the firm's traditional subcontractors

B. A limited bidding competition among the firm's favorite subcontractors

C. An open competition (for all interested subcontractors).

Within the firm's general policy, different contractual arrangements and conditions are generally open to the procurement officer's discretion (unless commitment has already been made during bidding stage as in case of bid depository).

Performance Measures

1. Timely Procurement

The causes of a deficiency, highlighted by this performance measure are identified below:

1. Inappropriate procedure adopted for procurement (negotiation versus competitive bidding, etc.);

2. Inadequate performance by the procurement officer either in the procurement of the subcontractors or in coordination with subcontractors to have them on site at the appropriate time;

3. Shortages in the market due to mismatch of demand and supply in certain trades;
4. Unfavorable reputation of the firm regarding the transactions with subcontractors.

2. Within Budget Procurement

The causes of a deficiency, spotted by this performance measure, are:

1. Unexpected escalation in prices as a result of mismatch in demand and supply or other reasons (such as inflation) related to the national economy or labour agreements;
2. Inappropriate procurement procedures adopted;
3. Inadequate evaluation of certain provisions included in the accepted offer;
4. Cost of activities underestimated in the initial plan by the general contractor's estimator.

2.3.3 Equipment Procurement

Definition and Procedures

It is important to recall that the equipment meant here does not include the ones which will be affixed in the constructed facility. These are being considered as materials. The reason behind this classification is that they are dealt with in the same way as materials as far as their procurement and usage in construction are concerned.

The procedure of equipment procurement as meant here is strictly limited to renting, leasing or moving from the firm's other projects, workshop or stores. The purchasing of a piece of equipment by the firm

for operational purposes are not included here in this category of resources for two reasons:

1. Their procurement can be handled the same way as for materials procurement;
2. In most of the cases this is a multi-project investment and therefore the purchase cost should be treated at a higher level than the specific project management.

Basic Planning Requirements

A schedule showing the type of equipment required along with its commencing date and needed duration should be furnished to the procurement officer. An estimation of the transportation cost or the rental rates (if applicable), is also required.

Performance Measures

1. Timely Procurement

The causes of delay in procurement of a piece of equipment are identified as follows:

1. Market shortages due to increase of demand on certain pieces of equipment;
2. Unexpected transportation problems or accidents;
3. Inappropriate logistics procedures;
4. Incompetent procurement and/or logistics officers;
5. A delay or disruption encountered in another project from which a piece of equipment is supposed to be moved to the project under consideration.
6. Inter project planning errors (such as under estimation of activities duration or transportation time).

2. Within Budget Procurement

which is composed of two components:

A. Transporation Cost

B. Rental Rates (if applicable)

An overrun in either or both of the above cost components can be simply attributed to any of the following causes:

1. Unfavourable market conditions that push up the rates mainly because of the mismatch between supply and demand;
2. Inadequate procurement efforts that lead to missing chances of attaining better rates, for example exploring the possibility of renting from another contractor his currently idle equipment.
3. Defective estimation of rates in the original planning.

2.3.4 Monetary Resources Procurement

Definition, Basic Planning Required and Procedures

The monetary resources meant here are those needed to be acquired from sources other than the project's owner.

From a cash flow planning schedule the required working capital throughout the project's construction duration can be estimated. In Fig. 2.4 the ordinate (ab) represents the required working capital at time (t).

The cost of borrowed money (due to interest rates) should be estimated in the project's initial plan.

Working capital can be acquired by way of retained earnings, new equity input, bank credit or credit from suppliers. In any case,

allowance must be made for the cost of funds.

Performance Measures

1. Within Budget Cost of Money

A higher than estimated cost of money can be attributed to any of the following causes:

1. Unexpected escalation of interest rates;
2. The company's overall financial situation which may force financing institutions to raise the risk premium in financing the firm's projects;
3. Unfavourable relationships with bankers;
4. A defective estimate of the cost of money in the initial plan.

2. Timely Availability of Resources

The potential causes of delays in procurement of monetary resources are:

1. A defective cash flow planning as to the estimation of the capital required or its timing. A request for additional monetary resources may not be made at an early time to allow timely procurement;
2. Delay or withholding of the payments by the owner;
3. The company's financial situation which might discourage financing institutions;
4. The market situation which might affect the availability of resources.

2.4 PROCESS PROBLEMS

This part is concerned with the problems resulting from the way of processing the procured resources towards the accomplishment of the construction task. The way of processing includes all the methods and tools utilized by the management. These can be identified as follows:

1. Construction methods and techniques
2. Planning and scheduling techniques
3. Personnel management which includes:
   a. Organizational structure which includes the distribution of responsibilities and authorities, structuring of activities;
   b. Motivation policy
   c. Reporting systems
   d. Communication and coordination channels
   e. Labour relation program
   f. Labour safety program
   g. Management styles (bureaucratic versus participative)
4. Material control which includes:
   a. Inventory policy
   b. Store keeping procedures
   c. Purchasing of miscellaneous operational materials
5. Equipment management which includes:
   a. Maintenance program
   b. Repair policy
   c. On site transportation

Process problems are not as easily detectable as resource problems because they are not usually accompanied by physical signs that

flag their presence, which is the case for resources problems where an activity can be discontinued (or not started) because of the nonavailability of any of the resources.

The following scheme will suggest, (similar to what has been done in the case of resource problems) a set of performance measures to detect deficiencies of various aspects of performance. The measures will be broken up into separate groups, each of which is measuring the magnitude of direct impact on the individual cost of one of the resources. The potential causes of a deficiency detected by each of the measures, will also be identified.

2.4.1 PROBLEMS AFFECTING THE COST OF HUMAN RESOURCES

2.4.1.1 Contractor's Own Labour Force

Performance Measures

1. Labour Productivity

Basic Planning Requirements

An estimated productivity curve should be prepared. It should indicate the number of labour hours versus some milestone events throughout the life cycle of an activity. Fig. 2.5 shows a typical curve of job progress versus total man hours for a single activity (reinforcing steel for a floor slab). Notice the different units used for the given rates. This is to allow a meaningful and easy measurement of work done.

Causes of Low Productivity Are:

1. Inadequate performance by the first level supervisor;
2. Inappropriateness of certain management procedures. The related procedures are identified as follows:

a. The degree of autonomy, authority or discretion which is delegated to the various levels of project staff and in particular the first level supervisors. This might affect considerably the supervisor's capacity to control and motivate his subordinates.

b. Administrative procedures in relation to the day to day site requirements, such as:

- Procedures of purchasing miscellaneous operational material
- Procedures of workers' replacement
- Procedures of minor equipment repairs

c. Labour relations program which includes labour training, working conditions, incentives, etc. The labour's morale is obviously affected by such programs;

d. Inadequate safety precautions which might divert labour's attention to their safety instead of production;

3. Unfavourable weather conditions;

4. Overestimated productivity standards;

5. Over or under staffing of groups

6. Labour are underequipped (tools, machinery, scaffolding, etc.)

7. Inappropriate construction methods;

8. Unsettled labour climate

2. Labour Turnover

Significance of Problem:

Labour turnover has a direct impact on the project cost as a

result of the additional expenses involved in recruiting new labour. The effect on project's time is more obvious, especially in remote areas, or where demand is exceeding supply of labour.

Basic Planning Required

A standard turnover rate should be established on the basis of the market situation, project location, etc. The rate should be taken in consideration while planning labour requirements and activities duration and in estimating the project's cost. This provides a more realistic and more accurate basis for planning and estimation.

Causes of a High Rate of Turnover

The potential causes are:

1. A competitive market situation created usually by a mismatch of demand and supply;
2. Some unfavourable particularities related to site location such as weather and accomodation and entertainment facilities;
3. Unfavorable particularities related to the project's characteristics, such as job complexity, safety and safety measures;
4. Inadequate management procedures and styles such as authoretarian leadership style by various levels of management particularly the first levels supervisor, excessive control procedures, lack of feedback, etc.;
5. Financial straits or contraction in the company's work volume, as perceived by labour;
6. Inadequate labour relations program.

2.4.1.2 Management Personnel

The management overhead cost are functions of three parameters:

1. The project's actual duration (which will be analyzed under the monetary resources);
2. The initial remunerations of the staff (a resources problem);
3. The additional cost arising from the turnover of the management personnel.

Performance Measures

Management Personnel Turnover

Significance of the Problem

The turnover of the management personnel has a direct effect on the project's cost as a result of the additional expenditures incurred in recruiting replacements for the quitting staff. Also, it has a more important, indirect effect on cost as well as on the time through the disruption frequently encountered because of the mangement personnel's turnover. Turnover can also be taken as an indication of dissatisfaction among other employees which might, as well, affect the overall performance of the individuals in the near future.

Causes of a High Rate of Turnover

1. Inappropriate procedures or dimensions related to the firm's basic organizational structure. These can be identified as follows:
   a. The adopted degree of structuring of activities or tasks: Different categories of personnel have different

reactions towards structuring activities in a rather standard formats. This standardization does not leave many actions for the individual's discretion on judgement. Dissatisfaction can occur because of overstandardization for some individuals, and because of understandardization for other individuals.

b. Degree of formality of interrelationships among the various levels of management;

c. Purpose and nature of controlling procedures;
The control system can be perceived as a threat for the employee's security especially if it is used only for punishment instead of positive reinforcement or reward.

2. Limited chances of personal advancement because of the size or other characteristics of the firm;

3. Lack or insufficiency of personal development programs including training and education;

4. A competitive market situation which increases the demand for certain categories of personnel;

5. Financial straits or contraction in the company's work volume as perceived by the personnel;

6. Lack of information programs that keep the personnel aware of the company's situation and future.

2.4.2 PROBLEMS AFFECTING THE COST OF CONSTRUCTION MATERIALS

The performance measure suggested to detect deficiencies in the use of construction materials is the materials wastage rates.

The potential causes of high wastage rates are:

1. Inadequate performance by first level supervisors;
2. Inappropriate management procedures. These are identified as follows:
   a. Management - Labor relationship due to inadequate labour relation program. This may provoke sabotage or at best carelessness in using the materials.
   b. The degree of authority and discretion delegated to the various levels of management especially the first level supervisors. This considerably affects their capability to control and motivate their subordinates.
   c. Defective storekeeping procedures that lack accuracy in keeping track of the purpose, location and workers group by which various quantities of materials are being used (especially for materials used for several activities).
   d. Defective material delivery procedures that give rise to theft of materials.
   e. Inadequate procedures of handling and moving materials on site.
3. Inadequate material storage precautions that may result in damages to the stored materials.
4. Unrealistic standard rates of wastage used.
5. Inadequate attention paid to procedure of moving of material on site.

2.4.3 PROBLEMS AFFECTING THE EQUIPMENT COSTS

The performance measures for detecting deficiencies in the usage

of equipment can be arrived at by breaking down project equipment costs into their basic components:

(1) Cost of ownership:

This is the cost resulting from owning the piece of equipment (whether by buying, renting or leasing), regardless of the amount of the active time of using the equipment.

The performance measure suggested to measure this cost component is: "ratio of equipment idle time/total working time". This measure is selected to reflect the fact that the cost of ownership per unit of output (say a cubic meter of earth excavation), is directly proportional with the above ratio.

(2) Operational Costs:

These costs are directly attributable to the number of hours of equipment usage. An adequate measure is the total operational cost per unit of output. This measure will require a rather rigorous computation. Two simpler measures are suggested here:

1. Equipment productivity (per active hour)
2. Fuel, maintenance and repair costs (per active hour)

Performance Measures

1. Ratio of Idle Time: Total Working Time

Definition:

The total working time is the site's working hours, during certain time span (usually the reporting period), provided that the machine is physically at site.

The idle time is the time during which the machine is not actually in action due to any reason including breakdowns, non availability of operators, waiting time, etc. The time of adjusting the piece of equipment is an active time. These adjustments are the alterations readily made in the field (as anticipated in the original design of the piece of equipment). An example of such adjustment would be the manual change of the dozer's blade angle or the change from one type of crane pickup device to another. The adjustment time will be accounted for in the estimated productivity of the equipment.

Planning Requirement

An estimate for the ratio should be established on the basis of the specfic nature of the piece of equipment as to its normal maintenance and repairs requirements.

Causes of Deficiencies

The potential causes of a higher than estimated ratio, are:

1. Unfavourable sequence of activities that result in a long time lag between activities requiring the same piece of equipment. This may occur because of inadequate attention paid by the scheduler, or otherwise because of inevitable scheduling constraints;
2. Inappropriate task assignment to the piece of equipment. This may result in frequent breakdowns;
3. Inadequate performance by the mechanical or maintenance supervisor;
4. Inappropriate program for preventive maintenance;
5. Inappropriate maintenance policy as to the staff size or

quality, or the maintenance facilities available;

6. Limited versatility or adaptability capabilities of the piece of equipment;
7. Non-balancing of the interdependent equipment or human-resources, in case of activities requiring more than one piece of equipment or a mix of man and machine efforts. To the extent that it is possible, resources should be balanced in order to allow their full and continuous utilization;
8. Unfavorable weather conditions or site conditions which do not permit the operation;
9. A delay or disruption in previous activities that affect the readiness of the activities requiring the piece of equipment;
10. Under estimation of the standard ratio.

2. Equipment Productivity (Per Active Hour)

Definition

Equipment productivity is the quantity of output units the equipment produces per unit time period. During this time period there may be both active and idle time.

Planning Requirements

It is extremely difficult to establish a general standard productivity for equipment. This is because there is no standard operating environment in construction.

Standard productivity should be expressed as a fixed rate for a given piece of equipment for a certain assignment, or indeed it can be presented as a variable rate which is a function of the time or the

specific part of the task the equipment is working on (See Fig. 2.6)

Causes of Deficiencies

The potential causes of a low productivity are identified as follows:

1. Incompetent operator;
2. Inadequate supervision or guidance by the first line's supervisor;
3. Unfavorable weather conditions;
4. Unexpected working conditions (such as variable soil conditions) which mismatch the capabilities of the piece of equipment;
5. A defective program for regular care and maintenance which leads to a lower efficiency of the machine or repetitive minor failure;
6. Overestimated productivity standards.

3. Fuel, Maintenance and Repair Costs (per active hour)

Definition:

These are cost components directly related to the amount of time the machine is actually operating. They include:

a. Cost of fuel
b. Cost of lubrication and lubricating oil
c. Cost of minor repairs and adjustment
d. Cost of tire repairs and replacement.

Planning Requirements

A set of standard rates for each of the above components should

be present for each piece of equipment. The actual cost is to be compared with these established estimates.

Causes of Deficiencies

A cost overrun here can be attributed to any of the following reasons:

1. Inadequate program of regular care and maintenance;
2. Unusual work conditions as to the type of soil or topography of the site;
3. Equipment's mechanical deficiency;
4. Underestimation of standard cost;
5. Inappropriate task assignment to the pice of equipment;
6. An escalation in full prices or wages.

2.4.4 PROBLEMS AFFECTING THE COST OF MONETARY RESOURCES

The cost of monetary resources (financing charges) is a function of the following variables:

1. The market situation as to the cost of money (interest rates);
2. Terms of supplier credit;
3. Promptness of owners processing of progress claims;
4. Timing of activities;
5. The project's overall duration;
6. The project's overall cost.

The first three variables have been already dealt with in the resource problems. Deficiencies associated with the fourth variable are mainly attributable to a defective scheduling of activities. The last two variables are the main sources of financing charges overruns that fall within the "Process" domain.

The performance measures suggested to detect deficiencies in the project's duration are:

a. Resources and physical progress of individual subcontracted activities

b. Overall project's time to complete.

While the first measure seems redundant of the second measure, its inclusion is of major significance. This is due to the fact that the second measure does not possess the capability of detecting delay trends for a subcontracted activity before the activity has become already critical. This does not allow the system to provide an early warning so that early corrective actions can be made. The same argument does not apply to the activities directly carried out by the contractor's own force, since such delay trends in these activities can be detected by one or set of the previously suggested measures of the system, such as productivity, timely procurement of resources etc.

The performance measure suggested to detect deficiencies in the project's overall cost, is the direct costs of individual activities. The rationale of this choice will be presented later on, in this chapter.

Performance Measures

1. Physical Progress of Individual Subcontracted Activities and Subcontractor's Resources

Planning Requirement

The subcontractor should submit a detailed time schedule for the execution of the activities undertaken by him, along with a schedule for the resources he is supposed to supply for the implementation of

his proposed schedule. The schedule should be checked by the general contractor's management team and should be agreed upon and could be made part of the subcontract agreement in order to make possible the rescission of the contract as a corrective action in cases of excessive delay or negligence by either party.

The general contractor should follow up, closely and quite frequently, the subcontractor's adherence to the schedules. The resources assigned by the subcontractor to the project should be inspected by the general contractor's team whether on site, on the subcontractor's own stores and offices, or on his supplier's premises. This provides a very effective tool for early detection of an expected delay by the subcontractor.

Causes of Deficiencies

A behind the schedules situation can be attributed to any of the following causes:

A. In the General Contractor's Domain

1. Delay of due payments to the subcontractor, because of either negligence by certain employees, or inadequate procedure or policy of payments to the subcontractor may hinder the subcontractor's ability to acquire the required resources or pay his labour and hence delaying the work. (Note that the subcontractor's payment could be withheld by the general contractor as a tactic to force a better response from the subcontractor).

2. The lack of effective channels for solving the subcontractor's daily problems promptly and meeting his justified

requirements.

3. Poor planning or scheduling of activities which might result in work interference or conflicts among the independent groups on site i.e. poor coordination by the general contractor.

4. Delay or nonfulfillment of any of the general contractor's obligations and duties that are necessary for the accomplishment of the subcontractor's activity. These include duties like site preparation, completion of precedent activities, supply of certain pieces of equipment, certain materials, site utilities, etc.

B. In the Subcontractor's Domain

1. Inadequate planning or scheduling of activities or resources;
2. Late deliveries of materials by suppliers or material shortages in the market;
3. Labour shortages because of unexpected market condition;
4. Low labour productivity;
5. Labour relations problems;
6. Inadequate programs for regular care or maintenance of equipment;
7. Inadequate follow up and control procedures;
8. Ambiguity of drawings or specification that leads to underestimation of activities' durations;
9. Incompetence of subcontractor's supervising personnel;
10. Incompetence of subcontractor's estimators.

2. Overall Time to Complete

Measurement of Time to Complete

The measurement of the time to complete should make use of the project's previous trends. For instance, after a considerable part of the project has been executed, measures like equipment productivity should be re-evaluated on the basis of the actual average productivity of previous similar activities. Also delays due to matters like labour absenteeism, labour or material shortages should also be considered in the re-evaluation of future activities' durations. A similar trend should be assumed unless strong evidences of its non-recurrence are available. This provides a realistic estimate for the time to complete measure so that management would be able to evaluate more accurately the consequences of any proposed corrective action.

Causes of Deficiencies

The potential causes of expected delays are identified as follows:

1. Low labour or machine productivity, delay by subcontractors, labour absenteeism or turnover or late deliveries of resources. The potential cause of each of these measures have been identified previously;
2. Improper decision made by the site management in respect with the resource mix or quality, or the construction methods to be employed;
3. Labour strikes;
4. Problems with coordination of subcontractors;
5. Inspection or supervision problems including sample

approval problems;

6. Construction errors;
7. Equipment breakdown;
8. Access to the site problems;
9. Underestimation of activities duration;
10. Underestimation of labour or equipment requirements;
11. Weather conditions.

3. The Direct Cost to Complete of Individual Activities

Definition

The direct cost of any activity is composed of the cost of the three major resources, the direct labour, material and equipment.

It might seem that this measure is redundant since the cost of each of the above resources has been already accounted for by the other performance measure suggested earlier. In fact, the direct cost of activity is an independent measure that controls the frequently encountered situations where the project's management decide to introduce certain alterations to the originally planned methods of construction, resources mix or resources quality. These alterations are introduced either at the management's discretion in the intention of improving the project's performance, or as called for by some contingencies such as strikes, major breakdown of a piece of equipment, market shortages of certain resources, etc. To illustrate, consider the case when the earthworks foreman decides to use a machine in lieu of manual labour. In this case the labour productivity or even the equipment productivity would not measure the appropriateness of his decision, and further, it would not measure the consequences on the total cost of the project.

Comparing the expected total cost to complete of an activity with the initially budgeted one, is more appropriate here.

Causes of Cost Overruns

1. Low labour or machine productivity, and high rates of materials wastages (PROCESS PROBLEMS);
2. Unfavorable market conditions, inappropriate procedures or efforts in procurement of the resources (PROCUREMENT PROBLEMS).

The above cuases should be pinpointed by the respective performance measures which have been identified earlier. In case no deficiencies have been detected by these measures, or if the total consequences of the detected deficiencies did not amount to the cost overrun of the direct cost of the activity, then the causes of such overruns could be attributed to any of the following causes:

1. Inappropriate decision taken by any level of management to change the construction methods, resources mix or resources quality;
2. Construction errors;
3. Overzealous or inexperienced supervising engineer/architect;
4. Underestimation of the direct cost of activities because of any of the following reasons:
   a. Ambiguity of specifications or drawings;
   b. Human errors or incompetent estimator;
   c. Unexpected escalation in any of the resources price;
   d. Errors in quantity takeoff, unexpected wastage, theft,

etc.

5. Inadequate cost coding system which may result in inaccurate assignment of man hours, equipment hours or material to the various activities;

6. Special problems related to the subcontracted activities such as the inaccurate stipulation of the scope of work or other conditions in the subcontract which may give rise to subcontractor's claims for extra payment, or the rescission of the subcontract and the appointment of another subcontractor under different (usually more expensive) terms. This action is usually taken by the management in order to avoid excessive delay by the first subcontractor.

2.5 SUMMARY

This chapter has presented a proposal for an integrated set of performance measures that are considered to be, collectively, capable of detecting the vast majority of performance deficiencies which have direct or indirect impact on a project's cost, time or quality. The major causes of the deficiencies highlighted by each individual measure have also been identified.

To demonstrate that all the variables affecting a project's cost and duration have been accounted for in the proposed scheme of measures, a model for the total cost of the project is shown in Fig. 2.7.A. Figures 2.7.A, 2.7.B exhibit the performance measures that can detect deficiencies in each cost component. In the model cost is divided into its direct and indirect components. The total direct cost is the sum of the direct costs of all individual activities. The indirect cost cannot, by definition, be traced to any single activity and should be handled, therefore, on the level of the entire project.

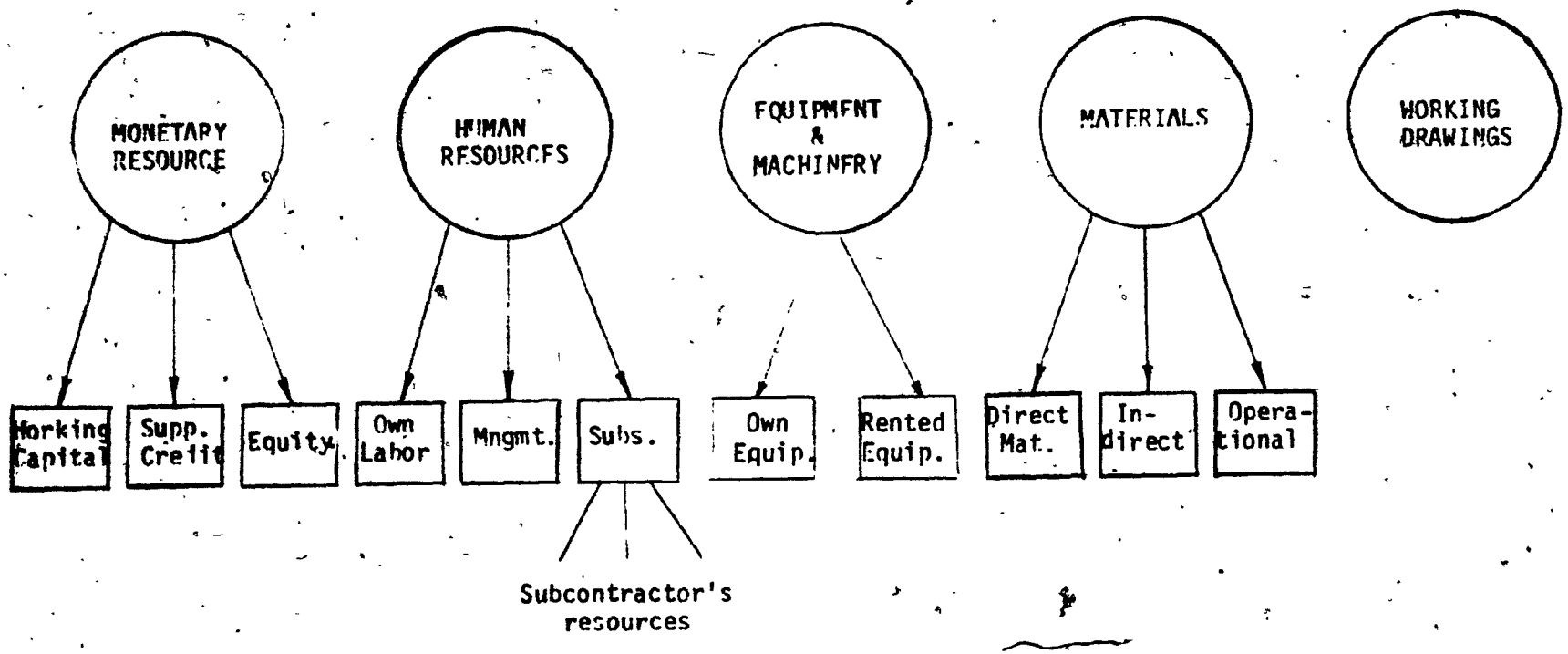


FIG. 2.1 CONSTRUCTION RESOURCES

16 - Delivery at site

15 - Cleared from customs

14 - Arrived at port

13 - Shipment

12 - Packaging

11 - Equipment checked and approved

10 - Manufacturing completed

9 - Vendor's drawing approved

8 - Vendor's drawing submitted

7 - Letter of credit issued

6 - Contract awarded and signed

5 - Recommendation for award

4 - Tenders opening

3 - Inviting tenders

2 - Preparation of bid packages

1 - Project awarded

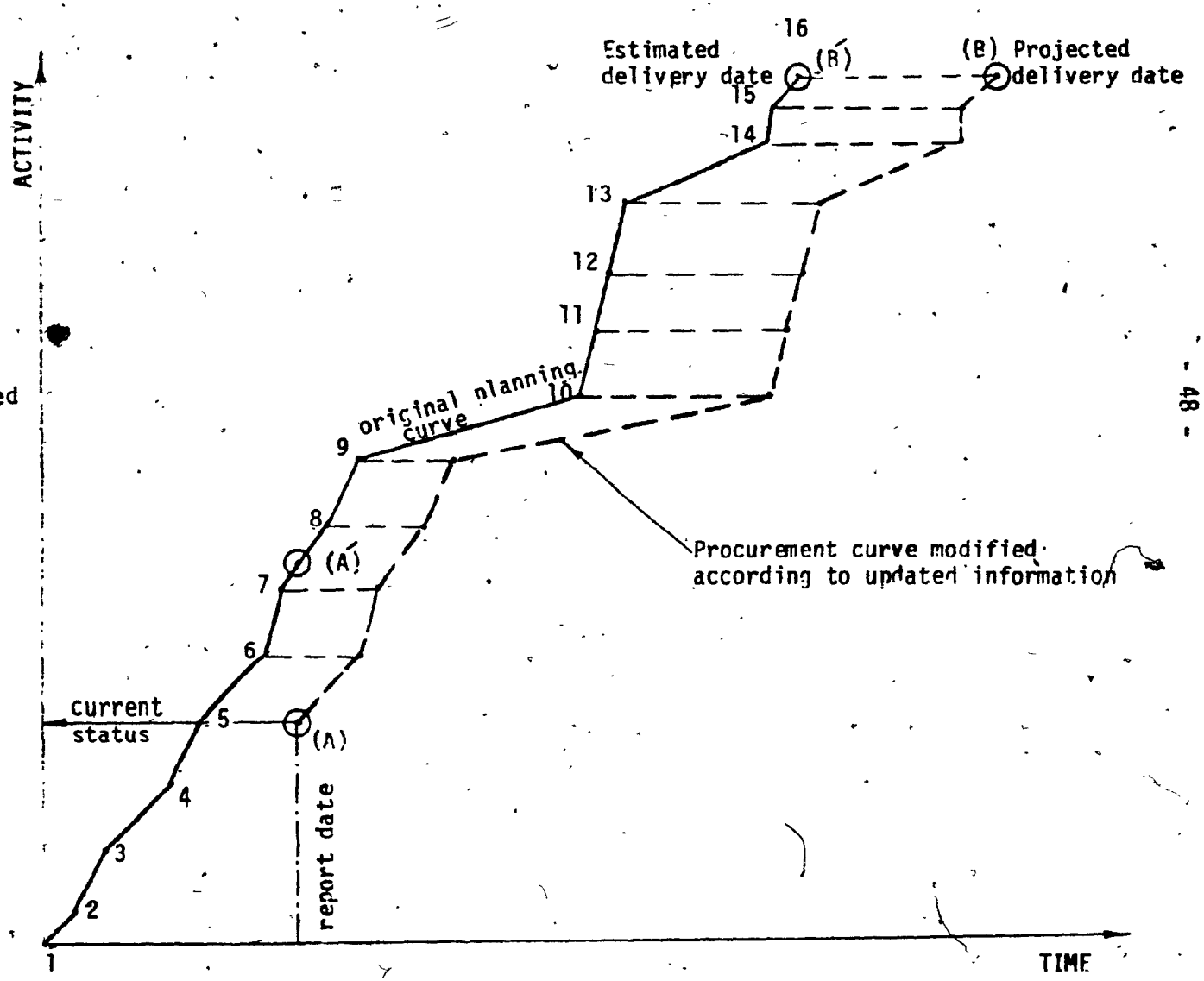
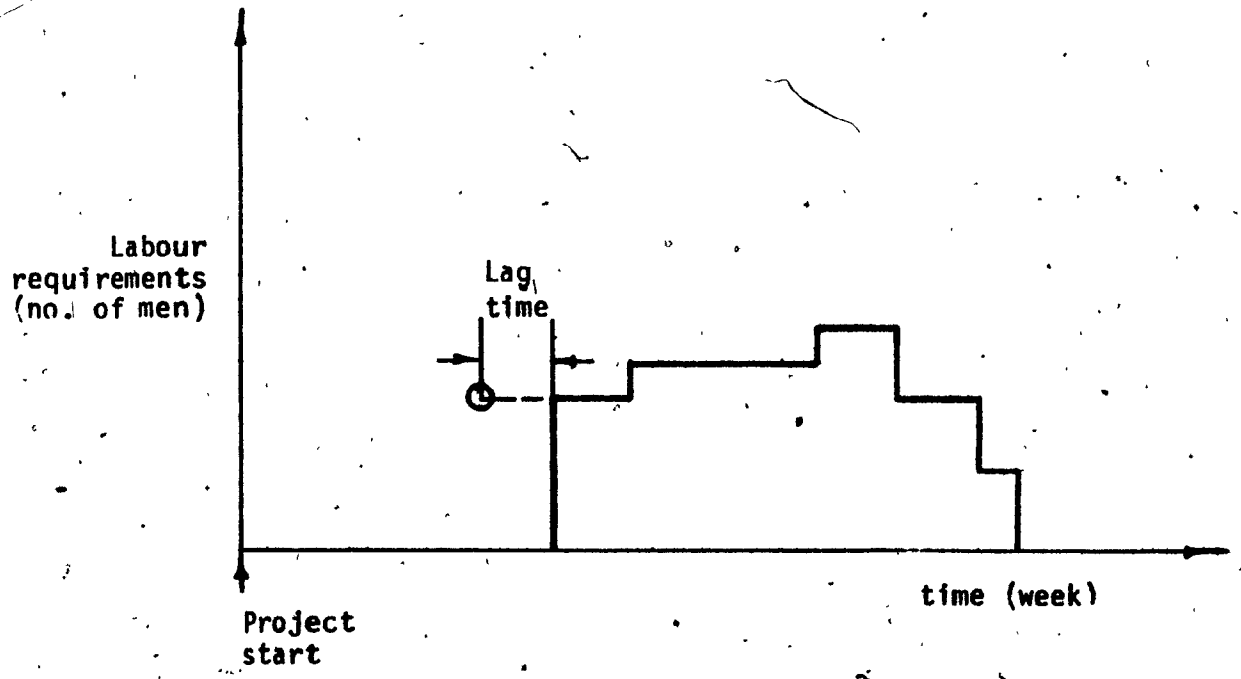
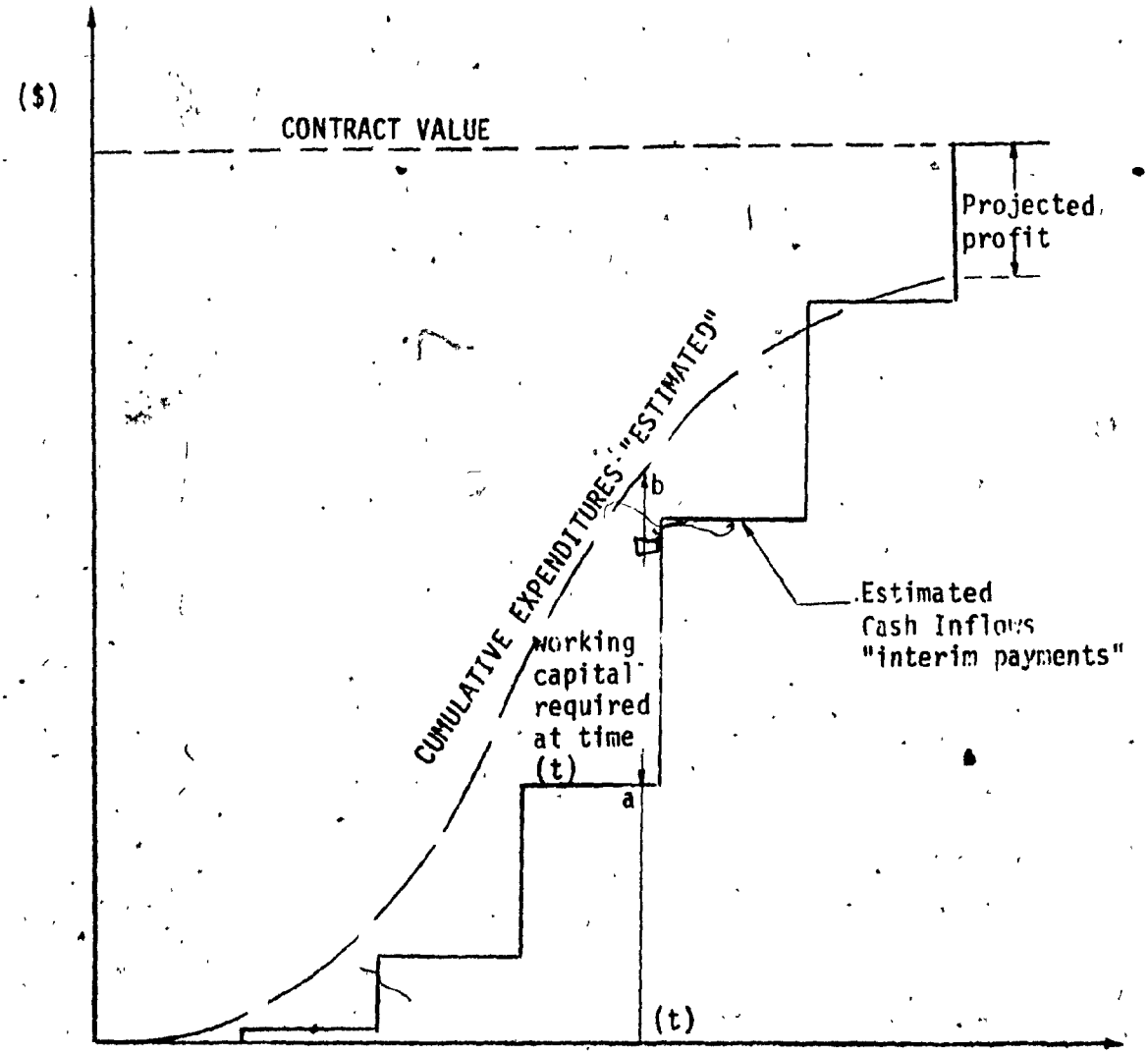


FIG. 2.2. SAMPLE PROCUREMENT PLANNING CURVE



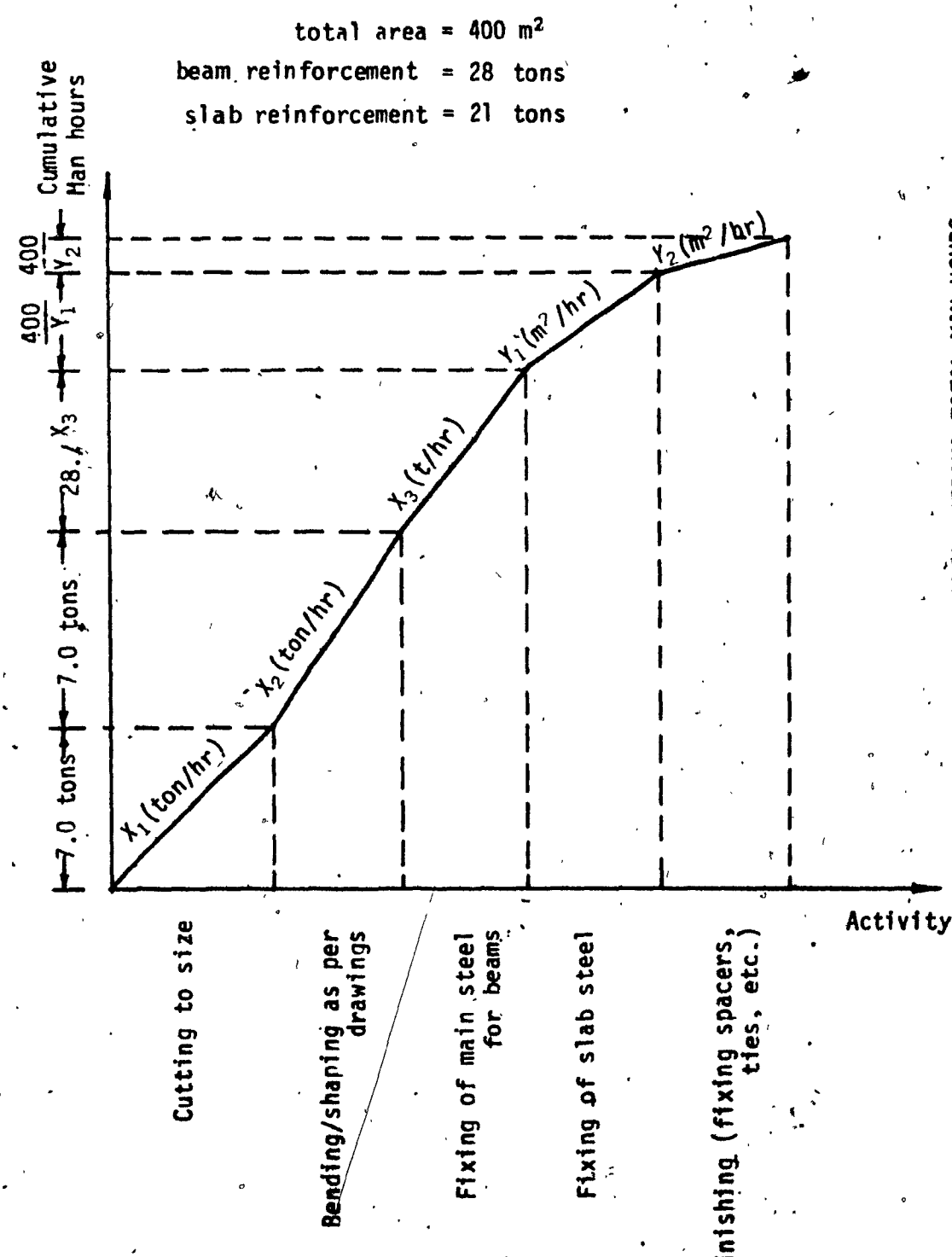
LABOUR REQUIREMENT SCHEDULE

FIG. 2.3



SCHEMATIC REPRESENTATION OF CASH FLOW

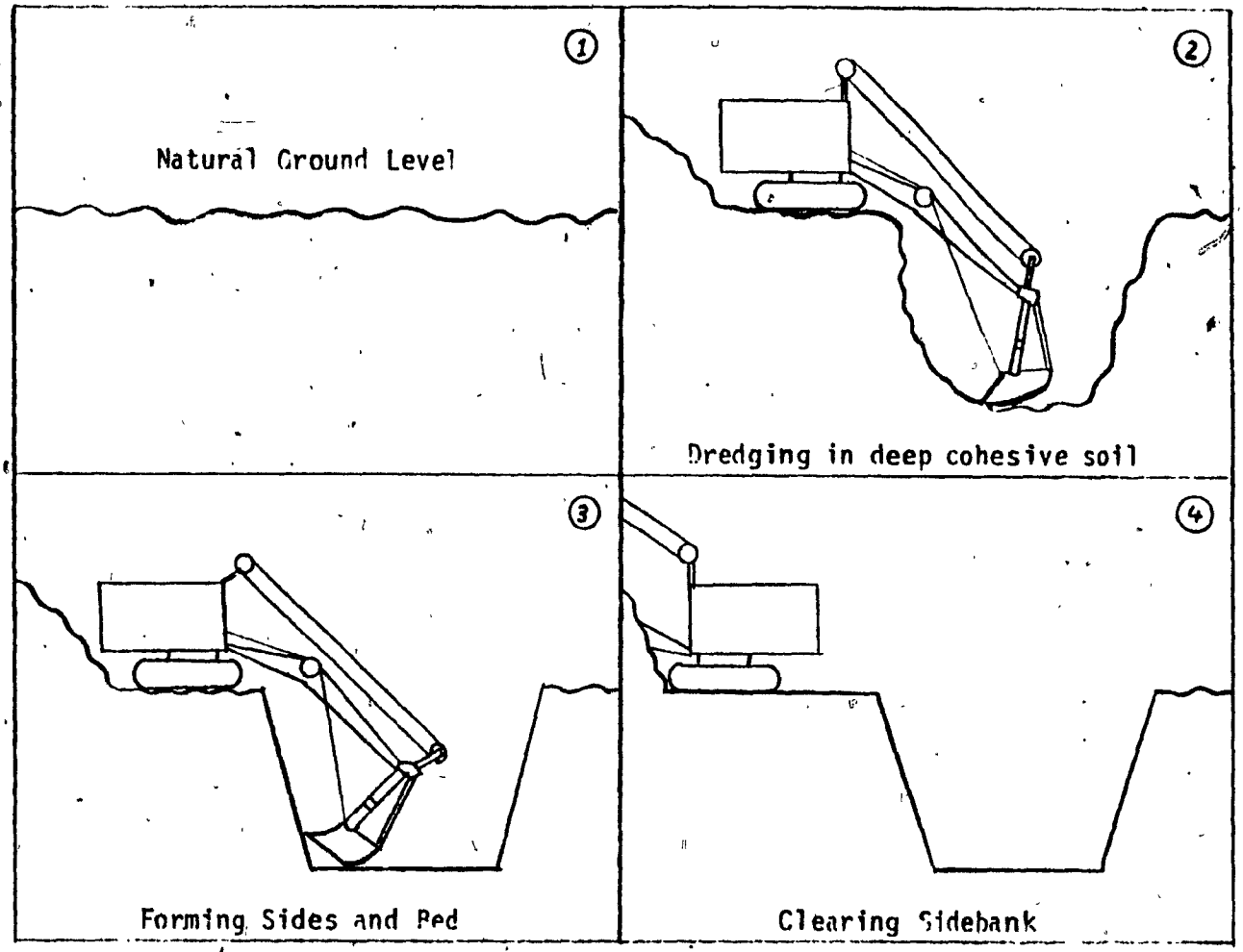
FIG. 2.4

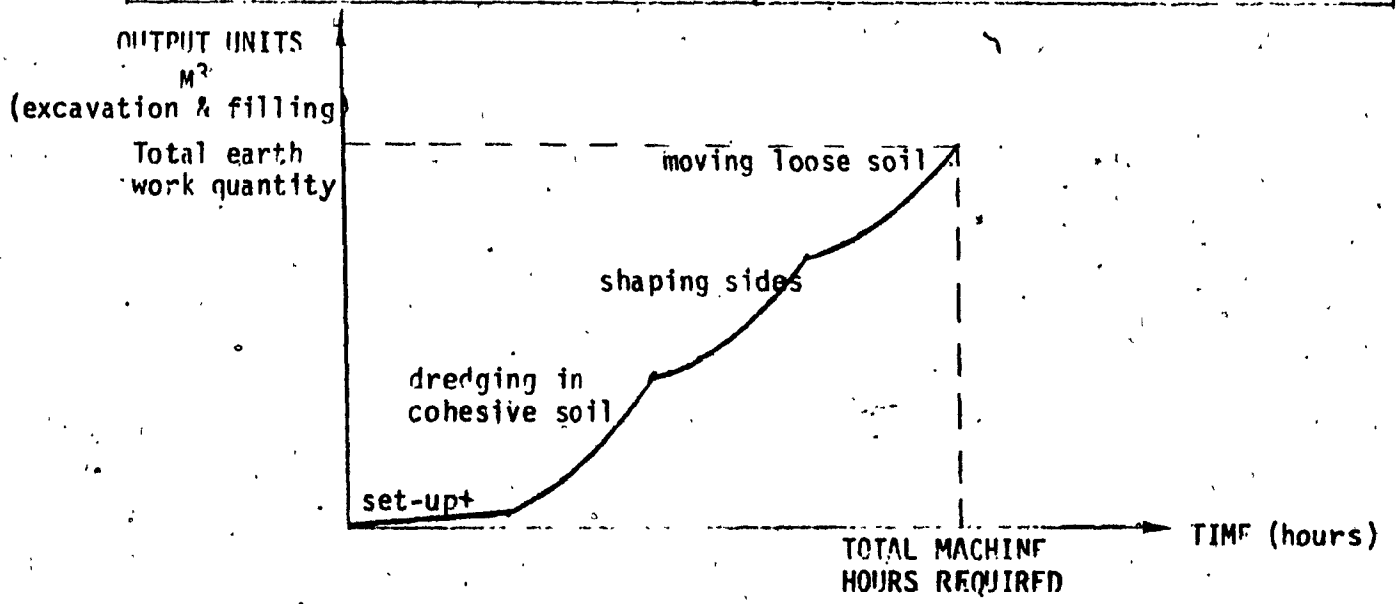


JOB PROGRESS VERSUS TOTAL MAN HOURS

FIG. 2.5

X_1, X_2, X_3, Y_1, Y_2 = productivity of corresponding activity





PRODUCTIVITY CURVE FOR A DREDGER
CUTTING AN EARTH CANAL AND
CLEARING SIDE EARTH BANK

FIG. 2.6

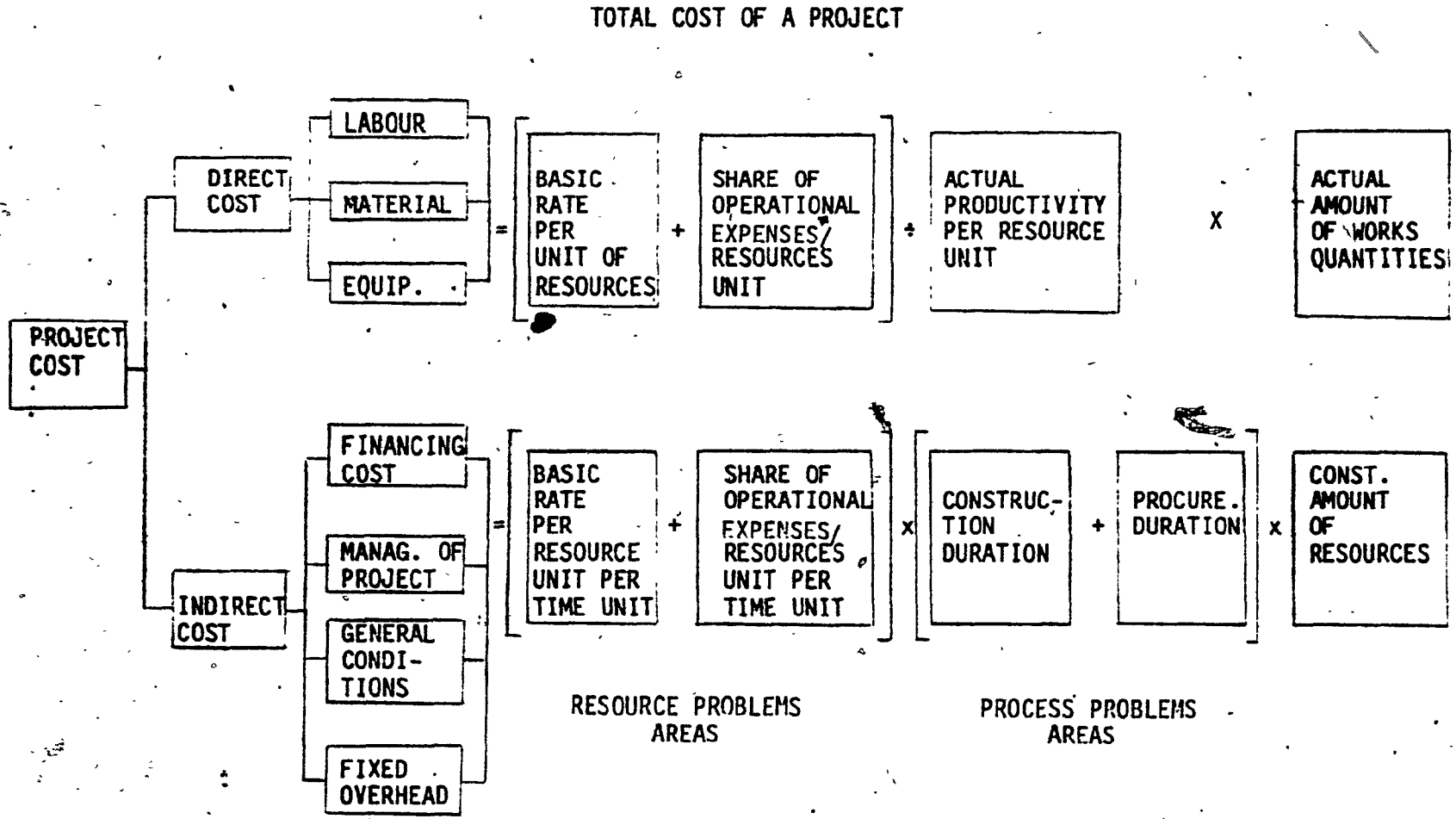


FIG 2.7.A - UTILIZATION OF PERFORMANCE MEASURES TO DETECT VARIANCES IN PROJECT COST - "TOTAL COST"

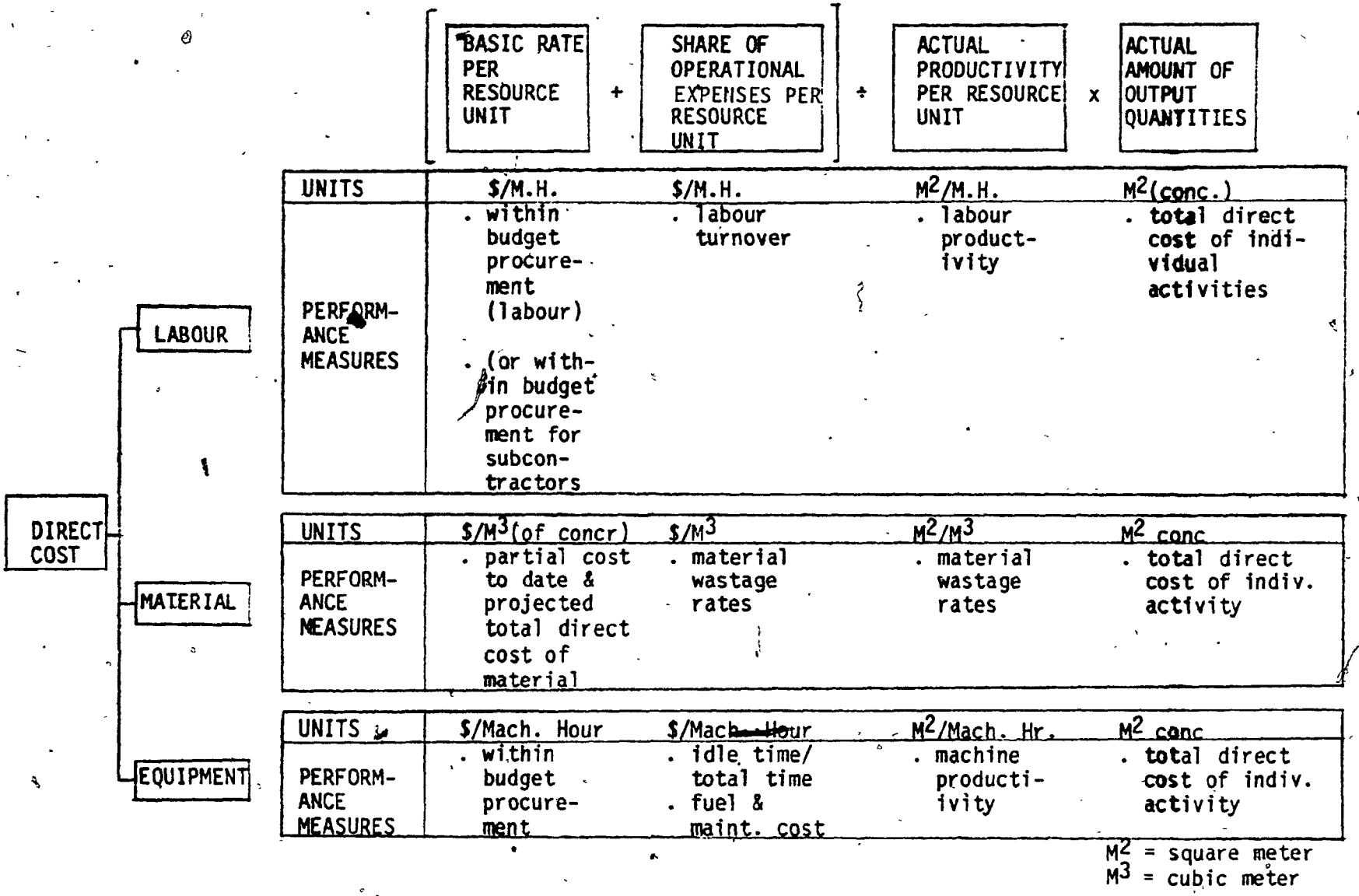
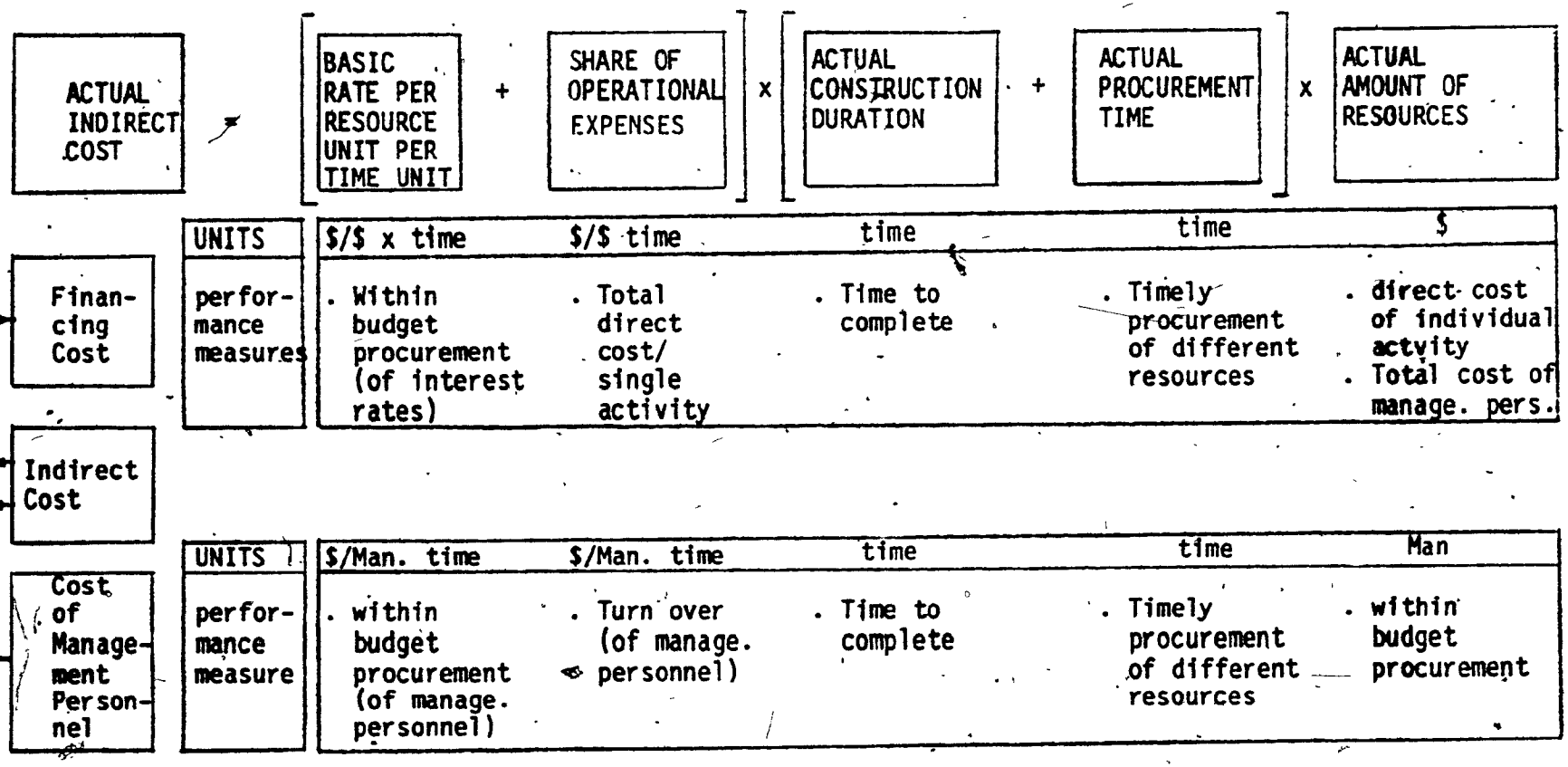


FIG. 2.7.B - UTILIZATION OF PERFORMANCE MEASURES TO DETECT VARIANCES IN PROJECT DIRECT COST OF A SINGLE ACTIVITY (APPLIED TO CONCRETING OF FLOOR SLAB)



Note Problems in the fixed amount of resource variable arise only as a result of underestimation of the relevant resources.

General conditions and project's fixed overheads can be also treated the same way. They are omitted here for illustrative purposes.

FIG. 2.7.C - UTILIZATION OF PERFORMANCE MEASURES TO DETECT VARIANCES IN PROJECT INDIRECT COSTS

CHAPTER 3

REALISTIC CHARACTERISTICS AND CONTROL PRACTICES OF BUILDING CONTRACTORS

3.1 INTRODUCTION

Identifying the realities within contracting firms is a task of vital importance, if the developed system is to be of practical value.

Unfortunately, there is little information available in the literature to help in this task. Moreover, those realities cannot be assumed or perceived throughtfully, simply because they are far from being systematic and idealistic. The substantial dissimilarities among firms hinder any attempts to make valid generalizations based on an individual's practical experience (17).

Consequently there is a need to obtain reliable information on the individual characteristics of firms from as large a sample size as possible.

As was pointed out earlier, a previous phase of this research program has investigated in considerable depth, through case studies, the various procedures and characteristics of three contracting firms (17). The task assigned to this chapter is to suggest the means of providing the lacking width.

3.2 PROPOSED TECHNIQUE

A questionnaire for the top management of contracting firms is suggested here as the mechanism for obtaining information on a large

number of firms. However, a major problem with mail questionnaires is lack of confidence in some of the responses as opposed to detailed interviews. On the other hand, interviews are very costly as compared to a questionnaire approach. There seems to be no way to avoid this trade off. The mail questionnaire described in this chapter has been tested by means of running it on a narrow range. The details of the test and results will be presented later on in this chapter. It is suggested that the accuracy of responses to the questions asked be tested by way of a limited set of interviews with selected firms.

3.2.1 QUESTIONNAIRE OBJECTIVES

The specific objective of the proposed questionnaire is to collect information about the user's needs which will help in directing the research team in the following crucial topics:

1. To identify priorities and areas of emphasis of the system;
2. To evaluate the degree of success of current contractor control procedures and identify areas of weaknesses;
3. To correlate problem areas with certain management practices and characteristics of the firm;
4. To measure certain dimensions of the firm's characteristics and practices which may have a direct impact on the basic characteristics of a management information system for control. These dimensions include: the degree of sophistication of current procedures, the acceptable degree of change in work relationships which might be imposed by the application of the control system, and the efforts and resources that might be utilized by or allocated to the control function; and

5. To help the system designers determine the basic components of the system which are applicable to all firms, as distinguished from those of special need or occasional use for individual firms.

3.2.2 THE PROPOSED QUESTIONNAIRE

The proposed questionnaire is divided into four parts as follows:

1. Background Information on Firm,
2. Firm's Objectives,
3. Techniques and Procedures,
4. Causes of Delays and Cost Overruns

A complete copy of the questionnaire may be found in Appendix 1.

The information sought in each of the above four parts will be discussed below along with the specific contribution, logic and implications of the individual questions included in each part.

3.2.2.1 Background Information on Firm

Some understanding of the firm's background and basic characteristics is needed for the following purposes:

1. Important conclusions about the root causes of problems might be derived from correlating specific problem areas with particular characteristics of the firm. Also it might be possible to attribute some deviations in response to specific questions, from general patterns, to some unusual characteristics of individual firms. For instance, suppose that the work subcontracted by a firm is found to be a very high portion of its total work. This piece of information would help explain a response

which indicates that labour productivity problems are of no significance on their projects.

2. To exclude from analysis, firms that do not fall within the specific range of this study as related to the firm's size, role or project types.
3. To derive some information which will help establish the boundaries of some of the basic characteristics of the developed system, such as degree of sophistication of the techniques as influenced by the employees' level of education, etc.

QUESTIONS AND THEIR CONTRIBUTION:

CONTRACTOR QUESTIONNAIRE

I. BACKGROUND INFORMATION ON FIRM

1. Please identify the major role of this firm:

___ General Contractor
___ Prime Contractor
___ Specialist Contractor (or sub-contractor)
___ Prefabricated Items Supplier
___ Maintenance Contractor
___ Other, please specify _____

2. The annual work volume of the firm is:

___ Below 2,000,000	___ 20,000,000 - 30,000,000
___ 2,000,000 - 5,000,000	___ 30,000,000 - 50,000,000
___ 5,000,000 -10,000,000	___ 50,000,000 -100,000,000
___ 10,000,000 -20,000,000	___ Over 100,000,000

The above questions will be employed for the following purposes:

1. To screen out firms which do not fall within the present range for this study ($5 million to $50 million);
2. To correlate construction problems and control practices

with the size and role of the firm.

3. a) The firm is a: Public Corporation _____
Private Corporation _____

The type of ownership can provide some useful notion about the nature of the management procedures, as to the acceptable degree of formality in the interrelationships as well as the perceived need for control and the need for accountability to external bodies or shareholders. For those firms which are private corporations, an assumption can be made that the majority of them are family owned, based on previous experience (17) and consultation with knowledgeable persons in the industry.

4. Please describe the types of projects with which the firm is involved by completing the table below. Please indicate, in percentage terms, how much of the annual work volume in dollars is accounted for by each project type.

PROJECT TYPE	% OF TOTAL WORK	PLEASE INDICATE SPECIFIC PROJECT TYPE (e.g. LOW-RISE APARTMENT BLDGS.)
a) Residential Projects b) Commercial buildings c) Institutional building d) Civil Engineering projects -water treatment and distribution project -highway project -other transportation projects -marine engineering -hydro projects -other:_____ e) Transportation projects f) Industrial projects g) Other types (please specify) _____ _____ _____		

The detailed type of projects provides the research team with a rather clear image of the technical complexity of the projects undertaken by the firm, which might be correlated with the kinds of control problems faced by the company, or with the nature of the controlling procedures currently adopted by the firm. These correlations are of significant value for the designers of the control system, in the task of distinguishing between the basic components of the system and those needed under occasional circumstances or by only a few users.

5. The approximate annual growth rate of the firm over the last three years is _____$.

The growth rate in terms of annual volume gives some notion about the firm's relative success, (especially in a stable market). The relative success can be correlated with their current control trends and many other characteristics such as the types of projects undertaken, ratio of work carried out by own forces versus subcontractors type of contracts, educational background of employees and firm's goals.

As well, it yields important information regarding allowances to be made for expansion in the capacity of the firm's control system.

6. The MAIN market in which the firm operates is:
   Within the city of _____
   Within the province of _____
   All over Canada _____
   International (please specify countries) _____
   _____

This question helps explore the implications of geographical dispersion of work with cost and time control problems and specific control practices.

7. Please complete the following table which deals with several characteristics of the firm's projects. Please divide the range of projects undertaken by your firm into the categories "Large" and "Small".

DESCRIPTION	LARGE PROJECTS	SMALL PROJECTS
a) Average project value	$ _____	$ _____
b) Average project duration	_____	_____
c) % of work usually sub-contracted	_____%	_____%
d) The company's own labour work force at peak	_____Men	_____Men
e) The firm's site management staff Per project consists of:	No. ___ Project Manager ___ Project Engineer ___ Superintendent ___ Asst. Superintend. ___ Foreman ___ Clerk (time-keeper) ___ Other (pls.specify) _____ _____	No. ___ Project Manager ___ Project Engineer ___ Superintendent ___ Asst. Superintend. ___ Foreman ___ Clerk (time-keeper) ___ Other (pls.specify) _____ _____
f) The percentage breakdown in contract types for large and small project is:	% ___ Fixed price ___ Cost plus ___ Turnkey ___ Construction mgmt. ___ Other (pls.specify) _____ _____ _____	% ___ Fixed price ___ Cost plus ___ Turnkey ___ Construction mgmt. ___ Other (pls.specify) _____ _____ _____
g) Nature of work usually carried out by the company's own labour force		

The information sought by the above question serves the following purposes:

1. To develop a better understanding about the firm's actual role in a construction project. This understanding will help the system designers meeting the contractors real needs. For example, knowing the amount of work subcontracted, can help the system designers understand the relative importance, to the contractor, of problems related to subcontractors coordination versus the problems of labour and material control.
2. The types of contract provide useful information about the degree of formality required for the firm's planning and control systems. For example, cost plus contracts require that the contractor demonstrate to the client the basis for actual expenditures, which requires a formalized control system.
3. Project value and duration help in assessing the response time and/or frequency of reporting required in order to initiate corrective action, as required.
4. The size of a project's management staff provides vital input regarding:
   a) The appropriate classification of and number of levels of management personnel which impacts directly on the data available for control. The amount of data available determines the level of detailed reporting that can be carried out with respect to time, cost and

content control.

8. The average number of projects undertaken at any time is _____
How many of these are large projects? _____

The number and size of projects undertaken simultaneously provide some understanding of the intensity of involvement, by the top management, in the affairs of the individual project. This provides some notion about the nature and quantity of information which is actually needed by head office management with respect to individual projects.

The number of projects also has some significance on deciding about certain basic characteristics of the system such as the size of the computing facilities required. Finally, the number of simultaneous projects affects the task of multi-project control and reflects on the sophistication of the planning, scheduling and resource allocation and cash flow management techniques that are required

9. Head Office staff consists of _____ people, of which _____ are clerical and secretarial staff.

The size of office staff will give some notion about the degree of centralization of the firm which impacts directly on the nature of information required for the various levels of management, as determined by the duties and responsibilites assigned to various management personnel.

10. Listed below are job categories and a range of educational backgrounds which may be associated with them. Please indicate all applicable types of background for the categories relevant to your firm.

	BACKGROUND						
CATEGORIES	Exper. Trades-man	Technol-ogist	Graduate Engineer	Commerce or Bus. Graduate	Other Univ. Degrees	High School Graduate	Other Qual.
Vice-President(s)							
Department Mgrs.							
Project Managers							
Project Engineers							
Superintendents							
Foremen							
Estimators							
Planners							

The educational background of the personnel on each level of management is directly related to the acceptable degree of sophistication of the techniques that can be employed in the MIS and the output formats presented to each level of management.

3.2.2.2 The Firm's Objectives

The firm's objectives reflect its general philosophy and trends. The organization's philosophy has important implications that might influence the basic directions of the design of the control system, as will be demonstrated below. Firm's objectives also give important implications about the market and environment in which the firm operates.

THE PROPOSED QUESTIONS AND THEIR CONTRIBUTION:

II. FIRM'S OBJECTIVES

11. Please rank the following objectives in terms of their current importance to the firm (most important first):

___ Survival
___ Maintain a specific volume of work
___ Achieve a specified return on volume
___ Achieve a specified return on equity
___ Achieve a specified growth rate
___ Develop and maintain a reputation for timely completion of work within budget
___ Diversification into a larger number of project types
___ Other; please specify: _____

Some examples of the conclusions that can be derived from the above questions along with their implications for design of a control system are:

1. If growth is highly ranked as an objective, the system capacity should be made adjustable to accomodate such growth in the future.
2. The relative ranking of the return on equity objective versus the return on volume may be utilized to conclude the best way of expressing the project's profitability in order to be consistent with the contractor's concerns and way of thinking. If these two objectives are given high priority, then cash flow management should be treated as a key component of the information system.

12. Please rank the following factors in terms of their significance to the company's success and effectiveness:
___ The development of a reputation for timely completion of work within budget
___ Satisfaction of employees
___ The internal development of the firm's management and operational procedures
___ The capability to adapt to changes in technology and market requirements
___ Other; please specify: _____

Examples of the way of reaching conclusions from the above question are given below:

1. If timely completion of projects is found to be of high significance to the majority of the firms, the system must be made capable to compute time to complete which might require some degree of sophistication in planning and scheduling algorithms.
2. A high significance to the factors of internal development and the adaptability to changes in technology may reflect a perceived need to improve the current management and operational procedures. This helps establish the boundaries of the acceptable degree of changes to current procedures and trends.

3.2.2.3 Techniques and Procedures

This section of the questionnaire is directed at identifying currently used procedures and techniques, as well as the data collected by the firms in areas related to control. This information is needed since dramatic departures from current practices are very likely to be resisted. However, a question has been included to measure the severity of such presumed resistance.

13. If you make use of computer services, please check off the appropriate entries in the following table:

FUNCTIONS	COMPUTER FACILITIES			
	SERVICE BUREAU BATCH PROCESSING	TIME SHARING	IN-HOUSE MINI-COMPUTER	OTHER (PLEASE SPECIFY)
a) Payroll				
b) Financial (acctg.)				
c) Job cost acctg.				
d) Estimating				
e) Cash flow analysis				
f) Planning & scheduling				
g) Procurement				
h) Inventory control				
i) Work progress measurement				
j) Other (pls. specify) _____				
_____				
_____				

The question is directed at measuring the degree of computerization of the procedures related to control. The question also seeks to identify the most prevailing type of computer service utilized by contractors. Also the use of computers can be correlated with problems, or lack of it, with respect to time and cost.

14. For each function identified in the table below, please indicate the techniques employed, such as C.P.M., Bar Chart, line of balance, cost accounting, committee reports, etc. for the firm's large and small projects. Also, please indicate whether you are satisfied or dissatisfied with the techniques in each case.

FUNCTION	LARGE PROJECTS			SMALL PROJECTS		
	TECHNIQUES	SATISFIED? YES	NO	TECHNIQUES	SATISFIED? YES	NO
a) Estimation of project duration for bidding purposes						
b) Cash flow planning						
c) Work planning (scheduling of activities)						
d) Procurement planning and follow-up						
e) Resource planning and allocation						
f) Measuring work progress						
g) Controlling cost and expenditures						
h) Inventory control						
i) Evaluating and documenting delays due to change orders						

The question is measuring the degree of sophistication of the techniques currently in use by contractors. Significant changes in existing techniques required by a control system, in terms of the degree of sophistication, are very unlikely to be accepted by the contractor.

The degree of dissatisfaction can be used as an indicator that spots the control areas that need improvements and subsequently the areas that should be given more attention by the system designers.

The techniques used for each function can be correlated with certain areas of problems, in terms of cost and time control.

15. Which of the following data are collected by your firm during the execution of a project. Where applicable, please indicate the frequency (Daily, Weekly, Monthly) of collection these data for both large and small projects.

DATA	FREQUENCY FOR LARGE PROJECTS			FREQUENCY FOR SMALL PROJECTS		
	DAILY	WKLY.	MO.	DAILY	WKLY.	MO.
a) Foreman's report on the distribution of labour hours to cost codes or activity numbers						
b) Foreman's report on the distribution of equipment hours to cost codes or activity numbers						
c) Cumulative list of materials (delivered to site to date)						
d) Unused material on site						
e) Overall progress for each activity						
f) Report on sub-contractors work force, machinery and materials on site						
g) Supervising engineers' comments and verbal instruction record						
h) Other (please specify) _____ _____ _____ _____						

Each of the above listed data is basic and essential for certain control areas. The non-gathering or inadequate frequency of gathering of any of these data, can be used as an indicator of a deficiency in the control procedures related to the specific area and can severely limit the degree to which problem causes can be pin-pointed.

16. When a firm attempts to refine its existing project and planning control techniques, changes in existing practices and procedures of the firm, along with the roles of individuals, may be required. Some potential areas of change are identified in the table below. For each change type, please indicate the likely degree of acceptability.

POTENTIAL AREAS OF CHANGE	ACCEPTABLE	NOT RECOMMENDED	ABSOLUTELY UNACCEPTABLE
a) Motivation and incentive policy			
b) Degree of formality of work relationships among employees			
c) Degree of modelling work procedures (standard formats, official job descriptions, etc.)			
d) Degree of centralization of decision making authority			
e) Degree of sophistication of management procedures and technology			
f) Structure of this firm's organization			

The introduction of a control system is usually accompanied by some changes in procedures and the social and power structure of the firm. The resistance to such changes is a commonly cited event in the behavioral literature on organizations (8). The obvious cause advanced for this resistance is that those changes have the potential of threatening the status and the relative power of the management personnel.

The question is seeking to measure the severity of resistance to particular areas of change. This will obviously help the designer in drawing his boundary lines for the acceptable range of change imposed by or resulting from the use of the system.

17. Which of the following information is usually included in a job's progress report? (Please check off when included)

INFORMATION	LARGE PROJECT	SMALL PROJECT
a) Labour productivity for each activity		
b) Equipment productivity for each activity		
c) Man-hours actually consumed to date for each activity		
d) Equipment hours actually consumed to date for each activity		
e) Materials actually consumed to date for each activity		
f) Physical progress		
g) Expected time to complete		
h) Cost to complete		
i) Material requirements (e.g. for the next reporting period)		
j) Change orders report		
k) Claim for extras		
l) Quality of work		
m) Site problems report		

Although certain data appears to be collected, as investigated in question 15, there is a possibility that these data are not fully utilized. The question is trying to identify the information actually processed and made available to use by the management. This processed information, or more specifically the lack of it, will be correlated with the areas of time and cost control problems a certain contractor is facing.

3.2.2.4 Causes of Delay and Cost Overruns

Understanding the relative significance of construction problems can be utilized by the system designers as follows:

1. Appropriate allocation of the system design resources, by focusing on the aspects of performance that cause the greatest number of problems.

2. Correlating the significant problems encountered by a certain firm, with the firm's general characteristics, will help differentiate between the system's essential components, and the subsidiary components. For instance, suppose it is observed that labour turnover is causing significant cost overruns for only a few firms that are working in a certain area (probably where a temporary construction boom is occuring), therefore, the rate of labour turnover can be dropped as a component of the basic system and can be made available as an optional additional component.

3. Correlating the problems faced with by a certain firm, with the control procedures adopted by the firm and related with the certain area of problems, may help spot-light the deficiencies in those procedures.

THE QUESTIONS:

IV. CAUSES OF DELAY AND COST OVERRUNS

18. Listed below are several factors which can cause construction delays, and which the contractor can exert some control over. Please indicate the degree of significance of each factor in terms of its cause for time delays on YOUR projects. Note that factors such as force majeur, delay of drawing, etc. are not included as they are regarded as being completely beyond the control of the contractor.

18.(cont'd.)

FACTORS	DEGREE OF SIGNIFICANCE			
	VERY CONSIDERABLE	CONSIDERABLE	MINOR	NOT SIGNIFICANT OR N/A
a) Late deliveries of materials by suppliers				
b) Temporary material shortages in the market, especially for continuously supplied materials (sand, cement, etc)				
c) Low labour productivity				
d) Labour absenteeism				
e) Labour turnover				
f) Labour relations problems				
g) Lack of overall plan for execution of project				
h) Insufficient detail in project plan				
i) Duration of activities underestimated				
j) Equipment and labour requirements underestimated				
k) Schedules not updated frequently enough to identify problem areas				
l) Lack of accurate data on job progress				
m) Delays by sub-contractors				
n) Problems in co-ordination of sub-contractors				
o) Equipment breakdown				
p) Problems with access to the site				
q) Errors in drawings				
r) Construction errors				
s) Inspection or supervision problems				
t) Sample approval procedure				
u) Lack of an effective tool for forecasting time to complete				
v) Other factors (please specify)				
_____				
_____				
_____				
_____				
_____				

19. Please rank in order of significance (most significant first) the five most important factors which cause construction delays in your projects.

1. _____
2. _____
3. _____
4. _____
5. _____

20. Listed below are several factors which can cause cost overruns, and over which the contractor can exert some control. Please indicate the extent to which each of the factors results in cost overruns. Note that some factors are not included here, as they are regarded as being completely beyond the control of the contractor.

FACTORS	DEGREE OF SIGNIFICANCE			
	VERY CONSIDERABLE	CONSIDERABLE	MINOR	NOT SIGNIFICANT OR N/A
1) Delay caused by labour shortages in certain trades				
2) Delay caused by late delivery of materials				
3) Delay caused by sub-contractors				
4) High rates of material wastage on site				
5) Material loss or theft				
6) Low labour productivity				
7) Labour turnover				
8) Labour relations problems				
9) Labour costs underestimated				
10) Material costs underestimated				
11) Equipment costs underestimated				
12) General conditions underestimated				
13) Financing charges underestimated				
14) Unexpected escalation of labour wages				
15) Unexpected escalation of material prices				
16) Unexpected increase in interest rates				
17) Subcontractors co-ordination problems				

20. (cont'd.)

FACTORS	DEGREE OF SIGNIFICANCE			
	VERY CONSIDERABLE	CONSIDERABLE	MINOR	NOT SIGNIFINANT OR N/A
18) Equipment breakdown				
19) Errors in drawings				
20) Ambiguity of specifications or drawings which result in an inaccurate cost estimate				
21) Construction errors				
22) Inadequate quality control				
23) Inspection of supervision problems				
24) Lack of documentation of claims				
25) Inaccurate assignment of manhours and equipment hours to cost codes				
26) The lack of effective tools for forecasting cost and time to complete				
27) Other factors (pls.specify)				
_____				
_____				
_____				
_____				

21. Please rank in order of significance (most significant first) the five most important factors which cause cost overruns on your projects.

1. _____
2. _____
3. _____
4. _____
5. _____

3.3 QUESTIONNAIRE TESTING

The proposed questionnaire has been submitted by mail to a sample of eight Montreal based contractors, for the purpose of:

a) Deciding about the appropriate method of circulating the questionnaire; by mail versus personal interviews, bearing in mind the economical considerations measured by the cost per single response, and constrained by the need for a fairly high number of responses.

b) Revealing deficiencies, if any, in the questionnaire structure such as ambiguity, perceived over curiosity, length, question missing, etc.

3.3.1 RESPONSES

3.3.1.1 Response Rate

Three questionnaires have been received back from contractors. The response rate is encouraging, but still efforts should be exerted to ensure high rate of response, bearing in mind the very small sample used. A considerable body of literature exists on how to maximize the response rate to mail questionnaires (5), (6), (9), (10), (12) and (16).

In spite of the contradictory results occasionally reported about the effect of some of the techniques for running questionnaires, some of these techniques appear to carry potential impact on improving the response rates of the proposed questionnaire. These techniques are summarized below:

1. Advance Notification:

There is agreement among researchers that contac-

ting respondents prior to sending them the mail questionnaire increases the number of questionnaires returned. Advance notification in our case could be effective if it can be submitted by one of the reputable contractors' associations recommending co-operation of contractors.

2. Personalization:

The sponsor may add as a personal touch a hand written signature or hand written postscript to the covering letter. Also, he should introduce and personalize the researcher and identify the sponsoring organization.

3. Confidentiality of Response:

This should be clearly stated in the covering letter (a copy of the covering letter used for the questionnaire described in this chapter can be found in the Appendix).

4. Follow-Ups:

This includes any contact with respondents after the initial mail out of the questionnaire. Contact can take the form of letters, post cards, telephone calls, personal visits or some combination of these. These techniques seem to be consistently effective in increasing response rates. An additional copy of the questionnaire may be enclosed since the first may have been lost or mislaid.

5. Incentives:

The covering letter which accompanied the questionnaire in the tested samples included as an incentive for contractors a promise to forward the results obtained from compilation and an analysis of responses to those providing information. There is an agreement among researchers about the positive effect of incentives on increasing response rates.

3.3.1.2 Response Analysis

While it is beyond the scope of this dissertation, it is worthwhile to indicate briefly how the questionnaire could be formally analyzed. The most prevailing method of analysis is correlation. A correlation coefficient can be computed to indicate the degree of linearity between two variables being considered. This is a measure of the strength of association between the two factors. Further, the square of the correlation coefficient is the proportion of variance in one variable explained by the other variable. Additionally, a standard significance test indicates it any association statistically exists. Some examples of variables that could be correlated here, are given in the following table:

DEPENDENT VARIABLE	INDEPENDENT VARIABLES		
	(1)	(2)	(3)
-Use of sophisticated techniques(eg:C.P.M)	-Size of project	-Type of project	-Size of firm
-Construction errors	-Site staff's educational background	-Size of project staff	-Type of contract
-Low labour. productivity	-Use of cost codes	-A perceived significance to satisfaction of employees by management	-Site staff size

Other statistical techniques for analysis are: (1) Analysis of variance, (2) Factor analysis, (3) Correlation and variance using factored data, (4) Regression using factored data, (5) Path analysis; and their description may be found in reference (13).

3.4 PROPOSED IMPROVEMENTS TO THE QUESTIONNAIRE

The following improvements or alterations are suggested on the basis of the analysis of the returned questionnaires:

1. All spaces requiring long written comments or specifications should be omitted in the questionnaire and replaced by a list of possible answers to be checked or circled by the respondents. The spaces allocated for such comments in the tested questionnaire have been left blank in almost all the cases.
2. A question might be added at the end of the questionnaire to ask the respondents whether he accepts a personal interview for follow-up, (if needed). In case of acceptance, he should identify his name and firm. Some of the answers were found to need explanations or clarification.
3. For those firms making use of computers, a question should be included regarding the criteria considered for deciding to use and selecting computers.
4. A question might be added about the firm's strategies for training and developing the skills and knowledge of its employees.
5. Modifications to some Questions:

   A. Question (7), item (g) should be reworded to make clear

that the information sought is the description of the work carried out by the firm. In one of the returned questionnaires, some percentages were given by the respondent. In item (e) the list may be extended to include additional positions, especially for project administrative staff.

B. In question (10), the president may be included as a category. The president's education may be correlated with the employee's average educational background and with the degree of sophistication of the firm's procedures.

C. Question (14), degree of satisfaction with the used technique should replace the satisfied/dissatisfied classification. In all three questionnaires returned, respondents were satisfied with the techniques used for all functions.

D. Questions (15), (17), it could be useful to ask respondents to attach forms used for collecting various data for control, if they are willing.

E. Question (16), the question may be reworded in order to be better understood. In one of the returned questionnaires, this was the only unanswered question.

F. Question (17), respondents might be asked to attach forms of progress reports if they are willing.

G. Questions (18), (20), the causes of delay and cost overruns may be expanded to be more detailed and specific and to include other potential causes.

H. In question (4), transportation projects were repeated twice in the same question. The error can be corrected by omitting item (e).

CHAPTER 4

ACTION AUTHORITY AS A DETERMINANT OF INFORMATION NEEDS

4.1 INFORMATION BOUNDARIES

As was stated earlier, there exists considerations which impose important limitations on both the nature and the amount of information that can and should be made available to management personnel in a contracting firm. Information given should be relevant with the duties and responsibilities of the individual.

The function of the control system is to assist in correcting the direction of any aspect of performance that is not consistent with the firm's goals and interests. These corrections are effected by means of corrective actions taken by the various levels of management. The information needs of an individual can, therefore, be defined as the essential information needed by the individual in order to assist him taking the optimum corrective action among the various decision alternatives open to him under his job capacity.

Identifying the corrective actions that a job incumbent is empowered to initiate, can be used, therefore as a determinant of the information presented to him by the control system.

4.2 PROBLEM IN APPLICATION

In order to put the action authority in use as an information determinant, a difficulty exists as a result of the assignment of different duties and responsibilities to personnel having the same job title

but being in different firms. The pertinent dissimalarities among firms include:

1. The project organizational structures of site management personnel and their interface with the head office;
2. The distribution of authority among the various management levels.

4.2.1. THE PROJECT'S ORGANIZATIONAL STRUCTURE

The organizational patterns of a project embraces the following dimensions:

a. Vertical span of control: which is basically the number of hierarchial levels of management (eg. project manager, project engineer, superintendent, foreman);

b. Horizontal span of supervision of the various levels of management which is the number of units, groups or persons which are supervised by an individual at each level of management;

c. Design configuration: which is the way the control and reporting lines are designed. A project team might have a one way authority line or instead, two way authority lines where functional authority line is added. A previous phase of this research program has investigated in detail, the reporting and control lines adopted in three contracting firms (17).

The organizational patterns vary consideranly from one firm to another and also within the same firm, for different projects. These patterns are a function of several variables, of which the most influential

are: the project size and type (complexity), the degree of sophistication of the firm's procedures, and the management personnel's skills and educational background.

4.2.2 THE DISTRIBUTION OF AUTHORITY AMONG THE VARIOUS LEVELS OF MANAGEMENT

The authority and degree of autonomy designated to each of the firm's levels of management vary considerably as a function of the following parameters:

1. The overall quality of the firm's human resources, as well as the magnitude of the differences in skill and educational background among the various levels of management.
2. Formal versus information patterns of work relationships among the various levels of management. Informal relationship patterns can be identified by the domination of verbal reporting procedures as opposed to written procedures, lack of clear distinction between responsibilities, duties and authority and the lack of policy-manuals or non-adherence to them.
3. The top management trends declared policy as to the bureaucratic versus the nonbureaucratic style of management. In the bureaucratic style decisions are standardized and authority is more centralized.
4. The size and the degree of complexity of the project.
5. The number of the firm's ongoing projects, which determines the extent to which top management can become involved in the day to day or operational control aspects of an individual job and the managerial aspects of an individual job.

Variations in job functions because of the foregoing factors, exclude the use of a standard format, for information output, for the individuals holding the same job titles in different firms or even in the same firm but in different projects. Consequently, an adjustable format is suggested here. The working details of this format are given below:

4.3 THE ADJUSTABLE FORMAT CONCEPT

Recalling the basic hypothesis here is that the information presented to a certain individual in a firm should be commensurate with the authorities assigned to him in initiating certain corrective actions.

In order to identify the boundaries of authority assigned to certain individuals in a given firm, a breakdown of authority is to be presented to the individual's superior or the top management in the form of a check list. The superior checks off the list to specify the individual's capacity in the action making process. If a formal job description is in use by the firm, the list can be checked off for all levels of management by the cost engineer (or the control officer in general).

4.3.1 SUBDIVISION OF THE CHECK LIST

If a single check list is used for all levels of management, it could be too lengthy for practical use, as it should include the full range of actions that might be taken by all individuals in a firm. A way of subdividing the list is required. The major prerequisite of such a subdividing scheme is to provide a way by which each individual may be categorized only in one subdivision. The following subdivision scheme is suggested:

4.3.2 THE CLASSIFICATION SCHEME

The scheme uses the variable, span of supervision, whereby any individual is classified according to the span of activities he is concerned with. The classification is as follows:

1. A single activity span (eg. form work, steel fixing, painting, etc.);
2. A group of activities span (eg. finishing work, structural shell);
3. An integrated part of the site work, which could be a part of a large site or an integrated site in a multi-sites project;
4. Overall site work span (eg. Site Engineer, Superintendent);
5. Overall project responsibility span (eg. Project Manager, Project Engineer, Project Cost Engineer, Personnel Officer);
6. Multi-projects span (eg. Projects Manager, Area Manager, Area Accountant, etc.);
7. Overall Functional span (Engineering Director, Purchasing Manager etc.);
8. Firms top management (President, board of directors, etc.).

4.3.3 CONSTRUCTING THE CHECK LIST AND IDENTIFYING THE REQUIRED INFORMATION

The procedure is as follows:

1. The major sources or causes of deficiencies should be established (this has already been covered in Chapter 2 of this study).
2. The full range of actions that can be initiated by all

levels of management to correct certain deficiency, given its specific source, is to be determined.

3. For each action identified in 2, the following corresponding variables are to be established:
   a. The information required for evaluating the appropriateness of the action;
   b. The specific authority required for initiating the action;
   c. All potential levels of management that might be assigned the specific authority, bearing in mind the dissimilarities among firms regarding the authority distribution and organizational patterns, which have been mentioned earlier.
4. The check list for a certain level of management should contain only the components of authority (identified in 3.b above) which apply to that level (as identified in 3.c above).
5. By checking the appropriate check list, the authority limits of certain individuals can be identified. The information corresponding to the authority components assigned to the individual should be made available to him.

4.3.4 APPLICATION OF THE CONCEPT

The concept will be applied below to the major sources of deficiencies in a construction project, as identified in Chapter 2.

It is important to emphasize that the actions listed below, are those which are open to management after a deficiency has been detected and its specific cause has been pinpointed.

Identifying the specific cause of a detected deficiency and taking corrective measures is a task that might require certain actions or investigations. These are not included in the actions listed below. Nevertheless, this is a crucial aspect of the control system.

The following analysis excludes the authorities which are unquestionably inherent into the job functions, such as directing a subordinate or recommending to a superior certain courses of action for improving the performance, etc.

SOURCE OF DEFICIENCY

(1) Incompetent Performance by Immediate Subordinate

(Applied to First Level Supervisor)

POSSIBLE CORRECTIVE ACTIONS	SPECIFIC AUTHORITY REQUIRED FOR ACTION MAKING	INFORMATION REQUIRED FOR DECISION MAKING	SPAN OF SUPERVISION						
			Single activity span	Group of activities"	Part of the site "	Overall site "	Overall project "	Multi project "	Overall functional "	Top management "
Recommend shifting the subordinate to another position, warning or dismissing him		relevant performance measures & standards (eg. standard and actual rate of labour productivity or rate of material wastage)		x	x	x				
Intensify direct involvement in directing the activity(ies) concerned		" "		x	x					
Allocate special attention to the training of the subordinate		" "		x	x	x				
Change subordinate's work assignment	allocating work assignments (at the subordinate's level	" "		x	x	x	x			
Shift the employee to another position	shifting subordinates (at the specific level)	" "			x	x	x	x		
Warn or dismiss the employee	dismissing authority (at the subordinate's level)	" " & past record of employee				x	x	x	x	
Introduce or modify training program	investments for management procedures development	average performance measure for the overall firm (rate of equipment, idle time, labour productivity)							x	x

POSSIBLE CORRECTIVE ACTIONS	SPECIFIC AUTHORITY REQUIRED FOR ACTION MAKING	INFORMATION REQUIRED FOR DECISION MAKING	SPAN OF SUPERVISION							
			Single activity span	Group of activities"	Part of the site "	Overall site "	Overall project "	Multi project "	Overall functional "	Top management "
Draw attention (or take any of the above action against) recruiting officer	line senority over recruiting officer	past record of recruitment officer						x	x	x
Modify hiring criteria	Setting recruitment criteria for project's personnel	recruitment officer's report on reasoning of hiring						x	x	x

SOURCE OF DEFICIENCY

(2) Inappropriate Management Procedures

For the purpose of this analysis the management procedures can be classified into two major categories:

A. Procedures Determined by the Firm's General Policy

B. Procedures Determined by the Project Manager's Operational Policy.

A. Procedures Determined by the Firm's General Policy

examples of these policies are:

a. Labour relations program

b. General organisation of site staff and the interface with main office

c. Procedures of labour firing and replacement

d. Planning, scheduling and updating practices

e. Equipment maintenance and major repairs policy

f. Procurement policy and procedures

g. Purchasing procedures (for operational materials)

h. Cost accounting procedure

POSSIBLE CORRECTIVE ACTIONS	SPECIFIC AUTHORITY REQUIRED FOR ACTION MAKING	INFORMATION REQUIRED FOR DECISION MAKING	SPAN OF SUPERVISION							
			Single activity span	Group of activities"	Part of the site "	Overall site "	Overall project "	Multi project "	Overall functional "	Top management "
Suggest changes			X	X	X	X	X	X		
Support proposals		Relevant performance measure for groups or units under supervision		X	X	X	X	X	X	
Approve/reject proposals	Modifying of general policy (relevant discipline)	Relevant performance measure for the overall firm (eg. equipment, idle time, labour, turnover, etc)							X	X

B. Procedures Determined by the Project Managers Chosen Policy

examples of these policies are:

a. Safety precautions

b. Degree of autonomy and authority delegated to the various levels of the project management team

c. Coordination channels

d. Material storage and handling procedures

POSSIBLE CORRECTIVE ACTIONS	SPECIFIC AUTHORITY REQUIRED FOR ACTION MAKING	INFORMATION REQUIRED FOR DECISION MAKING	SPAN OF SUPERVISION						
			Single activity span	Group of activities"	Part of the site "	Overall site "	Overall project "	Multi project "	Overall functional " Top management "
Suggest changes			x	x	x	x			
Support changes		Relevent performance measure for under supervision		x	x	x	x		
Approve/reject proposals	Modifying project's policy (relevant discipline)	Relevant performance measure for the overall project (ef. average labour productivity, management, personnel turnover, rate of material wastage)					x	x	

(3) Incompetent Subcontractor

POSSIBLE CORRECTIVE ACTIONS	SPECIFIC AUTHORITY REQUIRED FOR ACTION MAKING	INFORMATION REQUIRED FOR DECISION MAKING	SPAN OF SUPERVISION							
			Single activity span	Group of activities"	Part of the site "	Overall site "	Overall project "	Multi project "	Overall functional "	Top management "
Recommend warning subcontractor				x	x	x	x			
Recommend work withdrawal from subcontractor				x	x	x	x			
Warn subcontractor	Legal transaction with subcontractor	Actual & scheduled progress Contractual arrangements with subcontractor				x	x	x		
Withdraw work from subcontractor	Full responsibilities for project	" "					x	x	x	
Draw attention of contract procurement office	line seniority over procurement officer	Actual and scheduled progress						x	x	x

(4) Lack of Effective Handling of Subcontractors Daily Problems (Physical Progress)

POSSIBLE CORRECTIVE ACTIONS	SPECIFIC AUTHORITY REQUIRED FOR ACTION MAKING	INFORMATION REQUIRED FOR DECISION MAKING	SPAN OF SUPERVISION							
			Single activity span	Group of activities	Part of the site	Overall site	Overall project	Multi project	Overall functional	Top management
Draw attention of responsible personnel	Direct senority on responsible personnel	Actual and scheduled progress of activity			x	x	x			
Introduce the function of subcontractor's cooperation in the future	Project's organization responsibility	Actual and scheduled progress of project				x	x	x		
Emphasize the role of facilitating subcontractor's task as a criterion for evaluating individuals' performance	Modification of motivation policy	Actual and scheduled performance measure (company wide)						x	x	x
Shift the current direct communication channel to another level of management	project administrative policy	Actual and scheduled progress (project scale)				x	x	x		

SOURCE OF DEFICIENCIES

(5) Competitive Labour Market Situation (Affecting Labour Turnover)

POSSIBLE CORRECTIVE ACTIONS	SPECIFIC AUTHORITY REQUIRED FOR ACTION MAKING	INFORMATION REQUIRED FOR DECISION MAKING	SPAN OF SUPERVISION							
			Single activity span	Group of activities "	Part of the site "	Overall site "	Overall project "	Multi project "	Overall functional "	Top management "
Suggest improvements to Labour relation program (training, personal development, etc.)			x	x	x	x	x	x		
Suggest introducing certain improvements to work conditions, incentives plan, or fringe and other benefits in order to keep up with the market competition			x	x	x	x	x	x		
Approve/reject modifications to labour relation program	Modification of general policty (labour relation)	Cost/benefit analysis							x	x
Approve/reject improvement to work conditions etc.	Modification of general policy (wages and benefits	Cost/benefit analysis						x	x	x

Note: The local labour environment may impose some limitations on the validity of some of the above listed actions.

(6) Overstaffing/Understaffing of Individual Work Crews

POSSIBLE CORRECTIVE ACTIONS	SPECIFIC AUTHORITY REQUIRED FOR ACTION MAKING	INFORMATION REQUIRED FOR DECISION MAKING	SPAN OF SUPERVISION							
			Single activity span	Group of activities"	Part of the site "	Overall site "	Overall project "	Multi project "	Overall functional "	Top management "
Adjust group size internally (within the groups under your supervision)	Internal group formation	optimum size and composition of groups Actual and standard performance measure (labour productivity)		x	x	x				
Split or merge groups	" "	" "		x	x	x				
Declare need for additional work force or the existence of spare force		" "	x	x	x	x				
Allow shifting of spare labour to groups facing shortages	Labour force distribution	" "		x	x	x	x			
Allow firing or dismissing the relevant group	Human resources programming	Overall requirements of units under supervision			x	x	x	x	x	

(7) Inappropriate Construction Methods

POSSIBLE CORRECTIVE ACTIONS	SPECIFIC AUTHORITY REQUIRED FOR ACTION MAKING	INFORMATION REQUIRED FOR DECISION MAKING	SPAN OF SUPERVISION							
			Single activity span	Group of activities"	Part of the site "	Overall site "	Overall project "	Multi project "	Overall functional "	Top management "
Suggest minor modifications to the specific defective construction method		Standard and actual defective performance measure (eg. labour productivity, total direct cost of activity, overall time to complete. etc.	x	x	x	x				
Approve reject modifications	Minor modifications to construction methods	" " Additional cost involved in change and benefits expected		x	x	x	x	x		
Suggest changes to basic construction procedures (eg. cast in place to precast, conventional forms work to sliding forms		Standard and actual performance measure, such as overal time to complete, cost of individual activities, etc.			x	x	x	x	x	
Approve/reject major changes	Major modifications to construction methods	" " Cost/benefit analysis				x	x	x	x	x
Instruct conducting study about the methods adopted by the firms in general as compared with the recent technology in the market	System development expenditures "within budget"	Actual and standard performance measure such as cost of individual activi-							x	x

POSSIBLE CORRECTIVE ACTIONS	SPECIFIC AUTHORITY REQUIRED FOR ACTION MAKING	INFORMATION REQUIRED FOR DECISION MAKING	SPAN OF SUPERVISION						
			Single activity span	Group of activities"	Part of the site "	Overall site "	Overall project "	Multi project "	Overall functional "	Top management "
		ty or time to complete							
Hire a construction technology consultant to suggest solutions or changes	system development investments	" "						x	x
		Cost/benefit analysis							
Suggest a personnel training program in order to adapt to intended changes in firm's methods		Actual and budgeted performance measures such as cost of individual activities, time to complete etc.					x	x	x	
Approve/reject training program	system development investments	" " Cost of program						x	x

(8) Inefficient Storekeeping & Material Delivery Accounting Procedures (Material Wastage Rate)

POSSIBLE CORRECTIVE ACTIONS	SPECIFIC AUTHORITY REQUIRED FOR ACTION MAKING	INFORMATION REQUIRED FOR DECISION MAKING	SPAN OF SUPERVISION							
			Single activity span	Group of activities"	Part of the site"	Overall site"	Overall project"	Multi project"	Overall functional"	Top management"
Suggest changes			x	x	x	x	x	x		
Order a study about weaknesses and possible solutions	Formation of special task groups	Scheduled & actual performance							x	x
Change storekeeping team	top firing and dismissing capacity	Scheduled and actual performance							x	x
Hire management consultant for suggesting solutions	Developing management procedures	Scheduled and actual performance Cost/benefit analysis							x	x

(9) Inadequate Attention Paid to Material Storage Precautions

POSSIBLE CORRECTIVE ACTIONS	SPECIFIC AUTHORITY REQUIRED FOR ACTION MAKING	INFORMATION REQUIRED FOR DECISION MAKING	SPAN OF SUPERVISION						
			Single activity span	Group of activities"	Part of the site "	Overall site "	Overall project "	Multi project "	Overall functional "	Top management "
Draw attention of personnel concerned		Actual and scheduled material wastage for units under supervision		x	x	x	x	x	x	
Introduce the function of material control officer	system development investments	Actual and scheduled material wastage at the firm's level							x	x
Instruct, establishing (or enforce) general rules for material storage		Actual and scheduled material wastage at the respective level				x	x	x	x	x

(10) Inappropriate Equipment Maintenance Policy (Machine Idle Time)

POSSIBLE CORRECTIVE ACTIONS	SPECIFIC AUTHORITY REQUIRED FOR ACTION MAKING	INFORMATION REQUIRED FOR DECISION MAKING	SPAN OF SUPERVISION							
			Single activity span	Group of activities"	Part of the site "	Overall site "	Overall project "	Multi project "	Overall functional "	Top management "
Redistribute mechanical staff between sites and central workshop	Mechanical departments overall administration capacity	Relative effective productivity of site/central workshops (total fuel and maintenance cost)						x	x	
Increase/decrease size of the mechanical staff	General policy (mechanical affairs)	Actual and standard performance measure (Machine productivity, fuel and maintenance cost)							x	
Increase/decrease dependency on out of the house workshops	General policy (mechanical affairs)	Actual and standard performance measure (eg. idle time on machine productivity)						x	x	x
Improve mechanical facilities and capabilities	Long term investments	Cost/benefit analysis								
		Actual and standard performance measures (idle time, machine productivity)							x	x

(11) Over Estimated/Under Estimated Performance Standards

POSSIBLE CORRECTIVE ACTIONS	SPECIFIC AUTHORITY REQUIRED FOR ACTION MAKING	INFORMATION REQUIRED FOR DECISION MAKING	SPAN OF SUPERVISION							
			Single activity span	Group of activities"	Part of the site "	Overall site "	Overall project "	Multi project "	Overall functional "	Top management "
Request modifying standards			x	x	x	x	x			
Approve modification of standards and budgeted cost	Standards & budget alterations						x	x	x	
Draw attention of scheduler	Line seniority over scheduler	Overall deviation from standards					x	x	x	
Warn or dismiss scheduler	" "	" "							x	x
	Warning & dismissing authority over scheduler	Past record								
Suggest training program for schedulers and estimators								x	x	
Accept/reject training program	System development investment	Cost/benefit analysis							x	x
Instruct setting up records for historical data for feed back or enforce using the existing data	System development responsibility							x	x	x

(12) Ambiguity of Drawings and/or Specifications

POSSIBLE CORRECTIVE ACTIONS	SPECIFIC AUTHORITY REQUIRED FOR ACTION MAKING	INFORMATION REQUIRED FOR DECISION MAKING	SPAN OF SUPERVISION							
			Single activity span	Group of activities"	Part of the site "	Overall site "	Overall project "	Multi project "	Overall functional "	Top management "
Prepare or request preparing detailed working drawings for site use			x	x	x	x				
Check drawings/specification and identify ambiguities for discussion with designers well in advance				x	x	x	x			
Allow/reject preparation of working drawings in or out of the house	Special operating expenditures	Cost/benefit analysis Budgeted and actual contingencies expenditures to date				x	x	x		
Name an individual or committee to check drawings/specification and coordinate with designers	Formation of special tasks	Cost/benefit analysis					x	x	x	

(13) Financial Straits or Contraction in the Firm's Work Volume As Perceived by Management Personnel as Well as Labour

POSSIBLE CORRECTIVE ACTIONS	SPECIFIC AUTHORITY REQUIRED FOR ACTION MAKING	INFORMATION REQUIRED — FOR DECISION MAKING	SPAN OF SUPERVISION							
			Single activity span	Group of activities"	Part of the site "	Overall site "	Overall project "	Multi project "	Overall functional "	Top management "
Recommend meeting for clarifying situation or suggest other remedies							x	x	x	
Call for a general meeting	Top Seniority	Overall rate of turnover							x	x
Offer commitments to provide security for employees	Long term investment capacity	Cost/benefit analysis							x	x
Introduce a permanent program for informing employees and workers	system development investments	cost/benefit analysis							x	x
Offer additional benefits to make up for the actual disadvantage incurred by the employees, if any, because of the uncertainty involved	Modifying general policy (wages & benefits)	Cost of plan Projected cost of turnover							x	x

(14) Unfavourable Weather Conditions

POSSIBLE CORRECTIVE ACTIONS	SPECIFIC AUTHORITY REQUIRED FOR ACTION MAKING	INFORMATION REQUIRED FOR DECISION MAKING	SPAN OF SUPERVISION							
			Single activity span	Group of activities"	Part of the site "	Overall site "	Overall project "	Multi project "	Overall functional "	Top management "
Suggest extra shifts or overtime work to make up for the delay		Overall time to complete								
		Criticality of the various activities	x	x	x	x	x			
Approve/reject proposals	Overtime work permission authority	Budgeted contingency status				x	x	x		
		Subsequent delay expected								
Suggest increase of the machine efforts or replace the equipment		Overall time to complete								
		Criticality of various activities								
Approve/reject the proposal	Multi-project resource allocation capacity	Overall implications on the affected projects								
Suggest awarding some activities to subcontractors to make up for the delay		Overall time to complete								
		Criticality of various activities								
Approve/reject the above proposal		" "								
		Overall implications (time and cost) of the action								

CHAPTER 5

SUMMARY AND RECOMMENDATIONS

5.1. SUMMARY

The basic features and requirements that should be met by a Management Information System for construction project control are identified. These features and requirements can be summarized as follows:

1. The system should provide the user with the following:
   a. It should reveal as many types or causes of deficiencies or weaknesses in project cost and time performance as possible;
   b. It should be able to highlight the key source of the detected deficiencies;
   c. It should be capable of evaluating the implications of potential corrective actions postulated by management.

2. The system should be designed to reflect the actual characteristic and real needs of the contractor as opposed to the often idealized characteristics and conditions adopted in many academic studies.

3. The system should be able to present different types of output formats for the various levels of management in order to cope with the differences in the scope of responsibility and educational background among these levels of management.

This study has focused on providing an approach or methodology to be followed by the designers of a control system in order to meet each of the above identified requirements. These proposals are summarized as

follows:

1. First, an integrated scheme of performance measures has been proposed. These measures are thought to be, collectively, capable of detecting all deficiencies in performance that have a significant impact on the project cost, time or quality. The major causes of the deficiencies, highlighted by each individual performance measure, have been also identified.
2. Second, a questionnaire has been proposed as an appropriate tool for collecting the information about actual characteristics and current practices of the building contractors. The questionnaire was mailed to a small sample of contracting firms for the purpose of assessing the most efficient way of running it and to spot any weaknesses in its content.

   Some techniques for improving response rates were suggested. The analysis of the returned questionnaires has helped detect some potential areas of improvements to the proposed questionnaire.
3. Third, to achieve the requirement of providing different types of information for the different levels of management, a detailed procedure has been suggested for the purpose of identifying the information that should be made available to certain individuals in a given firm, bearing in mind the dissimilarities among firms in terms of organizational patterns, degree of centralization of authority and the number and skills of management personnel.

5.2. RECOMMENDATIONS FOR FUTURE WORK

The study mainly consists of proposals and recommendations for those pursuing research on contractor project control information systems.

Recommendations for further work include:

1. Refinement of the questionnaire developed and its distribution to a large number of Canadian contractors. Endorsement of contractors' associations both at the federal and provincial levels should be sought.
2. Analysis of the results of the questionnaires in a manner which links characteristics of the firm, (size, number of employees, training levels, etc.), with existing control practices and problems experienced with time and cost overruns.
3. Analysis of the questionnaire to determine the elements of a control system which would be common to the majority of potential users.
4. Further study of problem causes and identification of the minimal data set required to identify performance deficiencies and their sources.
5. A brief effect/cause check list can be concluded from Chapter 2 for the daily use of the system designer and later on for the contractor using the system.. Fig. 5.1 suggests a matrix presentation of the proposed check list.

CAUSE \ EFFECT				TIME			COST			
PROBLEM TYPE	MAIN CATEGORIES	DETAILS		Late delivery of materials	Low machine productivity	Delay by subcontractor	Above budget procurement	Low labour productivity	High interest rates	High ratio of machine idle time
RESOURCES PROBLEMS	Human resources	Own Labour	Group 1		x			x		x
			Group 2							
		Management	Procurement dept.	x		x	x		x	x
			Logistics "	x						
			Planning "	x	x	x	x	x		x
			First level supervisors					x		x
		Sub-contractors	Sub (Activity 1)							
			Sub (Activity 2)			x				
	Material						x	x		
	Equipment				x	x	x	x		x
	Monetary resources			x		x	x	x	x	
	Designs & drawings			x						
PROCESS PROBLEMS	Planning & scheduling			x	x	x	x	x	x	x
	Labour policy						x	x		
	Mainten. policy				x					x
	Construction methods				x			x		x
	Safety programs									
	Motivation techniques									
UNCONTROLLABLE PROBLEMS	Weather conditions				x	x		x		x
	Permits			x						
	National economy								x	

SAMPLE CAUSE/EFFECT MATRIX

FIG. 5.1

REFERENCES

[1] Ahuja, H.N., Construction Performance Control By Networks, New York: Wiley Interscience, 1976.

[2] Barrie, Donald S., and Paulson, Byod C., Professional Construction Management, New York: McGraw Hill, 1978.

[3] Day, David A., Construction Equipment Guide, New York: Wiley Series of Practical Construction Guides, 1973.

[4] Douglas, James, Construction Equipment Policy, New York: McGraw Hill, 1975.

[5] Erdos, Paul L. and Morgan, Arthur J., Professional Mail Surveys, New York: McGraw Hill, 1970.

[6] Ford, N.M., "The Advance Letter in Mail Surveys", Journal of Marketing Research, May 1967.

[7] Hamner, W. Clay, and Orcan, Dennis W., Organizational Behaviour: An Applied Psychological Approach, Dallas, Texas: Business Publications, Inc., 1978.

[8] Jackson, John H., and Morgan, Cyril P., Organization Theory, New Jersey: Prentice Hall, Inc., 1978.

[9] Kanuk, L. and Berenson C., "Mail Surveys and Response Rates: A Literature Review", Journal of Marketing Research, November 1975.

[10] Kerin, Roger A., "Personalization Strategies, Response Rate and Response Quality in Mail Survey", Social Science Quarterly, June 1974.

[11] Kirittopoulos, Mihalis C., Some Considerations for Reporting Systems for Medium-Sized Contractor, Montreal, Centre for Building Studies, Concordia University, Report No. CBS-31, 1977.

[12] Linsky, Arnold S., "Stimulating Responses to Mailed Questionnaires, A Review", Public Opinion Quarterly, Spring 1975.

[13] Murphy, David Charles, Baker, Bruce N., and Fisher, Daluar, Determinants of Project Success, Springfield, National Technical Informat Services, 1974.

[14] Pilcher, Roy, Principles of Construction Management, London: McGraw Hill, 1976.

[15] Russell, Alan D., and Triassi, Emmanuel, "Requirements For Building Contractor Project Management Information System", Garmisch-Partenkirchen, The 6th Internet Congress, 1979.

[16] Statistics Canada, Mail Survey: Improving Response Rates.

[17] Triassi, Emmanuel, The Building Contractor and Project Control: Case Studies, Montreal A Master thesis, Centre for Building Studies, Concordia University, 1979.

[18] West, J.A. and Ferdinand, R. Levy, A Management Guide to PERT/CPM, New Jersey, Prentice-Hall, Inc., 1977.

APPENDIX

SAMPLE COVER LETTER AND CONTRACTOR QUESTIONNAIRE

March 26, 1980

[1]
Dear [1]

A research group at the Centre for Building Studies is in the process of designing and developing management information systems to aid in the task of time and cost control for individual projects. The specific audience of this work is the Canadian contractor whose annual work volume lies in the range of 5 to 50 million dollars. For these systems to be of practical use, they must reflect the specific needs and capabilities of their intended audience. To date, considerable preliminary work in identifying these needs and capabilities has been done through the form of extensive consultation with five general contractors and with banks and surety companies. A reasonably complete profile of the Canadian contractor has emerged from this consultation process. Findings suggest that priority should be given to developing an information system for time, subcontractor progress and changeorder control, for forecasting time and cost to complete and to provide feedback information in a form useful for estimating future projects. As well, it would appear that the concept of a totally integrated system is unlikely to prove workable.

What needs to be done now is to strengthen and generalize our concepts and understanding regarding the Canadian contractor in terms of how he works, his problems, and so forth prior to formulating designs for information systems for project time and cost control. To do this, we are requesting that as many contractors as possible complete the enclosed questionnaire. Feedback from construction firms such as your own is vitally important to us and will determine whether or not our work can yield meaningful benefits to Canadian contractors.

The questionnaire contains just twenty one questions. Most of these questions have been formulated in a manner which requires only very short answers - hence the length of the questionnaire. For your convenience, we have enclosed a pre-addressed envelope for return of the questionnaire.

All information obtained from these questionnaires will be treated in strictest confidence as to source. Results obtained from the compilation and analysis of the responses will be forwarded to all those providing information.

./2

Your cooperation in providing essential input to this study is greatly appreciated. We look forward to hearing from you at your earliest convenience.

Yours sincerely,

Alan D. Russell,
Associate Professor and
Associate Director

Enclosure

cc. Study Team
M. Bekhit, M.Eng.
N. McGowan, MBA

/clb

Centre for Building Studies
Centre des études sur le bâtiment

CONTRACTOR QUESTIONNAIRE

I. BACKGROUND INFORMATION ON FIRM

1. Please identify the major role of this firm :

___ General Contractor
___ Prime Contractor
___ Specialist Contractor (or sub-contractor) Type : _____
___ Prefabricated Items Supplier
___ Maintenance Contractor
___ Other; please specify _____

2. The annual work volume of the firm is :

___ Below 2,000,000
___ 2,000,000 - 5,000,000
___ 5,000,000 - 10,000,000
___ 10,000,000 - 20,000,000
___ 20,000,000 - 30,000,000
___ 30,000,000 - 50,000,000
___ 50,000,000 - 100,000,000
___ Over 100,000,000

3. a) The firm is a : Public Corporation ___
Private Corporation ___

4. Please describe the types of projects with which the firm is involved by completing the table below. Please indicate, in percentage terms, how much of the annual work volume in dollars is accounted for by each project type.

PROJECT TYPE	% OF TOTAL WORK UNDERTAKEN	PLEASE INDICATE SPECIFIC PROJECT TYPE (e.g. LOW-RISE APPARTMENT BUILDINGS)
a) Residential projects	_____	
b) Commerical buildings	_____	
c) Institutional buildings	_____	
d) Civil Engineering projects		
- water treatment and distribution project	_____	
- highway project	_____	
- other transportation projects	_____	
- marine engineering	_____	
- hydro projects	_____	
- other : _____		
e) Transportation projects	_____	
f) Industrial projects	_____	
g) Other types (please specify)		
_____	_____	
_____	_____	
_____	_____	

Centre for Building Studies
Centre des études sur le bâtiment

5. The average annual growth rate of the firm over the last three years has been __% per year.

6. The MAIN market in which the firm operates is :
   Within the city of _____
   Within the province of _____
   All over Canada _____
   International (please specify countries) _____
   _____

7. Please complete the following table which deals with several characteristics of the firm's projects. Please divide the range of projects undertaken by your firm into the categories "Large" and "Small".

DESCRIPTION	LARGE PROJECTS	SMALL PROJECTS
a) Average project value	$ _____	$ _____
b) Average project duration	____%	____%
c) % of work usually sub-contracted		
d) The company's own labour work force at peak	____ Men	____ Men
e) The firm's site management staff per project consists of :	No. ___ Project Manager ___ Project Engineer ___ Superintendent ___ Asst. superintend. ___ Foreman ___ Clerk (time-keeper) ___ Other (pls.specify) _____ _____	No. ___ Project Manager ___ Project Engineer ___ Superintendent ___ Asst. superintend. ___ Foreman ___ Clerk (time-keeper ___ Other (pls.specify _____ _____
f) The percentage breakdown in contract types for large and small project is :	% ___ Fixed price ___ Cost plus ___ Turnkey ___ Construction mgmt. ___ Other (pls.specify) _____ _____ _____	% ___ Fixed price ___ Cost plus ___ Turnkey ___ Construction mgmt. ___ Other (pls.specify _____ _____ _____
g) Nature of work usually carried out by the company's own labour force		

8. The average number of projects undertaken at any time is _____
How many of these are large projects ? _____

9. Head office staff consists of _____ people, of which _____ are clerical and secretarial staff.

10. Listed below are job categories and a range of educational backgrounds which may be associated with them. Please indicate all applicable types of background for the categories relevant to your firm.

BACKGROUND / CATEGORIES	Exper. Tradesman	Technologist	Graduate Engineer	Commerce or Bus. Graduate	Other Univ. Degrees	High School Graduate	Other Qual.
Vice-President(s)							
Department Mgrs.							
Project Managers							
Project Engineers							
Superintendents							
Foremen							
Estimators							
Planners							

II. FIRM'S OBJECTIVES

11. Please rank the following objectives in terms of their current importance to the firm (most important first) :

___ Survival
___ Maintain a specific volume of work
___ Achieve a specified return on volume
___ Achieve a specified return on equity
___ Achieve a specified growth rate
___ Develop and maintain a reputation for timely completion of work within budget
___ Diversification into a larger number of project types
___ Other; please specify : _____

12. Please rank the following factors in terms of their significance to the company's success and effectiveness :

___ The development of a reputation for timely completion of work within budget
___ Satisfaction of employees
___ The internal development of the firm's management and operational procedures
___ The capability to adapt to changes in technology and market requirements
___ Other; please specify : _____

Centre for Building Studies
Centre des études sur le bâtiment

III. TECHNIQUES AND PROCEDURES

13. If you make use of computer services, please check off the appropriate entries in the following table :

FUNCTIONS / COMPUTER FACILITIES	SERVICE BUREAU BATCH PROCESSING	TIME SHARING	IN-HOUSE MINI-COMPUTER	OTHER (PLEASE SPECIFY)
a) Payroll				
b) Financial (acctg.)				
c) Job cost acctg.				
d) Estimating				
e) Cash flow analysis				
f) Planning & scheduling				
g) Procurement				
h) Inventory control				
i) Work progress measurement				
j) Other (pls.specify)				

14. For each function identified in the table below, please indicate the techniques employed, such as C.P.M., Bar Chart, line of balance, cost codes, cost accounting, committee reports, etc. for the firm's large and small projects. Also, please indicate whether you are satisfied or dissatisfied with the techniques in each case.

FUNCTION	LARGE PROJECTS			SMALL PROJECTS		
	TECHNIQUES	SATISFIED ? YES	SATISFIED ? NO	TECHNIQUE	SATISFIED? YES	SATISFIED? NO
a) Estimation of project duration for bidding purposes						
b) Cash flow planning						
c) Work planning (scheduling of activities)						
d) Procurement planning and follow-up						
e) Resource planning and allocation						
f) Measuring work progress						
g) Controlling cost and expenditures						
h) Inventory control						
i) Evaluating and documenting delays due to change orders						

Centre for Building Studies
Centre des études sur le bâtiment

14. (cont'd.)

FUNCTION	LARGE PROJECTS			SMALL PROJECTS		
	TOOLS	SATISFIED ? YES	SATISFIED ? NO	TOOLS	SATISFIED ? YES	SATISFIED ? NO
j) Detecting time over-runs						
k) Detecting cost over-runs						
l) Assisting top management in the process of evaluating the various options for corrective actions						
m) Forecasting time and cost to complete						

15. Which of the following data are collected by your firm during the execution of a project. Where applicable, please indicate the frequency (Daily, Weekly, Monthly) of collecting these data for both large and small projects.

DATA	FREQUENCY FOR LARGE PROJECTS			FREQUENCY FOR SMALL PROJECTS		
	DAILY	WKLY.	MO.	DAILY	WKLY.	MO.
a) Foreman's report on the distribution of labour hours to cost codes or activity numbers						
b) Foreman's report on the distribution of equipment hours to cost codes or activity numbers						
c) Cumulative list of materials (delivered to site to date)						
d) Unused material on site						
e) Overall progress for each activity						
f) Report on sub-contractors work force, machinery and materials on site						
g) Supervising engineers comments and verbal instruction record						
h) Other (please specify)						
_____						
_____						
_____						

16. When a firm attempts to refine its existing project and planning control techniques, changes in existing practices and procedures of the firm, along with the roles of individuals, may be required. Some potential areas of change are identified in the table below. For each change type, please indicate the likely degree of acceptability.

POTENTIAL AREAS OF CHANGE	ACCEPTABLE	NOT RECOMMENDED	ABSOLUTELY UNACCEPTABLE
a) Motivation and incentive policy			
b) Degree of formality of work relationships among employees			
c) Degree of modelling work procedures (standard formats, offical job descriptions, etc.)			
c) Degree of centralization of decicion-making authority			
d) Degree of sophistication of management procedures and technology			
e) Structure of this firm's organization			

17. Which of the following information is usually included in a job's progress report? (Please check off when included).

INFORMATION	LARGE PROJECT	SMALL PROJECT
a) Labour productivity for each activity		
b) Equipment productivity for each activity		
c) Man-hours actually consumed to date for each activity		
d) Equipment hours actually consumed to date for each activity		
e) Materials actually consumed to date for each activity		
f) Physical progress		
g) Expected time to complete		
h) Cost to complete		
i) Material requirements (e.g. for the next reporting period)		
j) Change orders report		
k) Claim for extras		
l) Quality of work		
m) Site problems report		

Centre for Building Studies
Centre des études sur le bâtiment

IV. CAUSES OF DELAY AND COST OVERRUNS

18. Listed below are several factors which can cause construction delays, and which the contractor can exert some control over. Please indicate the degree of significance of each factor in terms of its cause for time delays on YOUR projects. Note that factors such as force majeur, delay of drawings, etc. are not included, as they are regarded as being completely beyond the control of the contractor.

FACTORS	DEGREE OF SIGNIFICANCE			
	VERY CONSIDERABLE	CONSIDERABLE	MINOR	NOT SIGNIFICANT OR N/A
1. Late deliveries of materials by suppliers				
2. Temporary material shortages in the market, especially for continuously supplied materials (sand, cement, etc.)				
3. Low labour productivity				
4. Labour absenteeism				
5. Labour turnover				
6. Labour relations problems				
7. Lack of overall plan for execution of project				
8. Insufficient detail in project plan				
9. Duration of activities underestimated				
10. Equipment and labour requirements underestimated				
11. Schedules not updated frequently enough to identify problem areas				
12. Lack of accurate data on job progress				
13. Delays by subcontractors				
14. Problems in co-ordination of subcontractors				
15. Equipment breakdown				
16. Problems with access to the site				
17. Errors in drawings				
18. Construction errors				
19. Inspection or supervision problems				
20. Sample approval procedure				
21. Lack of an effective tool for forecasting time to complete				

Centre for Building Studies
Centre des études sur le bâtiment

18. (cont'd.)

FACTORS	DEGREE OF SIGNIFICANCE			
	VERY CONSIDERABLE	CONSIDERABLE	MINOR	NOT SIGNIFICANT OR N/A
22. Other factors (please specify)				
_____	____	____	____	____
_____	____	____	____	____
_____	____	____	____	____
_____	____	____	____	____

19. Please rank in order of significance (most significant first) the five most important factors which cause construction delays in your projects.

1. _____
2. _____
3. _____
4. _____
5. _____

20. Listed below are several factors which can cause cost overruns, and over which the contractor can exert some control. Please indicate the extent to which each of the factors results in cost overruns. Note that some factors are not included here, as they are regarded as being completely beyond the control of the contractor.

FACTORS	DEGREE OF SIGNIFICANCE			
	VERY CONSIDERABLE	CONSIDERABLE	MINOR	NOT SIGNIFICANT OR N/A
1. Delay caused by labour shortages in certain trades	____	____	____	____
2. Delay caused by late delivery of materials	____	____	____	____
3. Delay caused by sub-contractors	____	____	____	____
4. High rates of material wastage on site	____	____	____	____
5. Material loss or theft	____	____	____	____
6. Low labour productivity	____	____	____	____
7. Labour turnover	____	____	____	____
8. Labour relations problems	____	____	____	____
9. Labour costs underestimated	____	____	____	____

Centre for Building Studies
Centre des etudes sur le bâtiment

20. (cont'd.)

FACTORS	DEGREE OF SIGNIFICANCE			
	VERY CONSIDERABLE	CONSIDERABLE	MINOR	NOT SIGNIFINANT OR N/A
10. Material costs underestimated				
11. Equipment costs underestimated				
12. General conditions underestimated				
13. Financing charges underestimated				
14. Unexpected escalation of labour wages				
15. Unexpected escalation of material prices				
16. Unexpected increase in interest rates				
17. Subcontractor co-ordination problems				
18. Equipment breakdown				
19. Errors in drawings				
20. Ambiguity of specifications or drawings which result in an inaccurate cost estimate				
21. Construction errors				
22. Inadequate quality control				
23. Inspection or supervision problems				
24. Lack of documentation of claims				
25. Inaccurate assignment of manhours and equipment hours to cost codes				
26. The lack of effective tools for forecasting cost and time to complete				
27. Other factors (please specify)				
_____				
_____				
_____				

21. Please rank in order of significance (most significant first) the five most important factors which cause cost overruns in your projects.

1. _____
2. _____
3. _____
4. _____
5. _____