A SYSTEMATIC IMPLEMENTATION STRATEGY FOR COMPUTER ASSISTED LEARNING IN INDUSTRY

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ABSTRACT

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A systematic implementation strategy for computer assisted learning in industrial training is outlined on the basis of the literature in the field. The strategy is then applied to the situation prevailing in Air Canada in order to determine the crucial variables and the limits within which profitable implementation could take place. The analysis reveals that the most sensitive assumptions for the selected alternative are those connected with the rate of implementation and in particular the size of the instructional development team and its learning curve coefficient while the threshold of profitability depends largely on the cost of computer transactions. This could also probably be the case in other corporate settings where the operation of the CAL unit requires a limited fraction of the capabilities of an existing large computer network, although the magnitude of the benefits would depend on the pattern of training, financial compensation of the work-force and internal criteria of evaluation. It is concluded that this system modelling method provides a more than adequate basis for implementation decision-making since it provides specific directions regarding the optimum rate of implementation and the prioritization of production, specifies the key areas to be monitored and delimits the range of profitability. Further research on the optimal composition of development teams and of their production output of precisely defined types of CAL materials would be of considerable value for this type of study.

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CHAPTER 1

GENERAL ENVIRONMENT

In today's dynamic environment, survival depends as much as ever on the faculty of adaptation. Social systems must absorb various forms of dissent and adjust to pressures in order to retain their fundamental integrity and avoid revolutionary upheavals which could destroy or misshape them beyond recognition. In a similar vein, the viability of economic entities depends in large part on their ability to adapt to changing conditions and to adopt emerging technologies. They can thus keep on developing, although in a somewhat modified form, instead of becoming fossilized and withering away.

In the business world, the early adoption of an innovation carries with it an implied gamble. In case of success the corporation is far ahead of its competition and can reap unchallenged the benefits of its decision, one of them being the recognition of its lead in the field, while others must struggle to regain their position and their share of the market. If, however, the undertaking turns out to be a failure, the firm must absorb the losses and regain lost ground. It is therefore quite understandable that thorough objective research must be conducted prior to committing resources in a new direction.

The selection of the optimal timing for the changeover to a successful technology is a critical decision because there is a penalty to be paid by those who let themselves lag behind in the business field: They have to struggle to rejoin the main group and keep up with their predecessors, or they are left to perish behind as the industry keeps forging ahead in great forward surges. When they succeed in rejoining the mainstream, they find that they have to accept standards created by others without their input.

Innovations must be adopted at the appropriate pace which will minimize the hazards to the organization. The degree of complexity of the decisions required of a corporation to move at that pace demands the use of the rational objective techniques of Operations Research.

A similar situation prevails in the educational domain. Montemerlo and Tennyson (1976, p. 8) describe some of the problems associated with the predictable life cycles of educational innovations and refer in particular to the bandwagon effect described by Milsum (1968, p. 43): As the number of researchers with a vested interest increases, the resistance to critical examination and to consideration of alternatives grows together with unreasonably optimistic claims. The reputation of a 'panacea' disappoints people with high expectations, who attempt to use it, and this, in turn, creates a wave of criticism and backlash leading to the downfall of the innovation.

This pattern has occurred in connection with the use of computers in education. It now appears, however, that their application in the instructional field has been institutionalized and that the period of extravagant claims and boundless enthusiasm is over. A stage of maturity has been reached when experimentation is conducted systematically and the various uses of computers in education are being thoroughly documented. Some of the most visible examples on a major scale are the setting up of the National Development Programme in Computer Assisted Learning in 1973 in the U.K., the research conducted by the Canada National Research Council and the studies undertaken by the Industrial College of the Armed Forces in the United States.

Computer-assisted learning has been adopted in airline branches and divisions where safety reasons and the high cost of alternative methods of training make it the obvious choice, such as in flight simulators used for flight deck personnel training. Its use has also been extended to applications affecting directly a steadily increasing segment of the population with the resulting effect that, while it retains some of its initial glamour and aura of mystery, it is being readily accepted by potential users.

In the business environment, the goal of corporate management is to optimize the profitability of the firm, and instruction is but one of the means available to achieve this. The value of a training organization is based on its contribution to the accomplishment of the firm's primary goals. Because it is responsible to ensure that its methods are, and remain, the most efficient under the prevailing circumstances, the training organization must periodically survey the current situation and assess the potential effects of available innovations on its operations. Current trends indicate that the volume of training requirements, and their costs, are increasing, while the cost of computer hardware is decreasing. It seems therefore reasonable to expect that, at some point, the curves will intersect and the introduction of computer assisted learning will become cost-justified.

The effect of a new technology is generally not limited to a simple material or procedural substitution; it also modifies to a certain degree the environment into which it is being incorporated. Thus, it is misleading and sometimes pointless to attempt a straight comparison of the "before" and "after" type without considering the peripheral modifications resulting from the implementation.. For example, the quality of the current training activities can be improved by the introduction of automated methods because of the strict discipline that they impose on the instructional designers. Barrette (1976, p. 279) mentions, for instance, that the introduction of CAI in the Canadian Armed Forces has clearly revealed that the instructors on the conventional courses were not covering as much detail as the course description suggested. Although this may be seen as an incidental side benefit, it makes it worthwhile to ensure that the new technology is implemented as soon as possible after it passes the cost-justification point, and not just at a much later date when the advantages have become quite obvious to the casual observer.

The subject of this thesis is to construct a methodology to determine whether, on the basis of the currently available knowledge, the creation of a Computer Assisted Learning unit within a specific industrial environment could be economically justified at the present time. The environment selected is the Transportation Service Branch of Air Canada, with its actual structure and constraints. Although the introduction of computer technology would undoubtedly result in benefits in the areas of increased standardization and efficiency, it is not possible to state without some research whether this innovation is cost-justified. The study will reveal whether the time is appropriate for this transition from an economic standpoint; if it is not, it will indicate which conditions are to be met before it should be considered in the future. Although the project centers on the characteristics of a particular segment of the airline industry, it is expected that the main interest lies in its potential for generalization to other similar situations.

Definition of the Wider System

The environment within which the Computer Assisted Learning unit could be created can be seen as a hierarchical arrangement of open systems, open in the sense that they exchange information, energy and materials among themselves. Within the framework of the study, the corporation may be seen as the encompassing suprasystem, operating within a commercial, social and political context. As such, it provides purpose, input, resources and constraints to its subordinate elements.

At the next lower level, the supersystems are the various geographical regions and functional branches of the corporation such as Transportation Services, In-Flight Service, Maintenance, and Computer Services. These are parallel entities, each one with its autonomous organization and specific purposes. Their missions complement one another so that the goals of the corporation can be reached, and they compete for a limited set of available resources.

The Transportation Services branch differs from the others in that its personnel is subdivided into a greater variety of employee classifications, spread over a wider number of locations than is the case for the other branches. Furthermore, the scope of its activities, reflecting its close association with the daily operation, manifests itself in a fairly constant stream of relatively minor procedural changes between major modifications affecting the corporation as a whole (such as the introduction of a new aircraft type or of a computerized support system, for instance).

This branch is subdivided into smaller elements, such as its training organization and divisions corresponding to Aircraft, Cargo, Load and Passenger services, each one being a complex grouping of human beings, machines and facilities, together with their interrelationships. Geographically, the training organization is spread over six semi-autonomous regions, with representation in headquarters

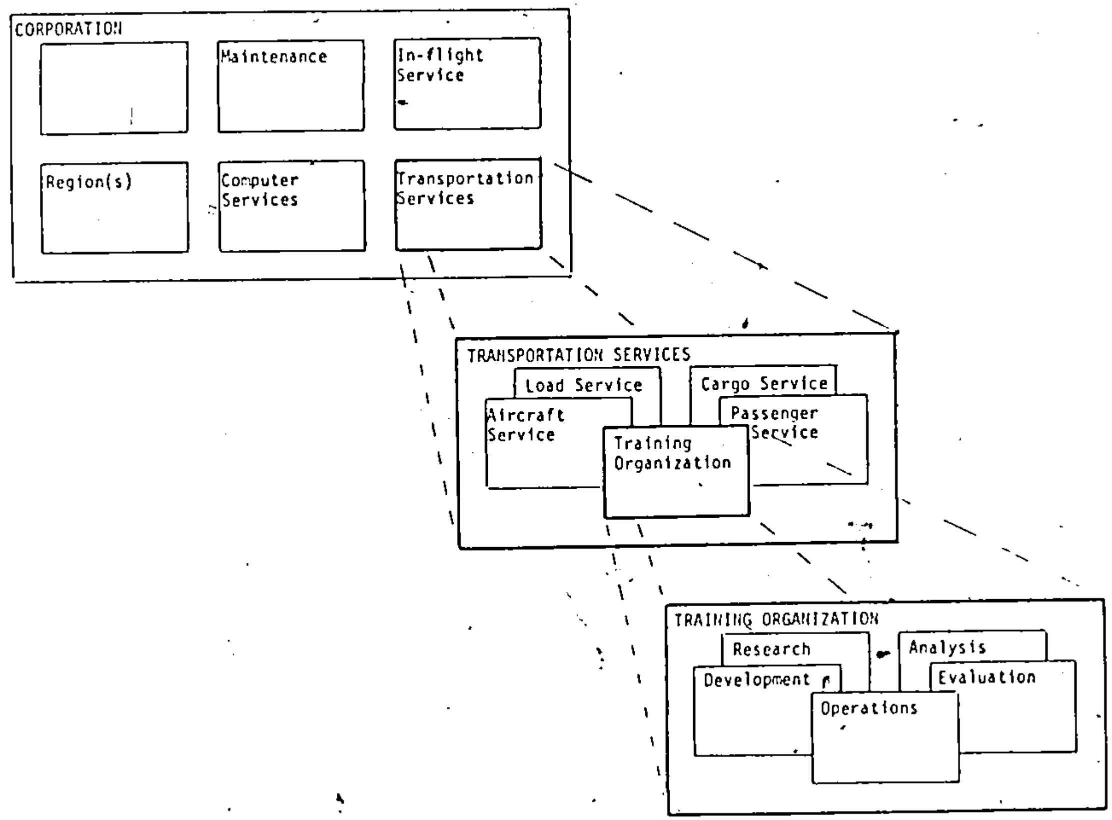

Figure 1 - SYSTEMIC CONTEXT OF THE TRAINING ORGANIZATION

for coordination and development.

Functionally its activities may be grouped into the five clusters identified by Warren (1969, p. 26): (a) Research, to keep abreast of development in instructional areas, (b) Analysis, to define the scope of the training action required, (c) Development, to design and produce training plans and materials, (d) Operations, to implement the training action, and (e) Evaluation, to produce the strategies and materials for judging the training action and the trainees' performance.

The training organization includes managers and supervisors, training program developers and instructors. It also includes the various categories of trainees: The majority are company employees, most of them covered by collective agreements and following a set career path by promotion from an "attendant" to an "agent" level. The balance is constituted by outsiders such as travel agents for whom the corporation has training responsibilities. The resources of the training organization include a financial budget approved at a higher hierarchical level, which is translated into manpower levels, equipment and facilities.

Objectives of the Wider System

The objectives of a system cannot be disassociated from those of the higher level units which provide the general goals and the specific directions for all their subordinate elements. Thus, with its inspiration flowing from the top, the training organization is seen by Warren (1969) as the element of the corporation which has for mission "the attainment of a group of planned and predefined behaviour changes required by the other systems in the organization to carry out their mission" (p. 26).

The output of the training organization of the Transportation Services branch reflects the demands stated by the parallel systems in the form of performance standards representing the desired attitudinal, skill and knowledge changes required. The input of resources is controlled in such a way as to eliminate or reduce the danger of suboptimization at a higher level. Conflicts in the area of objectives are resolved by (a) weighting of certain aspects and (b) imposition of certain constraints.

As a result the product of training reflects the concerns of the corporation while its quality matches closely the level of actual needs. While the analysis and evaluation of training programs could be carried to a more refined degree, and the details of their preparation measured and recorded with more precision, the resources expended would not be recovered over the life of that training program. This situation is an application of a cardinal rule of accounting systems design stated by Fremgen (1966): "The benefit derived from an accounting technique must always at least equal the expense of that technique" (p. 20).

As part of its mission the training organization is responsible to increase its productivity through internal efficiency. As expressed by Montemerlo and Tennyson (1976) "the primary goal of training designers is to ensure cost-effectiveness, that is, the meeting of all training objectives in the least costly manner" (p. 17). It makes better use of its resources by aiming at a higher internal return on investment.

To meet these responsibilities the training organization is engaged in a continuous scan of new possibilities which it can assess for potential use. This search task includes: the collection and examination of relevant published materials and the interface with similar organizations which may be applying effective new training approaches, especially in the same context, such as British Airways and United Airlines.

Formulation of the Training Organization's Problem

The training organization of the Transportation Services branch has been instructed to reduce its expenditures, or more specifically its unit costs. This implies a streamlining or rationalization of its internal operation in order to increase its productivity. While the level of its resources remains basically unchanged, it is expected that the volume of demands placed on the organization will increase significantly.

The growth of the training production level can be traced to several causes such as: (a) a faster rate of change in basic procedures, designed to enable the corporation to react more readily to environmental pressures such as competition, consumerism, and governmental regulations, (b) progressive installation of more sophisticated, (e.g. computerized) systems in the areas of passenger reservations, cargo handling, and aircraft weight and balance, and (c) increase in training contacts with travel agencies as a result of expanding industry-wide standardization of procedures.

An analysis of the expense budget of the training organization reveals that its major cost items are attributable to on-going implementation of the training action, that is the "Operations" element of the Warren (1969) classification. These costs, which are easily determined because they are regulated by labour relations contracts, fall under such areas as: (a) salaries of trainees and instructors during a course, or while proceeding to a course location, (b) travel expenses of trainees and instructors away from their home bases, and (c) overtime wages of trainees attending courses during their scheduled time off.

The analysis also reveals that other circumstances contribute to the high cost of training, for instance: (a) new procedures require a lengthy implementation time because the number of instructors is insufficient to train the workforce rapidly, (b) training records are time-consuming and cumbersome to maintain, and (c) in standard courses with a set duration, no provision is made for the individualization of training with respect to speed of learning and the course is geared to the speed of the slowest learners.

While several remedial measures could be implemented, it would appear that a computer based facility could improve the picture considerably. In 1971 McLean, Ragsdale and Churchill of the Ontario Institute for Studies in Education concluded their report on a computer based training laboratory by mentioning that:

> The continuing downward spiral in costs of computers and terminals now makes it possible to move into the application of computer assisted vocational instruction with a solid promise of achieving results which are of real benefit to the students, and can be obtained at a cost which the educational system can rationally support. (p. 46)

Some of the most obvious benefits resulting from the simultaneous and permanent availability in CAL form of a course include: (a) a reduction in the lead time required for implementation of a new procedure so that its benefits can be reaped earlier, (b) the elimination of waiting time so that a promoted individual can assume his higher position earlier, (c) the possibility of training during downtime, thus eliminating the need for overtime pay; (d) the reduction or elimination of travel expenses, and (e) the overall reduction of training time as a result of self-pacing.

While the "operations" element of the training organization would become less costly, the "development" element responsible for the design and production of didactic materials would become more expensive. A shift of manpower from instructors (Operations) to program developers (Development) can be anticipated. Because some of the resources required are within another branch (Computer Services), it becomes necessary to assess the overall effect on the suprasystem with precision and to determine whether the final outcome benefits the corporation, either because the training organization is able to contribute proportionally more, or because it can release some of its previous resources.

Because the situation investigated is expected to fall in a marginal area of economic profitability, the selection of an off-the-shelf system which would meet the needs with wide margins allowing long experimentation periods under conditions of dubious operating efficiency is not appropriate. The manner in which the problem is tackled may very well mean the difference between success and failure: Any decision, from the selection of personnel to the rate of introduction of additional programs, can affect the profitability of the facility. Under these circumstances it is wiser to accept initially a minimal system which can be expanded progressively to optimal capabilities. This approach involves the use of available manpower, equipment and facilities in successive steps of increasing sophistication.

The thesis problem therefore consists in developing a good procedure to assess whether, under a specific set of circumstances, the time is ripe for transition to this capital-intensive technology.

Sufficient material of suitable quality is available in the research literature covering the state-of-the-art in Computer Assisted Instruction to allow Educational Technologists faced with the specific combination of resources and constraints of an actual situation to design a model which will provide a rational basis for an implementation decision through the use of some simple Operations Research techniques without the assistance of a team of specialists.

Despite the divergence of opinions published in most areas connected with this subject, a sufficient core of informed agreement is now available for the creation of a model fitting actual circumstances and which, while pinpointing how risk can be minimized, will reduce the margin of uncertainty to a degree where sensible decisions concerning the allocation of resources can be made.

This is an investigation of the extent to which such a procedure is viable as a method for reaching an appropriate decision meeting the approval of those levels of management responsible for the final results and accountable for the resources expended.

A 'Systems Approach', more precisely the version described by Jenkins (1972), will be used as a framework for combining the theoretical elements of the contemporary research literature on Computer Assisted Instruction with the specific resources and constraints of an actual situation.

The search for the answer will lead to the factors which influence the final decision and allow to determine which alternatives are open.

It will clarify which order of progression or which strategy should be adopted in order to obtain maximum benefits from the decision and to minimize the hazards to the corporation. It will provide answers to such questions as: (a) in which succession of stages should the development proceed?, (b) should the designer rely on commercially available systems or develop the internal capabilities of the corporation?, (c) what economies of scale can be realized by increasing the number of trainees?, and (d) what would be the cost of developing the same courses in two different languages? etc...

The result will indicate whether a change would prove beneficial at this time. If it proves to be the case, the decision to implement will be complemented by a set of specific steps to be taken in a specified sequence within a known margin of tolerance. If the outcome is negative, the study will provide a blueprint for decision which can be used again at a later date with an indication of the conditions to be met before the implementation of a CAL facility may prove cost-justified.

CHAPTER 2

REVIEW OF THE LITERATURE

The subject matter of this study may be seen as located at the intersection of several specialized areas of human activities. The bulk of the relevant literature can therefore be found in four main clusters: (a) Computer Assisted Learning, partly for its instructional, but mostly for the technical aspects of its implementation, (b) Economics, for the provision of key financial concepts, (c) Operations Research, for the development of the methodology, and (d) the Systems Approach for the provision of an encompassing framework. Although each of these fields can be studied in abstract terms, they provide their most valuable contribution in the areas of combination where they overlap into practical applications.

Computer Assisted Learning

The number of books and publications on computer assisted learning (CAL) seems to be growing at an exponential rate. It is therefore necessary to survey the field and summarize periodically the situation: Zinn (1978) has conducted, for instance, such an evaluative review of uses of computers in instruction which outlines the full spectrum of computer uses, of methods of implementation, and of suitable equipment from which appropriate combinations can be selected for further investigation.

Magazines and other periodicals, whether addressed to the teaching community, such as "Educational Technology", or to the data-processing professionals, such as "Datamation", constitute another valuable source of information. Vendor documentation, such as that produced by Control Data and Univac, specifies the availability and operating characteristics of actual systems. These sources ensure that we are up to date with the current state-of-the-art in a field where the rate of change is quite rapid and information therefore becomes obsolete within a year or two.

Management Decisions in Business and Education

In his article tracing the development of decision systems in business management, Hocking (1976) concluded that "current trends indicate that the need for quantitative models to be incorporated within these systems is just now arising" (p.57). He remarked that in 1964 John Diebold already saw the need for a new profession which could bridge the gap between operations researcher and manager. He related the implementation of complex computerized decision systems to General Systems theory and to the systems approach while pointing out that management must recognize that no machine can be better than its data input, and that where hard data are not available, human judgement will have to be substituted.

McMillan and Gonzalez (1965) show that mathematical and statistical methods are available for this type of undertaking. After depicting concepts such as probability and queueing, they cover areas such as modelling and simulation and move into the areas of computerized models for complex decision processes. Although they recognize that computer simulation is no substitute for formal analytical procedures, they consider that it allows us to build and process systems models which produce operationally useful information at an acceptable investment of time and effort.

In the business world a decision tool of this nature has been designed by the McDonnell Douglas Corporation(1976). The Air Freight Decision Tool (AFDT) is a computer based system providing a breakeven point (in value per pound) where it becomes advantageous to switch from surface to air transportation. The various inputs can be manipulated to show their influence on the final results. This industrial approach to selling, rational and objective, replaces the traditional salesman's approach based on persuasive personal characteristics and interpersonal rapport. The final display is the result of logical decision processes built into the computer program. These processes are represented by a set of interrelated equations based on well-defined assumptions. The computer merely calculates and presents the results as a value figure or a graphic display; these results are purely logical and must be accepted if the underlying equations and input data are undisputed.

The AFDT incorporates a sensitivity analysis which, being a useful method for identifying the factors most likely to affect the outcome, is a desirable first step in the appraisal of risk and uncertainty. Risk has been differentiated from uncertainty by several authors, such as Pearce (1971, p. 60) who defines a risk situation as one "where the value of a variable (the benefit flow, discount rate, costs) is not known but its probability is known", whereas "...uncertainty...pertains to a situation in which the probability distribution is not known at all". Corti (1973, p. 75), who uses a similar definition, finds the usefulness of the risk-uncertainty distinction to be open to question in practice and considers that the essential point is the incorporation of the available information into the decision process through the use of: (a) analysis, involving the estimation of probabilities, and (b) decision criteria.

In conditions of great uncertainty Corti(1973, p.79) considers that the decision rules developed from game theory, while avoiding the doubtful stage of subjective probabilities, do not make full use of the knowledge available. In risk situations where reasonably objective probabilities can be assigned, the expected monetary value, incorporating an allowance for risk, can be derived through the multiplication of the average of each possible outcome by its probability. This stochastic approach is also considered and described by Pearce (1971, p.61) and Dewhurst (1972, p.42).

Corti (1973, p.79) also mentions that a different approach to the treatment of risk is to adjust the discount rate used to calculate the net present value of an investment. Pearce (1971, p.60) presents a formula showing the addition of a 'risk premium' to the discount rate. Both agree that this method is more appropriate when risks are a function of time and that its use should be restricted to those cases.

Since education is a form of management it must apply the methods which are successful in the business world. Mitchell, for instance, who has established and substantiated the connection between Operations Research and Educational Technology in his papers on queueing theory (1976a) and network flows (1976b), sees the educational technologist as bridging the gap between educational needs and resources.

Silvern (1972, p.47) found in his applications of systems engineering to training that the key to success is organization using the logical meticulous design and implementation of an orderly structure which is provided by systems engineering where techniques such as flowchart modelling and simulation have been responsible for much progress. For him, whether it is in business or in training areas, the use of the digital computer, once a mathematized flowchart model has been produced, is a most natural step.

Cost Analysis

Kopstein and Seidel (1969) have produced a comprehensive study of the economics of computer administered instruction which may be considered as a classic example of the kind. Covering categories such as: (a) elementary and secondary education, (b) higher education, and (c) military technical training, it may be seen as an attempt to map out the territory of a medium in its growing stages.

While recognizing the difficulties inherent in comparing two methods with different characteristics and areas of application, especially when one of them is in its development period, they were able to arrive at representative cost figures by combining typical cost data and standard industry practices with conservative estimates based on a variety of reasonable assumptions ranging from the relative effectiveness of CAL and traditional instruction, to the composition and duration of formal classes, and to the ability and willingness of society to invest in means toward educational goals.

Finding the concept of a mean CAI cost to be obviously meaningless, they concentrated their attention on the cost determinants (hardware, maintenance, software, instructional programming, and administration) and the degree of their effect under various conditions. They were able to make comparisons based on the cost per student hour for the educational strata considered.

Because computer facilities differ in practically every respect, the cost of the student-contact-hour (SCH) is often used for comparative purposes. This convenient measure, however, can be used only as a rough index unless the facilities are quite similar because "that calculated cost... is strongly affected by assumptions about factors in each cost category" (Kopstein, 1969, p.336).

Because of the lack of some objective information, the approach becomes more meaningful when it turns away from precarious comparisons and towards an estimation of how much CAI can be permitted to cost. The study becomes an investigation of the conditions under which CAI can remain below the expected cost of traditional instruction projected into the future.

Because the study is restricted to facilities designed for training very large numbers of users and because the hypothetical situations described are not expected to match actual facilities, its value resides more in its comprehensive description of what the field of computer assisted instruction entails, rather than in the cost figures derived.

A different approach was taken by Fitzgerald (1973) to calculate CAI costs by means of an oversimplified cost-benefit model embodying the specifications of: (a) personnel, and (b) delivery costs in a series of steps involving givens, postulates, examples and conclusions. Although he pointed out that an exhaustive analysis can become obsolete before its completion as a result of the announcement of a new technological development with a different price tag, this treatment appears superficial because it mentions "hours of consumable CAI" without regard to their effectiveness and because it considers average ratios throughout the model (number of 'job units' for each SCH, and production by each category of personnel) without making provision for variations in the types of lessons or in the yearly SCH requirements of students. As a result the value of the study is to be found more in his outline of the problem and of the need for quantification in instruction, and CAI in particular, than in the model which only illustrates points made in the paper.

Kopstein and Seidel consider that "the rate at which any technological innovation is allowed to develop and the acceptable level of risk accompanying the development are primarily functions of its economic utility" (p.328). Since cost analyses are affected by the assumptions underlying the raw data as well as those made in the course of calculating comparison indices, these assumptions must be stated clearly so that the readers can be in a position to recalculate with their own set of assumptions.

This point is also made by Mishan (1971, p.175) who covers useful investment criteria such as present discounted value. He points out that, in order to come up with firm quantitative results, the economist must ignore the less-easily measured spillovers: When their effects are adverse, they impart a bias towards favouring commercially-viable projects, irrespective of their ability to withstand more searching criteria. The economist should resist this temptation by, at least, clearly revealing the area of ignorance.

Kopstein and Seidel point out that Computer Assisted Instruction demands a careful total systems approach and that even moderately effective CAI demands systematic integration of hardware, software, instructional strategy and instructional content. Such a systematic approach is described by Rosenthal (1976) who proposes a model for implementation encompasing hardware, software, curriculum materials, training and physical installation. The four phases (definition, design, installation, and operational support) are subdivided hierarchically into segments, activities and tasks for scheduling into a work program. This model implies but does not reveal the dynamic interrelations existing between its elements. A more comprehensive approach is given by Jenkins (1972) who delves into the various stages of Systems Analysis, Systems Design, Implementation and Operation and who shows how to decide on the compromises which have to be achieved between the conflicting objectives of a system to formulate an economic criterion.

Cost Effectiveness in Education and Training

Current concerns for cost effectiveness are reflected by the numerous papers dealing with the subject of relative values of instructional alternatives, in which the common trends of an underlying rationale can be found.

Chuang (1972a, 1972b) in two separate papers presented to the same meeting of the Operations Research Society of America outlined the basic theory of 'Cost Analysis' which he defines as "the process of examining various alternatives in order to ensure an efficient and effective allocation of resources" (1972a, abstract). He finds that the effectiveness considerations of Systems Analysis have already been applied to Education, but that cost considerations have lagged behind in the educational decision-making process. To remedy the situation he proposes a cost effectiveness planning system made up of thirteen subsystems corresponding to various tasks (1972b). Although the description of the procedure is rather sketchy and may be regarded as still another variation on a theme already explored in more depth by other researchers, it has the merit of emphasizing the need for assessment of the results (Task 12) and recycling of the activities

(Task 13), two activities which are often neglected after a project has been implemented and the responsibility for its operation handed over to the users.

Following Silvern's lead in applying systems engineering to training situations, numerous researchers have developed cost models of instructional systems. For instance, Nance (1973) supplied techniques for making media decisions within a systems context in his Operations Research Analysis of Audio Tutorial Systems where he identifies costs (or efficiency) elements as opposed to the benefits (or effectiveness) elements.

The construction of a model incorporating all elements which contribute costs to the system precedes the analysis of each function and the determination, for each of them, of a general formula for the computation of costs. The selection of specific equipment is then explained and its corresponding cost inserted into the model, the final result being a cost per student-hour, the standard required to obtain the cost projections needed for comparison of alternative systems. The method, easy to follow, is appropriate for the subject. Its description is particularly detailed for equipment and facilities, but too sketchy when it comes to manpower: Although it recognizes in the 'Originate' function such factors as the experience level of the programmer, the average gain score expected and the style of programming chosen, it does not relate them into an equation, but merely provides a total figure for this subsystem.

Bramble (1975) developed a cost estimation model for the objective selection of alternative formats and delivery modes. He investigated the cost to develop, produce, transmit and handle each of the learning activities, such as taped televised programs and audio reviews, and the effect on course costs of adding or deleting activities. The number of variables in his equations can be altered to estimate the costs for courses under different conditions such as audience size and number of programs.

Although the model aims at determining the point where education by satellite is efficient in relation to alternative methods of instruction, it is restricted to the learning activity format actually used by the Appalachian Education Satellite Project courses in 1974 and its value could have been increased by the costing of alternative activity formats and delivery systems.

The Training Analysis and Evaluation Group (TAEG) of the U.S. Navy has been most prolific in the instructional research area. Thus Miller and Duffy (1975) have developed, under the name of Educational Technology Assessment Model, a procedure for evaluating innovations or changes proposed for instruction: Its objective is to formalize the dimensions and elements of potential applicability and to structure the relevant cost and benefit variables. For them:

> The decision to adopt, reject, postpone or further study a proposed innovation should be a rational choice based upon the relationship of the costs to introduce and maintain the innovation, balanced against the range and magnitude of the benefits to be derived. (p.13)

They propose an eight-task procedure, starting with the formalization of the innovation (Task 1), to guide the researcher throughout the required data collection and analysis steps leading to a decision to accept, reject, or continue to study the innovation (Task 8). Each task is made of subtasks, such as the assembly of data and the sensitivity analysis which are two of the eight elements of Task 6. Although Miller and Duffy identify the portions which are amenable to computerization, they recognize that "the large number of loose interactions...demands informed judgemental processes and outcome monitoring" (p.I-2).

This assessment model, when used as a totally manual procedure, requires an apparently excessive amount of time and effort to explore a wide spectrum of multiple alternatives. Its value to the general researcher seems to derive mainly from the fact that it represents a comprehensive review of relevant elements and may be used as a check list for similar types of research.

Within the same organization and in the same spirit, Braby and al. (1975) proposed a 'Training Effectiveness, Cost Effectiveness Prediction' (TECEP) technique for facilitating the economic analysis and selection of the most appropriate instructional delivery system for various types of military training. The approach provides a systematic procedure for the identification of training systems and associated resource requirements. After the training objectives have been organized into groups and the appropriate learning strategies identified by means of delivery system selection charts, the cost of alternative forms of training is projected.

The cost model, embodied in a Fortran IV program, is simply a computational algorithm for determining both the cost of the components and of the total instructional delivery system. The input variables fall into seven classes: facilities, equipment, instructional material development, personnel, supplies, students, and miscellaneous. They include, for instance, the average cost of developing the master copy for one hour of instruction, the number of unique hours of new instructional material to be developed each year, and the percentage of the original development of instructional material expended each year to maintain the courseware. While the basic output is the present value of each alternative, the model also provides numerical values for 31 factors such as the total and average cost per student position, the average cost per graduate, and the distribution of the incidence of costs over the life of the alternative being studied.

Because of the computerization of its cost model this comprehensive approach exhibits a still higher degree of complexity than the Miller assessment model. This approach necessitates a considerable amount of work by an expert team to ensure that the proper information is fed in since it leaves to the training specialists the responsibility to develop the values assigned to each of the input variables dictated by the problem under analysis. Since the time spent on an evaluation should be proportional to the magnitude of the financial implications, this approach seems particularly suitable for very large organizations, which must conduct a high volume of evaluation on recurring combinations of adequately substantiated data.

Summary of the Literature

The introduction of Computer Assisted Learning in school settings and military institutions has already been well documented, particularly in the U.S. and U.K. This probably is so because: (a) education is the main purpose of these organizations, (b) subjects are available in large numbers and controllable, (c) development of improved methods forms part of their mission, (d) research and validation are conducted systematically, and (e) funds are available for that purpose.

On the other hand, information regarding implementation in an industrial setting is scarcer. When available, the information concerns the successful introduction of a large system which is nearing its cutover phase, or operating in the dynamic equilibrium of its planned "steady state".

Methods to design instructional systems are described in numerous prescriptive papers, where the emphasis reflects the author's main concern: They are valuable as building blocks, which must be combined and interrelated within a specific context. Each facility designed is different from the others in some of its aspects, especially when it is not meant for a new entity, but must be superimposed on an existing organization and adjusted to its peculiarities. This explains the growth of the profession of system analysts who must combine a variety of products available "off the shelf" into a composite product which will meet their client's need.

A survey of the literature is most useful in that it provides a wealth of potential avenues which can be combined in various manners to fit the problem being considered in a creative manner. The introduction of a particular facility must always be considered in the context of its specific environment. The value of studies which attempt to define the cost of computer assisted learning lies in their approach, rather than in their results, because the latter are soon outdated in a changing society. A sophisticated system such as Braby's TECEP is well thought-out and precise: It can provide the information required for a wide variety of situations. For the presentation of a feasibility study to an organization, however, it is necessary to outline the underlying assumptions, meaning that the equations of the cost model must be explicated. In cases where the complexity of the situation is limited, the design of a simpler model tailored to the specific circumstances and restricted to the relevant factors may prove more appropriate.

CHAPTER 3

METHOD AND SCOPE OF THE PROJECT

To solve the thesis problem as defined at the end of the first chapter, an eclectic approach combining the findings of previous researchers outlined in the literature is used, focusing on the Computer Assisted learning 'unit': After promoting this to the rank of system and ascertaining its objectives, it lists the financial criteria used by the sponsoring organization to assess the efficiency of any project submitted for approval.

Organization of the Analysis

The scope of this management-science project has been defined in the formulation of the thesis problem: to develop a good procedure to determine under an actual set of circumstances, the appropriate time to design and to introduce Computer Assisted Learning facilities. This will be the case if the creation of the CAL element within the training organization contributes to an overall increase of its net productivity. It is a problem of the optimal allocation of resources subject to time and cost constraints and in the presence of uncertainty, for the achievement of specified outcomes. It is appropriate at this point to describe the strategy to be used for formulating and solving this problem of allocation of resources.

Within the general framework of a 'Systems Approach', the economic aspects of the project will be evaluated by means of a cost-benefit analysis.

First a qualitative analysis of the environment will define the purposes, identify the constraints and establish the criteria by which the organization assesses the value of its investments.

Next, a quantitative analysis of the present curriculum and target population, with their expected trends, will translate them into terms suitable for incorporation into the study. The existing courses will be examined for potential convertibility to CAL methodology. Those which qualify will be analyzed further on the basis of their actual documentation and broken down into learning activities, for classification into corresponding instructional modes of computer uses, such as "tutorial" or "drill and practice". Each of those divisions will be accompanied by its duration, to provide an estimate of the number of 'hours' of didactic materials to be produced.

A by-product of the examination of the instructional characteristics of the curriculum will be a list of minimum requirements to be found in the new computer-based facility.

The target population will be similarly analyzed: The potential trainee groups will be identified by employee classifications and geographical locations. They will be cross-referenced with the planned courses into a matrix which will indicate the expected use of each of the course units and permit their ranking in terms of relative usefulness. The statistical data concerning the target population are based on current figures and average rates of turnover among this segment of the corporation.

The next step will be the design of a graphic analog or 'LOGOS' model of the kind used by Silvern (1972) in his system engineering approach to training. This model will highlight the system under consideration so that its functions can be interrelated adequately. It will permit the identification of the relationships between the functions, ensuring that there are neither gaps nor duplications, and will enable the insertion of the necessary paths for cybernetic adjustments where required. It will pinpoint the areas where decisions concerning alternatives must be made and, finally, it will constitute a check list for a comprehensive enumeration of sources of costs and tangible economic benefits.

The benefits will be identified in terms of current expenses expected to be eliminated as a result of the continual availability through the CAL facility of training courses at all locations. A format will be designed for the grouping of costs and benefits in a consistent manner for comparative purposes.

After these tools, flowchart model and cost benefit format, have been designed, the simulation of the introduction of alternative CAL facilities will provide figures to be pigeonholed in line with the pattern selected. Once a particular combination has been chosed, the development of a production schedule becomes the key element. It is based on a prioritized list of courses to be produced and is affected by the characteristics of the facility selected and the rate of improvement of the development team. The production of additional courses is to be stopped when it results in an excess of costs over benefits during the economic life of the project.

The production schedule, once established, is translated simultaneously into parallel patterns of costs, resulting from the course production and the use of lessons by the trainees via the computer facility, and of benefits identified earlier and attributable to the availability of this new methodology. The differential resulting from these variable, course-related costs and benefits offsets the fixed, system-related, costs. The total economic picture is reflected in cash flows over the experimental period.

Because of the long time span over which this project is planned, discounted cash flow methods, which introduce the 'time-value-of-money', will be used to indicate its financial advantages. They will include both: (a) the Net Present Value to show if the investment has sufficient recurring benefits to satisfy the minimum profitability level in use within the organization, and (b) the Internal Rate of Return for comparison with the minimum acceptable rate. These indices will be used to determine whether a particular alternative meets the criteria of evaluation and to compare these alternatives.

A sensitivity analysis, to test the effects of deviations from the averages used, and to establish margins of confidence will be conducted on the preferred alternative before the results are summarized and the conclusions drawn.

Throughout the process, actual data and figures when available are used. In their absence, the closest and most reliable information available is applied with a mention of the underlying assumptions, these being defined as the best application of judgement and experience to the determination of critical conditions or factors. If, at a later date, additional data become available they can be inserted into the model for more accurate results. The summary indicates where quality control devices must be set up along the paths of the model for use during the operation of the facility, so that any deviation from the assumptions used in the simulation may trigger the appropriate action to return it to its planned state.

Definition of the System and its Boundaries

The corporation has been described as a hierarchical arrangement of systems with the training organization of the Transportation Services branch as a junior element. At this point a switch to the next level of magnification reveals the details of the subsystems constituting that training organization with particular emphasis on the CAL unit to be created. For the sake of clarity it is appropriate to promote all elements to a higher level. The training organization becomes the supersystem while its CAL component will be considered the system in its own right, the one to be studied in detail here.

At this analytical stage the CAL system is still in the realm of ideation and can therefore be visualized only as an imprecise and malleable conceptualization which will materialize later during the synthesis stage: By then it will have gone through a process of purpose formalization and definition of objectives. This is the sequence mentioned by Banathy (1968, p.12) who sees purpose as giving direction to the whole system and determining the processes to be generated in order to accomplish the purpose. The nature of the processes in turn suggests the kind of components to be employed in making up the content of the system.

The CAL component of training may be considered a system in its own right because it will have the properties spelled out by Jenkins (1972, p.60), to wit: a complex grouping of human beings and machines, divisible into subsystems, forming part of a hierarchy, having an overall objective and designed in such a way that it is capable of achieving its overall objective in the best way possible.

At its inception the CAL system is embedded within the Transportation Services training organization from which it receives its direction, resources and constraints. It is conceivable that the CAL system may need resources which are allocated to a supersystem of which it is not a part, such as the Computer Services branch. In that case the transfer would take place through its own parent supersystem, the Transportation Services branch. It is also conceivable that the CAL system may provide services to a supersystem of which it is not part, such as the In-Flight Service branch. The basic assumptions would however remain the same until the CAL element becomes hierarchically parallel to these supersystems through a structural modification of the total environment. This change of boundaries is not deemed to take place within the time span considered.

Objectives of the CAL System

The objectives of the CAL system are derived from those of the next higher echelon in its environment: the training organization, whose mission it is to upgrade and maintain the competency level of the workforce, and which has, as one of its objectives the optimization of its use of available resources. To play its role in that scheme, the CAL system has the goal of improving or, at least, of maintaining the current quantitative and qualitative level of the training product by means of a switch to computer based technology.

Computer assisted learning has been shown to be advantageous under certain conditions. When these conditions are met, the training organizazation, or more specifically its program development unit may, after thorough analysis of the methods available, elect to use Computer Assisted Instruction as the most appropriate means of presentation. Whenever this is the case, the CAL unit will start processing the material in the most efficient manner.

The objectives of the CAL system are: (a) to handle instructionally suitable training activities for the target population, whenever this can be achieved efficiently and effectively, (b) to provide assistance in the management of activities such as testing and record-keeping, and (c) to provide analysis and evaluation data for increasing the internal efficiency of the training organization. Furthermore, the CAL system must be suitable for later expansion to other locations and employee classifications, and it should have built-in quality controls so that a change of pace, speeding-up or termination of implementation can be planned and carried out.

The criteria of applicability of a CAL facility within the corporation should be the same as those listed by Davis (1969, p.465) for computer data processing in any business enterprise: the reduction of operating costs or the significant improvement of the ability to provide service. The factors for decisions covering both reduced costs and better service must therefore be identified in an accurate definition of financial criteria.

Definition of Financial Criteria

In order to measure the efficiency with which the system can achieve its objective, it is necessary to define, at the outset, a criterion in economic terms, to be used as a performance assessment instrument.

The computer assisted training facility will constitute an addition to the various methodologies available to the training organization. As such it will use up some of its resources and contribute to its effectiveness. These two elements must be expressed in economic terms for a meaningful comparison leading to adequate decisions.

Whereas it is possible in some cases to inject a new element into a particular environment and to observe the results to determine its effect, this method is not suitable here because of the anticipated length of time necessary for implementation. The actual effect of the progressive introduction of CAL on the overall efficiency of the training organization cannot be measured with precision, because that efficiency is the result of many factors operating simulateously. It is, therefore, necessary to isolate as much as possible both the costs and the benefits which can be attributed unambiguously to the new method.

The economic factors involved in the costs will be the additional expenses resulting from the decision to implement CAL, such as necessary equipment, conversion of instructors to CAL lesson-writers and consultants, costs of computer transactions, etc... They do not include elements which exist or are performed in the current situation, such as the preparation of training materials up to the development of a courseware outline to the teaching point (COTP) or the periodic in-service development of instructors. The costs considered may therefore be seen as the differential between the expenses occurring under the present and the proposed situations.

In a similar vein, the benefits will include items which can be attributed to the existence of the CAL facility, and can be positively identified and measured. They will include in particular the amounts which will no longer need to be spent, because the training will now be available to the trainee at his home base. The requirements for travel and therefore, the related expenses will be sharply reduced for instructors and trainees alike.

By restricting the benefits to the items which can be positively identified, the study underestimates them to some extent. For instance, a trainee currently travelling to attend a five-day course at a remote location will be considered as spending the same five days studying at his home base, even though a portion of this time will now be part of his regular work periods, resulting in additional savings for the corporation. Also left out are benefits which are not easily quantifiable, or which are often evaluated subjectively, such as those resulting from the timely availability of training materials or the higher quality of objectively validated materials.

Thus, through the use of conservative estimates in the areas of potential benefits, the credibility of the results is increased: A more detailed study taking into consideration additional items such as the release of classroom space, for instance, will show results even more favourable. It is, therefore, necessary to demonstrate only a minimal margin of contribution to bring about the next step: the undertaking by the Computer Service branch of the formal implementation to study the introduction of CAL.

Although the benefit-cost ratio of a project is a popular criterion for selection, it can turn to be deceptive because it disguises the problem of scale. Projects are sometimes selected because their benefits exceed their costs but, when it comes to comparison of alternatives, two projects with the same net benefits may vary widely in their costs. For this reason "...it is rare that any one criterion will suffice for making a sound decision. Several criteria...must be examined by the analysis" (Bordman, 1973, p.74).

Because training is a means of reaching objectives as opposed to being one of the primary goals of the corporation, the consideration of projects such as the introduction of CAI for prioritization into the work-load of the Computer Service branch is subject to their meeting minimum profitability criteria established for this category of projects. These figures, amended once a year, ensure a reasonable match between the expected workload and capabilities of that branch. Under these circumstances the economic criteria to measure the efficiency of a computer based facility within the training organization for the sample case study are that:

1. This project must show a Net Present Value of no less than $200,000 when the cash flows are discounted at the predetermined rate of 15% in accordance with the established practices of the corporation for under-takings of this nature. The Net Present Value will be calculated over an expected economic life of five years. The present value is, according to a United Nations document (1972, p.18) outlining guidelines for project evaluation, a fairly good measure of profitability because "it converts the entire stream of profits into one number representing the total amount of profit today that would be equivalent to the entire stream of profits." To arrive at the present value of the project, the cash flows for each con-secutive year are multiplied by the appropriate values extracted from a table of discount factors, which have been compiled by compounding at the end of each year.

2. Furthermore, to be considered for implementation in the current year, the Internal Rate of Return must exceed the minimum acceptable rate of 40%. This restriction is placed on new projects because of the backlog of poten-tial development proposals. This evaluation method examines the cash flows

for the entire economic life of the investment and segregates them into the one-time cost portion and the recurring benefit portion. The internal Rate of Return is that rate of discount, extracted from a table of discount factors, which is found to equate the recurring benefits to the one-time costs. The figure of 40% is used in all projects involving computer applications because they are considered more 'volatile' than other undertakings in the sense that they are subject to more changes during their development and implementation stages. Historical records show that the resources initially planned can easily be overexpended. Corti (1973, p.79) has stated that "adoption of a higher discount rate will cause a fall in the net present value of a project and hence build into the calculation an allowance for risk". When a post-audit is made, the project will still be shown to be viable despite substantial increases in costs.

3. The Payback Period, an index of the liquidity of the project defined as the number of years of cash flow benefits required to re-compensate the one-time costs of the investment, must not exceed three years.

4. Finally, at no time during the five year experimental period can the cumulative figure of expenses over benefits for any year exceed $200,000. This is a feature of risk minimization in case it becomes necessary to abort the project at any point if it does not meet the minimum expectations.

It is expected that as many courses and locations as possible will be included in the project as long as they contribute to the optimization of the financial aspects of the project. When the point is reached where the addition of courses for a particular functional branch results in higher overall costs, consideration should be given to the participation of another branch for which courses with a higher ratio of benefits to costs can be developed.

Evaluation of the Methodology

The method chosen makes use of a LOGOS model to provide a comprehensive description of a CAL facility which outlines the technical specifications, determines the cash flow pattern, and permits the assessment of the measures of profitability against the corporate criteria. This is only one of the numerous decision tools available to the researcher and possible alternatives include: (a) methods based on the use of PERT/CPM or of Gantt charts which translate the processes into chronologically related sequences of activities, (b) the use of a specialized computer-based model such as Braby's TECEP, or (c) the formalized sequence of conceptual, feasibility and implementation studies used by the Computer Services branch for the assessment of innovative projects.

At this early stage the LOGOS model seems more appropriate than the time-based charts because the system to be created could develop into a variety of designs. Its iterative process lends itself well to the investigation of alternative possibilities and to the identification of economic data. Because it indicates how the various solution systems would result in different mixes of costs and benefits, it is superior to a method which may not have the same flexibility to take into account perturbations in implementation. Its simplicity of presentation and visual impact permits the participation of various personnel from the training organization, which is responsible, to a certain extent, for its own development, and has time budgeted for research activities. This involvement of the users in the design stage will facilitate the acceptance and introduction of the system.

After the features of the system have been defined, the proposal must be presented for the approval of management, not only in terms of indices of profitability, but with a full explanation of the underlying rationale and a complete display of the features incorporated in the facility. It would not be sufficient to quote figures obtained from a model which is not perfectly known and recognized as fully applicable by the judging authority. Thus, the amount of effort put into a TECEP-type of model would not be justified despite its comprehensiveness because the study should be confined to, and include all the elements which are relevant to the organization authorizing the project.

The normal sequence of studies by the Computer Services branch is a time-consuming process undertaken only when the propects of profitability are fairly certain. While the final implementation study remains the responsibility of that branch, its duration is now expected to be reduced to three man-months, once the LOGOS model has permitted completion of the phases normally covered by the conceptual and feasibility studies. The training organization investigates the potential introduction of CAL on a routine basis and can determine when its implementation would pass the cost justification point. Its involvement, besides reducing the workload of the Computer Services branch, can result in the earlier availability of CAL within the corporation. This shift of functional tasks is in line with an emerging corporate philosophy which favors more initiative and participation on the part of the users in the development stages of any computer-based project.

CHAPTER 4

INFORMATION AND DATA COLLECTION

(TRAINING NEEDS AND TRAINING POPULATION)

Prior to the design of an adequate system, one more activity in the analysis phase must be performed: the precise determination of the scope and characteristics of the curriculum, of the size and location of the target population and of their interrelationships. The analysis of the courses will then be translated into profiles suitable for assessing the amount of development work to be done, while the dimensions of the trainee population will allow the calculation of the potential benefits. The accurate delimitation of the scope of the task will permit the compilation of a list of minimum requirement specifications which, combined with the list of financial criteria already established, will be used in the design phase of the study.

The Curriculum

The course constituting the four main training programmes of the Transportation Services branch (Passenger Service, Cargo Service, Aircraft Service and Load Service) are analyzed for their suitability to a computer-based methodology. The first stage screens out those which are obviously unsuitable because: (a) they depend on interpersonal interaction, (b) they aim mostly at the acquisition of manual skills and other psychomotor activities, (c) they affect only a small number of individuals, or are aimed at trainees who have neither access to, nor the ability to operate keyboards, or finally because (d) they are short duration courses for trainees who are not scheduled to take other CAL courses since a high percentage of the time would be consumed by the explanation required to operate the facility.

The remaining courses aim principally at the acquisition of cognitive abilities for personnel at the "agent" level (see Table 1). These individuals, although heterogeneous in terms of aptitudes, meet a specified minimum entry requirement with regard to arithmetic, geography and typing.

The duration of each course is entered on the basis of the information indicated on existing training documents. Whenever this information is missing, the course duration is converted into actual classroom time: A 40-hour or 5-day course is equivalent to 32.5 hours of productive classroom time since a training day is made up of 6.5 hours of training activities.

The classroom activities of the current traditional method are then studied, either through examination of the training documents or through observation of actual instruction, and slotted into five main classifications:

1. Familiarization visits, hands-on training on specific office equipment, and activities requiring the presence of an instructor.

2. Acquisition of theoretical knowledge contained in source manuals. The objective generally consists in locating procedural materials and applying algorithmic sequences of actions. There is a finite number of key points explained by the instructor, and they run parallel to the COTP of the lesson plan.

3. Practical applications of the theoretical materials described

TABLE 1

PROSPECTIVE CAI- CONVERTIBLE COURSES AND THEIR DURATION

Course identification number	Courses	Duration (hours)
1.	Passenger Service	
1.1	Reservations - Basic	65
1.2	Reservations - Advanced	32.5
1.3	Domestic Ticketing	32.5
1.4	Internation Ticketing	58.5
1.5	Reservec - Off Premise	32.5
2.	Aircraft Service	
2.1	Commissary Service	19.5
2.2	Baggage Service	26
3.	Load Service	
3.1	Basic Load Dispatch	65
3.2	Boeing 727	13
3.3	Douglas DC-8	26
3.4	Wide-bodied Aircraft	39
4.	Cargo Service	
4.1	Cargo Procedures	52
4.2	Cargo Rating - Basic	71.5
4.3	Cargo Rating - Advanced	58.5

above. This involves exercises on the part of the trainee, monitoring and remedial action by the instructor.

4. Testing to check the level of understanding or of competence of the trainee. This may include both pre- and post-tests.

5. Simulation by means of an existing training mode of computerized airline applications such as the on-line reservations system. Since its inception the Reservec system used for operational purposes has been equipped with a 'ghost' mode, which makes use of the actual data bank (flight schedules, passenger records) to present to trainees reproductions of realistic displays. After signing into that mode, the trainees, following the instructions of a training guide, can modify these displays by using the proper input transactions. Throughout the process the actual records in the 'live' mode remain unaffected. This facility, mirroring the actual system, provides opportunities for practice but is not considered computer-based training because the didactic content is in the training guide, a document which could conceivably be transposed into CAL. This fifth classification of classroom activities does not include the high actuality devices, such as the flight simulators used for pilot training, which duplicate as closely as possible the structural and dynamic features of the flight decks of modern aircraft. Such a simulator, whose replacement by any other method of training is hard to conceive would be included as specific equipment under the first classification above. Any other type of simulation falling between these extremes would have to be judged on its own merits since some simulation can be done cheaper and just as well on a CAL system as on a special simulator.

The course units are then subdivided into categories corresponding to this breakdown of classroom activities and labelled:

1. Conventional: These activities do not lend themselves well to computerized instruction, and should not be contemplated for conversion. They require the presence of an instructor, or presence at a specific location, e.g. familiarization visits or on-the-job training, or high actuality simulators.

2. Tutorial: This instructional mode of computer use presents exposition in which the author maintains the conversational initiative throughout by defining the objectives and describing the subject material in considerable detail. It aims at the acquisition of theoretical knowledge but may include some practice by the trainee.

3. Drill and Practice: An instructional mode making use of sets of test items which have been designed for graduated levels of complexity. Each set may be seen as a template with variables randomly generated to provide variety. The trainee receives straightforward exercises illustrating key points of the lesson and is guided throughout along the proper path until he masters the particular skill or technique.

4. Testing: The trainee is tested on his understanding or performance. Unless the testing is part of a qualifying examination, some interpretation of the results may be given for diagnostic purposes.

5. Simulation: These existing activities are isomorphic with the actual work situation and currently produce satisfactory results. Although no change is contemplated in their use, they are considered here because CAI activities should, to the largest extent possible, be designed for compatibility with them.

For each course unit, the time used in current classroom instruction is broken down into the five columns corresponding to these categories (see Table 2). This will provide a rough estimate of the amount of work to be performed by the Instructional Programmer for the instructional modes of computer use: (a) Testing, (b) Drill and Practice, and (c) Tutorial, which may have differing ratios of preparation to presentation.

Next, the portions of the course units selected as suitable for conversion to computer assisted instruction (that is excluding the elements classified as "conventional" or "simulation") are analyzed to determine specific requirements of the support and delivery system in the areas of graphic and computational capabilities, which may be identified as either (a) necessary: meaning that the unit cannot be used in CAI form unless this facility is available, or (b) recommended: meaning that the overall efficiency would be enhanced by the presence of this feature. Its absence would not jeopardize the unit because of the possibility of using other adjunct materials.

The same portions of course units are studied with respect to specific requirements of the display system. It is assumed that either Video Display Units or Hardcopy terminals are equally suitable unless they are shown as: (a) necessary, meaning that the lesson cannot be translated to CAI form unless this type of terminal is available, or (b) recommended, meaning that the operation would be greatly enhanced by the use of that feature.

Table 2 indicates that the current courses contain 271.5, 129.5 and 33.0 hours of tutorial, drill and practice, and testing respectively, representing a total of 434 unduplicated hours of instruction suitable for conversion to CAI methodology.

TABLE 2

ANALYTIC PROFILE OF COURSE ACTIVITIES

Course identification number	Convent'l	Tutorial	D & P	Testing	Simulation	Notes
1. Passenger Service						
1.1	-	30	5	4	26	
1.2	-	20	4	2	6.5	
1.3	-	16	8	2	6.5	a,d
1.4	-	32	16	4	6.5	a,d
1.5	-	(6.5)	-	-	(26)	a,b
2. Aircraft Service						
2.1	6.5	13	-	-	-	
2.2	6.5	18.5	-	1	1	
3. Load Service						
3.1	5	37	7	4	12	a,c
3.2	1.5	3	2.5	2	4	a,d
3.3	1.5	7	7.5	2	8	a,d
3.4	3	14	5.5	4.5	12	a,d
4. Cargo Service						
4.1	-	41.5	8	2.5	-	d
4.2	-	21	29	2	19.5	a,d
4.3	-	18.5	37	3	-	
TOTALS	24.0	271.5	129.5	33.0	101.0	

NOTE: a. Graphic capability is recommended.

b. Made up entirely of modules used in 1.1 through 1.4.

c. Made up of 19.5 hours of self-study and 45.5 of classroom training.

d. Hardcopy and computation capability necessary.

The Target Population

Size and Distribution

The target population for the courses of the Transportation Services branch of Air Canada in North America is made up of 5,247 individuals, broken down into nine employee classifications and spread over 41 different locations. These locations fall into four categories based on their relative importance reflected by the number of potential trainees. These stations may be classified as major (more than 500 trainees), large (over 100 trainees), medium (over 40), or small. This breakdown is meaningful because: (a) instructors are based only at certain types of stations, and (b) the scope of training activities varies in accordance with the operational requirements of the types of stations.

The trainee population is considered stable with no major fluctuation expected, except for the travel agents where a yearly increase of 10% is anticipated for the next five years. While the detailed geographical distribution of the target population is displayed in the appendix, Table 3 summarizes this information by type of station.

Pattern of Training

Employees receive the initial training corresponding to their tasks at the time of hiring or of promotion to a higher classification. This training is conducted by instructors at major locations. The number of classes held depends on the demand which reflects the rate of employee turnover (hiring and promotion).

There is no one-to-one correspondence between the courses offered and

TABLE 3

DISTRIBUTION OF TRAINEES BY TYPES OF STATIONS

Employee Classifications	Stations: Major	Large	Medium	Small	Totals
A - Passenger Agent	944	488	214	121	1767
B - Reservations Agent	774	372	152	33	1331
C - Off Premise Travel Agent	890	160	50	16	1116
D - Cargo Agent	188	107	44	13	352
E - Load Agent	128	38	4	3	173
F - Baggage Agent	103	45	4	3	155
G - Commissary Agent	63	22	-	-	85
H - Station Agent I	-	39	93	44	176
I - Station Agent II	-	-	-	92	92
Totals	3090	1271	561	325	5247

the employee classifications. Thus, a Station Agent II attends courses intended for several other, more specialized, classifications. On the other hand, the scope and frequency of his follow-up training is tailored to the specific requirements of his work.

Table 4 relates the courses, identified by the numbers already used in Tables 1 and 2, to the various employee classifications, identified by the code letter used in Table 3: Course 1.1 (Reservations-Basic) is meant for classifications A (Passenger Agents), B(Reservations Agent) and I (Station Agents II). The total number of employees in a classification is shown under the appropriate code letter: There are 1,767 Passenger Agents in the trainee population. Where only a fraction of the employees in a classification is to attend a specific course, their number is indicated in the body of the table: Only 339 Cargo Agents (D) out of 352 may attend Course 4.3 (Cargo Rating - Advanced). The totals in the right-hand coumn are obtained by adding horizontally the trainees, in any classification, who are part of the target population for the courses.

Processes of the Training Organization

The development of training materials is centralized under a Training Program Development Manager, while the responsibility for the training operation and the performance level of the workforce is delegated to the regional level. The regional training managers contribute manpower resources to the development unit which produces training materials for lectures, self study packages, sound-slide presentation or other methods in the form of publications. Regional instructors conduct training either at their

TABLE 4

PATTERN OF TRAINING REQUIREMENTS BY EMPLOYEE CLASSIFICATIONS

Course ident.	Employee Classifications					
	A	B	C	G	I	Totals
	1767	1331	1116	85	92	
1.1	x	x			x	3190
1.2	x	x				3098
1.3	x				x	1859
1.4	x					1767
1.5			x			1196
2.1				x		85
	D	E	F	H		
	352	173	155	176		
2.2			x	x	x	423
3.1		x		x	x	441
3.2		x		x	x	441
3.3		(170)		(132)		302
3.4		(166)		(39)		205
4.1	x			x	x	620
4.2	x			x	x	620
4.3	(339)					339

home base or at remote locations while some minor programs (short duration or structured self-study) are monitored by local supervisors.

Regular courses are scheduled at intervals based on historical data and anticipated requirements to take care of the requirements of promotion and classification changes; their content and terminal performance standards are precisely stated. Additional training sessions are designed and given whenever a major change - procedure or equipment - is introduced. These events require optimal use of instructor resources to reduce implementation delays. After the workforce has been trained, training materials designed to cover the changes are incorporated into the regular courses. Periodic refresher 'follow-up' courses are given on a yearly basis to maintain performance levels and to ensure that the employees are aware of the minor procedural changes implemented over the previous year.

Individual training records are prepared and forwarded at weekly intervals to the regional level to be compiled into statistical reports, such as the utilization of instructors, for local use and transmission to the corporate level. On the other hand information relative to the use and validation of training materials is forwarded rapidly, particularly in the case of new training programs, to the development unit for action.

To ensure the continuing smooth operation of the training organization it is necessary to maintain or improve the integrity of these processes and to consider them in any list of specifications of the minimum requirements of the CAL facility.

CHAPTER 5

DESIGN OF A GENERAL MODEL OF THE SYSTEM

Up to this point the analysis of the project has been conducted within the framework of the systems approach advocated by Jenkins (1972). Indeed, the headings of Chapter 4 and the subheadings in Chapters 1 and 3 represent the stages of the Systems Analysis which he spells out, although they have been resequenced here to facilitate the presentation of their interrelationships.

In his systems engineering approach to training, Silvern (1972) develops the concept of anasynthesis, an iterative process of analysis, synthesis, modelling and simulation permitting the solution of complex problems with many alternatives and interrelationships.

In this context the conceptualization of a system was begun by means of an initial analysis performed on existing information dealing with the general environment in terms of its existing elements and organizational needs: the challenge facing the training organization.

A first incursion into the synthesis stage combined some currently unrelated elements into a general direction: the consideration of Computer Assisted Learning as a potentially viable solution. A return to the analytical aspects led to a more detailed study of the curriculum, of the target population, and of their interrelationships, in order to ascertain their impact on the implementation of such a system prior to the third stage of anasynthesis: the construction of a graphic analog or management planning and process model which allows the decision maker to predict the effectiveness of a project prior to its implementation and, therefore, to minimize the risks inherent in its introduction.

This general model enables the researcher to conduct a series of "narration simulations", that is, to "talk through" this analog, function by function, in order to ensure that no necessary element is left out and to list alternative solutions which will be examined to determine the consequences of their adoption.

The narration simulation, described by Silvern (1972, p.154) as a 'giant step' towards quantification, can substitute for actual experience at lesser costs and risks. As a tool for refining the model it pinpoints, for planning purposes, where feedback paths should be inserted for cybernetic adjustments and, for monitoring purposes, where quality control devices should be installed.

The model will show a series of sequential but interrelated decisions concerning the selection of hardware, software, courseware development and delivery, curriculum prioritization and rate of introduction. The decision process involves the analysis of the contents of each cell of a multi-dimensional matrix, and the combination of selected cells into a compatible and optimally effective system. In order to reduce this overwhelming workload to a task of manageable proportions, the choice must be restricted to a limited number of promising and reasonable alternatives within each main subdivision.

The decisions to be made for the design of the CAL facility may be classified as major, intermediate, or minor.

Major level decisions involve the selection of computer hardware and software, and of personnel. Once made, they can be changed only with difficulty and at considerable expense because of their physical character, their high initial cost and the involvement of parties outside the training organization. Their review is limited to periodic external evaluations.

Intermediate-level decisions initially affect major-level decisions to some extent, but permit some latitude for modifications. They include the geographical coverage, the instructional mode of computer use, the pattern of course prioritization and the rate of introduction.

Minor-level decisions involve mostly instructional programming and the conduct of courses. They can be changed on short notice within the system to refine performance and constitute a form of continuous internal review.

The decisions will be made in the following order: After selecting the hardware and software components of the system and some key personnel, a study will be made of the effect of various intermediate decisions on the profitability of the system, following a similar pattern for all alternatives on the basis of the information currently available (actual data, literature data, estimates). The final picture for the most promising alternative will be refined by means of the leeway provided by the minor decision areas.

The Flowchart Model

Silvern has described a methodology for the design of flowchart models and has provided many examples for instructional systems such as the

'General System Model for Effective Curriculums' (1971). Such models, since they remove ambiguity regardless of the complexity of the undertaking are most suitable for the study of systems. This method is selected here because of the amount of investigative work to be done, since a PERT/CPM type model appears more suited for the detailed progress and coordination of a project for which a specified approach has already been selected.

These models are drawn using LOGOS. the 'Language for Optimizing Graphically Ordered Systems'. a graphic mode of expression which relies, not only on alphanumerics, but also on shapes and symbols representing fundamental vocabulary elements. The model represents the division of the system into its functional subsystems and reveals a network of signal paths carrying information or data between functions, represented by a point-numeric code.

In Chapter 3, the system was defined as the CAL element which could be incorporated into the training environment of the airline's Transportation Services branch. The model will therefore show its various constituent subsystems and their interrelationships. It is obtained by subtracting from the total functional requirements necessitated by a training organization equipped with CAL facilities, the network of functions already being performed by the current organization. Thus it represents a differential between the present and the future situations and isolates the planned element so that it can be studied independently, without eliminating the necessary interfaces required under the new arrangement.

While certain functions are new to the training organization, e.g., "Develop CAI processor", othersrepresent modifications or realignment of tasks currently performed, e.g. "Develop curriculum", "conduct course". By concentrating on the functions to be performed, it ensures that there is no duplication or gap of activities and avoids the biasing influence of existing organizational structures. Once the necessary tasks have been delimited, and their interfaces made clear, their allocation to specific groups and individuals can be done on an objective basis, thus combining flexibility with efficiency.

Figure 2 shows the general model of the system constituted, at the first level of detail, of six interrelated functional subsystems (1.0 to 6.0). It also shows, except for the first two of these, a second level of detail. Subsystems 3.0 and 5.0 being more complex, will be drawn to the third level of detail in conjunction with the narration simulation.

The model brings into focus the five clusters of activities listed by Warren (1969) and mentioned in Chapter 3: Research and Analysis are spread over subsystems 1.0 to 4.0, Development is the realm of subsystem 5.0, while both Operations, the implementing of the training action , and most of Evaluation are included in subsystem 6.0.

For the model to be valid, there must be consistency between planning, construction and implementation: It should satisfy the needs of these consecutive stages without requiring any modifications. The model may therefore be considered in the light of these three functions.

It is first a research tool allowing the determination of the possible options and the analysis of these alternatives. Along its paths will be found the points where decisions will affect the final configuration and

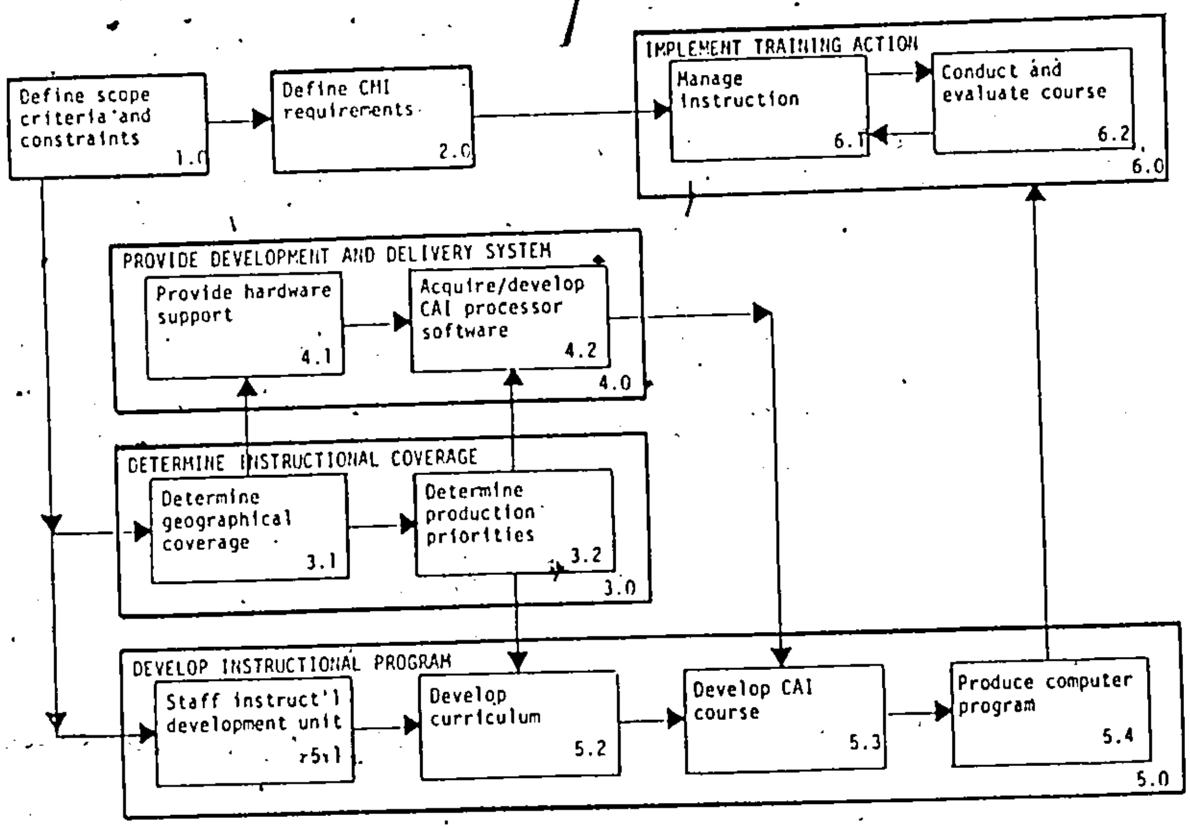

FIGURE 2 - MODEL OF A SYSTEM FOR PLANNING THE INTRODUCTION OF COMPUTER ASSISTED LEARNING IN TRANSPORTATION SERVICES

reduce the areas of uncertainty. Each simulation will provide a new set of figures for evaluation and comparison. The purpose of this project is to provide a rational tool for an objective decision-making process in the absence of complete data. This model merges the actual situation with the theoretical knowledge selected as being the most appropriate. In the process the instances of use of data which are not extracted from actuality are identified so that they can be replaced later by empirical information during the implementation stages.

If the study indicates that the implementation of CAL would meet the profitability criteria set up by the corporation and detailed earlier in Chapter 3, the general model can double as an implementation instrument for the selected alternative. In this second use, after one alternative solution has been selected, the choice of paths within the model is confined to one track leading chronologically through all the necessary steps which have to be considered: It thus provides a comprehensive checklist ensuring that no mandatory detail is left out. Furthermore it points out where controls have to be installed to ensure the validity of the assumptions on which the productivity level depends.

Thirdly, after the system is in operation, the model can be used for monitoring purposes by comparing the actual data gathered by experience with the estimates used during the research phase. The examination of the blueprint, coupled with the quality control data regarding deviations from planned performance, will facilitate operational decisions ranging from minor internal fine-tuning to phased-in termination.

Narration Simulation

Once the general approach has been mapped out, the narration simulation phase takes the researcher through the various functions of the system for the purpose of exploring the options open. While establishing the signal paths which must ensure a smooth operation, it delimits the scope of possible selections and thus remains generalizable to a variety of situations. Later iterations restrict the choice to specific modes of operation which can then be analyzed in economic terms for comparison purposes.

The 1.0 Subsystem: Define Scope, Criteria and Constraints

This function outlines the general conditions under which the system will be operating. It provides guiding principles to be used as selection criteria for all subsequent subsystems. The conditions emanate mainly from the preceding chapters and are listed below, with a mention of the subsystems on which they have a direct influence:

1. Existing course materials found instructionally suitable for this methodology will be converted on a progressive basis and, once available in CAL format, will be maintained up-to-date. This affects directly subsystem 3.2 (Determine production priorities).

2. Computer assisted instruction will be introduced to every employee classification whenever it proves economically justified (Sub. 3.1, determine geographical coverage).

3. The CAL system, after being operational for the Transportation Services employee classfications, must be suitable for expansion to other

branches of the Corporation such as In-Flight Service, since the training of Flight Attendants has already been identified as a promising area for CAL by other researchers.

4. There will be a management element. The output of the system will be monitored (Sub. 2.0, Sub. 6.0). The analysis and evaluation data will be substantiated for the purpose of quality control.

5. The CAI facility must be accessible for an established minimum percentage of time. This requirement involves both a standard of service (response time) and of availability (average waiting time) impacting on the number of learning stations, as well as a standard of reliability of the equipment (down-time) impacting on the computer hardware maintenance schedule.

6. Whenever economically justified,existing personnel, facilities and equipment will be used.

7. The functions of computer programming will be clearly separated from those of instructional programming. This means that the instructional programmer (course author) will not have to concern himself with the intricacies of computer operation. This affects the CAI processor made available through Subsystem 4.2.

8. The training staff is responsible for the output of the CAL facility. This implies that the Manager in charge of instructional programming advises the computer staff of the requirements of his group with regard to facilities and technical needs, monitors the performance of the system, and approves the final product.

The 2.0 Subsystem: Define CMI Requirements

The term Computer Assisted Learning (CAL) is fairly general and implies that the computer plays a central role in guiding the learning of the student and the evaluation of his performance. Here this concept is subdivided into two separate but interrelated parts:

1. Computer Assisted Instruction (CAI) refers specifically to the teaching and learning activities aided directly by a digital computer. It is the domain of the instructional programming itself (Subsystem 5.0). CAI requires that some features be incorporated into the CAI language (Subsystem 4.2). Examples of these requirements would be (a) the need for computation capability and (b) the need to accept answers based on some criteria such as 'exact match' or 'keyword match'.

2. Computer Managed Instruction (CMI) may refer to a mode of use in which the computer assists in managing instruction by handling performance records and curriculum files, by prescribing and scheduling instruction on an individual basis. CMI requires that some features be incorporated into the software program in Subsystem 4.2.

In this project the CMI requirements will be limited. However Subsystem 1.0 (Scope definition) calls for a training management element: This will include minimally: (a) a registration component, and (b) a report generation element.

Furthermore, the software package must include features enabling the instructional developer to assess the performance of the program. It requires saving data on user interaction, recording unanticipated answers, etc... for use in validation and updating of programs.

Finally it should have features contributing to the convenience of the trainee. It must be possible: (a) to branch to a designated position of a training program segment in which the user last signed off or otherwise stopped using the program, and (b) to establish restart points, at which execution will begin again if a disconnection occurs before a sequence is completed, whether by accident or intention.

The information defining which CMI features will be incorporated into the processor software package (Sub. 4.2) is fed forward to Subsystem 6.0 where it meshes with the main stream of CAI to permit the implementation of the training action as planned.

The 3.0 Subsystem: Determine Instructional Coverage

In order to maximize the effect of the CAL facility, it is necessary to decide which courses will be available (Sub. 3.2) and where they will be available (Sub. 3.1). The factors to be considered are: (a) the number of employees in a classification for which a course is developed, and (b) the frequency at which this course will be used. Both factors will have a direct effect on the student contact hour cost, since the preparation and production costs are spread over the number of trainees.

The location of the trainee is another factor to be considered because (a) it will be necessary to provide learning stations and data communications lines, which will increase the cost of operating the facility (to Sub. 4.1), and (b) CAI service to an outstation may result in benefits since the need to travel to a training center is reduced or eliminated. This explains why the selection of instructional coverage involves an iterative process between Subsystems 3.1 and 3.2.

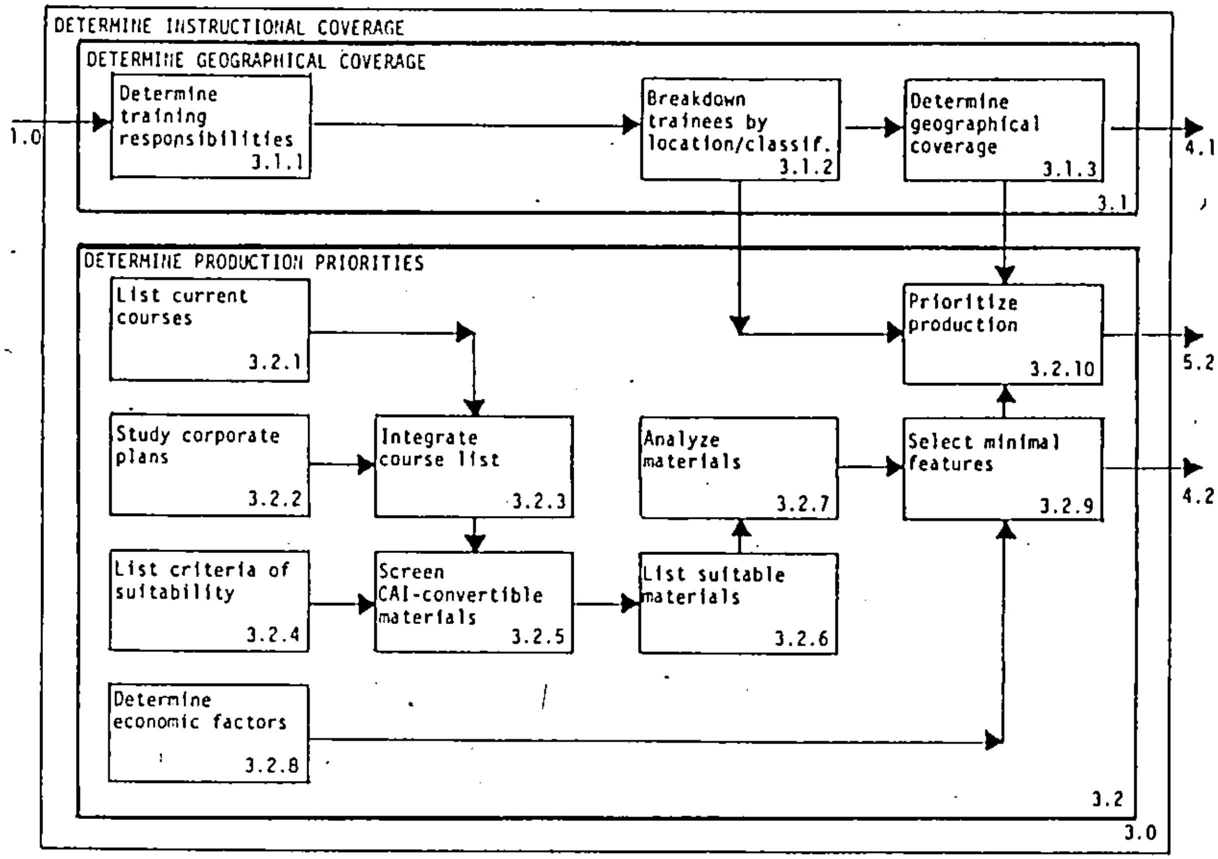

FIGURE 3 - THE INSTRUCTIONAL COVERAGE SUBSYSTEM OF THE CAL PROJECT

The 3.1 Subsystem: Determine Geographical Coverage

The first step (Sub. 3.1.1) in this subsystem consists in identifying: (a) the whole target population under the organizational jurisdiction of Transportation Services and (b) the extent of the technical training they are to receive. This latter information flows to Subsystem 3.2.1.

In 3.1.2 the target population is then sorted out by locations and work classifications. This information flows to Subsystem 3.2.10 where it is integrated for the purpose of determining the degree of use of specific course units.

In 3.1.3, the input from Subsystem 3.2.10 (Prioritize production) determines which combinations of locations and classifications listed in Subsystem 3.1.2 will have access to the CAI facility. The output is to Subsystem 4.1 which will result in procuring hardware support to the selected locations. After implementation, when the CAI facility is in a steady operational state the signal flow "3.1.3 to 4.1" is reversed "4.1 to 3.1.3": The availability of learning stations connected by data communications lines dictates the geographical coverage, until another round of planning is initiated.

The 3.2 Subsystem: Determine Production Priorities

It is generally recognized that any lesson in any subject can be programmed for computer assisted instruction if the lesson strategy can be explicitly defined and the lesson materials represented in words, pictures, and experiments to be displayed to the student by the computer based system. Although this method has, in fact, been attempted for a wide spectrum of instructional activities, Hicks and Hunka (1972) have expressed doubts as to "whether these CAI programs are effective from a learning point of view, or whether they are as effective as they should be..." (p.36). This effectiveness depends on suitability criteria of the subject, falling basically into two distinct areas: technical and economic.

Epistemological factors indicate to what degree the computerization of the training program is feasible, that is, how suitable is the subject matter to that form of treatment, while economic factors indicate to what extent the computerization of the training program is cost-justifiable. Since each particular unit can be ranked along the 'technical feasibility' and the 'economic cost' axes, it can be plotted on a grid where the intersection of the most favourable coordinates would indicate the highest priority item.

The subsystem begins with a listing of the current training areas within Transportation Services (3.2.1). The corporate and branch plans are studied to assess their effect on areas of training responsibilities. (3.2.2). This information is incorporated into a comprehensive list projecting the training requirements over the time-span of the study (3.2.3). The list is then screened to determine which materials are technically suitable for convertibility to CAI methodology (3.2.5) on the basis of criteria gathered from the literature and current users such as British Airways and United Airlines (3.2.4).

Generally speaking, the assessment of applicability of an instructional program to computer based technology takes into consideration the nature of the content and that of the learners. Thus, subsystem 4.2.5 eliminates the areas which are obviously not suitable because the content is dependent of interpersonal interaction or because the objective is the acquisition of psycho-motor skills. The constituent units of the courses found suitable are then analyzed in terms of stability and structure of content, taxonomy of objectives and types of cognitive activities involved.

This process, started in 3.2.5 to produce a listing in 3.2.6, is further refined in 3.2.7 to find out which instructional mode of oomputer use is the most suitable (fed back to Sub. 4.2), which type of terminal and equipment is required at the learning stations (to Sub. 4.1), and which additional features, such as computational capability, not previously identified in the CMI management module (Sub. 2.0) are required.

Subsystem 3.2.9 filters the features which are economically jusitified before requesting them through Sub. 4.1 and 4.2 on the basis of the cost criteria listed in 3.2.8 while Subsystem 3.2.10 prioritizes the production of courses on the basis of instructional content, mode of computer use, and target population. This information flows to 5.2 where the instructional program will be developed.

The 4.0 Subsystem: Provide Development and Delivery Systems

This subsystem groups functions which are performed mostly by specialized personnel of the Computer Services branch. The associated expenses are mostly one-time fixed costs incurred for operating the facility.

The 4.1 Subsystem: Provide Hardware Support

This subsystem encompasses the functions of selecting, procuring and maintaining the computer and ancillary hardware required to operate the CAL facility.

The technical specifications for the selection of computer equipment emanate mostly from Subsystem 1.0, especially with respect to standards of reliability and compatibility with existing equipment. This computer equipment may be subdivided into: (a) the Central Processing Unit, (b) the peripheral devices, (c) the data communications lines, and (d) the learning stations.

The Central Processing Unit (CPU) must be capable of handling the progressively increasing peak demand within the response time suitable for interactive systems and with appropriate reliability.

The peripheral devices include data storage with a capacity sufficient for the number of programs produced (Sub. 5.3) and the files and records generated by the CMI facility (Sub. 2.0). They also include the equipment selected for the production of the training program, such as keyboard, card punch, tape punch, and magnetic tape (Sub. 5.3).

The type of data communications lines is dictated by the equipment they connect. The number and location depend on the input of Subsystem 3.1 which determines which locations will be served.

The minimum equipment for the learning stations is the console (terminal plus modem). The type of terminal used must not only be compatible with the rest of the system, but also possess the features necessitated by the course, such as graphic capabilities. The number of terminals depends not only on the geographical boundaries of coverage (Sub. 3.1), but also on the standard of service set in 1.0.

The selection of computer system hardware components may be done by, accepting an existing system as is, or by assembling or synthesizing heterogeneous components. In the former case, it may already include a suitable CAI language, a circumstance which would obviate the necessity of going through Subsystem 4.2.

The requirements listed here, which provide a convenient breakdown for analysis, should not be seen as reducing the variety of possible configurations. Thus, if it is decided to use a microprocessor system, the term "communications lines" may be interpreted as the forwarding by various means of courseware cassettes to the necessary locations.

The 4.2 Subsystem: Acquire/Develop CAI Processor Software

A CAI course may be written by using either a specialized CAI language or a general computer programming language. In the latter case, there is no need to acquire or develop a CAI processor, that is, a computer program which manipulates the instructional program inside the computer: So long as the instructional programmer (course author, lesson writer) is willing to use a general purpose language such as BASIC or FORTRAN, this step disappears. This alternative is however ruled out in the present case by Constraint 7 in Subsystem 1.0: Because computer programming must be clearly separated from instructional programming, a CAI language must be used.

The selection or design of a CAI language is partly dependent on the choice of computer hardware (Sub. 4.1). It may be selected from existing languages such as Univac/ASET, Plato/TUTOR, Honeywell/EXPER, LYRIC or designed on the basis of language specifications emanating from: (a) the CMI features required (Sub. 2.0), and (b) the CAI features determined useful after an analysis of the courses is performed by the Instructional Programmer in Sub. 3.2 (e.g. line graphics, computational requirements).

Language specifications can be extensive and extremely technical. The instructional programmer must make realistic and practical recommendations, ensuring that he does not request features of little instructional value or of infrequent use. He must trade off the non-essential features against their incremental design cost.

The software requirements may be divided into three separate categories corresponding to the needs of consecutive phases of the operation of the CAL facility.

Category 1 represents the mandatory requirements for Phase 1 described in this paper and includes:

1. On-line editing by the Instructional Programmer staff to speed up the debugging process, facilitate the updating of materials, and allow for modification and expansion of lessons.

2. Response Recording and Elementary Analysis: The system must be able to save data on both user and program interaction for use by the author. Initially the system could simply record students' responses for later retrieval. It should also incorporate record-handling routines to produce summaries of program performance to assist the lesson-writer in improving and revising lessons and their internal logic on an objective basis.

3. Time-control feature to record time elapsed during trainee interaction, to measure elapsed time of user input, and to control the timing of display presentation.

4. User Registration: The system must include provision for the registration of trainees, authors, and management personnel to allow (and to restrict) access to the system, to allocate storage space for user records, and to account for the resources used.

5. Record Keeping: Record handling routines, similar to the one mentioned for elementary response analysis, will be used to generate and maintain individual students records which will be kept to determine the degree of proficiency of the workforce in a particular area, with a resulting printout indicating when refresher training becomes due.

Category 2 covers the needs of the next stage which is anticipated to contribute improvements to the system after it has been operating successfully for some time. If these features were available initially, they would represent a remarkable asset, but the CAL unit can operate without them through modifications in programs, such as replacement of "Drill and Practice" by "Tutorial" and inclusion of additional adjunct materials. It includes:

1. Computational Capability: The software must include a simple computational facility available to the users and able to generate random numbers. It must be able to execute computations and manipulations of arithmetic data, store and use numeric information that may change in value as a lesson is executed, and assess student answers in numeric form.

2. Graphic Capability: The system must be able to display predefined simple-line static graphics. These straight lines are displayed

on the screen without the need to define each point on the line. Furthermore this facility must permit to erase selectively, write over, fill-in or add to the displays.

3. Selective Restart Point: The language must permit the author to establish restart points at which the execution of the lesson will begin again if a disconnection occurs before a sequence is completed, either by accident or intention.

4. Mode Switching Capability: This feature, an extension of the previous one, allows the trainee to switch from the training mode to an operational mode. This enables him to practice simulation of what was covered in the tutorial, and to alternate learning activities with actual work, when the latter is unevenly distributed over the shift period.

Category 3 represents the needs of a future stage to be developed when the previous phases will have been operated successfully for a long period and when most of the potential materials are available through the CAL facility. They are listed to indicate the general intended direction of progress and to ensure that preceding decisions are compatible with future goals. In contradistinction to Category 2, they would not contribute significantly to the initial operation of the system if they were available from the very beginning because of their degree of sophistication.

1. Communications: The system will include a common area or file, where system users can leave messages for which they may or may not request a reply.

2. Diagnostic Testing: Tests will be tailored to the individual

trainee's performance so that a diagnosis will identify the specific objectives which remain to be mastered. The next step will be the development of a personalized learning prescription, recommending a specific path of learning activities through the remaining curriculum.

3. Instructional Response Analysis: Basically an expansion of the elementary response analysis listed under Category 1, this feature provides an efficient means for the lesson writer to evaluate the effectiveness of a lesson, by asking questions through the keyset, about the body of student response data stored by the computer.

The 5.0 Subsystem: Develop Instructional Program

The functions in this subsystem represent the general scope of responsibility of the Instructional Developer. Initially they could be performed serially by the same individual, but as the workload increases it will become necessary to split up the function and allocate tasks to personnel who will specialize in a particular area. As the development function grows with the production of CAI units, the need for field instructors will be reduced in Sub. 6.0 (Administer training), with a resulting shift of manpower from 6.0 to 5.0. At a higher level of production it may become economically justified to shift functions such as keyboard entry or card punching to clerical personnel.

Because of the experimental nature of this project it is necessary to time-record all activities (e.g. time required to input a coding sheet into the computer at the keyboard). This information will allow to refine the operation in economical terms and will provide empirical data for other branches of the corporation contemplating a similar move.

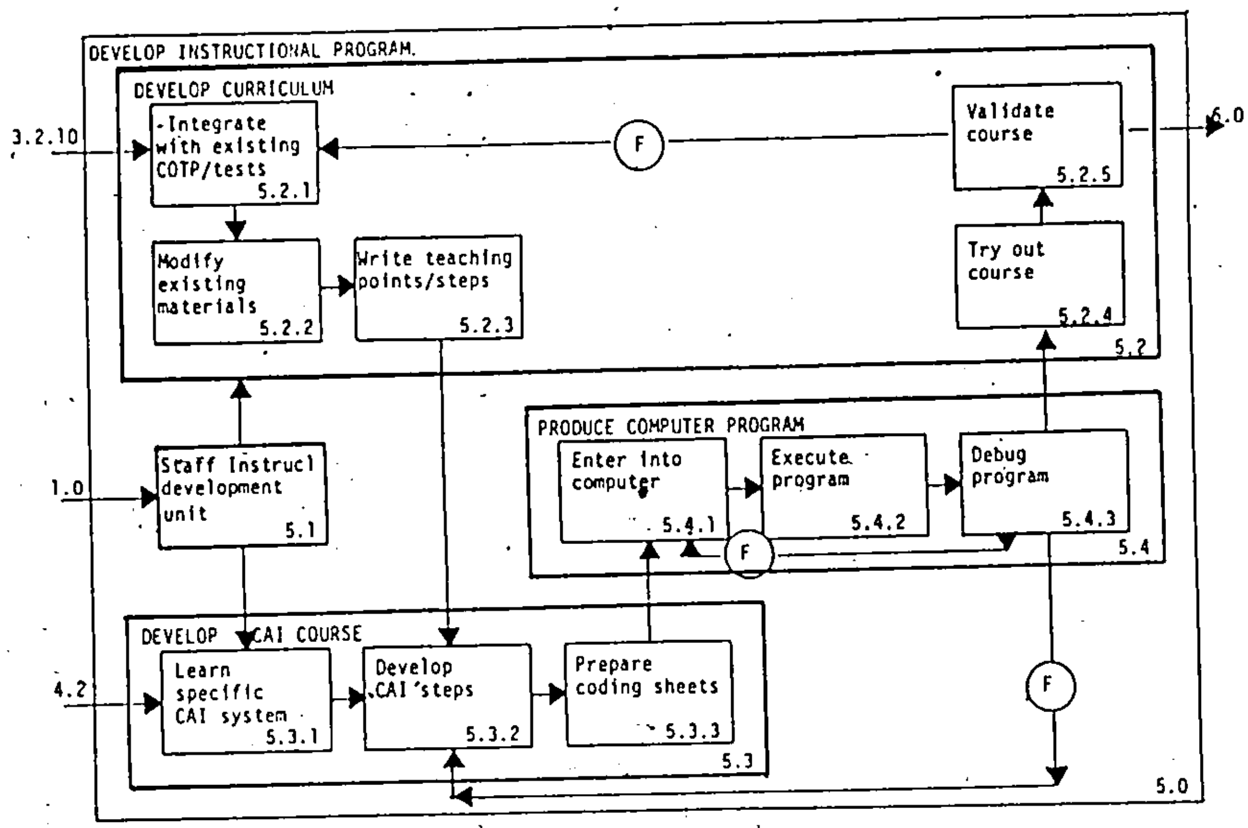

FIGURE 4 - THE INSTRUCTIONAL PROGRAM DEVELOPMENT SUBSYSTEM OF THE CAL PROJECT

The 5.1 Subsystem: Staff Instructional Development Unit

Members of the instructional development team, identified as course authors or lesson writers are selected from the instructor ranks on the basis of their qualifications and experience. They bring to the instructional programming unit both subject matter expertise and training background. A trial period, during which they receive the necessary complementary instruction, establishes their predilection and aptitude for this type of work.

The 5.2 Subsystem: Develop Curriculum

This function is currently performed by Training Program Managers who, assisted by instructors, produce in training publications the Courseware Outlines to the Teaching Point (COTP) as well as the corresponding pre- and post-tests.

In costing the implementation of CAL, the differential between the current and the anticipated system is the relevant element. The costs start adding up from the time the Instructional Programmer receives the COTP and tests (Sub. 5.2.1) corresponding to the prioritized list established in 4.2.10. This applies also to new courses: They would be developed along stringent guidelines to produce a COTP and tests meant for locations not connected to the CAL network. However the costs attributable to CAL are only those incurred after the COTP is developed.

In subsystem 5.2.2 minor adjustments are made to the COTP and tests to ensure their compatibility with the available computer assisted capabilities. In subsystem 5.2.3 each teaching point, chronologically sequenced in the COTP is subdivided into a series of steps (e.g. introductory, generative, review, etc.) which will optimally elicit the intended trainee behaviour. This information then flows into subsystem 5.3.

The signal path from subsystem 5.4 re-enters subsystem 5.2: The lesson writer evaluates the effectiveness of the CAI lessons with the help of microteaching characterized by very small classes. He analyzes the response files to detect areas in need of improvement. During tryout in 5.2.4, the specific responses and their pattern received from a population sample are analyzed as a basis for validation in 5.2.5. If the course meets the pre-established criteria, it may be used in 6.0. If it does not, this information is fed back to 5.2.1 or any subsequent subsystem for overhaul.

The 5.3 Subsystem: Develop CAI Course

In 5.3.1 the members of the instructional development team learn the specific CAI system with the assistance of specialists from the Computer Services branch and the manufacturer or supplier. In Subsystem 5.3.2 they elaborate a strategy supported by a flowchart model for the steps written in 5.1.3. This flowcharted strategy is then transferred in 5.3.3 to coding sheets which besides being used for computer entry constitute part of the documentation of the program. The commonly used strategies will be pre-established, so that the author can select the most appropriate from a choice of templates.

The 5.4 Subsystem: Produce Computer Program

The method of entry into the computer of the contents of the coding sheets (5.4.1) depends on the computer hardware selected in Subsystem 3.1. It will include a keyboard terminal for ease of dubugging programs. A Video Display Unit will facilitate formatting, while a hardcopy unit will provide a permanent record which could be studied off-line. Other means of entry include magnetic tape, card-punch, and perforated tape.

As part of the formative evaluation, the computer program is executed in 5.4.2 and debugged in 5.4.3. In some cases the modifications can be made on the spot and the information fed back to 5.4.1 where the error is corrected on-line at the keyboard terminal. If the error is more serious, the feeback information is injected at an earlier point such as 5.3.2 for a modification to the CAI steps. When the program has passed the debugging stage it is advanced to 5.2.4 for course try-out with a representative sample of the target population.

The 6.0 Subsystem: Implement Training Action

Like Subsystem 5.2 (Develop Curriculum) this last subsystem covers existing functions which are modified to some extent. It represents the culmination of the project, in the sense that it constitutes the junction point of all components of the system: trainees, equipment, courseware, etc. Although it has costs associated with it, this subsystem is the only one where benefits are evidenced.

The costs incurred in Subsystem 4.0 may be described as mainly one-time fixed costs. They represent a necessary investment to move ahead with a CAI project of modest scope. The costs incurred in Subsystem 5.0 are dependent on the number of programs produced. The increase is roughly proportional to the volume and quality of the material produced, although economies of scale are realized.

The costs incurred in Subsystem 6.0, on the other hand, depend on the number of trainees using the facility. The number of trainees simultaneously accessing the CAI lessons affects: (a) the size of the required core memory in the central processing unit and (b) the processing cost. The total number of students affects the peripheral devices required to store the data on user interaction and records of individual and program performance. They may therefore be considered as variable costs.

As the utilization grows the total costs can be spread over a larger number of trainees (or trainee-hours, student contact hours) to reduce the unit cost. The effect of the decisions made earlier in Sub. 3.0 (Instructional Coverage) are reflected in the extent of benefits to be reaped.

The 6.1 Subsystem: Manage Instruction

Training Managers currently perform this function: Their responsibilities include the acquisition and maintenance of facilities, as well as the provision of instructors and materials at the right time and place. This remains basically the same, the major change being that some instruction is now available in mediated form at remote locations on a continual basis. It is still necessary to ensure that trainees receive the appropriate initial or recurring competence checks either at their own base or at regional training facilities. The registration and record keeping procedures are now modified by the use of the CMI features defined in Subsystem 2.0, while the marking of tests is performed by the central facility, with compiled reports available to the Training Manager.

The 6.2 Subsystem: Conduct and Evaluate Instruction

The trainee receives instruction which is tailored to his individual learning aptitudes and modularized to meet specific requirements to maintain a recognized level of proficiency.

The instructor's role is changed in that he is able to manage the learning experience to a greater degree. In multi-media courses such as lecture with CAI-support he concentrates on the teaching of concepts and on areas highly dependent on personal interaction, while he leaves the repetitive 'drill and practice' to the computer.

There is a shift in pattern of occupations: Station supervisors, who have a recognized responsibility for training, can monitor CAI training for their personnel. Instructors spend less time in the classroom and more on program development. This occupational shift provides a new dimension in manpower flexibility: Depending on the operational requirements, some individuals move from an instructor position to either field assignment or program development.

The instructional development team by means of the Instructional Response Analysis mode asks questions through the keyset about the body of student response data being stored by the computer. They get the help of the computer in analyzing the response data as a basis for correcting and improving the CAI programs.

CHAPTER 6

COST BENEFIT ANALYSIS

In a systemic context, the training organization, to accomplish its mission, receives from the corporation an amount of resources to be transformed into a product which can then be translated into economic terms for evaluation: The higher the ratio of output to input, the greater is the efficiency of the organization.

In a similar manner the CAL system consumes resources received either from its parent training organization, or directly from a higher-order system, such as the Computer Services Branch on behalf of that parent organization. Its efficiency is measured by converting both the input and the output to a comparable yardstick such as economic value for conversion into a ratio. To define accurately the effect of a new entity, such as a CAL facility, on the mission of the training organization, it is necessary to determine to what extent the shifting of resources results in higher overall efficiency.

In order to do so, the relevant elements must be quantified to allow the calculation of the costs which will accumulate during the Research and Development of the CAL system as well as during the design and production of particular course units. The effect of the availability of a training program in CAI form must be transposed into financial terms: It will result not only in operating costs, but also in a reduction of some current expenses when compared to the traditional method of imparting knowledge. There will be an accumulation of net benefits whenever the overall differential amount represents a decrease in costs.

This chapter explains the general pattern which will be used to compare the various alternatives considered, covering successively the costs, the benefits, and the production schedule which will directly affect their magnitude.

Classification of Costs and Benefits

Each comparative study of training methods identifies the relevant elements bearing on the outcome and classifies them into discrete categories so that the relationships between the variables can be determined with precision and conclusions drawn. The various equations describing these relationships can be grouped into a mathematical model which will be used to predict the effect of variations in the value of the input variables.

The costs and benefits of the projected facility can be identified comprehensively by following the paths of the flowchart model through its separate subsystems. During this process a segregation of the elements is performed between those which will have to be considered during the comparison of the alternative solutions, those which are common to all alternatives, and those which may be disregarded because they represent current obligations of the training organization regardless of the methodology used.

Subsystem 1.0: Define Scope, Criteria and Constraints. The study of potential methods is one of the routine tasks of the training organization, because it has a responsibility for research of effective new training approaches. Its cost is included in the overhead and, although a portion of it could be allocated to the CAL facility, it does not affect this specific project. When the request for implementation is turned over to the Computer Service Branch, this unit will perform an analysis of its own in accordance with its internal practices which include research activities by systems analysts under the direction of a project leader. A specific cost representing the research manpower required will be charged back to this project. This amount is independent of the system selected and remains therefore the same regardless of the alternative being considered.

Subsystem 2.0: Define the CMI requirements. The definition of the registration and reporting capabilities deemed necessary for the operation of the facility at the selected degree of sophistication will affect the selection of the required software support package and therefore will have a bearing on its cost.

Subsystem 3.0: Determine Instructional Coverage. The training organization has a scope of responsibilities with well defined boundaries. Within that scope the selection of media is a routine decision which does not entail more expenses as a result of this project.

Subsystem 4.0: Provide Development and Delivery System. The provision of hardware support affects areas in all subsystems. It includes the Central Processing Unit, either purchased or rented, and its operating personnel, the peripheral storage units, the data communications lines and the learning stations (terminals and modems connecting them to the distribution network). These are not limited to the trainees' stations, but are part of the equipment required by the Curriculum Development Team.

The Delivery system could include auxiliary equipment such as student carrels and audiovisual equipment.

Subsystem 4.0 must cover the cost of acquiring through purchase or rental, or of developing either in-house or in co-operation with other institutions, the software selected on the basis of the CMI specifications and of the Instructional Programming requirements.

Subsystem 5.0: Develop Instructional Program. One of the implementation costs will result from the initial training of the Instructional Programming Team. Although the potential course authors are selected on the basis of their abilities in areas such as Programmed Instruction, they must learn the use of the new facility. These expenses will vary with the type of system selected but will remain within the same general bracket. Since both hardware and software have been considered in previous subsystems, the remaining costs are constituted by the salary of the Instructional Programming staff.

Subsystem 6.0: Implement the Training Action. At present the training organization includes field instructors at 'major' and 'large' locations, while at other stations, the local managers and supervisors are responsible for some aspects of training. The scope of activities of these personnel will be somewhat modified. Instructors who participate periodically in training program development workshops will now be using a new methodology. There will be a flow of personnel from the instructor to the supervisor ranks and the supervisors must be able to guide and monitor the progress of the employees using CAL at their stations. Although these personnel will have to be familiarized with their new role, no additional charge is assigned to this project because in-service development is part of the routine responsibilities of the training organization. Similarly the administrative activities connected with the management of instruction, such as scheduling and report keeping are currently budgeted and therefore do not result in additional itemization for this project. It is expected that the facility adopted will modify the division of labour in these areas, but not its total quantity. The time used by trainees in the classroom is considered only when it deviates significantly from the time currently spent: A reduction would result in benefits.

Whereas subsystem 1.0 to 5.0 represent additions to the organization, which result in either modifications of existing activities or new activities and incremental costs, subsystem 6.0 is the only one where economic benefits can be found. In fact these benefits which derive mostly from the elimination of certain expenses currently incurred, must offset all other costs if the introduction of the CAL facility is to be cost-justified.

This is, of course, a very conservative approach since it is quite conceivable that the process of developing instructional programs taking place in subsystem 5.0 will become more efficient than the present method. This is expected to become the case after the CAL unit takes over the initial development of new training programs, instead of being an additional element converting materials selected as suitable to CAL form.

Furthermore, the level of performance of the trainees is expected not only to be higher than with the current methods at the end of the course, but also to remain at that higher level because of the availability of periodic competency checks and of remedial instruction through the CAL medium. These effects will manifest themselves in other divisions of the company in the form of increased productivity and quality of output.

The introduction of Computer Assisted Instruction will result in many side effects which may be complex to quantify and remain too intangible to be incorporated into this type of study. To retain credibility, even at the risk of remaining in the marginal area of profitability, this study considers on the positive side of the balance sheet only these tangible elements which can be identified unambiguously and quantified in economic terms.

After identification, the various economic components listed above which do not differ markedly from those considered by researchers in this field, are regrouped into four main functional categories representing respectively:

1. The initial acquisition of the CAL capability. This would include one-time costs as well as the expenses necessary to set up the network facilities. Although the total purchase cost or rental of the complete network is covered here, data for individual locations can be identified so a[illegible]sess the effect of addition and deletion of stations.

[illegible]he expenses related to the development of training programmes. Besides [illegible] costs of transactions and storage required during the creation and evaluation of courses, the main item is the Instructional Programmer staff salary which is a function of the programme development time.

3. The expenses related to the use by the trainees of the developed training programs. They consist mainly of the costs of the transactions generated by the use of the programs.

4. The tangible benefits occurring in the Training Operation stage. They are financial benefits in the sense that they are made up of a reduction of expenses which are currently being incurred and will be eliminated by the availability of the CAL courses such as: travel time between home base and training location, related travel expenses, and instructor classroom time. If the duration of training is reduced for the trainee, it will also increase the amount of benefits being derived from the existence of the new methodology.

This classification, summarized in Figure 5, allocates the costs identified as necessary to the proper functioning of the facility to specific budget divisions which correspond roughly to the subsystems of the flowchart model and which permit the analysis of the system by assigning costs to either the facility, or the development of a particular course unit, or the use of that course unit by a trainee.

Determination of Benefits

Whereas the costs associated with the implementation of a facility depend on the characteristics of the various components selected, the benefits to be derived from the availability of a curriculum of courses in CAL form can be calculated with sufficient accuracy on the basis of statistical information to provide a ceiling figure for the cost justification exercise.

When a course unit has been converted and becomes available in CAL form, certain activities associated with the current mode of conventional instruction are no longer performed. Their elimination represents a

COSTS			BENEFITS
ACQUISITION	PROGRAM DEVELOPMENT	TRAINING OPERATION	TRAINING OPERATION
Initial Study	Initial Training of Instrn'l Programmer	*Familiarization Field Personnel	Tangible (included): Trainee time Instructor time Travel time Travel expenses Other: Enhanced performance Improved validation etc...
HARDWARE Equipment incl. C.P.U. Peripherals Maintenance Salaries Communications	Transactions Storage	Transactions Storage	
SOFTWARE	Development time (man power)		
Sub 1.0 - 4.0	Sub 5.0	Sub 6.0	Sub 6.0

FIGURE 5 - OVERVIEW OF THE CLASSIFICATION OF COSTS AND BENEFITS ASSOCIATED WITH THE CAL PROJECT

reduction in costs and therefore potential savings. The amount of savings depends on factors such as the length of the course, the number of trainees, and their geographical location, the average class size, the amount of the travel allowance, etc.

Each course must therefore be analyzed separately on the basis of these characteristics to arrive at a dollar figure, representing the potential saving over a full year of availability, in the manner shown below for Course 1.1 (Reservations - Basic).

The Course Profile describes the course as consisting of 65 hours (10 days or 2 weeks) broken down into 39 hours of computer assisted instruction and 26 hours of simulation. After conversion, the course no longer requires the presence of an instructor while the trainee is receiving instruction. At major stations where instructors are based, the trainee may receive additional coaching from an instructor, while at other stations, the trainee receives assistance from his supervisors: These are currently available and being used, and therefore do not represent an additional expense, when CAL is introduced. Since only part of the curriculum will use this methodology, a number of instructors who are able to monitor the operation of the system, remain available while performing other duties such as course preparation and various administrative activities.

The pattern of training requirements indicates that the course is given to new Passenger Agents (A), Reservations Agents (B), and Station Agents II (I), while the geographical distribution of trainees provides the breakdown of these employee classification for the various categories of stations:

	A	B	I	Totals
Major	944	744	0	1,718
Large	488	372	0	860
Other	335	185	92	612
Totals	1,767	1,331	92	3,190

The manpower budget provides the following average figures for salary and expenses:

Instructors and Trainees:	
Travel Expenses	$45.00 daily
Workdays/Productive days	230 yearly
Instructor	
Yearly salary (including benefits)	$26,496.00
Equivalent daily salary	$115.20
Equivalent hourly salary	$14.40
Trainee	
Yearly salary (including benefits)	$19,504.00
Equivalent daily salary	$84.80

The turnover rate determines how often a particular course must be made available to qualify enough agents to meet the needs of the operation. It depends mostly on the number of new hires and internal transfers. It is most closely approximated on the basis of historical data by comparing the actual number of trainees over the last three years with the size of the workforce. The examination of records also provides the average class size for the various courses and locations.

The records indicate that the turnover rate varies between a low of 0 to a high of 30%. When it cannot be determined with precision, a conservative figure of 8%, representing the average figure for new hires and internal transfers, is used. Personnel who do not receive the initial training described qualify for follow-up or "refresher" training.

Thus, if in any one year 8% of a particular employee classification receive initial training in a specific area, the remaining 92% will receive follow-up training on the same subject to maintain their competency level. The information listed above leads to itemization of the expenses related to training under the current method, or, in other words, the potential saving under the proposed method:

1. Instructors, based at 'major' stations conduct classes at these locations for an average 186.4 trainees a year. This number is made up of 137.44 trainees from the 'major' stations (potential 1718, turnover rate 8%) and 48.96 from the other stations (potential 612, turnover rate 8%). Based on an average of ten students per class, this number of trainees correspond to a yearly 18.64 classes.

2. Furthermore, these same instructors conduct 13.76 classes of 5 students each, for the 68.8 trainees (potential 860, turnover rate 8%) at 'large' stations. The instructors therefore conduct a yearly total of 32.4 classes of ten days, equivalent to a cost of $37,324.80 (324 days at $115.20).

3. To conduct the 13.76 classes conducted at 'large' stations, the instructors will travel one day in each direction, and this will result in an additional outlay of:

13.76 x 2 x $115.20 = $3,170.30.

4. The instructors receive the travel allowance of $45.00 per diem, for the 13.76 courses conducted away from their home base, 14 days per course (10 days instruction, one intervening 2 days week end, and 2 days travel):

13.76 x 14 x $45 = $8,668.80

5. The trainees travelling from 'other' stations to receive training at a 'major' station travel one day in each direction. This time reduces their yearly productive days by two:

48.96 x 2 x $84.80 = $8,303.62

6. These trainees also receive a travel allowance while away from their home stations:

48.96 x 14 x $45.00 = $30,844.80

These expense items total $88,312, an amount representing the yearly benefit resulting from the availability in CAL from of Course 1.1, when used for initial training.

During the year in which it is produced, a course is only available for a fraction of the time and the amount of savings to be derived from its availability is proportional to the period extending from the date of its completion, determined by the production schedule, to the end of the year. Thus, if Course 1.1 is ready for use on April 1st, its availability covers 75% of the year and will result in a saving of $66,234 for that year. If, on the other hand, the production is behind schedule by three months, the availability is reduced to 50% of the year and the benefits will drop down to $44,156. Deviations from the production schedule therefore directly affect the amount of benefits to be derived from the CAL system.

When all the courses in the Passenger Service category (1.1 to 1.4) are converted to the CAL methodology, additional savings result from the use of these materials for refresher training aimed at the 92% of these employee classifications which do not receive the initial training in that year. The duration of follow-up training varies up to 6.5 hours a year depending on the course and the type of station.

The process of calculation of the benefits resulting from the availability of a course in CAL format, exemplified by Course 1.1, is repeated for each individual course, taking into consideration the target population. the turnover rate, and the other relevant elements along similar lines. The result of this process is summarized in Table 5. One assumption of this process is the stability of the size of the work force which is projected as being constant over the period considered.

An exception to the general pattern is found in Course 1.5 and its follow-up aimed at an expanding target population of Travel Agency personnel. The course itself is made up entirely of modules created for courses 1.1 to 1.4 and therefore requires only a minimal amount of Program Development work. The target population is currently 1,116 with a projected expansion rate of 10% per annum. The only source of benefits is the instructor time since he conducts courses at his base for trainees whose expenses are covered by their respective employers. With a turnover rate of 10% the amount of benefits is restricted to $6,428 in 1979, growing yearly at a compound rate of 10%.

The follow-up to Course 1.5 (F1.5) is currently conducted by instructors at 519 off-base locations for two days each year representing a total of 1038 training days and 168 travel days. The estimated costs for 1979

TABLE 5

YEARLY SAVINGS RESULTING FROM THE AVAILABILITY OF COURSES IN CAL FORM

Course identification number	SAVINGS		
	Initial training	Follow-up training	Totals
1.1	$88,312	-	$88,312
1.2	45,900	-	45,900
1.3	31,631	-	31,631
1.4	45,295	45,363[a]	90,658
1.5[b]	6,428	156,871	163,299
2.1	1,118	1,802	2,920
2.2	1,293	11,181	12,474
3.1	17,375	10,559	27,934
3.2	4,025	616	4,641
3.3	6,565	616	7,181
3.4	4,842	1,231	6,073
4.1	52,956	-	52,956
4.2	55,928	13,926[c]	69,854
4.3	18,131	4,030	22,161

[a]The benefits of follow-up training begin when all courses 1.1 to 1.4 are completed (F1.1-4).

[b]Course 1.5 is made up of modules of courses 1.1 to 1.4. Savings start to accrue when courses 1.1 to 1.4 are available. These savings increase each year because of an expanding population.

[c]The benefits of follow-up $13,926 start to accrue only when both 4.1 and 4.2 are completed and available (F4.1-2).

amount to $156,871, and are projected to grow at 10% compounded yearly. The size of this current expense militates in favour of an early switch to a cost-saving methodology.

Production Schedule

The availability of courses in CAL form determines the maximum amount of benefits to be reaped in the production year. On the other hand, from the time they are used, these courses will result in expenses caused by the generation of transactions by the trainees. It is therefore necessary to plan a production schedule which will maximize the net benefits, through proper sequencing of courseware production. The schedule of production will affect the Curriculum Development costs in the form of wages and computer transactions. The Production Schedule is therefore the keystone of the financial analysis as a result of its effects on the other functions. Besides the specific characteristics of the courses and the related instructional mode of computer use, the duration required for the development of training materials depends on factors such as the relative effectiveness of current conventional vs. computer-based instruction, the ratio of preparation to presentation, the maintenance (course update) requirements and the learning curve effect.

Relative Effectiveness of CAI

Chapter 4 has revealed the existence of 434 hours of conventional instruction suitable for conversion to CAI methodology. To circumscribe the magnitude of the task, this figure must be translated into the number of hours of CAI materials to be produced to obtain an equivalent result, that is, the number of student contact hours (SCH) for each specific programme required to bring a trainee to an identical level of proficiency, formally defined as a training performance standard. These figures can then be added up to provide the figure representing the number of unduplicated trainee hours for conversion of the whole programme.

Posner (1969) has remarked that the cost per student hour of instruction is a convenient but inappropriate measure of the efficiency of instruction because the student hour of instruction is more a measure of the input of student time than one of the output from education. Silvern (1970 p. 148) also attracts attention to the fact that the effectiveness per learner per hour is a function of several factors, one of them being the quality of content. For consistency we shall use the term Student Contact Hour (SCH) to represent one hour at the terminal for the average trainee during validation of the completed programme to the same standards used for validation of our current conventional instruction.

If one hour at the terminal results in the same proficiency level as one hour of conventional instruction, both methods may be considered as equally effective. Kopstein and Seidel (1969 p.345) have expressed the opinion that the fundamental assumption of equal effectiveness is necessary in economic comparisons of computer and traditionally administered instruction in the studies where a tight methodology is not available. Posner (1969), on the other hand, found that the assumption of equal effectiveness of computer and traditional techniques is convenient but not essential for economic comparisons.

In their study Kopstein and Seidel (1969 p. 347) found the notion of at least equal effectiveness to be reasonable and on the conservative side. In this regard Fahlmann (1975 p. 37-38) of the Canadian Forces Personnel Applied Research Unit has concluded from a review of empirical research that several inferences can be drawn and in particular that: (a) CAI is as effective or more effective than conventional instruction as measured by student achievement, and (b) a difference which consistently appears is a time saving ranging between 10 and 90 percent in favour of CAI, with some time saving also evidenced in comparisons with programmed instruction.

Similarly Sherron (1976 p. 70) of the U.S. Industrial College of the Armed Forces reported that the U.S. Marine Corps Communications Electronics School in Twentynine Palms was able to considerably reduce the number of instructors and the length of the courses through the use of computer assisted training. In a similar vein, Hansen (1975) has reported savings resulting from course reductions ranging from 24 to 80 percent in the U.S. Navy.

With regard to cost comparisons between instructional alternatives, the consensus is that hard reliable figures are difficult to come by. Kopstein (1969 p.345) writes that "it is precisely with respect to the relative effectiveness of CAI and TAI that reliable objective information is practically non-existent", while Sherron (1976 p.44) states that "comparable cost data on instructional strategies are almost non-existent", and attributes this unlikely state of affairs to the lack of a required discipline of measurement and recording. This is especially true for traditionally administered instruction which is consequently very poorly standardized.

The reduction in course lengths encountered in the literature are certainly appealing but the spread between the most and least favourable figures is too wide for even rough projections. Furthermore, it is a factor of both the pedagogical value of the original instruction and of the care used in the production of the newer innovative product. It is expected that the didactic value of a product such as CAI, when prepared in accordance with the strictly defined methodology required, will be greater than that of an existing course which was created at an earlier stage when less was known about proper development methods and which has been allowed to grow and be patched up over a period of time.

It may therefore be confidently expected that the qualitative improvements brought about by the conversion process to CAI methodology will result in quantitative reduction of the training time. The initial calculations will, however, be based on equivalence of effectiveness between similar times spent in conventional instruction and in CAI. This initial assumption will be modified later on the basis of the monitoring of actual training, once the CAI facility is operational.

Requirements for Maintenance of Materials (Update)

In the dynamic environment of the airline, there is a continual generation of procedures and methods which must be communicated to and applied by the workforce. As a result existing training instruments must be updated and employees periodically retrained. The amount of change may be determined by examining the volume or percentage of pages affected in the existing source manuals published internally by the corporate Publishing Services. The updating of the training instruments to reflect these new procedures takes precedence over the routine conversion of course materials.

because their availability must precede the implementation date of the changes. Furthermore obsolete content in training publications is misleading and may result in operational problems.

The maintenance production requirement may be expressed as a percentage of the existing inventory of available courses expressed in student contact hours. Although modifications may affect any of the available didactic materials, the areas potentially affected are generally known ahead of time since they are indicated in the corporate, regional and branch plans. By judicious selection of the course units to be produced, the instructional developer can ensure that the programs he prepares will not be affected by changes in their first year of existence.

The amount of CAI hours available is related to the production rate and to the update requirements. Thus, for a constant production rate of 100 hours of CAI materials a year and a 15% update requirement based on the inventory at the end of the previous year, the production schedule would be:

Year	Update	New	Available
1	0	100	100
2	10	90	190
3	19	81	271

Actual field experience indicates that updating of training materials requires proportionally more time than the actual amount of change in the source materials would indicate. This is apparently an area which is often underestimated in the design of CAI systems. The experience of United Airlines suggests that up to 20% of production time may be needed for the updating of existing programs, although the proportion of courseware actually changed is considerably less.

The programs intended for conversion to CAI methodology deal with subject matter either similar to the one treated by United Airlines, or less subject to change. The overall rate of change in these fields oscillates around 8% of the existing content per annum. Initially a figure of 15% will be used for the calculations, as a conservative figure subject to modification on the basis of actual experience.

Ratio of Preparation to Presentation

One key factor affecting the cost of CAI materials is the production time required to design, produce and validate one CAI unit. The ratio of preparation to presentation is reported to vary over a considerable range. A high of 350 hours has been quoted by Mirabal (1976) while a low of 20 hours is mentionned by Hicks and Hunka (1972, p.166). The latter summarize the situation by stating that at least 40 hours, and in some instances as many as 200 hours of programming are required to produce one hour of teaching time at the computer terminal.

The time required depends on the specific application. Hicks and Hunka emphasize that the time required for programming and production of the audiovisual parts should not be underestimated. Programs in that category would fall in the upper part of the range. The Air Canada Flight Operations AVCAT (Audio Visual Computer Aided Tutor) system requires a ratio of 200:1, but this includes the audio and visual elements which are produced by the instructional programmers themselves. Figures quoted for Plato IV centre around the upper half of the range when the full extent of possibilities of this sophisticated system are experimented with. However, because it is a powerful interactive system which makes it easy for the authors to write their materials, a smaller ratio is possible. In fact, "a college teacher experienced in the PLATO system will spend 10 to 50 hours at a terminal while creating an hour of instruction, with some additional planning time spent away from the terminal" (Smith and Sherwood, 1976, p.350).

If the features of the system are more limited, the ratio decreases. Thus Silvern (1970, p.152) quotes a figure of 59.3 hours for a CRT-alpha-numeric system, including production and validation of job analysis, course outline to the teaching point, and tests. He summarizes by stating that it takes about one week to produce one hour of instruction.

The present study deals mostly with programmes which, at most, require simple line drawings and no audio features whatsoever. Furthermore these training programs exist in conventional form in training publications where the job analysis and course outline to the training point have already been developed. For this simple type of material it seems reasonable to expect that the instructional programmer staff could attain a ratio of 40:1 after approximately three years of practice.

Learning Curve

Hein (1967, p.91) has pointed out that, when constructing a series of relatively complex and similar objects, the time required to construct the second was appreciably less than the time required to construct the first. The learning process seems to continue indefinitely and have a measurable and fairly constant rate. He recommends that this tool, which is applicable to group operations, be used on an experimental basis along with current procedures to compute standard error figures and to determine confidence limits. The law of the effect of learning on production states that, given any specific point in the production series, the accumulated average time per unit is a percentage (between 50 and 100%) of the accumulated average time per unit at one-half that point in the production series. The 100% figure represents a no-learning situation where each consecutive unit is produced at the same speed as the previous one. A lower percentage corresponds to an improvement when units are produced progressively faster. The 50% figure is a physical impossibility; Such a coefficient would mean that, if 10 units had been produced in 100 hours, that is at an average time per unit of 10 hours, the production of the first five units would have required an average time per unit of 20 hours, that is the same 100 hours used by the total production.

Data concerning the production of CAI course units are obtained by constructing the regression line corresponding to the learning curve. The production depends on both the learning curve coefficient and the time required to develop the first course unit, figures which must be determined empirically. It will therefore be necessary to record the progress of the development activities under actual conditions: A form of quality control counter must be inserted in subsystem 5.0 of the flowchart model to ascertain the rate of productivity of the Instructional Development team.

For planning purposes a coefficient of 90% and an initial ratio of 120 hours of production for one hour of presentation will be used. These figures are selected as a result of limited experimentation by a three-man development team for the production in CAI format of typical course materials of the Transportation Services Branch. Coincidentally the learning curve coefficient is approximately the same as the one found to prevail when the training organization started developing sound-slide presentations.

In order to determine the production schedule the productive man-hours available are converted into a number of CAI course hours produced. For a project of this nature the instructional development team responsible for the production of the didactic materials should consist of a minimum of three individuals on a permanent basis: This provides continuity in case of absence or transfer of one of the members and allows the effects of synergy to take place within a small dedicated group. This nucleus can be complemented as required by additional members, such as conventional instructional developers or instructors on a temporary basis. It is the experience of British Airways that the addition of personnel does not increase proportionally the output of the unit.

Permanent instructional developers are initially selected from the senior instructor ranks on the basis of personal qualifications and specific abilities. They receive the additional training required for the adequate performance of their new functions. On a yearly basis they work an average of 46 weeks of 40 hours (230 days of 8 hours), thus providing the development unit with a yearly total of 5520 hours.

These 5520 hours of productive manpower available yearly can be translated into a figure representing the production of CAI materials, either on a cumulative basis or for any particular year of the project. Table 6 summarizing these results shows the progressive reduction of the preparation-to-presentation ratio over the years. With the figures selected, the ratio of 40:1 is achieved when the production team reaches the development of the 465th to 470th hour of CAI materials, that is towards the end of the fourth year.

The effects of a learning curve coefficient of 90% and of a maintenance requirement of 15% can be merged to reflect the availability of updated CAI course materials at the conclusion of each year. Table 7 reveals that the original target of 434 hours of available CAI materials can be reached within five years.

The general method outlined in this chapter for the performance of a cost benefit analysis suitable for the implementation of a CAL facility can now be used for the evaluation of various alternative configurations.

TABLE 6

PRODUCTION POTENTIAL OF DEVELOPMENT TEAM

Years	Cumulative		Yearly	
	Man-hours	Production	Production	Ratio
1	5520 hrs	91.4 hrs	91.4 hrs	60.4:1
2	11040	206.9	115.5	47.8
3	16560	333.8	126.9	43.5
4	22080	468.6	134.8	40.9
5	27600	609.6	141.0	39.1

TABLE 7

AVAILABILITY SCHEDULE OF UPDATED CAI MATERIALS

Year	Production			Materials available
	Total	Update	New	
1	91.4	0	91.4	91.4
2	115.5	13.7	101.8	193.2
3	126.9	29.0	97.9	291.1
4	134.8	43.7	91.1	382.2
5	141.0	57.3	83.7	465.9

CHAPTER 7

APPLICATIONS

This chapter presents an economic comparison of three typical alternatives.

The first one makes use of internal resources by combining an existing delivery system, the Reservec network, with an existing CAI language, the Honeywell EXPER, suitably modified for compatibility. The second alternative uses the same network, but in conjuction with a rented software package, thus limiting the amount of modifications required for compatibility. The third facility is completely independent in the sense that it does not make use of any internal resources, except of course, the required personnel: It is a system fully dedicated to training, and as such must be cost-justified on the basis of achievement in the field of training alone.

The alternatives selected vary in their cost patterns. The first two are roughly similar in their development and operation costs, but differ mostly in the acquisition costs, requiring respectively more for in-house programming and rental costs. The third one is characterized by high costs in all areas since neither the terminals nor the communication links are shared with any other function within the corporation. This is of course an extreme case, and hybrid solutions could be designed, that would combine features of several possible systems, with results falling between them. But this alternative is shown as an example of a radically different possibility, for comparison purposes.

Another type of application that suggests itself would include standalones, or minicomputers, with the courseware available on cassettes or cartridges. One of the main advantages would be the elimination of the high cost of communications lines. The cassettes would be made available to the various locations on permanent loan or on request, by using the internal company mail service, a natural channel for a transportation company. But, because there is a requirement to examine the trainees' input rapidly and to make frequent updates to the courseware, this solution is not considered here. Futhermore, the logistic problems connected with the forwarding, recall and modifications of cassettes are too complex and time-consuming, as shown by previous corporate experience with sound slide presentations and video-cassettes. It would also be possible to transmit and update the courseware by means of existing communications lines for recording on cassettes at the various locations but this solution would mean an additional workload at these stations and would require personnel qualified for this function. Since the use of the terminal would initially be restricted to training functions, this method would be comparable to the third alternative, without the communications lines and with cheaper terminals. Because of the constraints in the areas of courseware update and evaluation of trainees' input, this solution is not considered suitable at this time, but could become so in the future when minicomputers become commonplace and training programs have reached a sufficient degree of stability through refinements brought about by constant monitoring of trainees' performance.

The First Alternative: Reservec/EXPER

Description

The first alternative makes use of existing components:

1. The Reservec system made up of the Univac 1110 Central Processing Unit, the Network Controller located in Toronto, the Network communications lines, and CRT terminals located at the various stations operated by the corporation.

2. The EXPER language, described in its technical manual (1970) as a FORTRAN-based CAI author language designed to operate on the General Electric 200 Series time-sharing computer systems, currently available on the Honeywell system and used in a minor way for some training within the Computer Services branch. It can be used in conjunction with the Reservec system through emulation.

CRT sets are connected and are in use at all required stations so that training can be decentralized with the trainees using the set at their own work location. At "major" and "large" stations, however, it is necessary to complement these facilities with some additional sets in a classroom environment.

The Reservec system is designed to meet the highly demanding operational requirements of the airline. Thus its characteristics, such as average response time, minimum time between failures (MTBF) etc. are suitable for instructional purposes. It is equipped with a device which prohibits the use of certain low-priority transactions during exceptional peak demand periods, such as those caused by irregular operations because of weather, when operational traffic increases significantly. It is expected that during these periods, the CAI facility will not be operating. This situation, although occurring infrequently, must be anticipated at locations where trainees are gathered for initial or basic training, so that alternative activities may be provided during these periods when the trainees cannot be returned to their work environment for productive duties.

One of the advantages of CAL is that it will permit training at the work locations. The workload of Transportation Services personnel follows a cyclical pattern of activity throughout the day: Thus Load agents and Passenger agents are very active around the departure times of flights which tend to be more frequent between the hours of 0700 - 0900 and 1700 - 1900, while Reservations agents see increases in the volume of incoming telephone calls in late morning and late afternoon. The Reservec system is designed to handle these peaks of activity even when they are combined. The agents are scheduled to work an eight hour shift which is therefore made up of peaks and valleys of activity: When they are busy with operational duties, no training takes place and it is only when the job-related volume of transactions decreases that they can turn their attention to training and generate training-related computer transactions. Training and operations complement each other with the result that the flow of total transactions is more even throughout the day.

While the Reservec system meets the minimum requirements specified earlier for the instructional requirements, the EXPER language with minor modifications will meet those software needs which have been listed under Category 1, that is those representing the mandatory minimum requirements for phase 1 of the programme: (a) On-line editing, (b) Response recording and elementary analysis, (c) Time control feature, (d) User registration, including security, and (e) Record keeping.

The effective use of computers for tutorial teaching requires that course authors have powerful special-purpose languages. EXPER, designed for non-programming educators, has a fairly simple structure, including a set of eleven symbols and instructions executable by the computer. Its capabilities are limited and the preparation of lessons is somewhat cumbersome. It is therefore necessary to develop, through programming modifications, a more powerful version which will extend its capabilities and simplify the task of the authors. It is proposed to make this development a joint project with the participation of the airline Computer Services branch and of the owners of EXPER for the mutual benefit of both.

In particular it will have to include programs for the creation of secure student registration and student performance files, from which items can be copied and displayed. Both files must include system initialization information in connection with the student identification, and this data will be used for subsequent restart in case a student interrupts a lesson without completing it. This is a very important feature since instruction is planned to take place at the work location for a significant portion of the training.

These modifications will be translated into additional costs resulting from the use of in-house programming resources. The possibility exists of developing a CAI language in cooperation with other organizations, instead of starting with EXPER. In either case, developmental costs are involved, which must be considered here. Nevertheless, because it makes use of existing components, this facility does not require the acquisition of large expensive units. It thus provides a relatively inexpensive way of introducing a simple form of CAI, which permits to evaluate its potential.

The Computer Services branch operates as a profit centre and the resources that it places at the disposal of the other divisions must be accounted for since they could be used in other profitable areas. The figures used for costing the planned CAL facility must therefore be based on fully allocated costs.

The calculation of the costs of the CAL facility, such as production and distribution are facilitated by the fact that 'fully-allocated-costs' tables have been designed, incorporating all the aspects of the operation such as maintenance, ownership, depreciation and operation. It is therefore necessary only to convert activities such as instructional development and training operations to a number of transactions. Those figures will then include the cost of additional CRT's required, as well as costs such as those required for the maintenance of hardware and software.

Acquisition Costs

The costs resulting from acquisiton activities fall under the jurisdiction of the Computer Services Branch, which will internally charge

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them back to the training organization. They are mostly One-Time costs occurring during the implementation stage.

There is first a cost for a study to be conducted by the Computer Branch to ascertain the feasibility of the project, select the best alternative, and design the implementation plan. The study is performed only if a preliminary research, such as this one, indicates that there is sufficient ground to believe it to be worth undertaking, because it is an expensive stage involving a research group including a project leader and systems analysts interfacing with users and managers who have a stake in the project. A study of this magnitude is estimated to use up three man-months for an equivalent expenditure of $10,000.

Second, there are only minor modifications to the existing network and the cost of additional CRT sets is included in the fully allocated costs. Despite the fact that additional storage is also included in these figures, it is considered necessary, pending completion of the Computer Services Branch study, to include a contingency amount of $10,000 under the heading of hardware, as a rough approximation based on the description of the anticipated facility usage.

Third, software-related expenses will include the cost of the programming required to make the existing CAI language compatible to the planned network, and to incorporate all the features required for the operation as defined earlier under the specifications of minimum requirements. This is an extensive undertaking estimated to take two man-years of programming. Since the salary scales for programmers and instructional developers are similar, this can be translated into an initial cost of $52,992.

Furthermore, the Computer Services Branch will assign manpower for systems management, technical maintenande and assistance to the Curriculum Development staff as long as the facility remains operational. The manpower provided for these functions will be equivalent to one man-year for each of the first two years, reduced to nine man-months in the third, and six man-months thereafter, these figures being subject to change on the basis of a continual monitoring of the operation.

The expenses for the acquisition of the facility are thus made up of a one-time cost of $72,992 prior to the cutover date, followed by recurring costs decreasing over the years from $26,496 to $13,248.

Program Development Costs

Initial training of the instructional development team. Instructors selected form among the training organization for their knowledge and experience in areas such as Programmed Instruction will receive the training required to qualify them as lesson-writers. To obtain a wider scope of experience within this small group, their preparation will be diversified. One team member will attend a specialized two-week course on Computer Assisted Instruction Systems. The other two will each spend one week with a different airline already using CAL, and then attend either a one-term university level evening course (for which they will receive equivalent time off of one week), or a one-week course for CAI lesson writers.

The various experiences of these three team members will then be integrated through attendance at a workshop conducted by one instructor of the Computer Services Branch, so that they can form an effective work unit.

The expenses, which are expected to amount to $9,650, will cover the tuition fees ($2,000), ten man-weeks of instructor time ($5,760) and forty two days of travelling expenses ($1,890).

There is no need for recurring expenses in this area because:

(1) instructors from outside the CAI unit are phased in for familiarization, as part of their regular career development on a yearly basis, and will provide a pool of potential candidates for the development team in cases of transfers, retirement and program expansion. This represents an extension of their professional activities, but not a new expense.

(2) instructional development team members maintain their competency through instructor seminars and similar activities at the present time: They will continue to do so in their new area. This does not represent an added cost.

<u>Instructional development time (manpower)</u>: An initial production schedule is planned on the basis of:

(1) a three-member instructional development team,

(2) a 15% rate of maintenance for didactic materials,

(3) a 90% engineering learning curve coefficient, levelling off when the ratio of preparation to presentation reaches 40:1.

In order to maximize the benefits, the courses are ranked in terms of potential yearly savings by CAI hour produced. Thus, course 1.1, for which 39 hours of CAI have to be prepared, can provide a benefit of $88,312 for each full year of utilization and receives an index of 2264 (88312 ÷ 39). Details of this ranking are shown in Table 8. Of particular interest is course 1.5 which results in considerable savings with a negligible amount of production time, once courses 1.1 through 1.4 have been developed since it is made up of modules developed for these courses.

The production of the courses is then sequenced in terms of decreasing indexes. A total production time is calculated for the cumulative amount of CAI hour-units to be developed. The total production time is then divided by 5520, corresponding to the hours of production in one year, in order to determine the time elapsed, and the availability of the courses during their year of production. Thus, course 1.1, requiring 2,681.7 hours of production, or 48.58% of the first development year, will be available 51.42% of that first year. This last figure is a key element because it allows to determine the exact amount of benefits, as well as of transaction costs during the year of production.

The complete production schedule is shown in Table 9. Besides the course units, it also indicates at the end of each year, except the first, an update production period to maintain the programs available at the close of the previous year in operational condition. This amounts to 15% of respectively 91.4 (interpolated), 195 and 314.5 hours.

The production schedule reflects two deviations from the index ranking:

TABLE 8

RANKING OF COURSES IN TERMS OF RELATIVE POTENTIAL BENEFITS

Course ident.	Unduplicated hours	Yearly benefits	Benefit index	Ranking order
1.1	39	$88,312	2264	2
1.2	26	45,900	1765	3
1.3	26	31,631	1217	4
1.4	52	45,295	871	7
1.5	0	163,299	–	1
2.1	13	2,920	225	14
2.2	19.5	12,474	640	8
3.1	48	27,934	582	10
3.2	7.5	4,641	619	9
3.3	16.5	7,180	435	11
3.4	24	6,073	253	13
4.1	52	52,956	1018	6
4.2	52	55,928	1076	5
4.3	58.5	22,161	379	12

TABLE 9

INITIAL PRODUCTION SCHEDULE FOR THE FIRST ALTERNATIVE (RESERVEC/EXPER)

Course ident.	Course hours	Cumulative hours	Production hours	Availability of course
1.1	39	39	2,681.7	51.42% of 1st year
1.2	26	65	4,135.5	25.08% of 1st year
1.3	26	91	5,501.1	0.34% of 1st year
1.4	52	143	8,070.7	53.79% of 2nd year
4.2	52	195	10,498.4	9.81% of 2nd year
Update	(13.7)	208.7	11,120.9	–
4.1	52	260.7	13,429.9	56.70% of 3rd year
2.2	19.5	280.2	14,276.9	41.36% of 3rd year
3.1	48	328.2	16,325.4	4.25% of 3rd year
Update	(29.3)	357.5	17,553.3	–
3.2	7.5	365	17,865.1	76.36% of 4th year
3.3	16.5	381.5	18,547.6	63.99% of 4th year
4.3	58.5	440	20,932.6	20.79% of 4th year
3.4	24	464	21,897.4	3.31% of 4th year
Update	(47.2)	511.2	23,771.8	–
2.1	13	524.2	24,283.4	60.08% of 5th year

(1) Course 1.5 has the highest index, but is made up of modules extracted from the other courses in the Passenger Service series (1.1 to 1.4). These are then produced first, in order of decreasing indexes.

(2) Course 3.1 is produced before course 3.2, although the latter has a higher index, because this combination results in increased savings of $5046 by allowing a shift in an intervening update production period.

On the basis of this production schedule indicating that it will take 4.4 years to convert the 434 hours of the curriculum to CAI methodology, the cost of the Instructional Development three-man team will amount to $79,488 in the first four years and $37,094 in the fifth.

Instructional development - transaction costs. The number of transactions necessitated by the development of instructional courses will depend on the individual inputting and editing the materials on-line. His proficiency will increase with experience, not only for the initial input, but for the validation process with groups of trainees.

The number of transactions may roughly be seen as a function of the CAI hours developed (new courses as well as update of existing courses). Besides the initial input the developer will use transactions in the course of checking, listing, debugging and validation of the program. The author's past experimentation with typical CAI programs indicated that the developer uses approximately twelve times the number of transactions available in the lesson during the development stage. The fully allocated cost of a transaction, compiled by the Computer

Services Branch is $0.022, made up of:

- data processing	$.0087
- network controller	.0023
- data network	.0060
- man machine interface	.0050

Because the lessons average 224 transactions an hour (either terminal to Central Processing Unit, or vice versa) the cost of the transactions required for their development will add up to $59.14, a figure which, applied against the production schedule, will provide the yearly expense. Thus, during the first year 91.37 hours of CAI materials will have been produced for a transactions cost of $5,403.

Training Operation Costs

Although instructors, who are not directly involved with the initial stages of the CAI facility, will have to be familiarized with its impact on their activities, this will not result in an added cost chargeable to this project, since the progressive improvement of the instructor workforce is part of the current method of operation. The novelty will be a change in the subject content, and not an additional activity.

The cost of the training operation will result mainly from the use by trainees of the CAI facility and will increase with the volume of transactions.

The number of transactions used over a certain period depends on three factors: (a) the course units available, or more precisely the number of student course hours (S.C.H.) available corresponding to these courses. This information is embodied in the production schedule, (b) the number of trainees in the various classifications, who are scheduled to take theses course units in each period. This information results from the combination of the "pattern of training" table with the turn-over ratio, which has been used to derive the potential benefits, (c) the average number of transactions per student contact hour, determined previously as 224, for a corresponding cost of $4.93.

The number of student contact hours corresponding to a full year of availability is summarized in Table B (see Appendix) which combines the potential number of trainees derived from the benefit analysis, with the actual duration of the initial and follow-up courses. These latter are broken down as separate entries whenever the duration of courses is not similar for all types of stations. The figures for these student contact hours multiplied by the hourly cost of $4.93 provide the transaction cost resulting from student use of an available course during a complete year of operation.

Optimization

The production schedule may now be refined by taking more factors into consideration. Whereas, in the initial iteration, only the number of course hours to be produced and the potential benefits were considered; the training operation costs resulting from the trainees' transactions and the initial development costs can now be inserted into the calculations.

The initial production schedule revealed that it would take 24,283 production hours to develop 524.2 hours of CAI, that is an average ratio of 46.32:1 which multiplied by an hourly salary of $14.40 for an instructional developer corresponds to $667.08. To this must be added $59.14 for the cost of the transactions used during the development process, i.e. a total of $726.22 for each hour of produced CAI. This is an average figure for comparative purposes only, since it takes into consideration neither the sequence of production, nor the update periods.

The net benefit obtained by subtracting the operation transaction costs from the potential benefits, on a full year basis, may be related to the recovery of other costs. This differential can be divided into the initial production cost of the course to obtain a relative index of profitability. Thus course 1.1 with a net yearly benefit of $39,625 and an initial production cost of $28,322 has an index of 0.72, meaning that it takes 72% of the first year of operation to recover the cost of initial production. Table 10 summarizes the calculations for the various courses.

This index does not indicate whether the production of courses is cost-justified but it pinpoints which courses should not be considered because they cannot be expected to reach a breakeven point within the period of the experiment, even when we consider only a fraction of the cost factors. If they cannot cover the cost of their own development, they cannot contribute to a reduction of the initial implementation costs.

Thus the follow-up to certain courses (such as 1.1 through 1.4, 3.2, 3.3) should not be done by means of CAI on economic grounds because under the present assumptions this method results in higher costs: The

TABLE 10

RATIOS OF PRODUCTION COSTS TO NET YEARLY BENEFITS FOR THE FIRST ALTERNATIVE

Course ident.	CAI hours produced	Net yearly benefit	Initial production costs	cost/benefit ratio
1.1	39	$39,265	$28,322	0.72:1
1.2	26	9,020	18,882	2.09
1.3	26	12,576	18,882	1.50
1.4	52	9,071	37,763	4.16
F1.1-4	-	(-41,708)	minimal	-
1.5	-	2,853	"	-
F1.5	-	123,622	"	-
4.2	52	35,274	37,763	1.07
4.1	52	32,302	37,763	1.17
F4.1-2	-	1,278	minimal	-
2.2	19.5	1,429	14,161	9.91
3.1	48	6,417	34,858	5.43
3.2	7.5	2,819	5,447	1.93
F3.2	-	(-437)	minimal	-
3.3	16.5	3,716	11,982	3.22
F3.3	-	(-437)	minimal	-
4.3	58.5	2,899	42,483	14.65
3.4	24	1,015	17,429	17,17
2.1	13	229	9,441	41.23

cost of the trainee transactions alone is greater than the expected savings.

Because course 1.5 is made up of modules developed for other courses it is possible (and even necessary) to include course 1.4 in the production schedule despite its relatively high index of 4.16. The combined figures for courses 1.1 through 1.5, without follow-up training, result in a very attractive ratio of 0.49. A revised production schedule (see Table 11) is drawn with minor changes in sequence and truncated after the development of seven courses.

On the basis of this revised production schedule we can recalculate:

(1) The accumulation of financial benefits resulting from a switch to the CAI methodology over the duration of the experimental phase. The potential savings for each individual course, calculated earlier, are repeated for each year after the year of production. In the case of course 1.5, they are increased yearly at a compounded rate of 10 percent corresponding to the expected growth of the target population. During the year of production the yearly benefits are prorated on the basis of a coefficient representing the percentage of availability of the fully developed course during that year, shown in the right-hand column of the production schedule (Table 12).

(2) The progressive accumulation of costs resulting from the use of transactions by the trainees for each course which becomes available. Here also the increasing target population for course 1.5 and its follow-up is reflected in a corresponding increase in transaction costs, while the figure used for the year of production is also based on the same

TABLE 11

REVISED PRODUCTION SCHEDULE FOR THE FIRST ALTERNATIVE

Course ident.	Course hours	Cumulative hours	Production hours	Availability of course
1.1	39	39	2,681.7	51.42% of 1st year
1.3	26	65	4,135.5	25.08 "
1.2	26	91	5,501.1	0.34 "
1.4	52	143	8,070.7	53.79% of 2nd year
4.2	52	195	10,498.4	9.81 "
Update	(13.7)	208.7	11,120.9	–
4.1	52	260.7	13,429.9	56.70% of 3rd year
3.2	7.5	268.2	13,769.7	50.55 "
Update	(29.3)	297.5	15,021.1	–

TABLE 12

FINANCIAL BENEFITS FOR THE FIRST ALTERNATIVE

Course ident.	YEAR 1 (1979)	2	3	4	5
1.1	$45,410	88,312			
1.3	7,933	31,631			
1.2	156	45,900			
SUB	53,499	165,843	165,843	165,848	165,843
1.4		24,364	45,295		
1.5		3,803	7,778	8,556	9,411
F1.5		92,819	189.314	208,796	229,675
4.2		5,486	55,927		
SUB		126,472	298,815	318,575	340,309
4.1			30,026	52,956	
F4.1-2			7,896	13,926	
3.2			2,035	4,025	
SUB			39,957	70,907	70,907
TOTALS YEARLY	53,499	292,315	504,615	555,325	577,059

coefficient showing the availability of the course during that year (Table 13).

(3) The program development costs in terms both of manpower, reflecting a decrease after the courses have been developed and need only to be up-dated, and of transactions required to develop and maintain these courses (Table 14).

The various elements calculated in this chapter for the Reservec/Exper alternative can be brought together into a table (Table 15) summarizing the cash flow over the duration of the initial five year experimental period.

Financial Evaluation of Alternative I

A cost-reduction type of project, such as the introduction of a CAL facility, must be evaluated over a useful and reasonable life-span which recognizes the time-value of money. Both benefits and costs flowing from any alternative version of this project have a time profile which must be considered to determine whether a particular investment should be under-taken, and to select which one would be the most profitable.

Discounted cash-flow and present-value techniques consider future flows of net benefits deriving from an investment and discount the entire stream of benefits by a suitable interest rate to determine its current value, thus providing a number which an be used as an index for comparison purposes (Dewhurst, 1972; Mishan, 1971).

One of these, the Net Present Value (NPV) method demonstrates whether the investment has sufficient recurring benefits to satisfy some minimum profitability level. Here each annual cash flow, represented by its dual

TABLE 13

TRAINEE TRANSACTION COSTS FOR THE FIRST ALTERNATIVE

Course ident.	YEAR 1 (1979)	2	3	4	5
1.1	25,220	49,047			
1.3	4,779	19,055			
1.2	125	36,880			
SUB	30,124	104,982	104,982	104,982	104,982
1.4		19,485	36,224		
1.5[a]		21,788	44,557	49,013	53,914
4.2		2,026	20,654		
SUB		43,299	101,435	105,891	110,792
4.1			11,711	20,654	
F4.1-2			7,171	12,648	
3.2			610	1,206	
SUB			19,492	34,508	34,508
TOTALS	30,124	148,281	225,909	245,381	250,282

[a]Including Follow-up (F1.5)

TABLE 14

PROGRAM DEVELOPMENT COSTS FOR THE FIRST ALTERNATIVE

Development costs	YEAR 1	2	3	4	5
Manpower	$79,488	79,488	57,327	22,484	21,989
Transactions	5,403	6,833	5,357	2,258	2,258
Totals	84,891	86,321	62,684	24,742	24,247

TABLE 15

CASH FLOW FOR THE FIRST ALTERNATIVE

Financial data	PRE	YEAR 1	2	3	4	5
COSTS:						
Acquisition	$72,992	26,496	26,496	19,872	13,248	13,248
Prog. Dev.	9,650	84,891	86,321	62,684	24,742	24,247
Trng. Oper.		30,124	148,281	225,909	245,381	250,282
Total	82,642	141,511	261,098	308,465	283,371	287,777
BENEFITS		53,499	292,315	504,615	555,325	577,059
CASH FLOW	-82,642	-88,012	31,217	196,150	271,954	289,282

TABLE 16

COST/BENEFIT ANALYSIS ($'000) FOR THE FIRST ALTERNATIVE (RESERVEC/EXPER)

Calendar year	Cash flow timing	0% Rate Amount	15% Interest Rate Factor	15% Interest Rate Present value
COSTS:				
1978	0	82.6	1.000	82.6
Total				-82.6
CASH FLOWS:				
1979	1	-88.0	.870	-76.6
1980	2	31.2	.756	23.6
1981	3	196.2	.658	129.1
1982	4	272.0	.572	155.6
1983	5	289.3	.497	143.8
Total				375.5

NET PRESENT VALUE $292,900

INTERNAL RATE OF RETURN 57%

PAYBACK PERIOD 2.71 years

elements of costs and of benefits, is discounted by means of a present value factor table to arrive at a NPV by simple summation of the negative and positive flows. The rate used by the Corporation for evaluation of this type of project is 15%: The final figure of $292,900 indicates that the investment meets the profitability requirement.

The Internal Rate of Return (IROR) method measures the relative profitability level of one-time cost investments generating cash flow recurring,benefits and converts this into an index which makes the difference quite visible to management. It examines the cash flows for the entire economic life of the investment and discounts them at a rate sufficient to equate the recurring benefits to the One Time Costs. The project is said to have an IROR equal to that discount interest rate, here 57%.

To provide a measure of the liquidity of the project, that is of the risk associated with time, the pay back period, defined as the number of years of cash flow benefits required to recompensate the One-Time Costs of the investment,is calculated at 2.71. This alternative, therefore, meets all the criteria of economic evaluations set by the sponsoring organization.

The Second Alternative: Reservec/ASET

Description

The second alternative makes use of the existing Reserved system and of a rented software package, the Sperry Univac ASET-1100, for Education and Training purposes, thus combining the availability of a suitable geographical network with the advanced capabilities of a sophisticated software.

The ASET language as described in its technical manual meets not only the basic requirements listed in the previous chapters as Category 1, (and this to a much higher degree than the EXPER system) but includes the quasi totality of the requirements listed for the future and advanced stages. The features expected to have the major impact on the operation are:

1. The Conversational Lesson Development Module providing the Instructional Developer with the capability to build simple lessons without concern about the Author Language Syntax, which has the potential of reducing the production time. It is expected that the acceleration of production would be minimal, but that this feature would contribute highly to improvement in quality and consistency of presentation.

2. The availability of a calculator and the generation of random numbers would provide great flexibility in areas where calculations are key points of the subject matter such as fare calculations, cargo rating and weight and balance. Test items could be evaluated on their numerical contents, and exercises could be designed as frameworks to be used with random numbers falling within specified limits. In both the "testing" and "drill and practice" modes of computer use, the production time required for one "student contact hour" could be reduced, thus speeding up the development schedule, which in turn would make course units available earlier.

3. The Support system, and especially its Report Generation and its Registration modules, will result in added benefits to the training organization through reduction of the time and manpower required to maintain

the training records of the workforce up-to-date.

Acquisition Costs

As in the previous alternative, and for the same reasons, we include in the acquisition expenses an amount of $10,000 for hardware. The installation costs are very limited. The ASET requirements call for a minimum hardware configuration of a Univac 1106 with 131 K, a card reader, a printer, a tape drive, disc/drums and a terminal communications subsystem. The Reservec system with its Univac 1110 exceeds these requirements. The Raytheon or Westinghouse models 401-405 CRT units may be used instead of the Uniscope 100 or 200 Display terminals of 24 lines of 64 or 80 characters, which are standard equipment with the Sperry Univac ASET system. The Reservec System Operating Software is compatible with the simultaneous use of ASET.

Because the software package includes the features listed under specifications of minimum requirements the programming modifications are relatively minor and are conservatively estimated not to exceed six man-months prior to implementation, at a cost of $13,248. Furthermore, the manpower assigned to the instructional development staff is set at its minimum level of six man-months per year (13,248), and this, from the very first year of operation.

On the other hand, the rental cost of the ASET package which includes full maintenance and improvement updates represents a recurring expense of $4,800 a year. The acquisition costs of the facility are then made up of One Time Costs of $33,248, and of recurring costs of $18,048 per year.

Program Development Costs

Initial training of development team. The training of the instructional development team will not deviate significantly from the pattern used for the first alternative: specialized courses and work with other airlines, followed by an internal workshop to prepare under the guidance of the Computer Services branch, for the implementation of the CAL facility.

Instructional development. A new production schedule is prepared, based on the same assumptions as the previous one, but with a reduction of 50% in the time required to produce 1 hour of CAI materials in the "testing" and "drill and practice " modes. Thus, course 1.1 made up of 30 hours "tutorial", 5 hours "drill and practice" and 4 hours "testing", required 39 hours under the first alternative (Reservec/EXPER), but requires only 34.5 hours in the speeded-up schedule for the Reservec/ASET alternative.

To make available to the trainees the 434 hours of instruction retained as technically suitable for conversion to computer assisted instruction, it was necessary in the first alternative to produce the equivalent of 524.2 CAI hours, made up of the targeted 434 plus 90.2 hours required for the intervening maintenance of those materials.

With the possibility of accelerating the production of certain segments of those courses the same amount of materials can be created by the workload equivalent to the production of 439.15 hours, including 86.4 hours for the intervening maintenance of materials. The corresponding production time in this second alternative totals up to 20,898 hours. The manpower cost of production of one hour of CAI under these circumstances is $685.26, to which must be added $59.14 representing the cost of the transactions used during the development process.

This total of $744.40 can be used to establish the production costs for each course in the curriculum. When these production costs are compared to the net yearly trainee transaction costs, they will provide a coefficient which can be used for: (a) sequencing the production in terms of increasing ratios, and (b) truncating the production schedule when the courses cannot be expected to produce an excess of benefits over variable costs during the experimental period. Table 17 indicates that 9 out of 13 courses may have their initial production costs recovered within a 5-year period.

The production of the courses is prioritized on the basis of increasing values of the ratio relating the initial production costs to the net yearly benefits (Table 18). For optimization purposes we introduce the following deviations to the sequence: The courses in the Passenger Service series (1.1 to 1.4) are produced first despite the 3.45 index of course 1.4, because their completion permits the operation of courses 1.5 and F1.5, resulting in higher overall benefits since the combination index for courses 1.1 to 1.5 inclusive is a low 0.46.

The production schedule is truncated after course 3.3 is completed, so that course 3.1 is not produced for the computer based facility. Since it takes approximately 4.9 years of use to recover the production costs of this latter course, it would have to be completed within the first month of the start of the project to be cost-justifiable during the economic life of five years. As it is not scheduled for production until

TABLE 17

RATIOS OF PRODUCTION COSTS TO NET YEARLY BENEFITS FOR THE SECOND ALTERNATIVE

Course ident.	CAI hours produced	Net yearly benefits	Initial production cost	Cost/Benefit ratio
1.1	34.5	$39,265	$25,682	0.65
1.2	23	9,020	17,121	1.90
1.3	21	12,576	15,632	1.24
1.4	42	9,071	31,265	3.45
2.1	13	229	9,677	42.26
2.2	19	1,429	14,144	9.90
3.1	42.5	6,417	31,637	4.93
3.2	5.25	2,819	3,908	1.39
3.3	11.75	3,716	8,747	2.35
3.4	19	1,015	14,144	13.93
4.1	46.75	32,302	34,801	1.08
4.2	36.5	35,274	27,171	0.77
4.3	38.5	2,899	28,659	9.89

TABLE 18

PRODUCTION SCHEDULE FOR THE SECOND ALTERNATIVE (RESERVEC/ASET).

Course ident.	Course hours	Cumulative hours	Production hours	Availability
1.1	34.5	34.5	2,416.8	56.22% of 1st year
1.3	21	55.5	3,616.9	34.48 "
1.2	23	78.5	4,853.2	12.08 "
1.4	42	120.5	6,979.9	73.55 of 2nd year
4.2	36.5	157.0	8,735.9	41.74 "
Update	(13.7)	170.7	9,378.2	–
4.1	46.75	217.45	11,514.9	91.40 of 3rd year
3.2	5.25	222.7	11,750.2	87.13 "
3.3	11.75	234.45	12,273.9	77.65 "
Update	(29.)	263.45	13,549.9	–

the third year, its inclusion would reduce the profitability of the CAL unit.

Course 3.3 on the other hand meets the cost-justification requirements. Its production cost based on the initial production schedule covering all courses had been calculated at $8,747. With the revised schedule, the actual production time for this course is 524 hours, corresponding to $7,546 for manpower and $695 for transaction costs, reducing the total to $8,241, a figure which compares favorably to the saving of $10,402 obtained by multiplying the net yearly benefit of $3,715 by the 2.8 years during which the course is available in the experimental period.

Financial Summary

The production schedule allows the calculation of: (a) the accumulation of financial benefits over the experimental period, (b) the progressive accumulation of costs resulting from the transactions generated by the trainees, and (c) the program development costs in terms of manpower and transactions. These results, which are displayed respectively in Tables 19 to 21, can be merged with the acquisition costs into Table 22, summarizing the financial evaluation by means of discounted cash flows for this project over its five year economic life: The final outcome indicates that this alternative also meets the profitability requirements of the sponsoring corporation.

The Third Alternative: PLATO System

Description

At the most advanced end of the spectrum of possibilities, the third alternative involves the use of a dedicated computer-based educational

TABLE 19

FINANCIAL BENEFITS FOR THE SECOND ALTERNATIVE

Course ident.	YEAR 1 (1979)	2	3	4	5
1.1	$49,649	88,312			
1.3	10,906	31,631			
1.2	5,545	45,900			
SUB	66,100	165,843	165,843	165,843	165,843
1.4		33,314	45,295		
1.5		5,201	7,778	8,556	9,411
F1.5		126,917	189,814	208,796	229,675
4.2		23,344	55,927		
SUB		188,776	298,815	318,575	340,309
4.1			48,402	52,956	
F4.1-2			12,728	13,926	
3.2[a]			3,507	4,025	
3.3[a]			5,098	6,565	
SUB			69,735	77,472	77,472
TOTAL	66,100	354,619	534,393	561,890	583,624

[a]Excluding follow-up

TABLE 20

TRAINEE TRANSACTION COSTS FOR THE SECOND ALTERNATIVE

Course ident.	YEAR 1 (1979)	2	3	4	5
1.1	$27,574	49,047			
1.3	6,570	19,055			
1.2	4,455	36,880			
SUB	38,599	104,982	104,982	104,982	104,982
1.4		26,643	36,224		
1.5		2,892	4,325	4,758	5,234
F1.5		26,900	40,232	44,255	48,680
4.2		8,621	20,654		
SUB		65,056	101,435	105,891	110,792
4.1			18,878	20,654	
F4.1-2			11,560	12,648	
3.2[a]			1,051	1,206	
3.3[a]			2,212	2,849	
SUB			33,701	37,357	37,357
Totals	38,599	170,038	240,118	248,230	253,131

[a]Excluding follow-up

TABLE 21

PROGRAM DEVELOPMENT COSTS FOR THE SECOND ALTERNATIVE

Development costs	YEAR 1	2	3	4	5
Manpower	$79,488	79,488	36,143	19,502	19,073
Transactions	5,403	6,833	3,344	1,958	1,958
Totals	84,891	86,321	39,487	21,460	21,031

TABLE 22

CASH FLOW AND COST BENEFIT ANALYSIS FOR

THE SECOND ALTERNATIVE (RESERVEC/ASET)

Yearly financial data	YEAR					
	PRE	1	2	3	4	5
COSTS						
Acquisition	$32,248	18,048	18,048	18,048	18,048	18,048
Program devel.	9,650	84,891	86,321	39,487	21,460	21,031
Training Oper.		38,599	170,038	240,118	248,230	253,131
Total	42,898	141,538	274,407	297,653	287,738	292,210
BENEFITS		66,100	354,619	534,393	561,890	583,624
CASH FLOW		-75,438	80,212	236,740	274,152	291,414
Rounded (S'000)	(-42.9)	-75.4	80.2	236.7	274.2	291.4
Discounted 15%		-65.6	60.6	155.7	156.8	144.8

NET PRESENT VALUE $409,400

Internal Rate of Return 96%

Payback period 2.16 years

delivery system: Control Data PLATO combining a CDC CYBER 70 or 170 Series Computer with plasma display terminals, a compatible communications network and a fast response time-sharing operating system.

Both the hardware and software are extremely advanced and go well beyond our future requirements, with features such as the touch-sensitive plasma display screen, a vast library of curricular materials available to the subscribers, forms of interactive communications, instructional evaluations and prescriptions, generation and maintenance of records, and extensive graphic capabilities.

Besides being an easy system on which to author high-quality courseware with dynamic and graphic capabilities, the PLATO system has the key advantage, through its extensive linkages, of being a form of courseware exchange whereby training packages can be bought, sold, or exchanged between organizations with similar needs. If the proper training materials are already in the inventory, the system provides the means of speeding up the implementation schedule. If they are not, the new subscriber may find that the incentive provided by the possibility of selling his production and recouping some of his costs, may result in the development of materials of higher quality. This feature is particularly valuable where the material is stable and of general interest, such as the maintenance of aircraft engines, or basic principles of flight operations. In the case of Transportation Services training, however, the majority of the courses deal with procedures which are particular to the airline and have therefore less appeal for the other subscribers.

The Plato System can be tailored in several ways to meet the needs of the customer organization: A dedicated training system could be created within the airline for its exclusive purpose. Another method would make use of the existing communications network. The configuration considered here, however, involves clusters of stations connected to a computer centre city, such as Quebec City. These stations would be linked by dial-up telephones at cities listed as telecommunications FOB points (e.g. Montreal), or by communications lines to be installed for that purpose (e.g. Fredericton).

Cost Comparison

The cost pattern of this facility differs from that of the alternatives already described in that the acquisition of the terminal (purchase or rental) and of the communications links is fully chargeable to this project since the network installed is dedicated to training. On the other hand, the cost of the trainee transactions is included in the purchase or rental price.

The benefits to be derived from the installation of a terminal at a specific location can be determined by using the same methods as for the other alternatives. The savings realized should cover the cost of all the elements of the facility, not only the installation of the network but also the amounts chargeable to the initial study, the program development etc. If they do not, the project is not cost-justified and should not be undertaken.

The potential savings to be realized from the installation of the educational network can be calculated as follows for the four different types of stations:

1. Major stations. The number of trainees listed under each station includes airline employees based at these locations and travel agents scattered over a wide area and receiving their training on their employer's premises. For obvious economic reasons the installation of terminals would be restricted to airline locations so that the potential target population must exclude the participation of travel agents and be limited to 1.082, 791 and 327 personnel at Toronto, Montreal and Vancouver.

Despite the availability of the facility every day of the year, it is unlikely that training would be scheduled for other than weekdays. The elimination of statutory vacations and peak holiday periods limits the expected use to approximately 230 days a year. Although it is possible to schedule trainees up to 16 hours a day, a more realistic expectation is to consider that operational requirements will limit the use of the facility to ten hours a day with an utilization coefficient of 80%, thus making it available for eight hours of the 230 days, or a yearly total of 1,840 hours.

Because the student contact hours needs at Toronto, Montreal and Vancouver are 18,149, 13,762, and 5,345 hours each year these stations will require respectively 10, 8, and 3 units. The benefits resulting from the availability of the CAL facility at these locations is calculated at $91,665, a relatively small amount because the only area of saving is the instructor classroom time.

2. Large stations. In Canada, five stations with personnel ranging from 188 to 155 are included in this category. The yearly savings resulting from the availability of computer assisted learning amount to $116,557 while the requirements for student contact hours range from 2,342.2 to 3,216.7 hours. The use of the criteria for potential usage selected for the major stations (1840 hours a year) indicates a need for two terminals at each station. These figures translate into an equivalent saving of $971 a month for each installed terminal.

3. Medium sized stations. Regina, the largest Canadian station in this category, has a yearly requirement of 1,053.4 student contact hours. One terminal unit is therefore amply sufficient to meet its needs since its daily utilization would range from 2.89 to 4.58 hours depending on whether it is spread over 364 or 230 days. The resulting benefits would add up to $14,481 a year, currently spent on: (a) instructor time in the classroom, (b) instructor and trainee travel time, and (c) expenses for personnel away from their home base. Together, these seven stations, each equipped with one terminal, could realize a yearly saving of $84,534.

4. Small stations. The minimum installation of one terminal at each of these locations would result in a very low utilization factor since their personnel varies between six and twenty eight agents. For the largest of them, Thunder Bay, the yearly use of 440.9 hours represents an average 1.92 hours a day over 230 days, while the yearly savings resulting from the elimination of the expenses already listed for medium-sized stations amount only to $6,521.

Conclusions

The potential monthly savings per terminal at the major, large, medium, and small stations are $364. $971, $1,006 and $543 respectively. The greatest savings are realized at the medium-sized stations, although the daily utilization is less than five hours, because the current expenses related to training are high. In the major stations, despite a high utilization factor, the benefits are limited because the training-related expenses are relatively low, with both instructors and trainees being at their home-base.

However, even under the best conditions, the benefits derived at a particular station do not cover the cost of the subscription service, whether the terminal is included as part of the Full Service or purchased separately under the Basic Service: Either alternative runs in the vicinity of a monthly $1,100. Since this element represents only a fraction of the costs accruing to the facility, there is no possible breakeven point for which even a subset of the stations would justify the implementation of the system.

This result is not unexpected since the network is not utilized to the full extent of its capabilities: Neither the sophisticated features, such as the graphic capabilities which make it so attractive and advanced, nor the extensive library of programs, are used. The implementation of such a system would become more advantageous if it were restricted to locations where the utilization factor would remain high, and to subject matter which would be more appropriate to the features offered than the one covered by the courses of the Transportation Services branch. Another method for reducing the cost would be the use of the existing communications network of the airline: This is however a hybrid solution more akin to the alternatives investigated earlier.

Because the installation of terminals is not cost justified at locations with minimal requirements, the network could not include Travel Agencies, which currently represent a very high training expense. It is the ability to deliver course 1.5 to these many scattered locations which provided the most important economic contribution to the alternatives involving the use of the Reservec network and of its terminals.

CHAPTER 8

RECOMMENDED IMPLEMENTATION STRATEGY

After the potential profitability of the various CAL facilities under consideration has been calculated, the alternatives meeting the predetermined specifications can be compared for selection of the most advantageous. After a choice has been made, a sensitivity analysis is performed so that the researcher can determine to what extent deviations from the values used for the calculations will affect the final outcome. The idea behind this step is, according to Corti (1973, p.77) that "management must become aware of the financial consequences of all likely outcomes before being able to make a reasoned evaluation of the worth of a project". Once it has been ascertained that variations resulting from actual operating conditions will not move the profitability indices out of the acceptable range, the researcher may proceed with the next stage of the project and prepare an implementation plan.

Selection of the Optimal CAL Alternative

While the dedicated training facility provided by the PLATO system would meet all the specifications for technical requirements, its costs exceed the ecomomic benefits in every period, so that the cash flows remain negative: There is therefore no hope of compensating, or even of offsetting the initial one-time costs. Since the project cannot show a positive Net-Present-Value, it does not meet the profitability requirements set by the corporation and this alternative must consequently be dropped.

The other alternatives having the existing operational Reservec network as a common element may readily be compared on an economic basis. The financial analysis favors the Reservec/ASET alternative over the in-house modified version of a basic author language on every count:

1. Net Present Value of $409,400 as opposed to 292,900
2. Internal Rate of Return of 96% versus 57%.
3. Payback period reduced to 2.16 years from 2.71.
4. Maximum outlay of $118,300 versus 170,600.

Furthermore, the ASET package, already validated and available immediately, reduces the risk of possible programming delays. It simplifies the interface between the programming personnel of the Computer Services branch and the curriculum authors. For these reasons, the Reservec/ASET facility is the favored alternative and may be recommended provided that potential variations in the values of the variables do not shift the end result outside the acceptable range defined by the set of original constraints.

Sensitivity Analysis

The economic indices of profitability were obtained by means of a mathematized model made up of a set of interrelated equations reflecting basic assumptions. A learning curve coefficient of 90% was combined with an initial production ratio of 120:1 and 5520 hours of manpower to establish a schedule of production. Another equation blended the production schedule with the benefits deriving from the availability of specific courses to obtain the yearly savings. A later equation merged the total benefits with the costs for the various functions to compile yearly cash flows, which were then discounted to a Net Present Value. This same mathematical model can be used for the Sensitivity Analysis of the selected alternative. Each value of the design parameters will produce a new series of economic indices which can be compared with the ones found initially and which can be plotted on a graph for easy visual comparison (Figure 6 and Appendix C).

The variation in the value of the parameters is depicted along the horizontal axis as percentages, while the overall economic index is shown along the vertical axis. The point of initial reference A with the coordinates (0; 409.4) represents the Net Present Value of $409.400 calculated for the Reservec ASET alternative. Along the horizontal axis the abscissa (10%) indicates that the value of the variable, such as Training Operation Cost has been increased by 10% of the value used for the initial calculation. Such a variation is calculated to result in a drop of $58,900 in the Net Present Value. This is the situation represented on the graph by point D with coordinates (10%; 350.5). The line AD, extending beyond both points, represents the effect of the Training Operation costs on the NPV of the project. It allows the researcher to determine the NPV corresponding to a specific variation in Training Operation costs, or to find out which percentage of increase in these costs will reduce the profitability of the project to the minimum acceptable level.

An advantage of the presentation of cost information by means of the continuum of a graph instead of the discrete figures of a table is that it allows the researcher to visualize the effect of deviations for any percentage he considers likely to occur. It thus avoids a shortcoming pointed out

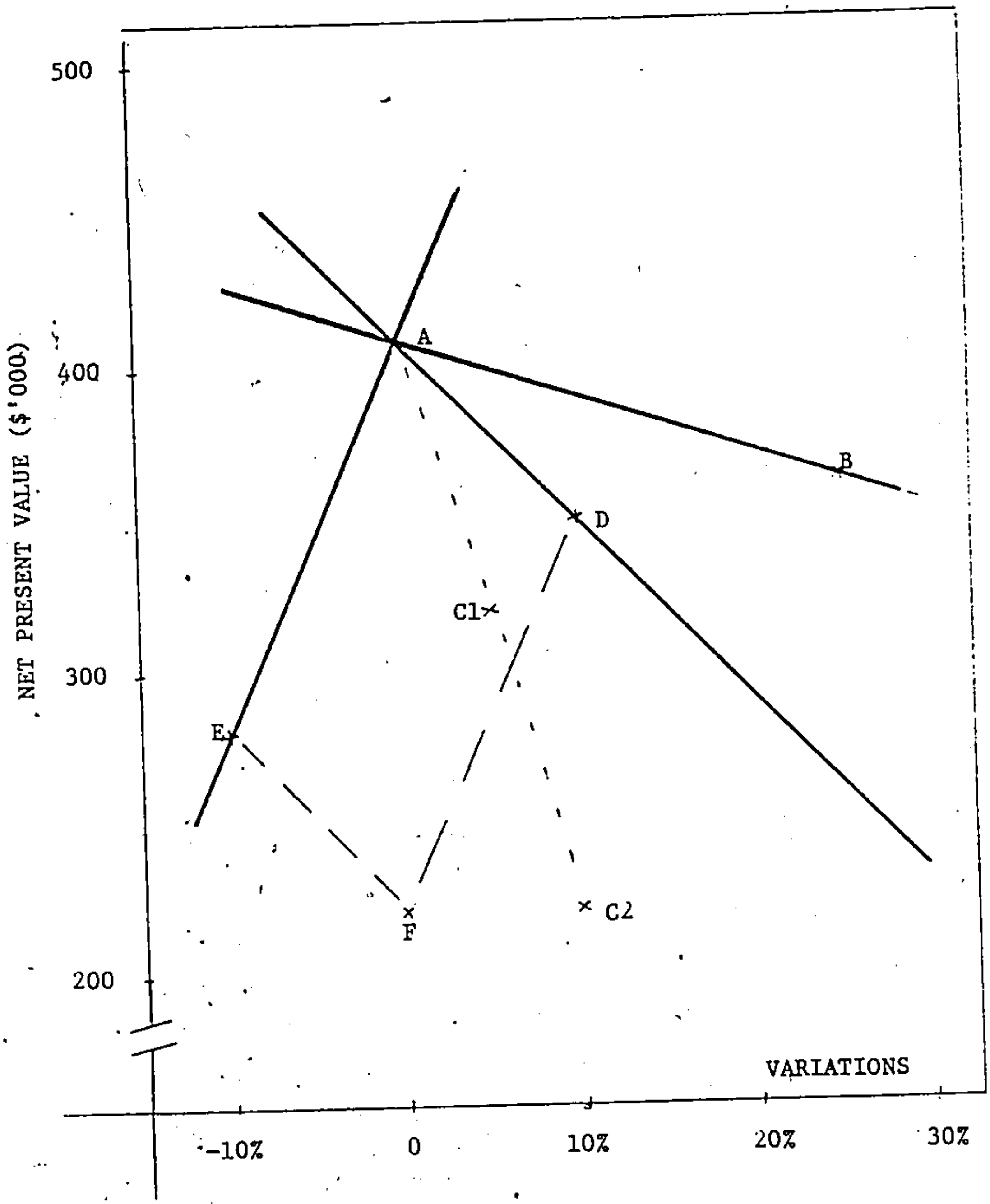

FIGURE 6 - EFFECT OF VARIATIONS IN THE VALUE OF THE DESIGN FACTORS ON THE NET PRESENT VALUE OF THE PROJECT

by Dewhurst (1972, p.120) who considers that "it is mathematically satisfying, but unfortunately not very realistic to calculate the effect of an increase or decrease of each of the variables by a fixed percentage figure. Not realistic because, of course, in making such a comparison, there is the implied assumption that all these changes are equally likely".

Initial Investment

Any increase in the costs incurred during the pre-implementation period, such as installation, training of lesson writers, and additional hardware, is reflected in the NPV. Thus if the Computer Service branch decides to purchase $10,000 worth of additional storage for the CAL facility, the NPV drops from $409,400 to $399,400 since the initial investment jumps from $42,900 to $52,900. This is represented by a downward shift of the same magnitude on the ordinate axis.

Acquisition Costs

Increases in the rental cost of ASET software or in the amount of manpower allocated by the Computer Services branch to this project would be added on a discounted basis over the years. This change is not shown on the graph because of the relatively small percentage of this item on the total financial picture.

Program Development

Manpower. If, after implementation, the three-man team is found insufficient to produce the expected amount of materials and a fourth man is added, the manpower component of the program development cost is incremented by one third, corresponding in the first year to his salary of $26,496. This reduces the Net Present Value of the project by $57,700 bringing it down to $351,700. If done at the beginning this option costs another $3,200 for the training of the lesson-writer.

Manpower and transactions. Since the cost of program development is made up not only of manpower, but also of computer transactions, both components will be affected if the addition of a team member is accompanied by a corresponding increase in the volume of transactions. The percentage of manpower increase, which is not necesarily represented by the addition of full time members, is reflected in the value of the Net Present Value as follows:

0%	25%	50%	75%	100%
409.4	362.6	315.6	268.7	221.8

Each increase of 25% results in an average drop of $46,900, a situation reflected by the slope of line AB on the graph (Figure 6).

Bilingualization. If training programs are prepared in two languages the cost of program development will be increased, while all other expense areas will remain basically the same since the trainees would have the option of selecting either version without generating a different volume of transactions. A second three-man team would be used for parallel production of the training materials in the second language. Both teams start with the same basic materials since training documents are currently routinely translated. With the doubling of the production workload, the expenses for both manpower and transactions are also doubled. The cost of bilingualization can be estimated at $197,300, representing the combination of: (a) a drop of $187,600 in the NPV resulting from the increase of 100% of the development costs indicated in the previous paragraph, and (b) an increase of $9,700 under the heading of initial investment, corresponding to the training of the second production team.

Speeded-up production. To reap faster the benefits resulting from the availability of courses in CAI form, the strength of the development unit can be increased. Because the production of a team is not proportional to its size, as a result of the law of diminishing returns, a better strategy is to increase the number of teams. The first course (1.1; 34.5 hours) required 2,416.1 hours of production. Doubling the number of teams does not halve this production time because each has to go through the learning process represented by the curve. A new production schedule based on each team developing half of each course must be drawn. For each team the production of 17.25 hours of course 1.1 takes 1,342.7 for a total of 2,685.4 hours as opposed to 2,416.1 hours for a one-team production. The production of more courses becomes cost-justified during the experimental five-year period. However, a comparison limited to the courses produced in the initial arrangement reveals that the NPV of the investment increases to $489,700. Although the maximum outlay, occurring at the end of the first year of operation, rises to $154,400 reflecting the higher initial expenses, it remains within the constraints of the project. This suggests that, to minimize the risks of the project, it would be wise to start with a three member team, ascertain the value of the variables under actual working conditions and then phase in a second team, to reap the benefits of the earlier availability of materials.

Learning curve coefficient. Another key assumption affecting the production schedule was a learning curve coefficient of 90%. If actual experience shows the coefficient to be higher, the production of courses will be stretched over longer periods, and the schedule will have to be truncated earlier, since some courses would no longer be cost-justifiable within the five-year period. The cost of the training operation as well as the benefits are lower as a result of the later availability of the courses. A new balance sheet reflecting these changes shows that coefficients of 92.5% and 95% reduce the expected NPV to $319,300 and $221,400, respectively, with the production schedule truncated after courses 3.2 and 4.1. On the graph the points C_1 and C_2 represent respectively the situations when coefficients of 92.5 and 95% are used. Although A, C_1 and C_2 appear to be on a straight line, there is no implication of linearity since in fact the cash flow is affected by a revised production schedule incorporating a different number of courses and a modified sequence of update periods.

Timing of maintenance. Another potential impact on the production schedule may derive from the timing of update of the training materials. This task may be designed on stricter rules: Thus, it could be planned for the beginning of each year after the first instead of later in the year. This tightening of the rules, when applied to the "initial" ASET production, would result in depressing the NPV by $24,600, a relatively small but significant amount.

Training Operation

The study started with the conservative estimate that CAI was equivalent to traditional instruction, meaning that one hour of suitably selected classroom instruction could be replaced by one hour of CAI. If the latter is more efficient, a shorter period could be sufficient and would be reflected in fewer hours at the terminal, with a comparable reduction in the number of transactions and their associated cost. A 10% decrease in Training Operation costs would boost the NPV to $468,300.

On the other hand, increases in the number of transactions caused by a higher rate of transactions per hour would have the opposite effect. Increments of 10% in Training Operation costs result in NPV decreases of $58,900 on the average and are plotted along Line AD.(Figure 6).

Benefits

When the amount of financial benefits is decreased, as a result of initial overestimations, for instance, the NPV is seen to drop by approximately $129,000 for each 10% increment (Line AE in Fig.6). Conversely any expansion in the factors considered under benefits, such as periodic pay increases and other forms of compensation (travel expenses, employee benefits) would contribute to the improvement of the Net Present Value.

Combination of Factors

These effects are cumulative: A decrease in Benefits of 10%, combined with a 10% increase in Training Operation costs, results in an NPV drop of

$187,500, corresponding to the addition of the $128,600 and $58,900 differentials. This combination is represented on the graph at point F, fourth corner of the parallelogram ADFE, whose sides are sloped to match the increase in Training Operation costs and in economic Benefits.

Conclusions

The sensitivity analysis points out that a change in the learning curve coefficient from 90 to 95% reduces the NPV to 54% of its value. It is therefore a crucial factor to be monitored closely. This coefficient can only vary between the theoretical extremes of 0.5 and 1.0, so that a change from 90 to 95% can be considered a drastic deviation. Because of its theoretical range, the deviation percentages of the learning curve coefficient cannot be directly compared with those of the other elements for which no such limitations apply.

A 10% deviation for the other components such as Initial Investment, Development costs, Training Operation costs, and Benefits indicates respective variation of 1.05, 4.57, 14.39 and 31.51% in the Net Present Value of the project, and permits a comparison of their relative influences on the profitability of the investment.

This means that the accrual of benefits must be audited with care, so that they are not diluted in the process. This would happen, for instance, if a trainee after having been trained by means of CAI were to be sent to a regional centre for the same course, thus incurring expenses which had been planned to be eliminated. The 31.51 percentage also indicates that any increase in the items included under that heading, such as travel allowances and wage levels, would make the project that much more attractive financially.

On the other hand, increases in Initial Investment and Development costs influence significantly less the NPV. It is therefore wise to increase the amount of expenses in these areas if the change results in lower Training Operations costs.

After the initial years of operation the acquisition costs settle down to an average of 6% of the total yearly costs, (see Table 23) while the program development costs drop progressively from 31 to 7% and the training operations costs, reflecting an increase in volume of transactions, climb from 62 to 87%. During that period these training operations costs consume approximately 45% of the financial benefits attributable to the existence of the computer based facility.

Table 23

Percentage of total cost of the main expense categories

Expense	Year				
	1	2	3	4	5
Acquisition	.13	.07	.06	.06	.06
Development	.60	.31	.13	.07	.07
Operation	.27	.62	.81	.86	.87

This brings out the cost of transactions as a critical variable to be monitored closely. A greater availability of CAI materials means increased transaction costs, accompanied by a relatively higher level of benefits. Considering the low percentage represented by the instructional development manpower cost, it seems wise to increase the rate of production through enlargement of the production team as soon as it becomes reasonably feasible so that a greater share of benefits can be reaped earlier. This is an area where an amount of discretion is available to the decision-maker desirous of optimizing the return on the investment since a doubling up of the teams results in a 19.6% increase in the Net Present Value.

Implementation Plan

Once the sensitivity analysis is completed, the Educational Technologist can present to the corporate management responsible for the decision to proceed with the implementation of the CAL facility, not only economic indices of profitability such as the Net Present Value of the investment and its Internal Rate of Return, but also the reasonable range of deviation which may be expected under realistic operational conditions. Together they can agree on the most likely extent of potential variations and deduct the results corresponding to the best and worst cases.

At this point, the project will be compared to others in different fields and the decision to proceed will be based on criteria of relative desirability among projects competing for a limited amount of resources. It is therefore necessary to add to the economic study a full description of the elements which have been taken into consideration as well as of those which have been left out as not quantifiable with precision. In addition, an implementation plan must be prepared to outline the details of implementation, operation and maintenance. The sequence of events may be displayed graphically by means of charts converting the activities of the previous flowchart model into a chronological sequence.

While the training organization was not geared to provide accurate economic data broken down for its various activities, the CAL unit will be able to gather some operating information such as number of transactions, and duration of trainee interface with considerable ease. In order to assess with precision its effectiveness, it will be necessary to incorporate into the design additional controls and instrumentation to capture all the relevant data.

The study was based on assumptions and figures which will admittedly differ somewhat from the reality. The initial phase, of modest proportions, making use of available manpower and machines whenever possible, is considered experimental with the expectation that it will generate sufficient data of high reliability for expansion of the facility.

Shortly after operational start-up a retrospective appraisal of the project will point out the modifications required to improve its operation. Periodic iterations of the simulation on both the flowchart and the mathematical models will lead to better management of the facility through the progressive replacement of earlier assumptions by actual operational data on a dynamic basis. Van Court Hare Jr. (1972, p.280) has pointed out that "systems... have adjustable elements 'set' at the time of installation. As time passes, these settings may no longer be appropriate to the system's condition of operation, so the system fails". It is therefore necessary to ensure that adequate provision is made to update the system.

One purpose of these yearly reappraisals is to ascertain whether the operators are actually performing according to the system definition and plan, another recommendation from Van Court Hare Jr. (1972, p.281) who found out that "many systems have not performed as predicted because an essential operation was not performed by an operator according to the plan assumed by the systems analyst". Another purpose is to plan extensions: Although the economic life of the project which was used to determine its indices of profitability had been set at five years, it is intended to keep it operating indefinitely on the basis of periodic evaluations in the context of overall environmental change and in particular of its Net Present Value for the next five-year period.

This is the time when the phasing-in of the training requirements of other branches is considered, since it will affect the performance and therefore the cost justification of the operating system. If it is decided not to add any course units, the production requirements will eventually be limited to the maintenance of existing materials by a small team of curriculum writers who may not need to be dedicated to production for the full year, with an accompanying drop in performance. If, on the other hand, additional areas of training are included, the instructional development team works at full production pace and keeps on improving to the point when the learning curve becomes asymptotic to the horizontal axis. There is a need to adjust the composition of the team by including content experts from the new branch, but at that point the addition is calculated as an incremental cost to the existing facility.

To determine whether a course should be added to the production schedule, an abbreviated version of the mathematical model is used. Once the CAL facility is in operation, the addition of a course does not affect the acquisition cost: The rental of the software package is already justified by the current training operation. Its cost, however, will be spread over a greater number of units. The criteria of cost justification are therefore limited to the incremental costs of development and of training operation, compared to the expected incremental benefits.

The development costs depend on the length of the course or, more specifically, the number of equivalent unduplicated student-contact-hours to be produced and on the timing of the production: Until such time as the ratio of forty hours of preparation to one hour of presentation is reached, the productivity of the curriculum development team is dependent upon the position along the learning curve. The training operation costs are a function of the length of the course, while the financial benefits depend on the pattern of training of the target population. The net benefits represent the difference between the training operation costs and the financial benefits. The ratio of the development costs to the net benefits indicates the time required to recoup the development costs and thus helps decide whether the course should be produced.

For instance, if Course 3.1 of 42.5 hours is examined for potential production after two and a half years of operation, when the production ratio has dropped to 43:1, its development costs add up to $28,829, representing the addition of

- manpower: 42.5 x 43 x $14.40, and
- transactions : 42.5 x $59.14

The yearly net benefits have been conservatively calculated earlier at $6,417. The corresponding payback period of 4.49 years means that the inclusion of the course is cost-justified if an economic life of five years from the date of availability is being considered.

There is therefore a need for a continual monitoring of the operation of the CAI unit. Some data, such as fully allocated standard costs of the computer facilities are easily gathered. The results of tests, which are similar to those used in traditional instruction, combined with interaction data provide a measure of the relative effectiveness of the method. Still others will have to be collected by means of a detailed bookkeeping system. In order to extrapolate the learning curve, a precise schedule of the progress of development must be kept.

Furthermore this information will be broken down into separate identifiable functions at the highest level of detail shown on the flowchart model: Subsystem 5.0 (Develop Instructional Program) will be monitored to provide data on such activities as: (a) modifying the COTP and tests used in traditional instruction, (b) writing the teaching points and steps, (c) preparing the coding sheets, (d) entering into the computer, etc...

The analysis of this information will allow the optimization of the composition of the instructional development team, by providing objective data for the optimum unit of personnel that will result in overall minimization of time, in the manner recommended by Fitzgerald (1973): The result will be a new division of labour, wherein the Content Expert and the Instructional Programming aspects of the curriculum authoring team can be emphasized to different degrees. It may lead to the inclusion of lower-paid clerical classifications such as keypunch operators.

The performance of the individual members of the team is also assessed periodically on the basis of the production data and used as a guide for remedial or complementary training as well as allocation of duties on the basis of suitability. In addition, information on activities performed outside the CAL unit, such as initial analysis of the content matter and preparation of the COTP will also be gathered in quantified form, to be used at a later date when the preparation of some subjects will be the full responsibility of the CAL unit.

Together with the anticipated production schedule, a budget will be prepared prior to implementation showing the volume of transactions and related costs. Any deviation between the actual and the budgeted figures will trigger a search of the time-records of activities to determine the cause and to devise a solution to return the actual performance to its planned level.

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CHAPTER 9

SUMMARY AND CONCLUSIONS

The instruments used for decision-making may be found on a continuum ranging from subjective intuition, cheap but unreliable, to a realistically detailed feasibility study, trustworthy but costly. The former may be found suitable for minor decisions concerning small investments, while the latter is a requisite for major undertakings involving the allocation of resources on a greater scale. The point selected on the continuum should represent an optimal trade-off between the efforts to be expended and the required accuracy of the results. The methodology described in this paper represents a mid-point enabling the decision-maker to reach conclusions with a sufficient amount of confidence for a reasonable expense of time and money when a limited investment of resources in considered.

Summary of the Project

The study of the conditions prevailing in a particular environment resulted in some specific findings, such as:

1. The introduction of Computer Assisted Learning is cost-justifiable on the basis of the economic criteria used by the sponsoring organization.
2. The number of trainees does not have to be excessively large to economically justify this innovation (e.g. 302 agents for course 3.3).
3. The judicious use of existing facilities is an important contributing factor to the reduction of large initial cash outlays.

Furthermore, although it was initially assumed that CAL would be used for all courses if financially justified, the economics dictated that some follow-up courses remain in the traditional instructor-led form. The resulting mix is a less radical switch from the current method and a more acceptable solution in the actual environment of the training organization. This happy circumstance will facilitate the acceptance of the new facility.

The study offers various scenarios for progressive implementation, keeps the facility open-ended for possible additions, and indicates the quality control points which will provide the necessary imput for cybernetic control once the facility becomes operative. It provides formulae to determine when the production schedule should be truncated and how to assess whether an additional course unit should be considered for inclusion into the CAL curriculum.

In order to do so, it isolates the CAL facility from its parent system to highlight the features which must be considered, while retaining the conceptualization of the CAL unit as an 'open system'. The project is possible because there already exists a training organization from which instructors can be drawn, assigned to a particular task, and returned to their initial position when no longer needed: Thus the calculations can make use of fractional manpower units. At a higher level there is a continual adjustment of the flow, in either direction, of instructors and supervisors between the training world and the field operations. The smooth operation of the CAL unit is contingent upon the existence of a large enough enveloping organization to meet its needs and absorb the slack.

Similarly the operation of the CAL unit is also dependent upon the resources of the Computer Services Branch, which provides for its various needs exactly as required. Therefore it does not have to absorb disproportionate idle costs, which would be the case if it were to be operating as a separate unit. The fact that the computer transaction requirements of training are higher at times of day when the operational requirements of the airline are lower facilitates the integration of CAL operations, since these activities may then be seen as complementary to other loads, the volume of transactions resulting from training contributing, albeit to a minor degree, to evening out the peaks and valleys of the total computer workload. The study would be much more complex, were it not for the existence of an operating system already built for a high level of performance with guaranteed indices, such as the Average Response Time and the Minimum Time Between Failures (MTBF). Here again the introduction of the CAL unit is facilitated because it is only one of the elements of a huge system able to absorb a gradual increase of workload over time and to reach a higher level of steady operational state.

The study has used statistical averages up to the sensitivity analysis performed on the selected alternative. These figures cover cost and benefit areas which can be determined and quantified precisely. Other potential areas of economic benefits such as release of classroom space, facilitation of record-keeping, reduction of training time through elimination of lock-step progressing have been intentionally left out. Positive results achieved by using assumptions on the pessimistic side are more conducive to a decision to proceed than those remaining marginal after every possibility of squeezing out all sources of potential benefits has been exhausted. The presentation gains in clarity when the research is limited to the elements sufficient to provide evidence of profitability, provided of course that no corresponding cost item is left out.

The amount of benefits which could be expected to flow from the introduction and operation of the CAL facility established a ceiling for the cost of that facility. This resulted in the elimination of the fully dedicated training system for economic reasons at an early stage, thus obviating the need for detailed calculations of a production schedule. Once it is established, on the other hand, that a potential solution meets the cost-justification criteria, it becomes worthwhile to investigate further. When none of the potential solutions meets the criteria, it is still beneficial to rank them in order of profitability and to select the most promising ones for further study in order to determine the conditions under which they may become cost-justified. The effort expanded in the study is never wasted since it will always yield a useful answer to the organization.

The degree of trustworthiness of the results depends on the assumptions outlined in the presentation and the value of the data collected. The outcome is considered to be of sufficient value for the purpose of implementation because it presents an acceptable range of operating data which will be refined through the monitoring of the actual operation.

Further Research

As indicated, this study is the inital step for the implementation of a computer based facility in an actual industrial setting. It will prove interesting to compare its operation with the projections made in this paper and particularly to gather the actual data that were missing and had to be estimated, such as the information leading to the determination of the learning curve coefficient for the development team, or the average update requirements. Other 'building blocks' for a project of this nature would include the relative effort required to produce materials in the various instructional modes of computer use, and the optimal composition of the instructional development team for this type of didactic materials.

Despite the detailed bookkeeping that will take place, the results recorded will only be examples of the actual experience of one corporation. To give them a proper context further research should be conducted on the relevant aspects. In particular a taxonomy of CAI programs, based on a comprehensive analysis of a large sample, would permit valid comparisons within narrow margins, so that general statements could be qualified. This taxonomy would classify CAI programs in terms of their features ranging from the use of alphanumerics to audiovisual capabilities; it would distinguish between lessons which are based on the use of adjunct materials, between those which give the student the option or explore side issues and those which lead him along a fairly well defined track to learn specific procedures.

The aids available to the author represent another dimension for investigation. For instance, the writer who uses a Conversational Lesson Development Module with prompts instead of coding the lesson, inputting it into the computer and having it translated, may produce more materials than if he had to generate his own pattern and select a more flexible strategy. The result may be a stereotyped product of lower quality: The optimal point of trade-off can be determined through a separate study. Similarly the availability of a graphic capability may lead the author to experiment and make a greater use of it than instructionally required. On the other hand a writer may restrict himself to the features he knows and likes best.

With a reliable definition of these dimensions, the ratio of preparation to presentation, described as ranging from 350:1 to 20:1 could be specified with more precision, which would permit the measurement of the productivity of teams against a norm, and lead to the determination of the optimal size and composition of a development team based on a particular workload.

Finally the relative quality of the programs, reflecting the efficiency of the production team, should be assessed objectively. Since the structure of a lesson can be defined with precision and the number of teaching points identified exactly, the hazy concept of student-contact-hour could be replaced by a quantitative measure such as the number of teaching points, learned and retained, corresponding to an hour of student time or to a number of transactions.

The results of this research would be a multidimensional matrix providing a variety of specific cells to be used as accurate building blocks by other researchers attempting to reduce the range of their projections.

Conclusions

The comprehensiveness of the method is evidenced by the fact that the study covers the cost headings used by other researchers in this area, although it resequences them and changes their respective emphasis. Because of the specific circumstances of the application considered, some parts are considerably reduced while others take on more importance.

Just as the previous research, despite its scope and the variety of methods described in the literature, did not provide a model that would match exactly the needs of the situation investigated in this paper, the solution presented here would probably not fit without some modification the requirements of an organization with a slightly different set of constraints and another pattern of available facilities. This is due to the fact that the introduction of a computer installation never occurs in a vacuum and is therefore situation-specific: It must always be planned in its own context, with a methodology flexible enough to tailor the feasibility study to the needs of the situation.

The method, however, is easily generalizable to a variety of situations. It is as follows: A flowchart model is used to delineate the scope of the application, reduce the alternative to a few typical ones, identify the cost and benefit elements with the necessary degree of detail, bring their relationships into a mathematical model with discounted cash flows, which can be used to run any number of simulations with varied parameters to observe the effects, the choice being made with due concern for the sensitivity of the results to changes in assumptions.

This composite of various techniques provides a large degree of flexibility in the search for optimization. The level of detail can be selected on the basis of the actual data available, while any existing feature such as the availability of a CAI language in the inventory of the parent organization can be incorporated into the model. The reliability of the results and, with them, the credibility of the method depend on the tightness of the assumptions used, which must be clearly identified.

Once the equations underlying the mathematical cost model have been established, the next step is to design a short computer program in a simple language, such as BASIC, so that a greater number of intermediate solutions can be found and represented on graphs for easier visual evaluation, without the tedious repetition of a series of mathematical calculations. Although the use of a specialized simulation language would provide a more sophisticated approach incorporating more elements, it would detract from the simplicity which is sufficient for the adequate preliminary investigation of a project, where even limited computerization adds a dynamic dimension to the cost analysis.

For optimal results this research is better conducted by a task force of training personnel under the guidance of a project leader well versed in educational technology, who will conduct periodic meetings and specialized workshops. At these gatherings the design of the facility will be progressively refined with the occasional assistance of specialists from other divisions (finance, computer services) and outside firms. The final result will be a clearly defined project, integrating the relevant elements and designed to the appropriate degree of precision, which will be presented to the management level responsible for its authorization and handed over to the Computer Services branch for the subsequent development of the detailed implementation design.

This sequence of events represents a shift of responsibility and initiative. The training organization must define its environment and its role with precision in order to design a facility meeting its needs, whereas the past practice has been for a systems analyst to discover the needs by means of interviews and then to design a system on the basis of his perception of those needs. Although the results were generally commendable, this practice did not result in the same degree of involvement and responsibility on the part of the users. In this respect the research may be seen as an educational tool which is, not only useful because of the investigation of relevant areas and of the development of a common understanding of concepts, but necessary since the early participation of the training community will facilitate the acceptance of the innovation during the critical early stages, without the recourse to numerous and lengthy familiarization sessions.

The point where the training organization turns over the study to the Computer Services branch will vary with the organization of the corporation. The number of variables to be considered in the research study may be increased, but depends on the qualifications of the personnel and on the internal division of responsibilities. The more comprehensive the preparatory work of the training organization, the easier it is for the Computer Services branch to reduce the manpower required to complete the implementation study. In the present case it will take the training organization about one man-year to complete its research: The educational technologist will devote four consecutive months to the project, while the training program manager will contribute 50% of his time during that period and six individuals drawn from the Montreal, Toronto and New York training units will contribute the equivalent of one month each. The corresponding cost was not charged against any of the solutions investigated because it is built into the present organization for research and development purposes. Within that framework these personnel can deal with the training-related aspects of the project, and even learn about LOGOS since it has other applications in training. On the other hand, learning about marginal areas involving for instance leases and rentals of buildings and materials, is questionable. These aspects of the analysis will be left for the Computer Services to handle, but other corporations may want to shift these responsibilities to match the specific abilities of their personnel.

Because it features the differential between an existing and a proposed system, the method followed here is not suitable for new installations where all the components must stand on their own merits and be fully accounted for. It is, on the other hand, particularly suited for organizations which consider the introduction of a CAL system of relatively modest proportions in an environment which already includes computer applications and where the availability of resources may be used to offset a sizeable portion of the costs. It is particularly suitable to the study of marginal conditions where the approach selected may spell the difference between success and failure, because it can lead to the early adoption of an innovation.

Regardless of the amount of theoretical information and empirical data available, and despite improvements in the formalization of the process, each study of this nature requires a measure of creativity which must be grounded on logical, rational assumptions. I believe that the method described here offers the Educational Technologist desirous to see innovations introduced at the right time into his area of activity, the opportunity to become a leading influence and the tool to contribute directly to the improvement of his environment on a rationally defensible basis.

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APPENDIX

TABLE A

GEOGRAPHICAL DISTRIBUTION OF EMPLOYEE CLASSIFICATIONS

STATIONS :	EMPLOYEE CLASSIFICATIONS :									TOTALS
	A	B	C	D	E	F	G	H	I	
1. Toronto	485	359	444	84	60	55	39			1526
2. Montreal	310	287	174	85	52	38	19			965
3. Vancouver	149	128	272	19	16	10	5			599
4. Winnipeg	73	70	40	14	15	9	7			228
5. Calgary	81	65	40	15		7	7	12		227
6. Edmonton	63	56	55	10		6	4	9		203
7. Ottawa	109	32	12	10		10		18		191
8. Halifax	68	47	13	15	12	9	4			168
9. New York	37	68		29	7	4				145
10. Miami	57	34		14	4					109
11. Chicago	17	33		23	4	3				80
12. Regina	24	24	13					12		73
13. Saskatoon	24	19	10			1		11		65
14. St. John's	23	17	8	9				7		64
15. Los Angeles	16	23		2				21		62
16. Moncton	14	16	4	5				6		45
17. Victoria	21		12					12		45
18. Quebec	31		2	3				7		43
19. Saint John	12	20	1	2				8		43
20. Tampa	32							9		41

TABLE A (Continued)

STATIONS :	A	B	C	D	E	F	G	H	I	TOTALS
21. Thunder Bay	7	14						7		28
22. Cleveland	10			10	3	3				26
23. Windsor	15							10		25
24. London	15							9		24
25. Sudbury	2	12							9	23
26. Boston	18							4		22
27. Fredericton	3		4	1					13	21
28. S.S. Marie	3	7							10	20
29. Sydney	12							7		19
30. Gander	8		3					5		16
31. Timmins	6								8	14
32. Sept-Iles	1		1	2					9	13
33. San Francisco	8							2		10
34. Val [illegible]			2						8	10
35. Stephenville									9	9
36. Yarmouth									9	9
37. Rouyn			2						7	9
38. North Bay	1								7	8
39. Charlottetown			4						3	7
40. Dallas	6									6
41. Houston	6									6
TOTALS	1767	1331	1116	352	173	155	85	176	92	5247

TABLE B

YEARLY TOTAL OF STUDENT CONTACT HOURS

Course	Trainees	Course Hours	Total Hours
1.1	255.20	39	9,952.80
1.2	247.84	26	7,483.84
1.3	148.72	26	3,866.72
1.4	141.36	52	7,350.72
F1.1-4	2,371.76	6.5	15,416.44
"	563.04	4	2,252.16
1.5	111.60[a]	6.5	725.40[a]
F1.5	1,038.00[a]	6.5	6,747.00[a]
2.1	6.80	13	88.40
F2.1	57.96	6.5	376.74
"	20.24	4	80.96
2.2	22.45	19.5	437.78
F2.2	80.55	6.5	523.58
"	320.00	4.0	1,280.00

[a]Subject to yearly growth factor.

TABLE B (Continued)

Course	Trainees	Course Hours	Total Hours
3.1	54.05	48.0	2,594.40
F3.1	89.60	6.5	582.40
"	297.35	4.0	1,189.40
3.2	32.64	7.5	244.80
F3.2	106.88	2.0	213.76
3.3	35.04	16.5	578.16
F3.3	106.88	2.0	213.76
3.4	24.95	24.0	598.80
F3.4	106.90	4.0	427.60
4.1	80.60	52.0	4,191.20
4.2	80.60	52.0	4,191.20
F4.1-2	163.56	6.5	1,063.14
"	375.84	4.0	1,503.36
4.3	43.48	58.5	2,543.58
F4.3	156.60	6.5	1,017.90
"	138.92	2.5	347.30

APPENDIX C

CALCULATION PROCEDURE

This section outlines the sequence of calculations underlying the mathematical model applied to the selected alternative (Reservec/ASET) and to its sensitivity analysis.

Production Schedule

The number of man-hours required for the production of CAI hours is obtained by the formula : $Z = AX^{c}$, where

- Z is the total number of production man-hours required,
- A the number of man-hours required for the production of the first hour of CAI materials,
- X the number of CAI hours to be produced, and
- c the exponent corresponding to the learning curve coefficient of the production team.

The value of the exponent c can be derived from the formula given above. With a learning curve coefficient of 90%, the average production time of the first 2 units is equal to 90% of the average production time of the first unit. If the first unit takes 100 hours , the second would take 80 , for a total of 180 and an overall average of 90. These values are substituted for their symbols in the formula :

$$Z = AX^{c} \quad \text{or} \quad 180 = 100 \times 2^{c} \quad \text{or} \quad 2^{c} = 1.8$$

meaning that : $c \log 2 = \log 1.8$ and therefore :

$$c = \log 1.8 / \log 2 \quad \text{or} \quad .25527/.30103 \quad \text{or} \quad .848$$

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The number of manhours required for the production of the first 34.5 hours of CAI materials (Course 1.1) ; when the initial ratio of preparation to presentation is 120:1 and the learning curve coefficient 90% , is calculated as : $Z = AX^c$ or $120 \times 34.5^{.848}$
meaning that :

$\log Z = \log 120 + .848 \log 34.5$ or 3.38325

for a total of :

Z = 2,416.8 manhours (Table 18 , p.138).

Under the same circumstances the first 69 hours of CAI materials would require : $Z = 120 \times 69^{.848}$ or 4,350.3 manhours.

Thus the average production time of the first 69 hours of CAI materials (63.05 or 4350.3/69) is shown to be indeed 90% of the average production time of the first 34.5 hours (70.05 or 2416.8/34.5).

Availability of Courses

Since the three-man development team provides 5520 manhours a year , the production of the 34.5 hours of CAI materials for the first course requires 43.78% of the working year (2416.8 hours out of the available 5520). This course is therefore available for 56.22% of that year (100 minus 43.78%).

After the production of the next course (1.1 ; 21 hours) , 55.5 hours have been produced at an expense of 3,616.9 manhours or 65.52% of that first working year , making the course available for 34.48% of the year.

Course 3.3 is available after a total of 12,273.9 manhours , equivalent to 2.2235 years , have been used : It is therefore available for the remaining 77.65% of that year (3 - 2.2235).

Effects of Course Availability

The percentage of availability of a particular course in its production year is multiplied by the amount of total benefits to be derived in a full year of operation (Table 5 , p.95) to obtain the benefits derived during that year , e.g. Course 1.1 , 56.22% of $ 88,312 or $ 49,649 , as shown in Table 19 , p.140 .

The number of students is multiplied by the average time spent at the terminal to determine the yearly total of student contact hours (Table B , p.184). This figure is then multiplied by the average number of transactions per hour (224) and the transaction cost ($ 0.022) to obtain the yearly cost of trainee transactions , e.g. $ 49,047 for Course 1.1 , as shown for Year 2 , on Table 20 , p.141 .

This yearly figure is also multiplied by the percentage of the time the course is available in its production year. Course 1.1 available 56.22% of the first year results therefore in transaction costs of $ 27,574 (Year 1 , Table 20 , p.141).

Development Costs

The manpower costs are represented by the product of the manhours required for the production of a course by the hourly salary figure. Thus Course 1.1 requiring 2416.8 hours at $ 14.40 will represent a total of $ 34,802 . This figure , which takes into consideration the prioritization of production differs from the one shown on page 137 where an overall production time average is used for comparative purposes .

Initially the development team is working for the whole year , so that the manpower cost is $ 79,448 representing either 5,520 hours at $ 14.40, or three developers at a yearly salary of $ 26,496 (Table 21 , p.142).

The development transaction costs are obtained by multiplying the hours of CAI materials by 12 times the number of 224 transactions per hour at a cost of $ o.o22 per transaction. In the first year 91.37 hours are produced , at a cost of $ 59.137 per hour , or a total of $ 5,403 (Table 21 , p.142).

Cash Flow Sheets

The costs and benefits displayed in Tables 19 , 20 and 21 are grouped in Table 22 , page 143 , with the acquisition costs and expenses occurring prior to the start of the program , to provide and overview of the cash flows over the period considered. These figures are rounded to the nearest $ 100 and discounted by means of present value factors (three decimals).

Sensitivity Analysis

Table 22 is used as the departure point for some of the calculations required in the sensitivity analysis , with new sets of figures under a specific heading being substituted for the initial ones , while the other elements remain constant. Thus , the addition of a fourth man to the development team , described under "Program Development - Manpower" on page 154 , has the following effects :

1. The manpower figures of Table 21 are incremented one third to the new values of :

(1)	(2)	(3)	(4)	(5)
$ 105,984	105,984	48,191	26,003	25,431

2. The development costs shown on Table 21 and carried over to Table 22 now become :

111,387	112,827	51,535	27,961	27,389

3. The total costs on Table 22 increase to :

168,034	300,903	309,701	294,239	298,568

4. With resulting cash flows (rounded and discounted) of :

-88.7	40.6	147.9	153.1	141.7

5. Adding up, with the unchanged initial cost of -42.9 , to a Net Present Value of $ 351,700 .

This new situation can be depicted by a point on the graph with the coordinates (33.33 ; 351.7) evidencing the fact that a one third increase in manpower results in an NPV drop of $ 57,700 , from the initial $ 409,400 to $ 351,700 .

This substitution of figures in the cash flow sheet shown as Table 22 applies equally to other deviations, such as Manpower and Transactions (p.155), Bilingualization (p.155), Training Operation (p.158) and Benefits (p.158). Other variations considered, such as Speeded-up Production (p.156), Learning Curve Coefficient (p.157), and Timing of Maintenance (p.157) require that new production schedules be determined before the effects on the balance sheet can be ascertained.