DECISION MODEL FOR A CONSTRUCTION CONTRACTOR TO DEVELOP OR BUY COST CONTROL SOFTWARE

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Decision Model for a Construction Contractor to Develop or Buy a Cost Control Software

PROJECT

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by

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ABSTRACT

Construction contractors are increasingly using computer data processing on their projects. The practice of purchasing or leasing software and the alternative of in-house development of suitable software exists concurrently among construction contractors. Adequate attention is not given to the selection of the most beneficial mode for acquiring software. This project develops a systematic decision approach to select the mode of software acquisition.

This systematic decision approach delineates the controllable variables and the states of nature. Relative weightage is assigned to the variables, and importance rating is assigned to the states of nature. From the outcomes of the interactions between controllable variables and the states of nature, the expected value of each alternative is determined, and the one with maximum expected value is selected. This gives the most economical acquisition mode of software required by a construction contractor.

The decision process can be used either as a rigorous methodology or to improve the quality of intuitive decisions by ensuring that all the variables are given due consideration.

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CHAPTER I

PROBLEM DEFINITION

Construction projects are increasing in size, intricacy and monetary value. The requirement of integrated, unified and comprehensive planning, monitoring and transmitting of information to management has become crucial. The rise in capital cost has made month-to-month cashflow forecast mandatory to prevent a block of money being committed for an unwarranted length of time, and thereby utilizing that resource to its ultimate. This applies equally to all other resources. The need to optimize the use of resources has made planning and monitoring aids so important that they mean the difference between the survival and non-survival of virtually any construction contractor.

CPM[1] based networking technique is a basic planning tool in modern construction projects and the majority of construction firms use the computer for CPM network analysis. The computer has greatly simplified planning and scheduling, resource allocation, cost control, cashflow forecast, monitoring and communication of pertinent information to management. Besides speeding up normal problem solving, problems that are virtually unsolvable can be tackled. The computer also provides early warnings of faults or potential problems in control procedures, leading to indeterminable but important savings.

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[1]H.N. Ahuja, Construction Performance Control by Networks, St. John's, Newfoundland, Canada, January 1976.

The command to the computer is the program. It makes data supplied to the computer meaningful. With effort, almost any problem can be solved by a custom-made computer program. The development of diversified software has enlarged computer use and capacity.

Software development is a continuous and never ending process which is very expensive in terms of money, time and labor. At present, although so many different types of computer programs exist in every field, many organizations and construction contractors are writing their own specialized programs. Independent development of specialized software ignores the use of existing programs and increases their obsolescence. Then why not use existing programs? Whether a contractor should buy or develop a program is still an unsettled issue. The aim of this project report is to answer the question whether it is justifiable to buy a ready-made software package or develop in-house an entirely new program. Cost analysis of ready-made software versus an in-house development is necessary. A better appreciation of the problem can be achieved as the various aspects of the problem are described. These are:

1.1 Contractor's Objectives

1.2 Diversity of Software Needs

1.3 Cost Control Softwares in Construction

1.4 Cost of Acquiring Software

1.5 State of Art

1.6 Lack in the Environment

1.7 Statement of the Problem

1.1 CONTRACTOR'S OBJECTIVES

The main concern of a construction contractor is to meet the challenges of increasing costs, declining profits and increasing competition. The significance of profit maximization and cost minimization is so much for the contractor to be operative and progressive, that even his survival in the business is constantly challenged by the increasing expenditure and declining mark-up. Therefore, speed and economy in every operation become the inevitable objectives of a construction contractor. A computer-based cost control system ensures both speed and economy and therefore becomes important in any project.

A computer program that is economical to run, easy to modify, is fast, accurate, easily manageable and which is obtainable at a reasonable cost can serve a contractor's cost control objectives best. The cost control objectives of a construction contractor are perceived by the set of questions summarized in Appendix A.

1.2 DIVERSITY OF SOFTWARE NEEDS

Data processing systems are being used for planning and scheduling of projects, resource allocation and leveling, estimating, cost control and cashflow forecast, payroll, accounting and auditing, material expediting and inventory control, and for various other operations within the context of management aids. Nor does it end there. Various computer programs aid in structural analysis, surveying calculations, specification writing and other specialized areas.

Unfortunately, these applications are mainly isolated tools and are useful at only one stage of a project. As a result, many contractors cannot afford the equipment or specialized manpower needed for computer processing of these special functions. With many construction contractors geared to operate within a conventional manual framework, they find that the benefits derived from mechanization of merely one function are not sufficient to warrant the hiring of trained personnel or education of existing staff. In order to be economical, the data processing applications within the company must be large enough to provide cost savings larger than the expenses incurred.

Furthermore, no two construction projects are alike. Because they differ greatly in size, location, costs and constraints, each project may require a different set of computer applications than the previous projects.

Any uniform system that could meet such a broad range of needs would be so general as to be practically impossible in most cases and would still be insufficient to handle many situations. Another drawback in developing such a system is that construction organizations differ. To be useful a system must be compatible with the methods presently in use in a particular company. Developing a uniform computer system capable of fulfilling the needs of each construction contractor would be almost an impossible task. Finally, such a system would have to be capable of being integrated with present management functions within the various departments of the organization. Again, construction projects are obtained under different types of contracts and the needs under each contract are not the same, which further enhances the

diversity of need for software. This is discussed under different types of contracts in the following section.

1.2.1. Stipulated-Price Contract: Under stipulated-price contract, the contractor agrees to construct a project for a stipulated amount, no matter what difficulty or expense he encounters. The remuneration may be made in a series of partial payments as the work progresses rather than in one final payment after acceptance of the contractor's work. The contractor essentially receives detail drawings and specifications. The immediate need for the contractor is estimating and bid preparation.

i. Estimating and Bid Preparation: Functions of estimating and bid preparation can be broken down into four data processing applications: quantity take-off, pricing, printing and evaluation of changes and alternatives.

Quantity take-off: From the drawings and specifications, the estimator prepares the input to the data processing system in accordance with the format and coding structure specified by software.

Pricing: Pricing or costing is the application of rates to previously determined items of work. The pricing function is often the first estimating function to be automated by a construction contractor. The input generally includes the project number, cost code, estimated quantity, efficiency factor and so on.

Printing: Printing includes the classification, summarization, and preparation of all printed reports for use in estimating.

Evaluation of changes and alternatives: This data processing application relates to any major or minor changes in estimates and creation of new estimates after changes. It can include a facility to evaluate quickly the effects of alternative proposals.

The computer generated estimate is used as the basis for bidding. Once the contractor is awarded the project, the immediate task is its planning and scheduling, a discussion of which follows.

ii. Planning and Scheduling: Planning and scheduling cover the allocation of time and dollars to produce acceptable budgets and schedules for construction of projects. The planning phase involves budgeting time and money. The scheduling phase converts decisions made during planning into a schedule to be implemented by the field force. The construction industry has been a leader in the use of data processing systems to assist planning and scheduling functions. There are at least four different ways in which data processing systems are now being used in the industry to facilitate project planning and scheduling. These are budgeting, scheduling, reports and simulation of alternatives.

Budgeting: The basic function of financial planning is to develop and provide an acceptable budget. An estimate of cost related to time, on approval, becomes a budget. This budget is represented in a data processing system by a file of records containing cost codes, estimated total quantity, unit of measure and estimated unit cost. Information

from the budget is used to compare actual cost and quantity with data reported from the project site to determine how the job is progressing costwise.

Scheduling: For scheduling, the necessary operations are: development of work breakdown structure, network construction, coding of activities, and finally, an analysis to prepare a schedule. The analysis of a network is preferably a computer-based operation which requires the use of a specialized computer program.

Reports: For scheduling and budgeting, it is necessary to obtain the following typical output reports with the information listed against each.

- Schedule report: Activity, its description, duration, start and finish dates and floats. Project network is drawn by using a plotting program.
- Milestone report: Milestone number, description, start and finish dates, and floats.
- Bargraph: Activity schedule plotted against calendar time.
- Resource report: Activity, required resources, start and finish dates and available resources.
- Work status and progress report: Once the project is underway, the schedule must be constantly reviewed and analysed in view of accomplishment and modification. Project management must remain informed of job status throughout the life of the project. Therefore, periodical progress reporting and updating of the project are necessary and any computer program should have this capability.

Data reported on a work and progress report include activity description, remaining duration, percent completion and start and finish dates.

- Exception report: The principle is that exceptional situations are specifically pointed out to management and normal situations are passed over. One method is to point out only items in progress or which are likely to commence within a specified period. Another method is to point out only the specific items for management action. Information can be critical items that should have been started but were not started, and critical items that should have been completed but were not completed.

Simulation of alternatives: Project scheduling using CPM on a data processing system, provides construction management with a tool to evaluate readily the effectiveness of proposed alternatives. A construction contractor can in effect simulate suggested changes in network sequence and, in short order, be aware of the results of such changes.

iii. Project Cost Control: The objectives of cost control are:

- to provide management with timely information concerning the relationship of actual cost to budgeted cost;
- through the accumulation of cost information, to provide current performance information to be used in future estimates.

These objectives are fulfilled by the following reports:

Labor cost performance report: These are manhour schedule, payroll and labor productivity reports. These reports help in improving and maintaining labor productivity and assist in monitoring labor cost.

Equipment cost report: Cost keeping of construction equipment, particularly in heavy construction, constitutes an important application area for a data processing system. Because of the large investment in equipment, contractors emphasize record keeping on data processing machines. A sound equipment management system requires a record of depreciation, maintenance charges and fuel consumption, scheduling of preventive maintenance, comparative analysis of productive and repair time, and evaluation of operating and repair rates.

Material cost report: A data processing system combines the related functions of paying for material and controlling its use. Maintenance of project inventories can be performed and tied directly into the material requirement aspect of the planning and scheduling system. Comparative analysis of actual material cost to budgeted cost is performed and deviations are noted. An extension of material costing activity and accounts payable application provide information to management for progress billing of on-site material.

Sub-contractor cost report: A significant part of the total cost for a project may be represented by charges for work which is sub-

contracted. When the progress claim of a sub-contractor is received and approved by the project manager, the documents enter into an accounts payable system. The dollar amounts are coded to cost classification set up in the job budget. Sub-contractor cost distribution records are processed against the job cost file to update the actual cost and to be reflected in the monthly financial statement for the project. Management is provided information that shows the remaining balance of sub-contract cost. Tied into the project schedule this information is used for cashflow projections.

Overhead cost report: Because of day to day operations including office expenses, management and engineering expenses, taxes, insurance, and so on, the overhead or direct cost is unavoidable. Depending upon the volume of the construction business, these expenses are quite significant and proper cost control is essential. Computerized payroll, accounting and auditing can reduce the contractor's overhead considerably.

Scope changes: The contractor uses data processing to estimate and monitor his costs due to owner imposed alterations.

Progress claim: The contractor prepares progress claims, the engineer certifies them and the owner makes the payment. The contractor uses a data processing system for his progress claim preparation.

Apart from these, a contractor has to exercise control over his contingency funds, escalation, interest on his bank loans, and so on, and he needs a computer program for these. However, the data processing needs are not similar under all types of contract, for example, cost-plus or management contracts which are discussed next, do have certain other needs.

1.2.2. Cost-plus Contract: On a cost-plus contract, the contractor agrees to construct a project for the actual cost of material, labor, and equipment plus a fee. Under this contract, the contractor is often involved prior to completion of contract documents to coordinate the overlap between design and construction.

Sometimes the contractor estimates and submits a guaranteed maximum price. He is also responsible for planning and scheduling of the project and resource allocation in a manner similar to a stipulated price contract. The contractor submits the actual expenditure on manpower, equipment, material, and overhead cost by periodical statements. These periodical statements on labor, materials, and equipment should comply with owner imposed auditing system. Therefore, computer software is needed for estimating, scheduling, resource allocation and job-site reporting of actual labor, material and equipment expenses.

1.2.3. Management Contract: Sometimes a construction contractor is successful in obtaining a project under a management contract. Management contracts are of two types—project management contract and construction management contract.

i. Project management contract: The project manager who is hired by an owner is the sole project administrator. In turn he hires the services of architects, engineers and other consultants. The initiation of policy, programming and planning, budgeting, and design to completion of project are controlled by a team of professionals under the direction of the project manager. Tender and construction documents are produced by the project manager's staff who ensures that the intent of these documents is followed by the contractor. His staff prepares an estimate, calls tenders, prepares network and project schedule, performs resource allocation, cost control and auditing. Computer programs help perform these functions for which the project manager is responsible.

ii. Construction management contract: Sometimes the contractor obtains a project under a construction management contract. This type of contract allows the owner to exercise control over the project through a construction manager, design being separately entrusted to a design engineer. The construction manager is experienced in construction, supervises activities relating to scheduling, estimating, value analysis, cost control, cashflow forecasting, contract interfacing, quality control and similar construction related matters. He provides construction related input to designers, general directions to contractors on the projects, as well as progress reporting to the owner during construction. Construction equipment and material contracts are between the contractor and the owner. Computer programs are helpful in estimating, scheduling, resource allocation and cost control of the

project.

In view of the diverse software needs of a contractor, there is obviously no one single program that meets all requirements. Since the scope of the project discussed in this report is confined to consideration of cost control software needed by a contractor, further discussion relates to this topic only; computer programs needed for other functions such as surveying, dredging and so on are excluded.

1.3 COST CONTROL SOFTWARE IN CONSTRUCTION

Cost control software being used in construction can be classified into general programs and special programs.

General programs can perform all types of cost control operations from planning to completion of project. One such program is Project Management System (PMS) IV which for cost control purposes is used in project scheduling, resource allocation, cost processing and output reporting. Some other similar programs are listed in Appendix B. Any of these programs serves as a useful tool for planning, monitoring, and communicating relevant information to management as a feedback system for possible control measures. These programs are fast, simple, large and multi-purpose, capable of addition, subtraction, simplification and modification. Simple coding and data manipulation, quick error detection and elimination are some other characteristics of these programs. Most of the programs are available for lease, rent or purchase at a reasonable price.

Specific programs are good for cost control purposes only at one stage of the project, for example an estimating program. Some of these specific programs are listed in Appendix C. These specific programs are good for only one particular function and require a limited storage capacity. Such programs are comparatively inflexible and present difficulty to add to, delete from, modify and simplify. Thus they are unadaptable for broader usage. Each of these programs is developed for the solution of a specific problem. Some of them are not proprietary and are not leasable. Because of the large and complex nature of modern projects, it sometimes is necessary in a single project to use a series of specific programs.

The other matters of concern relating to cost control software are the sources of software and hardware, a discussion of which follows.

1.3.1. Software Sources: Computer programs can be created by or obtained from five possible sources: firms specializing in program development; developers of package programs; moonlighters; manufacturers of construction equipment; and the contractor's own staff.

i. Firms specializing in program development: These are firms who specialize in creating programs. Some of them are part of a computer manufacturing company. Most of them are consulting firms who provide these services. They develop software but most of them are not knowledgeable in construction, particularly in the heavy construction field. Therefore, much of the work has to be done by the contractor's staff.

ii. Developers of package programs: These programs are developed by universities, professional societies, or by computer manufacturers who have established programming libraries over a period of time and make them available to their customers with or without charge. Another source of these programs is the various groups of computer users that have banded together to establish a library for joint use. Manufacturers naturally develop these package programs for obvious market reasons.

iii. Moonlighters: They generally are engineers working for colleges or highway departments who have become interested in programming and do it as an avocation. This could be a good way to start developing programs but it is not satisfactory for either party on a permanent basis. The programmer is at a disadvantage because as he develops programs, the contractor might change the system requirement or may decide to employ full time staff. The programmer is not sure just what is really required by the contractor and what can be counted upon.

iv. Manufacturers of construction equipment: Many manufacturers of heavy, automated type equipment have developed programs to evaluate the performance of different types of equipment.

v. Programs developed by contractor's own staff: The ultimate alternative for a contractor is to develop programs by his own programmers, engineers and estimators. This seems to be the best alternative if it is economical. Again, a significant portion of

software development is the cost of computer hardware. The option to select ready-made software from the market or to develop in-house is appreciably influenced by hardware selection as discussed here.

1.3.2. Hardware Sources: Obviously there is an economic limitation as to what can be spent on a computer. At the present time there are two alternatives for making use of what is presently available within practical economic limits. These are, the contractor's own computer facility, and the facility of a service bureau.

i. The contractor's own computer facility: A contractor can own or lease three types of computers. The first is the relatively high cost and high speed computer. The second type is low cost, and low speed principally oriented for engineering purposes. Both of these are punch-card oriented, and will therefore usually require raw input data to be transcribed in a punch-card entry format which is set by the software. The third kind is the micro-computer, which can be high or low speed but with less storage capacity.

ii. The facilities of a service bureau: The facilities of a service bureau can offer almost anything. It can make available the largest computers as well as provide a portion of a large computer. The contractor can share the use of these computers with others, and communications with it can be achieved through a terminal similar to a typewriter and located in the contractor's

office. For high speed and high cost computers, the speed is about 1000 lines per minute and lease cost would be between $1000-$5000 a month.[2] Use of the facility can become more economical if the contractor has besides project cost control a computerized payroll, accounting, auditing and inventory system, as well as use for it in other engineering applications.

The service bureau can provide an engineering type of computer which is slower - about 10-30 percent of the speed of a commercial computer. The service bureau can even provide the software necessary but such programs are written for commercial purposes. The contractor can use either of these facilities or both on an hourly rental basis. The computer can be located in a different town or in a separate building. The remote teletype terminal even eliminates the use of a data deck. Once the sources of software and hardware are known, the next requirement is to analyse the cost of acquiring software. This is now discussed.

1.4 COST OF ACQUIRING SOFTWARE

Table 1.1 describes the cost of leasing, renting and purchasing package programs. It is observed that the present worth of buying a software package is much less than that of leasing or renting. Further investigation in this research is limited to buying a software

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[2] W. Myers, Software Productivity, Quality and Cost: All Up. Computer, Dec., 1977.

TABLE 1.1. COST OF PROGRAMS* (YEAR 1975)

NO.	NAME OF PROGRAM	COST (U.S. DOLLAR) PURCHASE	RENT/LEASE
1.	CAS/CPA/FMR	17000	-
2.	CONTROL/IMS	-	5000/year
3.	CPM/RPSM-Critical Path Method/Resource Planning and Scheduling Method	22000	625/month
4.	CPMIS-CPM based Management Information System	15000	300/month
5.	EMS-Equipment Management System	10000	400/month
6.	EZPERT-Easy Pert	32000	1280/month
7.	FASTNET-Fast Network	0.05/activity	0/03/activity
8.	GASP IV-General Activity Simulation	-	7500 + 200/m
9.	JARS	6000	-
10.	NPSCP-Network Project Scheduling Program	24000	1500/year
11.	PAC II	17800	-
12.	PERT 6	12400	500/month
13.	PRIDE-Profitable Information by Design	75000	-
14.	PROCON	12500	1.50/report
15.	PROJECT/2	-	250/month
16.	PROMIS/RAM	5000	150/month
17.	PROMIS/TIME	5000	150/month
18.	PMS-Project Management System	90000	496/month
19.	SPACE-BANK	3000	10 + 0.50/
		20000 includes computer also	-
20.	T/A Series CPM Program	18000	7000/year

* PMI, Computer Software Survey, Drexel Hill, Pa., 1975.

package. Another fact is that the cost of leasing or renting a special program varies and in some cases is higher than leasing a general program. On the other hand, program writing and debugging cost time and money. The cost of programming expertise is extremely high as compared to mechanical computing. The cost of programming for large projects now appears to be averaging about $120 per instruction as compared to fully debugged and documented instruction averaged at $15-$20 previously, both within International Business Machines (IBM) and elsewhere.

Table 1.2 provides the actual development cost for single and multi-step special programs. The table indicates that the cost of a single step special program is higher in terms of manhour and computer time per card than that of a multi-step iterative program.

Besides financial restraints,[3] there are other factors deserving consideration in this context, such as:

i. To develop a program in-house, it takes generally from a few months to several years and is often subject to serious delays, whereas package programs can usually be installed and made operational within a week or a few days.

ii. The cost of in-house development is almost impossible to predict accurately and is often seriously underestimated, whereas package programs are offered at a fixed or negotiated price.

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[3]Datapro Research Corporation, Datapro 70, Buyer's Bible, Delran, New Jersey, 1977.

TABLE 1.2 DEVELOPMENT COSTS FOR SINGLE AND MULTI-STEP PROGRAMS[4] (YEAR 1976)

ITEMS	PROGRAM NAME	NO. OF CARDS	PROGRAM TYPE	MAN-TIME SPENT (DAYS)		COMPUTER COST ($)	
				TOTAL	/CARD	TOTAL	/CARD
1	Space Frame	1020	Multi	49	0.048	-	-
2	Section Property	380	Single	20	0.053	-	-
3	Concrete Est.	2520	Multi	30	0.012	1300	0.52
4	Concrete Slab	8080	Multi	45	0.006	2700	0.33
5	CISC - 1	2970	Multi	54	0.018	480	0.16
6	CISC - 2	2810	Multi	28	0.010	1130	0.40
7	Geometry Gen.	3500	Multi	63	0.018	5000	1.43
8	Load Cases	1800	Multi	24	0.013	1500	0.83
9	Dome Geometry	100	Single	5	0.050	100	1.00
10	Mesh-Plotter	1800	Multi	14	0.008	500	0.28
11	Moment Plotter	200	Single	5	0.025	60	0.30
12	Finite Element Analysis	9000	Multi	500	0.055	5500	0.59
13	Column Stack Design	7600	Multi	93	0.012	5800	0.76

[4]Chris M. Szalwinski, Specialized Computer Program Development-Expectation and Costs. Ontario, Canada, presented at the Annual Conference of Engineering Institute of Canada held at Halifax, 1976.

iii. Some in-house development efforts never reach completion, for a variety of reasons, whereas package programs are usually a known quantity.

iv. Comprehensive documentation, often sadly neglected on in-house projects, can be demanded as a prerequisite when purchasing most packages. There may be considerable resistance in both management and technical circles to the idea of purchasing applicable software from outside sources. However, this can easily be overcome by stressing the clear-cut economic advantages and the fact that the in-house staff will be relieved of the need to program mundane, commonplace applications and be free to work on more unconventional and challenging aspects of projects.

In spite of the difficulties associated with in-house development, some contractors are still found developing programs because of circumstances discussed in the following section.

1.5 STATE OF ART

Presently, as related to the use of computer data processing, construction contractors can be divided into three groups. The first is contractors who deal in large projects and are regular users of computer data processing systems. They depend considerably on data processing as an efficient tool to aid management in planning and control. These contractors become quite efficient in computer applications and usually have in-house programming personnel. As they grow and encounter new problems, they engage in developing computer

programs pertinent to their specific needs. The development process is continuous and as a result they constantly develop numerous small programs, and gradually link them together into a mammoth general program.

The second group on the other hand, contractors dealing in small projects, depend mostly on manual data processing. But as they expand they find manual data processing tedious, slow and prone to errors. They realize the usefulness of an electronic assistant, the computer. Naturally they get interested in it and start using some proprietary software, but because of inherent human instinct they start believing that their problems are special, and that existing ready-made programs are complex. Consequently they get involved in developing in-house new computer programs.

Initially each small contractor starts with a specific program for minor application. However, in due course the manifold demands of his organization, the diversity of projects and the variety of contractual needs, forces him to commit his resources at an increasing rate. He also keeps adding and expanding. Gradually the specific program becomes larger, more complex, and comparatively general. Finally, he ends up with a general program which he could have obtained in the first instance as a canned package. This is how new programs are being continuously added to the list of existing programs.

The third group of contractors deal in very small projects and their business being very small does not warrant the use of computer data processing. They depend mostly on manual data handling.

At the most they use a ready-made package program and never develop any sort of in-house computer program for their use.

Proliferation of new program development exists in all industries, perhaps in a similar manner as described here for the construction industry. The estimate[5] of the overall cost of software development and maintenance in the United States ranges from 15 to 25 billion dollars.

The following developments in software technology are some of the other reasons that attract contractors to develop their own programs.

-Software productivity is improving at a rate of 3-7% (20% at IBM).[5]

-The software/hardware ratio is 7:1 costwise.[5]

-Programming quality once in the area of 34-35 errors per 1000 lines of code has dropped to about 0.6 errors per 1000 lines of code.[6]

-The maintenance ratio for existing programs is 75-80%.[5]

-Modern programming practices are very efficient.[5]

Further, some contractors are specialty contractors and deal in only one particular field, for example fabricating prestressed beams. Such contractors believe that their needs are special, existing programs

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[5]W. Myers, The Need for Software Engineering, Computer, February, 1978.

[6]W. Myers, Software Productivity, Quality and Cost: All Up. Computer, Dec., 1977.

are too general, complex and difficult to use. They like to develop programs that are simple, easy, fast, appropriate, accurate, time and cost saving. The other areas of interest to them are payroll, accounting, bookkeeping, auditing and inventory control. Some of them aim at prestige associated with being progressive in computer applications.

However, the decision to buy ready-made software or to develop a specific program is not based on sound economic criteria. It is characterized by a gradual drift toward specific software development. There is a lack in the construction industry environment of a suitable methodology to aid in making any strategic decision on the software make-or-buy issue.

1.6 THE NEED FOR A DECISION MODEL

There exists a need for a methodology that can assist a contractor in selecting a software buy or develop mode. There is a need for a decision model that will result in economy for the contractor.

There are many factors that will have direct bearing on a contractor's decision to buy or develop a computer program. The system should be comprehensive and easy to use, and harness computer power to the task of helping the contractor do a better job economically. Questions of economy, budget, and system flexibility are priorities. So there is a need to optimize every factor, for efficiency of the decision model. Therefore, if there exists an optimized model for decision simulation, taking into account causes and constraints, the decision making body, management, can easily handle the issue; management can confidently buy

software or engage in in-house development.

1.7 STATEMENT OF THE PROBLEM

The needs of construction contractors for diversified projects and different types of contracts vary. In spite of profuseness of ready-made software for the construction industry, high developing and debugging cost as well as many other constraints, both small and large firms have become involved in in-house software development. There is no evidence of a sound economic decision strategy. Therefore, there is need for a methodology to improve the quality of a contractor's decision to develop or buy computer software. The problem is to help the construction contractor's decision making process in selecting software acquisition mode. The variables that influence this decision need to be delineated so they can be incorporated in a decision methodology or considered to improve the quality of contractor's intuitive decision.

CHAPTER II

VARIABLES

This chapter lists and describes the variables which affect the decision for software acquisition mode. Some of these variables which are uncontrollable are called states of nature; other variables are listed as controllable variables. The inputs and outputs of the decision model are described in the chapter.

The states of nature and controllable variables that are described in the following pages are assigned alphabetic symbols which are used later in Chapter III.

2.1 STATES OF NATURE

The following variables being for a major part uncontrollable by the contractor are classified as the states of nature for the decision model.

2.1.1. Financial Capability and Volume of Business (A)

2.1.2. Company Clientele (B)

2.1.3. Contractual Needs (C)

2.1.4. Additional Projects (D)

2.1.5. Uncertainties (E)

2.1.6. Hardware Availability (F)

2.1.7. Life Span of Software (G)

2.1.1. Financial Capability and Volume of Business (A): Financial capability denotes the availability of capital to a construction contractor, and volume of business indicates the number and size of projects the contractor can build simultaneously.

Construction contractors can be classified into three classes - small, medium and large. The contractors with capital of one hundred thousand, one million and more than one million dollars are considered to be small, medium and large contractors respectively. Then again, there are general contractors and specialty contractors. The general contractors are those who are responsible for and coordinate all aspects of a project. The specialty contractors only deal in one aspect of a project and are usually subcontractors.

A decision on software 'develop or buy' is neatly tied with the contractor's financial capability and volume of business. If the contractor is financially capable and has a large volume of growing business, once he is convinced of the need for a computer program he will be much inclined to develop it in-house rather than buy it from others. On the other hand, if the contractor's financial capability and volume of business are small, he would rather buy ready-made software if needed.

2.1.2. Company Clientele (B): Company clientele refer to the owners of company projects. If the owner of a project is a government department, a bank, or a trust company, it will prefer a contractor who is running his business efficiently, which includes efficiency in data processing by computers. This is because these

public bodies are convinced of the benefits of computer data processing and use it for their own business. Such clientele would like the contractor to submit schedule reports, progress claims and expediting reports generated by the computer. If the client is an individual who is not used to computer reports, he may not insist on computer usage. Thus the type of clientele exerts some influence on the contractor's decision to use a computer in his business.

2.1.3. Contractual Needs (C): A contractor does not always obtain projects under a signular type of contract; he accepts any contract that looks promising. Under different types of contracts, the contractor needs to process his data in different ways and present reports to satisfy a client's needs as per his contract. Many proprietary software can process data and generate reports suitable for certain contract types but not for all of them. Therefore, the contractor's decision on software acquisition should correspond with his contractual needs.

2.1.4. Additional Projects (D): This pertains to his expectation of obtaining additional projects providing there is an opportunity for use of software and is based on market trend, political and other influences. To a large degree, the nature, size, and complexity of a project determine the extent to which computer programs are used. The versatility of software, so that it can be used on projects of varying size and complexity that a contractor expects to perform in the future, is a desirable feature which must be considered in deciding the mode of software acquisition.

2.1.5. Uncertainties (E): In-house software development projects generally take from a few months to several years to complete, and are often subject to serious delays.

The cost of in-house softward development is almost impossible to predict accurately and is often seriously underestimated. Similar uncertainties exist over expertise requirements and some in-house development efforts never reach completion. Further, there is no guarantee of quality. Not being in the software development business, the contractor does not have much control over these uncertainties. Their consideration is necessary in software acquisition decision.

2.1.6. Hardware Availability (F): This includes the computer size, type, its memory and its peripheral devices such as printer, plotter and so on. The selection of software acquisition mode also depends on the ownership and location of the computer facilities. Does the contractor have his own computer or does he have access to a terminal? Must he use the computer in time sharing mode via a teletype or use cards in batch processing? The software which is compatible with the hardware facilities available to him must suit his needs unless he can afford to buy computer hardware to match computer software, which does not seem to be a prudent policy. He does not have any influence over the computer hardware market, he is only a user of the facilities.

2.1.7. Life Span of Software (G): The advancement of computer technology renders many computer programs uneconomical to run. The life span of software indicates the length of time that a certain program will continue to be useful for the contractor's purposes from an economic point of view, and therefore the length of time allowed to amortise the capital cost of the program. The economic life is predicted considering the influence of technical obsolescence of computer hardware. If a contractor has developed his own computer program which he runs in time sharing mode on a computer, his program may become useless if the computer data processing centre decides to change its hardware. Also, if he is using an old computer program which is not modified to take advantage of the new hardware capabilities, his computer processing becomes uneconomical. It is therefore necessary to consider the life span of a program in selecting the software acquisition mode.

2.2 CONTROLLABLE VARIABLES

The following factors are considered to be the controllable variables:

2.2.1. Company Investment Strategy (H)

2.2.2. Company Prestige Factor (I)

2.2.3. Company Organization Structure (J)

2.2.4. Project Needs (K)

2.2.5. Other Needs (L)

2.2.6. Software Operational Characteristics (M)

2.2.7. Software Facility and Capacity (N)

2.2.8. Software Legal Aspects (V)

2.2.9. Software Purchase Cost (P)

2.2.10. Software Development Cost (Q)

2.2.11. Software Maintenance Cost (R)

2.2.12. Overhead Expenses (S)

2.2.13. Time Factor (T)

2.2.14. Expertise Requirements (U)

2.2.1. Company Investment Strategy (H): This is the policy adopted by the contractor to optimize the use of his company resources. Each contractor has a 'line of credit' and consequently, a maximum of available investment capital. The maximum investment is distributed over all projects of the company and therefore only the surplus capital if any, after meeting the capital and operating needs of the projects, is available to meet other needs. If funds are available, the contractor develops policy for their investment.

A contractor with large unutilized funds may like to develop his own programs. Others with cashflow problems may like to purchase or rent the services required.

2.2.2. Company Prestige Factor (I): It is recognized that a contractor may wish to own a sophisticated computer or a specialized construction equipment unit, employ a reputed project manager or even complete a project before its stipulated completion date for reasons of prestige, political obligations or continued good business relationship. If this should be the case, his selection of mode of acquisition of a computer program will certainly be affected by his desire for prestige, even to a disregard for cost.

2.2.3. Company Organization Structure (J): The construction organization is a system in which men, machines and money are deliberately combined for the accomplishment of the contractor's objectives. Initially the contractor starts with a very small organization which may be run on an owner-operator or partnership basis. At some point a partnership company becomes a corporation. With further growth, the company organization structure changes from a simple line and staff to a very complex matrix organization. But because of complexity, huge size, and the distance of projects from the company headquarters, the original communication channels become very inefficient and the contractor has to consider the introduction of a computer aided information flow system. If it is decided to develop software internally, a question arises - whether there should be a separate programming department or should the programming functions

be absorbed in any of the existing departments as a new section? How should this additional department or section function in the whole organization of the contractor? In this way the contractor's organization is first responsible for the decision to acquire a computerized information flow system and then its own structure is influenced by the decision to buy or develop the software.

2.2.4. Project Needs (K): The contractor usually starts with one type of project but the market situation, government regulations and company strategy for diversification make it necessary for him at some stage to do other types of projects also. There may be many types of projects but the most common ones are:

i. Dams, canals and hydro-electric work
ii. Highways and railroads
iii. Tunnels
iv. Bridges
v. Piers, jetties, and breakwaters
vi. Airports
vii. Pipelines and pumping stations
viii. Water and sewer lines, sewerage plants, and other more sophisticated antipollution installations
ix. Atomic plants, missile launching pads, tracking stations and other military installation.

Some projects have special data processing needs. For instance a simulation program can be very beneficial for a tunneling project, or a program to calculate cut and fill volumes of earthwork can be

very useful for road construction contractors. In general, proprietary programs are written for specific construction environment and are therefore not suitable for meeting all the needs of a contractor. This fact doubtlessly has an influence on a contractor's decision to buy or develop his own software.

2.2.5. Other Needs (L): Computerization of payroll, accounting and bookkeeping, auditing and inventory control enable a contractor to get the routine work in his business performed more efficiently. Sooner or later every contractor has to computerize these routine functions. Whatever programs he decides to use for construction cost control, they must have the capability to be interfaced with these general business programs for efficiency in data handling. The interface capability is therefore an important factor that influences his decision to buy or develop a program.

2.2.6. Software Operational Characteristics (M): The operational characteristics are important factors to be considered in deciding whether or not to buy a proprietary program package. These are:

i. Simplicity: The system must be relatively easy to install and operate. The input data should be easy to operate and output reports must be understandable.

ii. Flexibility: The system must provide allowance for the retrieval of non-standard reports, either through a defined report generator or by additional programming. It must have the ability to interface different projects. It should be flexible for modification. It is desirable, as well, to allow for variable combinations of input

parameters for flexibility in output reporting format.

iii. Reliability: The system should have been fully tested and made free from bugs. It must have a proven record.

iv. Controls: The system must have extensive editing capability for the detection of errors in the input data, and must contain controls which ensure that all input data is accounted for. Sufficient audit trails must be provided as well as restart or recovery procedures.

v. Documentation: Adequate documentation must be supplied with the package for computer operations personnel as well as the user. It must be complete in all respects and readily comprehensible by those who will use it.

vi. Maintainability: The user must have access to programming personnel familiar with the system for the purpose of correcting latent program bugs, as well as for the implementation of any modifications and/or extensions which are deemed necessary.

vii. Capacity: The software must be capable of handling both large and small networks as well as all types of reports necessary.

viii. Efficiency: The program must be written in such a manner as to take advantage of current programming technologies and must make efficient use of computer resources. The operating and file handling procedures must be such as to avoid complications in the computer room and allow for adequate turnaround.

ix. Compatability: The system must allow for interfacing with other financial accounting systems, whether this be done automatically or by manual procedure. In terms of running the system on two or more

separate computers, the programs and files must be compatible from hardware to hardware.

x. Data Base: The data base must contain all the elements necessary to provide management with the desired information reports, but retain historical information relative to cost.

xi. Data Sequencing: The System must provide extensive sorting capabilities which permit the user to produce management reports in any desired sequence.

xii. Cost: The system must be economical in terms of installation and operation.

2.2.7. Software Facility and Capacity (N): This includes the program facilities such as network processing, resource allocation, estimating or cost processing and program capacity pertaining to the number of activities, events, subnets, networks, interfaces and so on, that it can process. A match between his needs and the program facilities and capacity is required which guides his decision in acquiring a program.

2.2.8. Software Legal Aspects (V): When a computer program is acquired from an outside agency, the agency guarantees the successful operation of the program but takes no responsibility when a difficulty arises due to unauthorized changes made by the user. On the other hand, there is no restriction on the changes to a program developed by the contractor's own organization. The in-house developed program is therefore more responsive to his needs without any fear of losing a guarantee.

2.2.9. Software Purchase Cost (P): The capital cost of purchasing at market value a proprietary software package including taxes is one of the most important considerations in making his choice of a program. If the cost is high, he is deterred from buying.

2.2.10. Software Development Cost (Q): This is the capital cost of developing a completely new software in-house. It includes the cost of men, machines and mechanism to develop the program. If the cost is high, he prefers to buy.

2.2.11. Software Maintenance Cost (R): This is the cost of effort including the wages of program operator and analyst during the trial runs, additional runs, error elimination, obtaining successful runs and computer time to make a proprietary program package completely operational. This is essential because a newly developed program is not free from bugs and needs several trial runs to make it operational for the purpose it has been developed.

2.2.12. Overhead Expenses (S): This implies a daily, weekly or monthly fixed cost of non-productive operations. It comprises a pro-rated cost of management and office facilities chargeable to the direct cost of in-house program development.

2.2.13. Time Factor (T): This is the time required to develop the program in-house or alternatively the time required to make a proprietary software package operational and free from bugs. This time should not be later than the time the contractor requires a computer program for a project. Thus a time factor enters the decision process

both from the point of view of the time available and the time required.

2.2.14. Manpower Requirements (U): This refers to the skilled manpower requirement to develop a program in-house or to make a proprietary program package operational. While the manpower required to make a program operational is not very much, manpower requirement in the in-house development of a program is directly related to the program size and complexity. The decision on the mode of software acquisition will certainly be biased toward in-house development, if the required expertise is available within the organization.

2.3. INPUT - OUTPUT

While the system which is the decision model is described in the next chapter, the controllable variables which form the system input and the states of nature with which the input interacts, have been described in this chapter and are illustrated in Figure 2.1. The outcome of the interactions is processed via the decision model to generate the output which is the selection of the most economic mode of software acquisition.

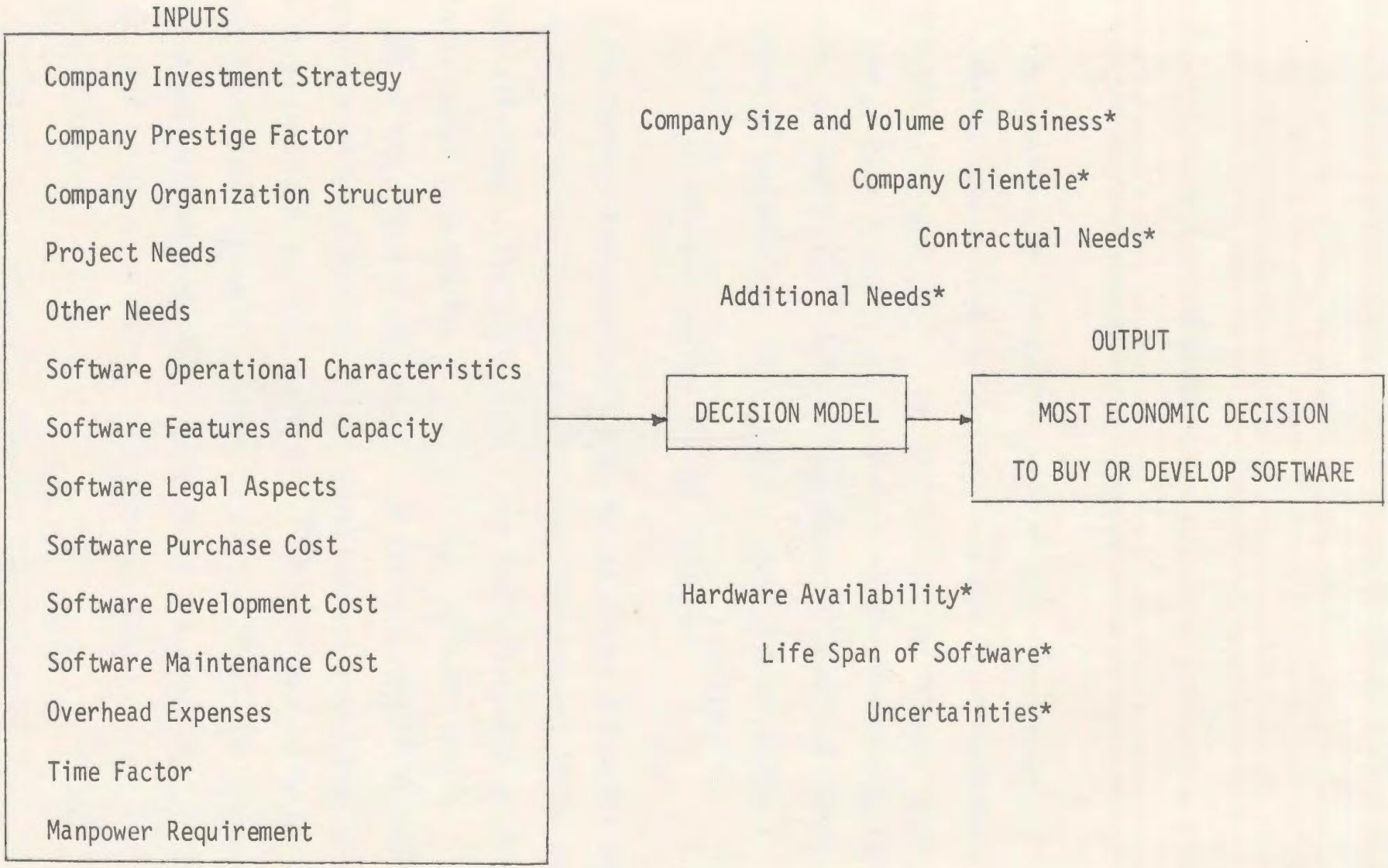


Figure 2.1 Input-Output for the Decision Model

* States of Nature

CHAPTER III

METHOD OF SOLUTION

The problem and variables affecting the software acquisition decision having been presented in Chapters I and II, this chapter describes the solution. First, an overview of the methodology for solving the problem is presented through a Summary Flowchart, then a description of the Detail Flowchart and Decision Matrices follows as a comprehensive methodology for a software acquisition model.

3.1 EXPLANATION OF SUMMARY FLOWCHART

The Summary Flowchart is presented in Figure 3.1 which gives an overview of the methodology used for the decision model. This chart comprises six steps. The first five steps are information gathering operations which form the basis of subsequent decision action. The sixth step is the comparative analysis of costs and physical limitations and selection of software acquisition mode through a decision process for which the methodology is developed. This methodology is a systematic decision approach in which payoff matrices are developed to select the software acquisition mode which is the outcome. The matrices are described by decision rules. A brief explanation of the Summary Flowchart follows.

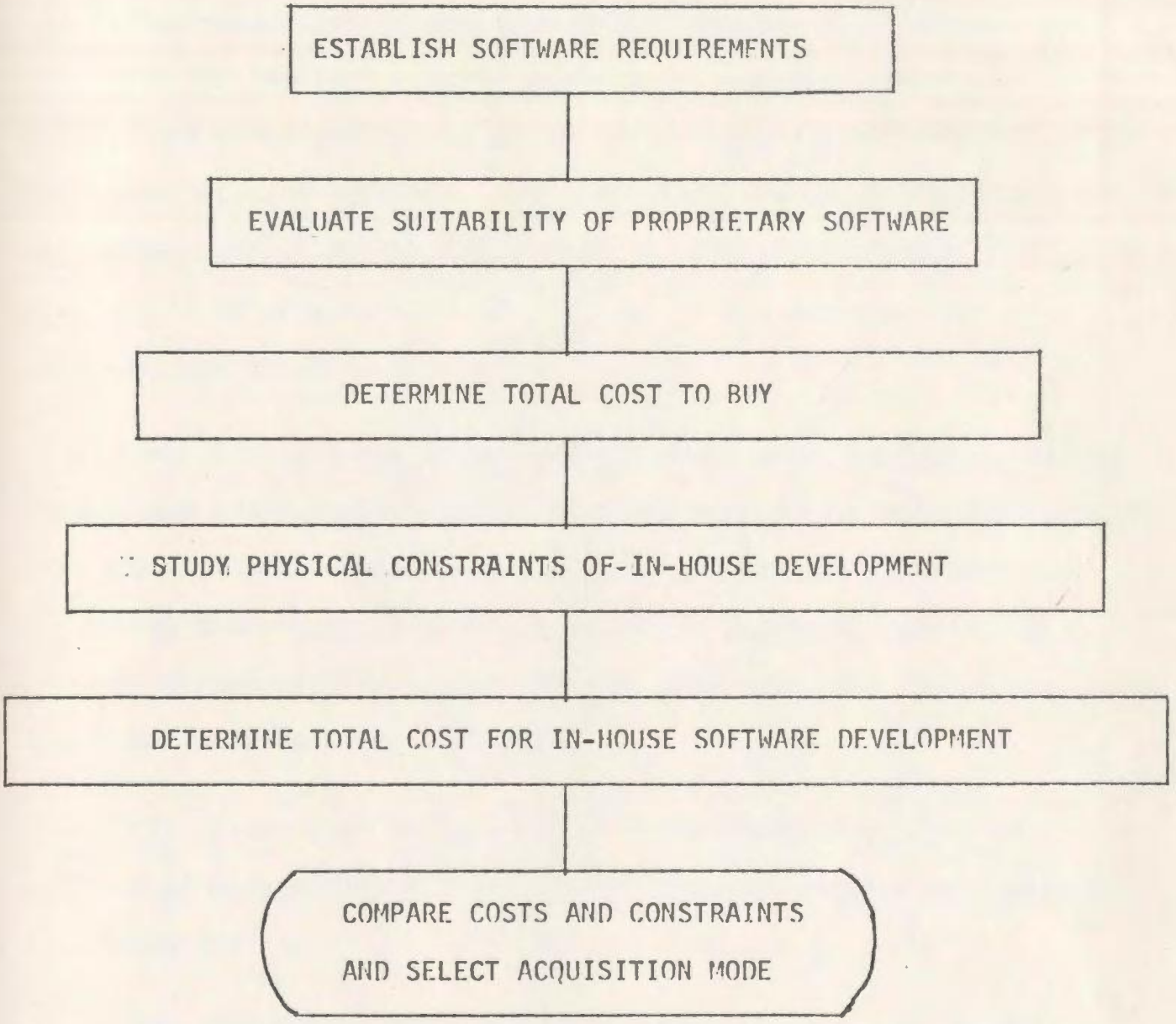


Figure 3.1 Summary Flowchart

i. Establish Software Requirements: These requirements are the basic information to consider before computer application is justified for the contractor's operation. They are established through the consideration of volume of business, types of construction contracts, company clientele, the volume of work related to financial accounting such as payroll, inventory, bookkeeping, auditing and so on, that should be computerized, and company policy such as investment strategy, and prestige factor.

ii. Evaluate the Suitability of Proprietary Software: Having established his software requirements and knowing the various kinds of data processing and reporting, the contractor should look into the functional characteristics of the available programs. Analysing program characteristics in the light of his needs, the contractor can determine their comparative suitability.

iii. Total Cost to Buy: This is the cumulative cost for purchase of proprietary software, sales tax, maintenance and overhead associated with it.

iv. Physical Constraints of In-house Development: Apart from the monetary considerations certain physical considerations are necessary for developing a program in-house. It is very difficult to predict when the program development will actually be complete and how much expertise will be required. Neither can it be stated with certainty whether the program development will complete at all.

v. Development Cost: This is the cumulative cost of all types of expertise for production and maintenance of a program, computer time, and overhead chargeable to in-house program development.

vi. Compare Costs and Constraints: Knowing the total costs and constraints affecting purchase and development, a comparison of Expected Values (EV) is made to select the mode of acquisition at minimum cost. In the unlikely case of two values being equal, priority is given to the method of acquisition involving the least capital outlay. If the two choices have equal costs, purchase has the highest priority. The selection is made through a decision matrix which is the heart of the methodology presented here. The outcome is the most economic mode that ensures the suitability of the software acquired.

3.2 DETAIL FLOWCHART

The Detail Flowchart presented by Figures 3.2.1 to 3.2.5 illustrate the comprehensive procedure used to solve the software acquisition problem. The completion of each step of the Summary Flowchart is denoted by a corresponding node number in the Detail Flowchart. Every step of the Summary Flowchart is broken down into substeps in the Detail Flowchart. The Detail Flowchart enumerates each substep which in most cases is dependent upon a number of measuring components. These measuring components influence to varying degrees the value of variables determined in a substep and consequently require comparative weightage. In applying this methodology to a problem, comparative weightages are to be provided by the user in view of his own situation.

The substeps in the Detail Flowchart up to node 5 depict information collection, organization and analysis for the seven states of nature and 14 controllable variables as described in the preceding chapter. Following node 5, development of the matrices and their analysis, until the final decision block for Expected Value (EV) is reached, is discussed and a systematic decision approach is described. The following four types of matrices are developed in connection with the Detail Flowchart. These are:

i. Relative Weightage Matrices

ii. Interaction Matrix

iii. Importance Rating Matrix

iv. Expected Value Matrix

However, before developing matrices it is necessary to determine numerical values for each controllable variable and states of nature represented by various substeps of the Detail Flowchart. This is done by enumerating its measuring components, assigning to each a symbol for later reference, and assigning comparative weightage. The weightages are assigned to measuring components using a scale of one to ten, the total weightage for each substep being 10. This is illustrated in Table 3.2.1 taking as an example substep A. The weightage will subsequently help determine the relative weightages of variables in terms of 'buy' or 'develop' options.

TABLE 3.2.1

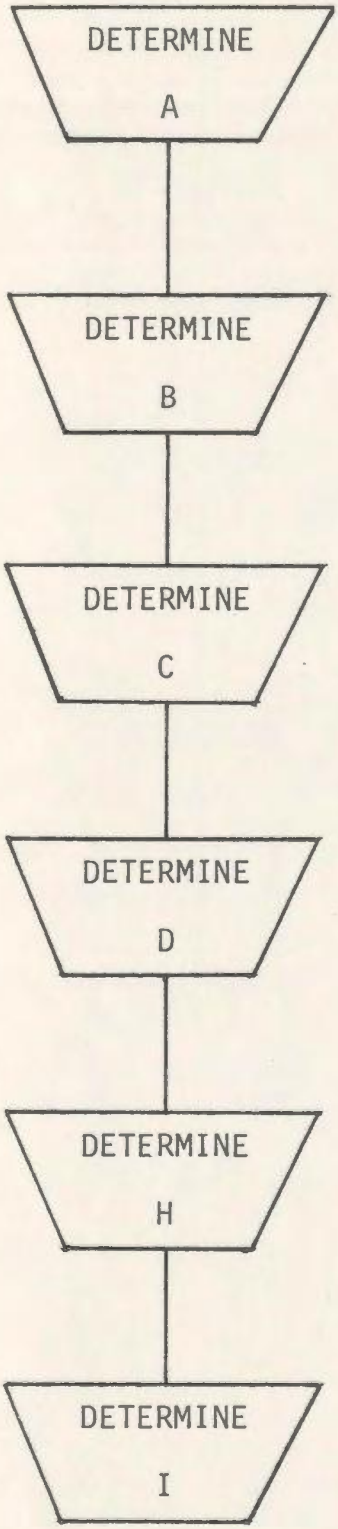
MEASURING COMPONENTS FOR SUBSTEP A

Measuring Component	Symbol	Weightage
Number of employees	A_1	1
Number of projects	A_2	1
Total worth of business	A_3	5
Period of operation	A_4	1
Growth rate	A_5	2

Relative weightage matrices will be developed for each substep in Chapter IV where an example is presented. However, the measuring components for each substep are presented in this chapter.

The Detail Flowchart for node 1 - ESTABLISH SOFTWARE REQUIREMENTS - comprises 9 substeps: A, B, C, D, H, I, J, K, and L. The measuring components of A being presented in Table 3.2.1 above, the remaining measuring components are being presented in Table 3.2.2.

DETAIL FLOWCHART



FINANCIAL CAPABILITY & VOLUME OF BUSINESS (A)

(Table 3.2.1)

COMPANY CLIENTELE (B)

(Table 3.2.2 Substep B)

CONTRACTUAL NEEDS (C)

(Table 3.2.2 Substep C)

ADDITIONAL PROJECTS (D)

(Table 3.2.2 Substep D)

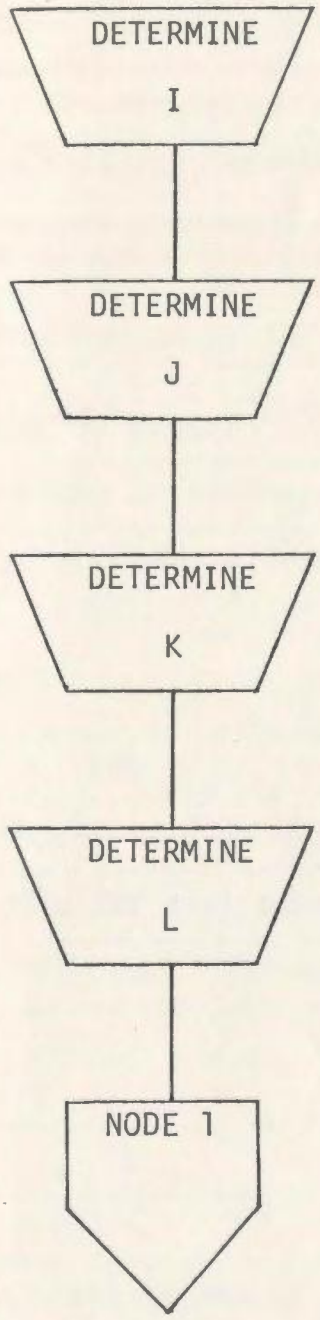
COMPANY INVESTMENT STRATEGY (H)

(Table 3.2.2 Substep H)

COMPANY PRESTIGE FACTOR (I)

(Table 3.2.2 Substep I)

Figure 3.2.1 Detail Flowchart for node 1



COMPANY ORGANIZATION STRUCTURE (J)

(Table 3.2.2 Substep J)

PROJECT NEEDS (K)

(Table 3.2.2 Substep K)

OTHER NEEDS (L)

(Table 3.2.2 Substep L)

ESTABLISH SOFTWARE REQUIREMENTS

Figure 3.2.1 (Continued)

TABLE 3.2.2

MEASURING COMPONENTS FOR NODE 1

Substep B		
Measuring Component (MC)	Symbol (SY)	Weightage (WT)
The owner of project	B_1	5
The designer of project	B_2	3
Business profession of owner	B_3	2
Substep C		
MC	SY	WT
Type of contracts	C_1	1
Processing for each contract	C_2	4
Reports for each contract	C_3	5
Substep D		
MC	SY	WT
Market trend	D_1	3
Political obligation & influence	D_2	4
Government regulation	D_3	3
Substep H		
MC	SY	WT
Company priority criteria	H_1	4
Company objectives	H_2	4
Company's line of credit	H_3	2

TABLE 3.2.2 (Continued)

Substep I		
Measuring component (MC)	Symbol (SY)	Weightage (WT)
Performance	I_1	4
Labor relationship	I_2	2
Clientele	I_3	4
Substep J		
MC	SY	WT
Type of organization	J_1	2
Number of communication channels	J_2	2
Length of communication channel	J_3	2
Nature of reporting system	J_4	2
Extent of reporting system	J_5	2
Substep K		
MC	SY	WT
Types of projects at hand	K_1	1
Types of processing for each project	K_2	4
Types of reports for each project	K_3	5
Substep L		
MC	SY	WT
Payroll	L_1	2
Inventory	L_2	2
General ledger	L_3	2
Accounts receivable	L_4	1.5
Accounts payable		1.5
Purchase order module	L_5	1

The Detail Flowchart for node 2 - EVALUATE SUITABILITY OF PROPRIETARY SOFTWARE - comprises six substeps as illustrated in Figure 3.2.2. The first substep does not need any measuring component and the measuring components of the remaining substeps are presented in Table 3.2.3.

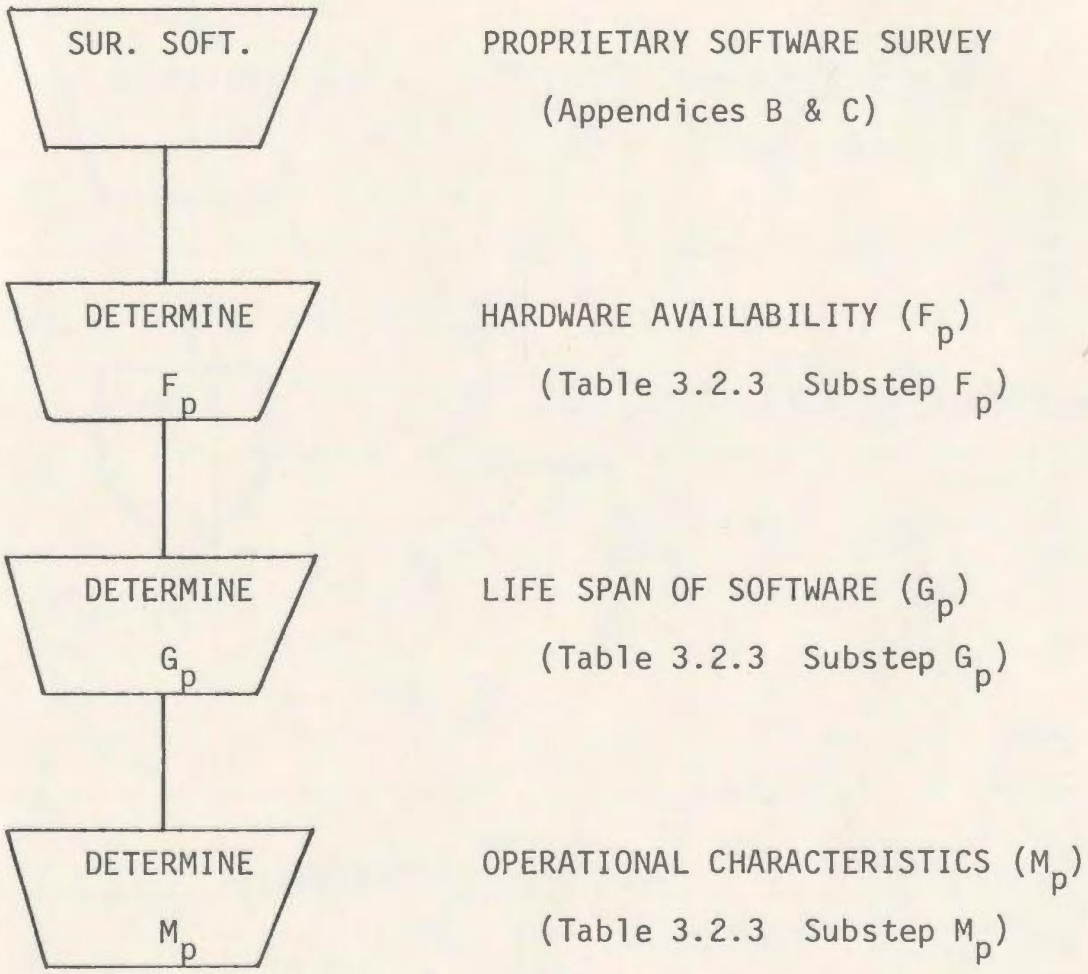
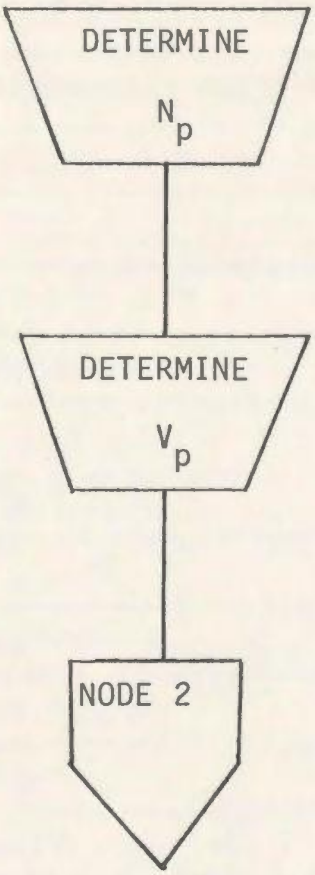


Figure 3.2.2 Detail Flowchart for node 2



FACILITIES AND CAPACITY (N_p)
(Table 3.2.3 Substep N_p)

SOFTWARE LEGAL ASPECTS (V_p)
(Table 3.2.3 Substep V_p)

EVALUATE SUITABILITY OF PROPRIETARY SOFTWARE

Figure 3.2.2 (Continued)

The measuring components of F_p, G_p, M_p, N_p, and V_p are presented here following the completion of the Detail Flowchart for node 2.

TABLE 3.2.3

MEASURING COMPONENTS FOR NODE 2

Substep (F_p & F_I)*		
Measuring component (MC)	Symbol (SY)	Weightage (WT)
Printer	F_1	2
Plotter	F_2	2
Memory type and core	F_3	3
Software/hardware ratio	F_4	3
Substep (G_p & G_I)*		
MC	SY	WT
Software growth	G_1	2
Maintenance ratio	G_2	2
Productivity	G_3	2
Program quality	G_4	2
Program reliability	G_5	2
Substep (M_p & M_I)*		
MC	SY	WT
Number of characteristics	M_1	4
Quality of each characteristic	M_2	3
Reliability of each characteristic	M_3	3

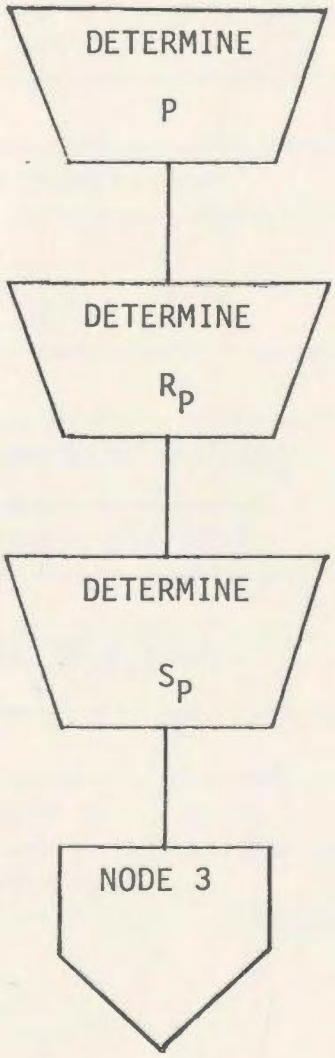
* The substep has two subscripts to denote the alternative with which it is associated. The subscript P stands for proprietary software and subscript I stands for in-house developed software.

TABLE 3.2.3 (Continued)

Substep (N_p & N_I)*		
Measuring component (MC)	Symbol (SY)	Weightage (WT)
Network processing	N_1	1
Resource allocation		1
Cost control		2
Report processing		2
Number of networks	N_2	1.5
Number of subnets		1.5
Number of activities and cards	N_3	1
Substep (V_p & V_I)*		
MC	SY	WT
Modification flexibility of features	V_1	5
Modification flexibility of operational characteristics	V_2	5

* The substep has two subscripts to denote the alternative with which it is associated. The subscript P stands for proprietary software and the subscript I stands for in-house developed software.

The Detail Flowchart for node 3 - DETERMINE TOTAL COST TO BUY - comprises three substeps as illustrated in Figure 3.2.3. The measuring components of these substeps are illustrated in Table 3.2.4 following the Detail Flowchart for node 3.



SOFTWARE PURCHASE COST (P)
(Table 3.2.4 Substep P)

MAINTENANCE COST OF PROPRIETARY SOFTWARE (R_p), (Table 3.2.4 Substep R_p)

OVERHEAD WITH PROPRIETARY SOFTWARE (S_p)
(Table 3.2.4 Substep S_p)

DETERMINE TOTAL COST TO BUY

Figure 3.2.3 Detail Flowchart for node 3

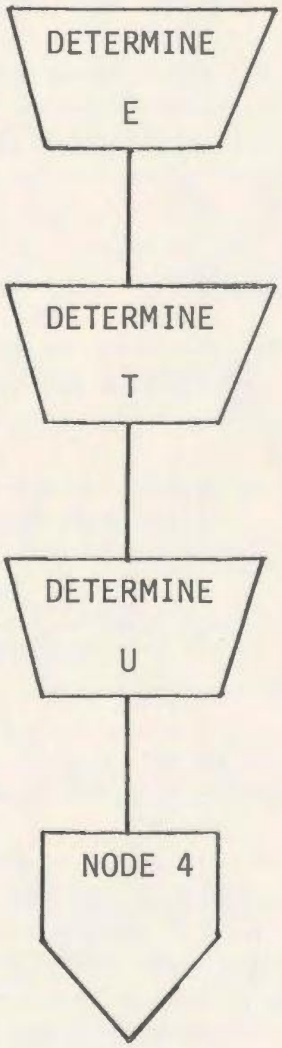
TABLE 3.2.4

MEASURING COMPONENTS FOR NODE 3

Substep P		
Measuring component (MC)	Symbol (SY)	Weightage (WT)
Purchase cost	P_1	8
Sales tax	P_2	1
Brokerage commission	P_3	1
Substep (R_p & R_I)*		
MC	SY	WT
Program operator and wage	R_1	5
Computer time and cost	R_2	5
Substep (S_p & S_I)*		
MC	SY	WT
Office staff and costs	S_1	7
Support services	S_2	3

* The substep has two subscripts to denote the alternative with which it is associated. The subscript P stands for proprietary software and the subscript I stands for in-house developed software.

The Detail Flowchart for node 4 - STUDY PHYSICAL CONSTRAINTS OF IN-HOUSE DEVELOPMENT - comprises three substeps as illustrated in Figure 3.2.4. The measuring components of these substeps are presented in Table 3.2.5 following the Detail Flowchart for node 4.



UNCERTAINTY (E)
(Table 3.2.5 Substep E)

TIME FACTOR (T)
(Table 3.2.5 Substep T)

MANPOWER REQUIREMENT TO DEVELOP (U)
(Table 3.2.5 Substep U)

STUDY PHYSICAL CONSTRAINTS OF
IN-HOUSE DEVELOPMENT

Figure 3.2.4 Detail Flowchart for node 4

TABLE 3.2.5

MEASURING COMPONENTS FOR NODE 4

Substep E		
Measuring component (MC)	Symbol (SY)	Weightage (WT)
Uncertainty over cost	E_1	4
Uncertainty over time	E_2	4
Uncertainty over manpower need	E_3	2
Substep T		
MC	SY	WT
Initiation and analysis	T_1	2
Planning	T_2	2
Analysis and design	T_3	2
Development	T_4	2
Implementation	T_5	2
Substep U		
MC	SY	WT
Number of senior system analysts	U_1	2
Number of system analysts	U_2	2
Number of programmers	U_3	2
Number of program analysts	U_4	2
Number of program operators	U_5	2

The Detail Flowchart for node 5 - DETERMINE TOTAL COST FOR IN-HOUSE SOFTWARE DEVELOPMENT - comprises eight substeps as illustrated in Figure 3.2.5. The measuring components of substeps F_I, G_I, M_I, N_I, R_I, S_I, and V_I being presented previously, the measuring component of remaining substep Q is presented in Table 3.2.6.

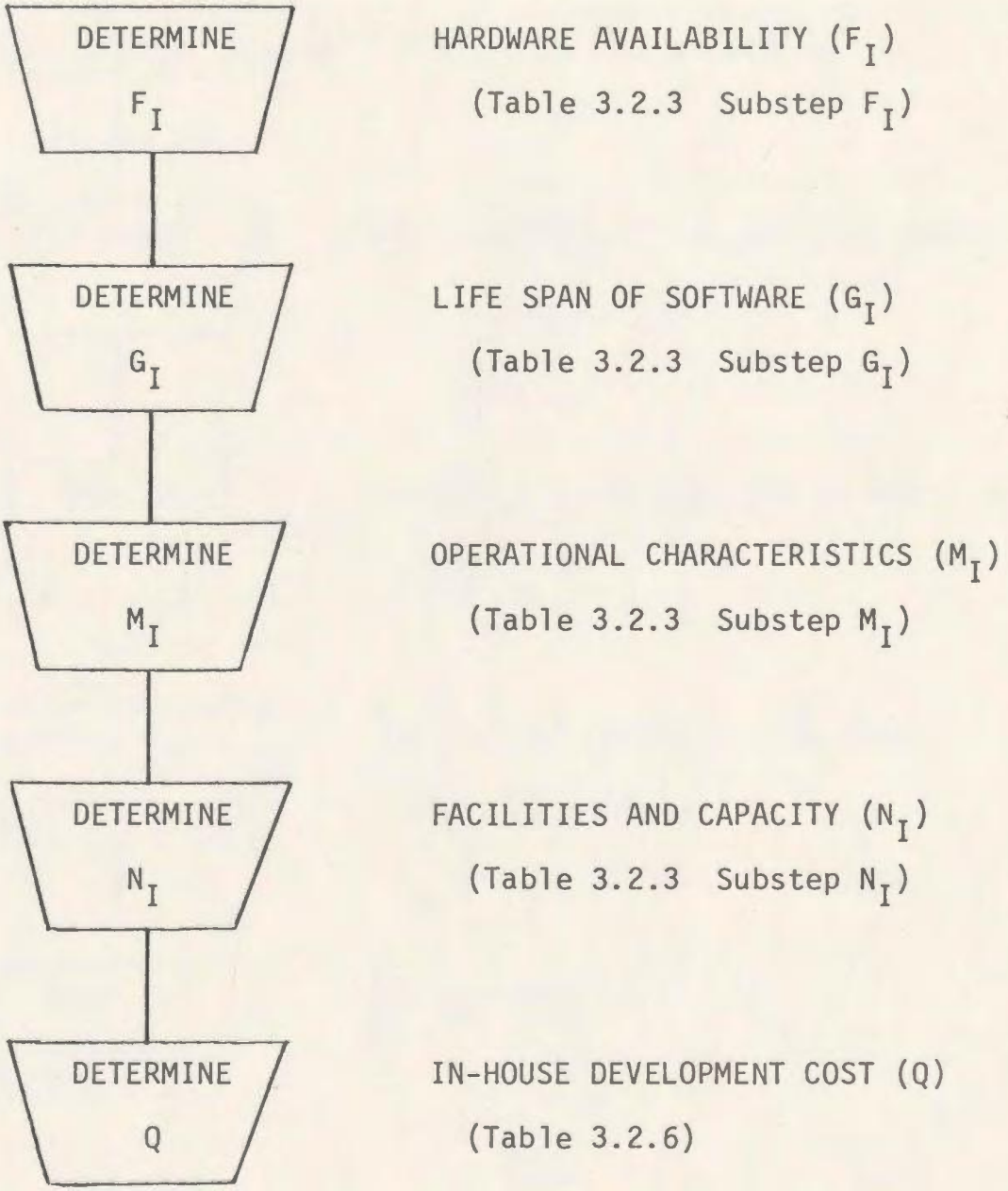
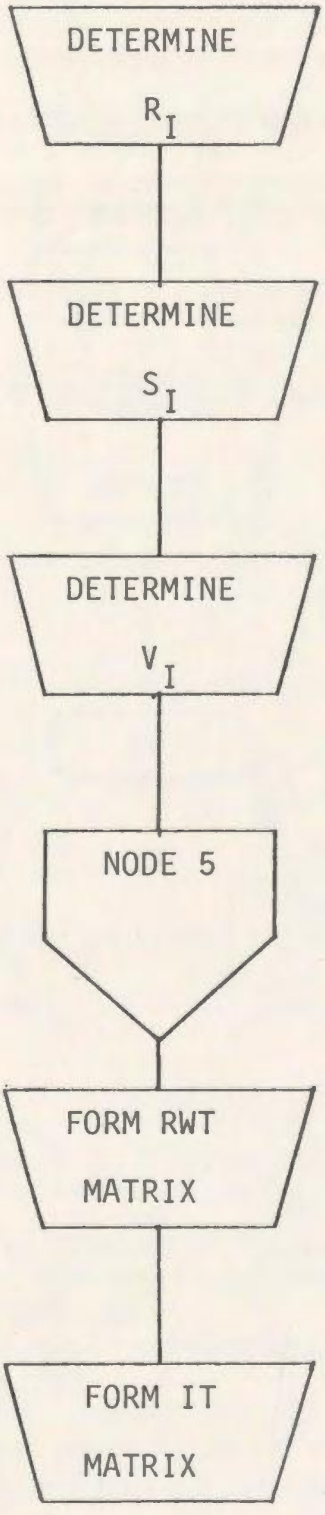


Figure 3.2.5 Detail Flowchart for node 5 and Decision Matrices



MAINTENANCE COST OF IN-HOUSE SOFTWARE (R_I)
(Table 3.2.4 Substep R_I)

OVERHEAD WITH IN-HOUSE SOFTWARE (S_I)
(Table 3.2.4 Substep S_I)

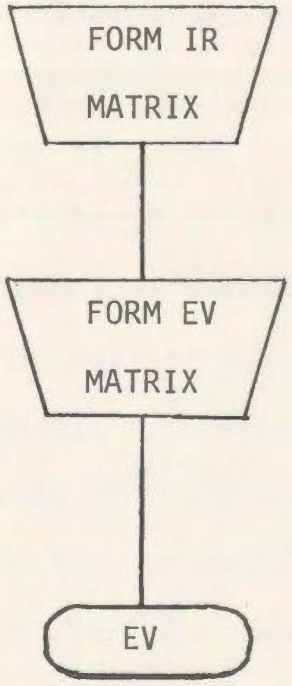
LEGAL ASPECTS OF IN-HOUSE SOFTWARE (V_I)
(Table 3.2.3 Substep V_I)

DETERMINE TOTAL COST FOR IN-HOUSE SOFTWARE DEVELOPMENT

RELATIVE WEIGHTAGE MATRIX (RWT)
(Figure 3.3)

INTERACTION MATRIX (IT)
(Figure 3.4)

Figure 3.2.5 (Continued)



IMPORTANCE RATING MATRIX (IR)

(Figure 3.5)

EXPECTED VALUE MATRIX (EV)

(Figure 3.6)

SOFTWARE ACQUISITION MODE

Figure 3.2.5 (Continued)

Table 3.2.6 Measuring Components for Substep Q

Measuring component (MC)	Symbol (SY)	Weightage (WT)
Development cost	Q_1	8
Property tax	Q_2	1
Brokerage commission	Q_3	1

3.3 RELATIVE WEIGHTAGE MATRICES

In matrix Table 3.2.1, each measuring component favours either a strategy to buy (SB), a strategy to develop (SD) or both strategies by parts. For instance, if the number of employees in a company is large, it may be desirable to reduce costs of personnel and at the same time increase the efficiency of data processing. A contractor may therefore opt to buy a program without losing any time. The weightage associated with number of employees is thus assigned entirely to SB. The alternative strategy is assigned zero weightage. Following this procedure both strategies are considered with respect to each measuring component successively, and weightage assigned to one or both of them in each case. By summing up these weights the relative weightage of each option is determined. The result is illustrated in a Relative Weightage Matrix, Figure 3.3, for Substep A (weightages used are from Table 3.2.1).

Strategy	Measuring Component					Relative Weightage (RWT)
	A_1	A_2	A_3	A_4	A_5	
SB	1.0	1.0	3.0	0.0	1.5	6.5
SD	0.0	0.0	2.0	1.0	0.5	3.5

Figure 3.3. Relative Weightage Matrix for Substep A

Similarly, Relative Weightage Matrices can be developed for all of the substeps of the Detail Flowchart. This will be done in the example presented in Chapter IV.

3.4 INTERACTION MATRIX

The controllable variables (CV) interact with states of nature (SN) to form the outcome. These interactions of variables with the states of nature are tabulated in an Interaction Matrix which is developed from the relative weightages as determined in the Relative Weightage Matrix.

There are 14 Relative Weightage Matrices for controllable variables and 7 for states of nature, corresponding to the 21 substeps of the Detail Flowchart. The relative weightage of each controllable variable reacts separately with the relative weightage of each state of nature. The interaction between a state of nature and a controllable variable is determined by taking the arithmetic mean of the relative weightages of state of nature and controllable variable. For example, if the relative weightage of a variable is SB = 8, SD = 2, and that of a state of nature is SB = 5, SD = 5, then the interactions of the two are OB* = (8 + 5) / 2 = 6.5 and OD* = (2 + 5) / 2 = 3.5 or simply their arithmetic average. This procedure is followed to determine all interactions. A specimen Interaction Matrix is shown in Figure 3.4. In the given matrix, combining the interaction of relative weightage (RWT) favouring strategy to buy under state of nature SN_1 with relative weightage favouring SB for controllable variable CV_1, OB_1 is obtained which corresponds to 6.5 in the numerical example. Similarly the interaction between RWTs of SD under SN_1 and SD for CV_1 is OD_1 which corresponds to 3.5 in the numerical example.

OB* - outcome for SB, OD* - outcome for SD

CV \ SN			SN_1		SN_2		.....	SN_n	
			SB	SD	SB	SD	.....	SB	SD
			RWT	RWT	RWT	RWT	.....	RWT	RWT
CV_1	SB	RWT	OB_{11}		OB_{12}		.....	OB_{1n}	
	SD	RWT		OD_{11}		OD_{12}	.....		OD_{1n}
CV_2	SB	RWT	OB_{21}		OB_{22}		.....	OB_{2n}	
	SD	RWT		OD_{21}		OD_{22}	.....		OD_{2n}
...	...	...	...	...	...	...	.....	...	...
CV_m	SB	RWT	OB_{m1}		OB_{m2}			OB_{mn}	
	SD	RWT		OD_{m1}		OD_{m2}			OD_{mn}

Where n = interger

m = interger ($m \neq n$)

Figure 3.4 Interaction Matrix

3.5 IMPORTANCE RATING MATRIX

The states of nature such as financial capability and volume of business, company clientele and so on are not under the contractor's control. They have varying impact on the company objectives. These objectives are:

- Economy
- Profit
- Growth
- Goodwill
- Performance

The importance of the states of nature in relation to the company objectives is not reflected in the interactions illustrated in the Interaction Matrix. It is therefore necessary to assign importance rating to the states of nature which will be used in determining the Expected Values in the Expected Value Matrix, so that the final decision is weighed by their relative importance to the company objectives.

To determine the relative importance of states of nature to the company objectives, an importance rating matrix is formed by listing the states of nature horizontally and the company objectives vertically. This is presented in Figure 3.5. The effect of a state of nature (IF) on a company objective is rated as excellent (4), good (3), fair (2), and poor (1). The rating under each state of nature is summed up vertically to arrive at a number (Sum) for each state of nature. These sums are prorated from a total weightage of 100

to assign an importance rating (IR) to individual states of nature.

Company Objectives	States of Nature			
	SN_1	SN_2	.....	SN_n
$Objective_1$	IF_1	IF_2	.....	IF_n
$Objective_2$	IF_3	IF_4	.....	IF_n
.....	...	....	.....	....
Sum	Sum_1	Sum_2	.....	Sum_n
Prorated Importance	IR_1	IR_2	.....	IR_n

Note: where n = interger

Figure 3.5 Importance Rating Matrix

3.6 EXPECTED VALUE MATRIX

The Expected Value Matrix is the final step of the systematic decision approach. It comprises five elements which are: the controllable variables, states of nature, their importance ratings, outcomes which are the interactions between states of nature and controllable variables, and the expected value (EV) for each (SB and SD) alternative. These elements are combined and illustrated in the Expected Value Matrix, Figure 3.6.

IR		IR_1	IR_2	IR_3	....	IR_n	EV
CV \ SN		SN_1	SN_2	SN_3	....	SN_n	
CV_1	SB	OB_{11}	OB_{12}	OB_{13}	....	OB_{1n}	EV_1
	SD	OD_{11}	OD_{12}	OD_{13}	....	OD_{1n}	EV_2
CV_2	SB	OB_{21}	OB_{22}	OB_{23}	....	OB_{2n}	EV_3
	SD	OD_{21}	OD_{22}	OD_{23}		OD_{2n}	EV_4
CV_3	SB	OB_{31}	OB_{32}	OB_{33}		OB_{3n}	EV_5
	SD	OD_{31}	OD_{32}	OD_{33}		OD_{3n}	EV_6
...	.....	.....	.....	.....	.....	.....	.....
CV_m	SB	OB_{m1}	OB_{m2}	OD_{m3}	....	OB_{mn}	EV_{2m-1}
	SD	OD_{m1}	OD_{m2}	OD_{m3}	....	OD_{mn}	EV_m

where m = interger, n = interger ($m \neq n$)

Figure 3.6 Expected Value Matrix

$OB_{1...n}$ and $OD_{1...n}$ which are the numerical values brought from the Interaction Matrix are multiplied by the importance rating of states of nature from the Importance Rating Matrix to obtain EV in the following manner:

$$EV_1 = OB_{11}.IR_1 + OB_{12}.IR_2 + \ldots\ldots\ldots\ldots\ldots + OB_{1n}.IR_n$$

$$EV_{2m1} = OB_{m1}.IR_1 + OB_{m2}.IR_2 \ldots\ldots\ldots\ldots\ldots OB_{mn}.IR_n$$

$$EV_2 = OD_{11}.IR_. + OD_{12}.IR_2 + \ldots\ldots\ldots\ldots\ldots + OD_{1n}.IR_n$$

$$EV_{2m} = OD_{m1}.IR_. + OD_{m2}.IR_2 \ldots\ldots\ldots\ldots\ldots OD_{mn}.IR_n$$

The sums of expected values for SB and SD are obtained separately and compared. The strategy which has the highest expected value is the viable alternative and the desired software acquisition mode.

CHAPTER IV

EXAMPLE

In order to demonstrate the model developed in Chapter III, a hypothetical situation involving a construction contractor's organization is described, with assumptions made regarding the cost of i) buying, and ii) developing a computer program, data coming from a survey of proprietary software in construction (Appendices B & C).

Estimated numerical values are assigned to each controllable variable and states of nature. Relative weightage matrices are developed for each controllable variable and state of nature separately. Following this an interaction matrix is developed using the relative weights of controllable variables and states of nature. After determining the importance rating of states of nature, the final decision matrix, the Expected Value Matrix is developed. The strategy with highest Expected Value (EV) is selected.

4.1 THE CONTRACTOR'S ORGANIZATION

The construction contractor assumed for this example is doing an annual business of $5-6 million. His organization has 19 permanent and 11 temporary staff. An organization chart showing only the permanent staff is illustrated in Figure 4.1.

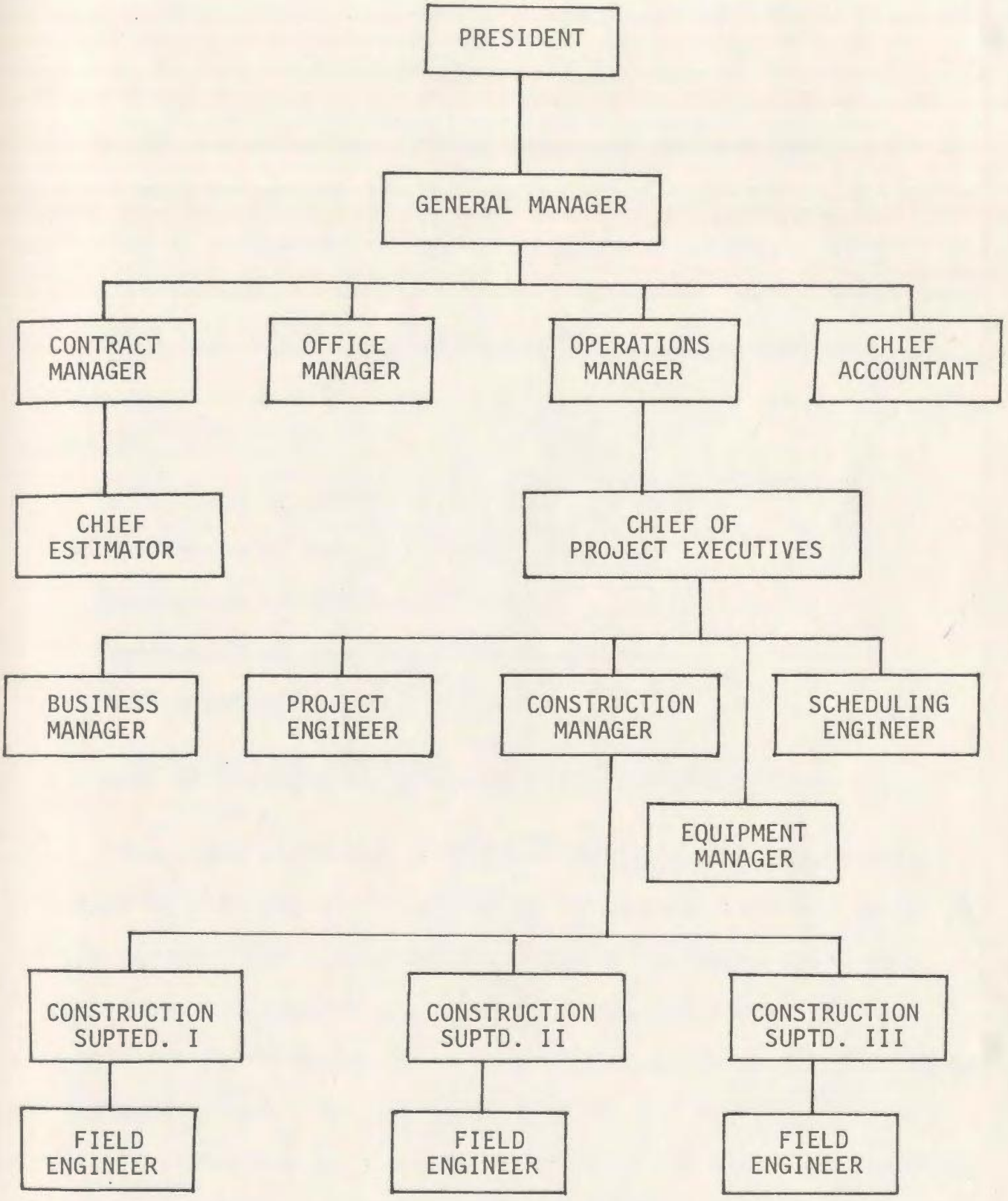


Figure 4.1 Company Organization Structure

4.2 THE DECISION PROCESS

The contractor has already justified computer application to meet his data processing needs. The immediate question to him is whether it is economical to buy the required proprietary software or develop it in-house. Therefore, he has to make a strategic decision to select a buy or develop alternative, based on the decision methodology developed in Chapter III, which involves the following operations:

- An Estimate of Numerical Values of Variables
- Development of Relative Weightage Matrix
- Development of Interaction Matrix
- Development of Importance Rating Matrix
- Development of Expected Value Matrix

4.3 AN ESTIMATE OF NUMERICAL VALUES OF VARIABLES

The model described in Chapter III outlines a comprehensive procedure to estimate all states of nature and controllable variables for the ultimate software acquisition mode. Following the Detail Flowchart and its explanation in Article 3.2, the states of nature and controllable variables pertaining to the contractor's organization are assigned values. A_1, A_2, A_3, A_4, and A_5 are the measuring components of Substep A, financial capability and volume of business, as listed in Table 3.2.1 are assigned necessary values in the following manner.

A. Financial Capability and Volume of Business:

A_1 - 6 projects of about $1 million each

A_2 - 30 employees

A_3 - $5 million per annum

A_4 - Year round

A_5 - 12% per annum

Similarly, the measuring components of other variables as listed in Tables 3.2.2 to 3.2.6 in Chapter III are also assigned values. Where necessary, suitable explanation is also provided. The values assigned to the measuring components are subsequently used in the various matrices later in the chapter.

B. Company Clientele:

B_1 - Department of Public Works (DPW), and Private Developers

B_2 - Consultant

B_3 - Construction

C. Contractual Needs:

C_1 - Stipulated price contract

C_2 - Estimating, network processing, resource allocation, cost control, and report processing

C_3 - To monitor the costs, the contractor has a series of questions and to answer these questions, certain computer reports must be provided by project cost control software. These questions and necessary reports are illustrated in Appendix E.

D. Additional Projects:

D_1 - Very potential for construction

D_2 - Very satisfactory

D_3 - Anti-inflationary

E. Uncertainties:

E_1 - $\pm$ 15 %*

E_2 - 50 %*

E_3 - 73 %*

F. Hardware Parameter: The contractor rents the services of a remote terminal operated hardware system from IBM Company (IBM/360, 370, 05, DOS)

F_1 - High speed

F_2 - High speed

F_3 - 500k

F_4 - 6 : 1[1]

G. Life Span of Software:

G_1 - 15 % per annum[1]

G_2 - 70-80 % of manhour need*

G_3 - 3-7 % (20% at IBM)[1]

G_4 - Improving*

G_5 - Slow improvement[1]

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* Appendix D

[1]W. Myers, The Need for Software Engineering, Computer, February, 1978.

H. Company Investment Stretegy:

H_1 - 1st : Economy

2nd : Cost-saving

3rd : Profit

4th : Expansion

5th : Growth

6th : Goodwill

H_2 - Long term : expansion, growth and goodwill

Short term : economy, cost-saving and profit

H_3 - $ 0.5 million

I. Company Prestige Factor:

I_1 - Satisfactory

I_2 - Satisfactory

I_3 - Excellent

J. Company Organization Structure:

J_1 - Matrix type of organization (Figure 4.1)

J_2 - 6

J_3 - One step

J_4 - Bottom up

J_5 - Explained in K_3

L. Other Needs: The contractor wants to computerize the functions of payroll, accounting, auditing and inventory system.

M. Software Operational Characteristics:*

Characteristics	PMS IV
Simplicity **	(X)
Flexibility	X
Controls	X
Reliability	X
Documentation	-
Maintainability	-
Efficiency	X
Capacity	X
Compatability	X
Data Base	X
Data sequencing	X
Cost	-

where 'X' stands for the existence of a particular feature in the program, '(X)' indicates that the program does not presently possess a particular feature but that it can be added with suitable modifications, and '-' stands for non-existence of the desirable feature and a lack of ability to modify or add the feature to the program.

---

* - Users' ratings of additional proprietary software for suitability analysis is illustrated in Appendix F.

** - It must be realized that PMS IV is a very generalized package and would require extensive tailoring to fit the specific requirements of a construction company's various projects.

K. Project Needs:

K_1 - 2 highways, 2 residential buildings, 2 office buildings, and 1 airport construction project

K_2 - Same as above

K_3 - To control the cost of the projects and to monitor their progress, the contractor wants cost/progress information distributed to the project executives in the form of regular reports based on field data. Distribution of the project cost/progress reports as required by the project executive and supervisory staff is shown in Appendix E (Part III). The company executive staff receive exception reports at summary level.

K_4 - Network processing, resource allocation, report processing and cost control.

N. Program Facility and Capacity: Five general programs from Appendix B have been analysed for evaluation of system features and the result of this analysis is illustrated in Appendix G. Among these five general programs PMS IV, which has a wide application in the construction industry is found to best match the needs and therefore is selected for this example. PMS IV can perform network, resource, report and cost processing. It can process up to 254 networks, 255 subnetworks, and 2200 activities for each subnet at one time.

P/Q Costs: The cost estimates are illustrated in Tables 4.1 and 4.2. Table 4.1 illustrates the time and cost estimate of software development by percentage. Table 4.2 illustrates purchase v/s development cost of

Table 4.1 Time and Cost Estimate of Software Development* (Year 1976)

Project phase	Cost (%)	Time (%)
Initiation and preliminary analysis	5	2
Planning	10	5
Analysis and design	25	18
Development	40	45
Implementation	20	30

Table 4.2 Purchase v/s Development Cost of Proprietary Software** (Year 1978

System	Purchase Cost $	Development Cost $	Maintenance Cost of Proprietary Software* $	Maintenance Cost In-House Developed Software $
Estimating	35000	75-100000	4000	10000
Payroll	35000	75-100000	4000	10000
General Ledger	35000	75-100000	3000	1500
Accounts Payable	25000	75-100000	2500	2500
Accounts Receivable	25000	75-100000	2500	2500
Fixed Assets	20000	50-250000	2000	5000
Inventory	35000	75-150000	4000	10000

* Evans, R.W., The EDP Guide, Volume 3-1, R.W. Evans Associates Ltd., Dec. 1976.

** Appendix H.

proprietary software.

R. Maintenance Cost: Maintenance cost is slightly higher for proprietary software compared with in-house developed software. This is because the software development, being a slow process, helps company personnel acquire experience. As a result of their experience and familiarity with their own product, in-house software becomes comparatively easy for them. Maintenance cost varies with the vendor of proprietary software but averages at R_p - 12% and R_I - 10% of the purchase cost.[2]

S. Overhead Expenses: These are assumed to average at 30% of the total cost.

T. Time Factor: Time to acquire a proprietary software is negligible as compared to the time required to develop a program in-house. Table 4.1 shows the time required for different stages of program development by percentage completion. A proprietary software is available for immediate application which is not so for an in-house developed program. Before it is applied, an in-house developed software must be thoroughly debugged. Time required to develop a program in terms of computer cards is 0.054[3] day per card.

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[2]Datapro Research Corporation, Datapro 70, Buyer's Bible. Delran, New Jersey, 1977.

[3]Chris M. Szalwinski, Specialized Computer Program Development-Expectation and Costs. Ontario, Canada.

U. Manpower Requirement: Personnel required to run a proprietary software package such as PMS IV is one program operator and one program analyst, but to develop a program like PMS IV the personnel required will be

2 senior system analysts - U_1

3 system analysts - U_2

8 programmers - U_3

4 program analysts - U_4

8 program operators - U_5

V. Legal Aspects of Software:

V_1 - Report processor of PMS, V_2 - All characteristics can be modified.

4.4 RELATIVE WEIGHTAGE MATRICES

The first step of the decision process is to develop the Relative Weightage Matrices according to Article 3.3 of the preceding chapter and using the estimates of variables made in Article 4.3. Individual matrices are developed for each state of nature and controllable variables.

The measuring components of each substep favour either SB or SD, or both partially. For instance, substep A has five measuring components. A_1 is the number of employees and the contractor assumed for this example has 30 employees. The contractor feels it necessary to reduce the expenses incurred for hiring personnel and at the same

time to increase efficiency of data processing. Thus the estimate of A_1 favours SB entirely and correspondingly its weightage is assigned to SB while zero weightage is assigned to SD.

Then A_2 is the number of projects - the contractor has four projects at hand at present. To furnish the required data handling for these projects, the contractor need not develop in-house software and can economically furnish required data processing by acquiring suitable proprietary software. Thus the estimate of A_2 also favours the strategy to buy proprietary software and consequently its weightage is assigned to SB, and zero weightage assigned to SD.

A_3 is the total worth of business. The contractor is doing a business of $5 million per annum. The contractor rationalizes that the present size of business favours SB by 60% and SD by 40% and accordingly assigns 3 to SB and 2 to SD out of its assigned relative weightage of 5.0. A_4 is the period of operation and the contractor operates year round, so he needs software year round and foresees that his in-house developed software is more economical and therefore assigns its assigned weightage to SD alone.

A_5 is growth rate and the contractor has 12% growth at present and considers that he can best maintain it by not incurring further capital investment. He fears that an in-house software development project can cause further capital involvement. Thus he rationalizes that the estimate of A_5 affects SB by 75% and SD by 25% and correspondingly assigns 1.5 to SB and 0.5 to SD. If we summarise all these results in a table, we get the Relative Weightage Matrix for substep A (see Table 4.3).

Table 4.3 RWT Matrix for Substep A

Strategy (ST)	A_1	A_2	A_3	A_4	A_5	RWT
SB	1.0	1.0	3.0	0	1.5	6.5
SD	0	0.0	2.0	1.0	0.5	3.5

RWT is obtained by summing up the assigned weightages in each row.

Similarly, following this rigorous analysis, the Relative Weightage Matrices are developed for the remaining substeps in Table 4.4.

Table 4.4 Relative Weightage Matrices

Substep B

ST	B_1	B_2	B_3	RWT
SB	2.5	2.0	1.0	5.5
SD	2.5	1.0	1.0	4.5

Substep C

ST	C_1	C_2	C_3	RWT
SB	1.0	3.0	3.0	7.0
SD	0.0	1.0	2.0	3.0

Substep D

ST	D_1	D_2	D_3	RWT
SB	2.0	2.0	1.0	5.0
SD	1.0	2.0	2.0	5.0

Table 4.4 (continued)

Substep E

ST	E_1	E_2	E_3	RWT
SB	4.0	4.0	2.0	10
SD	0.0	0.0	0.0	0.0

Substep F

ST	F_1	F_2	F_3	F_4	RWT
SB	0.5	0.5	1.0	0.0	2.0
SD	1.5	1.5	2.0	3.0	8.0

Substep G

ST	G_1	G_2	G_3	G_4	G_5	RWT
SB	0.0	0.0	0.5	0.5	1.0	2.0
SD	2.0	2.0	1.5	1.5	1.0	8.0

Substep H

ST	H_1	H_2	H_3	RWT
SB	3.0	2.0	1.5	6.5
SD	1.0	2.0	0.5	3.5

Substep I

ST	I_1	I_2	I_3	RWT
SB	2.0	0.0	1.0	3.0
SD	2.0	2.0	3.0	7.0

Table 4.4 (continued)

Substep J

ST	J_1	J_2	J_3	J_4	J_5	RWT
SB	0.5	0.5	0.5	0.5	0.5	2.5
SD	1.5	1.5	1.5	1.5	1.5	7.5

Substep K

ST	K_1	K_2	K_3	RWT
SB	1.0	3.0	3.0	7.0
SD	0.0	1.0	2.0	3.0

Substep L

ST	L_1	L_2	L_3	L_4	L_5	RWT
SB	2.0	2.0	2.0	3.0	1.0	10.0
SD	0.0	0.0	0.0	0.0	0.0	0.0

Substep M

ST	M_1	M_2	M_3	RWT
SB	3.0	1.5	2.0	6.5
SD	1.0	1.5	1.0	3.5

Substep N

ST	N_1	N_2	N_3	RWT
SB	6.0	3.0	1.0	10.0
SD	0.0	0.0	0.0	0.0

Table 4.4 (continued)

Substep P

ST	P_1	P_2	P_3	RWT
SB	6.0	0.0	0.0	6.0
SD	2.0	1.0	1.0	4.0

Substep Q

ST	Q_1	Q_2	Q_3	RWT
SB	6.0	1.0	0.0	7.0
SD	2.0	0.0	1.0	3.0

Substep R

ST	R_1	R_2	RWT
SB	3.5	3.5	7.0
SD	1.5	1.5	3.0

Substep S

ST	S_1	S_2	RWT
SB	6.5	1.0	7.5
SD	1.5	1.0	2.5

Substep T

ST	RWT
SB	9.0
SD	1.0

Table 4.4 (continued)

Substep U

ST	U_1	U_2	U_3	U_4	U_5	RWT
SB	2.0	2.0	2.0	1.0	1.0	8.0
SD	0.0	0.0	0.0	1.0	1.0	2.0

Substep V

ST	V_1	V_2	RWT
SB	1.5	1.5	3.0
SD	3.5	3.5	7.0

4.5. INTERACTION MATRIX

The second operation of the decision process is to develop an Interaction Matrix for the present example. It is developed here using the data generated from Relative Weightage Matrices and following the procedure described in Article 3.4 of the preceding chapter.

RWTs of a state of nature (forming the column headings in the matrix) interact with the RWTs of all controllable variables (forming the new headings in the matrix) separately under each alternative. For instance, RWT of state of nature A will interact with the RWTs of controllable variables H - V separately under each alternative. RWT of A under SB is 6.5 and under SD 3.5 and that of H is 6.5 and 3.5 respectively. So the interaction of A with H under SB is (6.5 + 6.5) / 2 = 6.5 and under SD is (3.5 + 3.5) / 2 = 3.5. Similarly, interaction (IT) of A with I whose RWT for SB and SD are respectively 3.0 and 7.0, under SB is (6.5 + 3.0) / 2 = 4.75 and under SD is (3.5 + 7.0) / 2 = 5.25. In the same way the interactions of A with the other controllable variables are determined and tabulated in the first column of the Interaction Matrix. The procedure is continued to determine these interactions under all of the states of nature and the result is tabulated in Table 4.5 which is the Interaction Matrix.

Table 4.5 Interaction Matrix

	SN	A		B		C		D		E		F		G	
CV	ST	SB	SD	SB	SD	SB	SD	SB	SD	SB	SD	SB	SD	SB	SD
	RWT	6.5	3.5	5.5	4.5	7.0	3.0	5.0	5.0	10	0.0	2.0	8.0	2.0	8.0
H	SB	6.5	6.5		6.0		6.75		5.75		8.25		4.25		4.25	
	SD	3.5		3.5		4.0		3.25		4.25		1.75		5.75		5.75
I	SB	3.0	4.75		4.25		5.0		4.0		6.5		2.5		2.5	
	SD	7.0		5.25		5.75		5.0		6.0		3.5		7.5		7.5
J	SB	2.5	4.5		4.0		4.75		3.75		6.25		2.25		2.25	
	SD	7.5		5.5		6.0		5.25		6.25		3.75		7.75		7.75
K	SB	7.0	6.75		6.25		7.0		6.0		8.5		4.5		4.5	
	SD	3.0		3.25		3.75		3.0		4.0		1.5		5.5		5.5
L	SB	10	8.25		7.75		8.5		7.5		10		6.0		6.0	
	SD	0.0		1.75		2.25		1.5		2.5		0.0		4.0		4.0
M	SB	6.5	6.5		6.0		6.75		5.75		8.25		4.25		4.25	
	SD	3.5		3.5		4.0		3.25		4.25		2.75		5.75		5.75
N	SB	10	8.25		7.75		8.5		7.5		10		6.0		6.0	
	SD	0.0		1.75		2.25		1.5		2.5		0.0		4.0		4.0
P	SB	6.0	6.25		5.75		6.5		5.5		8.0		4.0		4.0	
	SD	4.0		3.75		4.25		3.5		4.5		2.0		6.0		6.0
Q	SB	7.0	6.75		6.25		7.0		6.0		8.5		4.5		4.5	
	SD	3.0		3.25		4.75		3.0		4.0		1.5		5.5		5.5
R	SB	7.0	6.75		6.25		7.0		6.0		8.5		4.5		4.5	
	SD	3.0		3.25		4.75		3.0		4.0		1.5		5.5		5.5
S	SB	7.5	7.0		6.50		7.25		6.25		8.75		4.75		4.75	
	SD	2.5		3.0		3.5		2.75		3.75		1.25		5.25		5.25
T	SB	9.0	7.75		7.25		8.0		7.0		9.5		5.5		5.5	
	SD	1.0		2.25		2.75		2.0		3.0		0.5		4.5		4.5
U	SB	8.0	7.25		6.75		7.5		6.5		9.0		5.0		5.0	
	SD	2.0		2.75		3.25		2.5		3.5		1.0		5.0		5.0
V	SB	3.0	4.75		4.25		5.0		4.0		6.5		2.5		2.5	
	SD	7.0		5.25		5.75		5.0		6.0		3.5		7.5		7.5

4.6. IMPORTANCE RATING MATRIX

The importance rating is assigned to states of nature according to the procedure described in Article 3.5 of the preceding chapter. Assignment of the importance rating to the states of nature is the third step in the decision process.

The importance rating of each state of nature is furnished by determining the effect of each state of nature on each of the company objectives separately. For example, the effect of A on the economy objective is excellent, on profit is good, on growth is excellent, on goodwill is good, and on performance is fair. Then numerically substituting excellent by 4, good by 3, fair by 2 and so on, and adding all these numerical values, we get the numerical sum of 16 under state of nature A. This procedure is continued to determine the numerical sums under all of the states of nature. These numerical sums are then prorated from a total weightage of 100 and correspondingly an importance rating is assigned to each of the states of nature. The result is summarized in Table 4.6.

Table 4.6 Importance Rating Matrix

Company Objective	A	B	C	D	E	F	G	Total
Economy	4	3	1	2	4	2	2	
Profit	3	3	1	3	3	3	3	
Growth	4	3	2	3	4	2	2	
Goodwill	3	4	2	2	3	2	2	
Performance	2	3	2	1	4	2	2	
Sum	16	16	8	11	18	11	11	91
Importance by %	17.58	17.58	8.79	12.09	19.78	12.09	12.09	100
Importance (IR)	17.58	17.58	8.79	12.09	19.78	12.09	12.09	100

4.7 EXPECTED VALUE MATRIX

The fourth step of the decision process is to develop an Expected Value Matrix which is presented in Table 4.7. The Expected Value Matrix is developed following the procedure described in Article 3.6 and brings together the states of nature, controllable variables, their interactions as tabulated in the Interaction Matrix, and the importance ratings of the states of nature as tabulated in the Importance Rating Matrix.

The expected values are calculated according to the formulae given in Article 3.6 of the preceding chapter. For instance, expected values of H are:

Expected Value (EV) for SB = 6.5 x 17.58 + 6.0 x 17.58 + 6.75 x 8.79
+ 5.75 x 12.09 + 8.25 x 19.78 + 4.25 x
12.09 + 4.25 x 12.09 = 614.55

Table 4.7 Expected Value Matrix

IR		17.58	17.58	8.79	12.09	19.78	12.09	12.09	EV
CV	SN	A	B	C	D	E	F	G	
H	SB	6.5	6.0	6.75	5.75	8.25	4.25	4.25	614.55
	SD	3.5	4.0	3.25	4.25	1.75	5.75	5.75	385.45
I	SB	4.75	4.25	5.0	4.0	6.5	2.5	2.5	439.205
	SD	5.25	5.75	5.0	6.0	3.5	7.5	7.5	560.795
J	SB	4.5	4.0	4.75	3.75	6.25	2.25	2.25	360.145
	SD	5.5	6.0	5.25	6.25	3.75	7.75	7.75	639.855
K	SB	6.75	6.25	7.0	6.0	8.5	4.5	4.5	639.556
	SD	3.25	3.75	3.0	4.0	1.5	5.5	5.5	360.444
L	SB	8.25	7.75	8.5	7.5	10	6.0	6.0	789.550
	SD	1.75	2.25	1.5	2.5	0.0	4.0	4.0	210.450
M	SB	6.5	6.0	6.75	5.75	8.25	4.25	4.25	614.55
	SD	3.5	4.0	3.25	4.25	1.75	5.75	5.75	385.45
N	SB	8.25	7.75	8.5	7.5	10	6.0	6.0	789.550
	SD	1.75	2.25	1.5	2.5	0.0	4.0	4.0	210.450
P	SB	6.25	5.75	6.5	5.5	8.0	4.0	4.0	589.550
	SD	3.75	4.25	3.5	4.5	2.0	6.0	6.0	410.450
Q	SB	6.75	6.25	7.0	6.0	8.5	4.5	4.5	639.556
	SD	3.25	3.75	3.0	4.0	1.5	5.5	5.5	360.444
R	SB	6.75	6.25	7.0	6.0	8.5	4.5	4.5	639.556
	SD	3.25	3.75	3.0	4.0	1.5	5.5	5.5	360.444
S	SB	7.0	6.5	7.25	6.25	8.75	4.75	4.75	664.550
	SD	3.0	3.5	2.75	3.75	1.25	5.25	5.25	335.450
T	SB	7.75	7.25	8.0	7.0	9.5	5.5	5.5	739.550
	SD	2.25	2.75	2.0	3.0	0.5	4.5	4.5	260.450
U	SB	7.25	6.75	7.5	6.5	9.0	5.0	5.0	689.550
	SD	2.75	3.25	2.5	3.5	1.0	5.0	5.0	310.450
V	SB	4.75	4.25	5.0	4.0	6.5	2.5	2.5	439.205
	SD	5.25	5.75	5.0	6.0	3.5	7.5	7.5	560.795

Expected Value (EV) for SD = 3.5 x 17.58 + 4.0 x 17.58 + 3.25 x 8.79
+ 4.25 x 12.09 + 1.75 x 19.78 + 5.75 x
12.09 + 5.75 x 12.09 = 385.45

Similarly, the expected values for all of the controllable variables are computed and presented in the last column of the Expected Value Matrix.

4.8. SELECTION OF SOFTWARE ACQUISITION MODE

EVs for SB and SD are added separately in Table 4.8:

Table 4.8 Summation of Expected Values

EV for SB	EV FOR SD
614.550	385.450
439.205	560.795
360.145	639.855
639.556	360.444
789.550	210.450
614.550	385.450
789.550	210.450
589.550	410.450
639.556	360.444
639.556	360.444
664.550	335.450
739.550	260.450
689.550	310.450
439.205	560.795
8648.623	5351.377

The Expected Value for 'Buy' strategy being higher, the mode of software acquisition selected as a result of the decision methodology is 'BUY PROPRIETARY SOFTWARE'.

CHAPTER V

CONCLUSIONS

The project report has presented a methodology to aid a construction contractor in deciding whether to buy or develop cost control software. Its use can help the contractor systematically investigate all the factors that influence cost / benefits associated with the decision.

The methodology is intended for use in virtually any type and size of construction organization, or on any size and type of construction project where high volume of data processing is involved.

Combination of methods of maximum application of software and minimum cost of its acquisition and application reduces data processing costs which, it is hoped, will increase profits of a construction organization.

The project has introduced the problem area, defined the variables, developed a model and worked out an example using the model. Essentially the model involves substitution of each variable by a numerical value and combining the numerical values following a rigorous methodology to obtain meaningful results. Although decision rules generally described in texts on decision making are used, there is no proof that the user will get the best possible decision. However, a user even when he does not follow the methodology rigorously as presented, can also benefit from it by considering the effect of the

various controllable variables and states of nature, and taking them into consideration in making an intuitive decision. The quality of his intuitive decision will improve depending on the extent to which he considers the influence of the controllable variables on the 'buy' or 'develop' decision under the changes in the states of nature.

Further research could deal with other variables by investigating the production / down time ratio which is a function of statistical records and life expectancy of software. The methodology presented here helps make a one-shot decision to buy or develop software. Further research could develop a methodology whereby a program of gradual acquisition of software modules is compared against a software development program.

This methodology has assumed that once the contractor acquires software, its use is solely intended for the contractor's organization. Further research could investigate the benefits should the contractor's organization offer its software to others.

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APPENDIX A

Information requirements for

Cost Control Objectives

QUESTIONS	INFORMATION REQUIREMENT
SCHEDULE	SCHEDULE
Will the project be finished on target?	Project Schedule Deadline
Is each contractor/subcontractor meeting his schedule target?	
Is each subcontractor meeting the interface dates?	Contractors Schedule Targets
Is material procurement being expected according to plan?	Coordination of Contractors Work
Is each phase of project - preconstruction, construction and commissioning meeting the project target?	Control Over Expediting Monitoring of Project Phases
Are contract packages being worked on according to plan?	Control Over Tender Packages
RESOURCES	RESOURCES
Are manhours expended within the estimate?	Control Manhour Resources
Is the change in manhour requirement gradual?	Manpower Leveling
Is the project so planned that work will not stop due to shortage of resources?	Physical Feasibility of Schedule

APPENDIX A (continued)

QUESTIONS	INFORMATION REQUIREMENT
BUDGET AND COST CONTROL	BUDGET AND COST CONTROL
Does the bid price include provision for contingencies, escalation, overhead and mark-up?	Control Over Revisions To Estimates
	Control Over Escalation and Contingency
Do the change orders include provision for contingencies, escalation, overhead and mark-up?	Control over design engineering and engineering management costs.
	Control Over Appropriations
What is the deviation of actual cost from estimated cost?	Control Over Progress Payments
Is the project cost after periodical revisions of estimates as per original estimate?	Control Over Change Orders
Are the appropriations out of contingencies and excalation allowances as per estimate?	Control Over Capital Disbursements
Are design engineering and engineering management costs as per estimate?	Control over owner furnished material
Are the total appropriations within the project estimated cost?	Project completion within authorized budget
Do progress claim certifications represent the closest approximation of the cost for work done to date?	Contract completion within cost targets
	Analysis of Unit Prices
Is the cost of all change orders included in the revised estimate?	
Is the quantity of materials requisitioned as per bill of materials?	Obtainable by User Modification
Are material losses and wastage within reasonable limits?	
Is the cost of owner-furnished materials as per estimate?	

APPENDIX A (continued)

QUESTIONS	INFORMATION REQUIREMENT
Is equipment cost per unit of work as per plan?	Forecasting Cost Trend
Is equipment being fully utilized?	
Is each piece of equipment economical?	
Is each section of the organization executing the project within budget?	
Will each contract be completed within its cost target?	
Is productivity for various work classifications as per estimate?	
What is the production cost in each shop/plant?	
Have all reimbursable costs been claimed?	
Is the overhead cost as per plan?	Costing by Facility
In case of work not covered by contract, is documentation complete?	
Is the forecast for final cost as per estimate?	
Does the trend show overrun or underrun?	
What is the capital cost for each facility?	
CASH FLOW	CASH FLOW
What is the cash flow forecast?	Cash Flow Forecasting
Do the budgets conform with the cash flow forecast?	
Are the financing costs kept to the minimum?	

APPENDIX B. GENERAL PROGRAMS

PROGRAM NAME	APPLICATION	VENDOR	COMPUTER	REMARKS
1. PMS/IV Project Management System				A large scale project scheduling and control package designed for the IBM/370 Computer System. The user selects the type of processing required from the first three processors and produces the relevant reports using the fourth processor. Modification is possible.
a. PMS Network Processor	CPM/Precedence/PERT (without probability)	IBM	IBM/360,370,OS	
b. PMS Resource Allocation Processor	Resource Allocation			
c. PMS Cost Processor	Cost Analysis			
d. PMS Report Processor	Report Generation			
2. PROJACS--Project Analysis and Control System	CPM, Precedence resource allocation, cost control	IBM	IBM/360,370,OS/ VSIBM DOS/VS	It has a main processor which calls upon three other processors, Network preparation, Resource Allocation and Cost evaluation. It can store standard networks which can be used for preparing a project network. It also prints precedence diagrams. It can function in interactive mode.
3. PCS--Project Control System	Network Processing, Resource Allocation, Cash flow	IBM	IBM/1130 IBM/360,370,OS,DOS	Similar to PMS; however, somewhat simpler in concept.

APPENDIX B (CONTINUED)

PROGRAM NAME	APPLICATION	VENDOR	COMPUTER	REMARKS
4. CMCS--Construction Management Control System	CPM, Cost Analysis, Material expediting financial analysis	U.S. Public Building Service	IBM/1130	An integrated system for schedule reports, cost reports, financial reports, purchase order control and progress billing.
5. PMCS--Project Management and Control Systems	Planning, Scheduling, and controlling large complex projects	Multiple Access General Computer Corporation	CDC/6600	Processes and reports both time and cost information; it handles up to 1500 activities and 1800 events.
6. Project/Costing System	Time/Cost Analysis and employee Performance Reporting	Multiple Access General Computer Corporation	CDC/6600	Produces up-to-date information on the progress and cost of a project, manpower efficiency can be monitored.
7. MSCS--Management Scheduling and Control System	CPM/precedence Scheduling and Resource Leveling	McDonnel Douglas Automation Co, 500 Jefferson Bldg. Houston, Texas 77002	IBM/360/OS	A multiproject system for scheduling and resource leveling, especially tailored reports formats possible, costing and estimating probabilities.
8. PERT/TIME	Planning, monitoring, and evaluating the status of a project	Cybervet Services	CDC/6000 and Cyber 70	It utilizes a time oriented network structure. Handles up to 8000 activities and 6000 events.
9. PROMIS	Network processing and analysis	(BBM) Burroughs Business Machines	Burroughs Computers	Programmed in COBOL. Consists of three modules - time, cost and resources.
10. PACIFIC/370		IBM	IBM/370, DOS	An integrated system for estimating and billing for progress payments on unit price contracts and cost control.
a. Estimating Module	Estimating			
b. Work Measurement and Billing Module	Work Measurement and Billing			
c. Cost Control Module	Cost Control			

APPENDIX B (CONTINUED)

PROGRAM NAME	APPLICATION	VENDOR	COMPUTER	REMARKS
11. Project-II	CPM/Precedence, resource allocation, cash flow, time and cost control	Project Software and Development Inc.	IBM/370,OS	Problem oriented language for project managers. Scheduling control cost and resource management problems.
12. CPM/PROMOCOM	Network processing, cost analysis	General Electric	GE/200	Both "Normal" and "Crash" activities, times and costs can be input, to obtain a time-cost tradeoff.
13. (CPMIS) CPM Based Management Information System	CPM based multi project time and cost management system	Glenn L. White	370/125,OS,DOS	It provides multiple reporting, time and cost scheduling, trouble shooting, resource analysis, material and equipment acquisition scheduling, requisition and payment administration, budget analysis. It can produce in excess of 200 different reports.
14. CPM/RPSM (CPM/ Resource Planning and Scheduling Method	For project management	K & H Computer System Inc.	IBM 360/370,OS,DOS CDC 3300/3500 CDC 6600 ICL 1900 Univac 1108	Compute critical path. Resource allocati To assist the project manager in planning, directing, staffing, scheduling, analysing and controlling the project advantages.
15. (MPM) Multi-Project Management System	CPM based program to manage schedule dependent resources and costs for many projects	General Electric	Honeywell 6080	For top management; to control large projects and to meet company goal.
16. PROCON 3	In project planning and control	Craig & Nichols	IBM 360/370,OS,DOS	For data processing design engineering, plant maintenance, product development, sales campaign, financial audits, consulting assignments, contract proposals
17. PERT 6	Planning & monitoring single or multiple projects	Dynamic Solutions Inc.	DEC System 10	To provide project managers report on scheduling, resources, costs and responsibili multilevel reporting system. Can handle up t 100 projects with maximum of 2000 activities/ project.

APPENDIX B (CONTINUED)

PROGRAM NAME	APPLICATION	VENDOR	COMPUTER	REMARKS
18. PRIDE	For design, development	M. Bryce & Associates		It has: 1. Planning features which include planning simple and complex projects; planning check list; estimating guidelines; optional planning hierarchy; automatic schedule generation; resource availability analysis; network analysis with graphic plotter or printer out; project task dependencies and priorities. 2. Control features: Employee assignment report by week; easy turn around time sheet; forward impact scheduling; completion date and cost forecasting; resource forecasts; trend graph, bar charts at all levels
19. PCM (Project Cost Model)	For financial control in the capital investment and construction industry	Project Software Ltd.	IBM 360/370	It uses a simple model of a project in terms of tasks, resources, money and time. Estimating, planning, cost control, decision making. Forecasting, cash-flow control, resource planning, work schedule.
20. (SPREDX) Project Scheduling/Resource Analysis	For project scheduling and resource allocation CPM based	Computer Science Corp.	Univac 1108 65K Computer System	It can process network, resource allocation. It can do precedence diagramming and can process cost of activities.
21. Space-Bank	Text & file manipulation for the varied purposes of personnel/ student records and inventory accounting files	Spectrum Inc.	8.4 K Storage computer	It can be customised for specific purposes. It has limitless report styles, multiple inventor system, financial planning, comprehensive personnel system, safety records, payroll system data modification.

APPENDIX C. SPECIAL PROGRAMS

PROGRAM NAME	APPLICATION	VENDOR	COMPUTER	REMARKS
1. (COPES) Cost planning and Evaluation System	Cost control and reporting to management on both project and functional basis	McDonnel Douglas Automation Company	IBM 370/135,OS	COBOL-BAC,160K It can handle budgets, estimates, commitments forecasts, and actual costs incurred, time orientation to the cost types. Cost subdivisions are Labor, Material, Equipment, Subcontract, Indirect.
2. Remote Terminal Cost Estimating	Payroll, Accounting and estimating	Civil Engineering Sys. Lab., Univ. of Illinois, Urbana Champaign	Burrough B55000 computer high speed printer	For lump-sum, unit price and resource enumerating and costing. ALGOL programming language.
3. Construction Estimating	Cost estimate of construction projects for general and subcontractors	IBM	IBM 1130 Disk Monitor sys. Version 2, 1132 printer	Estimates are made in accordance with uniform system of 16 divisions. Programmed in Fortran under (PLAN) problem language analyzer. It can accommodate 176 cost categories. Over 800 cost codes, 8K,1442 Card Read Punch. Take off, specification, cost data.
4. Inventory Control	Inventory Control	General Electric	G.E. Mark II	Serves as generalized order processing and finished inventory control system.
5. CPM/Project Monitor and Control System	CPM Analysis	General Electric	G.E. 400	Creates network schedules and allows updating as the project progresses.
6. PERT/Cost	Cost Analysis	General Electric	G.E. 600	Produces cost control reports based on PERT time data.
7. Capital Equipment Investment Analysis	Analysis of alternatives to purchasing new equipment	General Electric	G.E. Mark II	Using Monte Carlo simulation, this program simulates the cash flow resulting from different production alternatives.

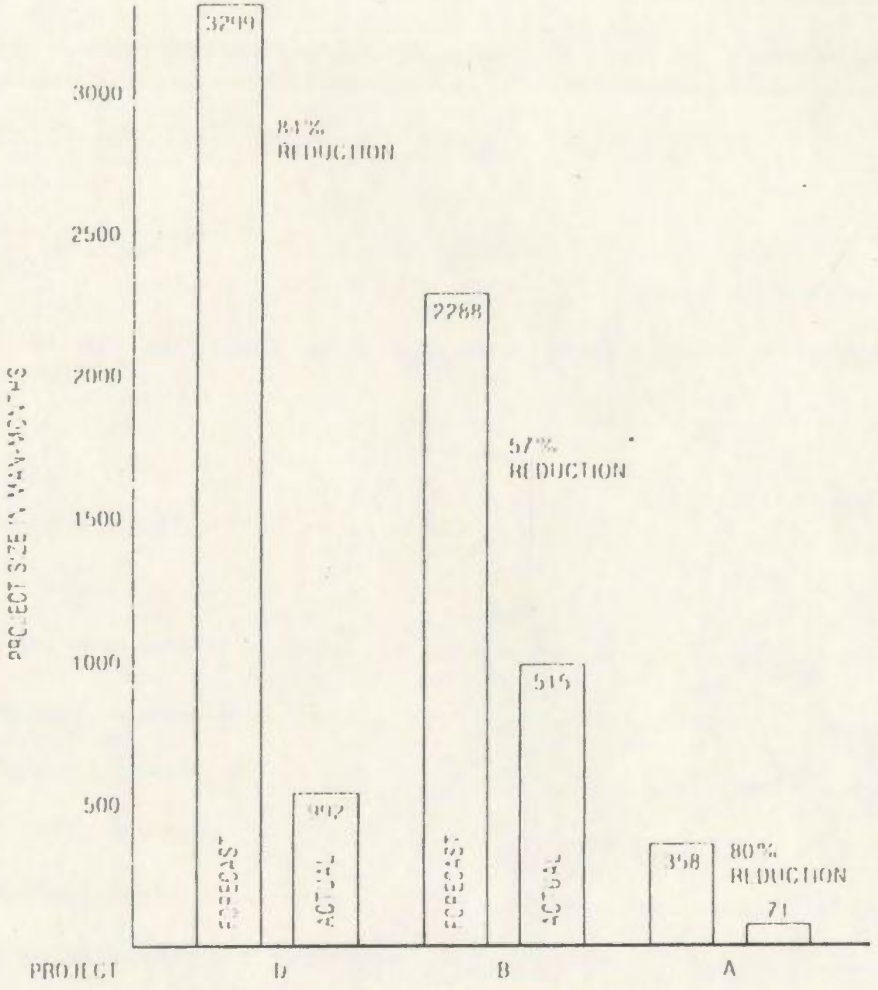
APPENDIX C (CONTINUED)

PROGRAM NAME	APPLICATION	VENDOR	COMPUTER	REMARKS
8. General Purpose Simulation System GASP IV	Simulation	IBM	IBM 370,OS CDC 3200,6500,6600, Burrough 5500,6700 PDP10,Xerox Sigma 9, GE635, XDS Sigma 7, Honeywell 600,635, 3200,6000	Problem-oriented language, based on queing theory, generates statistics for queues and facilities. GASP IV Subprogram provides System state and event control, statistical data collection; graphical plotting, histograph; random variate generation; information storage and retrieval.
9. Linear Programming System/370	Linear programming (Optimization)	IBM	IBM/370,OS	Use the simplex method of linear programming.
10. FASNET (Fast Network)	For fast network processing	University Computing Company		It can handle network with up to 2500 activities and 1000 events and based on CPM.Apath trace feature, multiple loop detector.
11. Equipment management System	For equipment management and control system	Construction information system	IBM 360/370,OS,DOS	It provides equipment inventory and cost accounting; equipment billing; equipment budgetary control system (rental and actual) productivity. Maintains equipment pool. Modification is possible
12. EZPERT (easy PERT)	For plotting Ganlt charts, time-scaled networks. Cost/ Resource graphs from PMS, MSCS Project II	Systonetics Inc.	IBM 360/370, Medium to large digital computers	It produces automatically graphical display of Ganlt barcharts, cost manpower resource graphs, task charts (an aid to developing the logic of a project network).
13. (SPREDP) Precedence Network Diagram Plotting	Precedence network Plotter	Computer Science Corp. (CSC)	Univac 1180, 65K Computer System and calcomp drum plotter	To prepare CPM precedence network diagrams for scheduling, lays out and produces a finished network diagram showing sequential relationship between activities with description, duration and label.
14. (PROMIS/RAM) Project Oriented Management Information System/Resource Allocation Module	To aid in project management of resources by profiling and or scheduling	Burroughs Corporation	B2500/2700/3700 3500/6700/7700	Resource allocation, resource profile, resource utilization reports. Functionally related to PROMIS/TIME & COST modules. Time module is the only prerequisite for it.

APPENDIX C (CONTINUED)

PROGRAM NAME	APPLICATION	VENDOR	COMPUTER	REMARKS
15. (Q-GERT) QUEUEING-Graphical Evaluation and review technique	A network simulation language for queueing problem and logistics	Pritsker & Ass. Inc.		It models and analyses networks of queues. It draws probability, statistics and histograms of Q-nodes
16. T/A Series CPM Programs	Network based management information system	Time/Audit Ltd.	IBM 155/370	Network scheduling by I-J oriented activity. Resources are handled by pacemaker.
17. CAS/CPA/FMR	Accounting	Boole & Babbage, Inc.	IBM 360/370, OS,VSI SVS,MVS	Billing, accounting, performance and management reporting.
18. CONTROL/IMS	Accounting	Boole & Babbage, Inc.	"	Transaction accounting, performance reporting, terminal accounting record, program accounting records
19. JASPER	Accounting	Datachron Corporation	"	Job accounting, billing, computer performance analysis reports, graphic displays.
20. GRASP	Accounting	SDI	"	Accounting, billing, and performance measurement

APPENDIX D: UNCERTAINTY CURVES[1]



Improvement of actual man-months over forecast man-months on three Boeing software projects as a result of adopting modern programming practices.

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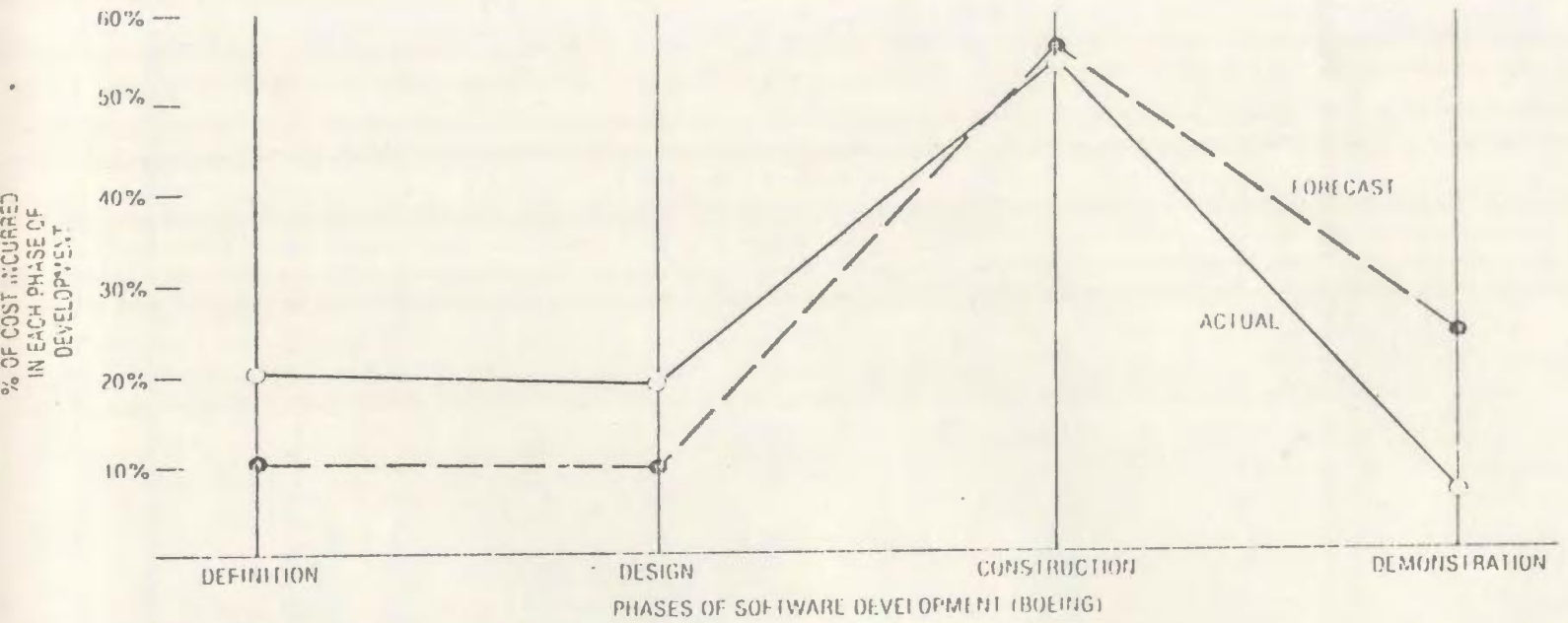
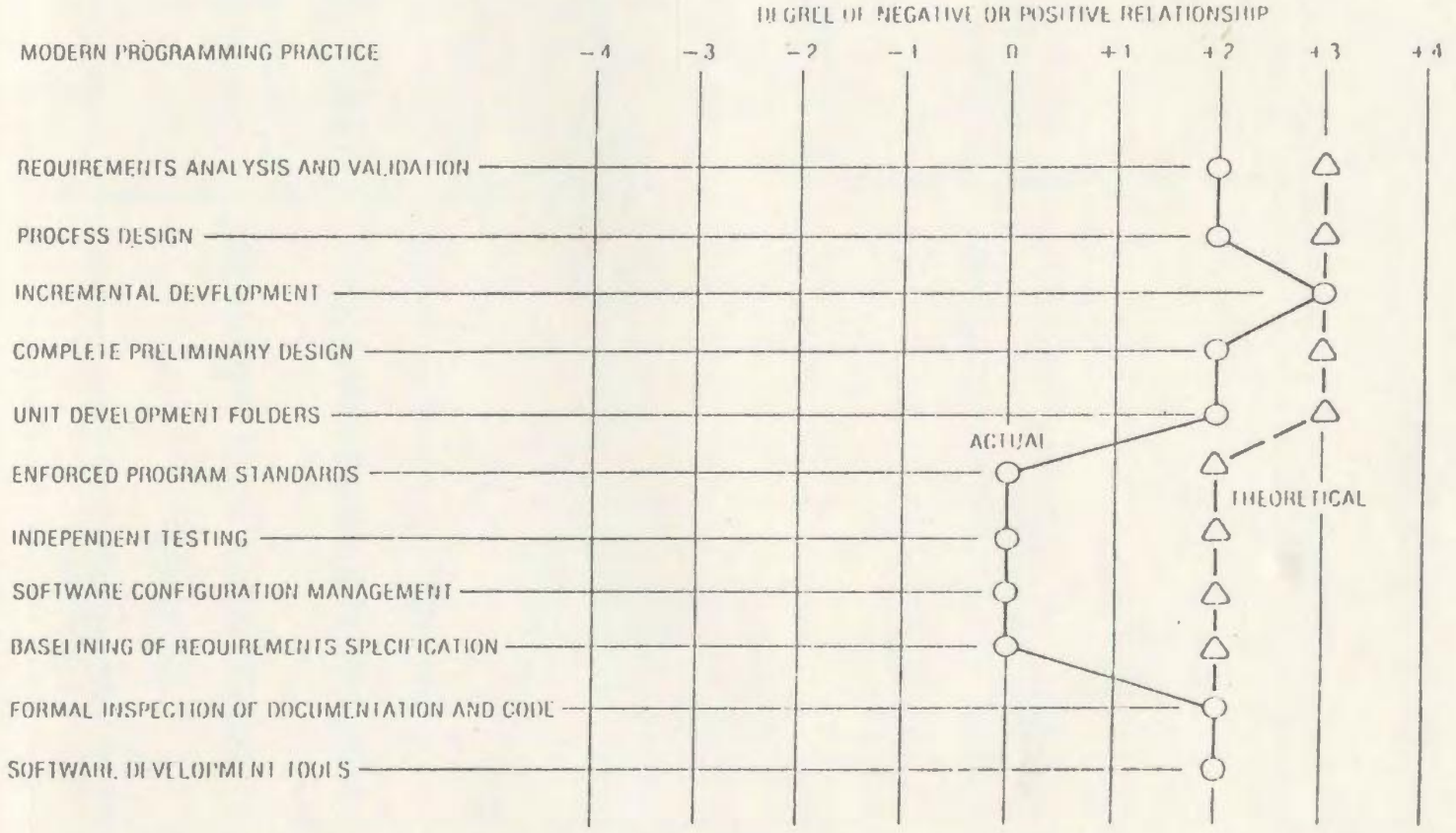
[1]W. Myers, The Need for Software Engineering, Computer, February, 1978.

APPENDIX D (continued)



Forecast cost distribution shifts to earlier phases when modern programming practices are employed (average of three projects).



The correlationships between the modern programming practices and the summation of the twelve software problems is stronger in the theoretical case than in the actual case by about two to one.

APPENDIX E (PART I): Questions and Reports for Contractual Needs

QUESTION	ESSENTIAL	BREAKDOWN	REPORTS*
SCHEDULING			
Are all milestone targets being accomplished?	Milestone Schedule Completion/ Milestone Actual Completion	Milestones	AS_1
Are all activities performed on schedule?	Activity Schedule Completion/	Activity	AS_2
If not, which activity is causing slippage?	Activity Actual Completion/ Slippage		
MANHOURS			
Are manhours utilized within the budget?	Revised Budget/Actual to Date/ Forecast to Complete/Manhours	Charge number	MH_1
Is productivity for various work classifications as per budget?	1. Estimated/This Period/To Date/ Manhour Unit Cost	Work classification	MH_2
	2. Qunatity of Work/Manhours	Cost code	
MATERIALS			
Is the quantity of materials requisitioned as per bill of materials?	Estimated, Required Quantity/ Description/Unit Cost/Amount	Individual material	MT_1

*- Reports are in Part II of this Appendix E.

APPENDIX E (PART I)

QUESTION	ESSENTIAL	BREAKDOWN	REPORTS*
Is material wastage within reasonable limits?	Actual/Budget/Forecast to Complete/Wastage	Individual Material	MT_2
Are materials being procured on time?	Description/Quantity/Expedite date/Delivery date	Individual Material	MT_3
EQUIPMENT			
Is equipment cost per unit of work as per plan?	Estimated/This Period/To date/ Equipment Unit Cost	Work classi-faction cost code	EQ_1
Is equipment being fully utilized?	Last Day of Use on the Present Project/Time Required to Repair/ Time Required to Deliver/Date When Required on the Project	Individual equipment	EQ_2
Is each piece of equipment economical?	1. Information for EQ_1 and EQ_2 2. Total Cost per Changes 3. Repairs/Maintenance/Insurance & Taxes/License/Rental Rate/ This month/To Date	Individual equipment	EQ_3

APPENDIX E (PART I)

QUESTION	ESSENTIAL	BREAKDOWN	REPORTS*
SUBCONTRACTOR			
Will each subcontract be finished within its cost target?	Revised Budget/Actual Cost to Date/ Forecast to Complete Cost	Charge number	SC_1
What will total cost of subcontract be with expected changes & alteration?	Budget/Change Orders/Revised Budget	Charge number/ Work classification cost code	SC_2
Do subcontract payments closely approximate actual progress on the subcontract?	Actual cost to date/Progress claim to date	Charge number	SC_3
INDIRECT COST			
What is the production cost in each shop/ plant?	1. Estimated/This period/To date manhour unit cost 2. Estimated/This Date/To Date Equipment Unit Cost 3. Actual/Budget/Forecast to Complete Cost/Quantity	Charge number/ Work classification cost code	IC_1
Are field overhead costs within budget?	Actual/Budget/Forecast to Complete Cost	Charge number/ Work classification cost code	

APPENDIX E (PART I)

QUESTION	ESSENTIAL	BREAKDOWN	REPORTS*
TOTAL COST			
Will the contract be completed within budget?	Revised Budget/Forecast to Complete Cost	Charge number	TC_1
What is the budget including all change orders?	Budget/Change Orders/Revised Budget	Charge number/ Work Classification cost code	TC_2
What and where are deviations of actual cost from budgeted cost?	Revised Budget/Forecast to Complete Cost/Overrun and Underrun	Same as above	TC_3
What is the deviation of present budget from the original budget?	Budget/Revised Budget	Charge number	TC_4
Are commitments included in the forecast to complete cost?	Commitment to Date/Forecast to Complete Cost	Charge number	TC_5
PROGRESS PAYMENT			
Do progress payments correspond to the value of work done?	1. Value of Work Complete to Date/ Total Amount Claimed to Date	Charge number/ Work	PP_1

APPENDIX E (PART I)

QUESTION	ESSENTIAL	BREAKDOWN	REPORTS*
	2. Revised Budget/Progress Claimed to Date	classification cost code	
CASHFLOW			
Does the availability of funds match the pace of progress?	Revenue/Expenditure	Charge number	CF_1
Are financing costs kept to a minimum?	Estimated/Actual Outflow/Interest Cost	Charge number	CF_2
CHANGE ORDER			
Do the change orders cover the direct costs and include provisions for contingencies, escalation, overhead and mark-up?	Change Order Cost Estimate	Charge number/ Work classification cost code	CO_1

APPENDIX E (PART I)

QUESTION	ESSENTIAL	BREAKDOWN	REPORTS*
OVERHEAD COST			
Is the cost of office overhead as per plan?	1. Standard Rates/Carrying Accounts 2. Actual/Budget/Forecast to Complete Cost	Charge number/ Work classification cost code	OC_1

Activity Status Report (AS_1)

(1) PROGRAM C3PCT BETA TEST PMS 442 NETWORK — BETA — RUN DATE 26JAN
PROJECT (2) 03PCT DESIGN AND MANUFACTURING SUPPORT SUB1

LEVEL DETAIL (5) — SORTED BY SUCC,PRED (4)

PRED. EVENT (6)	SUCC. EVENT (7)	CYCLE CODE (8) (9)	ACTIVITY DESCRIPTION (10)	TIME ESTIMATES (11) A	M	B	SLACK (12) PRIMR	SECND	COMPLETION DATES (13) EXPECTED	LATEST	SCHED. DATE (14)	DEPT. (15)
I1		I	INTERFACE FROM SUB1 TO SUB2				45.5	.0	21SEP87	14NOV69		
I2		I	INTERFACE FROM SUB1 TO SUB2				.0	.0	12JAN69	12JAN69		
I3		I	INTERFACE FROM SUB1 TO SUB2				60.5	.0	18JUN87	24SEP87		
I4		I	INTERFACE FROM SUB1 TO SUB2				12.5	.0	23NOV87	21NOV87		
23001		F	C MOTOR MANUFACTURING				.0	.0	02DEC68	02DEC68		
23021		F	1ST CUSTOMER ACCEPTANCE				.0	.0	02DEC68	02DEC68		
24030	I1	AA	INTERFACE FROM SUB1 TO SUB2	200.0			45.5	.0	21SEP87	14NOV69		
23020	I2	AA	INTERFACE FROM SUB1 TO SUB2	200.0			.0	.0	12JAN69	12JAN69		
22013	I3	AA	INTERFACE FROM SUB1 TO SUB2	200.0			60.5	.0	18JUN87	24SEP87		
20002	I4	AA	INTERFACE FROM SUB1 TO SUB2	200.0			12.5	.0	23NOV87	21NOV87		
	I5	I	INTERFACE TO SUB1 FROM SUB2				45.5	.0	01JAN88	02DEC68		
	I6	I	INTERFACE TO SUB1 FROM SUB2				10.0	.0	02APR88	02DEC68		
	I7	I	INTERFACE TO SUB1 FROM SUB2				60.5	.0	01SEP87	02DEC68		
	I8	I	INTERFACE TO SUB1 FROM SUB2				57.5	.0	01DEC87	02DEC68		
	START	S	MISSILE X 61				.0	.0	03DEC66	03DEC66		
START	10000	AA	S CHAMBER ASSEMBLY DESIGN	200.0			.0	.0	03DEC66	03DEC66		
10000	10001	AA	C CHAMBER ASSEMBLY DESIGN	400.0			.0	.0	19FEB67	19FEB67		
10001	10002	AA	CHAMBER ASSEMBLY DESIGN APPROV	400.0			.0	.0	26FEB67	26FEB67		
I5	10003	CC	CHAMBER ASSEMBLY DESIGN FIRMED	800.0			45.5	.0	12JAN68	02DEC68		

ACTIVITY SCHEDULE LISTING (AS_2)

PAGE 1

PROGRAM (1) PRELIMINARY CONSTRUCTION NETWORK FOR THE CHANNEL TUNNEL CHUNI — RUN DATE 06FEB70 (3)
PROJECT (2) ACTUAL CONSTRUCTION NET FOR THE CHUNNEL BUILD

SORTED BY DEPT,SCHED START (4)

PRED. EVENT	SUCC. EVENT	CYCLE CODE	ACTIVITY DESCRIPTION	SLACK (5) PRIMR	SCHED	DURATIONS ORIG.	LEFT	START DATES EARLY	SCHED	COMPLETION DATES EARLY	SCHED	DEPT
	ST020	S	START(2) DESIGN	26.8	26.8	0.00	0.00	01JAN70	A01JAN70	01JAN70	A01JAN70	
	ST010	S	START(1) SURVEY	16.8	16.8	0.00	0.00	01JAN70	A01JAN70	01JAN70	A01JAN70	
	FACE1	I	EQUIP START INTERFACE	16.8	16.8	0.00	0.00	26FEB71	26FEB71	26FEB71	26FEB71	
	FACE2	I	EQUIP END INTERFACE	16.8	16.8	0.00	0.00	21MAY75	21MAY75	21MAY75	21MAY75	
ST020	FACE1	DW	PRELIMINARY DESIGN	26.8	26.8	50.00	0.00	01JAN70	A01JAN70	17DEC70	17DEC70	DN
	PRIM RES TO AT LEVEL 1 FROM START TO END ALT CODE 0 NO ALT RES SPECIFIED ON CARD PRIM RES USED											
	MD 1 START END 0 NO ALT RES SPECIFIED ON CARD PRIM RES USED											
	CC 1 START END 0 NO ALT RES SPECIFIED ON CARD PRIM RES USED											
ST010	FACE1	DW	SURVEYING	16.8	16.8	60.00	0.00	01JAN70	A01JAN70	26FEB71	26FEB71	DN
	PRIM RES SV AT LEVEL 100 FROM START,TO END ALT CODE 0 NO ALT RES SPECIFIED ON CARD PRIM RES USED											
	LK 50 12.00 END 0 NO ALT RES SPECIFIED ON CARD PRIM RES USED											
FACE1	BORED	DW	DETAIL DESIGN (TUNNEL)	73.0	73.0	70.00	0.00	26FEB71	26FEB71	30JUN72	30JUN72	DN
	PRIM RES TC AT LEVEL 1 FROM START TO END ALT CODE 0 NO ALT RES SPECIFIED ON CARD PRIM RES USED											
	LK 50 52.60 END 0 NO ALT RES SPECIFIED ON CARD PRIM RES USED											

ACTIVITY BAR CHART (BC_1)

PAGE 1

① PROGRAM NETWORK DESCR.
② PROJECT SUBNET DESCR.SUBNET01

BRIDGEPR
SUBNET01

③ RUN DATE 19JUN7

PRED EVENT	④ SUCC EVENT	I	A - ACTIVITY COMPLETE * - ACTIVITY DURATION	⑤	C - ACTIVITY CRITICAL F - ACTIVITY FLOAT	I	⑥ FLOAT	⑦ DEPT
AA	V2	I				I	.0	OC
A1	A2	I				I	2.0	OW
A2	C2	I				I	2.0	HE
A2	D2	I				I	22.0	HX
A2	D2	I				I	22.0	HX
A2	D2	I				I	22.0	HX
C2	G2	I				I	.0	HE
C2	U2	I				I	72.0	OC
D2	U2	I				I	22.0	HX
D2	U2	I				I	22.0	HX
G2	I2	I				I	22.0	OC
I2	J2	I				I	22.0	OC
I2	J2	I				I	22.0	CC
J2	U2	I				I	.0	CC
J2	V2	I				I	28.0	HE
U2	AA	I				I	.0	HE
U2	V2	I				I	22.0	HE
V2	W2	I	CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC			I	.0	HE
W2	X2	I			CCCCCCCCCCCCCCCCCCCCCCCCCCCCCCCC	I	.0	OC
W2	A2	I			*********FFFFFFFFFFFFFFF	I	10.0	OC
X2	I2	I			******FFFFFFFFFFFFFFFFF	I	10.0	FW

15MAR69 27MAR69 08APR69 20APR69 02MAY69 14MAY69 26MAY69

⑧

ACTIVITY SCHEDULE BAR CHART (BC_2)

PAGE 1

① PROGRAM NETWORK DESCR.
② PROJECT SUBNET DESCR.SUBNET01

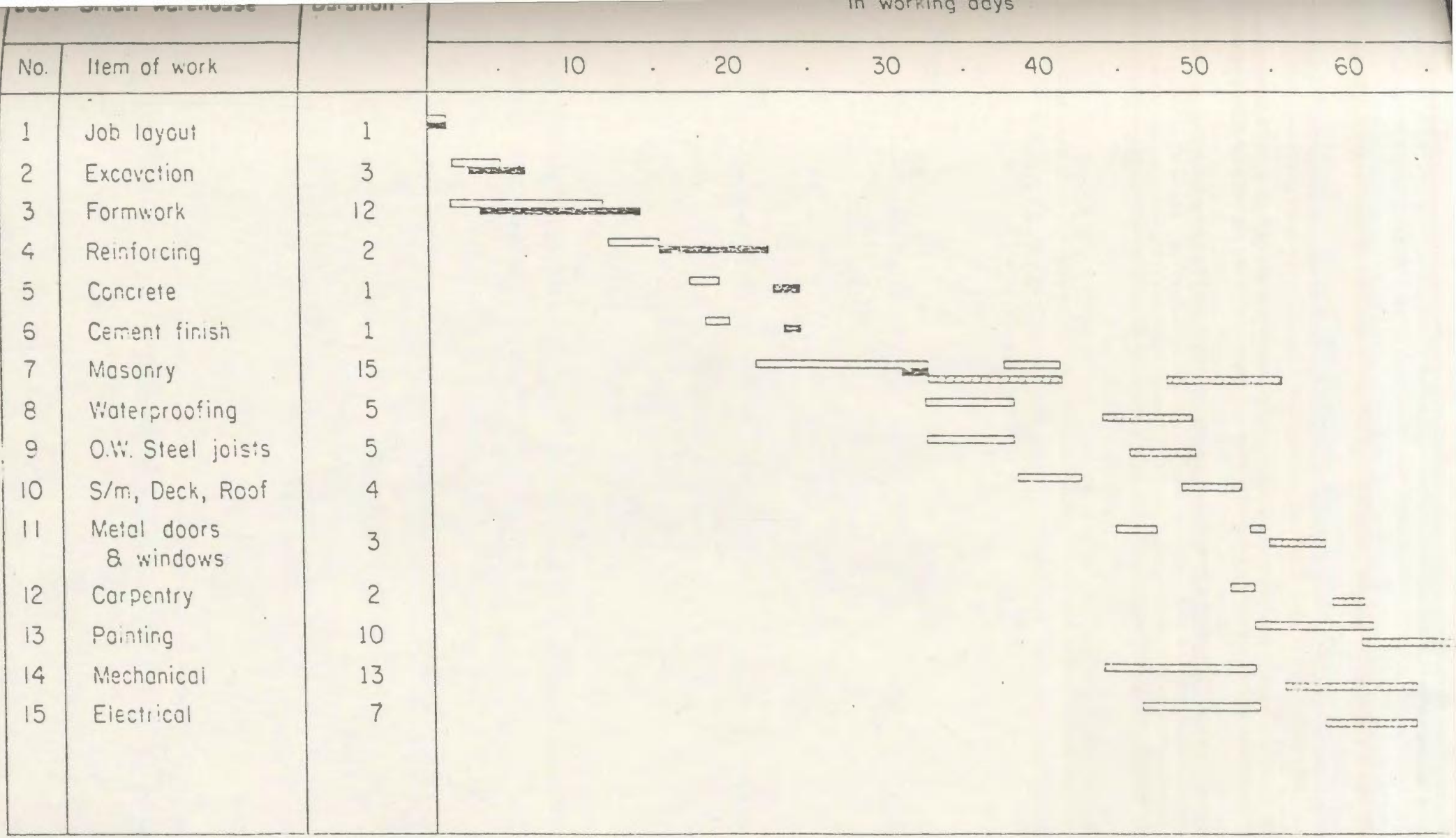
BRIDGEPR
SUBNET01

③ RUN DATE 19JUN70

PRED EVENT	④ SUCC EVENT	I	- - ACTIVITY SPAN	⑤	* - ACTIVITY SCHEDULED PERIOD	I	SCHED. ⑥ FINISH	⑦ DEPT
AA	V2	I				I	26FEB69	OC
A1	A2	I				I	06SEP68	OW
A2	C2	I				I	17SEP68	HE
A2	D2	I				I	12SEP68	HX
A2	D2	I				I	26SEP68	HX
A2	D2	I				I	24OCT68	HX
C2	G2	I				I	08OCT68	HE
C2	U2	I				I	22OCT68	OC
D2	U2	I				I	06JAN69	HX
D2	U2	I				I	27JAN69	HX
G2	I2	I				I	06NOV68	OC
I2	J2	I				I	06DEC68	OC
I2	J2	I				I	06DEC69	CC
J2	U2	I				I	14FEB69	CC
J2	V2	I				I	25FEB69	HE
U2	AA	I				I	17FEB69	HE
U2	V2	I				I	18FEB69	HE
V2	W2	I	**********			I	09APR69	HE
W2	X2	I			**********	I	07MAY69	OC
W2	A2	I			**********----------	I	30APR69	OC
X2	I2	I			******----------	I	05MAY69	FW

⑧ 15MAR69 27MAR69 08APR69 20APR69 02MAY69 14MAY69 26MAY69

No.	Item of work	Duration in working days
1	Job layout	1
2	Excavction	3
3	Formwork	12
4	Reinforcing	2
5	Concrete	1
6	Cement finish	1
7	Masonry	15
8	Waterproofing	5
9	O.W. Steel joists	5
10	S/m, Deck, Roof	4
11	Metal doors & windows	3
12	Carpentry	2
13	Painting	10
14	Mechanical	13
15	Electrical	7



Original plan

Actual progress

Revised plan

Bar Chart (BC_3)

CHANGE ORDER AUTHORIZATION

Newfoundland & Labrador Construction Co. Ltd.
Labrador City

Date _____

Change Order No. _____

Contractor's Change Estimate No. _____

Project:

To:

In accordance with the terms of our contract agreement covering the above-mentioned project you are authorized to

Add the sum of $

Deduct the sum of $

The new completion date will be _____

Newfoundland Development Corporation

By:

Change Order Authorization (CO_1 - part 1)

Newfoundland Construction Company Ltd.

Labrador City

Request for Change Order

TO:

No. _____

DATE: _____

Project No:

Description:

Below listed are changes in our contract price. Until formal change order has been issued this request for change will be held in suspense status.

Applications of increases (or decreases) in time and price of contract are as follows:

COST CODE	DESCRIPTION OF WORK	INCREASE	DECREASE
	TOTAL THIS CHANGE REQUEST		
	NET CHANGE		
	CONTRACTOR'S FEE		
	TOTAL CHANGE		

REQUEST CONTRACT TIME EXTENSION (OR DECREASE)OF _____CALENDER DAYS IF ABOVE ACCEPTED.

CONTRACTOR:

Approved _____ Date_____ By_____ Date_____

Request for Change Order (CO_1 - part 2)

Change Order Summary (CO_2)

D A T E DDMMYY PROJ NO-..... .TITLE.TITLE.TITLE.TITLE.TITLE.TITLE.TITL PAGE 1

P R O J E C T P H A S E		ORIGINAL AWARD OR ESTIMATE	APPROVED CHANGE ORDERS	REVISED CUMULATIVE COST ESTIMATE	FACE VALUE PENDING C/OS AND CLAIMS	MAXIMUM EXPOSURE AT COMPLETION	STATUS
		A	B	C=A+B	D	E=C+D	F
LAND	COST TO ACQUIRE LAND	1,900,000		1,900,000		1,900,000	CK
MISC	INSPETEST LABS,METHANE & MISC COST	436,240		436,240		436,240	CK
PROJ	MAN-BSC PROJECT ADMINISTRATION	4,794,660	133-	4,794,527		4,794,527	UCR
SITE	DIKE, UTILITIES, ROAD IMPROVEMENT	14,255,159	144,911	14,400,070	243,241	14,643,311	UCR
SOIL	TEST PILE & SOIL ENGINEERING WORK	752,013	11,414-	740,599		740,599	UCR
STUD	VARIOUS STUDIES & INVESTIGATIONS	221,016	2,686-	218,330		218,330	UCR
010	COLLEGE BUILDING 010	20,927,094	43,230-	20,883,864	8,019	20,891,883	UCR
020	COLLEGE BUILDING 020	20,118,234	232,221	20,350,455	18,163	20,368,618	UCR
080	SCIENCE BUILDING 080	24,685,183	303,759	24,988,942	164,248	25,153,190	UCR
090	LIBRARY BUILDING 090, PLAZA&RAMPS	22,201,629	395,928	22,597,557	127,594	22,725,151	UCR
110	ADMINISTRATION BUILDING 110	5,245,600	43,264-	5,202,336	5,658	5,207,994	UCR
150	SERVICE & SUPPLY BUILDING 150	4,409,115	27,876	4,435,991	3,711	4,439,702	UCR
160	UTILITY BUILDING 160 & PUMP HOUSE	2,553,350	35,552-	2,517,798	1,101	2,518,899	UCR
	U N A L L O C A T E D						
	••• T O T A L S •••	122,498,293	968,416	123,466,709	571,735	124,038,444	

APPENDIX E (PAGE 119)

Job Motel Vanguard

Job No. 34

EQUIPMENT SUMMARY SHEET

Date May 10, 1980

Weather Overcast

Prepared by D. Collin

Equipment No.	Equipment	working / idle / repair	Cost Classification AA 02200	Total Hours	Hourly Rate	Amount
791	D6 Dozer	W	5	5	25.00	$125.00
		I	1	1		25.00
		R	2	2		50.00
804	3/4 cu.yd. Backhoe	W	5½	5½	23.00	$126.50
		I	2½	2½		57.50
		R				
		W				
		I				
		R				
		W				
		I				
		R				
		W				
		I				
		R				
TOTAL			16		WHR TOTAL	125.00 50.00 357.50

Equipment Summary Sheet (EQ_1)

APPENDIX E (part-II) 120

Equipment Use Schedule (EQ_2)

Particulars of Equipment (number, manf., model, year, and description)	PROJECT on which currently in use.	PROJECT on which requisitioned.	LAST DAY of use on the present project.	TIME required to repair/ deliver equipment.	DATE when required on other project.	REMARKS
Equip. #798 Caterpiller D6C Dozer (1976) 140 HP	Job #34	Job #32	Mar 18/80	3 days	Mar 25/80	Repair & move to next job
Equip. #804 International 3/4 cyd. Backhoe (1977)	Job. #34	Job #34	Mar 25/80	1 day		Return to Equip Pool
Equip. #786 P.& H Model T-150 15 Ton Hydraulic Truck Crane (1973)	Job #33	Job #28				Still required Job #33

EQUIPMENT COST REPORT

EQUIPMENT	HRS. USED	OPERATING COSTS MAIN. & REPAIR COSTS	FUEL COSTS	TOTAL OPERAT. COSTS	AVERAGE COST PER HR.	OWNERSHIP COSTS DEPR. COSTS	TAXES INSURANCE INTEREST		AVERAGE COST PER HR.
MOTOR GRADER #1	200	1,250.00	1,000.00	2,250.00	11.25	4,000.00	500.00	4,500.00	22.50
MOTOR GRADER #2	500	1,300.00	1,450.00	2,750.00	9.16	4,000.00	500.00	4,500.00	15.00
MOTOR GRADER #3	100	1,600.00	600.00	2,200.00	22.00		500.00	300.00	3.00
TOTALS/ AVERAGES	600	4,150.00	3,050.00	7,200.00	12.00	8,000.00	1,300.00	9,300.00	15.50

DEPRECIATION RECORD (EQ_4)

DESCRIPTION *D7 Caterpillar tractor with pipelayer* EQUIPMENT NO. *14-82*

Date	Depreciation			Book value	Total cost	Date	Depreciation			Book value	Total cost
	Rate per mo	Amount	To date				Rate per mo	Amount	To date		
7/ :/68	409 43			19,552 84	19,552 84	7/31/69	409 43	409 43	5,322 59	14,230 25	19,552 84
7/31/68		409 43	409 43	19,143 41		8/31/69		409 43	5,732 02	13,820 82	
8/3 /68		409 43	818 86	18,733 98		9/30/69		409 43	6,141 45	13,411 39	
9/30/68		409 43	1,228 29	18,324 55							
10/31/68		409 43	1,637 72	17,915 12							
11/30/68		409 43	2,047 15	17,505 69							
12/31/68		409 43	2,456 58	17,096 26							
1/31/69		409 43	2,866 01	16,686 83							
2/28/69		409 43	3,275 44	16,277 40							
3/31/69		409 43	3,684 87	15,867 97							
4/30/69		409 43	4,094 30	15,458 54							
5/30/69		409 43	4,503 73	15,049 11							
6/30/69		409 43	4,913 16	14,639 68							

Depreciation rate *25* percent per year

RENTAL RECORD (EQ_5)

DESCRIPTION *D7 Caterpillar tractor with pipelayer* EQUIPMENT NO. *14-82*

Date	Rentals			Date		Date	Rentals			Date	
	Rate per month	Month	To date	In	Out		Rate per month	Month	To date	In	Out
11/68	1,850 00	1,850 00	1,850 00	11/1	11/30						
12/68		1,850 00	3,700 00	12/1	12/31						
1/69	18 days	1,386 00	5,086 00	1/3	1/24						
2/69	16 days	1,206 00	6,292 00	2/5	2/23						
3/69		1,850 00	8,142 00	3/1							
4/69		1,850 00	9,992 00								
5/69	14 days	1,050 00	11,042 00		5/17						
7/69	15 days	1,142 00	12,184 00	7/2	7/20						

REPAIRS AND OPERATING EXPENSE (EQ_6)

DESCRIPTION *D7 Caterpillar tractor with pipelayer* EQUIPMENT NO. *14-82*

Date	Ref	Description	Repairs	Maintenance	Insurance	License and taxes	Total	Total to date
9/4/68	B480	Misc labor & material	38 96					38 96
10/9/68	B524	Inst rockguards & labor	86 45					125 41
11/12/68	A624	Tune & adjust engine	6 25					131 66
1/8/69	A648	Labor repairing sideboom	16 80					148 46
4/16/69	A716	Labor repairing tracks	24 40					172 86
4/24/69	C562	Insurance - 1 yr.			92 60			265 46
4/26/69	D236	License & taxes - 1 yr.				128 60		394 06

JOB: Warehouse

EUIPMENT UNIT COST REPORT

DATE OF REPORT: April 1, 1980

JOS #: 2-7

PREPARED BY: G. Jones

WORK CLASSIFICATION	UNITS	QUANTITY			COST			UNIT COST			PERCENTAGE VARIANCE (Col. 9&11)
		ESTIMATED	THIS PERIOD	TO DATE	ESTIMATED	THIS PERIOD	TO DATE	ESTIMATED	THIS PERIOD	TO DATE	
1	2	3	4	5	6	7	8	9	10	11	12
AA02300	Cubic Meter	97	97	97	16	20	20	0.16	0.21	0.21	-31

Equipment Unit Cost Report (EQ_7)

EQUIPMENT TIME DISTRIBUTION SHEET

MONTH 1979
EQUIPMENT Truck
EQUIPMENT NO. 61
USE-RATE PER HR.

DATE	WORK CLASSIFICATION	103	125	Total Spare Hrs.	Work Delays	Idle Time	Total Time
1	7½			7½		½	8
2	7			7		1	8
3	6½			6½	1	½	8
4	4	3		7	1		8
5		8		8			8
6		8		8			8
7	2	5½		7½	½		8
8		4		4			4
9							
10							
11							
12							
13							
14							
15							
16							
17							
18							
19							
20							
21							
22							
23							
24							
25							
26							
27							
28							
29							
30							
31							
Hours	27						
WITH COST	128.25						CREDIT ACCOUNT NO.

Equipment Time Distribution Sheet (EQ_8)

NEWFOUNDLAND AND LABRADOR CONSTRUCTION CO. LTD.

Equipment Ownership Card

Description: International 3/4 CYD Excavator HP-105.

Serial No.: 25791

Engine No.: 0017643P

Equipment No.: 804

Year: 1980

Model: 3964

Make: International

Purchase Record

Date Acquired	New/ Used	Vendor's Name	P.O. Number
May 2/80	New	John Doe Equipment Ltd.	1013

Invoice Record

Invoice Number	Invoice Date	Purchase Price	Weight	Freight	Tax	Total Cost
3159	May 2/80	72,000	37,200	-	7,200	79,200

Changes Record

Date	Description of Change	Invoice Number	Invoice Date	Cost of Change	Total Cost
July 21/80	1 cycl. bucket	6021	July 21/80	$2500	$1,200

Sales Record

Date Sold: To:

Sales Price $

Book Value $

Gain or Loss $

Remarks:

Equipment Ownership Card (EO_9)

NEWFOUNDLAND CONSTRUCTION CO. LTD.

UNIT: m^2

PRODUCTIVITY ANALYSIS REPORT COST CODE BB 04200

Period	Quantity		Cumulative Man-hours by Trade					Man-hours per unit by Trade				
	This Period	To Date	Mason	Labor-er	Carp-enter			Mason	Labor-er	Carp-enter		
Mar. 1-31	-	-	-	-	-							
Apr. 1-30	178.4	178.4	84	24	8			0.414	0.134	0.442		

Productivity Analysis Report (IC_1)

MANHOUR STATUS REPORT

BY CRAFT, MONTH, FOREMAN, COST CODE

CONTRACT DESCRIPTION:	REPORTING ORGANIZATION:	CONTRACT NO.	PERIOD: 01 Feb. 79 - 28 Feb. 79
Motel Vanguard	Walsh Electrical Ltd.	E 453	Cutoff Date: 02 Mar. 79
Level/Summary Item – Electrical Work			Release Date: 05 Mar. 79

IDENTIFICATION				MANHOURS				REMARKS
Month	Craft	Foreman	Cost Code	Actual	Budget	Forecast at Completion	(Overrun) Underrun	
78-01	EL	E4L3	LB16515	420	600	500	100	
			LB16550	200	800	1000	(200)	
			TOTAL	620	1400	1500	(100)	
78-02	EL	E4L3	LC16720	278	500	650	(150)	
			LC16740	45	200	200	0	
		E4L6	LC16750	124	100	200	(100)	
			TOTAL	447	800	1050	(250)	

MANHOUR STATUS REPORT ($'H_1$)

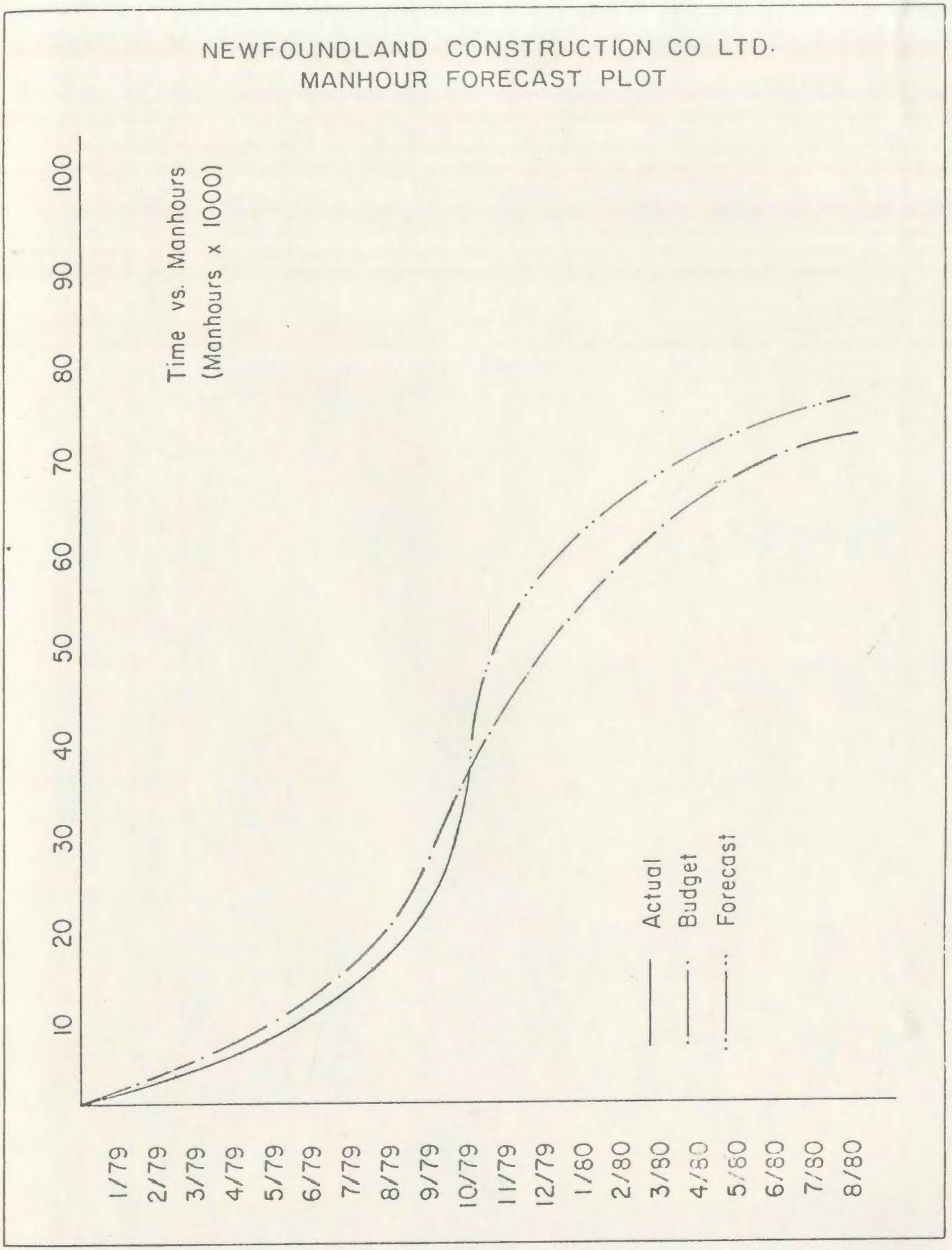
NEWFOUNDLAND CONSTRUCTION CO. LTD.
MANHOUR UNIT COST REPORT

JOB: Motel Vanguard
JOB #: 134

DATE OF REPORT: 80-03-01
PREPARED BY: A.K.Rielly

Work Classification Code	QUANTITY				COST			UNIT COST			PROFIT or (LOSS)	
	Units	Estimated	This Period	Forecast at Completion	Estimated	This Period	Forecast at Completion	Estimated	This Period	Forecast at Completion	To Date	Projected
1	2	3	4	5	6	7	8	9	10	11	12	13
BB 03100	m^2	353	83	354	$8550	$1795	$7011	$24 22	$21.52	$20.99	$224	$1539
BB 03200	tons	6.35	1.58	7.85	$4165	$1046	$2198	$656	$662	$655	($10)	($997)
BB 03300	m^3	191	46	201	$5776	$1534	$3239	$30.24	$33.35	$34.44	($143)	($1156)

Manhour Unit Cost Report ('11'2)



Manhour Forecast Plot (MH_3)

MANPOWER LOADING REPORT (MH_4)
BY RES.,PERIOD,PERF.DEPT., CHARGE NO.

CONTRACT DESCRIPTION | REPORTING ORGN. | CONTRACT NO. | REPORT DATES

CONTRACT DESCRIPTION 1111111111111111 | | CONTRACT NUMBER 11 | TERM (SPAN) -
CUT OFF DATE -10FEB67
LEVEL/SUMMARY ITEM- 1/CHARGE NUMBER DESCRIPTION OF LICI -- LICI | RELEASE DATE -12DEC66

IDENTIFICATION				MANHOURS				TIME	
ACCOUNTING PERIOD	RES. CODE	PERF DEPT	CHARGE NUMBER	ACTUAL	BUDGET	LATEST REVISED ESTIMATE	(OVER) UNDER PLAN	MOST CRIT. SLACK	REMARKS
1/66	AA	L4D3	L1C1	29	2,200	0	(29)		
			L4C1	2	0	0	(2)		
TOTAL				31	2,200	0	(31)		
2/66		L4D3	L1C1	88	2,000	0	(88)		
			L4C2	8	0	0	(8)		
		L6D3	L5C3	200	0	0	(200)		
TOTAL				296	2,000	0	(296)		
3/66		L4D3	L1C1	103	1,600	0	(103)		
			L5C3	160	0	0	(160)		
TOTAL				273	1,600	0	(273)		
4/66		L4D3	L1C1	103	1,600	0	(103)		
		L6D3	L5C3	160	0	0	(160)		
TOTAL				263	1,600	0	(163)		
5/66		L4D3	L1C1	77	2,000	0	(77)		
		L6D3	L5C3	200	0	0	(200)		
TOTAL				277	2,000	0	(277)		
6/66		L6D3	L5C3	200	0	0	(200)		
TOTAL				200	0	0	(200)		
7/66		L6D3	L5C3	240	0	0	(240)		
TOTAL				240	0	0	(240)		

SUBNET IDENTIFICATION D1A' MILESTONE REPORT (MR_1)

SUBNET DESCRIPTION-

CONTRACT DESCRIPTION	REPORTING ORGN.	CONTRACT NO.	REPORT DATES
			TERM (SPAN)-
			CUT OFF DATE- 31MAY66
LEVEL/SUMMARY ITEM- 1/9SO-G EXPERIMENTS		EXP	RESEASE DATE 15MAY68

MILESTONE DESCRIPTION	SLACK	DATE	P	SCHEDULE 1966 J F M A M J J A S O N D	1967 J F M A M J J A S O N D	1681691701701 1 1 1 1 1YR
				.		
		04JAN65	S	.		
60568	6.41	10JAN68		.		18
C PHOTO STRUCTURAL ASSY		22NOV67		.	L	
				.		
		04JAN65	S	.		
60600	5.91	26JAN68		.		18
PROTO ORAT SYS NO 1 ASSY		27NOV67		.	L	
				.		
		22DEC67		.	A	
60638	3.71	22DEC67		.	E	
PROTO UNIT TEST SLIT SYS		27NOV67		.	L	
				.		

TIME NOW

NEWFOUNDLAND CONSTRUCTION CO. LTD.
WAREHOUSE REQUISITION SLIP

REQ. NO. 1432

Storekeeper: Please furnish Mooney Const. with the following:

Date: Feb. 21, 1980

Charge Number 15332 Dept: Construction

Work Classification BA 03100

Quantity	Articles	Stock No.	Unit Cost	Amount
200	Timber 2" x 4" x 10'	201	$1.50	$300.00
300	Timber 1" x 6" x 20'	468	$2.00	$600.00

Entered on Ledger	Entered on Stock Ledger	Storekeeper:	Recipient:
293	154	Robert Gorman	Leonard Vivian

Warehouse Requisition Slip (HT_1)

NEWFOUNDLAND CONSTRUCTION CO. LTD.
MATERIAL STATUS REPORT
BY MATERIAL, MONTH, CHARGE NO.

CONTRACT DESCRIPTION:	REPORTING ORGN:	CONTRACT NO:	REPORT DATES:
Motel Vanguard	Walsh Electrical Co.	E 453	PERIOD Feb. 1, 79 - Feb. 28, 79 CUT OFF DATE - Mar. 2, 79 RELEASE DATE - Mar. 5, 79
LEVEL/SUMMARY ITEM	Owner Furnished Material		

IDENTIFICATION			MATERIALS					REMARKS
Month	Charge No.	Material	Unit	Actual	Budget	Forecast at Completion	Wastage	Remarks
1/79	LB16515	2/0 Wire	m	2000	5000	5500	500	

Material Status Report ($^{11}T_2$)

NDLAND CONSTRUCTION CO. LTD.

SE ORDER

Invoice in triplicate
All invoices and
packing slips must
100-457
show this number

DATE: Feb. 28 1979 JOB NO: 134

dor or subcontractor: R. and J. Company Ltd.

ress: Water Street City: Harbour Grace

to Location of Job: Motel Vanguard

e Required: Mar. 14, 1979 Your estimate:

ase supply the following materials or perform the services described below:

antity	Description	Unit Price	Amount
00 SF.	Vinyl Asbestos Tile, 12"x12"	$0.34	$2,550.00

conditions of this order are that:

The vendor must advise within two days if the terms of this order are not agreed to in full: otherwise this order is to be understood as accepted in all of its terms.

If the vendor fails to fill this order within 30 days from the date of issue the order will stand cancelled.

Vendor is to send shipping list with each delivery and shipping list and bill of lading with each shipment, and show purchase order number in each case.

or's Signature: B.A. Oldford Accepted by: W. Shea

Purchase Order (IIT_3)

SUMMARY EXPEDITING REPORT (MT_4)

NFLD GENERATING STATION
UTILITY CORPORATION

REPORT DATE 1FEB71
RUN NO. 14D PAGE 17

CINCOM
SUMMARY EXPEDITING REPORT

EXPEDITE -A10 HIGHLIGHT DATE 1APR71

ITEM CODE	ITEM DESCRIPTION	MFG TIMING START	DUR	COMPL'N	P.O. FLOAT	COMPL'N	DELIVERY TERMS & DESTINAT'N	SITE TRANSIT DUR	DATE	REMARKS - STATUS AS AT 16SEP71
RE013	TYPE LP CALANDRIA	REO 012-01			P.O.017-01-1		ORDER DATE 19JUN70	DOMINION BRIDGE		QUE.
R 21	CALANDRIA VESSEL SPRAY NOZZLES (S)	17JAN71	65	16APR71	-10	3APR71	F.O.D. MTL	16	25APR71	
R 22	SHIELDS BORING (S)	25MAR71	30	5MAY71	5	11MAY71	F.A.S. PORT	29	20JUN71	
RE014	TYPE ZIRCALLOY TUBES	REO 012-02			P.O.312-02-1		ORDER DATE 14JUL70	CARPENTER TECH. CORP.		USA
R 23	CALANDRIA ZIRCALLOY TUBES (S)	10JUL71	32	20SEP71	53	1DEC71	F.A.S. NYH	27	4JAN72	

BILL OF MATERIALS (MT_5)

Work package no.	Material code no.	Material description	Quantity	Unit of measure	Start date of first activity requiring this material
4	0421	Modular face brick	20,000	Ea.	54
4	0410	Masonry cement	200	C.Y.	54
4	0410	Masonry sand	50	C.Y.	54
5	0720	1½" roofmate insul.	5,000	S.F.	67
1	1526	4" Cast iron tyton joint pipe	200	L.F.	11

PROGRESS PAYMENT SUMMARY REPORT (PP_1)

DPW-CANADA + D+C = PCS

SORTED BY SUBCONTRACT

REPORT DATE 30 Apr 74

*** PROGRESS PAYMENT REPORT /6A/***

DESCRIPTION	CONTRACT AMOUNT	COMPLETED VALUE TO DATE	HOLDBACK	PAYABLE TO DATE	PAID TO DATE	AMOUNT PAYABLE
8100 Poole Construction	755,192.00	555,945.53	83,391.82	472,543.71	.00	472,553.71
8102 Poole Construction	601,212.00	461,002.00	69,150.30	391,851.70	.00	391,851.70
8103 Poole Construction	138,380.00	110,010.00	16,501.50	93,508.50	.00	93,508.50
8104 Summit Masonry Ltd.	140,490.00	71,673.00	10,750.95	60,922.05	.00	60,922.05
8108 Alpine Dryall Co. Ltd.	112,300.00	59,300.00	8,895.00	50,405,00	.00	50,405.00
8111 Robertson - Irwin Ltd.	414,361.00	292,160.91	43,824.12	248,336.79	.00	247,336.79
8113 Bridge & Tank Ltd.	719,000.00	570,790.95	85,618.63	485,172.32	.00	485,172.32
8121 Advance Roofing Ltd.	368,712.00	224,096.00	33,614.40	190,481.60	.00	190,481.60
8122 Flint Electric Ltd.	397,969.00	163,651.00	24,547.65	139,103.35	.00	139,103.35
8133 Botting & Associates	375,280.99	365,652.00	54,847.80	310,804.20	.00	310,804.20
PROJECT TOTALS	4,022,876.99	2,874,281.39	431,142.17	2,443,139.22	.00	2,443,439.22

Newfoundland & Labrador Construction Co. Ltd.

PROGRESS PAYMENT CLAIM NO. 4

DATE 17th March, 1980

JOB NAME Substation Const.

FOR PERIOD FROM Jan. 1st 1980 TO March 15th 1980

SUBCONTRACTOR Mooney Const.

DESCRIPTION OF WORK Foundation

(SC_1)

ORIGINAL CONTRACT PRICE	CHANGE ORDERS TO DATE	NET CONTRACT PRICE	VALUE OF WORK COMPLETED TO DATE
$69,000	$7,000	$76,000	$59,000

(SC_2)

CHANGE ORDER RECORD

C.O. No.	DATE	INCREASE	DECREASE	NET CHANGE TO CONTRACT PRICE
419	Jan. 22	4,500		73,500
420	Feb. 2	11,000		84,500
421	Mar. 1		8,500	76,000
TOTAL		15,500	8,500	76,000

PROGRESS PAYMENT RECORD (SC_3)

	PREVIOUS	THIS PERIOD	TO DATE
TOTAL AMOUNT CLAIMED	50,000	10,000	60,000
HOLD BACK (10%)	5,000	1,000	6,000
NET PAYMENT DUE	45,000	9,000	54,000

SUBCONTRACTOR Frank Campbell

VERIFIED AND APPROVED BY Graham Noseworthy

Progress Payment Claim (SC_1-SC_3)

NEWFOUNDLAND AND LABRADOR CONSTRUCTION COMPANY

MONTHLY CASH FLOW REPORT

Period: March 1st - [illegible] 31st/1980

PROJECT NUMBER	DESCRIPTION	TO DATE		TO DATE		INFLOW (OUTFLOW)		INTEREST COST	
		ESTIMATED	ACTUAL	ESTIMATED	ACTUAL	ESTIMATED	ACTUAL	ESTIMATED	ACTUAL
NLC - 80 - 05	Warehouse	30,000	25,000	25,000	26,500	5,000	(1,500)		
NLC - 80 - 16	Boiler Plant	14,000	16,000	10,000	12,000	4,000	4,000		
NLC - 80 - 14	Access Road	58,000	40,000	65,000	49,000	(7,000)	(9,000)		
	TOTALS ———	102,000	81,000	100,000	87,500	2,000	(6,500)	-	65

Monthly Cash Flow Report (TC_1)

Newfoundland & Labrador Construction Co. Ltd.

Job: Motel Vanguard

Charge No: 15332

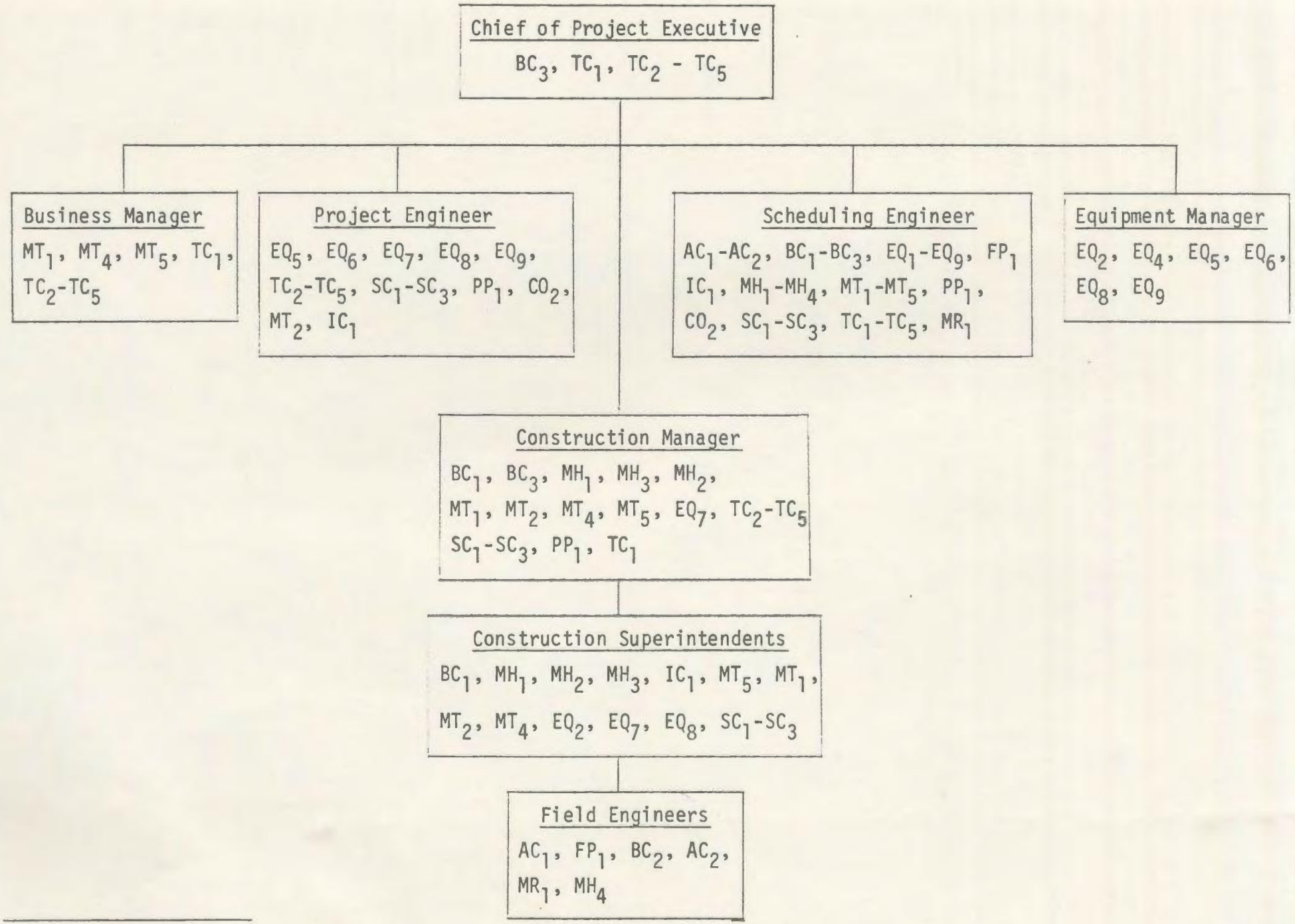
Project Cost Report

For the Period: April 1-30/80

Cost Code	Description	Budget	Change Orders	Revised Budget	Actual Cost To Date	Committment To-Date	Percentage Complete	Forecast at Completion	(overrun) underrun (9-5)
1	2	3	4	5	6	7	8	9	10
AA 02200	Earthquake	1020		1107	1107		100	1107	(87)
BB 03100	Formwork	7790		7800	7416		95	7828	(38)
BB 03300	Cast-in-place concrete	15525		15525	7491	1750	49	15525	0
BB 04200	Masonry	29664		33000	7507		28	32218	(2554)
BD 07150	Damp-proofing	594		527	527		100	527	67

Project Cost Report (TC_2 - TC_5)

Appendix E (Part III): Project Cost Progress Reports* for Project Executives



*Reports are in Appendix E (Part II)

Vendor and Package Name	No of User Ratings Received	Weighted Average User Ratings							Advantages Cited by Users				Disadvantages Cited by Users							Performs as Advertised?			Program Mods required?		
		Overall satisfaction	Throughput efficiency	Ease of installation	Ease of use	Documentation	Vendor technical support	Training	Flexible	Inexpensive	Saves system resources	Saves human resources	Inflexible	Costly	Complex	Slow	Uses excessive resources	Lacks key capabilities	Compatibility problems	Immediately	Eventually	Never	No	Yes, by vendor	Yes, by user
Management Science America (MSA)																									
Accounts Receivable	5	30	28	28	28	16	26	28	2	0	1	1	1	1	2	0	1	1	1	1	4	0	0	4	3
ALLTAX	28	37	35	34	35	36	34	35	14	14	7	24	0	0	1	1	2	0	1	26	1	0	17	3	9
Fixed Assets	7	24	25	22	27	25	18	20	3	1	1	4	1	1	3	2	2	2	0	1	2	3	0	2	2
FICS	11	30	20	25	25	28	17	28	8	2	0	3	0	0	4	5	4	1	2	3	8	0	6	2	5
General Ledger	29	29	21	22	24	28	25	25	20	3	2	14	2	3	18	13	10	1	3	8	12	4	9	3	12
Payroll	59	29	26	24	26	32	28	27	37	3	5	28	5	10	24	18	15	3	11	28	20	3	11	14	38
Personnel	3	33	30	30	30	37	37	37	2	1	1	3	0	0	0	0	1	0	0	2	1	0	0	0	2
Mathematica Products Group, Inc																									
RAMIS II	9	30	28	31	33	30	31	28	7	1	4	8	0	2	0	0	1	0	0	5	4	0	6	2	1
McCormack & Dodge Corp																									
Accounts Payable	9	30	28	27	29	30	26	26	5	2	2	5	0	0	0	0	1	0	0	1	7	0	0	3	7
Fixed Assets	18	29	26	27	28	28	25	25	7	2	1	9	2	4	3	6	3	0	1	7	10	1	4	9	10
Medical Information Technology, Inc																									
MIIS	6	35	33	38	37	25	34	28	3	1	2	3	0	2	1	1	0	1	3	5	1	0	2	3	0
Mini Computer Business Applications, Inc																									
Accounts Payable	5	40	36	36	32	32	33	40	5	4	2	4	0	0	0	0	0	1	1	4	1	0	2	1	2
MRI Systems Corp																									
SYSTEM 2000	20	32	25	30	31	24	28	28	15	1	0	14	1	7	3	6	6	0	0	8	10	0	11	8	0
NCI Inc																									
SLICK	36	35	35	35	33	29	31	28	13	14	13	12	0	0	2	0	1	0	1	30	5	1	35	1	0
NCR Corp																									
Accounts Payable	16	28	26	25	29	29	24	24	4	11	2	11	7	0	6	4	0	3	1	8	7	1	0	5	12
Accounts Receivable	11	29	26	25	28	23	18	20	6	6	3	7	2	1	4	3	1	2	1	6	4	0	1	5	9
CIF	9	34	28	26	31	29	29	28	7	4	2	6	0	0	6	1	1	2	0	3	5	1	0	6	9
General Ledger	22	33	30	32	31	29	28	27	8	17	4	14	4	0	6	3	0	1	3	14	7	0	6	6	12
Inventory Control	5	32	32	28	34	34	34	32	0	3	0	3	1	0	2	1	0	1	1	3	1	1	2	1	2
IPR (In Patient Records)	8	30	23	29	29	21	20	26	3	7	4	6	2	0	3	3	1	1	1	3	4	1	1	0	7
ORBIT	5	30	20	22	28	24	18	18	1	3	0	2	3	0	3	2	0	1	0	2	3	0	0	2	5
Payroll	48	33	30	32	31	28	25	25	27	25	13	30	6	0	12	11	1	4	10	28	17	1	14	10	30
SCHOLARS	6	33	28	32	25	32	20	23	2	3	0	3	0	0	2	2	2	1	0	2	4	0	1	1	5
Nichols & Co																									
N5500 (PROCON)	6	25	23	23	25	24	25	27	1	1	1	4	3	0	3	2	1	3	0	2	3	0	5	1	1
Northwestern Univ																									
SPSS	5	34	30	30	28	32	28	25	4	2	1	5	0	0	0	1	0	0	2	4	1	0	0	1	3
Optgen Inc																									
EXTRACTO	5	32	30	36	38	24	26	30	4	1	1	4	1	0	1	1	0	1	2	3	0	1	2	3	0
Oxford Software Corp																									
DFAST	19	31	34	30	33	24	22	21	13	8	18	13	2	2	1	0	1	3	3	7	10	1	10	3	3
SAVE RESTORE	6	33	23	35	35	28	28	10	5	4	5	4	0	0	1	0	0	1	1	4	2	0	3	1	1
TFAST	12	33	35	33	33	25	28	10	2	3	4	9	0	0	1	0	0	0	1	7	4	0	8	1	3

[1] Datapro Research Corporation, Datapro 70, Buyer's Bible, Delran, New Jersey, 1977.

User Ratings of Proprietary Software

Vendor and Package Name	No. of User Ratings Received	Weighted Average User Ratings							Advantages Cited by Users				Disadvantages Cited by Users							Perform as Advertised?			Require Modification?		
		Overall satisfaction	Throughput/efficiency	Ease of installation	Ease of use	Documentation	Vendor technical support	Training	Flexible	Inexpensive	Saves system resources	Saves human resources	Inflexible	Costly	Complex	Slow	Uses excessive resources	Lacks key capabilities	Compatibility problems	Immediately	Eventually	Never	No	Yes, by vendor	Yes, by user
Digital Research																									
CP/M	6	3.3	3.2	3.2	3.0	2.7	2.8	NA	5	6	1	2	0	0	0	1	0	0	0	6	0	0	2	1	3
DNA Systems, Inc.																									
TSO	10	3.5	3.7	3.2	3.3	2.6	3.1	2.3	8	0	5	4	0	3	0	0	0	1	2	8	2	0	2	5	6
1130/FORTRAN	17	3.8	3.6	3.3	3.7	3.1	3.3	3.0	9	10	4	7	0	0	0	0	0	1	3	16	1	0	9	6	2
1130/SORT	10	3.6	3.9	3.7	3.7	3.3	3.0	2.6	8	1	6	3	0	0	1	0	0	0	0	8	1	1	8	2	0
Dylakor Software Systems, Inc.																									
DYL-250	9	3.2	3.1	3.6	3.1	2.8	3.3	3.0	3	8	3	6	0	0	0	0	0	2	0	7	2	0	9	0	0
DYL-260	46	3.6	3.4	3.7	3.4	2.9	3.2	3.0	32	32	12	40	0	0	2	3	3	2	1	39	6	1	44	1	0
Financial Technology, Inc																									
General Ledger	5	2.4	2.6	2.2	2.8	1.8	2.0	2.0	2	2	1	2	0	1	0	1	0	0	0	3	2	0	1	2	3
Florida Software Services, Inc.																									
Certificate of Deposit	6	2.5	2.8	2.5	2.8	2.7	2.8	NA	3	2	0	2	1	0	1	1	0	0	1	2	3	1	2	2	5
Commercial Loan	6	3.0	2.8	2.8	2.4	3.7	3.2	2.8	1	3	1	4	0	0	2	0	0	2	2	3	3	0	0	1	5
Demand Deposit Accounting	5	3.2	2.8	2.8	3.6	3.8	3.2	NA	5	2	0	1	0	0	0	1	1	1	0	3	2	0	0	1	4
Installment Loan	11	3.1	2.5	2.5	2.9	2.6	2.2	1.5	7	6	1	2	2	1	2	3	3	3	0	6	5	0	4	0	7
Mortgage Loan	12	2.8	2.6	2.8	2.8	2.6	2.4	2.5	8	3	2	6	1	3	5	1	5	1	0	7	5	0	6	3	4
Payroll	5	3.0	2.8	2.8	3.0	3.4	2.6	3.0	4	3	1	3	0	0	0	1	1	0	1	4	1	0	1	1	4
Foresight Systems, Inc.																									
FORESIGHT	11	3.2	2.6	3.1	3.0	2.7	2.6	2.9	6	0	0	8	2	2	2	1	4	1	1	8	3	0	8	2	2
GBA International																									
GBASWIFT	10	3.2	3.0	3.5	3.5	3.3	3.4	2.6	5	5	6	5	0	1	1	0	0	0	1	7	3	0	6	4	1
GCS Computer Services																									
Payroll	5	2.4	2.4	2.4	2.8	3.2	2.6	2.8	4	2	1	2	0	1	3	2	1	0	0	1	4	0	1	3	4
Goal Systems																									
FAQS	11	3.9	3.9	3.8	3.8	3.9	4.0	4.0	6	7	8	7	0	0	0	0	0	0	0	8	3	0	10	1	0
FLEE/FLIM	35	4.0	3.9	3.8	3.8	3.7	3.1	3.8	25	25	31	15	0	0	0	0	0	0	0	35	0	0	33	1	1
Gulf Computer Sciences, Inc																									
TLMS	12	2.9	2.8	2.4	3.2	2.5	2.3	2.0	5	0	5	10	1	3	2	1	2	0	1	5	7	0	4	2	7
HBO & Co.																									
MEDPRO	8	3.9	3.9	3.6	4.0	2.9	3.6	3.0	5	3	2	4	0	2	2	0	0	1	0	4	4	0	0	7	0
Hewlett-Packard Co																									
IMAGE/1000	9	3.0	2.9	3.4	3.0	2.5	2.7	3.3	6	5	0	4	1	0	2	1	1	4	0	8	1	0	6	1	2
IMAGE/3000	30	3.5	3.3	3.7	3.6	3.2	3.0	2.7	19	5	8	22	1	1	1	3	2	4	2	28	1	1	27	1	1
RTE III	5	3.4	3.0	3.6	3.2	2.4	2.8	2.6	4	1	2	3	0	0	1	0	1	0	0	4	1	0	3	2	0
Honeywell Information Systems, Inc																									
Accounts Payable	7	3.0	2.3	2.3	2.6	1.7	2.2	2.0	1	5	1	2	2	0	0	2	0	1	1	3	4	0	2	0	4
COBOL	13	3.2	3.0	3.4	3.2	3.1	2.5	2.6	3	3	1	3	0	0	1	0	2	2	1	11	2	0	9	4	0
General Ledger	11	2.5	2.2	2.0	2.4	1.8	1.6	1.4	0	8	1	6	2	0	2	5	2	1	1	3	7	0	1	4	8
IMS	16	3.2	2.9	2.6	2.6	2.6	2.7	2.8	8	8	2	10	2	0	6	3	2	1	0	7	6	2	2	2	12
Payroll	14	2.6	2.4	2.2	2.3	2.3	2.8	2.3	6	11	3	7	3	0	5	4	3	3	4	5	8	0	2	4	9
SCRIBE	6	2.3	2.0	2.2	2.2	2.5	2.0	2.0	2	2	2	4	1	1	1	4	3	0	1	2	2	2	1	3	5
IBM Corp.																									
Accounts Payable (S/3)	27	2.7	2.5	2.7	2.7	3.0	2.4	2.2	10	13	3	14	4	1	4	7	8	2	3	8	17	2	1	2	25
Accounts Payable (S/32)	9	3.1	2.2	3.0	2.9	2.7	3.2	2.8	1	3	0	7	1	1	1	3	2	0	0	4	5	0	6	1	2
Accounts Receivable (S/3)	12	2.9	3.1	2.7	3.2	2.8	3.0	2.8	4	5	4	8	1	1	1	3	2	1	3	4	6	1	2	3	10

User Ratings of Proprietary Software

Vendor and Package Name	No. of User Ratings Received	Weighted Average User Ratings							Advantages Cited by Users				Disadvantages Cited by Users							Perform as Advertised?			Require Modification?		
		Overall satisfaction	Throughput efficiency	Ease of installation	Ease of use	Documentation	Vendor technical support	Training	Flexible	Inexpensive	Saves system resources	Saves human resources	Inflexible	Costly	Complex	Slow	Uses excessive resources	Lacks key capabilities	Compatibility problems	Immediately	Eventually	Never	No	Yes, by vendor	Yes, by user
IBM (continued)																									
PL/1	14	34	31	30	32	30	31	30	3	0	5	3	0	1	2	1	2	0	0	12	2	0	11	2	1
POWER	6	23	25	27	25	25	28	24	0	1	1	2	1	1	1	1	0	1	1	4	1	1	4	0	2
RPG (360/370)	51	34	33	36	34	32	28	31	10	21	10	10	0	1	5	4	2	5	5	48	3	0	45	2	2
RPG II (S/3)	51	35	33	35	35	34	34	33	18	10	3	21	4	1	1	3	6	4	2	48	2	0	41	8	1
RPG II (S/32)	8	34	31	35	35	33	29	37	3	4	3	5	0	0	0	1	0	1	1	6	2	0	6	2	0
Sort (S/3)	44	35	32	36	34	33	32	30	17	13	6	18	3	0	2	7	1	4	0	42	1	0	41	2	1
Sort Merge (360/370)	71	32	30	33	35	33	34	32	23	14	15	12	2	7	1	11	8	1	1	55	11	0	60	5	3
SPF	5	40	32	28	40	30	36	33	4	2	2	5	0	2	0	0	0	0	0	5	0	0	3	0	2
SPM (Source Program Maint.)	22	33	31	26	34	27	26	26	13	4	6	21	1	1	1	0	5	3	1	12	8	0	16	1	5
Utilities (S/3)	17	33	29	35	33	33	35	34	4	7	2	4	1	0	0	3	0	2	0	16	0	0	11	5	0
IMSL, Inc																									
IMSL	23	34	31	31	32	34	33	23	13	10	5	20	0	3	3	0	1	0	0	20	3	0	16	1	3
Infonational																									
Accounts Payable	8	31	28	33	35	31	26	29	3	3	3	8	3	0	0	1	0	1	0	5	4	0	1	2	7
General Ledger	7	33	24	29	31	31	28	30	4	4	2	6	2	0	1	2	0	0	0	3	4	0	1	3	5
Informatics Inc																									
Accounting IV	11	31	26	23	26	28	25	26	6	0	2	7	2	2	5	4	3	0	1	3	6	0	1	8	6
Intercom	6	30	28	22	25	23	23	23	4	1	0	3	1	3	4	0	3	0	0	1	5	0	2	1	1
MARK IV	47	33	27	34	33	29	29	29	30	3	7	39	1	10	4	6	16	3	6	33	10	0	34	3	3
Minicom	7	40	39	37	40	29	31	34	4	4	5	4	0	0	0	0	0	0	1	6	1	0	4	2	3
Scope	5	26	28	30	30	24	22	26	4	0	1	4	0	0	1	2	0	1	0	2	2	0	1	3	0
XREF	5	35	28	36	36	28	28	20	3	5	0	5	0	0	0	2	0	0	0	4	1	0	4	1	0
Innovation Data Processing Inc																									
Fast/Dump-Restore (FDR)	34	37	37	39	36	30	34	32	16	16	27	8	0	1	1	0	2	1	1	32	2	0	30	2	1
Insurance Systems of America Inc																									
Stocks & Bond System	7	29	30	24	29	29	27	28	4	0	2	4	0	0	1	1	0	0	2	3	4	0	2	1	5
Inside Datacom Corp																									
Datacom/DB	11	33	32	30	34	24	32	31	5	3	5	6	2	0	2	1	1	1	2	6	4	0	5	4	2
Datacom/DC	13	33	35	28	34	24	32	29	6	2	8	8	1	1	2	1	2	1	2	6	6	0	6	7	2
Interdata Inc																									
FORTRAN	6	23	22	30	22	22	12	20	0	3	1	0	0	0	0	1	2	1	1	1	2	2	1	3	1
OS32/MT	7	23	20	26	20	21	19	20	2	1	0	1	1	0	2	4	5	1	1	2	4	1	1	2	4
Jason Data Services																									
SPRINT	7	36	37	37	34	31	31	25	3	6	6	4	0	0	0	0	0	1	1	6	1	0	7	0	0
Johnson Systems Inc																									
Job Accounting (DOS)	21	33	30	31	29	30	28	26	13	6	3	13	1	2	5	4	1	3	2	12	8	1	14	6	1
Job Accounting (OS)	10	35	27	36	34	29	27	28	6	3	2	4	1	0	0	5	0	1	0	7	3	0	9	1	0
Management & Computer Services, Inc																									
DATAMACS	5	26	28	30	30	22	22	26	3	0	2	5	0	0	2	1	0	1	0	3	2	0	3	2	0

Vendor and Package Name	No of User Ratings Received	Weighted Average User Ratings							Advantages Cited by Users				Disadvantages Cited by Users							Performs as Advertised?			Requires Modification?		
		Overall satisfaction	Throughput efficiency	Ease of installation	Ease of use	Documentation	Vendor technical support	Training	Flexible	Inexpensive	Saves system resources	Saves human resources	Inflexible	Costly	Complex	Slow	Uses excessive resources	Lacks key capabilities	Compatibility problems	Immediately	Eventually	Never	No	Yes, by vendor	Yes, by user
Panaghic Systems Inc																									
EASYTRIEVE	62	3.7	3.4	3.7	3.5	3.2	3.1	2.8	43	18	23	59	1	8	2	2	4	7	2	53	9	5	60	2	0
PANDA	6	3.5	3.2	3.5	3.3	2.8	2.8	2.7	1	0	2	3	0	1	0	0	0	0	0	5	0	1	6	0	0
Panvalet	139	3.6	3.5	3.4	3.5	3.3	3.1	2.9	77	30	68	107	5	5	4	1	0	6	1	122	14	6	97	12	11
Program Products, Inc																									
Data Analyzer	7	3.1	2.7	2.7	2.7	2.8	2.8	2.8	4	1	2	7	2	0	1	0	1	2	0	5	2	0	5	2	0
SAB, Inc																									
Software 1040	19	3.5	3.2	3.6	3.6	3.3	3.7	2.9	4	5	2	15	2	1	0	3	1	2	0	13	5	1	9	10	0
SAS Institute, Inc																									
SAS	14	3.6	3.3	3.5	3.6	3.1	3.2	2.7	12	11	5	11	0	1	0	1	1	1	1	13	0	0	10	0	2
SDI																									
EPAT	41	3.5	3.3	3.2	3.2	3.1	3.1	3.0	8	5	21	31	4	9	2	3	1	2	7	34	6	0	35	5	1
FLEET EMAINT	7	3.6	3.4	3.4	3.3	3.0	3.0	3.2	3	1	6	2	0	3	0	0	0	0	0	6	1	0	5	1	0
GRASP	48	3.5	3.5	3.5	3.4	3.1	3.1	3.0	23	8	44	23	2	20	1	1	2	3	3	40	5	3	30	5	1
Software AG of North America, Inc																									
ADABAS	12	3.5	3.5	3.6	3.7	2.9	3.5	3.1	10	1	3	8	0	3	1	0	1	0	0	10	1	0	9	0	2
Software International Corp																									
Accounts Payable	8	2.4	2.1	2.6	2.6	2.3	2.8	2.3	4	1	1	4	1	0	3	3	2	0	1	4	3	0	3	3	2
Accounts Receivable	8	2.5	2.6	2.8	2.6	2.5	2.9	2.6	3	1	2	4	2	1	1	1	2	0	1	3	4	0	2	5	2
General Ledger	25	3.2	2.6	2.6	2.9	2.5	2.9	2.8	19	3	2	18	0	6	5	3	4	0	0	12	12	1	12	12	5
Q PAC (Payroll)	6	2.5	2.6	2.3	2.5	1.5	2.8	2.7	5	0	0	3	0	1	5	1	1	0	0	2	4	0	6	0	0
SPSS Inc																									
SPSS	48	3.5	2.9	3.1	3.4	3.4	2.9	2.8	39	18	5	39	2	6	6	7	9	6	1	38	11	0	26	10	10
Stockholder Systems Inc																									
PEP	15	3.3	2.3	2.6	2.7	3.1	3.2	2.5	8	4	2	10	0	1	5	6	4	0	2	6	8	1	7	4	6
Systems Management Inc (SMI)																									
Business Control Programs	7	3.3	2.7	3.3	3.3	2.4	2.9	2.5	5	3	1	2	0	0	1	1	0	0	1	5	2	0	1	3	3
System Support Software, Inc																									
QUIKJOB II III	29	3.6	3.5	3.7	3.6	3.2	3.2	3.0	23	19	8	26	0	0	0	1	0	4	1	25	4	0	22	3	2
Systemetics Inc																									
EZPERT	5	3.2	2.8	3.0	2.6	2.6	2.8	2.8	2	0	1	4	0	1	0	0	1	0	0	1	4	0	3	2	1
TCC Inc																									
LIFE 70	6	2.7	2.4	2.3	2.2	2.5	2.5	2.3	2	0	0	5	1	1	5	1	0	0	1	1	4	0	0	3	5
Tektronix Inc																									
Advanced Graphics	6	3.0	3.0	2.7	3.3	2.7	2.5	1.0	1	2	0	3	0	0	1	0	2	0	1	2	4	1	2	0	4
Terminal Control System	6	3.3	3.0	2.6	3.3	3.2	3.0	3.0	3	2	0	5	1	1	2	1	0	0	1	3	2	0	2	0	4
Triples Systems Inc																									
In Line	6	3.3	3.2	3.3	3.3	2.3	3.3	3.0	2	3	2	3	0	0	0	0	0	0	1	5	1	0	6	0	0

APPENDIX G

Evaluation of System Features

DESCRIPTION	PMS	MSCS	CMCS	CINCOM	PROJACS
CPM Arrow Netowrk	X	X	X	X	X
Precedence Network	X	X	X	-	X
Network Drawing	-	-	-	-	X
Estimating	-	-	**	-	-
Scheduling of Project Activities	X	X	X	X	X
- Activity Time Status Report	X	X	X	X	X
- Milestone Report	X	X	X	X	X
- Activity Bar Chart	X	X	X	-	-
- Updating and Revision	X	X	-	-	-
- Exception Reporting	X	(X)	X	-	-
- Job Site Reporting	X	-	-	-	-
Work Status & Progress Report					
- By Activity	X	X	X	X	X
- By Contract	X	-	-	X	X
- By Facility	X	-	X	-	-
- By Department	X	-	X	-	-
Interfacing of Subnets	X	-	-	X	X
Procurement Scheduling	(X)	-	-	X	(X)
Tender Scheduling and Control	(X)	-	-	X	(X)
Resource Allocation	X	X	-	X	X
Resource Scheduling	X	X	-	X	X
Resource Levelling	X	X	-	X	X
Manhour Projection & Control	X	X	-	X	X

APPENDIX G (Continued)

DESCRIPTION	PMS	MSCS	CMCS	CINCOM	PROJACS
Cost Reporting By					
- Activity	X	X	X	X	X
- Charge Numbers	X	X	X	-	-
- Contracts	X	X	X	X	X
- Facility	X	X	X	X	X
- Responsibility	X	-	-	X	X
- Account Number	X	(X)	X	-	-
- Milestone	X	X	X	-	-
Subcontractor Accounting	(X)	-	(X)	-	-
Project Overhead	(X)	-	(X)	-	-
Capital Appropriation Status	(X)	-	X	(X)	(X)
Escalation & Contingency	(X)	-	X	(X)	-
Forecast Final Cost	X	X	X	X	(X)
Financial Plan and Status Report	X	-	X	-	-
Trends (Cost & Financial)	X	X	X	X	-
Progress Payment	(X)	-	**	X	-
Cost Estimate Revision	(X)	X	X	X	-
Change Orders	X	-	**	X	-
Owner Furnished Material	(X)	-	-	(X)	-
Historical Cost Information	X	X	X	X	-
Management Summary Report	X	X	X	(X)	-
Organization Analysis Table	X	X	**	X	-
Work Breakdown Structure	X	-	X	-	-

APPENDIX G (Continued)

DESCRIPTION	PMS	MSCS	CMCS	CINCOM	PROJACS
Accounts Payable	-	-	-	X	X
Contractor's Holdback	-	-	-	X	-
Accounts Receivable	-	-	X	-	-
Inventory	-	-	-	-	-
Cashflow	(X)	-	X	X	-
Payroll and Auditing	-	-	-	-	-
Cash Advance Report	-	-	X	-	-
Capital Expenditure Report	X	-	-	-	-
Purchase Order Register	-	-	X	-	-
Cost Comparison Report	X	X	-	-	-

Where 'X' stands for the existence of a particular feature in the program, '(X)' depicts that the program does not presently possess a particular feature but can be added to it with suitable modifications, and '-' stands for non-existence of the desirable feature and a lack of ability to modifications to add the feature to the program.

PMS - Project Management System IV

MSCS - Management Scheduling and Control System

CMCS - Construction Management Control System

CINCOM - Computerized Project Management System

PROJACS - Project Analysis and Control System

NEWFOUNDLAND AND LABRADOR
COMPUTER SERVICES LIMITED

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1978 07 24

Mr. Zainnl Abedin
Graduate Student
Faculty of Engineering
Memorial University of Newfoundland
Elizabeth Avenue
St. John's, Newfoundland
A1B 3X5

Dear Mr. Abedin:

Subject: Package Purchase Costs
vs. Package Development Costs

Confirming our conversation of a few weeks ago, the following estimates are based on my experience in this field:

System	Package Costs		Annual Maintenance Cost	
	Purchase	Development	Purchase	Development
	$	$	$	$
Payroll	35,000	75-100,000	4,000	10,000
General Ledger	35,000	75-100,000	3,000	1,500
Accounts Payable	25,000	75-100,000	2,500	2,500
Accounts Receivable	25,000	75-100,000	2,500	2,500
Fixed Assets	20,000	50-250,000	2,000	5,000
Inventory	35,000	75-150,000	4,000	10,000

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It should be noted that the Annual Maintenance Cost usually required for in-house developed systems is not done and within a few years the system is obsolete and the users are demanding a new system. In reference to Purchased Systems, the Annual Maintenance is almost always done giving the users a system that is always current and accurate.

Note! The In-House Development Costs are based on writing a system to suit one client only and they are not meant to put a worth on the package systems. The package system development would be a much higher cost.

Yours truly,

George A. Campbell
Co-ordinator, Application Software

GAC/emcn