THE EVALUATION OF ALTERNATIVE AIRPORT PLANS

by

Margaret Aileen Smith, B. Comm.

Queen's University

A thesis presented to the Faculty of Commerce and Business Administration in partial fulfilment of the requirements for the degree of

MASTER OF BUSINESS ADMINISTRATION

This thesis is accepted as conforming to the required standard.

UNIVERSITY OF BRITISH COLUMBIA

September, 1968
In presenting this thesis in partial fulfilment of the requirements for an advanced degree at the University of British Columbia, I agree that the Library shall make it freely available for reference and study. I further agree that permission for extensive copying of this thesis for scholarly purposes may be granted by the Head of my Department or by his representatives. It is understood that copying or publication of this thesis for financial gain shall not be allowed without my written permission.

Department of  

The University of British Columbia  
Vancouver 8, Canada  

Date September 30, 1968
TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Chapter</th>
<th>INTRODUCTION ........................................</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.1 Background ...................................</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1.2 The Present Situation ......................</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>1.3 The Importance of Economic Evaluation ......</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>1.4 Purpose of the Thesis ......................</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>1.5 Limitations in Scope ......................</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>THEORY AND PROBLEMS OF ECONOMIC EVALUATION ....</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>2.1 Introduction ..................................</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>2.2 General Problems ............................</td>
<td>23</td>
</tr>
<tr>
<td></td>
<td>2.3 The Measurement of Costs ...................</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>2.3.1 Costs to the Agency ......................</td>
<td>26</td>
</tr>
<tr>
<td></td>
<td>2.3.2 Costs to the User ........................</td>
<td>31</td>
</tr>
<tr>
<td></td>
<td>2.3.3 Costs to the Non-User ....................</td>
<td>37</td>
</tr>
<tr>
<td></td>
<td>2.4 Measurement of Benefits ....................</td>
<td>39</td>
</tr>
<tr>
<td></td>
<td>2.5 Distribution of Benefits ...................</td>
<td>42</td>
</tr>
<tr>
<td></td>
<td>2.6 Price Levels ..................................</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>2.7 Discount Rate ................................</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td>2.8 Criteria ......................................</td>
<td>47</td>
</tr>
<tr>
<td>3</td>
<td>CANADIAN AIRPORT PLANNING ......................</td>
<td>50</td>
</tr>
</tbody>
</table>
# LIST OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Benefits and Costs</td>
<td>27</td>
</tr>
<tr>
<td>2</td>
<td>Sample Airline Questionnaire</td>
<td>53</td>
</tr>
<tr>
<td>3</td>
<td>Cost of Ships' Time in Port</td>
<td>68</td>
</tr>
<tr>
<td>4</td>
<td>Cost of Operating Port Equipment</td>
<td>73</td>
</tr>
<tr>
<td>5</td>
<td>Cost to Planes of Using the Airport</td>
<td>91</td>
</tr>
</tbody>
</table>
ABSTRACT

In the past, the planning of airports has largely been an intuitive process, leading to an often serious misallocation of resources. It is the contention of this thesis that the adoption of a more economic and integrated method of evaluating alternative airport plans could eliminate some of this mis-investment, and that the groundwork for such an evaluation process has already been done in the field of port planning. The evaluation method proposed is the use of a mathematical model of the airport's operation and of the benefit and cost interrelationships arising from the activities performed. The model can then be used to simulate the value of the benefits and costs of a number of possible alternative plans. It is the purpose of this thesis to discuss the applicability of the port model as a tool for airport planning and to point out the ease with which it could be applied both from the point of view of modifications and data requirements and availability.

As background to the evaluation process, Chapter 2 presents some general theory and problems of economic evaluation and of the measurement of benefits and costs. Chapter 3 presents a description of planning processes currently being used by the Department of Transport in planning Canada's airports and points out some of the flaws in this approach. Chapter 4 then describes the type of port model now developed in so far as it can be used to determine interrelationships between investment, cost to ships of using the port, cost of
port operation, and net community benefits. The calculations derived from the application of the model can then be used to determine the net present value of the benefit and cost streams arising from alternative ways of achieving a given level of port output, and thus to select the best possible combination of facilities.

Chapter 5 then points out the similarities and differences between port and airport operation and hence the applicability of and the modifications required in the application of the port model to airport planning situations. The remainder of the chapter delineates the type of data required to construct and use an airport model and the availability of this data to the airport planners.

Finally, Chapter 6 summarizes the findings and concludes that, while it has its limitations as a terminal model, as a representation of airport operation and as an evaluation process, the port model can be adapted relatively easily to airport planning to provide a more integrated, more economic approach to the evaluation of alternative airport plans.
CHAPTER 1

INTRODUCTION

1.1 Background

Ever since 1904, when Wilbur and Orville Wright launched their Kitty Hawk into the air and coincidentally launched a whole new era in travel, the air transport industry has grown by leaps and bounds. No other vehicle, except possibly the automobile, has managed to match the technological development and growth in acceptance and use that airplanes have attained in our society. Certainly, no other commercial transport mode has matched the percentage growth of air transport in the past thirty years. Nor does the growth appear to be slackening. Estimates have placed the world air passenger traffic at over four times its present level by the end of the next decade, and air cargo, in the same period, is expected to increase to more than six times today's figure.

In order to provide this growing market with transportation and in order to further expand the market by providing faster and more frequent service, the airlines are investing countless dollars in larger, faster planes. The next decade could see planes capable of carrying 500 passengers at super-sonic speeds in service. Yet the danger arises that these high capacity jets will take off carrying much less of a load than their capabilities warrant, for despite the rapid
advances in the field of aircraft technology, the technology of ground facilities has lagged far behind. The airports that exist today are, in many cases, not physically capable of handling even the present volume of passengers and cargo, let alone volumes four to six times greater. Thus, the outgrowth of this new era in aircraft could very well be severe congestion of planes, passengers and cargo on the ground. The new jets will require more space, (a 747 requires almost three acres of space for manoeuvering into a parking position), and their use will create a need for facilities capable of handling 500 debarking and 500 embarking passengers, their luggage and their family and friends in a single period of time. As a result, the need for new and expanded airports will become critical, and it would appear that the next few years will see many millions of dollars spent on airport development and construction.

1.2 The Present Situation

There are two main reasons for the writing of this thesis. The first is the probable acceleration in the near future of airport construction and development. The second reason lies in the costly blunders which have been made in airport construction programmes in the past, and in the possible reasons that these errors have occurred.

As Ruppenthal states:

"Few important decisions in the American community have been made with such reckless abandon and lack of sophisticated planning as those associated with most of the nation's airports. All too often, these sizeable expendi-
tures have resulted in architectural monstrosities, poorly designed traffic patterns, and a shocking disregard for the passenger himself.

"More than once, enthusiastic citizens have watched the ribbon-cutting ceremony that inaugurated a new airport terminal, only to find that it was obsolete the day it was opened. Then began that familiar process using 'baling wire, putty and glue' in an attempt to improvise on poorly designed facilities, hoping that somehow they might become adequate to the demands of the day." 3.

All too many examples of this sort of phenomenon exist. Even after jets had been in operation for two years, "not one single commercial airport in the United States was completely adequate for jet operations under all conditions." 4. After jet transport became more stabilized, the situation did not improve. The example of Trans World Airlines is typical of the general lack of foresight in the whole air transport field. This particular company budgeted $3.5 million between 1963 and 1965 for the construction of air cargo terminals and in 1967, with these terminals still under construction, traffic growth was two years ahead of schedule and the new facilities were already inadequate.

Nor is Canada exempt from such problems. Articles appear regularly in the popular press giving facetious and serious accounts of passengers waiting two hours in the terminal to board a one hour flight from Montreal to Toronto. The "ground barrier" seems to be more difficult to break than the sound barrier.

Several authors have offered reasons for the traditionally poor design and lack of planning of airports. Sefton-Brancker contends that "in many instances, airports have been designed and constructed
because they were considered essential, and thus not very much thought has been given to the future results in terms of revenue and expenditure." Brewer offers an argument similar to this when he states that:

"air freight transportation is growing so rapidly that carriers are finding it difficult to develop accurate handling costs. Carriers were impressed with the need to expand old facilities and construct new ones, and as a result, only rough estimates of final per-ton handling costs could be obtained. Each of these decisions was made without detailed studies or estimation of the changes in costs that occur because of implementation of newer handling methods." 7.

Goss states, with reference to similar problems in port planning, that problems arise because decisions are largely made intuitively and on the basis of recommendations of interested parties. In situations where an integrated operation of optimum efficiency is required, it would be more desirable to have an independent appraisal made, to prevent over- or under-investment in certain facets of the operation due to the bias in the recommendations of these interested parties.

This is not to say that no effort has been made to improve the airport situation. Research is being conducted in the design of high-speed baggage conveyors, in the efficient and rapid transportation of passengers from downtown to airports and from boarding rooms to the aircraft, and in the design of airports and runways to provide greater flexibility and ease of expansion should the facilities prove inadequate. Boeing also has been doing work in the area of system investigation, attempting to identify constraints and methods of
11.

removing them.

Despite progress in these areas, however, the work, generally speaking, has been widely diversified and not synthesized to any degree. As implied by Goss, an integrated approach to airport design is required but still lacking. Each activity performed by the airport facility is related to all other activities. If one activity area is capable of handling only 100 persons or units per hour, it is immaterial that the other activity areas can handle 1,000. The maximum capacity will remain, due to the bottleneck, at 100 units per hour.

It would appear, then, that part of the problem that exists is the lack of an integrated approach to airport planning. The airport operation should, for planning purposes, be regarded as a whole rather than as a series of segregated facilities, and the lack of such a viewpoint is perhaps one of the reasons for errors that have been made in the past. A second possible reason, however, as suggested by some of the authors above, is the lack of a sophisticated economic evaluation of proposed plans to determine if this plan represents the best available combination of resources. The existence of such a situation is borne out both by the literature and by interviews with the Canadian Department of Transport's airport planning division.

1.3 The Importance of Economic Evaluation.

The question arises as to why economic evaluation is justifiable and even necessary in airport planning. Some of the more important reasons are as follows:
(i) First, the amount of money involved would seem to justify a close investigation of the way in which it is to be spent, for these amounts are considerable. For example, in 1967 the Canadian government spent $100.1 million on air services. Of this, $44.6 million went into the operation and maintenance of existing airports around the country, and another $33.1 million was spent on the construction and acquisition of new facilities. Very rough estimates of the capital costs of Canada's mainline international airports would appear as follows: up to March 31, 1966:

- Halifax International Airport: $15,000,000
- Dorval Airport - Montreal: 82,000,000
- Toronto International Airport: 70,000,000
- Winnipeg Airport: 30,000,000
- Edmonton Airport: 35,000,000
- Calgary Airport: 9,000,000
- Vancouver International Airport: 27,000,000

When these amounts are being spent, it would be both desirable and justifiable to study carefully the economic and financial feasibility of the proposed facilities. If a few extra dollars invested in a particular area of the airport could drastically increase the return from or efficiency of the total airport operation, then the failure to include this investment in the plan would represent a less-than-optimum use of the large sums already allocated.

(ii) In Canada, airport construction is the responsibility of the Department of Transport and thus of the federal government. Consequently, airports are competing with a multitude of other important projects for government funds. Since it is public money which
is being spent, the government is obligated to invest this money where it will bring the greatest benefit to the taxpayers. Thus, investment in any transport facility is justified only when it can be shown that no other investments which the government can make are more profitable in terms of financial gain and national utility. Similarly, within the transport sector, the same criterion applies. Funds should be allocated to airport construction and development when no other transport investments can be shown to be more desirable; and more important from the point of view of this study, funds should be allocated to one particular airport plan only when it can be shown that of all possible airport plans, this one represents maximization of the criterion on which it is evaluated. Hence, as is the case with highway, port and other transport projects, some economic evaluation of the proposed airport project should be conducted if the government is to justify allocating its limited resources to this particular use.

(iii) Not only construction but also operating costs are an important factor in government spending. In most cases, airports are not self-supporting in monetary terms. Usually user charges or landing fees cover only a small percentage of the cost of operating the facilities. Consequently, some estimate should be made of the financial profitability of the project and of the quantities of public funds which will be required to maintain its operation. Also, the fact that the airport is essentially non-profit-making increases the
need for efficiency in the design and operation of its facilities. As was noted above, the cost of operating an airport is considerable, and the majority of this cost is paid from public funds. Hence the more carefully and efficiently designed the airport, the less will be the amount of public subsidy required to maintain it.

(iv) Economic evaluation is also justified by the part the ground facilities play in the total operating costs of the airlines. It has been estimated that terminal costs represent 50% of total air transport costs for combination (passenger and freight) carriers, and 35% of total costs for all-cargo planes. Factors such as delays, ground operations, sales, passenger services, landing fees, maintenance, etc. constitute an exceedingly high proportion of the airlines' expenses. Many of the expenses associated with using the airport are a natural outcome of the nature of the industry: the fact that the technology requires elaborate "base" operations; the necessity for an expensive reservation system to obtain high utilization of equipment; and the importance of service competition with other modes which creates high sales expenses. Others, however, such as delays and ground maintenance, which represent a substantial portion of the total, can be directly affected by the design of the airport. The Air Transport Association, for example, states that in 1967 scheduled planes were delayed 130,000 hours at or over airports, costing passengers 7,000,000 man-hours of waiting. One United States airline is predicting that delays caused by congestion
on the ground will add $20 million to operating expenses by the early 1970's. Even now, in the United States at least, the utilization of jets in revenue-hours per day is low: the average figures are 9.6 hours for a 707, 10.1 for a DC-8, and 7.1 hours per day for a 727 jet. Naturally, these expenses are eventually borne by the consumer of the transport service. If these expenses could be substantially reduced through more careful planning and evaluation of airport designs, the operating expenses of the airlines could be reduced and these savings possibly manifested in the form of lower passenger fares and freight rates.

(v) The final and possibly the most important justification of an economic evaluation of airport plans is the importance of the airport to the air transport system, and hence to the successful operation of the air transport mode. As with railways and shipping companies, so with airlines and airline users, the terminal is a part of the total process of getting from origin to destination. The total transport process can, in other words, be divided into two interdependent operations: (a) the actual lines of transportation in the air and (b) terminals or nodal points where goods or passengers are picked up, delivered, or transferred to other modes. Not only is the airport important as part of the facilities which the airline is compelled to use in providing air transport, but also it represents a stage of the journey to passengers and cargo. The relevant factor to the consumer in contemplating a trip, then, is not just the time, effort and money expended from the time of departure from
airport A to the arrival at airport B, but rather the total time, effort and money expended from the time he leaves his home until he arrives at his ultimate destination in another city. The total journey, therefore, encompasses driving to the airport and parking, checking in and checking baggage, waiting to board, flying time, luggage retrieval, and travelling from the second airport to the destination in the new city. The actual operations performed by the airlines are only a part of this process.

Thus Brewer states, "most aviation planners agree that airport facility problems may be some of the biggest deterrents to the future growth of passenger and cargo transportation." It has been suggested that the airlines are already in financial difficulty due to their heavy investments in equipment and their inability to derive a niche in the short-haul market. The hope undoubtedly exists that the new era of jets will solve many of their profit problems. For one thing, the large planes are more economical because they are faster. Therefore, they can achieve more passenger-seat-miles during operating hours. Also, since time obsolescence is the principal factor in airplane depreciation, the airlines' capital costs will decrease on a per-unit-of-output basis as the number of miles of operation per day increases.

Inefficient airport facilities, however, could cause large inroads to be made in both the existing and expected markets for air transport. Much of this market is likely to move to other surface
modes of transport, thus weakening the airlines' financial viability and preventing them from achieving the additional profits and growth that may follow from the purchase of new equipment.

The reasoning behind this proposition lies in the factors which have caused the growth in the past of the air transport industry. Some of these factors may be purely psychological - for example, the decreasing fear of air travel due to the improved safety records of the airlines, the desire to be "modern" and to identify with the status leaders who travel by plane, or just the growing acceptance of airplanes as a part of everyday life. Some more probable reasons are offered by W. A. Pulver, however, when he attributes this growth to the rise of an affluent society, an increased demand for travel to new and distant lands, and the acceleration of domestic and world trade. The combination of these factors leads to a more economic justification of air travel, based on the importance of time.

As the pace of life in a society increases, as ours has in the twentieth century, the pressure is on people to accomplish more within a given time span. As a result, the economic value of an hour of time, or the opportunity cost of an hour of idleness, increases at a rate equal to or greater than the rate of increase in the pace of life. Consequently, the total economic cost of travelling or shipping by air (i.e. - the monetary freight or passenger rate plus the value of the time consumed) can, in view of the high value of
time, be substantially less than the economic cost of using other modes of transport, provided that the airlines can maintain such a level of efficiency as to keep the time component of cost low enough to compensate for their higher rates.

As a result, any facility which affects the total journey time by air can affect the marketability of the air transport service, and thus affect the profitability and growth potential of the airlines. Airports, as part of the air transport system, are in such a position that they can cause the airlines to lose part of their market if not constructed and operated efficiently. If air transport is to remain as a competitive mode of transportation, it is necessary to ensure that the airport itself is as effective and efficient as possible. If this is to be accomplished, it is necessary to be sure that all possible approaches to airport design have been tested, and/or that the one plan selected for execution meets some minimum set of standards. To achieve this goal, it is necessary to apply some sort of economic terms to the expected performance of the new facility and to the expected performance of alternative designs.

1.4 Purpose of the Thesis

In view of both the lack of and the need for an integrated, economic approach to airport planning, it is therefore the purpose of this thesis to attempt to propose an approach to evaluating the economic characteristics of various alternative airport plans in order to determine the best possible combination of facilities to serve the
airlines, the passengers and shippers and the surrounding community.

The approach taken is essentially concerned with benefits and costs, and with trying to discern which of the many possible airport plans offers the greatest value in terms of the criterion against which it is evaluated. The feasibility of the plans will be constrained by the capital available, the forecasts of usage, the physical requirements of the aircraft using the port, and other technological and legal requirements. Even within these constraints, however, there is a large number of possible combinations of facilities with respect to the degree of efficiency built in to each. The determination of the benefits and costs of each of these various combinations would be well beyond the ability of manual calculations. Such a large number of complex computations could best be performed by a computer, and the results of these calculations could then be compared to determine the best possible airport plan.

In order to present such a problem to the computer, however, it is necessary to have a mathematical model of the way in which the airport operates. A model is, quite simply, a set of behaviour relations in the form of graphs or equations which describes the behaviour of the system in response to a change in some part of it. With a model showing, for example, the relation between terminal area, passenger costs, and terminal construction costs, it would be possible to determine the effect on the costs to passengers if varying de-
degrees of terminal area and varying amounts of money are incorporated into the plan. By developing this model further to include all facets of airport operation, it would be possible to determine the effects of a further investment in any one facility on the value of the airport plan.

There appears to be no existing model of airport operation. It is the contention of this thesis, however, that due to the many similarities between airport and harbour operations, the type of simulation model currently being proposed for the evaluation of port investments could be applied, with certain adjustments, to the evaluation of airport plans. The purpose of this thesis, then, will be to attempt to point through comments on the port models the way in which such models could be applied to airports, the adjustments that would be required due to differences in operation of the facilities and how these adjustments would be structured, and the types of data which would be required to run the model as a simulation program for airport planning.

The balance of the thesis can be divided into three main parts: general background, specific background, and the airport model. Since the use and value of any model depends on the accuracy of the benefit and cost inputs, Chapter 2 presents a general discussion of the theory of benefit-cost analysis and of the problems involved in the use of this technique. Chapters 3 and 4 present more specific background, chapter 3 dealing with the present practice of the Cana-
dian government when planning an airport project, and some of the shortcomings of their approach. Chapter 4 then presents a description of the type of models that are currently being used in the planning of harbour facilities. This description is used as a basis for Chapter 5, which then discusses the applicability of the port model to airport planning, the revisions that must be made, and the benefit-cost structure of airlines, passengers and the surrounding community with emphasis on the type of data that would have to be gathered. Chapter 5 also includes some comments on the availability of this data, thus leading to a continuation of the presentation of the solution to the problems pointed out in Chapter 3. Chapter 6 is a summary of the ideas presented, and a commentary on the potential and limitations of the simulation model as an evaluation tool.

1.5 Limitations in Scope

Before proceeding, there are two main limitations which have been set on the scope of this thesis which should be noted here. The first of these is concerned with those facets of the airport operation which will and will not be included in the plan and hence in the model. For the purpose of this thesis, the benefits and costs resulting from airport operation will comprise, for the airlines, those incurred from the time the plane begins circling as part of the stack waiting to land until it completes its takeoff for the next airport on its route. The passengers and cargo will be considered from the time they enter the doors of the airport until the time of
takeoff, and from the time the plane begins circling above its destination until they are ready to leave this second airport. It is realized that this limitation eliminates consideration of the airport access problem which, in many cases, represents a major part of the delay encountered by air transport users. However, it was felt that such a consideration would involve trespassing into the field of highway planning and highway models and thus was excluded from the scope of the thesis. Similarly, with reference to the cost-benefit structure of the community, inconveniences and benefits resulting from the condition of airport access routes were eliminated from the analysis.

The second limitation in scope is that the approach taken in this paper is one of general description. For example, while it may be stated that there is a strong positive relationship between two factors, no attempt will be made to apply numerical values to this relationship. Nor does the thesis go into detail about the technological requirements of aircraft, runway thickness and the like. It does consider the availability of such information, but since much of the data comes from confidential files of the airlines, it is left to others to assign accurate monetary values to the relationships and constraints, within the framework of the model as it is described.

Footnotes:


4. ibid.


7. S. H. Brewer, D. T. DeCoste, op. cit., p. 16


10. One example of this type of design is the so-called "Masefield" plan, and is described in: G. Fletcher, "Linear Development for Airport Expansion", *American Aviation*, Vol. 31, No. 6, November, 1967, pp. 98-104, and also in the article: "Airports for Tomorrow: Lufthansa Concept", *Airports International*, June, 1968, pp. 39-45


13. From an interview with Mr. W. McNeal, Air Economics Branch,
Department of Transport, in Ottawa, Ontario, August 23, 1968


15. S. H. Brewer, D. T. DeCoster, op. cit., p. 15


18. E. H. Kolcum, op. cit., p. 43

19. From the Operating Statistics file of Mr. W. Wiedemann, Economic Planning Department, Canadian Pacific Airlines, Vancouver, B. C.


23. J. R. Meyer et al., op. cit., p. 136

CHAPTER 2

THEORY AND PROBLEMS OF ECONOMIC EVALUATION

2.1 Introduction

In order to derive an economic method of evaluating an airport plan, or any proposed transportation project, it is necessary to have some knowledge of economic evaluation processes. Thus, this chapter is devoted to a general discussion of the theory and problems involved with the evaluation of transportation plans. It is not meant to be a manual on economic evaluation. The breadth of the field and the number of problems which arise preclude a comprehensive coverage of the topic in a single chapter. However, the most important points in the evaluation process will be described, and those problems which may have pertinence in evaluating port or airport projects will be discussed.

Economic evaluation consists generally of the listing of the various benefits and costs which may arise from a proposed plan, the conversion of these into dollar values where possible, and the setting of a criterion or criteria against which the net values of various proposals can be compared. Because of the basis on which the projects are judged, this evaluation is frequently referred to as benefit-cost analysis. The first question which arises, then, is what are benefits and
what are costs. There is, in reality, no set solution to the distinction between these two. In many cases, operating costs will not be regarded in the cost half of the analysis but rather will be subtracted from what operating costs would be without the project and this difference termed a benefit. In other cases, the operating costs of the project will be considered as a cost of that particular project. The choice of a method of distinction is arbitrary, but this choice will determine whether each project can be adjudged separately from other possible alternatives or whether it must be adjudged with reference to the present situation or other alternatives. The distinction chosen does not affect the comparability of projects provided the planner is consistent throughout the evaluation.

Due to the nature of the model to be used, however, a particular approach is taken in this chapter. The purpose of the model is to determine a least-cost combination of resources to attain a given desired level of output. Since the model represents the operation of the airport, it is easier for the computer to deal in non-relative terms. Thus, each alternative is considered in turn, and its costs and benefits determined by use of the model. These streams of benefits and costs for each alternative are then converted to present value and that alternative which provides the least-cost method of providing the airport facility can be determined.

Consequently, since each alternative is considered independently from the rest, benefits and costs are considered as they exist for
each possible plan rather than in relation to some base. Cost reductions do not play a part in the analysis, nor do increases in benefits. The evaluation of alternative projects involves delineating and quantifying all relevant costs which arise from the construction and operation of the plan and the benefits which arise from adopting this proposal.

The approach is not concerned, however, with determining the financial profitability of a particular project, nor with determining the economic feasibility of a single plan (i.e. - determining whether the benefits are greater than the costs). It is rather concerned with finding the best possible combination of the resources required to build the facility. The analyst quantifies all those costs and benefits which may vary among the various alternatives. Thus, while a non-relative approach is adopted in measuring costs and benefits, the analysis is not completely independent of the alternatives, in the sense that costs and benefits which remain constant among the various choices available are eliminated from the analysis.

Also, since the model is concerned primarily with the efficiency of operation of the facilities, cash flows such as port dues can be ignored. The amount paid by users for the use of the facility does not affect the internal efficiency of the port or airport's operation. It should be noted, however, that dues and charges can affect the ability of the project to attain the level of output specified and must therefore be included as a part of user costs in a supplemental calculation to determine if the alternative is feasible in view of the traffic
volume desired. In other words, it must be determined if the user costs are consistent with the demand forecast for the terminal's services. Dues and fees can, however, be eliminated from the calculation of benefits and costs for the purpose of comparing alternatives.

Thus, in view of the approach taken in the analysis, the following items of benefit and cost would be relevant. On the cost side, the evaluator would determine for each alternative the costs of constructing and operating the facility, the costs incurred by each class of user in conjunction with using the terminal, and the costs to the community which arise from the construction, existence and operation of the project.

The output or benefits to users of the project is specified at the beginning of the analysis since the terminal is being designed to attain a given level of output. It is thus constant for each alternative and can be ignored in the analysis. Benefits in the form of revenues to the agency can also be ignored as they do not affect the operating efficiency of the project. Thus the only relevant benefits are those accruing to the community as a result of the project. The outcome of the analysis should therefore be a stream of costs including costs to the agency, (construction and operation), costs to the users, and costs to non-users of the facility, and a stream of benefits including output accruing to non-users of the terminal's services. The delineation and measurement of these streams is discussed further in the following sections.
2.2 General Problems

Before proceeding to an actual discussion of the measurement of benefits and costs, there are a few points which should be kept in mind as being general to all economic analysis. First of all, before any benefits and costs are delineated, the scope of the evaluation must be set. Without this limitation, there would be no criterion to determine which benefits and costs arising from the project should be included in the analysis. Garrison et al. speak of "absurd" benefits and criticize many planners for their failure to take these benefits into account. By absurd they seem to mean benefits not arising directly from or within a reasonable degree of remoteness from the construction of the project. The question of absurdity, however, and its definition is resolved by the scope set on the study. For example, the benefits to foreign countries of lower freight rates on international shipping as a result of a port development in Canada would be "absurd" if the analysis were restricted to a provincial or even a national level, but would be relevant if an international scope were set for the analysis.

The "best" criterion for defining the scope of the evaluation is debatable. The criterion could be based on the purpose of the project (i.e. - if a project is designed to increase "national welfare", then the effect on all aspects of national welfare must be considered), or it could be based on the level at which the decision was being made (i.e. - a national evaluation for a project built by the federal government, etc.). Whatever the basis for setting the scope, however, this
definition is one of the first tasks which must be performed.

A second point to keep in mind is that care must be taken in delineating benefits and costs. It is in this area that errors can most easily occur. One of the most common errors is the failure to include all benefits and costs. Frequently, an item may be so difficult to quantify that it is easiest to ignore it completely. It would also be quite easy to count a benefit, such as a new industry, and fail to count the cost involved in setting up this new enterprise. Either of these omissions could distort the results of the analysis. On the other hand, the analyst can become over-zealous in trying to include all costs and benefits, and include benefits and costs not really attributable to the project in question. A careful test should be made to ensure that all items included result solely from the new plan, and that these items would not otherwise have occurred had the project not been built.

Double counting is another error which may occur in the delineating of benefits and costs. Appreciation of land values, for example, may result directly from decreases in transportation costs caused by the project. The analyst might be inclined to count this appreciation as a benefit from the project. It is, however, the decrease in transportation costs which makes the buyer willing to pay that much more for the land. Thus, to count both the cost savings to shippers and the rise in the value of the land as benefits would be to count the same thing twice.

The above errors are generally avoidable. One other general
problem exists, however, which can not be completely eliminated from the analysis. That is the presence of uncertainty. As in any type of consideration of the future, benefit-cost analysis is subject to error due to the failures of the analyst to predict accurately that which will occur. Two of the most important areas in which uncertainty poses a problem are the forecasting of traffic and thus the definition of the desired level of output, and the specification of future gains and costs.

The main reason for uncertainty in forecasts is the susceptibility of traffic to influences from other parts of or from outside of the system. A number of environmental items such as technological change, actions by decision makers in other parts of the system, economic factors and so on can upset the accuracy of the prediction. This problem is particularly critical in the air transport field. The industry is growing so rapidly that it is almost impossible to predict what changes will occur ten to twenty years from now. Nor is the timing of technology changes easy to predict. New discoveries in the next few months or years could radically alter the whole science of aviation. The forecaster can not, unfortunately, include these factors in his analysis.

Uncertainty also prevails in the estimation of future benefits and costs. It is indirectly manifested in the fact that the amount of benefits and costs accruing may be materially influenced by the actual amount of traffic using the facility. Thus, the estimation of benefits and costs is subject to the uncertainty in the forecasts. Uncertainty
arises more directly, however, in trying to predict the incidence of benefits and costs on a per unit basis. Some benefits, for example, may not materialize at all, such as new industry in an area or savings in operating costs. Others may occur to a greater or lesser degree than that allowed for in the analysis.

Uncertainty can not be dealt with directly in the evaluation process. Out of the possible range of forecasts, those levels which are most likely to occur must be selected for use. However, the degree of uncertainty should be noted by the evaluator, and the accuracy or his results and hence his confidence in them should be tempered by the amount of uncertainty present.

The above problems are general in nature and pertain to benefit-cost analysis as a whole. Other problems arise with respect to specific areas and the measurement of specific benefits and costs and these will be discussed in the following sections.

2.3 The Measurement of Costs

The actual measurement of benefits and costs can be viewed as pictured in Figure 1. Total costs have three components: expenditures of the agency, costs to users of the facility, and costs to non-users.

2.3.1 Costs to the Agency

Dealing first with the expenditures of the agency, it is found that these consist of the capital cost of building the facility and an annual cost for the maintenance and operation of the project. This annual cost comprises both a fixed and a variable component.
FIGURE 1

BENEFITS & COSTS

- Benefits to Agency
- Benefits to Users
- Benefits to Non-Users
  - Less Associated Costs
- Costs to Agency
- Costs to Users
- Costs to Non-Users

- Market Consequences
The capital costs of building a transport project should, for evaluation purposes, be expressed as the economic costs of the resources used. That is, adjustments must be made to the actual expenses paid out in so far as they do not reflect the economic value of the resources used. Thus, the capital outlay for a transportation project should be valued at the opportunity cost of the resources used to build it, or in other words, at the total value of goods which these resources could have produced if used elsewhere.

According to Winch, this need not pose any special problems of measurement. He argues that if one considers the resources used in building a facility - labour, materials, machinery and land, - he will find that the first three of these can be valued at market prices. He argues in the following manner that the market prices of these resources adequately reflect the value of alternative goods which the resources could have produced elsewhere. The value of any good is composed of the cost of the resources used, the implicit cost of entrepreneurial effort (or normal profits), and pure profits. These three costs, in that they represent the value of other goods, also represent the opportunity cost of the resources used in the transport project. The first component, the cost of resources used, will be included in the cost of the transport project by the inclusion of the purchase price of the resources, assuming they were purchased in a free market, and thus that the resources have a constant price to all sectors. The second component is really the opportunity cost of entrepreneurial effort, and since it can be transferred elsewhere with no
loss to the entrepreneur, it can be ignored in calculating the opportunity cost of the resources used. As Winch states, "when the resources in question are used for a highway, the alternative user will presumably follow another line of endeavor and still earn a normal rate of profit which is therefore not part of the opportunity cost of the highway."

The pure profit component of alternate goods can result either from the goods' being sold in disequilibrium or from their being sold under conditions of imperfect competition. The former case will correct itself in time, and thus these profits can be ignored in calculating the opportunity cost of resources used. The latter case of some form of monopoly power could result from special rights of the producer such as patents, or from some special quality of the resources used (such as scarcity) which prohibits extensive competition in the production and sale of the final product. In the case of patent rights as in the case of entrepreneurial effort, the producer will continue to make pure profits by replacing the resources used for the transportation project with others of similar nature and thus nothing over and above the value of the resources is given up. Where the basis of monopoly power rests on the unique characteristics of the resources used, "the existence of pure profits is fictitious since they will be absorbed by the market value of the resources in question."

Thus, where the resources used for the construction of the transport project are purchased in a free market (i.e. - all units of a set of resources are comparable), the market price adequately
reflects the opportunity cost of using these resources. The one point which should be noted, however, is that the market price used should be the price that will have to be paid when these resources are to be purchased, and not the prevailing price under present conditions of demand. The added demand for resources caused by the transport project may raise the market price above its present level, and this price is the one that should be included as a cost of the project.

In the case where units of a set of resources are not interchangeable, market price may not adequately reflect their opportunity cost. Such is the case with land. In building a transport project, one tract of land is not the same as all other tracts of land by virtue of the fact that it has been selected as the site of the facility. Consequently, the owner of the land has acquired monopoly power in the event that he is aware of the proposed use of his resources, and the market price of the land will be inflated to reflect this power. Thus, it will not represent the true opportunity cost of the land used. Nor is the market price of adjoining land adequate for use, for it may also have become inflated due to the proposed project. The correct value to use would be the market price of the land were the project not to be constructed. This can be determined by the market price of a comparable piece of land in another location where no transportation project is planned.

One item which has been subject to some debate is whether or not property taxes should be included in the costs of the project, despite the fact that the government would not pay taxes on the land.
This can be resolved to some extent by considering the components of property taxes. One part represents the cost of municipal services such as police and fire departments, and the other represents transfer payments from one group to another. It is McKean's contention that if two government projects are being compared, as is the case in this analysis, with a view to finding which one represents the best combination of resources, that portion of taxes which represents a real cost to the community should be included. This portion would include those monies going to the support of municipal services. If, on the other hand, government and private projects are to be compared, the full amount of property tax should be included to place the projects on an equal footing.

The other costs incurred by the agency in charge, that is, the annual costs of operating and maintaining the facilities, present no theoretical problems of measurement. They can be included in the analysis at their accounting value. These costs are, however, subject to distortions due to errors in the forecast and to problems of price level adjustments which will be discussed later.

2.3.2 Costs to the User

The costs of the project to the user of the transport facility can be divided into two classes:

(i) market costs - i.e. those costs for which the market provides a basis for money valuation, and

(ii) extra-market costs, or those costs for which the market
12. does not provide a basis for money valuations.

This distinction parallels the distinction normally made between tangible and intangible costs, but since there are different degrees of intangibility, the above terminology has been used for purposes of clarification.

Among the market costs would be vehicle operating costs, time costs to commercial vehicles, direct costs of vehicle accidents, and other costs to which a money value can be easily applied. These costs can be generally set at market prices.

The second group of user costs are more difficult to quantify, for they do not represent actual monetary outlays. They can be broken down, however, into two degrees of intangibility:

(i) costs where a basis may be found for a somewhat arbitrary assignment of money valuations, such as deaths and disabilities, and the cost of time to users other than commercial vehicles, such as people and cargo;

(ii) costs to which money values cannot be assigned such as loss of pleasure or scenic views, discomfort, etc. Some attempts have been made to place values on these costs, or at least to account for them in the evaluation. Since all of these costs are pertinent to the port and airport models, some attempt will be made here to summarize the methods used for valuing deaths, injuries, time, and those intangibles such as pleasure to which no arbitrary value can be assigned.
One measure of the cost of death that has been suggested is the average court award for accidental deaths. A similar and probably comparable method is the calculation of the value of output sacrificed by the loss of the person, less his expected consumption of goods and services. Both these measures probably represent the monetary loss to society from the death of a person. They fail, however, to take into account the cost of side effects of that death, such as the costs of pain and suffering to those acquainted with the deceased, and the perpetual fear of accident to those who use the facilities. Thus, the value which society places on a life is more than just the loss of earning power. At the same time, this additional value will vary widely, depending on the amount of sentiment aroused by the way the life is lost. The loss felt for an only child run over by a car could well exceed the loss felt for an escaped criminal who runs his car off the road. This lack of homogeneity in the consequences of death, and the intangible nature of personal grief complicate the problem of placing a value on a human life.

The measurement of the value of time is most hampered by the heterogeneity of users of the facility. Each user or group of users will place a different value on the amount of time consumed. The measure of the value of time can only be approached on an average opportunity cost basis. Any attempt to measure the value of time by how much people are willing to pay for an extra hour of it would not be valid, however, because the time aspect of a transport service
cannot be separated from its other aspects. Consider, for example, a toll turnpike between two cities, which saves the driver one hour of time over that which would have been required on the old road. It would not be correct to say that the value of that one hour is equal to the amount of toll the turnpike user is willing to pay, for the demand for the turnpike services may be a function of greater driving ease, more pleasant scenery and so on, as well as time. Consequently, the toll does not represent the value of time alone but represents also the value of comfort, convenience and other facets of using the turnpike route.

Therefore, the approach taken must consist of calculating the average opportunity cost of an hour of time for the users of the facility. Due to the heterogeneity of the market, this involves calculating a different value of time for each group of users. The market can generally be divided into three groups: goods, persons travelling on working time, and persons travelling on leisure time. The value of time to each of these classes of users will be different.

The value of time to a unit of cargo is the sum of the interest on the value of goods in that time and the depreciation on the goods in that same time period. Except in cases of extremely valuable, goods, the interest per hour would be very slight. Depreciation, however, can be very costly, especially in the case of highly perishable goods. Cut flowers, for example, may perish under normal circumstances in three days. Thus, every hour, the total shipment loses 1/72 of its value. The value of time to cargo, then, can be relatively
easily calculated by taking a representative sample of normal cargo and computing these values per ton or per load.

This analysis is lacking in one respect, however. It fails to account for the fact that the value of time may not be constant for every hour of the product's life. Consider, for example, a producer trying to meet a deadline on the shipment of parts. The value of each hour of time up to the deadline is constant and can be calculated as above. The opportunity cost of the first hour after the deadline, however, will be considerably greater, for it will cost the shipper the penalty for late shipment, or even the profits on the goods if they are rejected. Unfortunately, such cases where the depreciation of goods varies at different points in time cannot be accommodated in an "average" analysis of the value of an hour's time, unless the average incidence and average cost of such an occurrence is calculated and added into the calculation.

The value of an hour to a person travelling on working time is generally accepted to be his wage rate. This can be relatively easily calculated on an average basis for a representative sample of person's using the mode. The value of leisure time is more difficult to determine and is consequently under debate. Winch, however, attempts to offer proof that the value of an hour of leisure would be the same as the person's wage rate, and could therefore be calculated as above. In a relatively lengthy argument, he asserts that the marginal value of leisure is the wage rate of the person concerned. For this to be so, it would be necessary first that the number of hours
spent working is such that the effort put into a marginal hour is equal
to the wage rate, and that the next hour has the same marginal value,
and secondly that the traveller is indifferent between work and leisure
at the margin. The first underlying assumption, Winch argues, is
valid for the average man. The second assumption, however, may
not be true due to the added inconvenience of an hour's work. How­
ever, he argues that a correction factor can be derived and applied
to take into account this inequality. If, for example, a person is in­
different on the average between one hour's work and two hours of
travel, the correction factor would be 1/2, and the value of travel
time would be 1/2 the wage rate. If people are indifferent between work
and leisure, no correction factor is needed. For a fuller discussion
of this argument, the reader is referred to the book by Winch listed
in the bibliography, particularly pages 80-81.

The second group of extra-market costs to users of a project,
those to which money values cannot be assigned by any rational pro­
cess, can still be dealt with in a useful manner. It is suggested in
some references that they be ignored completely, and unless they are
a material factor in the usefulness or cost of the project, they should
probably be handled in this manner. In the event that they may have
a real importance to the outcome of the analysis, however, (and in
transportation projects this is more likely than the former case), they
should be taken into account. The best procedure to follow here is
not to attempt to assign some meaningless monetary value to them, but
rather to calculate the implied value of these intangibles and subjec-
tively assess the realism of this implication. To illustrate, consider two highway projects equal in cost and both yielding the same amount per year. One alternative costs $500,000 per annum to operate and passes through a particularly drab area. The second costs $1,000,000 per year, but gives users a view of some particularly beautiful scenery. To select the second highway plan, then, places an implied cost on the loss of sightseeing pleasure of more than $500,000 per year. The evaluator must then proceed subjectively to determine whether or not this is a feasible value to place on the intangible costs. As McKean says, "this procedure ties no price tags to the intangible effects, but brings out explicitly the minimum valuation that would be implied in choosing a particular project."

2.3.3 Costs to the Non-User

Like user costs, costs to non-users fall into two classifications: market costs and extra-market costs. The two market costs most likely to occur in the evaluation of a transportation project are a decline in land values due to side effects of the existence of the project, and actual physical damage to adjacent property resulting from hazards created by the project. A decline in land values is most likely to occur if the adjacent land were intended or suited for residential purposes. If it were intended for industrial uses, land values might even rise due to the proximity of transportation, but this possibility will be discussed under community benefits. The loss in po-
potential land revenue can be estimated by comparing the forecasted value of the land after the development has taken place to the forecasted value of a similar tract of land not adjacent to such a project.

Physical damage to property may occur due to smoke, flooding, pollution, accidents, and other tangible hazards created by the project. To calculate this cost component, the analyst must first determine the expected incidence and degree of the hazard, and then evaluate the monetary costs required to repair the damage, or the loss of value of the property if the damage is irreparable.

The extra-market costs to non-users generally fall into the category of personal inconvenience or discomfort. In most cases, not even an arbitrary market value can be assigned to them. Such costs would include death or personal injury to members of the community resulting from the hazardous aspects of the project, loss of scenic views and property, inconveniences due to noise, and inconvenience and discomfort due to other aspects of the facility. Deaths and personal injury can be dealt with as described under user costs. A certain amount of the cost of the loss of scenery may have already been included in the cost of the land, especially if the owner is aware of its scenic value. That portion of the cost of loss of scenery which has not been included, however, as well as the cost of the inconvenience aspects mentioned, could be treated as described above for costs to which no arbitrary value can be assigned. That is, their implied value can be determined and this value assessed subjectively as part of the analysis.
2.4 Measurement of Benefits

Benefits may also be subdivided in so far as they accrue to the agency, the users and the non-users of the project. In general cases, the benefits to the agency would be the dues or fees which accrue to it as a result of the project's operation. However, as explained previously, these benefits are not included in the terminal models used.

Benefits to users are also ignored in the terminal model, but as part of the general theory of economic analysis do warrant some mention here. The value of these benefits is logically the value of the output of the project. The value of a unit of output is, however, particularly difficult to determine in terminal cases. The value cannot be measured by the market price which would be paid to have the product shipped, for this value would include more than simply the value of the output of the terminal operation. It would include instead the value of the output of the whole shipping process. Consequently, the approach generally adopted in terminal evaluations is to determine the value of additional output, rather than the total output. Such an approach is workable, however, only in the event that there is some base of output and costs to which the output and costs of the new project can be compared.

The hypothesis held in the comparative analysis is that if the value of an additional unit of output had been greater than the cost of shipping it before the new terminal was built, that unit would have been shipped. Thus, the value of this output is somewhat less than
the original cost of using the terminal to ship it. At the margin, the value of the last additional unit of output shipped would be equal to the cost of picking it up at the terminal, or the cost to the ship of using the terminal. Thus, one part of the value of the output is the cost per unit of output shipped times the number of additional units shipped after the new port has been constructed. Because the demand curve for the harbour is downward sloping, however, some of these additional units would have been shipped at a higher cost and thus have a higher value. Consequently, a value must be added to the basic value calculated in the first stage to account for the greater value of some of the additional units. This addition can, assuming a straight-line demand curve, be approximated by multiplying the number of additional units by one-half the decrease in per unit costs of using the port after the new facility has been built.

The benefits to non-users of a transportation project can, once again, be classified as market and extra-market. The market consequences generally consist of the many aspects of the stimulation of economic development. These would include rises in property values, greater employment, increased amounts of money spent in the community, and other such benefits which may arise from an increased amount of industry in the area. Before attempting to assess these aspects, however, the analyst should bear in mind that if they are to be counted as benefits, the following conditions must be met. First, it must be shown that this economic development would not have taken place without the transport development, and secondly, it
must be shown that the resources used in the new development would otherwise have remained idle.

If these conditions can be met, then the net value of the economic development may be considered as a benefit of the project. It is important to note, however, that the net value will include a deduction for those associated costs required to realize the economic development, such as construction costs of new buildings, capital equipment, etc. Furthermore, when associated costs are included, some of the benefits arising may be a result of the transport investment, while others may be attributable to capital investment in other industries. Consequently, there is the problem of making some allocation of these benefits among the investments. Adler suggests that there is no one correct solution to this problem. He does suggest three possible approaches, however, to its resolution. One approach would be to make no allocation of benefits and simply consider all investments as part of a single project. A second approach would be to annualize the costs of the other investments and deduct them from the total benefits. This keeps the cost of the project segregated to the actual costs to the agency building it, and considers net benefits instead of total benefits. The final approach suggested by Adler is to allocate benefits to transport investment in the same proportion that the transport investment bears to the total investment incurred.

Extra-market community benefits are more difficult to value.
They encompass such items as the attractiveness of a more cosmopolitan life style, the pride to be gained from having advanced transport facilities nearby, and other such intangibles as may occur. Any attempt to place an arbitrary value on these items must be accepted as guesswork at best. In this area also, the analyst must remember to include associated costs.

2.5 Distribution of Benefits.

Those benefits to be included in the analysis have been discussed above under the section on the delineation of the scope of the analysis. It should be also noted, however, that whether or not various benefits arising from the project will fall within the scope of the analysis depends largely on the policy on user charges of the agency operating the facilities.

Consider for example the case of a mainline, international airport. If the agency sets the fees at a level equal to the level before the new airport was built, the benefits of the new facility will accrue predominantly to airlines and other airport users. Many of these users will be from other countries, and the benefits may thus fall outside the scope of the analysis. If, however, the agency sets the fees at a higher level, benefits to the user will be less (due to increased costs of using the facility in the form of fees), and benefits to the agency will rise. As a result, the amount of benefits which can be included in the analysis will increase as a result of the change in pricing policy.
2.6 Price Levels

This completes the discussion of the measurement of benefits and costs for a given year in the life of a project. When costs and benefits are measured over the life of the project, however, the analysis is complicated by the introduction of varying price levels. For example, as a result of economic influences, the monetary cost of operating a project in year ten of its life may be greater than the cost of operating it in year one, even though the physical resources required remain the same. Costs of labour and materials may rise as may the value of the project's benefits. The question arises as to whether the costs and benefits should be valued at a single price level or valued at the price levels expected during various years in the project's life.

Generally, cost-benefit analyses are made in terms of a constant price level. That is, the dollar value of costs and benefits will differ for different years only if the incidence or degree of these items varies. This approach has two disadvantages, however. First, since estimates of benefits and costs would in many cases have a different value at later times in the project's life, the use of a constant price level would be of no assistance in trying to establish repayment obligations and schedules. Secondly, it is argued that when a constant price level is used, the monetary value of the project is under- or over-stated. Assuming a predicted period of inflation, benefits should be blown up relative to costs since most of the benefits would be realized after the costs had been incurred.
The alternative to a constant price level, therefore, is a projection of changes in the price level and the calculation of costs and benefits in terms of the resulting undeflated prices. Such a procedure would provide a measure of the financial feasibility of the plan. McKean, however, disagrees quite adamantly with the application of this procedure. For one thing, the purpose of a benefit-cost analysis, he argues, is to select the project which would provide the nearest to the maximum possible level of production. Consequently, in terms of seeking productive efficiency, he feels that it is incorrect and misleading to say that if the price level has risen from 100 to 300 then benefits have trebled. Furthermore, he argues that to have the government bet on inflation would make projects spuriously attractive to the nation. Finally, he claims that such a procedure would be "a bet by the government on its own failure to win in its struggle for stability - a type of wagering that is frowned upon in most contests."

McKean's first criticism is the most pertinent to the general case. The implication, therefore, is that the decision of whether to use a constant or a floating price level must rest on the purpose of the analysis. If the analysis is designed to determine financial feasibility of a project or to assess the payback period required, a moving price level would be most suitable. If, however, it is designed to select the most efficient of alternative projects, a constant price level would give more accurate results.
2.7 Discount Rate

Once benefits and costs have been defined and measured for the life of the alternative projects, some means must be established for bringing these economic streams to a common base so that the alternatives may be compared. Due to the so-called "time value of money", benefits and costs occurring at some time in the future have a different value than the same benefits or costs occurring at some other future time or in the present. In order to allow for this difference, it is necessary to discount future amounts and to convert streams of benefits and costs to their present value. The appropriate rate at which to discount these streams has, however, been the subject of much controversy.

It appears to be generally accepted that the rate used for discounting should be the opportunity cost of capital - that is, what the funds could earn if invested elsewhere. The United States Federal Inter-Agency River Basin Committee suggests that the appropriate rate would be the risk-free return expected to be realized on capital elsewhere, assuming that risk elements have been adequately accounted for in the calculations of benefits and costs. While it is true that some predictable risks such as physical damage can be included in the measurement of benefits and costs, there are other risks which cannot be directly accounted for in the first stages of the analysis. Consequently, to adopt the approach suggested by the Committee would involve assuming that government projects are relatively free from
business and financial risk and from risks involved in estimating the future.

McKean argues that the appropriate rate to use for discounting under conditions of no capital rationing, would be the market rate of interest. He uses this argument, however, with reference to "firms". It is uncertain, therefore, when dealing with government projects, whether he is recommending the use of the market rate of interest or the cost of capital to the government. These two figures could be very different, and would materially affect the results of the analysis.

Grant and Sewell are more specific in their recommendations. Since government funds are obtained from taxation and since, if this money were not collected, the public would invest the funds, the discount rate or opportunity cost used should be that return which the public could acquire on the capital. As Sewell states, "it is necessary in an economic analysis to find out the typical yield the national economy (not merely its government) might obtain from alternative private or public uses of the funds required for the project."

The choice of the "best" discount rate to use, therefore, cannot be decisively made. One possible solution to the controversy, suggested by Sewell, is to perform the benefit-cost analysis at several rates of interest. In this way, it may be found that the ranking of projects is marked enough so as to be relatively independent of the rate used. This procedure fails to be of any assistance, however, in cases where projects are so competitive that the discount rate used
becomes a material factor in making the choice among alternatives.

2.8 Criteria

When the benefit and cost streams are discounted to present value, several formats can be used to compare the streams of one project to those of another. Among these are benefit-cost ratios, internal rate of return, pay-back period and net present value. All of these are subject to some degree of criticism, and the "best" method is once again a matter for subjective evaluation. Finally, the selection of the most desirable alternative involves choosing that project which represents the greatest advantage in the format in which it is displayed.

With this as background, the following chapters proceed to put into practice some of the theory described above. In the models to be described, the scope has been extended to include benefits and costs accruing directly to the agency, the users of the project and the neighbouring community. The criterion chosen for evaluation of alternatives is that of maximum net present value of the benefit and cost streams, and a constant price level has been assumed. The remaining areas that may be subject to debate, such as discount rate and some items of measurement are not specified, however. Since no ideal answer is readily available in any of these areas, specification was made only where necessary to the description of the models. The only other ways in which the analysis varies from that procedure described above are, first, that operating costs borne by the
agency are included with user costs to calculate "total operating costs", and secondly, that non-user costs are moved to the other side of the analysis and deducted from non-user benefits.

Footnotes


3. ibid., p. 69


7. ibid.

8. ibid.

9. ibid., p. 15

10. ibid., p. 61

11. R. N. McKean, op. cit., p. 165

12. C. H. Oglesby, E. L. Grant, op. cit., p. 50

13. ibid.

14. R. N. McKean, op. cit., p. 62

15. D. M. Winch, op. cit., p. 86
16. ibid., p. 72
17. ibid.
18. ibid.
19. ibid., p. 80
20. R. N. McKean, op. cit., p. 63
21. ibid.
22. C. H. Oglesby, E. L. Grant, op. cit., p. 50
23. H. A. Adler, op. cit., p. 179
24. ibid., p. 190
25. R. N. McKean, op. cit., p. 180
26. ibid., p. 181
27. ibid., p. 182
29. R. N. McKean, op. cit., p. 77
32. ibid., p. 17
33. ibid., p. 18
CHAPTER 3
CANADIAN AIRPORT PLANNING

Since it is the purpose of this thesis to propose a new and better means of planning airports, it would be well to consider in a little more detail the present practice of the Canadian Department of Transport in planning airport projects. From this basis, the thesis can move towards pointing out areas where improvement can be made and the applicability of the model as an airport planning tool in achieving these improvements.

The original instigation for a new airport or improvement of an existing facility can come from a number of sources. First of all, the Department of Transport has a general, flexible national airport plan for possibly five years into the future. Barring specific requests, this plan will be roughly followed. The plan, however, can be altered by requests for improvements on the airport situation in a locality. Such requests generally come from the municipality itself, or from airlines using the airport in question or desiring an airport in the area.

When such requests arise, preliminary investigations are made by the Regional Director of Air Services and his staff. The country is divided into six regions: Maritime, Quebec, Ontario, Central Provinces, Mountain and Pacific Coast. The Regional Director is responsible for airports of all sizes and classifications in his area. Thus, the director
for the Pacific Coast region would have jurisdiction over Vancouver International, Abbotsford, Castlegar, and any other airports in British Columbia operated by the federal government. His department is, in the preliminary stages of planning, responsible for a rough site selection and for preliminary economic investigation of the area. The planning is then turned over to the Airports and Field Operations Branch in Ottawa which acts as a coordinator over three divisions, each contributing to the final plan.

One of the divisions contacted is the Civil Aeronautics Branch. This department provides information on technical factors such as the navigational facilities required, runway length and specifications and the like. A second department, the Engineering department, is used to provide some rough idea of the costs which will be involved in building the facility. The third department involved is the Air Economics Branch. This department is responsible for such economic assessment as is performed by the Department of Transport. It is here that recommendations for acceptance or rejection of the proposal appear to come from.

The Air Economics Branch first studies the area in which the airport is being built and investigates its economic structure and possible economic growth if the terminal is constructed. This evaluation is also used as a check on traffic forecasts in so far as it relates to the amount of traffic the community will provide. Secondly, the branch sends out questionnaires to the various airlines using the
airport. This questionnaire is, by the department's own statement, patterned after the questionnaire recommended by the International Air Transport Association in their booklet "Airport Terminals", and a copy of the latter is included as Figure 2 in the following pages.

The actual questionnaire sent out by the government is almost identical to this sample. It will be noted that the information requested comprises predominantly the airlines' traffic forecasts and the space and type of facilities they will require in and around the new terminal. The economics branch then performs a forecast of their own on future passenger, cargo and aircraft movements through the terminal. The emphasis in making this forecast is placed on an extrapolation of past traffic trends, taking into account future economic conditions and changes in technology. The airlines' forecasts are used merely as a check on these figures, on the grounds that the airlines would be inclined to be overly optimistic about their future business.

From these various investigations, the Airports and Field Operations Branch derives an estimate of the amount of building space and number of runways and of the number of other facilities required. Such calculations are predicated on the recommendations of the Civil Aeronautics Branch and on certain basic criteria which the government has derived. For example, if it is estimated that the number of passengers using the airport at some hour below the peak will be 100, then with a standard of 25 square feet allowed per person, the waiting and boarding areas should consist of 2,500 square feet. Other space re-
AIRPORT PASSENGER TERMINAL PLANNING QUESTIONNAIRE

Note: Where a new airport is being contemplated at a particular location, it should be master planned for at least 20 years. At a current site which is expected to be saturated before 20 years, planning should cover the period up to the ultimate development at the time of saturation. The master plan should reflect ultimate development of the airport in five year increments and facilities should be constructed in stages with provision for expansion and modification to cover the ultimate master planning date. Before submitting this questionnaire, the Airport Authorities should select, after consultation with the airlines, two years for which forecast information will be supplied. One of these should preferably be five years in the future, and the other should be still further ahead (either ten years or the date at which the master plan would be fulfilled). It should encompass overall airport facilities, including such aspects as building facilities, air space, airport capacity, and ground vehicular traffic.

I. PASSENGER TRAFFIC FORECAST

<table>
<thead>
<tr>
<th>Current Year</th>
<th>Five years hence</th>
<th>Further forecast year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annual</td>
<td>Peak Hour*</td>
<td>Average Busy Hour**</td>
</tr>
</tbody>
</table>

1.1 International:
- Departing
- Arriving
- Transit
- Transfer

1.2 Domestic:
- Departing
- Arriving
- Transit
- Transfer

1.3 Percentage of total passenger handled in town rather than at airport

1.4 * Time and day of peak hour used in 1.1 and 1.2 (should be defined by airline)

1.5 ** Definition of Average Busy Hour used in 1.1 and 1.2 (should be given by airline)

1.6 Estimated annual growth rate used in 1.1 and 1.2

- [Current Year] - [5 years hence] - [Further forecast year]
2. AIRCRAFT FORECAST

<table>
<thead>
<tr>
<th>2.1 Aircraft Type</th>
<th>Current Year</th>
<th>Further Forecast Year</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Average Peak Hour Passenger Load</td>
<td>Scheduled Peak Hour Departures</td>
</tr>
<tr>
<td></td>
<td>Current Year</td>
<td>Further Forecast Year</td>
</tr>
<tr>
<td></td>
<td>---</td>
<td>---</td>
</tr>
</tbody>
</table>

2.2 Time and day of peak hour used in 2.1

3. AIRCRAFT PARKING

3.1 Check preferred system of aircraft parking:
   - self-maneuvering
   - taxi-in/push out

3.2 Total number of non-finger stands required for engineering servicing or long-term parking

3.1 Check preferred system of aircraft parking:  
   - self-maneuvering
   - taxi-in/push out

3.2 Total number of non-finger stands required for engineering servicing or long-term parking
4. APRON SERVICING

4.1 Will you do your own apron servicing, or be handled by another airline?

4.2 List types and quantities of apron servicing vehicles and equipment to be used, indicating with asterisk (*) which require covered parking

4.3 Total parking space requirement for apron servicing vehicles and equipment

4.4 Check desired fuel delivery method: refuelling vehicles

hydrant fuelling

4.5 Total Fuel Requirement:

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Total Annual Volume</th>
<th>Daily Volume</th>
<th>Peak Hour Fuel Volume</th>
<th>Average flow rate at Nozzle</th>
<th>Total Annual Volume</th>
<th>Daily Volume</th>
<th>Peak Hour Fuel Volume</th>
<th>Average flow rate at Nozzle</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4.6 Check Fixed Servicing Facilities desired:

aircraft air conditioning
heated air for aircraft
drinking water
non-drinking water
aircraft electrical power
compressed air for starting
other —
5. BUILDING SPACE REQUIREMENTS

Note: Indicate only those space requirements for which you would be willing to contract. (Requirements should be for usable space and should not include allowance for corridors, partitions, or mechanical equipment)

<table>
<thead>
<tr>
<th>Space in the terminal:</th>
<th>Current Year</th>
<th>Further Forecast Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ticket Counter (length and area)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales Counter (length and area)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Administrative Offices (area)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outbound baggage (depth and area)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baggage claim (length and area)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Porter and storage (area)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Communications equipment (area)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other in terminal (area)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Space in the concourse or finger:</th>
<th>Current Year</th>
<th>Further Forecast Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Departure rooms (number and unit area)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gate-Handling units (number and unit area)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operations space (area)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance and supply (area)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other in concourse or finger</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

6. AIR MAIL/CARGO

6.1 Check preferred location:
- Passenger Terminal
- Separate building
- Cargo building

7. EMPLOYEE CAR PARKING

7.1 Total employee car parking requirement at:
- Terminal
- Cargo Building
- Hangar
- Other locations —
### 8. INTERIOR FACILITIES

8.1 Check facilities required:

<table>
<thead>
<tr>
<th>Facility</th>
<th>Current Year</th>
<th>Further Forecast Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telephone</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intercom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Public Address system drop</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Telautograph</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pneumatic tubes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Closed-circuit television</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
requirements are also based on such criteria as number of square feet or facilities required per unit.

These figures on recommended space, runways, and other requirements are then turned over to the architecture and engineering departments. In the case of a small airport, the Department of Transport's architect draws up the plans, incorporating into them the requirements cited by the Airports and Field Operations Branch. For larger terminals such as Toronto or Vancouver, the work is turned over to a reputable firm of engineering architects who then proceed to plan and supervise construction of the airport, working under the auspices of the D.O.T.'s project architect who acts as a liaison officer between the departments and the firm employed.

The engineering consultants are employed on the basis of past work and reputation. For each project, a firm located in that area is selected and thus, generally, a different firm is used each time. At the same time, there is little or no communication among these firms in order to gain the benefits of past experience. The feeling at Phillips, Barrett and Partners, for example, who planned Vancouver's airport was that a totally new approach would have the best chance of overcoming many of the problems involved in airport planning and construction. Such an attitude, unfortunately, leads to many mistakes being repeated each time and to an extensive length of time's being required to get an airport completed.

For the actual planning of the airport, the consultants are
given the figures calculated by the D.O.T. on the amount of space required for various aspects of the airport's operation such as ticketing, baggage handling, customs and immigration, boarding, maintenance and so on. They then proceed to incorporate these requirements into a rational pattern which will minimize walking distance, congestion, crossing of traffic flows and the like. Such analysis as is concerned with this minimization is, however, purely intuitive. Exact figures are not assigned to the amount of time required or to the value of this time.

The above, then, constitutes a brief outline of the D.O.T.'s procedure in airport planning. At no time, apparently, are values assigned to the cost of planes' time or to the cost to passengers and cargo of using the airport. No effort is made to determine if it would be better to minimize the planes' time at the expense of the passengers or vice versa. The emphasis seems to be on minimizing everything with no effort made to find some tradeoff point, to calculate the shadow costs of various inputs in monetary terms, or to weigh the benefits of an action or facet of the plan against its costs. Thus, the D.O.T.'s planning procedure seems to include both faults mentioned in Chapter 1: the lack of an integrated approach to airport planning, and the lack of any economic terms of reference in the evaluation of a proposed plan.

It is the contention of this thesis that both these problems can be avoided and that a partial solution to them is already in existence.
in the form of the port model. Thus, the following chapters are directed first towards explaining the port model, and secondly towards discussing its applicability to airport planning, the modifications required, and the data required to use the model and their availability.

Footnotes

1. The remainder of the material in this chapter is a composite of information derived from interviews with Mr. W. Nayrod, of Phillips, Barrett and Partners in Vancouver on August 13, 1968, (Mr. Nayrod was the head of the team which planned Vancouver International Airport); with Mr. W. J. Whiskin, Representative, Properties and Facilities, Canadian Pacific Airlines, in Vancouver on August 8, 1968; with Mr. D. Keenan, Airways Department, Department of Transport in Toronto on August 22, 1968; and with Mr. W. McNeal, Air Economics Branch, Department of Transport in Ottawa on August 23, 1968.
CHAPTER 4

THE PORT MODEL

Unlike airport planning, in recent years port planning has received a good deal of attention. The impetus for this investigation seems to have arisen from the exceedingly high proportion of ships' time spent in port, and the consequent high costs to shipowners of using these facilities. R. O. Goss, for example, states that on the average, ships spend approximately 60% of the total voyage time in the harbours, either loading and unloading or merely waiting for tides, berths, men and equipment. Turnaround time has presented a serious problem to ship owners and to shippers, due to the high capital cost of the ships involved, and the resultant desire to get maximum utilization of the equipment, and due to the desire for faster, cheaper service in the field of ocean transport. The effect of improved harbour facilities could prove to be considerable in terms of cost reductions. In a study conducted once again by Goss, it was shown that if the 60% of ships' time spent in port could be reduced to 20%, the total costs of sea transport could be reduced anywhere from 18% to 35% depending on the length of the trip. It thus has become well worthwhile to make an attempt to reduce both handling costs and turnaround time.

Since the various operations performed by the port are inter-
related, it is not sufficient merely to improve one particular part of
the facility. Nor, considering the costs of port development, is it
feasible to adopt a guesswork approach and expand the facilities on the
basis of intuitive judgement. Either of these approaches would be cos-
tly and would undoubtedly result in under-utilization of some of the
equipment. Consequently, more sophisticated models of port operation
have been developed as an aid in the planning and evaluating of port
construction and development. The majority, and the most comprehen-
sive of these techniques involve building a model of the port operation
based on cost and benefit interrelationships, and then using this model
to simulate the operation of the port, generally with the aid of a com-
puter. In this way, some facets of the port can be held constant while
others are varied and the resultant benefit-cost relationship or net pre-
sent value of each improvement or combination of improvements calcu-
lated. Through a comparison of a number of such computations, a
design can be developed which represents the best or near-best combi-
nation of the resources required.

The balance of this chapter is concerned with the description
of the type of model being used in port simulation. The approach to
models described is taken from several works, but since all the models
were basically similar, this one does not diverge from the typical pat-
tern. Several models were combined only because some descriptions
gave more comprehensive accounts of different facets than did others.
The main papers used were those listed in the bibliography by P. C.
Omtvedt, by R. Chapman and R. R. P. Jackson of the British Iron and
Steel Research Association, by F. G. Culbert and F. C. Leighton of Swan Wooster Engineering Company, and by J. C. Clapham and W. J. Sheriff. While the approach described is undoubtedly not the only possible approach to port planning, it was felt that it was the most commonly used due first to the lack of literature in the field on other approaches and secondly to the fact that the authors of the last three papers were engaged by firms doing practical work in the port planning and port simulation fields.

The approach taken in evaluation is basically one of determining the net present value of some of the benefits and costs of an investment in port operation. The model is thus described in terms of benefits and costs for a sample time period. This time period can then be expanded to give the benefits and costs for any given year. On the cost side will be costs of port operation and fixed costs of building and equipping the facility. On the benefit side will be net community benefits.

The first factor to determine in developing the model is the level of output desired for the facility to provide a frame of reference in so far as the desired capacity of the port is concerned. Since the attainment of this level of output is dependent on the cost to ships of using the port, some maximum ships' cost must also be set. For a plan to be feasible, the cost to ships of using the facility must be less than this amount. Otherwise, some ships will not use the port, the desired level of output will not be attained and, to consider this alternative in the solution, a value must be assigned to the output lost.
This desired level of output should be set in conjunction with the forecasts of expected traffic, and it can be different for each year in the life of the port.

Once the desired levels of output and the maximum ships' costs associated with them have been determined, the costs of port operation can be considered. These costs can be broken down into two categories for the purpose of the model: costs of ships' time in port, and cost of operating port equipment. Although these are to a large degree interrelated, for purposes of description they will be considered separately.

4.1 Cost of Ships' Time in Port.

The first step in building a model which will determine the cost of ships' time is to describe the arrival pattern of ships. Unfortunately, ships do not arrive according to any set pattern. Arrivals will be spasmodic throughout the year due to peak seasons and also throughout the day or week due to delays which the ship has encountered either at sea or in other ports. Consequently, a ship may arrive at a port to find that all berthing facilities are in use and that it must queue up and wait for service, or it may arrive to find the port nearly empty and equipment lying idle. The length of time a ship spends in port will be different for each set of circumstances which it encounters. It will vary depending on the number and the size of ships which arrive beforehand and the amount of servicing these ships require. Thus, some method of generating a realistic arrival pattern must be developed.

Several attempts have been made to devise such a pattern.
Dmtvedt, for example, suggests observing a number of actual arrivals, and thereby finding their pattern. The frequency distribution of arrival times and the relative distribution of ship sizes can then be determined from these data. Then, considering time for example, the actual arrival time for vessel number $i$ would be defined as $(T_{i-1} + t_i)$ where $T_{i-1}$ is the time of arrival of the previous ship and $t_i$ is the time interval between its arrival and the arrival of vessel number $i$. $t_i$ is found by drawing, with the aid of random numbers, from the observed frequency distribution of arrival intervals at other ports. The size of ship arriving and the nature of its cargo can be determined in a like fashion by drawing from observed distributions.

This method presents a fairly realistic simulation of expected ship arrival patterns, since it is based on actual arrivals at similar ports. It has two main disadvantages, however. First, the collection of data is a time-consuming and expensive process. To devise a realistic pattern, it would be necessary to observe arrivals for no less than a year and preferably for a longer period of time at other ports. Otherwise the probability would be high that the period observed was not typical of the normal pattern. Secondly, the data collected at one port may not bear any resemblance to the type of pattern which would occur at the port being planned. Arrival times of various-sized ships will depend on the volume and composition of traffic entering the port, and no historical data may exist on a port with the same volume and composition as that range expected at the port under consideration. Arrival times of various ships will also depend on the area in which the
port is located, on surrounding weather conditions and navigation facilities, and on the nearness and capacity of other ports in the system.

A second device often used to generate arrival patterns is a Poisson distribution. Although not necessarily more accurate than Omtvedt's method, this device eliminates the problem of collecting information on other ports. The Poisson distribution itself is used to determine the probability that there will be x arrivals in a given time period t, by using the following formula:

\[ P(x) = \frac{(\lambda t)^x \cdot e^{-\lambda t}}{x!} \]

where \( \lambda \) is the average number of arrivals per unit time, and e is the constant, 2.71828... \( \lambda \) can be determined from the forecasted volume and composition of traffic. To find the probability distribution of inter-arrival intervals, it is necessary first to determine the probability that the time between two successive arrivals lies between two arbitrary numbers, a and b. This is calculated by the multiplication of the probability of zero arrivals up to time 'a' (using the Poisson formula) by the probability of at least one arrival between 'a' and 'b'. By calculating this probability for a number of 'a's and 'b's where the interval between them is very small, a probability distribution of inter-arrival times can be derived. For example, it may be found that the probability of an arrival between 50 and 55 minutes after the preceding arrival is .05, between 55 and 60 minutes is .08 and so on. Using this probability distribution, the user can randomly select a given arrival interval and can generate a pattern of arrivals to
simulate a Poisson distribution of ship arrivals.

Once the ships' arrival pattern has been set, the model can turn to the effect of the port facility on ships' costs. Essentially, a starting group of circumstances is set, the arrival of the first ship is generated from the above distributions, and the ship is followed through the harbour and its costs calculated en route. Then a new arrival interval is generated, and a second ship followed through the port. After a representative period of time, the costs to ships are summed and then converted to an annual cost.

The main interrelationships between the cost of ships' time in port, the port facilities and other factors are shown in Figure 3. The total cost of ships' time will be a function first of the size of ship and hence of the value of its time, and secondly of the total turnaround time required. The size of the ship will determine the opportunity cost of its idleness. Reducing the amount of time spent in port will provide more capital equipment for the shipowner in a given period of time, and the larger the capacity of the ship, the greater will be the addition to his available equipment for every hour of time saved.

Turnaround time is the sum of two factors - congestion delays and service time. Congestion delays can usually be attributed to four items: number of berths, berth occupancy, mean service time of other ships, and irregularity of ship arrivals.

To illustrate this type of delay, consider a ship arriving at a port with a load of cargo. It may arrive and find that, due to irregularity of arrivals, all berths are full and there is a waiting line of
FIGURE 3

COST OF SHIPS' TIME IN PORT

CAPACITY OF CARGO  DESIGN OF VESSEL  TYPE OF CARGO
HANDLING EQUIPMENT

BIRTH MEAN SERVICE TIME  IRRREGULARITY OF ARRIVALS
NO. OF BIRTHS OCCUPANCY OF OTHER SHIPS

RATE OF LOADING/UNLOADING OF BERTHS  TONNAGE CARRIED

CONGESTION DELAYS

SERVICE TIME

TURNAROUND TIME  SIZE OF SHIP

COST OF SHIPS' TIME IN PORT
ships. This situation will have arisen because of some combination of degree of the four factors mentioned above. Had all berths not already been occupied when the sudden large influx of ships arrived (berth occupancy), the majority of the ships now waiting for space would be less. Similarly, if all the ships in the waiting line had not arrived coincidentally (irregularity of arrivals), the waiting time for the ship under consideration would not be so great. If the number of berths were greater, more ships could be accommodated at one time, and the queue would not be so long. And finally, if the ships already being serviced could be loaded and unloaded more quickly (mean service time), the length of time the ship would have to wait in the queue would be decreased, for the ships preceding the one under consideration would be ready to depart sooner, thus making room for the latter to discharge its cargo.

The other half of turnaround time, service time, will depend on the accessibility of berths, the tonnage carried by the ship, and the rate of loading and/or discharging cargo. Assuming that there is no congestion delay, or that the waiting line has now been dealt with, the balance of the time the ship will spend in port will depend first of all on how easily it can manoeuvre into the berth and tie up in preparation for servicing. The more inaccessible the berth, the greater will be the time required to get the ship into position. Once the ship is tied up, the total time required to unload and take on cargo will depend on the amount of cargo carried and on the rate at which it can be loaded or discharged. If the amount of cargo is slight, or
if the men and machines can get it on and off the ship quickly, turn-around time can be reduced.

Finally, the rate of loading and discharging cargo depends on the type of cargo, the design of the hold of the ship, and the port facilities for cargo handling, (that is, the type of machines, the number of machines, and the number of shifts manned). With reference to type of cargo, for example, it may be found that bulk goods are much easier to unload than piecemeal or mixed cargo. On the other hand, even with two cargos of the same type, the service time may vary from ship to ship depending on the design of the ship's hold. While if may be very easy to remove the first few tons of coal, as the amount of coal in the hold decreases, each ton may be more difficult to unload than the previous one. Finally, as the number and efficiency of the unloading machines increases, and/or the number of shifts manned during the day increases, the rate of loading and discharging cargo will rise also. If the equipment is manned for three shifts a day instead of two, the rate of servicing a ship will increase, and the total service time for a given tonnage ship will fall. There is a further interrelationship here also, in that as the rate of loading and discharging increases, the mean service time of other ships will decrease, and the congestion delays will be reduced.

Several of the factors involved in the computation of the cost of ship's time in port are beyond the control of the port planner to manipulate, and must either be specified as given in the model or generated randomly. Interrelationships between time and cost fall
into this category as do interrelationships between time and equipment, etc. Physical factors, however, such as port facilities, can be varied to determine their effect on the ships' costs. By observing the flows according to Figure 2, and by applying numerical values to the relationships, it can be determined, for example, by what amount an additional berth would reduce congestion delays and thus reduce turnaround time and the cost of ships' time in port.

While this description considers only the cost of time, other factors can be included to make the model more realistic. The number of berths of varying sizes can be set and changed, and thus the computer program must determine not only whether there is a berth available, but also whether the berths will accommodate the ship whose arrival has just been generated. Similarly, other ships' costs can be included such as the extra fuel consumed by trying to move the ship into an inaccessible berth. This more comprehensive approach gives a computation of the total cost to ships of using the port facilities.

This total process can then be repeated for other ships in succession until a certain time period has elapsed. The total ships' costs for this presumably representative period can then be obtained by summing the costs to individual ships.

At this point, a supplemental calculation must be made whereby these ships' costs are added to port dues to determine if this total cost to ships is compatible with the level of output specified. If the cost is too high, the solution must be dropped from consideration and a new set of inputs or combination of facilities used. If the cost is compatible, the evaluator can then proceed with the remainder of
4.2 Cost of Operating Port Equipment

The other component of the cost of port operation is the cost of operating loading and unloading equipment. This cost is borne by the port authority and, for operators, unless it is reflected in port dues, has no effect on the demand for harbour services. The costs of operating equipment and their interrelationships are described schematically in Figure 4. The cost for a given time period of operating port equipment is a function of the fixed costs of the equipment and of the total variable costs, the latter being determined by berth usage or the number of ships unloaded in the time under consideration.

The fixed cost component will be determined by the annual fixed charges relating to the port installation. These fixed charges will include items such as capital charges, maintenance, guaranteed wages to the workers, administrative expenses and so on, and thus will depend on the nature of the port installation. A larger or more expensive machine would result in greater capital costs per unit time, for example, as would a greater number of machines or berths. Better equipment could increase or decrease maintenance charges and could also decrease the number of men required per shift. Similarly, more shifts per day would increase the fixed salaries paid to dock workers. In a like manner, the other facilities which comprise the nature of the port's installation will affect the amount of the fixed component of equipment operating costs.

Berth usage can be used to measure the variable costs of
FIGURE 4
COST OF OPERATING PORT EQUIPMENT

CAPACITY OF CARGO
HANDLING EQUIPMENT  TYPE OF CARGO
OF VESSEL

RATE OF LOADING/UNLOADING
TONNAGE CARRIED BY VESSEL

ACCESSIBILITY OF BERTHS

NO. OF MACHINES  TYPE OF MACHINE  NO. OF BERTHS  NO. OF SHIFTS HANDED

SERVICE TIME  ANNUAL TONNAGE  NO. OF BERTHS

NATURE OF PORT INSTALLATION

FIXED COSTS

BERTH USAGE

VARIABLE COSTS

COST OF OPERATING PORT EQUIPMENT
operating the port installation. The berth usage throughout the period will determine how many hours the equipment is in operation, or how many tons of cargo are handled. From this, the model can determine what will be: the costs of electricity, bonuses to workers, and other charges which depend on the amount of traffic using the port.

Berth usage will depend in turn on the number of berths available, the annual tonnage of cargo expected, and the time required to service a ship. The greater the number of berths, for example, the greater will be the total berth occupancy, assuming that there are enough ships to fill them. Similarly, the greater the amount of cargo expected per annum, the greater the berth usage is likely to be in the given period. The final influential factor is service time. If a ship can be serviced and leave the harbour more rapidly, berth occupancy will decline as will the total of those variable costs of operating equipment which are associated with time. The relationships between service time and the factors determining it as shown in Figure 4 are the same as those discussed above with reference to cost of ships' time in port.

Once again, certain factors in the analysis are beyond the control of the port planner, except in so far as they are limited by the nature of the facilities available. Items such as annual tonnage, type of cargo, design of hold, etc. must be taken as given or generated by the computer. Similarly, cost interrelationships must be derived either by observation or from historical information. The planner can, however, alter the specific facets of the port installation and their design thus altering the cost of operating the port equipment.
The final calculation necessary is the addition of the fixed and variable costs of operating the port equipment per year to the annual cost to ships of using the port. This gives the total annual cost of port operation for any given year of the port's life.

4.3 Port Benefits

The total benefit from the port installation is comprised, in this model of net community benefits. Value of output does not enter into the calculation as the total output is held constant among alternatives. Generally speaking, community benefits and costs can be considered to be a function of the size of the port installation and of the cost to ships of using the harbour facilities. The effect of the latter on the community depends, however, on whether greater efficiency of harbour operation gives rise to a decrease in freight rates. Omtvedt argues that if freight rates do decline, the community will benefit from a greater radius of economic activity. He assumes that since the cost of transportation is a function of the freight rate per distance unit of cargo \( f \) times the distance to be travelled \( d \), a decline in \( f \) would cause a corresponding increase in \( d \) and thus the radius of economic activity around the port would be increased. In essence, Omtvedt's argument implies first that existing businesses in the port region have not used the port for transportation due to their distance from it and will now find it economical to use these facilities, and secondly that resources in the outlying area which had not been put to use will now be employed due to lower freight rates. The first implication represents no measureable gain to the community as it involves merely a
transfer of activity already being performed by some other mode.
The second assumes that there are unutilized resources in outlying areas, and that these remain unutilized solely because of the high transportation costs. This facet of community benefits is, therefore, open to question except in the case of underdeveloped areas.

Other community benefits which might arise would result from greater economic activity in the community such as added housing for employees of ancillary industries, additional money spent in the community and so on. In this situation, however, if the members of the community are making greater profits than they would have been making without the port investment, competitive industries will move in and absorb this excess rate of return. Consequently, firms will be making the same rate of return as they would have been making without the terminal investment, and no measurable benefit occurs. Unless the resources used to build the competitive industries were unutilized, they also would have earned the same rate of return elsewhere. Thus, the only benefit resulting from the transfer of activities would be a non-monetary advantage of the new location. The only other situation in which additional profits may occur as a result of increased economic activity would arise if the firms could, through increased marketability of their product, achieve substantial economies of scale.

Thus, the only instances in which these economic community benefits could exist would be in the case of a community operating below capacity or, in other words, operating at a level such that the return it was making on its capital was less than could be made else-
where, or in a case where substantial economies of scale could be
gained by greater production. The assumption of excess capacity in
a single community would be extremely difficult to prove, as would be
the likelihood and degree of economies of scale. Consequently, it
would appear best, except in underdeveloped areas, to ignore the eco-
nomic community benefits of port operation. If it is felt that there is
justification for considering them, it should be stressed that the asso-
ciated costs of obtaining these benefits must be counted also.

The other benefits and costs of the port to the community are
of a more aesthetic and intangible nature. These could include a more
attractive waterfront, a more cosmopolitan atmosphere, or, on the cost
side, air and water pollution, loss of a suburban or residential atmos-
phere and the like. These, if they are included in the analysis, will
vary primarily with the nature of the port installation and with the
volume of traffic expected.

4.4 Installation Costs

A discussion has already been given in Chapter 2 of the pro-
blems involved in valuing costs of setting up transportation projects,
and thus will not be reiterated here. The type of costs to be asso-
ciated with installing the port, and hence to be included in the model,
would be costs of land, costs of building berths, costs of dredging,
labour costs, and costs of equipment and its installation. These costs
will be input into the program depending on the facilities included in
the alternative solution being tested.

4.5 Computations
The final step in the analysis procedure is the calculation of the above benefits and costs for each year of the project's life under a given port plan. Thus, annual variations resulting from expected growth and additional investments in the facilities of the port can be included in the analysis. With all this information on hand, the computer can then calculate the net present value of the benefit and cost streams of any one port plan by using the standard formula:

\[
N.P.V. = \sum_{i=1}^{n} \left[ (R_i - C_i)(1 + r)^{-i} \right] - \sum_{i=1}^{n} K_i(1 + r)^{-i}
\]

where: \( i \) = any year in the life of the project

- \( R_i \) = benefits for the year \( i \)
- \( C_i \) = total costs of port operation for the year \( i \)
- \( K_i \) = installation costs in the year \( i \)
- \( r \) = discounting rate
- \( n \) = number of years in the life of the project.

This calculation puts the proposed alternatives on a common basis. By performing these calculations for a number of proposed harbour plans (i.e. - a number of different combinations of types and sizes of facilities), the most desirable of the alternatives can be selected by finding the one with the greatest net present value.

The approach to a port model described above is fairly comprehensive and accounts for the majority of the cost and benefit inter-relationships which would occur in a port operation. Such details as are not mentioned above could readily be incorporated into the model. There are, however, two main limitations to this approach.
First of all, the calculation of costs stops as soon as the cargo is unloaded from the ship. No consideration is made either of the storing of incoming and outgoing cargo at the quay or of the hinterland connections with other modes. This limitation is much the same as the limitation placed earlier on the airport evaluation - that of ignoring the airport access problem. As was noted at that time, such a limitation could lead to the ignoring of the major aspect of the problem. While this aspect may not appear to have any direct connection with the calculation of the efficiency of the other facilities, ignoring it implies certain assumptions which may be questionable. By ending the evaluation at quayside, the evaluator is assuming that berths can be immediately cleared of cargo to prepare for another ship, and that ships will not be required to wait for cargo coming from the hinterland or from storage facilities at the port. Whether or not this assumption is valid can only be determined by a consideration of the dock-side storage equipment and the hinterland connections with other modes.

Secondly, the model as it is constructed cannot account for the elasticity of demand for terminal services, nor can it consider facilities with different capacities as alternatives. Although a maximum value is set on the ships' costs compatible with attaining the level of output, it is unrealistically assumed that if ships' costs fall below this level, no increases in traffic will occur. In actual fact, it is most likely that each of the alternatives considered will draw levels of traffic which, in most cases will be different from the volume of traffic specified. Thus, alternatives will be evaluated on the basis of
their ability to handle a given volume of traffic when the volume of traffic they would actually handle if constructed would be greater. Consequently, they are being evaluated on a basis which, in real life, would not exist.

The one other limitation to the model is that it does not include a calculation for the cost to cargo of using the port or for the time value of cargo. This does not present too serious a problem, however, for the time value of goods being transported by ship is generally small enough to have only a minimal effect on the calculation.

Despite these limitations, the modelling approach provides a fairly good basis for evaluating alternative port installations. It combines both the integrated approach required for terminal evaluations and an economic basis for choosing among alternatives. In this sense, if it could be applied to airports, it would represent a better means of evaluating airport plans than those means currently being employed.

Thus, the following chapter will discuss first the applicability of the model to the airport situation, then the modifications which must be made, and finally, the data which will be required to use the model as an airport planning tool and their availability.

Footnotes


2. ibid., p. 88

4. ibid.


7. P. C. Omtvedt, op. cit., p. 16
CHAPTER 5

THE AIRPORT MODEL

The groundwork for airport planning was laid in the previous chapter. It is the purpose of this chapter to point out how, with little difficulty of data collection or modifications, the port model can be applied to airport planning to provide a more integrated, economic approach to airport evaluation.

5.1 Applicability of the Model

Many similarities between port and airport operation, and hence between models of their operation, are obvious from the start. The airport, like the harbour, is a terminal or nodal point in the air transport process, where goods and passengers are loaded, unloaded and transferred to other modes. Like ships, planes require extensive ground operations which are reflected profoundly in the total transport costs, and the services provided at these ground bases for both ships and planes are similar: loading, unloading, maintenance, refuelling and the like. Similarly, the facilities required are much the same: berths can be equated to runways, cranes to loading platforms, and port dues to landing fees. In addition, like ships, planes are concerned with such factors as turnaround time, queueing for a runway, availability of facilities, etc., all of which affect the cost to the planes of using the airport.
The interrelationships between airports and plane costs are also very similar to the relationships between ship costs and ports, if not in degree at least in direction and in facilities involved. That is, planes are subject, for much the same reasons, to costs of delays, added fuel costs of manoeuvering, higher capital costs per unit shipped due to non-utilization of equipment, and loss of profits due to unavailability of planes. Therefore, the model used to determine the "cost to ships of using port facilities" can be applied with little revision to the "cost to planes of using airport facilities."

Since the airport provides much the same services as the harbour, the "cost of operating the airport" can also be determined in a similar fashion to its counterpart in the port model. The same sets of costs will apply for a given period of time: fixed costs relating to the level of equipment, set wages, etc., and variable charges relating to the amount of traffic the airport must service. The combination of cost to planes and cost of operating facilities represents part of the total cost of airport operation.

Community benefits and costs arising from the airport also follow much the same pattern as those arising from harbours and can easily be integrated into the model. Both airports and harbours are fixed facilities, large in area and serving large vehicles, and the consequences arising from each from the point of view of the community will be similar. Finally, installation charges or capital costs of the facility can be included in the model for airports in the same manner as they were for harbours. The cost of the total facility can be broken
down into its component parts, and the components can thus be varied
and the cost of the facility adjusted accordingly.

5.2 Modifications of the Model

To the extent pointed out above, the harbour model can be trans-
ferred almost directly to the airport planning situation. However,
some modifications, chiefly in the form of additions to the model, are
required. First, in the airport model, one further cost must be con-
sidered as part of the "total costs of airport operation" in addition to
the cost to planes and the cost of operating the equipment. That cost
is the cost to passengers and cargo of using the airport facilities.
Since passengers and cargo do not actually pay a monetary charge for
using the airport, this cost is usually composed predominantly of the
cost of time. While this factor could have been considered in the port
model as a time value of cargo, it was not so important an item in
the port situation as it is in the airport case. If time is the vital fac-
tor in air transportation, as was argued in Chapter 1, then passengers'
and cargo's time has an important value to those persons using the air-
port and also at times to the airlines in terms of lost revenue. Thus,
the cost to passengers and cargo of using the airport must be included
in the model under cost of airport operation. Ideally, a cost in lost
revenue to the airlines should be included when the time costs exceed
a certain level, but the incidence of this loss would be extremely diffi-
cult to predict. Even if the incidence of lost traffic due to time costs
could be predicted, the level of costs relevant to the loss would vary
depending on the length of the flight as well as on certain intangible fac-
tors. At the very least a flight length generator would have to be included in the model and the lost revenue tied to each flight length and each degree of delay determined. To incorporate this demand relationship might make the model excessively complicated.

A second point of difference between the two models would be the arrival pattern generated. As with ships, planes tend to arrive at irregular intervals and some means of generating their arrivals must be generated. However, their arrival pattern comprises a degree both of randomness and regularity, the former resulting from delays and environmental conditions and the latter resulting from the scheduling of planes. Even the scheduling does not incorporate a regularity into the arrivals and departures of planes, for the scheduling is done by the airlines and generally bears little regard for the efficiency of the airport's operation. When dealing with a consumer market, the airlines must set flights to take off and land at times most convenient to the passengers they are carrying. Similarly, the airline would like to carry passengers over as much of their trip as possible. Thus, if a large amount of traffic is going from Honolulu to Toronto, the airline will want to schedule their Honolulu flight to arrive in Vancouver about an hour before the trans-Canada flight leaves. The same scheduling will apply to flights originating in other areas which must make connections with some other flight. This will result in five or six planes landing within a narrow time span. Thus, there will be a built-in congestion factor due to the fact that several scheduled flights will be landing or taking off during one time period.
This scheduling must be taken into account, however, by setting up different distributions of arrival intervals and drawing from a certain distribution on the basis of those intervals which have already occurred. That is, if a peak occurs every five hours, after five hours of selecting from a distribution of normal arrival intervals, the computer will begin selecting from a distribution with arrival intervals of the type to be expected during peak hours.

Another point of difference between the two models is the time period during which the airport operation should be simulated. In the case of ships, the year could be divided into a few fairly representative seasons and the operation simulated for several days of each season in order to give a reasonably reliable picture of annual costs. In the airport case, however, several hundred planes may be landing and taking off in a given day, with small peaks occurring within a week and larger peaks throughout the year. Thus, the forecast will vary on a day of the week and month of the year basis, and, assuming a Poisson arrival generator, lambda ($\lambda$), or the average number of arrivals per time period, will have to be recalculated many times if a lengthy period is simulated. Also, the number of arrivals in a period of several days, would necessitate an extremely large number of calculations to determine the cost to planes and to passengers and cargo of using the facility. To avoid this quantity problem, it is suggested that the year could be divided into a small number of sections, and out of each section some day at a particular level below the peak of that se-
ction could be selected as representative on the average of the whole period and thus used for the simulation.

Finally, unlike ships, the plane may also encounter delays in taking off due to congestion of the runways. These delays must also be accounted for in the model, and the plane's movements followed until it completes its takeoff, and not just until servicing is completed.

5.3 Data Required and its Availability

Aside from these modifications, the airport planning model can operate in much the same way as the port model, with the exception of the input and cost relationship data used. Thus, rather than describing the actual workings of the model, the balance of the chapter will follow these workings or calculations performed from the point of view of the data that would be required and their availability to the airport planner.

5.3.1 General

The first data requirement is a forecast of the expected traffic at the airport for each section of the year and for each year in the life of the project. This would include not only number of planes but also their load capacity, the types and volume of cargo anticipated, the type of plane to be used and its technological requirements, and the volume of passengers anticipated. These forecasts should be related to the cost of using the airport facilities as was the case with ships. In other words, some maximum cost to planes must be set which, if exceeded, will render the solution infeasible. However, it
is probable that demand is not so elastic in the case of airports since the airlines will be forced to a certain degree to use the facilities that place the passengers and cargo as close as possible to their destination, regardless of cost. For example, if we assume that it costs an airline less to land its trans-Canada flights in Prince George rather than in Vancouver, it is still unlikely that the airlines would change their landings to the Prince George airport and let passengers find other modes to get to their destination. The forecast, therefore, is probably quite inelastic in so far as it relates to the cost to planes of using the airport facilities. It may be slightly more elastic as related to the cost to passengers of using the airport since this latter could affect the demand for air transport and hence the number of planes using the airport. However, the degree of this elasticity is, as noted above, dependent on a number of factors, and would be difficult to work into the analysis.

In terms of availability of data, accurate forecasts will probably be the most difficult item to obtain. For reasons emphasized in Chapter 2, forecasts of the demand for air transport are difficult to formulate. However, if care is taken, and inquiries are made of airlines and aircraft manufacturers, at least a workable forecast should be obtainable.

Data are also required to simulate an arrival pattern. If Om\-tvedt's method of generation is used, prolonged observations of arrival patterns at similar airports are required to develop a body of data from which the arrival interval and the type of arrival can be selected. The data will have to be collected for several different traffic levels to allow
for differently weighted probability distributions for peak and off-peak hours. In addition, data will be required on the peaks created by scheduling so that the arrival generator will know when to choose from a different distribution. If a Poisson generator is used, data will be required on the average number of arrivals in peak and off-peak hours for peak and off-peak seasons in order that the arrival distribution can be calculated. Data of these types can most easily be obtained by working in conjunction with the airlines. These companies would have the best idea of what hours and what days are most likely to receive the bulk of the traffic, and could provide historical information on the proportion of total traffic falling into peak periods and seasons.

Thus, the most difficult problem in the collection of general data would be the forecast. Changes in air technology and changes in other transport technologies which might affect the air transport sector's market make predictions uncertain. At the same time, the lead time required on planning and building large airports is of a magnitude (Vancouver airport has been in planning and construction stages since 1958 and is only now being officially opened) such that it is necessary to predict traffic not for the next ten years but for the period between ten and twenty years hence. Collection of historical data for use in Omtvedt's method of arrival generation could be time consuming, but could be circumvented by using a Poisson generator and obtaining data on scheduling and peak hours from the airlines.

5.3.2 Cost to Planes

The model for determining the cost to planes of using airport
facilities is depicted in Figure 5. As will be noted, the relationships between planes and airports are similar to those between ships and ports. The main difference is the inclusion of a mean clearance time for other planes in order that the delays the plane meets in taking off can be calculated. Data required to calculate the cost to planes of using the airport would include first of all information on the landing costs incurred by the plane. These costs would include landing fees charged, the added amount of fuel consumed by different planes at low speeds and altitudes, the wear on tires and landing gears, the costs of operating radio equipment and other landing aids, and the average cost of accidents resulting from landing manoeuvres.

Such data should be available from the various airlines using the airport. The airlines appear to have a fairly good idea of these costs and performance engineers keep records of them for different types of aircraft.

The data required to determine turnaround costs will include those data required to determine congestion delays, service times, and the value of the planes' time. Congestion delays will be influenced by number of runways, number of loading aprons, apron occupancy, irregularity of arrivals, mean service time, and mean clearance time for takeoff. Of these, the first four are inputs into the model and their relationship to the cost to planes will be computed internally. Consequently, no data is required in this part of the analysis. The determination of mean service and clearance time will also be internal and will be calculated from the total service and clearance times computed.
One further possible addition to the calculation of delays would be the inclusion of an average delay caused by weather, equipment breakdowns, and accidents. This could be included either by the addition of a portion of this average delay to each plane using the airport or by a probability distribution of such delays of different lengths which can be randomly applied to certain planes. In either case, data collection would be necessary to obtain historical information on the frequency of certain weather conditions and the proportion of landings or takeoffs which result in costly, semi-costly and minor accidents.

The data required to determine service and clearance time would be first the average taxiway speed of the plane and the length of taxiways to obtain the time required to get to and from runways of different degrees of accessibility. In addition, there will be a certain minimum amount of time required for this taxiing, below which the taxiing time cannot fall with any saving to the airlines. This would be comprised of the length of time the pilot requires to check out the plane - meters, landing flaps, fuel and the like. Even if taxiing time and clearance time for takeoff could be reduced below this minimum, the plane could not take off until all equipment had been checked by the pilot. The average time required to verify the plane's performance would have to be obtained from the airlines or from the pilots in question.

The other data required would be the capacity of the equipment used for loading, unloading and performing maintenance. This capacity is primarily a function of the type of equipment used and thus can
be varied by the user of the model. A certain amount of data collection is necessary, however, in that the capacity figure used for different pieces of equipment should be its actual and not its rated capacity. A loading platform may be able to handle 100 passengers per minute, and in the first four minutes may unload 400 out of 500 passengers. The remaining 100, however, may require another six minutes to be unloaded, thus dropping the actual capacity of the platform from 100 persons per minute to 50. Such discrepancies should be accounted for in the model, and actual capacities should therefore be used as input. However, by observation of the performance of such equipment, the planner should be able to obtain fairly accurate figures.

When turnaround time has been calculated, it must be multiplied by the value of planes' time to determine the time costs of using the airport. In terms of depreciation, this value can be quite readily calculated. It is known, for instance, that a DC-8 costs about $7 million, a stretched DC-8 costs $10-11 million, a 737 or DC-9 about $5 million, plus an additional 10% in each case for spare parts. With data on the average life of the plane, the depreciation for an hour can be calculated. In addition, data must be collected on pilot and crew wages, and on miscellaneous factors which may influence the value of time to the plane. An example of the latter would be the fact that engines are only allowed 5,000 hours of use before a complete overhaul must be done. The cost of overhaul, including opportunity cost, must be determined on a per hour basis and added to the value of planes' time.
All the above figures required to determine this value would be available from the cost files of the airlines.

Once the cost to planes has been calculated, a supplemental calculation must be performed to determine the feasibility of the plan in terms of output desired. To this end, landing fees, which are based on the size of the plane, must be collected and added to the existing cost figure determined. These landing fees are obtainable from Department of Transport schedules, or, if they are to be changed, these proposed changes should be available to the planner. The landing fees can then be eliminated from consideration for the balance of the analysis.

5.3.3 Cost of Operating Airport Equipment

The determination of the cost of operating airport equipment is similar in most respects to the calculation for cost of port equipment operation. That is, in both cases there is a fixed and a variable cost component. Determination of the fixed component requires data on the value and lifetime of the installation, on administrative costs, on fixed costs of labour and maintenance of equipment, on average damage done to the facilities by accidents, and on other fixed charges which may arise from the operation of the terminal.

Variable costs must also be determined on a per hour or per unit basis. This calculation will require information on the amount of electricity used by the equipment and its cost, maintenance costs which vary with use, peicemeal bonuses to workers, wear on runways, taxiways and aprons, costs of operating and wear on radio and control tower equipment, wear and damage done to the passenger sec-
tion of the terminal, and so on. The total of these variable costs will depend on apron usage and terminal usage, which will in turn depend on the number of aprons, the annual traffic expected and the service time. Number of aprons is an input and forecasted traffic and service time have been discussed above.

Thus, the only additional data collection required for this calculation will be the fixed and variable costs. These costs should be available from the Department of Transport's files on past costs of airport operation and from the engineering departments in the case of capital costs of equipment and the average life of various qualities of installation.

5.3.4 Cost of Passengers' and Cargo's Time

The final component of the total cost of airport operation is the cost of passengers' (cargo's) time in the airport. In this discussion, only passengers' time will be considered. Similar data, however, can be collected for cargo.

The determination of the value of time and of the problems involved have been discussed in Chapter 2. The most likely item of data required would be the average projected wage rates of a sample of airline travellers. The total amount of time required, by which the value must be multiplied to determine the total cost to passengers, can be broken down into three factors:

(i) congestion delays which the passenger himself encounters while in the airport and must therefore allow for in deciding what time he must reach the airport before departure and how long he will require
before he can leave the airport at the destination;

(ii) service time, which includes loading and unloading of passengers and taxi time required to move from aprons to runways;

(iii) congestion delays which the plane encounters at the airport both after the passengers are on board at the origin of the flight and before the deplane at the destination.

Congestion delays to passengers can take several forms: waiting in line to check-in, waiting for luggage, fighting through crowds, and so on. Although a part of these so-called delays actually consists of service time, it is easier to include the whole time as a congestion delay, since the final total time required is still the same.

The sum of the congestion delays will be a function of the number of people in the airport and hence of the irregularity of arrivals and size of planes currently on the aprons, and will also be a function of the capacity and efficiency of the airport facilities, including the baggage handling system, the location and type of boarding facilities and the check-in procedure. To calculate the total congestion delays to passengers, the planner will need to know first the relationship between the amount of congestion and the number and length of delays encountered, and secondly, the effect which various changes in the arrangement, efficiency and number of facilities will have on the total amount of congestion. An interesting study of this latter relationship can be found in the Federal Aviation Administration publication, "Airport Terminal Buildings" listed in the bibliography. Such publications, as well as observation and time studies of movement with various fa-
facilities and degrees of congestion can be used to gather this data.

Service time for passengers will be a function of three factors: the number of persons to be loaded and unloaded; the passenger handling facilities including check-in procedure, accessibility of boarding platforms, baggage handling facilities and the type of boarding ramps used; and the average taxi speed and taxiway length. The data required will be observations and estimations of the capacities per unit time of the equipment, of the number of activities and length of time necessary to check the passenger in, and of the average time required to taxi a given distance.

Finally, the congestion delays which the plane encounters while the passengers are on board must be considered. These include waiting for runways at takeoff and landing, waiting for unloading aprons, and waiting for equipment, and are a function of the availability of these facilities. The actual determination of the congestion delays while the passengers are on board can be borrowed from the calculation of the cost to planes of using the airport by selecting those delays which occur during the relevant period of time. Consequently, no new data is required for this calculation.

These delays and service times to passengers can be calculated in conjunction with each flight whose landing and departure is simulated, or they can be determined on an average basis and simply multiplied by the volume of passengers using the airport during the day. This latter approach is considerably easier as it eliminates a number of repetitive calculations, but the model loses some of its
realism as a result.

The remainder of the cost to passengers of using the airport consists of a number of intangible, unmeasurable items such as comfort and aesthetic value and convenience. While these are not included in the mathematical aspects of the model, they must be taken into account in the final analysis in the way described for handling intangibles in Chapter 2. Thus, for example, if $500,000 is to be spent on aesthetic decorations of the terminal such as sculpture, fountains, etc., it must be adjudged whether this a valid price to pay to eliminate the cost to passengers of a lack of surroundings which would be pleasing to the eye.

Certain conceptual problems may arise in this calculation, such as when does a passenger start to experience discomfort from crowding. Some passengers may feel uncomfortable if they have 25 square feet to stand in. Others may not be troubled by only having 10. The best that can be hoped for in setting figures to these qualities is an arbitrary average number.

It is important to note that these intangibles play a much larger part in the airport model than they did in the port situation. The number of facilities built into most airports today, the lack of which would represent no monetary cost, provides witness to the fact that these factors represent a significant part of the airport's usefulness in the eyes of the planner. The planner should, however, be aware of the actual cost these facilities represent, and thus of the implied cost to passengers and terminal users which would be eliminated by
their inclusion in the plan.

4.3.5 Net Community Benefits

The one item that remains to be considered now is the calculation of net community benefits. Here again, although some authors have included them in their delineation of airport benefits, economic benefits can be ignored except in cases where underutilization of resources or opportunities for substantial economies of scale can be clearly proven to exist. In the event that they should be included, these benefits may fall into some or all of the following categories: wages and salaries paid to airport employees, wages and salaries paid by direct airport-related activities, expenditures of these activities for local supplies, local expenditures by incoming travellers, local expenditures by airport and ancillary employees for housing, food and other supplies, and cost savings derived from economies of scale.

Data would have to be collected with respect to what would be the additional profit to the community resulting from these payments and expenditures, and also with respect to what would be the costs associated with achieving these extra profits.

Such an analysis is similar to the one currently performed by the Air Economics Branch of the Department of Transport. This analysis could be expanded somewhat to include the required data mentioned above.

The remainder of the net community benefits are predominantly in the form of costs. These may, according to J. T. Howard, take three forms:
(i) Land - according to the 1952 President's Airport Commission, the ideal amount of land for an airport would be 10-15 square miles. The figure today would of necessity be much greater. 10-15 square miles "could house 100,000 people plus all their factories, stores, offices, schools, playgrounds and streets". "The sheer size of airports spreads other urban land uses further apart, increasing the internal circulation system required and fragmenting the urban pattern".

(ii) a hazard to life and property on the ground in the approach zones, and

(iii) a noise nuisance to the population within earshot of the airport and the approach and takeoff patterns.

The additional lost value of the land may already have been included in the determination of the original cost of the land. To the extent that it was not, estimates should be made as to what the opportunity cost of the land would be, and should be included in the analysis. The effect of the airport on urban form should also be included if the added urban dispersion can be directly attributed to the incidence of the airport and if this dispersion gives rise to additional costs. Estimates would have to be made of the degree of dispersion expected and of the costs which this dispersion would cause.

Noise and safety aspects will be manifested in many forms. They will depreciate the attractiveness of the area around the airport for purposes of urban living, and may cause a corresponding decline in real estate values. They may also take more intangible forms in
terms of discomfort, lives lost, mental distress and the like. These latter items must also be handled in the method described previously for intangibles.

In order to calculate net community benefits, the planner must know what will be the effect of the airport on the community. Questions must be answered as to what is the relationship between the inconvenience suffered from noise and the amount of noise encountered, what degree of noise is caused by different aircraft, what are the probabilities that a certain combination of facilities will directly cause an accident, and what is the average damage done to the community if an accident occurs. Data must be gathered so that a reasonably realistic value can be assigned to these community benefits and costs. In many cases, the cost assigned will be largely arbitrary, but data on noise qualities of aircraft, on the degree of discomfort caused by different decibels, on average cost of accidents and the like can add some realism to the calculation.

The only additional data which must be collected is the capital cost of the airport installation. These costs should be fairly readily obtainable from the engineering department of the D.O.T. or from contractors acquainted with the costs involved.

Consequently, the bulk of the data required for the use of the modelling approach to airport planning is available to the planner either from airlines, aircraft manufacturers or the department's own records. The main problems will occur in the area of forecasting, and in the calculation of community costs and other intangibles. Despite these
difficulties, the model of airport operation should, with the background and data available, be fairly easy to construct and apply.

Footnotes


3. From an interview with Mr. W. Whiskin, Canadian Pacific Airlines, in Vancouver on August 8, 1968

4. ibid.

5. Civil Aviation Branch, Department of Transport, "Fees and Charges", Ottawa, 1965, p. 7


7. See for example: Economic Principles for Pricing Airport Services, Southern California Laboratories, Stanford Research Institute, SRI Project No. 1-3100, South Pasadena, Calif., 1961, p. 16

J. C. Gridley, "The Community Airport - Its Economic Value to the Area", 15th New York State Aviation Conference, N.Y. Department of Commerce, 1962, p. 4

8. ibid., Economic Principles for Pricing Airport Services, loc. cit.


10. ibid.

11. ibid.
CHAPTER 6

SUMMARY AND CONCLUSIONS

6.1 Summary

The preceding five chapters have presented an argument on behalf of greater care and evaluation in the planning of airports, have proposed a basis for a method of planning which would take into account all the various impacts of airport design and would provide an economic test for the feasibility and value of alternative plans, and have argued that such a method could be readily applied in view of the data and techniques already available.

In the first chapter, the likelihood of a need in the near future for new airports was pointed out, and the mistakes that have been made in airport planning in the past were cited. Some of the reasons for these mistakes were explored and the conclusion reached that these mistakes could be avoided by the use of an integrated, economic approach to airport planning. In addition, the importance of economic evaluation in its own right was stressed, particularly in view of the amounts of money spent, the need to justify building an airport when funds are scarce, and the need for an optimum airport design in view of the airport's effect on subsidy payments, airlines' costs, the market for air services, and the costs of using air transportation.

Because of the vast number of interrelationships involved between the airport's design and the various costs to users of the air-
port, and also because of the number of possible alternative airport plans available, it was felt that the method most ideally suited to the airport situation was a computer simulation. By using a simulation technique, once a model of the airport's operation had been built such that changes in one part of the system could be traced throughout the system, and once cost figures had been applied to these potential changes, the structure of the system could be changed and the effect of each change on the airport's value could be recomputed. In this way, a large number of airport plans could be tested until the best possible solution was reached.

The main step necessary, then, was the construction of a mathematical model of the airport's operation. Since no such model existed, this could become an unwieldy task. It was contended, however, that the type of model currently being used in harbour simulations could, with modifications, be applied to the airport planning situation. The port model could at least provide a basis on which to build. The purpose of the thesis was, therefore, to point out through examination of the port model, the similarities between the two situations, to describe the amendments which would have to be made to apply the port model to airports, and to discuss the data which would be required to use the model as an airport planning tool and its availability.

Since the model required inputs of the various benefits and costs related to airports, Chapter 2 was used to provide some background on benefit-cost theory and on the procedures and problems in-
Involved in attempting to assign monetary values to the various facets of a transportation project. Problems common to the evaluation of most transport projects were delineated and some possible approaches to their solution were discussed.

In Chapter 3, a brief discussion was given of the Department of Transport's methods of airport planning. Here it was pointed out that their procedure lacked either an integrated approach to planning or an economic frame of reference on which projects could be judged.

In Chapter 4, the port model was described. In order to simulate the operation of, and hence determine the net present value of a port plan, the aspects of port operation were broken down into two groups: benefits, which included net community benefits; and operating costs. Operating costs were comprised of the cost to ships of using the port and the costs of operating the port equipment. In order to determine what these operating costs would be for some period of time, some method was required to simulate the arrivals of ships of various types at the port. Two main methods were described, both of which involved random selection of an arrival interval and type from probability distributions. In one case, however, the probability distribution was developed from observations of other ports, and in the second case, the distribution was generated artificially with the aid of a Poisson distribution. Once this arrival pattern had been generated and opening conditions had been set, a single ship could be followed through the port and the various costs it incurred from delays, service time, etc. could be determined. A second arrival could then
be generated and this ship's costs calculated. The repetition of this process over a representative period of time would give a sum of the cost to ships of using the port in that time period. To this cost was then added port dues to determine in a supplemental calculation the compatibility of the ships' costs with the level of demand specified. The port dues were then eliminated from the analysis and the costs for the time period simulated extended to give annual costs. The various cost interrelationships between the ship, other ships and port facilities were described and set down schematically in Figure 3.

While the cost to ships of using the port were being calculated, the variable costs of operating port equipment could be calculated also. As a ship was being serviced, those costs dependent on time of servicing and bonuses to workers were calculated. At the end of the period, the total of these variable costs could also be extended to an annual basis and added to the fixed costs of operation of the port such as administration and time depreciation of equipment to determine the total costs of operating port equipment. This figure plus the annual cost to ships of using the port comprised the annual cost of port operation.

The benefit side of the picture was composed of net community benefits. In the discussion, it was decided that economic benefits to the community could only exist if the region's resources were underdeveloped or if substantial economies of scale could be derived as a result of greater economic activity. Consequently, the bulk of net benefits were of an intangible nature and it was recommended that
they be dealt with on an implied cost basis as described for intangibles in Chapter 2.

The final step in the model was the determination of the original or capital cost of the port facilities, including the costs of land, equipment and construction. When these costs and benefits had been determined for each year of the estimated life of the port project, the net present value of the benefit and cost streams could be determined by use of the formula:

\[
N.P.V. = \sum_{i=1}^{n} \left[ (R_i - C_i)(1 + r)^{-i} \right] - \sum_{i=1}^{n} K_i(1 + r)^{-i}
\]

where:
- \( \bar{a} \) = any year in the life of the project
- \( R_i \) = benefits for the year \( i \)
- \( C_i \) = total costs of port operation for the year \( i \)
- \( K_i \) = installation costs in the year \( i \)
- \( r \) = discounting rate
- \( n \) = number of years in the life of the project

This equation represents the value of the streams of one particular port plan. The inputs to the model can than be varied (for example, number of berths, types of equipment, etc.) and the net present value of an alternative port design calculated. By repeating this process several times for a number of alternatives, the net present value of a number of possible port plans or combinations of facilities could be determined and the best among these selected for execution.

Turning in Chapter 5 to the airport planning situation, it was noted that many of the operations associated with ports were almost
directly comparable to operations performed by airports and hence the models of their operation would be very similar. Some modifications were necessary, however, before the port model could be applied to airport planning. First, because time represents a large cost to users of air transportation, the cost of time to passengers and cargo using the airport had to be included in the cost of airport operation. Secondly, the generation of arrival patterns had to be modified to allow for the more predictable arrivals of planes due to scheduling. Thirdly, the period over which the airport's operation could be simulated had to be shortened due to the large number of arrivals and departures in a single day. Finally, the simulated movements of the plane had to be followed beyond service time to the actual takeoff because of the high likelihood of congestion delays on the departure runways.

Aside from these expansions of the port model, the airport model could operate in much the same manner to determine the cost of operating the airport, net community benefits, capital costs and the net present value of the benefit and cost streams. Thus, the port model could easily be applied to the airport situation with respect to the techniques involved. The only problem which might remain would be the availability of data required to use the airport model. Consequently, the balance of Chapter 5 was devoted to a discussion of the data which would be required and of its availability or probable availability to the airport planner. Through this discussion it was observed that the majority of the data could be fairly readily obtained by the user of the model, with the exception of forecasts of future traffic and
interrelationships between the airport facilities and its intangible effects.

6.2 Conclusions

In could therefore be concluded that a planning tool is readily available to airport planners. The modelling approach provides both an integrated and economic basis for selecting between alternative airport plans. At the same time, the techniques necessary for use of the model and many of the problems involved have already been tried and documented by port planners. The port model can be fairly readily transferred to the airport situation, and the data required can be collected with relative ease. The use of this modelling technique could provide a more rational combination of resources than is currently being achieved. It could help prevent over-investment in certain facilities, clear up bottlenecks in other areas, and generally assure that the various facilities are complementary to one another and to maximum efficiency in plane, cargo and passenger handling.

6.3 Limitations of the Model

To conclude this thesis, however, it should be noted that the model does have its limitations as a planning tool. First, of course, there are the built-in limitations of benefit-cost analysis: the difficulty of reducing all costs to monetary terms, the problems of uncertainty, the problems of measurement of costs and benefits, and so on. Forecasting in particular presents a thorny problem in air transportation, for the rapidly changing technology makes long term estimates of traffic highly unreliable. As the 1952 President's Airport Commission
states, "progress in the aeronautical sciences must be anticipated by the airport designers to provide necessary margins against early obsolescence".

There are other problems, however, more directly associated with the simulation technique. First of all, a simulation model must incorporate some degree of simplification. Many models may be too complicated for execution, not because the computer could not manage them, but because the time required to gather data and write the program could be excessive in terms of the benefits to be derived from better planning. Even the Poisson arrival generator represents some degree of simplification. In the event that these simplifying assumptions are made, the program loses some of its accuracy.

Secondly, the model does not automatically provide the best possible solution to airport design. In fact, the best solution available may never be reached. As inputs are varied, a trend towards a higher net present value may be noted, but only after a large number of trials could the planner be reasonably certain that a solution even near the best one possible had been reached. Only by combining the inputs in every way and degree possible could the best design for the purposes involved be determined and time could prevent this degree of care. Thus, the best the program user can hope to do is to observe a direction in costs and benefits and attempt to move towards increasing the net present value.

Thirdly, to be adjudged as useful and valid, the simulation program should have some sort of field trial. Many of the effects
and relationships used in the model are based on predictions, yet certain unpredictable effects could arise which could only be discovered through an actual test of the solution proposed. Airports, however, cannot be built on a trial basis due simply to the size of the investment involved. Thus, the results of the simulation must be accepted with no test available to determine their accuracy except the test of the amount of time and care involved in collecting the data and gathering information to build the model in the first place.

Finally, the simulation program is concerned with one airport only. The program determines the internal compatibility of the system where the system is composed of a single airport. Consequently, it fails to take into account the external effects of the larger system of which the airport is a part, and it ignores the compatibility of the airport with other parts of the system or with other systems in its environment.

These, then, are the limitations which arise directly from the nature of the modelling approach. However, one further limitation should be mentioned. No matter how good the planning technique used, the airport designer alone cannot solve the airport problem. He requires cooperation from the government, the airlines, the aircraft industry, and the surrounding community. Lack of such cooperation can seriously hamper the attempt to design an airport which meets the needs of its users and its neighbors. Assistance, for example, can come from the aircraft industry. While the noise problem can be solved by moving the airport thirty miles out of the city, the costs
of getting to and from the airport then rise to offset the cost savings to the community. The best solution to the problem would be technology advances which could reduce or eliminate this noise.

The airlines also have a responsibility to display a willingness to work with the airport planners, to advise them of their future plans for equipment and traffic, and to help them derive accurate cost relationships. Finally, the community and urban planners must cooperate if a satisfactory plan is to be developed. The airport designer does his best to reduce community costs, but situations arise such as in the case of Albuquerque, New Mexico. There the Federal Government built a high quality airport, with long runways, clear approaches and relatively good navigation facilities, and located it several miles from town in an area almost completely surrounded by desert. Soon, however, subdividers and real estate operators began building residences in the area, some with complete disregard for the airport traffic patterns. Although the airport was there first, occupants of many of the residences now complain vehemently about the noise it makes.

Against this type of cost the airport designer cannot plan, just as he cannot plan without knowledge of the future traffic expected to flow. The reduction of many of the costs of an airport can only be accomplished with the cooperation of the other parties involved.

Footnotes


4. ibid., p. 51


BIBLIOGRAPHY

Books


Brewer, S. H., DeCoster, D. T., The Nature of Air Cargo Costs, Graduate School of Business Administration, University of Washington, Seattle, 1967

Brewer, S. H., Air Cargo Comes of Age, Graduate School of Business Administration, University of Washington, Seattle, 1966

Brewer, S. H., The Environment of International Air Carriers in the Development of Freight Markets, Graduate School of Business Administration, University of Washington, Seattle, 1967

Currie, A. W., Canadian Transportation Economics, University of Toronto Press, Toronto, 1967


McArthur, N. B., Airport and Community, Queen's Printer, Ottawa, 1965


Omtvedt, P. C., Report on the Profitability of Port Investments, Oslo, Norway, 1963


Winch, D. M., The Economics of Highway Planning, University of Toronto Press, Toronto, 1963

Articles

_______, "Airports for Tomorrow, Lufthansa Concept", Airports International, June, 1968,


_______, "The Perils of Underestimation", Time, July 6, 1968

_______, "Breaking the Ground Barrier", Time, September 8, 1967

_______, "Airlines Face Ground Handling Challenge", Aviation Week and Space Technology, Vol. 87, No. 27, Mid-December, 1967


DeVoursney, A. M., "The Airport and the Airline", from The Issues


Howard, John T., "Regional Planning and the Airport Problem", from *The Issues and Challenges of Air Transportation*, Symposium sponsored by the Connecticut General Life Insurance Company, Hartford, Conn., 1961

International Air Transport Association, "World Air Transport Statistics", IATA, Montreal, 1965


ICAO, "The Airport Terminal, Future Problems and Possible Solutions", *ICAO Bulletin*, Volume XXIII, Number 4, April, 1968


Meeting, Washington, D. C., 1958


Pulver, W. A., "Time -- The Dollars and Sense of Air Transportation", From Transportation Century, G. F. Fox, editor, Louisiana State University Press, Baton Rouge, La., 1966


Schary, P., Williams, R. M., "Airline Fare Policy and Public Investment", Transportation Journal, Volume 7, Number 1, Fall, 1967


Government Publications


Civil Aviation Branch, Department of Transport, "Fees and Charges", Ottawa, 1965

Miscellaneous Papers

Economic Principles for Pricing Airport Services, Southern California Laboratories, Stanford Research Institute, SRI Project, No. 1-3100, South Pasadena, California, 1961


Clapham, J. C., Sheriff, W. J., "Computer Simulation -- A Tool in Port Planning", paper presented to the Canadian Transportation Research Forum, Vancouver, B. C., May 1-3, 1968


Studnicki, Gizbert, K. W., "The Economics of Canadian Air Transport Industry", Doctoral thesis presented to McGill University, Montreal, 1964

Interviews

Mr. W. J. Whiskin, Representative, Properties and Facilities, Canadian Pacific Airlines, Vancouver, in Vancouver on August 8, 1968

Mr. W. Nayrod, Phillips, Barrett and Partners, Vancouver, in Vancouver on August 13, 1968

Mr. D. Keenan, Airways Department, Regional Air Services Office, Department of Transport, Toronto, in Toronto on August 22, 1968

Mr. W. McNeal, Air Economics Branch, Department of Transport, Ottawa, in Ottawa on August 23, 1968