TRANSPORTATION AND COMMUNICATIONS

AS INSTRUMENTS OF NATIONAL POLICY

KATES, PEAT, MARWICK & CO.

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Prepared for the

Government of Canada
Department of Communications

by

Kates, Peat, Marwick & Co.

August 1971

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August 27, 1971

Mr. H. Flynn
Director
Technical Planning
Department of Communications
100 Metcalfe Street
Ottawa, Ontario

Dear Mr. Flynn:

Transport and Communications
as Instruments of National Policy

We are pleased to transmit herewith our report on the above subject, prepared in accordance with our letter of proposal dated January 22, 1971, and your reply dated March 23, 1971.

NATURE OF THE STUDY

This study examines the thesis that it is valid, and in fact necessary, to plan transportation and communications facilities and services on an integrated basis, as important means of helping to achieve national policy objectives. The term "TRANSCOM Systems" is used to describe the coordinated transportation and communications systems which could result from this approach.

Among the types of national objectives considered in this context are the following:

- national unity
- economic growth
- quality of the physical environment
- overcoming regional economic disparities
- enhancement of social wellbeing, including the important area of the "livability" of our urban areas.

On the basis of past and existing evidence, we conclude that both transportation and communications have played, and will continue to play, a vitally important role in the development, quality and very existence of Canada as a country.

The locational decisions of entrepreneurs and individuals are manifestly influenced, in many cases, by a desire to be "where the action is", whether this be in terms of markets, labour force skills, social interaction, or educational and cultural opportunities. As a vast country with a low population density by world standards we have, since the days of our earliest settlement, acted in part on the assumption that improved transportation and communications can overcome distance and distribute "the action", such that people, jobs, economic prosperity and social satisfaction can be distributed reasonably evenly throughout the country, in the best interests of all Canadians. The increasing concentration of population and economic activity in a relatively small number of urban centres close to the U. S. border, with large and apparently growing disparities in prosperity from region to region, forces us to examine this assumption carefully. In doing so, we are faced with questions such as the following:

- can the problems of pollution and congestion inherent in large urban concentrations best be met by greater decentralization of urban and economic development, or should we accept the gravitational pull of our Metropolitan areas and try to overcome these problems by better planning within them?

- if we contend that decentralization is a desirable objective, to what extent can we use transportation and communications, in concert with other public policies, as means of influencing and helping to achieve this type of development?

- if we can, in fact, achieve greater decentralization, to what extent can transportation and communications help to overcome the problems of remoteness and isolation so that Canadians living in distributed communities can experience full social, educational and cultural development as well as economic prosperity?

- assuming that transportation and communications are effective policy levers, to what extent should they be planned and developed on an integrated basis, and what costs are we prepared to accept as a country for these facilities to help achieve the above ends?

- finally, and of central relevance to this report, what information must we have to answer these questions intelligently, what information do we already have, and what must we do to overcome any gaps in the available information?

It would be presumptuous in a report of this nature to attempt to answer the first question listed above. The study does, however, address itself to the impact of transportation and communications upon land use, social and economic development patterns in Canada, the converse impact of development patterns and densities upon the demand for transportation and communications services, and the interactions between transportation and communications as means for overcoming distance and time.

REPORT STRUCTURE

The report is divided into three chapters. In the first, background concepts and trends are outlined, the importance of coordinated planning of transportation and communications is postulated, and the need for more information as a basis for such coordinated planning is suggested. An Information Improvement Program is outlined as a means of providing this information, and the objectives of such a program are set out.

The second chapter discusses in considerably greater detail the types of information which are required, the importance of developing methods for forecasting future impacts of suggested policies and evaluating alternative policies, and the data which should be collected now and in future years to provide a firm basis for such methods. Alternative forecasting methods or "models" are described and evaluated for their suitability as planning tools. Some basic data and relationships in this field are illustrated, and preliminary recommendations are made regarding the most promising methodologies for application in Canada.

Chapter III sets forward a recommended Information Improvement Program, including data collection, basic research, and development of mathematical models, as a basis for developing and evaluating alter-

native transportation and communications policies. The importance of direct research projects, in addition to development of mathematical models, is emphasized.

SUMMARY OF FINDINGS AND RECOMMENDATIONS

On the basis of available information, we conclude that:

- coordinated planning of transportation and communications to help achieve national objectives is valid and indeed increasingly necessary in the face of rapid growth and urbanization, greater residential mobility and dispersion of family groups, increasing economic internationalism, and rapid technological development

- it is increasingly important, therefore, to determine how significant transportation and communications are as instruments of national policy, and their cost/effectiveness relative to other policy levers for attaining national goals

- on the basis of currently available information, we are unable to determine the significance of transportation and communications in this context at a level of detail sufficient for systematic planning at the national, regional or urban levels

- further, we require more information on the degree and nature of interaction between transportation and communications as a basis for determining the extent to which they should be planned and implemented on an integrated basis

- the recommended Information Improvement Program is designed to produce, in a period of three years, the required information and techniques for more effective planning of transportation and communications (TRANSCOM) systems.

The content, and approximate timing and manpower requirements of the recommended Information Improvement Program are summarized in Table 1, opposite Page III-10. Additional details on data requirements, existing sources, suggested studies, and relevant mathematical models are provided in the appendices.

It is important, in our opinion, that the Information Improvement Program be initiated as quickly as possible in order to start providing time series data without which the necessary information cannot be developed and in order that models for forecasting and evaluating alternative transportation and communications policies will be ready in two or three years, when the need for them will be even more pressing than it is now. The Program will also help detect both desirable and undesirable trends so that the former can be reinforced and the latter changed, where feasible, by appropriate policies.

The resources required to initiate and complete this Program are negligible in comparison to the transportation and communications investments which will be made in Canada during the coming two or three decades and the impact which these investments will have, positively or negatively, on the people of this country.

We wish to acknowledge gratefully your advice and cooperation in carrying out this study, while stating that views presented herein are those of the report's authors: Messrs. Neal A. Irwin, Andrew Elek and Oscar Brecher. We appreciate the opportunity of assisting the Department of Communications in this important area and trust that the findings presented in this report will contribute to improved policy development and planning at the federal, provincial and local levels of government and in the private sector.

Yours truly

KATES, PEAT, MARWICK & CO.

Neal A. Irwin
Partner

NAI:db
Encl.

GOVERNMENT OF CANADA
DEPARTMENT OF COMMUNICATIONS

TRANSPORT AND COMMUNICATIONS AS INSTRUMENTS OF NATIONAL POLICY

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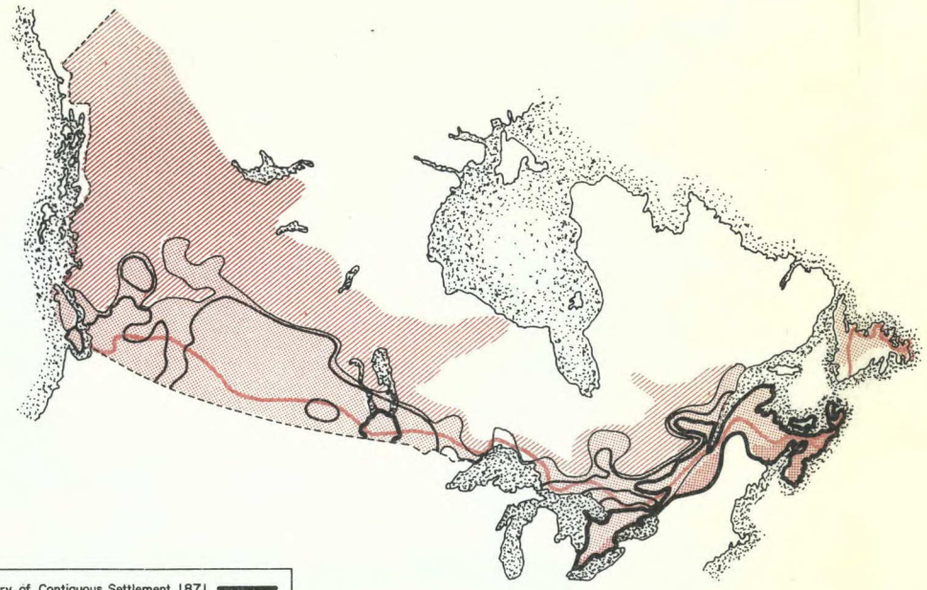
I - INTRODUCTION

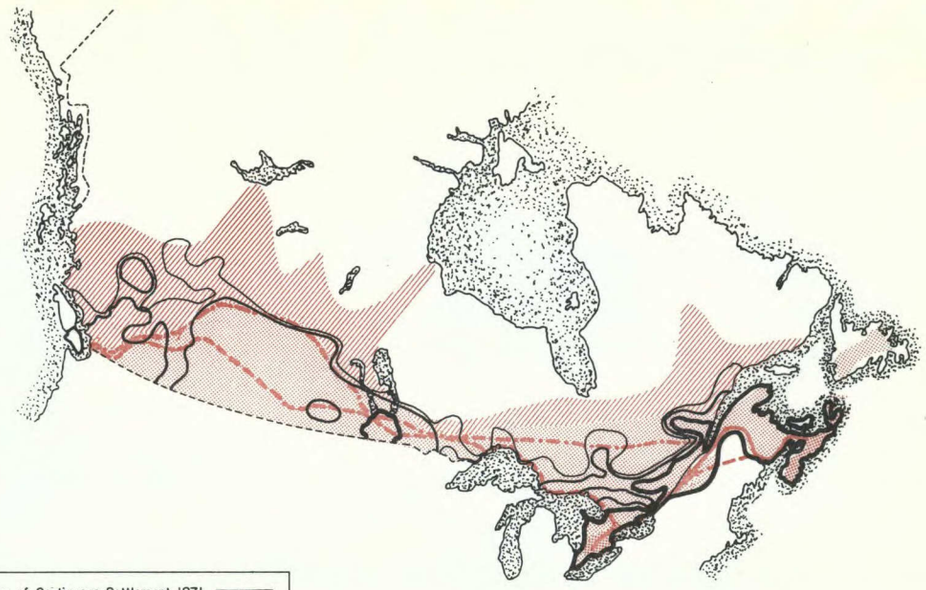
Since the earliest days of European settlement, transport and communications have played central roles in the formation and development of Canada as a country. Its patterns of settlement and economic development have been influenced strongly by the locations of sea ports, inland waterways, railways, roads and, more recently, airlines and airports. Similarly, the telegraph line, telephone, radio, and television have had an impact upon the culture and cohesiveness of our country.

Clearly, many other factors have shaped Canada, including the locations of good agricultural lands, timber stands and mineral deposits, world-wide social and economic conditions with their impact upon immigration rates and commodity prices, effects of the American Revolution and allegiance to the British Crown, and the impact of specific individuals, such as Sir John A. MacDonald, Wilfred Laurier, W. L. M. King, and others. Nevertheless, the building of a transcontinental railway in the 1880's, a rail network linking most towns of any consequence throughout the country, canals linking Lake Superior to the Atlantic Ocean, roads throughout the settled part of the country and probing into the remoter areas, and airports serving all regions, have determined which parts of the country would be opened up, the location of towns and major industries and the very existence of Canada as a national entity distinct from the United States.



ROAD NETWORK COVERAGE

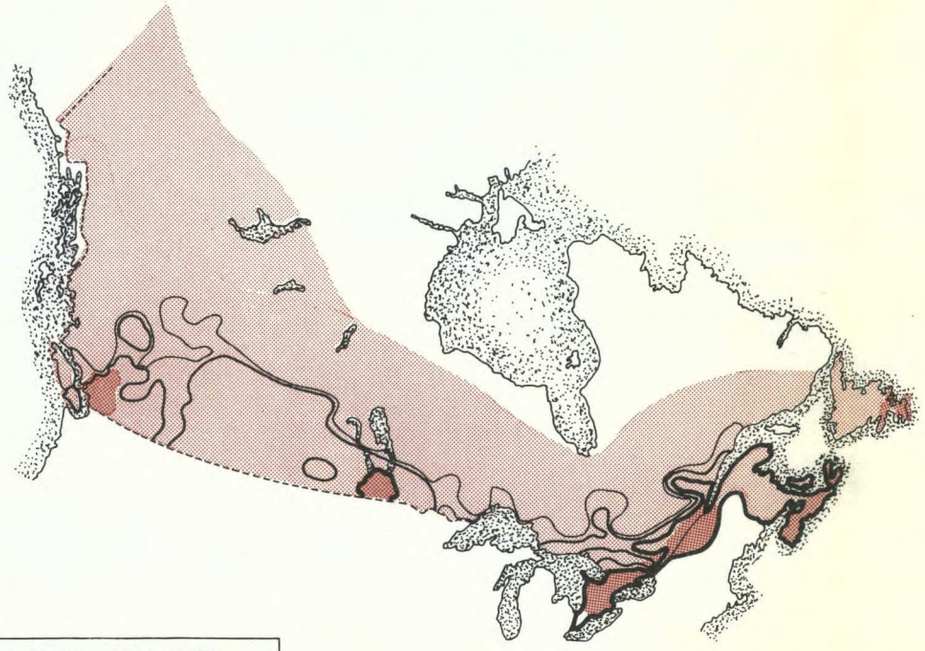
FIGURE Ia



RAIL NETWORK COVERAGE

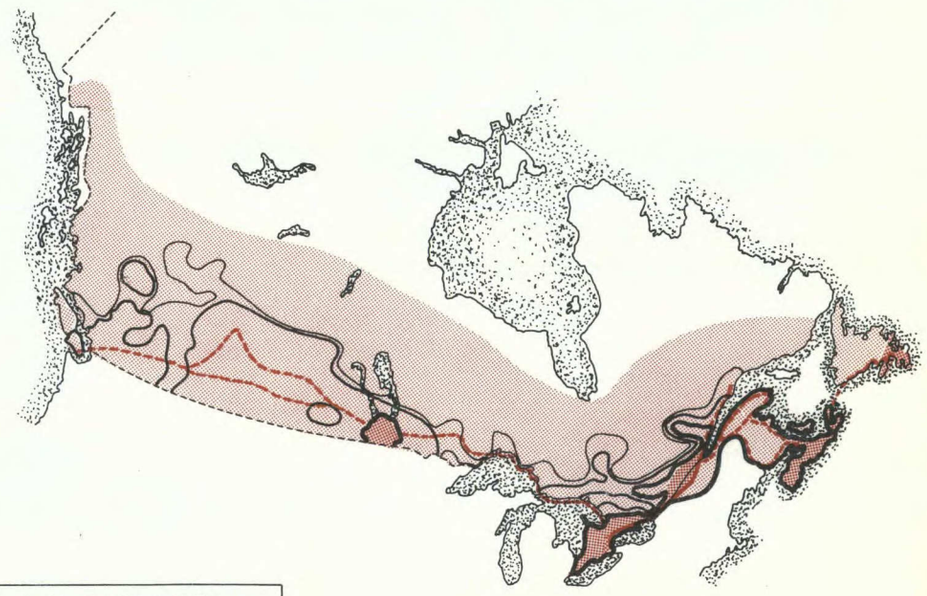
FIGURE Ib

NOTE: FOR SOURCE SEE APPENDIX F



TELEPHONE GRID COVERAGE

FIGURE Ic



TELEGRAPH NETWORK COVERAGE

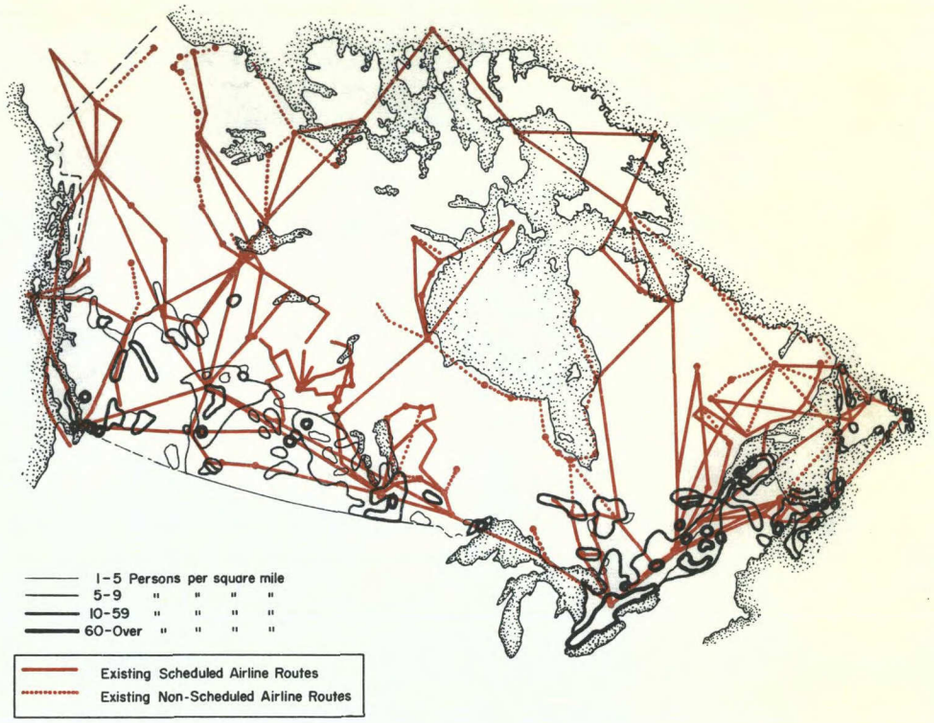
FIGURE Id

This is illustrated graphically in the maps, opposite and overleaf, which show the areas of settlement within Canada and areas served by various types of transportation and communications links at several points during the past 100 years. That there is a relationship between the two seems unmistakable. It is more difficult, however, to determine the nature of this relationship and how transportation interacts with other factors such as communications, land capability, resource locations, and other social and economic events, to influence the places where entrepreneurs choose to locate their factories and stores, and where individuals choose to live.

If we suspect that these factors have been important in the past, it seems reasonable to expect that they will continue to be important in shaping Canada's future. Accepting this, for the moment, as a premise, there are a number of factors which make it increasingly imperative that Canadians understand these relationships and be in a position to use them as a basis for achieving national objectives. Among the most important of these factors are the following:

- Urbanization: Canada is one of the most rapidly urbanizing countries in the world. The past 70 years have seen an accelerating trend toward our concentration into ten or twelve major cities, of which three - Montreal, Toronto, and Vancouver - may contain a total of some 15 million people by the end of this century, almost one-half of the country's population at that time (see Figure 9c opposite page II -45).

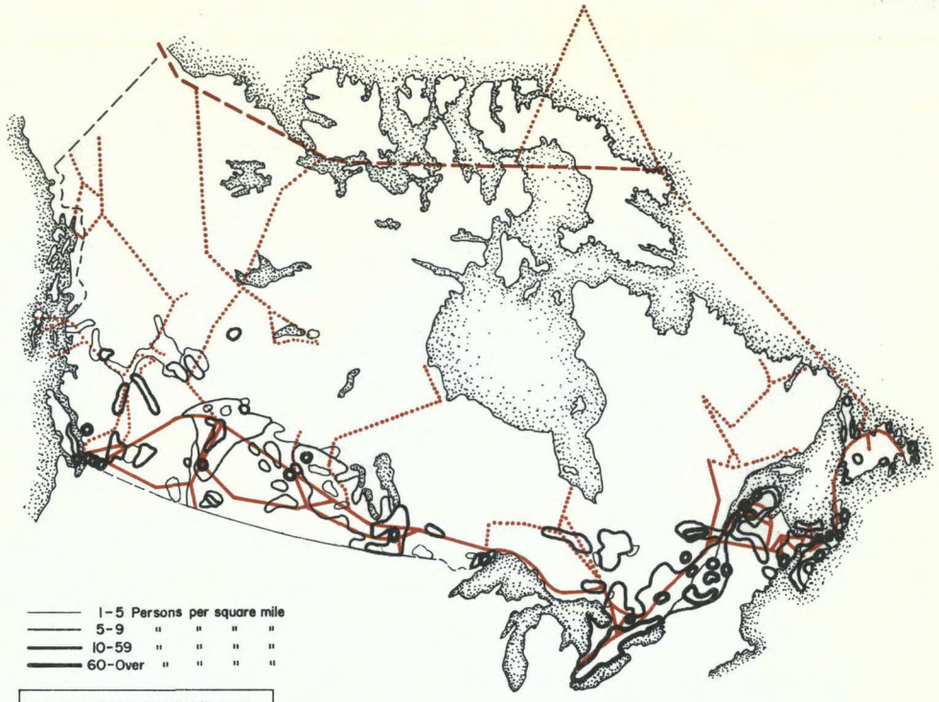
- Dominance by the United States: The growth in American ownership of Canadian industry and commerce has been startling during the past 50 years



1967

AIRLINE ROUTES

FIGURE 2a

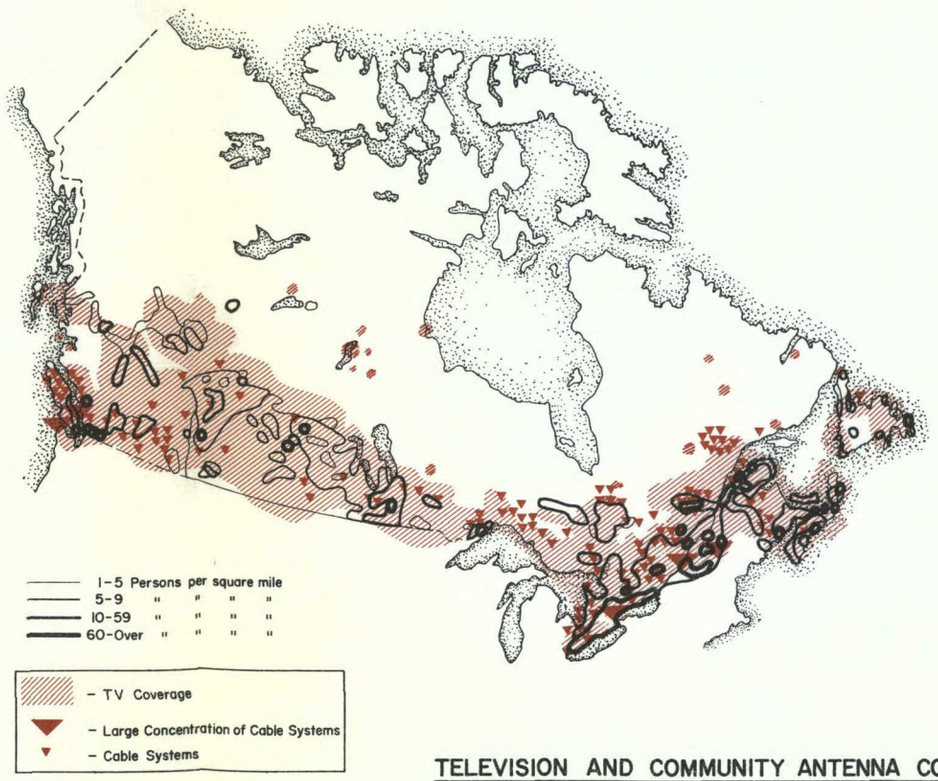


1967

MICROWAVE NETWORK

FIGURE 2b

NOTE: FOR SOURCE SEE APPENDIX F



1967

TELEVISION AND COMMUNITY ANTENNA COVERAGE

FIGURE 2c

and has reached a point at which many Canadians are wondering if we have enough control over our own economic affairs to ensure our survival as a country.

- New Technology: Technological developments, in transport and communications among other fields, will continue to provide new opportunities and challenges, including those of air cushion vehicles, pipelines, containers, unit trains, STOL aircraft, supertankers, cable television, satellite communications, hard copy transmission, videophones.

Important decisions are being made and will have to be made during the coming decade about the nature, location, and pricing of these transport and communications applications. If, as seems likely, they will have an impact upon the locations of people and jobs in Canada, it becomes essential that we understand in advance the probable nature of these impacts so that the decisions made will be in the best long-term interests of the people of Canada. Recognizing the interaction between transport and communications, and the potential for their combined use to achieve national objectives, the term TRANSCOM Systems* has been created to describe the type of interactive systems which include both transportation and communications.

The purpose of this report is to describe the information required in order that TRANSCOM Systems may be used effectively as an instrument of national policy. The Information Improvement Program presented herein is designed to provide a basic core of this information

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* See Appendix A, Glossary of Terms

as quickly as possible, with provision for an on-going program to expand our knowledge in this important area.

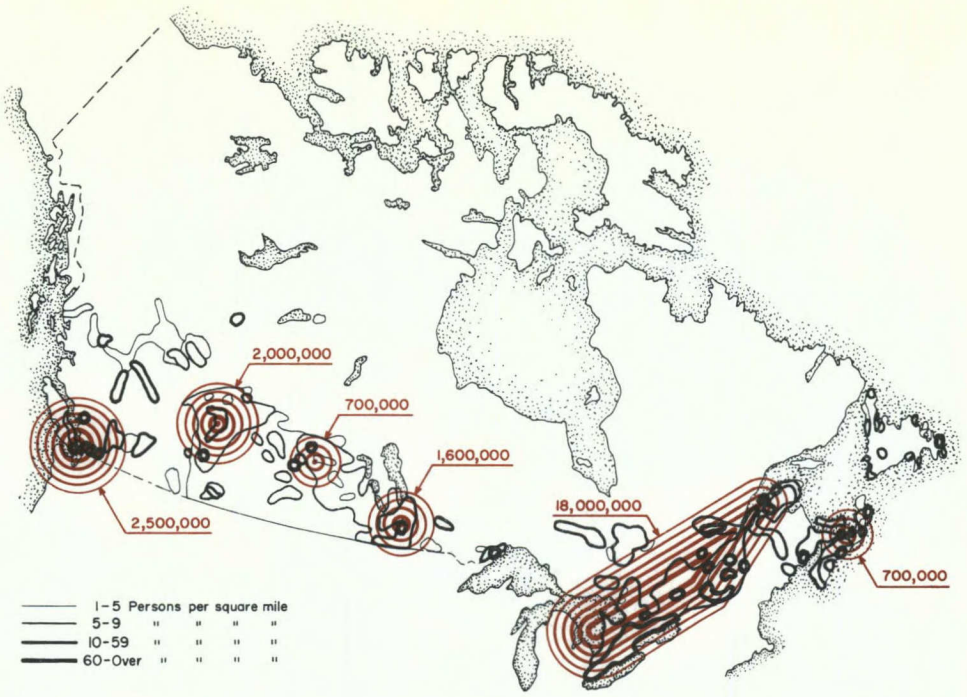
Whether or not we believe that fewer, larger cities are good for Canada, it is important for us to know the extent to which transport and communications facilities and services may be used to influence their development and centralize or decentralize urban patterns. Whether or not we believe that viable urban centers in our mid-north and Arctic regions are important to Canada, it is essential that we understand the extent to which transport and communications can influence the growth, stability, and amenities of such northern communities. Whether or not we believe that a Canadian identity and national unity are necessary for our survival as a country, it is important that we understand the impact of satellite communications, broad band electronic mail, videophones, and the possible simultaneous publishing of newspapers in several cities at once, on these areas. Whether or not we believe that Canadians should own our productive economy, it is important that we understand the probable effects of improved and cheaper communications on our ability to locate primary and secondary industries outside of our large urban centers yet direct their operations on an integrated basis from one point. Whether or not we believe that more than one means of travel or communications is important to the freedom of choice of our citizens, it is important that we understand how changes in the level of service or pricing of one transport or communications service may affect the demand for and use of other services.

These considerations indicate that some basic research on the relationships between transport, communications, and social/economic development patterns is in order. This knowledge would permit more efficient social and economic planning in Canada, and would provide a framework for important decisions on, and investments into, transport and communications facilities which will have to be made during the coming decade. Further benefits would result from the assistance that such knowledge would give in contingency planning for such short-term emergencies as airline strikes, post office strikes, interruption of an important communications facility, and so forth.

It is important that the construction, operation, and pricing of major transport and communications facilities and services in Canada take into account the effects they will undoubtedly have upon the location and nature of settlement patterns and economic activities throughout the country and, stemming from these, their impact upon the environment and quality of life experienced by Canadians. There are two possible approaches to such planning:

1. Trends Planning: In this approach, it is assumed by the planner that pasttrends of settlement, economic activities, use of transport and communications services, etc., will continue on a projected basis into the future. The trends planner accepts the forward implications of past trends, whether or not he considers them to be desirable and, by basing his plans upon them, tends to help make them come true.

2. Prescriptive or Normative Planning: Under this approach, the planner studies the implications of observed trends if they were to continue into the future,



THE UNCONSTRAINED FUTURE

FIGURE 3a

NOTE: FOR SOURCE SEE APPENDIX F

AN ALTERNATE FUTURE

DEVELOPING THE MID-CANADA CORRIDOR

FIGURE 3b

> but also develops a number of alternative futures, based on conditions which he considers to be desirable as well as possible, and compares the trends future with the various alternatives he has developed, relative to planning goals. In doing so, he applies a normative or value-setting process, and then prescribes the future which he considers to be most beneficial, taking into account both its feasibility and the degree to which it satisfies national goals. Decisions on transport and communications investments, among others, are then made in accordance with their tendency to reinforce the desired future.

The relative sizes of Canada's major urban regions in the year 2000, as shown opposite, illustrate projected trends (The Unconstrained Future *) and a possible alternative future which might be brought about by prescriptive planning aimed at more decentralized growth. Many other futures can be conceived. We are concerned in this study not with which future is better, but equally as important, whether or not government has the means at hand to influence future growth patterns significantly using transport, communications, and related policy levers.

The Information Improvement Program presented in this report starts from the premise that prescriptive planning is essential if Canada is to maintain the combined high quality of life and strong economic growth which we have enjoyed in the past. Its aim is to provide the information required so that transportation and communications decisions will contribute most strongly to this objective.

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* Lithwick, N.H. Urban Canada, Ottawa 1970, p. 133.

AN INFORMATION IMPROVEMENT PROGRAM - OBJECTIVES AND SCOPE

The overall objective of the Information Improvement Program is to develop information - past, present, and estimated future - required for policy formulation, planning, operation and pricing of TRANSCOM Systems as an instrument of national policy in Canada. By information we mean not only past and current data (given numerical facts describing past and present conditions), but also the interpretation of these facts (including interpolations, extrapolations, comparisons, correlations, etc.) as a means of estimating future conditions and evaluating alternative courses of action, so that informed decisions can properly be made.

The purpose of the present preliminary study is to translate this overall objective into practical tasks, assign priorities to them, and outline a plan for their execution within the Information Improvement Program. The information needs are identified in Part II of this study and a plan for the Information Improvement Program is outlined in Part III.

In accordance with the terms of reference for the present study, the proposed Information Improvement Program is concerned primarily with flows of people and messages via national networks of transportation and communications facilities; the impact of these facilities on locations of industry is also included. It includes information on the substitutive and synergistic* interactions of the pricing and service level of various TRANSCOM facilities, as well as their effects upon settlement and economic patterns at the national and regional scales.

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* See Appendix A, Glossary of Terms

The major TRANSCOM Systems facilities and services included in the Information Improvement Program will be as follows:

Transportation

- rail
- road (public and private transport)
- air
- air cushion vehicles.

Communications

- telegraph
- telephone
- broadcast radio and television
- cable television
- broad-band telegraphy and facsimile transmission
- videophones and scribble-phones
- data transmission.

Mail

The proposed Information Improvement Program concentrates upon an information base concerning TRANSCOM Systems facilities now in existence or likely to come into use during the 1970's, although longer-term possibilities will not be completely excluded. The effects of new technology on the effectiveness, efficiency, and cost/pricing of the facilities and services listed above will also be included in the Program.

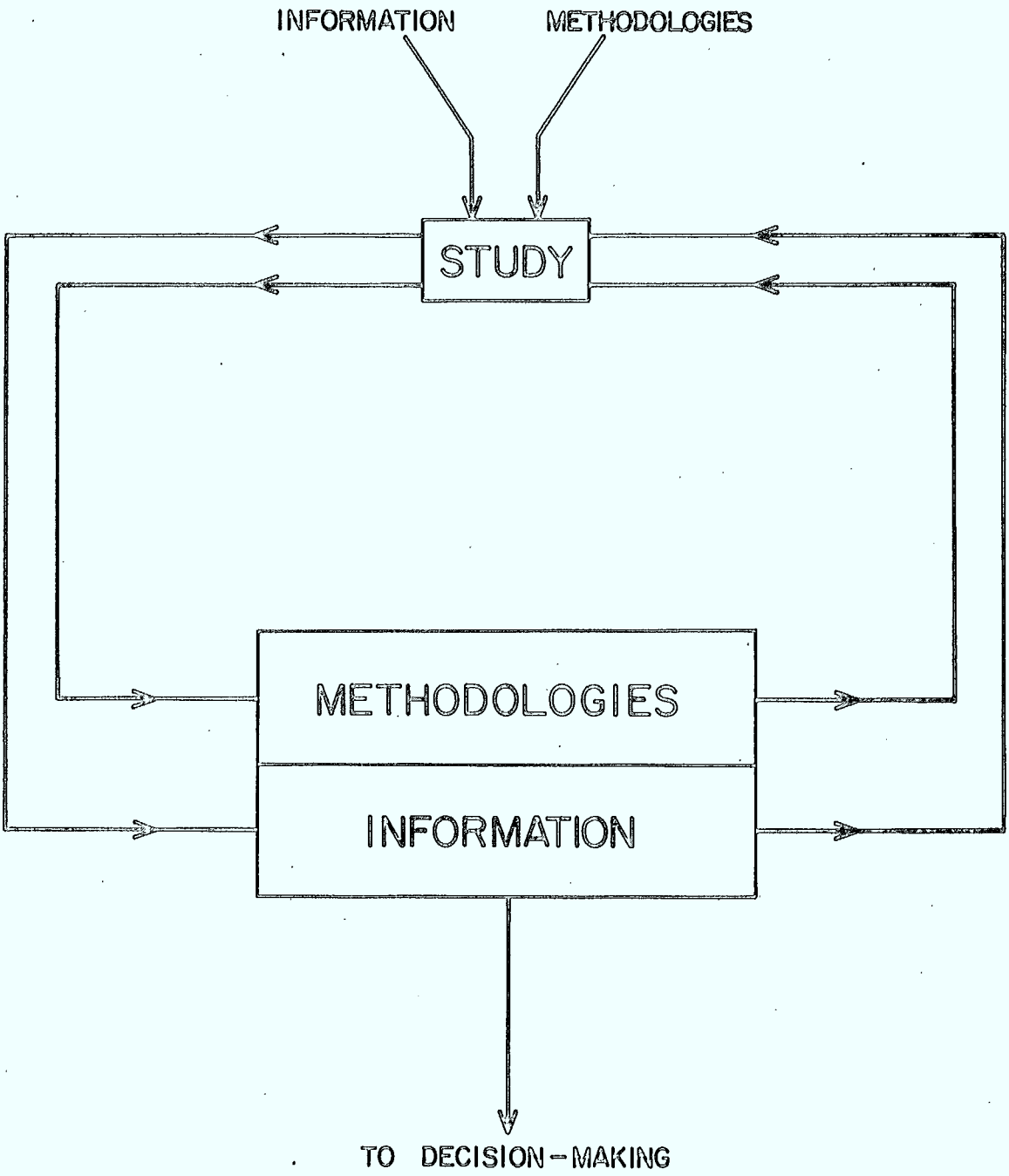
II - INFORMATION REQUIREMENTS FOR DECISIONS ON TRANSCOM SYSTEMS CHANGES

1. WHY DOES THE GOVERNMENT NEED INFORMATION?

Based upon the above introductory discussion, it is possible to summarize a number of important reasons why improved information is required as a basis for decisions regarding TRANSCOM Systems changes. These include the following:

- to develop criteria for evaluating TRANSCOM Systems changes as viewed by various groups, including users, other members of the public, operators, and government at various levels
- to forecast and evaluate the impact of alternative TRANSCOM System changes, as a means of selecting preferred plans and making investment, construction, operations, and pricing decisions
- to develop alternative TRANSCOM Systems policies as a means of furthering national objectives including the locations of persons and jobs throughout the country and the provision of appropriate service levels and pricing of TRANSCOM facilities, including alternative choices where possible, throughout the country
- to monitor, control, and adapt the implementation of TRANSCOM Systems changes such that they continue to meet national objectives and are in the best interests of Canadians.

It is apparent from these purposes, that a wide variety of information types are necessary as a basis for TRANSCOM Systems decisions. The required types of information are discussed in the following section.



INFORMATION DEVELOPMENT PROCESS

FIGURE 4

2. WHAT INFORMATION IS REQUIRED?

The Generation and Improvement of Information

To perform the tasks described in the previous paragraph, the government needs a wide range of information. Before attempting to identify the required types of information it is important to understand the meaning of "information".

According to the Glossary "information" is an "item of knowledge". It is knowledge in the general sense and should not be confused with such specific types of information as "data" which is defined as "quantitative information measured or recorded to describe past or present facts". To clarify the difference between information and data by an example, the number of telephone calls recorded in a past year is a type of information that can be called data. On the other hand a forecast of telephone calls for some future year is planning information but not data. Qualitative conclusions of a study are also items of information, but not data.

Figure 4 opposite is a representation of the process by which information is generated and improved. The square block in Figure 4 may represent a person, a group or an organization which possesses a pool of information. The primary purpose of this information is to serve the decision-making process. In order to perform his task the decision-maker has to draw from the pool of information. Frequently, however, this information, which is only as good as the underlying data, is not sufficient or is not in the proper form to enable the decision-maker

to make a decision. In such case a study has to be carried out which may sometimes consist of re-working existing information into a new form but more often requires gathering of additional external information. The new information or new form of information thus developed by the study is fed back into the pool and becomes available to the decision-maker and, at the same time, remains part of the pool for future use, thereby augmenting the inventory of information and data.

In conjunction with internal and external information the study must use a methodology. Like information, methodologies may be either available in the internal pool or acquired from outside. While carrying out a study its methodology itself may be developed or improved, so that as a result of the study a new or improved methodology can be fed back into the pool for future use.

The process of developing the information and methodologies required for a specific decision usually follows the described format. Frequently, the development of such information and methodologies takes a long time, depending on the complexity of the task. Sometimes, however, a decision is urgent and is required before all of the necessary information can be developed. In such case the decision would have to be based on insufficient information.

To minimize the likelihood of such occurrence, it is possible to develop general types of information and methodologies in anticipation of future information needs. The process depicted in Figure 4 can therefore be initiated without relating it to any specific project. This is the essence of the Information Improvement Program as envisaged.

The primary benefit of such a program is that it anticipates information needs in advance, thereby allowing sufficient time to develop the necessary methodologies and gather the necessary data. For example, information requirements may point to the need for certain forecasting models which require time series data for their development. If such data are not now being collected it is important to start collecting them as soon as possible, so that the necessary time series data will be available five or ten years from now when they will be needed.

The basic problem of designing a general Information Improvement Program is to identify the information and methodologies to be developed. Whereas in the case of a specific project the required information and the best methodologies can usually be readily identified, this is not so easy when one has to cater to less certain future needs.

It is clearly impossible to identify all the information and methodologies that would be needed for future studies. One can, however, establish priorities in accordance with certain criteria and identify the information and methodologies which should be developed by the Information Improvement Program so that the best returns are obtained in terms of required information, at reasonable cost.

The purpose of the present preliminary study is to:

- identify the types of information that would be most urgently and/or most frequently needed by the government of Canada for planning activities related jointly to communications and transportation and which can be developed within a reasonable time span

- identify the methodologies that would be needed to develop such information

- identify the data that would be needed to produce, through the methodologies, the desired information

- design a program in which the data would be collected, the methodologies applied and the identified information developed, resulting in continuous improvement of the Department of Communication's pool of information and of the methodologies themselves.

Information Improvement:
A Learning Process

The information improvement process depicted in Figure 4 is basically a learning process. If the square block of Figure 4 represents a person, his inventory of information and methodologies is his knowledge. He improves it through a learning process in which he uses both his existing knowledge and new information gained from outside.

A person can learn through experience, or in the course of an education program. Learning through experience is project-oriented; while working towards an immediate objective, the information developed in the course of the project will remain in the knowledge pool of the person thereby improving it. Learning through an education program has no immediate objective but improves a person's knowledge so that it can readily be applied to projects in the future.

The Information Improvement Program is the equivalent of the latter. It should be designed to improve the collective knowledge of the Department of Communication in specific areas. To design a "curriculum" for this Program is the task of the present study.

Required Information

The information to be developed in the Information Improvement Program must serve the government's needs for carrying out the tasks defined in Section II.1. Specifically, the Program should provide the Department of Communications with tools which will assist the Department in assessing the impact of changes in interactions in both directions between communications and transportation systems, and between the systems and the distribution of population and economic activities in Canada.

In determining the information needs of the Department of Communications, one should always keep in mind that the information will have to serve the decision-making process within the Department and within government as related to communications, recognizing the strong interactions of communications with transportation and socio-economic development. Although giving special consideration to the interrelations between communications and transportation and between communications and regional/urban development, the information should therefore be of such nature as to contribute to the knowledge and understanding of government regarding the factors that are relevant to future decisions expected from government in these areas.

It has been stated that it is not possible to foresee the entire range of decisions the government would be required to make, even in such a relatively short time as the next decade. It would therefore be too optimistic to expect that the government could draw entirely on the information developed in the Information Improvement Program; rather it would have to collect additional information and conduct additional studies to arrive at a particular decision. However, the Program should

provide the information that would most urgently or most frequently be required by government. The availability of such general types of information could greatly reduce the time and effort required for a specific project.

In this context the role of the Information Improvement Program is envisaged to be similar to the role of programs carried out by such institutions as the Dominion Bureau of Statistics. This agency produces information for general use by the public and does not attempt to predict all the possible uses to which the information will be put. However, before deciding to develop and publish any new type of information the Dominion Bureau of Statistics is very keen on identifying at least one or two possible uses of the information in order to ensure that the results of their efforts assist people in making practical decisions or in the development of policies. The same principle should be followed in the Information Improvement Program and it should be attempted not to produce information that is purely of academic interest.

A major difference between the types of information to be developed in the Information Improvement Program and those developed by the Dominion Bureau of Statistics is that the latter is mostly confined to data whereas the Information Improvement Program should also produce other types of information and methodologies for applying the information to specific problems. It should also develop correlations between various items of information.

While the Information Improvement Program is being developed for the Department of Communications, the relationships covered by the Program should concentrate on the benefits of planning communications and transportation in concert, taking into account causal interactions between these services and other areas in both directions.

The catalytic effect of changes in communications on other areas of economic and social development, and the effect of changes in other areas on the need for communications, are both of interest to the Department of Communications and should therefore be covered by the Program.

The "other areas" which are affected by communications or which, conversely, affect communications, are vast and embrace practically all activities of man. Some of these activities are:

- transportation
- socio-economic development
- working and living patterns
- quality of the physical and social environment
- culture
- national identity
- national unity
- security
- education
- health
- welfare.

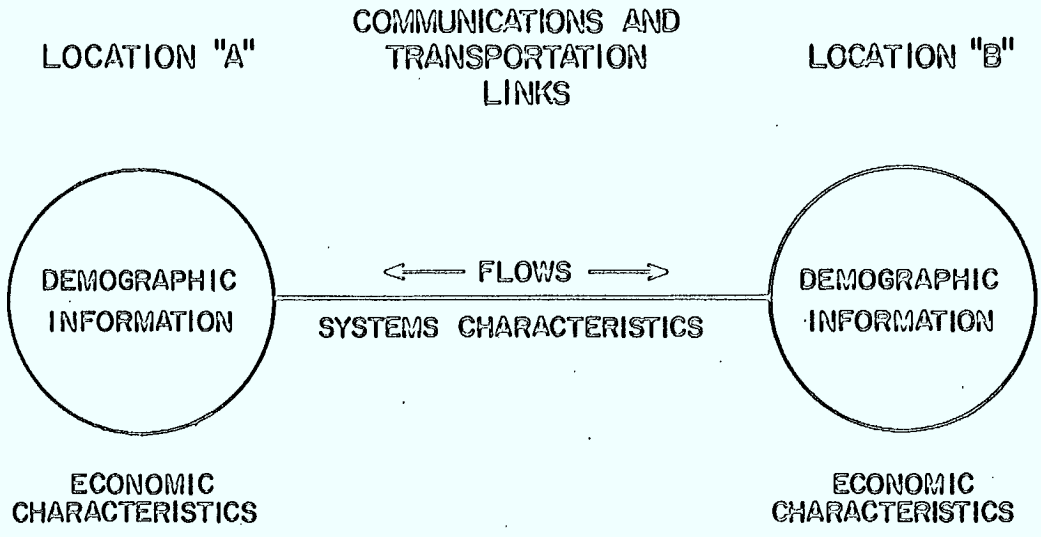
In order to produce useful information within practical limits of available time and resources it is necessary to narrow down the range of activity areas which should be covered by the Information Improvement Program in its present stage. In order to decide which areas should be covered in addition to communications by the Program at this time, one might attempt to rank the various areas according to certain criteria and choose those with top ranking. The ranking can be carried out using, among others, the following criteria:

- the strength of correlation between the particular area and communications, as estimated at this time
- the urgency and importance of gaining more knowledge about the reslationship between a particular area and communications from a national or governmental point of view
- the ease of establishing the relationships between a particular area and communications, considering the present state of the art.

In accordance with these criteria the following two areas have been established as top ranking and therefore earmarked to be covered by the Program at this stage:

- transportation
- socio-economic (regional/urban) development.

A system of communications media and transportation modes, in which these are interacting, has been termed a TRANSCOM System. It is most interesting to note that relatively little research has been carried out to explore the relationships between communications and transportation and even less between communications and socio-economic development. On the other hand the initial relationship between transportation and



STRUCTURE OF INFORMATION GROUPS

FIGURE 5

socio-economic development has been studied in great detail. The literature on the mutual effects of transportation and regional/urban development is extensive, particularly insofar as regional/urban development affects transportation demands. While interactions with communication are generally not included, the techniques and models applied to forecast and evaluate transportation systems interactions and alternatives may be quite relevant to studies which include communication interactions, as discussed in Section II.3 below.

Major Groups
of Information

The vast amount of information required by the Government of Canada in the areas of communications, transportation and regional/urban development can be structured in several ways. The simple model shown in Figure 5 opposite may serve as a basis for such a structure.

Basically, communications and passenger transportation consist of flow of people or their messages between two physically separated locations. Figure 5 shows a link between two of such locations; of course, a region or a city contains a complex network of such links.

One type of information is related to the facilities or environment represented by the locations and links. This group of information describes the economic characteristics of the locations and the systems characteristics of their links.

The other type of information is related to the people, that is, the users of the facilities in a broad sense. Users of the locations

are the people who live and work there and are described by demographic information. Users of the links are travellers and originators or receivers of messages, producing the various flows along the links.

Accordingly, six major groups of information have been identified which embrace most of the information required for the forecasting and evaluation of TRANSCOM System changes. Two of these are related to links, two to locations and two groups are of a general nature. In each case, the information group related to the "people" or "users" are listed first and the group related to the "facilities" or "environment" next.

Links

- communication and transportation flows
- systems characteristics.

Locations

- demographic information
- economic information.

General

- sociological and psychological information
- technological information.

These groups are strongly interrelated. In order to forecast or to evaluate specific TRANSCOM System changes, information would be needed from more than one of these groups.

For example, information on flow volumes, such as the number of trips, telephone calls, pieces of mail, their distance and/or duration

would be required for most studies both for the past and the future. Such information would be required for all of Canada as well as for specific regional or city pairs, for the whole population and for specific groups of the population.

System characteristics for various communication media and modes of transport, such as prices, service levels, etc. have to be known. These characteristics should primarily be defined from the users' point of view, since the users' attitude will ultimately determine flow volumes, economic and social impacts, and other variables needed for forecasting and evaluation.

Demographic information consists of past and predicted changes in the population of regions or areas and population characteristics with regards to such criteria as income, occupation, area of employment, ethnic origin, education, etc.

Economic information includes information on the various economic factors of a region or area such as population density, employment, type and quality of housing, type and quality of services, and others.

Sociological and psychological information covers a very wide field. In the context of communications and transportation only those aspects of these sciences should be considered which relate people's behaviour or ways of life to communications or transportation in one way or another. Whereas sociology is concerned with the behaviour of people as a group, psychology is concerned with behaviour of the individual. Both are important factors to be considered in the forecasting and evalu-

ation of TRANSCOM System changes. Sociological and psychological information is bound to be more specific to certain communication media or transportation modes and therefore less suitable for a generalized program of information development such as envisaged for the Information Improvement Program.

Technological information consists of a knowledge of the state of science in a particular field and can be developed to any desired detail regarding a specific topic. Specialized technological information, including information on costs, is always related to a project and any generalized information in this group would basically consist of the engineering and scientific knowledge of the people working in this field as obtained through higher education and continuing experience. The Information Improvement Program does not therefore call for a general approach to technological information, but rather assumes that it will be developed as required for specific project studies and accumulated on this basis. The impact of cost/efficiency/effectiveness changes caused by possible new technological developments will, however, be very much within the scope of the Information Improvement Program.

Priorities

Within the group of information identified in the previous section, certain items of information should have priority over others. The following criteria should be used in deciding on priorities:

- how much influence would an item of information have on government decisions?
- how urgently would the item of information be needed?
- how time-consuming is the gathering of information (such as time-series) and therefore how long will it take to obtain the necessary data?
- how general would be the value of the information to various users?
- how advanced is the methodology required to obtain this information?
- how readily is the information available?

Those items which score high on these counts should be given preference over those with lower scores.

It should be kept in mind that the information will be used to assist the decision-making process. It will be used mostly for forecasting and evaluation. Referring back to Figure 5, most of the questions which would have to be answered by using the information will fall into the following two major categories:

- What will be the volume and composition of various communication and transportation flows, given the systems characteristics of the links, the economic characteristics of the locations and their people?

- What will be the demographic volumes and composition of the various locations, given the economic characteristics of the locations, the systems characteristics of the links and their flows?

These questions would have to be answered both in the context of forecasting (what would probably occur under alternative sets of assumptions) and in the context of evaluation (which of the alternative possible futures is most desirable).

The items of information envisaged to be developed in the Information Improvement Program are summarized in the ensuing section and an attempt is made to establish preferences in accordance with the above criteria.

Identification of Information to be Developed

In view of the scope of the program as identified in the previous sections, the following major groups of information have been identified:

(i) Flow volumes.

(ii) Systems characteristics.

(iii) Demographic information.

(iv) Economic information.

(v) Sociological and psychological information.

(vi) Technological information.

(i) Flow Volumes

Flow volumes can be expressed in several ways, depending on the medium. For the sake of easier expression, we shall on occasion extend the meaning of the word "medium" from communication to transportation, although the word commonly used in transportation to convey the same notion is "mode" (see Appendix A, Glossary of Terms).

One way in which flow volumes can be expressed is the number of transactions, that is, number of calls, transmissions, trips, etc. In most cases, however, this information in itself is unsatisfactory since it does not express the amount of time for which a particular facility is used nor how much of the total system is used. Obviously, both the cost to the user and the value he obtains from the usage will depend on these factors.

For example, a telephone call identified simply as "one call" does not convey sufficient information. To obtain a full appreciation of the volume one must know both the distance of the call and the duration. On a train trip the identification of "one trip" is similarly unsatisfactory; for a full appreciation of the volume one must know the distance of the trip and the extent to which the facilities are used.

In the case of passenger transportation, passenger-miles is a convenient quantity which expresses both the number and distance of trips. In the case of goods transportation, ton-miles is a variable that expresses in one figure all the relevant variables. An equivalent variable in

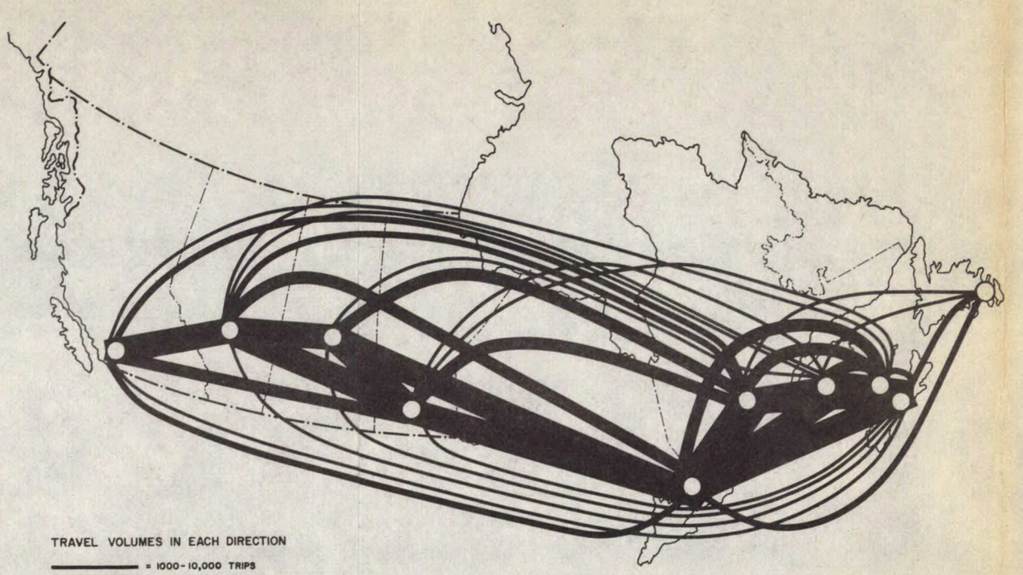
in telephone communications could be, for example, minute-miles.

A list of the suggested variables appears in Appendix B.

Each of the volumes, expressed by one of these variables, should be developed for various groups of users or uses. Thus, for example, it should be possible to separate telephone calls depending on whether they are business-to-business, business-to-private, private-to-business or private-to-private. Long distance calls should obviously be separated from local calls. It should be possible to separate postponable (off-peak) calls from non-postponable and emergency calls. It should be possible to make similar distinctions in the area of passenger transportation.

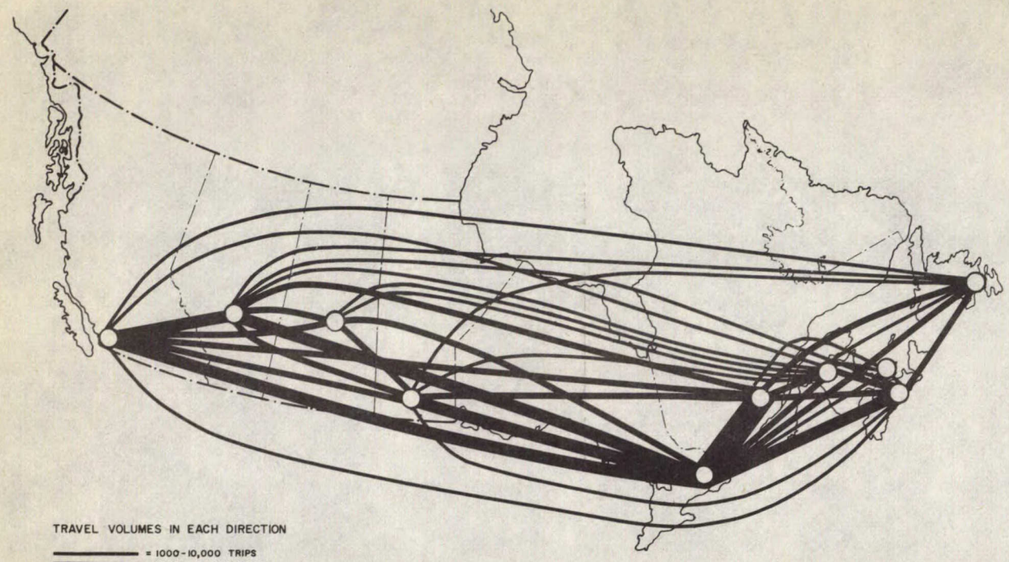
A suggested list of breakdowns is also shown in Appendix B.

We have thus identified the two key elements in the specification of variables: the units of measure and the breakdown into categories. It is obvious that the more of these are specified the more formidable will be the task of data collection, storage and retrieval. However, to use the information for forecasting and evaluation purposes, it is often necessary to provide such details. For example, if it is found that the introduction of the videophone will replace a certain percentage of business-to-business telephone calls but none of the other types, and will affect short-distance, long-duration calls more than long-distance, short-duration ones, there would be no way to predict the effect of the videophone on flow volumes unless the data are available in the necessary degree of detail.



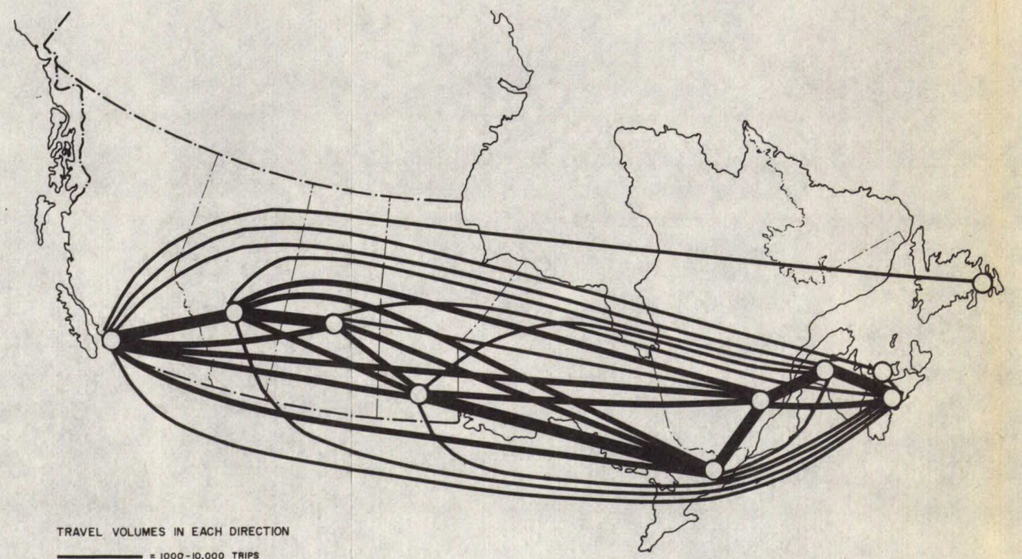
INTERPROVINCIAL TRAVEL BY CAR

FIGURE 6a



INTERPROVINCIAL TRAVEL BY AIR

FIGURE 6b

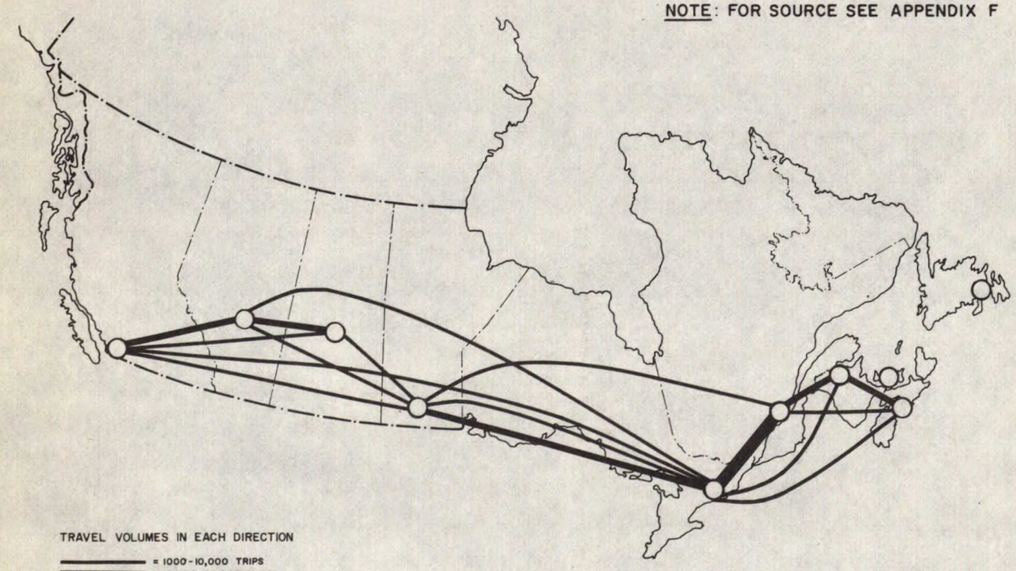


INTERPROVINCIAL TRAVEL BY RAIL

FIGURE 6c

PROVINCIAL TRIP-ENDS WITHIN EACH PROVINCE SHOWN SCHEMATICALLY RATHER THAN FOR SPECIFIC CITIES

NOTE: FOR SOURCE SEE APPENDIX F



INTERPROVINCIAL TRAVEL BY BUS

FIGURE 6d

The listings in Appendix B constitute a first attempt to identify the degrees of detail that might be required in future studies.

Flow volumes should be developed for the whole country, for regions and for a sample of city pairs. This sample, which should be developed early in the Information Improvement Program should be broad enough to include:

- pairs of large cities
- pairs of medium cities
- pairs of small cities
- cities at large distances
- cities at medium distances
- cities at short distances

and all possible combinations of these. All regions of Canada should be fairly represented and the hierarchical structure of city pairs should be taken into account by including in the sample pairs which are hierarchically linked and pairs which are not. Hierarchically linked city pairs are, for example, Toronto and Kitchener, or Kitchener and Stratford. Hierarchically not linked pairs are: Kitchener and Quebec City (one being linked to Toronto, the other to Montreal), or Stratford and Welland (one being linked to Kitchener, the other to St. Catharines).

Figure 6 opposite shows typical interprovincial flow-volumes for four transportation modes in 1964.

(ii) Systems Characteristics

The following basic systems characteristics can be identified:

- physical distance
- price of service
- level of service
- value of service.

These are the characteristics experienced by a user of a communication or transportation service. They are the ones that affect the users' choice between the available communications media and/or transportation modes and consequently they determine the flow volumes. The forecasting of such volumes therefore requires information on the characteristics listed above.

The effect of communications and transportation on regional/urban development is also exercised through their impact on people's decisions. For this reason also these types of interactions are governed by the user-oriented characteristics.

Physical Distance: The physical length of a communications or transportation link is one of its basic characteristics. It is conceived by the user of the link in terms of price and time, that is, in terms of the systems characteristics that follow.

Price of Service: It is obvious that the price of a particular service to the user will vitally affect its usage. As shown in Appendix B the price can be expressed in terms of rates for a specific

typical transaction or in terms of dollars per passenger-mile or dollars per minute-mile, etc.

Level of Service: It is usually difficult to find a single appropriate measure for the level of service. In terms of communications or transportation the level of service is basically a combination of the following factors:

- time required for contacting the other party
- time required for receiving response
- reliability of service
- safety of service
- comfort of service.

In the case of transportation the time required for contacting the other party is equal to the travel time plus waiting time. Waiting time is defined as the period between the time when the demand for contacting the other party arises and the time of the next scheduled departure of a convenient vehicle.

For trips of substantial length, travel time is shortest by air, and may be longest by private car. On the other hand, waiting time, being a function of the frequency of service, may be long for air travel and practically zero for private car. For telephone calls the time required for contacting the other party is practically zero regardless of distance. For mail this time can be one day or more, little affected by distance within Canada.

Changes in this criterion of service level are likely to occur in air travel, where both the speed and the frequency of service may change. Not much change is expected in the other media, although more frequent mail delivery is conceivable, as is "instantaneous" mail by means of broad-band transmission.

The influence of time on people's decisions will ultimately depend on the valuation of their own time for a specific purpose.

The time required for receiving a response after the initial contact has been made is practically zero for all media except for mail which is characterized by a slow response rate, especially since the speed of response depends on the action of the other party which is uncontrollable.

The reliability of service can generally be measured by the probability of occurrence of certain undesirable events. The most common measures are the probability of delays of various magnitudes and, for communications services, the probability of errors in message transmission.

Telephone is the least prone to unforeseen delays. The various transportation modes are prone to unforeseen delays to varying degrees. The most reliable is probably rail, followed by bus, air and, last, the private car. Mail is prone to rather erratic delays.

The probability with which certain amounts of delay occur could be subject to change during the next decade. It is difficult to tell, however, in which directions these changes may occur for the various media. Generally, the reliability of service is increased by

increases in capacity which allow the facility to maintain good performance in spite of high peak loading.

Other measures of reliability are:

- the probability of a certain degree of distortion or noise in message transmission
- the probability of losing the message altogether (mail).

These are primarily related to communications.

Safety of service is primarily related to transportation. Essentially, its measure is the probability of accidents of various degrees of severity.

The comfort of a service is not easily quantifiable. It would probably be possible to devise a simple rating system which would take into account cleanliness, environment, physical comfort, privacy, special amenities, etc.

Value of Service: The value of service is the value perceived by its user with regard to the type of contact made possible by the service. The basic criteria for the value of service are:

- the information content of the contact
- the subjective effects of the contact on oneself
- the subjective effects of the contact on the other party.

A personal visit has the highest information content. Mail, providing the receiver with visual information may, for certain applications, be superior in content to a telephone call. For other applications a voice-contact may represent greater information contact.

The subjective effects of a trip on oneself are obviously far different from the subjective effects of a telephone call or an exchange of letters. In many cases a trip provides the person with enjoyment far beyond the purpose of visiting somebody. In many instances a specific visit is not even involved, as in the case of holiday travel. In certain instances businessmen may consider trips as a status symbol giving them satisfaction in that regard. On the other hand, under certain circumstances a trip could be considered a nuisance by the traveller. For this reason the same physical activity may assume a wide range of values for different people under different circumstances, from a high positive value to a low negative one. This value will, of course, depend to a great extent on the transportation facility.

The subjective effect of a particular medium on the other party can similarly be wide-ranging. A great deal depends on the type of contact and the purpose. In some cases a telephone call is quite satisfactory and a personal visit would not achieve more. On other occasions a personal visit is much more valuable than either a telephone call or a letter. There is no way in which generalizations can be made in this regard.

It is obvious from the foregoing that it would be extremely difficult to find a single quantitative measure for the value of service, let alone to assign numerical values to it. The most one could expect is to find a simple empirical constant for the representation of this variable in a model.

It is quite likely that such a constant would not change in the years to come, since any change in the constant would mean a change in people's attitudes or social values. Nevertheless, it is conceivable that such a change could occur, for example, through the acceptance of the picture-phone, as a substitute for meetings or conferences. Where such a change is slow, it would be unlikely to become significant before the end of the seventies, and its quantitative effects would be largely or totally unpredictable during this decade. The type of studies called for as part of the Information Improvement Program would, however, help provide a basis for early detection of such changes.

(iii) Demographic Information

There is a vast amount of demographic information that could be developed nationally for a region, for a city or for part of a city. As suggested earlier, the Information Improvement Program should concentrate, at this time, on the information required for forecasting and evaluation of the following:

- communications and transportation flows
- allocation of regional/urban growth as affected by communications.

Characteristics related to people and most likely to be significant for the stated purposes are:

- income
- occupation by type of work
- occupation by industry grouping
- ethnic origin
- education.

A person in a high income group would tend to react differently to a change in communications or transportation than a person in a lower income group. Similarly, persons in different occupations or working in various areas of the economy, or having different education, ethnic backgrounds and/or affiliations in Canada would show different reactions.

Appendix B lists the categories suggested for the time being as the basis for grouping population data. The number of people broken down by these categories would eventually be required on a time-series basis for every region and principal city in Canada. Other population characteristics may be added to the list at a later stage.

Such types of information are rather standard and readily available from census publications: for this reason there appears to be no particular urgency for starting any new work regarding their development.

(iv) Economic Information

Like demographic information, economic information for a region, a city or part of a city embraces a vast amount of accumulated knowledge. It may be possible, however, to identify a few characteristics which would most likely be significant for the forecasting and evaluation of communications and transportation flows and of the allocation of regional/urban growth. These are:

- population density
- employment (opportunities) by type of work
- employment (opportunities) by industry grouping
- type of housing
- type of services.

The listed information about a region is significant from the point of view of the region's relative attraction to people. Variations in a region's attraction affect, in a fundamental way, both major areas of interest in the Information Improvement Program, the forecasting and evaluation of communications and transportation flows and the forecasting and evaluation of the allocation of regional/urban growth.

Many other types of economic information are published by the Dominion Bureau of Statistics. Specific studies will require a variety of this information which, however, would mostly be specific to the particular study. The listed items of information are basically those which would be required most frequently for forecasting and evaluation in the two major areas identified.

(v) Sociological and Psychological Information

Any sociological and psychological types of information which may be required for a study within the scope of forecasting and evaluating TRANSCOM systems changes would be rather specific to the individual study.

However, in order to gain insight into some fundamental relationships between the characteristics of communications and transportation systems and their usage by people and, further, to learn how such systems may affect a person's choice of his place of living or work, a few basic studies are suggested. These should be carried out as part of the Information Improvement Program. The following studies are suggested:

A Study of Factors Affecting Personal Preferences for Various Communications Media and Transportation Modes. This study would be aimed at establishing the relative effects of time, pricing, service levels, on personal preferences. It would also probe into determining what makes people choose a trip over communications or which factors other than time, cost and service are considered in the choice of medium.

A Study of the Location of Businesses as Affected by Communications. This study would establish the relative importance of communications among the criteria considered by business executives when choosing the location for a new plant or office. It would survey existing

businesses both in urban and non-urban areas and multi-location businesses, in order to assess the advantages and disadvantages of the different alternatives.

A Study of the Effect of Communications on the Migration of People. This study would establish the relative importance of communications among the criteria considered by a person before deciding to move from one place to another.

The suggested studies are outlined in more detail in Section III.

(vi) Technological Information

Most technological information is also quite specific to an individual study and may best be assembled at that time.

As outlined in Section III, at the present the following specific studies appear opportune in view of ongoing research and expected application in the near future:

- Review the State of Development and Broad Economics of Broad-Band Party-Line Telegraphy (Electronic Mail)
- Review the State of Development and Broad Economics of Broad-Band Facsimile Transmission
- Review the State of Development and Broad Economics of the Picturephone.
- Review the State of Development and Broad Economics of the Scribble-phone.

These four new communications media could make use of the networks of coaxial cables which are being installed throughout the North American continent at the present time. However, their introduction is not necessarlly contingent on these systems and the technology which would gain application would be the one most economically suited for each of the services or their combination. One purpose of the suggested studies would be to establish the background information that would make a prediction of the most suitable technology possible.

Any or all of the four services listed may become available on a continent-wide basis in the seventies. For this reason, specific studies related to these communications media could be among the most imminent ones to be carried out and government decisions related to the cable networks used by them could conceivably be required soon.

3. METHODOLOGIES

There are various methodologies which may be used in a study to develop new information, ranging from simple reviews of literature to sophisticated mathematical models. Normally more than one methodology will be used in any study.

Since the purpose of the studies envisaged in the Information Improvement Program is forecasting and evaluation, the methodologies may be classified broadly according to these categories.

Forecasting is basically the prediction of a future value or state of a specific variable or group of variables. If not qualified (such as "optimistic" or "pessimistic") a forecast usually predicts what appears, at the time of the forecast, to be the most probable future. Often, alternative futures are forecast, based on different sets of assumptions.

Evaluation is basically an examination of alternatives to establish how the variation of certain quantities or conditions affects the outcome and to rank the alternatives in terms of desirability.

There is no clear dividing line between forecasting and evaluation since the latter is usually based upon several forecasts. Nevertheless, evaluation is distinguished by the application of value judgement to compare advantages and disadvantages in a systematic manner.

Methodologies serving both forecasting and evaluation are:

- literature reviews and interviews
- logical estimates.

Methodologies of a predominantly forecasting character are:

- trend projections
- mathematical models.

Methodologies of a predominantly evaluating character are:

- experiments
- surveys
- cost/benefit analyses.

As mentioned, the dividing line between the groups is not definite. For example, mathematical forecasting models can be used repetitively using different variables and the outcomes compared with each other, thus accomplishing a form of evaluation. The evaluation of the costs and benefits of certain alternatives could point to the probable choice of one which may change future trends; this method can thus provide a basis for forecasting.

In the following sections the various methodologies will be briefly described, with a somewhat wider discussion of the methodology of mathematical models.

Literature Reviews and Interviews

These methodologies are rather trivial and listed only for the sake of completeness. Obviously any type of study would begin with a review of what has already been done, which includes a review of published material as well as interviews with people knowledgeable in the particular field.

Logical Estimates

Making estimates or "educated guesses" is often a useful method of forecasting or evaluation. It may be used when:

- there is no other way of predicting something (such as, for example, the market share for a yet unfamiliar product that will be marketed by several competitors)
- the range of possible alternatives and the accuracy requirements are such that a more complex study is not justified
- the results are not very sensitive to the estimated factor within the range of estimate.

In most cases estimates have to be used for non-quantifiable variables; these are common in the areas of sociology and psychology.

The simpler the activity or characteristic the easier it is to make a realistic estimate for it. Therefore, the reliability of estimates can be greatly improved by breaking down the problems into smaller elements and making separate estimates for each.

Trend Projections

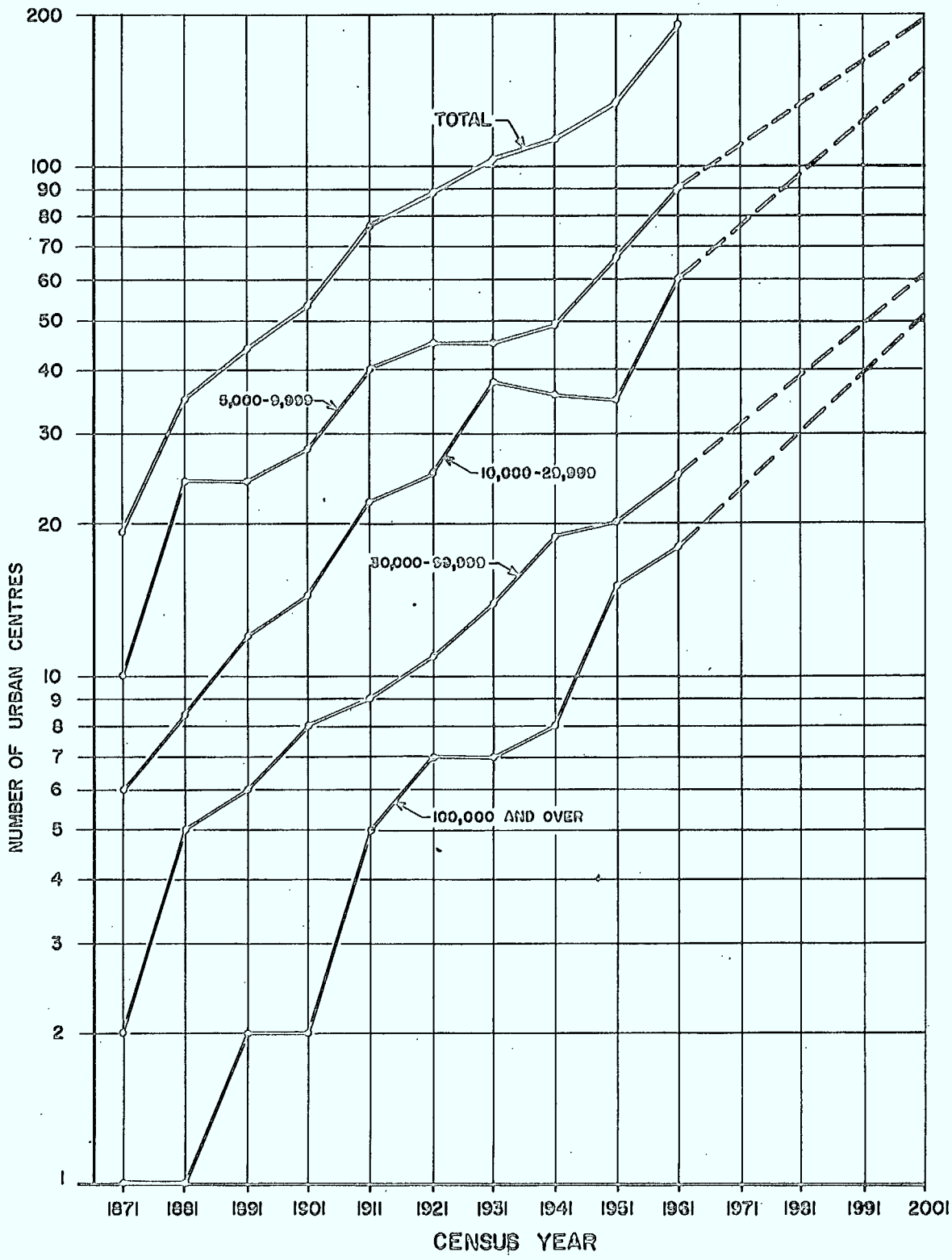
Trend projections are widely used since all they need is an accurate series of historical data. These are plotted graphically, often on semi-logarithmic graph paper on which exponential growth is represented by a straight line. Random variations are smoothed by fitting the straight line to the data using the least-square method of curve-fitting. The line is then continued (extrapolated) into the future.

Straight lines on the semi-logarithmic-scale are sometimes not adequate, especially in the following events:

- when a "market share" increases significantly during the growth process and competitive or political forces are expected to exert increased influence, slowing down or even stopping further growth
- when the growth rate is much larger than growth rates in other major areas, such as that of the gross national product.

The two events often occur concurrently. In such cases a "saturation" is experienced and the growth rate decreases, changing the straight line into a flattening curve on the semi-logarithmic scale.

One way of correcting for a changing growth rate is to plot the time series of the growth rate on semi-logarithmic paper and extrapolate it to estimate future rates. A growth rate following a downward straight-line trend would produce a smoothly saturating growth curve.



NUMBER OF URBAN COMPLEXES OF 5,000 AND OVER, BY SIZE GROUP, CANADA, 1871—2001

FIGURE 7

NOTE: FOR SOURCE SEE APPENDIX F

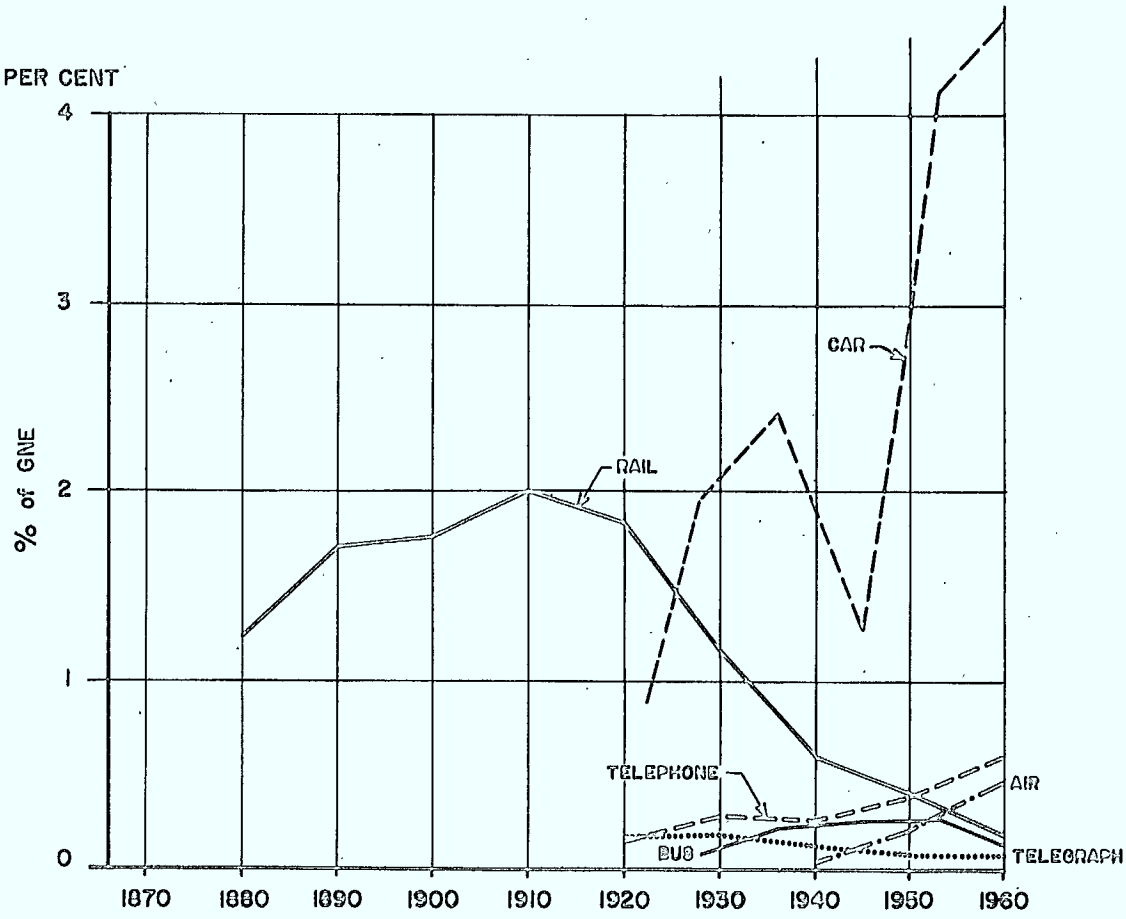
A further sophistication can be introduced by breaking down the activities to be predicted into smaller categories and preparing a separate projection for each. For example, the usage of a certain facility may grow faster by a low income population group than by a high income group. By forecasting the magnitude of these groups and then applying different projections to each, a more accurate forecast can be obtained.

It is obvious that the realism of the forecast decreases with the number of years involved in the forecast. It is important not to extend projections beyond the number of years for which the forecast can be used with reasonable confidence and definitely not for a future period that is longer than the past period on which the projection was based.

When fitting a curve to past data it is possible to apply weights to the variances which decrease with the "age" of the data and minimize the weighted variance.

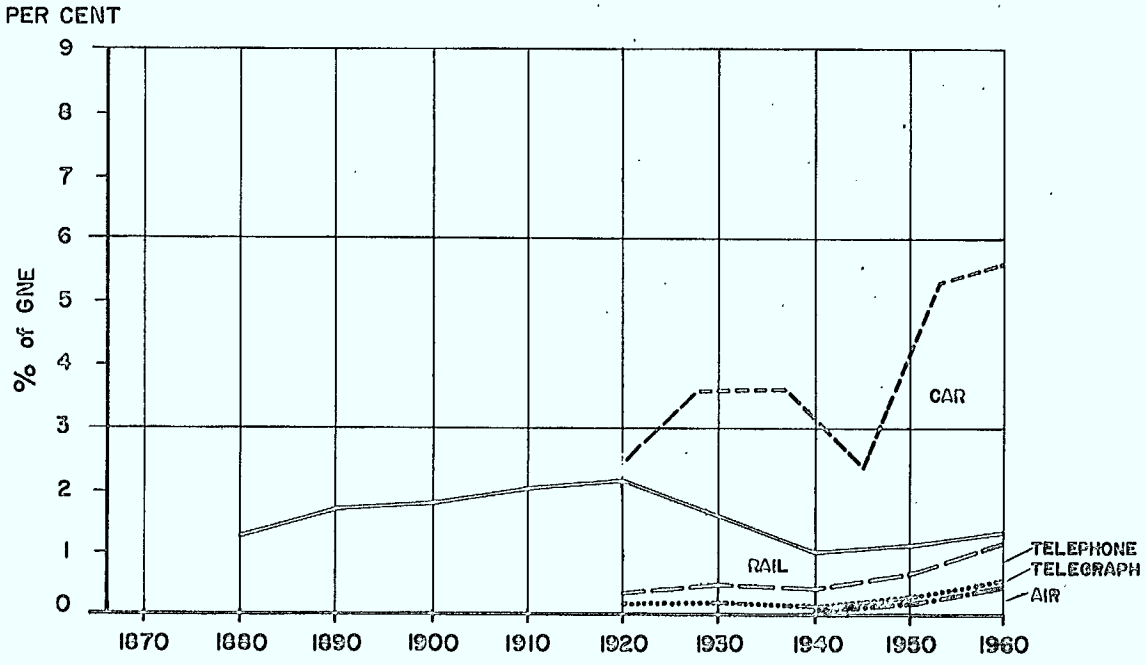
Figure 7 opposite shows an example of rather consistent trends. The number of Canadian urban centres within various population ranges grew at an approximately steady rate from 1881 to 1961, with the exception of the centres over 100,000 which did not pick up until after the turn of the century. The number of urban centres in each range is roughly doubled every 30 years; this trend is projected in Figure 7 from 1961 to 2001.

Figure 8 overleaf represents an opposite example. It shows how misleading it would have been if someone had projected the use of



% OF GROSS NATIONAL EXPENDITURES
ON INTERCITY TRANSPORTATION & COMMUNICATION

FIGURE 8a



CUMMULATIVE % OF GROSS NATIONAL EXPENDITURES (GNE)
ON INTERCITY TRANSPORTATION & COMMUNICATION

FIGURE 8b

NOTE: FOR SOURCE SEE APPENDIX F

passenger rail transportation in 1910, based on the trends between 1880 and 1910. Whereas the bottom diagram shows that cumulatively the spending on passenger transportation and communications grew steadily as a percentage of gross national product from 1880 to 1960, the appearance of the automobile, aircraft and other modes cut decisively into the railways' market share reversing their growth trend in a most significant way.

Mathematical Models

The term "model" as it is used here means any mathematical representation of the real world that allows the study of various systems involving transportation and communications media. A model could permit the study of the impact of a particular medium on population settlement patterns and regional economic development. Another type of model could, conversely, enable one to study the impact of population and systems characteristics on the usage of a particular medium.

These models all deal in one way or another with people. That is, they are designed to study various effects of service systems on people or various effects created by people on the systems. For this reason, they can be called behavioural models, although this term has sometimes been used in the past to describe a smaller and more restricted set of models.

Behavioural types of models have been developed for a wide variety of purposes in the past. For example, traffic prediction models have been used to determine traffic volumes that might be anticipated on pro-

posed new urban expressways or rapid transit systems, resulting from possible future distributions of residential, commercial and industrial development. Land use models have been developed to deal with the inverse problem, to determine the effects of different types of transportation and other services or policies on land use development patterns.

When a specific problem arises, very often a new type of model has to be developed due to the fact that none currently exists that will work adequately in the new situation. For example, modal choice models were developed and have been used successfully for many years to study urban transportation systems. However, they deal generally with only two modes of travel, private automobile and public transit. As more interest developed in inter-urban transportation systems in recent years involving four modes of travel (air, rail, bus and auto) the former modal split models were found to be inadequate and new multi-mode type of models had to be devised. Thus, although quite often it is possible to borrow concepts from similar situations, existing models are not usually directly applicable in a totally new problem area.

For TRANSCOM System models it will be possible in several instances to borrow from similar or analogous models that have been developed for other specific problem areas. By bringing these together and synthesizing the remainder, a complete model system can probably be constructed to handle the problems of TRANSCOM Systems.

It is not expected, however, that any of the existing models can be used directly for TRANSCOM Systems. Such models should be de-

veloped as part of the Information Improvement Program, using and/or borrowing as much from existing models as possible.

The remainder of this section will discuss broad generalizations about model types, the areas from which models can be borrowed including examples and their evaluation.

Types of Models

Models can be categorized in many different ways but it is useful in this discussion to consider only two primary categories, statistical and non-statistical models. Statistical models are those which require large amounts of time-series or cross-sectional data to develop the mathematical relationships using standard techniques of statistical analysis such as multiple linear or non-linear regression analysis, factor analysis, etc. By their very nature, these types of models usually require large amounts of behavioural observations in the form of sets of data in order to develop the required mathematical relationships.

Non-statistical models on the other hand are developed with a minimum of quantified observed data and parametric techniques are not used for the development of the relationships.

Instead of a dichotomy, there is really a continuum between statistical models and non-statistical models. None of the models that will be evaluated in this section are completely non-statistical; they are all based on a certain amount of quantified behavioural observa-

tions. The distinguishing characteristic of these models is that when observed data is not readily available, the required relationship is imputed based on logic and/or a micro-analysis of individuals' behaviour. The validity of the relationship is then checked through a trial-and-error process of actual trial applications of the model, and the parameters of the relationship are adjusted as necessary until the model performs satisfactorily.

Quite often during the development of a model system it is useful to think of and develop a framework which embodies the whole process in the problem area. During the staging of model development it will be possible within this framework to proceed through a micro-analysis or micro-model phase to a macro-model phase. The micro-analysis phase should rely heavily on experimental design techniques to help identify cause and effect relationships leading to the construction of the operational model or macro-model. Once these cause and effect relationships are identified the macro-model will be able to deal with relatively large groups of individuals whose relevant characteristics are similar.

Model Sources

As mentioned above, it will be possible to borrow modelling techniques for TRANSCOM Systems from other areas. These techniques fall into two classes: flow models and allocation models.

(i) Flow Models

These models are characterized by their ability to simulate and forecast volumes of interchanges spatially and to make assignments to the various facilities and services that are provided.

There are generally four major components to the flow modelling process. These are:

- generation
- distribution
- choice of facility type
- facility assignment.

In the generation process the number of transactions (i.e., messages or trips) originating and/or terminating in various geographic locations is estimated as a function of the development or economic activity in each of these locations.

The distribution process simulates the volume of these transactions occurring from each geographic location to each other geographic location in the spatial system being studied. Factors involved in determining distribution characteristics could include the cost and time for the transaction to take place (both of these could be related to distance) and other attributes of the system (as convenience, reliability) and of the users (as income, purpose of transaction).

Once the total volume of transactions between geographical areas has been established by the distribution component, the next

process is to allocate the transaction to the types of transaction facilities which are available to the user. The choice of facility type will be determined by the needs and preferences of the users within the range of those facilities available to them.

The final process is one of assignment to an actual physical facility. As before this could be based on time or cost or on other physical constraints of the system. If there is only one physical facility within a type then this model component is, of course, redundant.

(ii) Allocation Models

Allocation models are being used in urbanized regions to allocate growth and to forecast changes within the region of population and employment distribution patterns. The models are based on the concept that the changes in patterns are the results of locational decisions by family units and by commercial and industrial establishments, and that these decisions are functions of public development policies as well as of existing patterns and trends. The allocation model gives no indication of policy effects on overall regional growth rates; these must be provided independently by an economic base study.

The framework for developing these types of models should usually be capable of accommodating theoretical reasoning followed by empirical testing. The resulting model is then a mathematical technique capable of predicting sub-regional development patterns of demographic

and economic activities based on observations and measurements of various independent and causal factors occurring over a historical time interval.

This type of model should be applicable on a national scale for estimating the effects that various forms of transportation and communication systems would have on regional growth rates. Just as for the application of growth allocation models in smaller urbanized regions, a national allocation model would have to take account of all the significant factors which contribute to differential regional growth rates.

Criteria for the Evaluation of Models

Many different models have been developed within the two classes that have been described briefly above. The following are the most important criteria for a broad evaluation of the existing models in these classes to determine which of them would be most applicable for TRANSCOM Systems planning.

(i) Sensitivity to the Correct Variables

The models developed must be sensitive to the variables describing the transportation and communications systems being studied. The models must be capable of detecting the influences created by the systems as well as the effects on the systems themselves.

(ii) Realism

In order to have confidence in using the model for predictive purposes, particularly with new types of systems, it is essential that the relationships of the model are logical and agree with observed behaviour patterns.

(iii) Expandability

The structure of the model system should allow each model to be geographically expanded and contracted as necessary. In addition the model framework should permit expansion of the model system itself as more is learned through its use and through the availability of new data sources. In other words, the model system should be constructed, wherever possible, in a modular form so that when more information is gained about how a particular module can be refined, this can be done without any disruption to the rest of the model system.

(iv) Past Date for Calibration

Some models, particularly the statistical ones, quite often require large amounts of historical data before they can be adequately calibrated. In selecting any component for the model system, care should be taken to ensure that the data required to develop the relationship in required form are either available or could be made available without an unduly large amount of effort.

(v) Information Requirements for Forecasting

Assuming it is possible to calibrate the model with the available data, it is also important that the model be capable of being run

for some forecast period over which it is possible to estimate other independent variables required as input to the model.

Determining the Coefficients

The model coefficients which define the relationships between variables can be determined by statistical or non-statistical methods. To illustrate the two methods with a hypothetical example, consider the number of private and business telephone calls.

If it is found that in locations where the number of business subscribers is three times the number of private subscribers and the total number of calls is 33 per cent higher than in locations where the two types of subscribers are equal in number, one can use statistical (regression) techniques to conclude that the average number of calls per business subscriber is probably five times greater than that of the private subscriber. This is the macro-method, also called the statistical or the indirect method.

On the other hand one may apply another method, which is alternately called the micro-method, non-statistical method, or direct method. According to this one simply observes a proper sample of subscribers and reaches the same conclusion directly.

Whereas the macro-method (or indirect method) relies entirely on observed overall relations and does not probe into the reasons behind them, the micro-method (or direct method) establishes the relations by analyzing the basic activities that produce, in aggregate, the overall effects.

The disadvantages of the macro-method are:

- it usually requires large amounts of data
- deviations between different locations or between different points in time never occur in isolation and therefore statistical techniques do not always yield significant correlations.

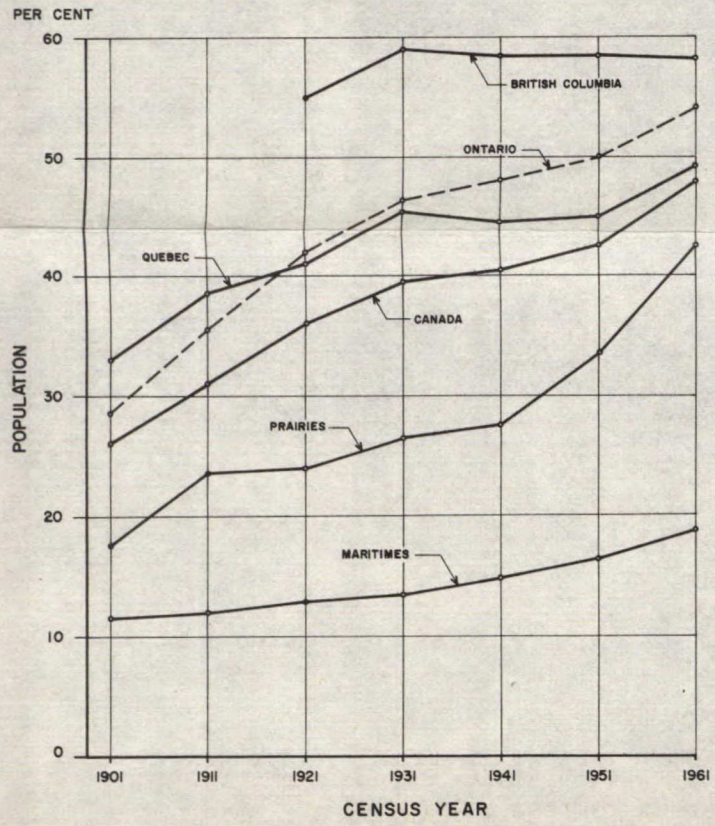
The disadvantage of the micro-method is the cost and difficulty of selecting a sample of a manageable size that represents all subscribers adequately.

Selecting the Number of Variables

Selecting the proper number of variables is a very important consideration. There are dangers involved both in selecting too many and too few.

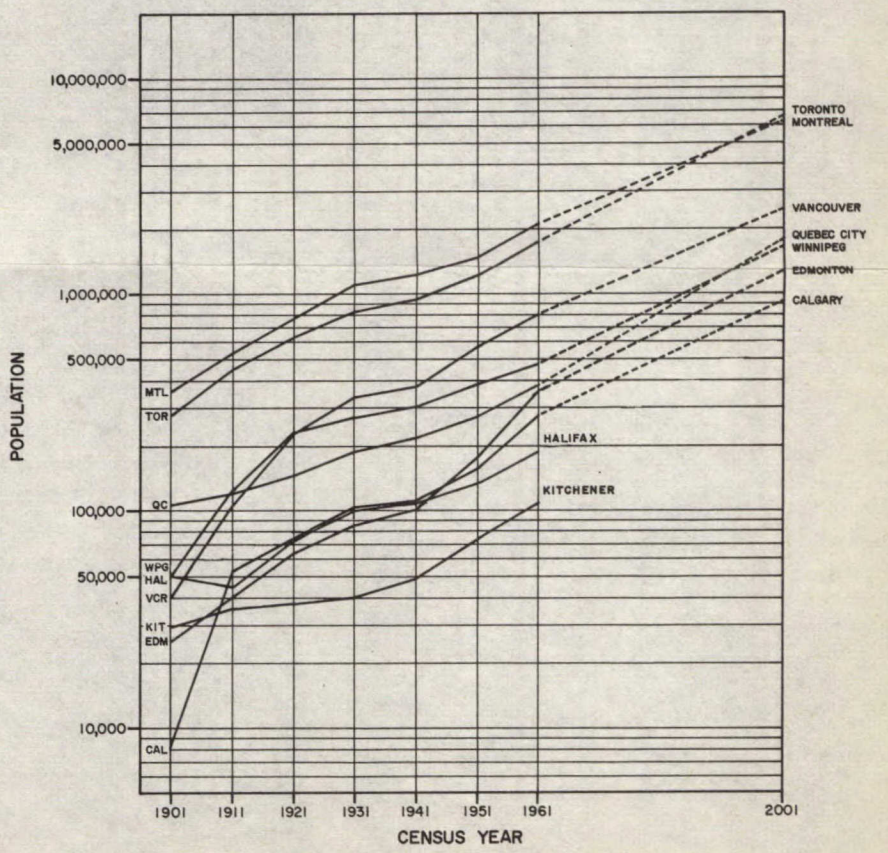
Selecting Too Many Variables

With too many variables the models become unwieldy and difficult to handle. An editing activity should therefore always precede the definition of the model structure to determine on a purely logical basis whether or not a particular variable may affect another in a significant way. Such preliminary investigation based on a few "micro-studies" may reveal that certain suspected correlations, although qualitatively existent, are quantitatively insignificant in view of the required accuracy and would therefore unnecessarily complicate the model.



% OF POPULATION IN PRINCIPAL REGIONS OF METROPOLITAN DEVELOPMENT

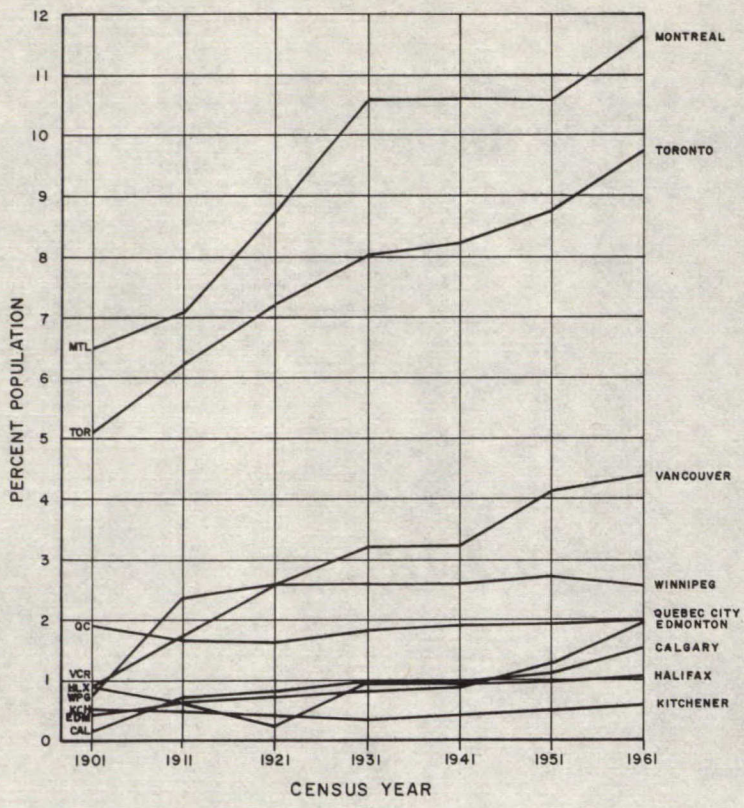
FIGURE 9a



GROWTH OF 9 MAJOR CANADIAN CITIES

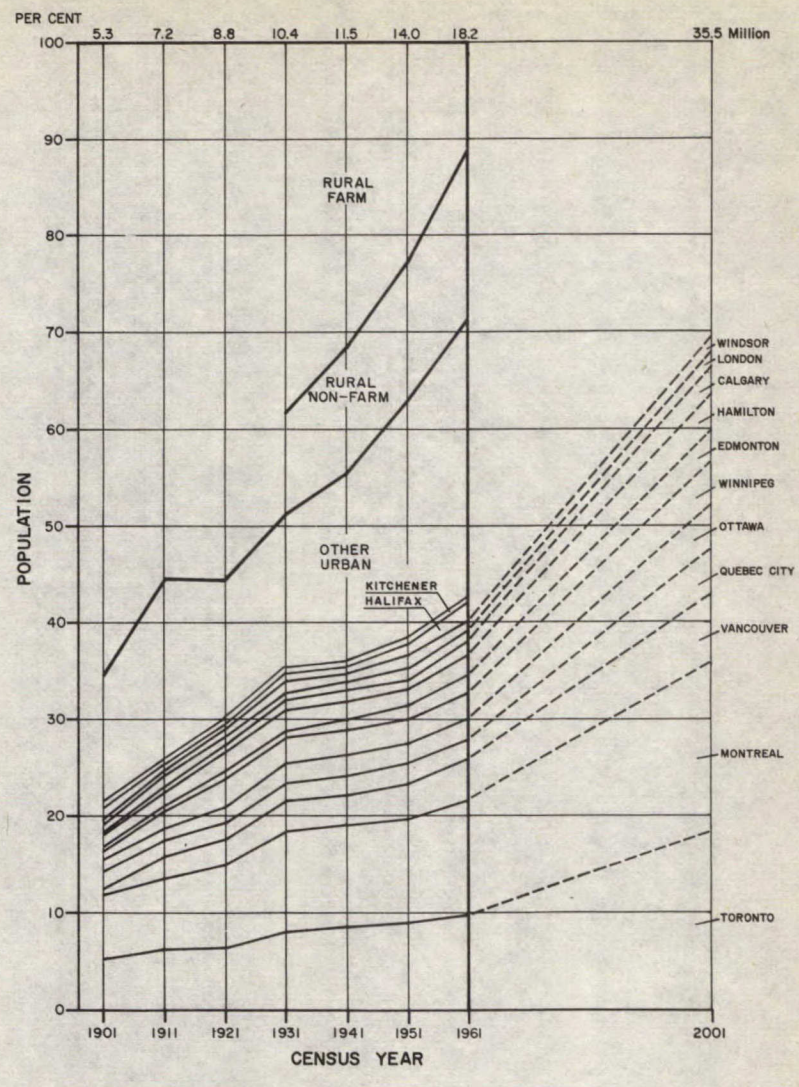
FIGURE 9b

NOTE: FOR SOURCE SEE APPENDIX F



POPULATION OF SELECTED MAJOR CITIES AS % SHARE OF CANADA'S POPULATION

FIGURE 9c



CUMULATIVE POPULATION DISTRIBUTION IN CANADA 1901—2001

(13 CITIES)

FIGURE 9d

Selecting Too Few Variables

On the other hand, if significant variables are not included in the model, even though they may be outside the scope of the correlations to be investigated, the model will not be reliable.

Figure 9 opposite illustrates this point. It can be seen that the percentage of people living in Metropolitan areas changed differently in the various regions over the years. A model that tries to establish the effect of communications on urbanization would not succeed unless most of the major variables causing this difference are included in the model.

An even more pronounced difference is shown in the growth of selected cities. For example, the growth of Edmonton between 1941 and 1961 was much faster than that of Winnipeg. Since such a difference could probably not be explained by the impact of communications and transportation alone, one would have to include more variables to explain it, otherwise the difference would be considered by the model as random. Random variations of such magnitude would reduce the sensitivity of the model to such an extent as to seriously jeopardize its usefulness regarding the detection of correlations between the variables included in the model.

Substitutive and Synergistic Effects

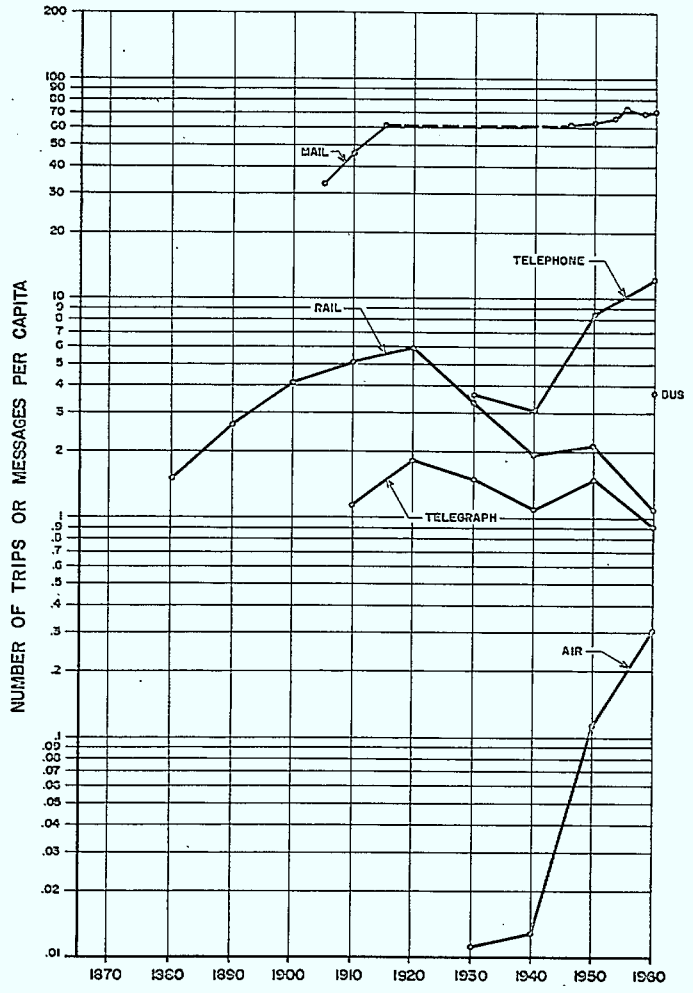
There has been much discussion, on a qualitative basis, about the substitutive and synergistic effects between communication media and transportation modes. If a flow model can be developed, it would shed more light on these effects in a quantitative way.

A substitutive effect means that an increase in the demand in one medium will cause a decrease in the demand for another. For example, it might be found that a decrease in the demand for air travel may increase the demand for telephone calls because people may switch from personal visits by air to telephone conversations.

The existence of substitutive effects could be proven, for example, by investigating the short term demand changes in telephone calls during an Air Canada strike. However, one should be cautious not to jump to general conclusions from the observation of such abnormal conditions as a strike without appropriate analysis. In the complete absence of one alternative, people will obviously choose the "next best", yet this alternative could be so far from the "best" in terms of price, service level or value, that under normal conditions one may not be a substitute for the other, regardless of what happened during a strike.

A synergistic effect means that various parts of the TRANSCOM System have a cooperative and mutually reinforcing effect and thus yield a total system, or system use, that is greater than the sum of its individual parts. For example, a personal trip may generate a number of telephone messages regarding hotel reservations, messages associated with transportation reservations, telephone calls directed towards advance arrangements of meetings, etc., so that an increase in travel of this type could cause an increase in communications demand.

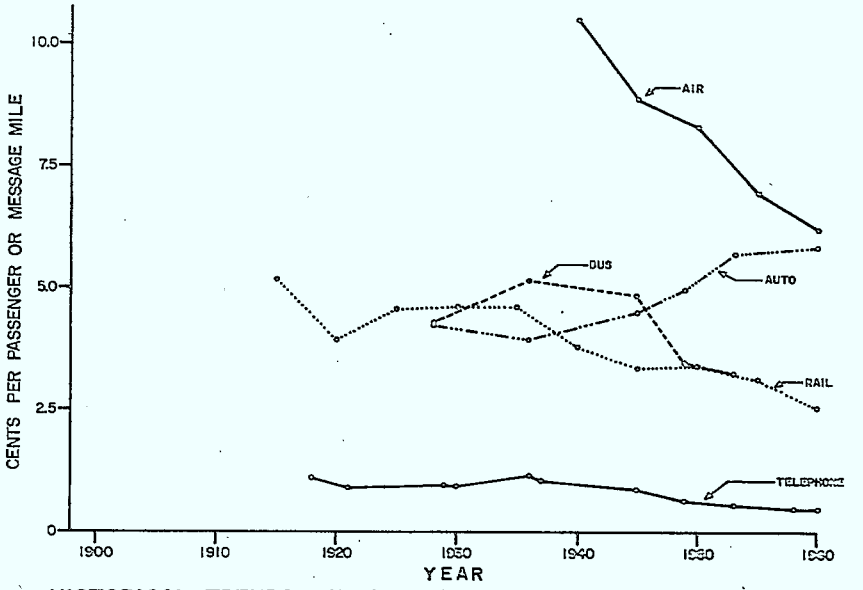
The question is whether the volume of such messages is significant in terms of all messages or whether transportation is similar in significance to the many human activities which generate telephone messages and which are too numerous to be analyzed individually for planning purposes.



NUMBER OF TRIPS OR MESSAGES PER CAPITA BY MAJOR TRANSPORTATION AND COMMUNICATION MEDIA

—INTERCITY—

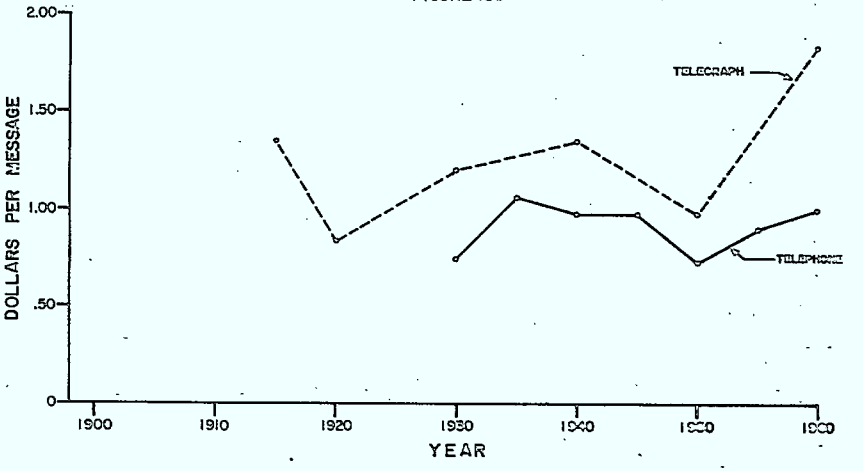
FIGURE 10a



HISTORICAL TRENDS OF COSTS PER PASSENGER OR MESSAGE MILE FOR MAJOR INTERCITY TRANSPORTATION & COMMUNICATION MEDIA

—CONSTANT (1960) DOLLARS—

FIGURE 10b



HISTORICAL TRENDS OF COSTS PER MESSAGE FOR SELECTED COMMUNICATION MEDIA

—CONSTANT (1960) DOLLARS—

FIGURE 10c

NOTE: FOR SOURCE SEE APPENDIX F

It is conceivable that within various communication media or within various modes of transportation the effects would be mostly substitutive. Figure 10 opposite shows, for example, how the usage of telegraph has fallen while the usage of telephone increased. This appears to be a substitutive effect, partially explained by the relative increase in the cost of telegrams as opposed to telephone calls, as shown on the bottom graph of Figure 10, and probably also explained by the development of better technologies such as TWX and Telex.

The effects between one communication medium and one transportation mode could be either substitutive or synergistic. It is easy to see qualitatively that such substitutive and synergistic effects exist. The question is whether quantitatively these effects are sufficiently significant to be considered in planning. For example, if a change in price or service level were to cause a switch from a transportation mode to a communications medium, that would change the volume of either by say, more than 20 per cent, one should consider such an effect in the planning process. On the other hand, if the envisaged change in volume is, say, less than five per cent, one would regard such an effect as being within the range of expected random variations and not complicate the planning process by giving it special consideration.

In summary, whereas interactions between communications and transportation obviously exist, whether or not communications and transportation should be planned in concert depends on the quantitative extent of the interactions which should be determined in the Information Improvement Program.

Evaluation of Existing Models

There are no models ready and available for the particular problems of TRANSCOM Systems. It is possible, however, to examine particular examples of models conceived for other problems which are similar in nature and analyze their usefulness to the TRANSCOM Systems approach. Particular elements can be chosen from these models to adapt and synthesize them in order to obtain a new model that will meet the needs of TRANSCOM Systems.

In the following sub-sections examples of models will be reviewed which have some of the characteristics required by TRANSCOM Systems and which possibly could be adapted or modified to meet these requirements.

Multiple Regression

Multiple regression is a widely used method and is one of the basic building blocks of many types of models. Multiple regression analysis is used, for example, to determine the relationship which may exist between the growth of traffic and a number of economic or sociological indicators whose future course can be determined with some degree of accuracy. These indicators usually include such variables as population, gross national (or regional) product, income (gross net disposable, etc.), years of schooling, degree of urbanization, number of cars per population and a host of others. This will produce a relationship of the following general form:

$$y = a_0 + a_1 x_1^{\beta_1} + a_2 x_2^{\beta_2} + - - - - - - + a_n x_n^{\beta_n}$$

The number of terms depends on the number of significant indicators that are found. In the simplest case the exponents of the independent variables (β_1, β_2, β_3...) are equal to one in which case the relations are linear.

In the so-called log-linear relation to the logarithm of x is used instead of x.

There are two basic ways of determining the coefficients (a_1, a_2, a_3...).

Some of the coefficients can be determined in a direct way. By this method one tries to establish to what extent an independent variable (x_1, x_2, x_3...) affects the dependent variable (y) through in-depth surveys, experiments or other methods which provide insight into the relationship between the dependent variable and the specific independent variable. This approach is termed the "micro-approach", (non-statistical or direct approach). While observing the variation of the dependent variable during the variation of one of the independent variables all the other variables have to stay constant. To achieve this in practice is the major difficulty of this approach.

One of the most significant roles of the "micro-approach" is to discover whether a variable has <u>any</u> significant effect at all on the dependent variable. If not, the term can be omitted. The micro-approach should therefore be tried first, where feasible, to identify which variables are relevant and which can be omitted.

The other approach is the "macro-approach" (statistical or indirect approach) in which all independent variables are allowed to vary. In this approach the number of observations must exceed the number of unknown coefficients and, to gain confidence in the method, their number should exceed that of the coefficients substantially. The determination of the coefficients by this method is called multiple regression.

To obtain a sufficient number of observations, one must either obtain data for different points in time for a location or, if data are not available for a sufficient number of points in time, for a sufficient number of similar locations.

For all types of models an understanding of the cause/effect relationships is imperative. Statistical or "macro" methods indicate relationships between variables but do not indicate which variable is the cause and which is the effect.

For example, statistics show that there has been a good correlation between passenger volumes and fares or passenger volumes and frequency of service. It is by no means clear, however, that passenger volumes increased because of lower fares or whether fares could be lowered because of increased traffic. Similarly, it is not clear whether more frequent service was made possible by increased traffic or whether the traffic increased because of more frequent service.

These questions are of vital importance for a forecasting model and can normally not be answered without direct or "micro"-analysis. They underline the importance of pilot projects, where feasible, to demonstrate the causal relationships under controlled conditions.

Traffic Models

Traffic models are typical of flow models in a general sense. They have been developed for forecasting urban or interurban traffic volumes under various conditions.

Traffic models attempt to relate flow demand by travel modes to two types of data for cities or regions in question:

- socio-economic data, such as population, employment, income, leisure time, etc.
- transport system data, such as travel time, cost, convenience, comfort, reliability, etc. of all available travel modes.

It is assumed in traffic models that the derived relationships incorporated in the model will hold true or nearly so over the forecasting period. Trend projection is therefore required only for estimating future values of the socio-economic variables. The model is then applied using these as input to estimate travel demand via each mode of travel for each proposed future transport system with its associated travel times, costs and convenience measures for each mode.

The most important types of traffic models which have been developed or are under development for estimating inter-city demand are summarized in Appendix D.

As indicated on Page II-39, most traffic models carry out the forecasting process in four stages, as follows:

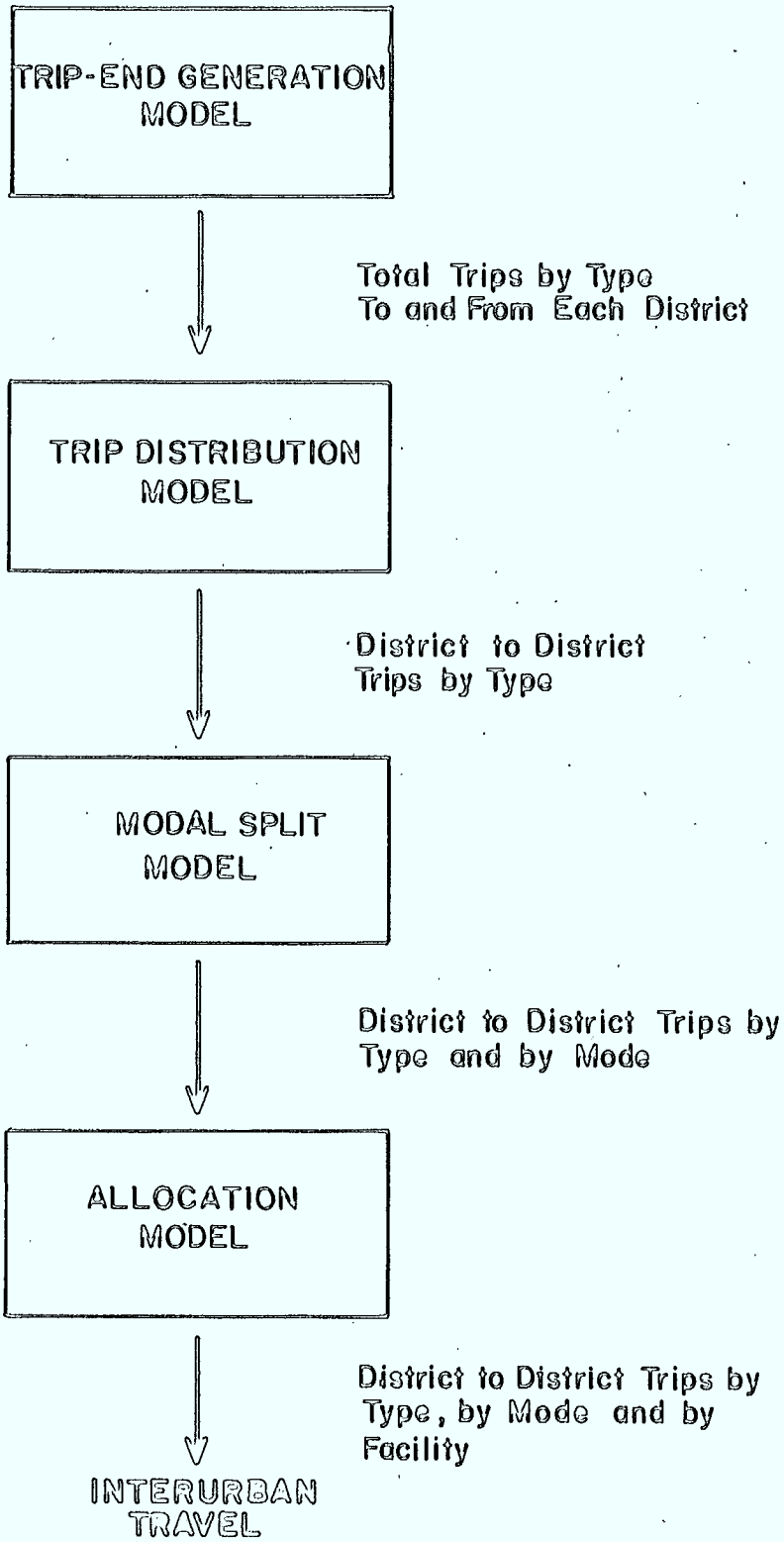

TRIP-END GENERATION MODEL
Total Trips by Type To and From Each District
TRIP DISTRIBUTION MODEL
District to District Trips by Type
MODAL SPLIT MODEL
District to District Trips by Type and by Mode
ALLOCATION MODEL
District to District Trips by Type, by Mode and by Facility
INTERURBAN TRAVEL

FIGURE II

1. Trip-end Generation is estimated on the basis of socio-economic and (in some cases) transportation network variables.

2. Based on estimates of trip-end generation, the Trip Distribution is estimated in a mode-sensitive manner utilizing a gravity formulation.

3. Modal Split is estimated by a mathematical model comprising socio-economic and transportation network variables.

4. Assignment of trips to specific routes and facilities within the selected modes of travel is shown on a least-time or least-time/cost basis.

The consecutive application of Stages 1, 2, 3, and 4 as shown in Figure 11 opposite provides estimates of inter-urban travel by modes separately for various trip categories as described by the income level of the traveller, type and purpose of trip, size of group travelling together, and other possible bases of stratification.

Advantages and Disadvantages of Traffic Models

For purposes of TRANSCOM Systems, traffic models such as those described above could have a number of significant advantages and disadvantages. Some of the advantages are as follows:

- sensitivity to specific transport and communication system and service changes on each network segment
- sensitivity to specific socio-economic changes in each city or region
- systematic and logical approach in which major assumptions must be stated explicitly
- great detail of forecast output, both by network segment, market segment, and media

- no reliance on trend projections for forecasts of variables which may change rapidly due to technological or transport system changes - trend projections are restricted to more slowly changing socio-economic variables which are used as input to the traffic model

- computerized model can quickly produce required forecasts for a large number of assumed transport system and/or economic development alternatives.

Some of the disadvantages are as follows:

- considerable data requirements (past and/or present) for calibration; demand data are necessary by origin-destination and by media, as are travel time, cost and convenience data for each relevant medium

- explicit assumptions are required concerning the time, cost, and convenience characteristics of each medium in the future, for each network segment

- explicit socio-economic projections are required for each city or district connected into the network

- because of the volume of data handled, usually computerization is required with resultant escalation of development time and cost

- model complexity may lull the analyst into a feeling of false security concerning the forecasts produced.

Recommendations
Regarding Flow Models

In the area of flow models, there are two major components where there exists a choice of approaches. These are in trip distribution and in modal split. In deciding which methodologies to borrow for TRANSCOM Systems an important criterion should be the ease with which

the model can be developed using data readily available or obtainable without a large expenditure of effort initially.

The gravity model is recommended for the distribution stage because of its superiority to the growth factor method and because it requires much less data to calibrate, is easier to apply and is comparable in effectiveness to the opportunity model in this application. It will be necessary to do much analysis, however, in order to determine the variables which are significant in the distrubiton process for each of the media being considered.

Again, in the modal split stage, the market segment-diversion curve approach is the easiest to apply, has the least stringent data requirements and is therefore recommended for this application. As more information and experience is gained in the application of the model in real situations, more refined techniques may be suggested. However, there are obvious advantages in embarking on the development of a model system in a new area of analysis using relatively simple tried and proven techniques borrowed from other areas.

Both for the gravity model and for the market segment-diversion curve method the principle criteria for estimating user volumes have been described in Section II.2 of the report. These are: distance, price, service level and service value.

The market segment-diversion curve method of determing modal split is a model for substitutive effects of transport modes and/or

communication media. It is not applicable for the representation of synergistic effects.

Allocation Models

Allocation models answer the inverse questions of the flow models. Whereas flow models predict the transportation flow characteristics of links connecting locations with given demographic and socio-economic characteristics, allocation models predict the demographic and socio-economic characteristics of locations connected by links with given transportation characteristics.

Allocation models have tended to be developed for predicting land use in problems of urban and regional planning. Their techniques are used to determine where, in the urban space, will be located the set of activities considered in the model, given the total amount of activities within the urban space as a whole. The latter is determined outside the model for some future year and used as an input.

The development of allocation models is more difficult than that of flow models because it is harder to identify the causes of people's spacial behaviour and the process by which they make their choice of where to live or work. Their choice is affected by many factors outside the scope of transportation and/or communications which are of at least equal importance. The complexity of these factors makes it difficult to estimate, from past information, the marginal effect of transportation or communications on the spacial behaviour of people.

From the above discussion, it can be inferred that the use of a statistical or macro-approach may prove to be very difficult. It is imperative that we first attempt a better understanding of the underlying processes. This can be achieved by studying the system directly through a micro-approach and using process type models that require little data or logical relationships.

Several examples of models used in land-use allocation type problems are described in Appendix D.

Recommendations Regarding Allocation Models

It can be concluded from the Appendix that all the allocation models developed have drawbacks of one kind or another. However, the regression approach described in the Appendix is probably the least complex and easiest to apply, particularly in a relatively new area of model building such as TRANSCOM. It does have rather stringent data requirements; however, most of the data required are available at present or can be synthesized, if necessary, until better information becomes available.

A point of major importance that has to be investigated further before any development of an allocation model is undertaken is the possible difficulty of calibration.

Since transportation links have different characteristics between various points in a region, a cross-sectional calibration of a model is possible. For example, high-quality links in one location will be associated with a different settlement pattern than links of lower quality in another location.

Communication services, unlike transportation services, are, however, not introduced or improved in specific locations (like a new highway or transit line). Communication services are usually introduced or improved sumultaneously in a wide region.

It may be found that this basic difference between communication and transportation services and the resulting difficulty of cross-sectional calibration makes it difficult to develop a statistical model for establishing the relationship between communications and settlement patterns and that therefore direct or micro-methods must be used for that purpose. This question will require study as part of the Information Improvement Program.

Experiments

Experiments are based on observations of a sample of the total population. Experimentation is one of the most direct methods of forecasting and evaluation, since it actually creates the situation or the environment for which the behaviour of a system or of people is to be predicted.

The methodology of experiments is a well-developed discipline and many textbooks have been written on the subject. The most important characteristics of an experiment are:

1. The sample should be representative of the population. This means that, in the sample, all the characteristics that are important relative to the purpose of the experiment should be distributed in the same proportion as in the population to which the results of the experiment will be extended. If this is not possible, the sample should be stra-

tified, that is, conclusions should be drawn for different groups within the sample separately and extended to the entire population in the same proportion as the particular group is represented in the sample.

2. The conditions of the experiment should be a faithful duplication of the future conditions to which inference will be made from the experiment.

3. Objectivity should be observed. This means that the conditions should not be affected by the fact that an experiment is being carried out. If the experiment is carried out with people, the best method for maintaining objectivity is to keep the people unaware of the fact that an experiment is being carried out. This is, however, often not possible and other ways have to be found to make people behave naturally, or answer questions truthfully.

4. Experiments with a control group are highly desirable. If similar experiments are carried out with two groups which differ in only one aspect, it can be ascertained that any difference between the two groups is a consequence of that aspect, and not of other uncontrolled factors.

An example of an experiment is the installation of videophones in various offices of the Westinghouse Electric Corporation in the United States for testing their usage in a corporate environment. According to information received from Bell Telephone, this experiment has now been discontinued.

Surveys

Like experiments, surveys are based on the observation of samples of a population. Whereas, however, in the case of experiments, the condition to be examined is created artificially, in the case of surveys the observations are made under conditions occurring naturally All of the observations made in connection with experiments regarding

the sample, the conditions, the objectivity, and the importance of control apply also to surveys.

Surveys fall, basically, into two categories: surveys of people and surveys of published information. In the first case, a large population of people is sampled; in the other case, a large population of data, or other type of information is sampled.

Surveys carried out on samples of people are either mass-surveys carried out on large samples but limited to a relatively small number of pertinent questions, or in-depth surveys carried out on small samples but probing into a much wider scope of information. Mass surveys use either questionnaires or quick personal interviews. In-depth surveys are almost always based on interviews and can either be:

- behavioural surveys probing into a person's past behaviour, or
- attitude surveys probing into what the person thinks or what he believes he may do under certain circumstances.

Cost/Benefit Analysis

Cost/benefit analysis is a method of evaluating alternatives through comparison. There are two important aspects in almost every cost/benefit analysis:

1. The costs and benefits of a certain alternative can usually not be expressed by the same unit of measure. That is, for example, a certain mode of travel can have a higher cost (expressed in dollars) but also a higher benefit in terms of time saving (expressed in hours). In order to decide

which of two alternatives is better, it is necessary to assign a cost to time in terms of dollars per hour. In other words trade-offs have to be established.

2. The costs and/or benefits often accrue to different groups or organizations. There may be several groups which bear the cost of a system and the same or other groups who gain benefits from it. It may occur that each group bears some of the cost and gains some of the benefits, but not in the same proportion. Often one group's point of view is viewed as more important to the decision-maker than that of another. In such cases different weights have to be applied to the costs and benefits accruing to the different groups.

The application of trade-offs and weights is normally the task of the decision-maker. The study carried out in preparation of decision making must present the results in such a way that the application of trade-offs and weights is relatively easy. This can be achieved in several ways, such as:

1. Alternative trade-offs and weights are suggested and their impact on the decision is given to the decision-maker so that all he has to do is to choose from a limited number of alternatives.

2. Critical values of the trade-offs or weights which would tilt a decision in one way or another are given to the decision-maker so that all he has to do is to decide whether his choice of trade-offs or weights is greater or smaller than the critical values.

Detailed cost benefit analyses should always be preceded by a broad evaluation. If, in such evaluation, it is found that the cost of a proposed system is higher than that of a competing system, and all the benefits are less, the conclusion can be drawn that the proposed system

will probably not stand up against its competition. If, on the other hand, it is found that the proposed system has a lower cost and yet all the benefits are greater, one would still have to examine how long it would take for the proposed system to gain ground over its competition in consideration of the inertia caused by socio-economic, political and behavioural realities.

Examples of
Cost/Benefit Analysis

An example of an excellent cost/benefit study is a paper published on the feasibility of broad-band party-line communication (electronic mail).* The paper is a broad evaluation of the conditions under which such a system could compete with mail and indicates that, in fact, it could cause a significant change in communications.

An example of a different method is a paper on the costs and benefits of a basically new social system in which employees would stay at home during work and be linked with their office via communications.** This paper identifies the trade-offs between costs and social values but does little more service to the reader than make him realize how immensely difficult it would be, if not impossible, to quantify them. (No results of further quantification along these lines have been noted in the literature.)

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* W.B. Gross: Distribution of Electronic Link over the Broad-Band Party-Line Communications Network. Proceedings of the IEEE, Vol. 58, No. 7. July 1970.

** T.J. Kealy: Transportation or Communications - Some Broad Considerations. IEEE Transactions on Communication Technology. Vol. COM-16, No. 7. April 1968.

Comparison of the two papers points to the fact that the electronic mail system is much closer to implementation than the "work at home" idea. The quantitative details in the first paper provide sufficient background to indicate that broad-band party-line electronic mail may be in the range of practical reality in the not too distant future.

On the other hand, one cannot avoid having doubts about the practical importance of the "work at home" idea in the next one or two decades. After all, the main objective of the idea is the reduction of city congestion. The same objective could be achieved through existing technology and without much change in the social structure simply by replacing private automobile travel by public transit. Yet for two decades, society has been unable to come to grips with this much simpler problem. It appears therefore somewhat untimely to look for a much more complex solution to the same problem as long as the simple solution has not been implemented.

4. DATA REQUIREMENTS

The pool of information to be developed in the Information Improvement Program will include a consiserable amount of data. The specific portion of an information pool that contains data is usually referred to as a data bank. In keeping with the general nature of the information pool, the data bank should consist of data expected to be of general use.

In this respect the role of the data bank would be very much like that of the information published by the Dominion Bureau of Statistics. It would serve many users and uses, many of them unknown at the time of publication. Accordingly, the gathering of the data should be considered a project in itself. The objective of this project should be the data development as a self-contained goal, serving government, industry and the public.

Any specific study, whether carried out by government, industry or others, would, of course, require additional specific data. However, it is expected that the data bank will assist researchers, both inside and outside the government, save time and help avoid duplications of effort.

To what extent the Department of Communications, the Dominion Bureau of Statistics or other government bodies should be responsible for the development of the data, should be a matter of later consideration. In this report a first attempt is made to tentatively identify the data

that could form the basis for the envisaged data bank.

Appendix B lists these data, grouped in three major sectors:

(i) Flow data

(ii) Price data

(iii) Demographic data.

Some of the data are related to the whole of Canada, others are related to selected cities or city pairs. These cities and city pairs should be selected in such a way as to form a representative sample of the country, in accordance with the principles outlined in Section II.1 of the report.

Various data categories are listed in each of the three sectors and each category is broken down into sub-categories. It is important to be able to cross-reference the sub-categories. For example, it is not sufficient to know how many of all telephone calls are "business-to-business" and, separately, how many are of "immediate" urgency, but one must also know how many of the business-to-business calls are of immediate urgency.

It is not foreseen that, for the time being, sectors should be cross-referenced. It would be a formidable task indeed to try to establish how many telephone calls are made in the individual categories, sub-categories, and their combinations, by individuals belonging to various income groups, occupation groups, ethnic backgrounds, educational backgrounds, etc.

The data sources are identified in Appendix B.

Most of the price data (Sector ii) can be obtained on a time series basis from Government records, since transportation and communication rates are subject to Government approval and must be published.

Data on passenger car costs are not available and must be developed. Similarly, costs or prices per passenger-mile, minute-mile or word-mile must be developed.

Demographic data (Sector iii) are mostly available from DBS publications on a time series basis. This is the most readily available data sector.

However, flow data (Sector i) are almost non-existent, and most of those which are available are proprietory. Some of the aggregate data are available, as noted in Appendix B, but none of the data are broken down into the sub-categories shown.

In order to acquire the data in the required detail, surveys would have to be carried out. These are envisaged to be time-consuming and expensive. They would require the consent of the people and organizations surveyed, which could make the selection of a random sample difficult.

In summary, the following steps are envisaged for the data collection task:

- Review of published data (see sources in Appendix B).

- Design of individual projects for obtaining data not found in publications. This should include:
    - studies of the feasibility of obtaining meaningful data,
    - the determination of sample sizes for surveys,
    - estimates of the reliability of projecting the sample results to the population, and
    - development of project methodologies.
- Implementation of the data collection projects.
- Evaluation of results and development of data for the data bank.

The task would require a high degree of cooperation between government, industry and the public.

The list of data shown in Appendix B is, of course, not complete. The need for more data will undoubtedly become apparent during the Information Improvement Program; these data will have to be added to the list as the need for them arises.

III - RECOMMENDED INFORMATION IMPROVEMENT PROGRAM

The implementation of the Information Improvement Program requires a clear definition of the tasks to be carried out and priorities assigned to the tasks.

In view of the present availability of information and the state of the art of methodologies it is recommended that the Information Improvement Program be carried out in three phases.

PHASE I:
- (a) General data collection
- (b) Basic studies
- (c) Preliminary design of specific studies

PHASE II:
- (a) Development of a Flow Forecasting Model
- (b) Examination of the substitutive and synergistic effects of various communications and transport media
- (c) Examination of the interactions between communications and population settlement through direct studies
- (d) Detailed design of specific studies

PHASE III: Development of a growth allocation model incorporating communications (if found feasible after the studies carried out under (c) of Phase II).

The proposed objectives and content of each phase are outlined in the following three sections. Approximate timing and manpower requirements for the Program are summarized in the fourth section of this chapter.

1. PHASE I

(a) General Data Collection

Data collection must begin at the earliest stage because of the time consuming nature of this task. The data which are foreseen to be required are listed in Appendix B. It is almost certain that the need for more data will become evident as the Information Improvement Program becomes more advanced.

The steps of the data collection task have been identified previously. These are:

- review of published data
- design of individual data collection projects
- implementation of data collection projects
- evaluation of results and development of data bank.

The effort required for the acquisition of presently unavailable data is considerable. The amount of effort can only be guessed at this time, and it is expected to be 10 to 20 man-years over a period of at least two years. In addition, considerable cooperation will be required of the surveyed people and organizations, for which compensations may have to be paid. The surveys outlined in Chapter II, Section 4, which would be initiated during a two-year period, would be continued at regular intervals to provide time series data.

(b) Basic Studies

Studies of a basic nature were listed in this report. The purpose of these studies is to provide insight into the motives of people

which ultimately influence their decisions, and indicate relationships between certain activities in a direct way. Although "micro-studies" of this nature could be complex they would require less effort than attempting to derive the same relationships through the calibration of mathematical models or "macro-studies". The development of such models should not be started until a basic understanding of the underlying relationships is developed through the proposed basic studies.

The proposed studies, described in more detail in Appendix C, are:

- A study of factors affecting personal preferences for various communications media and transportation modes
- A study of the location of businesses as affected by communications
- A study of the reasons for the migration of people and the impact of communications on their decisions.

The reason for the first priority of these studies is the fact that their results are needed for the next phases of the Information Improvement Program. Other studies have priorities because of imminent technological innovations which require the government to prepare itself for decisions it may have to make in the rather short-term future. Four studies have been identified in this category, all of a technical-economical nature:

- Review of the state of development and broad economics of broad-band party-line telegraphy (which may replace a significant portion of the mail in the near future)

- Review of the state of development and broad economics of broad-band facsimile transmission (which may replace another portion of mail)

- Review of the state of development and broad economics of the picturephone

- Review of the state of development and broad economics of the scribble-phone.

The studies are described in more detail in Appendix C.

(c) Preliminary Design of Specific Studies

In addition to the basic studies, there will be many specific studies which will become feasible as better understanding of the basic relationships is developed in the course of the Information Improvement Program. However, a design of such studies should be started in Phase I of the Program so that the development of information can be geared to the requirements of these specific studies as the Program progresses.

Possible studies could be related to such topics as the creation of hub cities in the North, the decentralization of Federal government departments, improvement of rural education through communications, etc. All of these would be multi-disciplinary studies, to which the Department of Communications would contribute only the expertise related to communications whereas other resources would have to be used for the many other aspects involved.

2. PHASE II

(a) Development of a Flow Forecasting Model

A Flow Forecasting Model would be a useful tool for the Department of Communications for the purpose of forecasting the demand for communications facilities - even without considering the interactions with transportation. Its use becomes even more important in connection with the planning of TRANSCOM Systems. Reference is made to the section on mathematical models regarding the development of such a forecasting model.

The development of a Flow Forecasting Model should concentrate on communications and on transportation provided that the interactions between communications and transportation are proven through direct methods to be significant.* In the development of the model maximum use should be made of the insight gained in the relationships as a result of the studies of Phase I and of the experience gained with transportation flow models.

(b) Examination of the Substitutive and Synergistic Effects of Various Communications and Transport Media

The examination of the substitutive effects of various communications and transport media have a higher priority than their synergistic effects since the economic and social impact of a substitutive effect is

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* The term "significant" must be defined at some stage. For example, one may consider the interaction between a communication and a transportation flow significant if the estimated switch by people from one to the other, following a change in price or service level, would affect either flow by more than, say, 20 per cent.

likely to be greater and of more concern to government than that of a synergistic effect. The latter may be found to affect only the carriers and even them only in a marginal way.

The examination of the substitutive interactions between the various media should follow the following consecutive steps:

- Development of the logic of substitution
- Collection of the supporting statistics
- Experiments, surveys, etc. carried out to obtain the missing information (direct or "micro" methods)
- Use of the Flow Forecasting model developed concurrently (indirect or "macro" method).

The model should be used for forecasting substitutive effects only as a last step after the various relationships and people's motives for choosing or switching between media have been thoroughly understood through such direct methods as experiments and surveys.

A switch from one medium to another can be envisaged, for example, for the following media:

From mail to: telephone

videophone

scribble-phone

broad-band telegraph

broad-band facsimile reproduction

From telephone to: telegraph

videophone

broad-band telegraph

travel

From telegraph to: telephone

broad-band telegraph

From travel to: mail

telephone

videophone

broad-band telegraph

broad-band facsimile reproduction.

(c) Examination of the Interactions between Transportation/Communications and Population Settlement Through Direct Studies

The interactions between transportation/communications and population settlement patterns should be examined first through direct methodologies, such as experiments, surveys, etc.

The first step should be to develop hypothetical scenarios which would qualitatively describe ways in which settlement patterns could change if:

- the price of transportation/communications were to decrease
- the service level were to increase, or
- new media were introduced.

The scenarios should be based on the recognition of one of the basic conflicts affecting the site selection of business enterprises.

Some locations are the most advantageous from an economic point of view. These locations are often disadvantageous from a social-environmental point of view. Examples are extremely congested cities (near the markets) or extremely remote sites (near the resources).

The scenarios should be directed toward the exploration of how improved communications can help resolve this conflict. There may basically be three ways:

- move the business to the best location from the social-environmental point of view and decrease the economic disadvantage through improved transportation/communications (linkage with markets)
- move the business to the best location from the economic point of view and decrease the social-environmental disadvantage through improved transportation/communications (communities in remote areas)
- split the business, moving the part mostly affected by economic considerations to its best location and the part mostly affected by socio-economic considerations to its best location, linking the two parts of the business through improved transportation/communications (plant near resources or markets, offices in pleasant environment)*.

Once such scenarios are identified, quantification of the interactions can be attempted through direct methods.

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* Scenarios with employees working "at home" and linked through improved communications to their offices, should have a low priority.

TABLE 1

APPROXIMATE TIMING AND MANPOWER REQUIREMENTS FOR THE INFORMATION IMPROVEMENT PROGRAM

Program Item	Approximate Timing		Approximate Manpower Requirements (Man-Years)
	Starting Month	Ending Month	
PHASE I			
(a) General Data Collection	1	24 (& Continuing)	10-20 during 1st 2 yrs.
(b) Basic Studies	1	24	3-6
(c) Preliminary Design of Specific Studies	1	6	0.5-1
PHASE II			
(a) Development of Flow Forecasting Model	1	24	5-10
(b) Examination of Substitutive and Synergistic Effects of Various Communications and Transport Media	12	24	1-3
(c) Examination of the Interactions Between Transportation/Communications and Population Settlement Through Direct Studies	1	12	2-4
(d) More Detailed Design of Specific Studies	12	24	0.5-1
PHASE III			
(a) Development of Growth Allocation Model	12	36	5-10

Kates, Peat, Marwick & Co.

These steps will provide sufficient insight to make it possible to determine the feasibility of developing a growth allocation model incorporating communications.

(d) More Detailed Design of Specific Studies

At this stage a more detailed design of the specific studies laid out in a preliminary way in Phase I can be carried out.

3. PHASE III

(a) Development of a Growth Allocation Model

Development of a growth allocation model incorporating communications can proceed if found feasible after completion of Phase II. Various types of existing growth allocation models which may be drawn upon in this study are described in Appendix D. While we have suggested that the empirical or statistical approach is most promising at this time, the decision on the type of growth allocation model to develop would be made after completion of Phase II and based on the results of Phases I and II.

4. SUMMARY OF APPROXIMATE TIMING AND MANPOWER REQUIREMENTS FOR THE INFORMATION IMPROVEMENT PROGRAM

Table 1, opposite, summarizes the approximate timing and manpower requirements of the proposed Information Improvement Program.

GOVERNMENT OF CANADA
DEPARTMENT OF COMMUNICATIONS

TRANSPORT AND COMMUNICATIONS AS INSTRUMENTS OF NATIONAL POLICY

APPENDIX A

GLOSSARY OF TERMS

GLOSSARY OF TERMS

TRANSCOM System. A system consisting of various communications media and passenger transportation modes which have a significant interaction with each other.

Information. An item of knowledge related to a specific subject.

Data. Quantitative information measured and recorded to describe past or present facts.

Data Bank. Portion of an information pool in which data are stored.

Criterion. A principle or characteristic a thing is judged by.

Standard. A value or set of values attributed to a criterion with which the characteristics of an item or a system can be compared in order to judge its quality.

Transportation Mode. A distinct method of moving people or goods from one place to another.

Communication Medium. A distinct method of transmitting a thought or a message.

Media. Common identifier used in this report for Transportation Modes and Communication Media.

Objective. A statement of an intended end status towards which one's activities are directed.

Program. A systematic group of activities planned to achieve an objective.

Substitutive. Characteristic of a system to which people switch from another to achieve the same goal.

Synergistic. Characteristic of systems which have a co-operative and mutually reinforcing effect and thus yield a total system or system use that is greater than the sum of its individual parts.

Service Level. A measurement of performance of a system as perceived by the user, e.g. in terms of frequency, speed, convenience, reliability, etc.

Methodology. A systematic set of procedures to achieve an objective.

System. A set of interrelated elements.

Forecasting. Prediction of future values or states of specific variables or group of variables. If not qualified as "optimistic" or "pessimistic" a forecast usually predicts what appears, at the time of the forecast, to be the most probable future.

Evaluation. An examination of alternatives to establish how the variation of certain quantities or conditions affects the outcome and to rank the alternatives in terms of desirability.

Experiment. A method of evaluation using observations on samples of the population in purposefully controlled situations or environments.

Survey. A method of evaluation to explore the characteristics of a population by examining a sample under natural conditions.

Behavioural Survey. A survey probing into people's past behaviour.

Attitude Survey. A survey probing into what people think or believe they may do under specific circumstances.

Cost/Benefit Analysis. A method of evaluating alternatives through comparison, including trade-offs between advantages and disadvantages and the assignment of weights of importance to various characteristics.

"Macro"-Method. ("Macro"-Approach, "Macro"-Technique). A method of finding relations between variables through deductions from observations of the overall behaviour of a system, a population or a group without probing into the reasons for the behaviour. Also termed the indirect or statistical method.

"Micro"-Method. ("Micro"-Approach, "Micro"-Technique). A method of finding relations between variables by observing individual persons or elements of a system, by probing into the direct effect of one variable on another, and by developing an understanding of the reasons for their behaviour. Also termed the direct or non-statistical method.

Model. A conceptually analogous system which incorporates the salient and significant characteristics of the original system and allows examination of the original system's characteristics and behaviour under alternative conditions without interference with the original system.

Behavioural Models. A model designed to study various effects of service systems on people and effects of people on the systems.

Traffic Model. A model to determine the volume of flows for transportation modes resulting from possible future distribution of economic and physical development.

Land Use or Growth Allocation Model. A model to determine the effect of different types of transportation and other services on land use development patterns.

Statistical Model. A model based on large amounts of time-series or cross-sectional data for the development of mathematical relationships using statistical techniques ("macro" or indirect methods).

Non-Statistical Model. A model based on logic and/or an in-depth analysis of individuals' behaviour to formulate relationships (through "micro" or direct methods).

Sensitivity. The responsiveness of the model to changes in the variables.

Calibration. The adjustment of the model coefficients so as to make the model analogous to the original system.

Trends Planning. A method of planning which assumes that past trends and relationships will continue on a projected basis in the future. This approach is used when dealing with systems with unalterable intrinsic or inherent characteristics.

Prescriptive or Normative Planning. A method of planning in which several alternative futures are constructed including a trends future. These futures are compared relative to planning goals by the application of a normative or value setting process.

Unconstrained Future. A future in which past trends and relationships remain unaltered and will act freely to produce conditions unconstrained by public policy changes.

GOVERNMENT OF CANADA
DEPARTMENT OF COMMUNICATIONS

TRANSPORT AND COMMUNICATIONS AS INSTRUMENTS OF NATIONAL POLICY

APPENDIX B

DATA REQUIREMENTS

DATA REQUIREMENTS

(i) FLOWS	AVAILABILITY	
	Public	Private
Number of Telephone Calls:		
(a) Total Canada - intercity	DBS 56-203	
- by purpose[1]		
- by urgency[2]		
- by duration (length)		
(b) Selected City Pairs		Bell Canada
- by purpose[1]		Bell Canada[3]
- by urgency[2]		Bell Canada[3]
- by duration (length)		Bell Canada
Telephone Minute-Miles:		
Total, Canada - intercity		
- by purpose[1]		
- by urgency[2]		
Number of Telegraph Messages:		
(a) Total Canada - intercity	DBS 56-201	
- by purpose[1]		
- by urgency[2]		
- by duration (length)		
(b) Selected City Pairs		CN/CP
- by purpose[1]		CN/CP[3]
- by urgency[2]		
- by duration (length)		CN/CP

[1] Business-business, business-private, private-business, private-private.

[2] Emergency, immediate, postponable, off-peak.

[3] Partially.

	AVAILABILITY	
	Public	Private
Telegraph Word-Miles:		
Total Canada - intercity		
- by purpose[1]		
- by urgency[2]		
Number of First-Class Mail Pieces:		
(a) Total, Canada - intercity		
- by purpose[1]		
- by content[5]		
- by weight category		
(b) Selected City Pairs		
- by purpose[1]		
- by content[5]		
- by weight category		
Passenger Trips, Domestic - Air		
(a) Total, Canada	DBS 51-202	
- by purpose[4]		
- by length of stay		
(b) Selected City Pairs	DBS - Aviation Statistics Centre	
- by purpose[4]		
- by length of stay		

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[4]Business, private.
- Business broken down, further as: meeting, convention, sales promotion, physical activity
- Private broken down further as: holiday, family event, other event, visit

[5]Letter, invoice, document (cheque), picture (drawing), book, physical object.

	AVAILABILITY	
	Public	Private
Passenger-Miles, Domestic - Air	DBS 51-202	
Total, Canada		
- by purpose [4]		
- by length of stay.		
Passenger Trips, Domestic - Rail, Intercity		
(a) Total, Canada	DBS 52-210	
- by purpose [4]		
- by length of stay		
(b) Selected City Pairs		
- by purpose [4]		
- by length of stay		
Passenger Miles, Domestic - Rail, Intercity		
Total, Canada		
- by purpose [4]		
- by length of stay		
Passenger Trips, Domestic - Bus, Intercity		
(a) Total, Canada	DBS 53-215	
- by purpose [4]		
- by length of stay		
(b) Selected City Pairs		
- by purpose [4]		
- by length of stay		

AVAILABILITY

Public | Private

Passenger Miles, Domestic - Bus, Intercity

Total, Canada

- by purpose[4]

- by length of stay

Passenger Trips, Domestic - Car, Intercity

(a) Total, Canada

- by purpose[4]

- by length of stay

(b) Selected City Pairs

- by purpose[4]

- by length of stay

Passenger Miles, Domestic - Car, Intercity

Total, Canada

- by purpose[4]

- by length of stay

(ii) PRICES

Price of Telephone Calls:

Selected City Pairs

- by time of day
- by duration

Price per minute-mile(intercity) - Canada

- by time of day

AVAILABILITY

Public Private

Price of Telegraph Messages:

Selected City Pairs

- by length

Price per word-mile(intercity) - Canada

Price of First Class Mail:

- by weight category(intercity)

Price of Air Travel:

Selected City Pairs

Price per passenger-mile - Canada

Price of Rail Travel - Intercity

Selected City Pairs

Price per passenger-mile - Canada

Price of Bus Travel - Intercity

Selected City Pairs

Price per passenger-mile - Canada

Cost of Car Travel - Intercity

Selected City Pairs

Cost per passenger-mile - Canada

		AVAILABILITY	
		Public	Private
(iii)	DEMOGRAPHIC DATA		
	For all Canada and for selected sample of Cities:		
	Population:		
	- by age	Census	
	- by ethnic background	"	
	- by educational background	"	
	Families:		
	- by size	"	
	- by type of lodging	"	
	Income and Occupation		
	- by income range	DBS 71-201	
	- by occupation	Census	
	- by industry group	DBS 71-501	

GOVERNMENT OF CANADA
DEPARTMENT OF COMMUNICATIONS

TRANSPORT AND COMMUNICATIONS AS INSTRUMENTS OF NATIONAL POLICY

APPENDIX C

SUGGESTED STUDIES

GOVERNMENT OF CANADA
DEPARTMENT OF COMMUNICATIONS

SUGGESTED STUDIES

SOCIOLOGICAL AND PSYCHOLOGICAL STUDIES

The following are a few specific studies for which there appears to be a need at the present time and which are therefore suggested for inclusion in the Information Evaluation Program:

- A Study of Factors Affecting Personal Preferences for Various Communications Media and Transportation Modes
- A Study of the Location of Businesses as Affected by Communications
- A Study of the Effect of Communications on the Migration of People.

A Study of Factors Affecting Personal Preferences for Various Communications Media and Transportation Modes

The factors considered by a person in making a choice between the various communications media and modes of transportation were outlined in the report. It is recommended that an in-depth study be included in the Information Improvement Program to find the effect of the following criteria on peoples' choice:

- distance
- price of service
- level of service
- value of service.

One aim of the study should be finding out how a person views the price of a service and how much he is willing to pay for certain improvements in service levels or in the value of a service. Major factors affecting this trade-off are the occupation and income of the person and the purpose and urgency of the transportation or communication.

Another aim of the study would be to find out to what extent a person considers additional costs, such as the cost of travelling from his home or office to the airport or railway station, the cost of accommodation, food and refreshments en route, etc. When writing a letter, sending a telegram, or making a telephone call, to what extent does a person consider secretarial and clerical costs?

Service levels are, in part, measured by time. In this regard it would be necessary to find out how various individuals value their time. Thus, for example, would someone change his choice of transportation mode if he could save one hour at the extra cost of $10.00 or would he expect a time-saving of two or more hours for this amount?

A person will value his time differently depending on the circumstances. For example, the value of time would be different if it is spent in an aircraft, waiting for an aircraft, dictating a letter, conducting a telephone conversation, etc. The valuation would also be different for a business trip or communication during working hours and a private trip or communication outside working hours.

Information of this nature, together with information regarding the valuation of other service level criteria, is being used extensively in the prediction of modal split in transportation. The Information Improvement Program should provide similar information to assist in the prediction of choice between communication media and transportation modes.

Identification of the factors related to the value of service as seen by the users is probably more difficult than the identification of the factors affecting the valuation of price and time. Since the subjective evaluation of service does not easily lend itself to quantification, in-depth surveys are particularly important in this area. Questions to be clarified are:

- what is the additional information content that a person would experience when using a more content-intensive medium (such as a picture-phone instead of a telephone, a trip instead of a picture-phone, etc.)

- in the present social environment what is the estimated worth of a personal meeting over a telephone call or of a telephone call over a letter as seen by the originator of the communication?

- what "fringe benefits" does a person consider when deciding to make a trip (such as seeing other parts of the country or the world, getting away from the daily routine, enjoying the status in the organization symbolized by frequent travels, etc.) or conversely how much nuisance does a trip represent under various circumstances?

Answers to such questions can be obtained from a relatively small sample of people. The findings of the surveys can be corroborated

by factual information. Thus, for example, if it is concluded that the implied equivalent differential cost between a transportation and a communication medium is larger for one city pair than for another, is this finding corroborated by a corresponding difference in market shares of the competing media?

A Study of the
Location of Businesses as
Affected by Communications

This study should probe into the motives behind decisions regarding business locations and how these motives are affected by communications facilities and services. The study may cover the following areas:

- Survey existing businesses to indicate the major reasons for the selection of their present location and the importance or lack of importance of communication and transportation among these factors.

- Survey companies with plants or offices at several locations in Canada, showing the reasons for the multiple locations, the communication facilities used and the companies' assessment of the advantages and disadvantages of inter-office or inter-plant communications.

- Simulate plant location studies for a sample of industrial plants to assess the relative importance of communications among the various factors affecting the final decision. Such studies can be construed as being representative of the types of analyses actually carried out by business management. Besides communications these studies would consider transportation, raw materials, markets, the availability of labour, wage levels, the cost of land, the cost of power and many other factors and would attempt to assess the extent to which each of these factors contributes to management's decision.

A Study of the
Effect of Communications
on the Migration of People

This study should probe into the motives behind the decisions of individuals to move from one location to another and how these motives are affected by communication facilities and services.

Besides specific and personal factors, people consider and weigh the following general criteria when comparing the attractions of a typical large city with those of a typical smaller community.

Attractions of the large city:

- Greater variety of jobs and the security inherent in a diversified economy as opposed to a small local economy controlled by a handfull of major employers.
- Better educational and cultural facilities.
- Better health care.
- The positive aspects of the quality of life, such as entertainment and encounter with a broad cross-section of people.
- Higher wages.
- Better climate (if compared with northern regions).

Attractions of the smaller community:

- Lower cost of living.
- The positive aspects of the quality of life, such as less congestion, less pollution and less crime.
- Less complex life.

Superimposed on peoples' judgment of these factors is a general tendency in people not to change their place of residence unless the factors in favour of the move are much stronger than the factors against it. This tendency is based on:

- fear of the unknown
- traditions
- friends
- status in local society
- general inertia and resistance to change
- educational continuity of children
- cost of moving
- etc.

The studies to be carried out in the Information Improvement Program should investigate these factors, with special consideration of the role of communications and the possible impact of changes in communications on peoples' valuation of these factors.

TECHNOLOGICAL STUDIES

It is recommended that the state of development and the broad economics of the following new communications media should be reviewed as part of the Information Improvement Program:

- broad-band party-line telegraphy (electronic mail)
- broad-band facsimile transmission
- picture-phone
- scribble-phone.

The studies would identify the present state-of-the-art and be based on literature reviews and on interviews with researchers working on the subject. They would also include a broad economic evaluation of various technologies that could be applied to the medium and the cost of these technologies.

It is important to make a distinction between the use of a new medium and the technology applied to it. For example, the popularity of facsimile transmission would be affected by price and speed as conceived by the user and not by the type of technology (such as subscriber connection through co-axial as against conventional cables, trunk connections by microwave links as against satellites), of which the user may not even be aware. However, if the technology affects price and service level, the usage will be significantly affected.

Broad-Band Party-Line
Telegraphy (Electronic Mail)

The present high cost of telegraphy (TELEX, TWX) is partly caused by the on-line use of equipment, which ties up a communication channel and switching plant between two points for a duration determined by terminal usage. A much more efficient use of the plant could be achieved through off-line use, duplicating in a way the post-office system, except that collection, sorting and delivery of messages would take place, say, every hour, instead of once a day. This fast service could become price-competitive with mail and could replace a substantial portion of it. The key factor is a terminal which would

accept and produce the usual letter format (upper and lower case characters) with the only exception of a printed letterhead and would have a much lower cost than present terminals.

Broad-Band Hard-Copy Transmission

Broad-band hard-copy transmission would provide fast reproduction of letters and documents over large distances. The difference between fast broad-band transmission and the present slow remote xerography or facsimile transmission is not purely quantitative. It is very likely that once a critical threshold speed is exceeded the usage of tele-copying services would increase to a very large extent. The main impact of such a change will probably be on the volume of mail but all communication and transportation media could be affected.

Picture-Phone

The Bell Telephone Company has established a pilot network to obtain information on this matter. Most of the results of this experiment are yet unpublished.

The purpose of the study would be to provide a tool for predicting the impact of this new medium on communications and transportation. The identification of the segment of the population which would change its choice of medium is particularly important. By identifying the size of this segment it would be possible to establish at an early stage whether the impact of the picture-phone will be significant and if so what could be the expected order or magnitude of the change.

Predictions regarding the impact of the picture-phone are mixed. High cost and little additional information as compared with the conventional telephone are mentioned as key problems. A low-cost version of the picture-phone that changes the frame every 30 seconds has been suggested as an alternative.

Scribble-Phone

The scribble-phone would have a significant impact if a low-cost technology is developed for using a common field for transmitting and receiving. In this system each party would have a single scribble-pad. One party would make a drawing on his own pad, the image of which would be duplicated on the other party's pad. The other party would then modify this drawing or add to it on the same pad, the image of which would appear on the first party's pad, directly modifying the original drawing.

This system is sufficiently different from the present one-way systems to be considered a new medium with a much higher potential for acceptance.

GOVERNMENT OF CANADA
DEPARTMENT OF COMMUNICATIONS

TRANSPORT AND COMMUNICATIONS AS INSTRUMENTS OF NATIONAL POLICY

APPENDIX D

REVIEW OF FLOW AND ALLOCATION MODELS

REVIEW OF FLOW AND ALLOCATION MODELS

TRAFFIC MODELS

In this section we shall list the most important types of traffic models which have been developed or are under development for estimating inter-city demand.

In general, most traffic models carry out the forecasting process in four stages, as follows:

1. Trip-end Generation
2. Trip Distribution
3. Modal Split
4. Assignment.

The consecutive application of Stages 1, 2, 3 and 4 provides estimates of inter-urban travel by modes separately for various trip categories as described by the economic type of traveller, type and purpose of trip, size of group travelling together, and other possible bases of stratification.

1. Trip-end Generation

Trip-end generation consists of the estimation of total trips out of, and into, each city, region or analysis district regardless of travel mode, is usually based on the use of linear or log-linear regression equations relating trip ends to socio-economic variables.

Such equations may take the following form:

$$T_i = A_o + A_1 X_1 + A_2 X_2 + A_3 X_3 + ... + A_n X_n ....(1)$$

Where: T_i = all trips into (or out of) the i^{th} district;
X_1, X_2, X_3, ... etc. = socio-economic variables (such as population, employment, income, etc.) describing the i^{th} district.

A_o, A_1, A_2, etc. = coefficients determined by regression analysis of data for one or more time points.

In some models an attempt is made* to relate trip end generation to transport system characteristics as described by the accessibility (measured in terms of travel time and/or cost) from the district in question to all other districts.

2. Trip Distribution

Trip distribution consists of the estimation of total trips (by all travel modes combined) between each pair of districts, is usually carried out by one of several possible techniques, including the Growth Factor Method, the Gravity Model, and the Opportunity Model. These may be briefly described as follows:

(i) Growth Factor Method

The growth factor method essentially forecasts future trips by multiplying the present trip pattern by an expansion factor which is a function of growth or decay in both the origin and destination districts. Such a method would require the existence of a major survey which gives present trip movement. All existing forms of this method may be represented as follows:

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* "Development and Calibration of a Trip-End Generation, Trip Distribution and Modal Split Model for Interurban Travel in the Northeast Corridor." by Traffic Research Corporation, November, 1966.

$$T_{ij} = t_{ij} \times E \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

where T_{ij} = trips between zones i and j
t_{ij} = present trips between zone i and j
E = expansion factor.

The expansion factor is either a uniform value or an average value which may be calculated, using an iterative technique as in the Fratar Technique.*

This method, however, does not take into account the various factors which are known to affect traffic - such as changes in travel costs and service levels. This method is therefore likely to be of less value than others.

(ii) Gravity Model Method

The gravity model is analytical in its method since it is necessary to analyze existing travel data in order to set up direct relationships between trips and measures of attractiveness and resistance between two zones. Its general form resembles Newton's Law of Gravitation:

$$T_{ij} = \frac{T_i \times S_j}{D_{ij}^{a}} \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Where T_{ij} = trips from zone i to zone j
T_i = generating source of zone i
S_j = attracting source of zone j
D_{ij} = distance (or travel time and/or cost), between zones i and j
a = an exponent derived from travel data

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* Fratar T.J., "Vehicular Trip Distribution by Successive Approximations." Traffic Quarterly, March 1954
Cress, D.R., "Forecasting Zonal Traffic Volumes for Lexington, Ky. Industry". Engineering Experiment Station Bulletin, University of Kentucky, December 1962, Volume 17, #2.

If the function $1/D_{ij}^{a}$ is considered as a function F_{ij}, then

$$T_{ij} = T_i \times S_j \times F_{ij} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

The most important difference between the Gravity Model method and the Growth Factor Method is in the technique for developing the function F_{ij}. In the Gravity Model F_{ij} may be calculated using a power of the distance, time and/or cost, or an exponential function or a combination of the two. The function F_{ij} may contain a number of significant socio-economic variables in the form of coefficients obtained from analysis of available data. The factor F_{ij} makes this method superior to the Growth Factor Method. However it requires more data.

The Gravity Model Method has been applied to communications* representing one of the scarce examples in which techniques borrowed from the transportation field were used to evaluate communication flows.

(iii) Opportunity Model Method

The Opportunity Model Method is basically a probabilistic model with the general form:

$$T_{ij} = T_i \times P(M_j) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

where T_{ij} = Trips from zone i to j
T_i = generating source at i
$P(M_j)$ = probability of a trip stopping at zone j

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* J. J. Seneca - C. J. Cicchetti: A Gravity Model Analysis of the Demand for Public Communication - Journal of Regional Science, Vol. 9, No. 3. 1969

The calculation of the probability function $P(M_j)$ has the following form:

$$P(M_j) = e^{-Lv} - e^{-L(v+v_j)} \quad \text{..... (6)}$$

where $P(M_j)$ = probability of a trip stopping in zone j

L = probability of a particular trip from an origin going to any randomly chosen destination

v_j = total destinations in zone j

v = total destinations in all zones closer to zone j than is zone i, in terms of travel time.

(The parameter L is obtained from analysis of an existing survey.)

This model is difficult to calibrate and is therefore of limited use.

3. Modal Split

Modal split is the portion of the model which estimates the breakdown, or split, of total person travel between each pair of cities or analysis districts which will travel via each available mode or carrier.

Modal split models commonly relate the proportion of each district pair's total travel market using each mode to the service offered by the various modes (in terms of travel time, cost, convenience, etc.) and to the socio-economic and other characteristics of travellers. The latter are characterized by such descriptors as age, sex, income level, trip purpose (e.g. business, vacation) size of party travelling, automobile ownership, etc.

Separate models, each with the same general form of equations but containing different numerical coefficient values, are developed for travellers having different trip purposes, different incomes, and possibly different party size characteristics. By this means the noticeably different travel preferences of the various segments of the travel market can be taken into account realistically.

The modal split models currently receiving most serious attention for interurban travel and described briefly herein are the Market Segment - Diversion Curve Approach, the Discriminant Function Model, and the Cross-Elasticity Model.

(i) Market Segment - Diversion Curve Approach*

In order to estimate the share that each travel carrier will obtain, given the total origin to destination travel demand by trip purpose, it is necessary to have developed some technique that relates share of market to transportation system variables.

The Market Segment - Diversion Curve Approach is premised on the feasibility of dividing the total travel market between a given origin area (say Toronto) and a given destination area (say British Columbia) into a number of separately defined categories. This would involve, for example, dividing the total travel market first into business and non-business travel.

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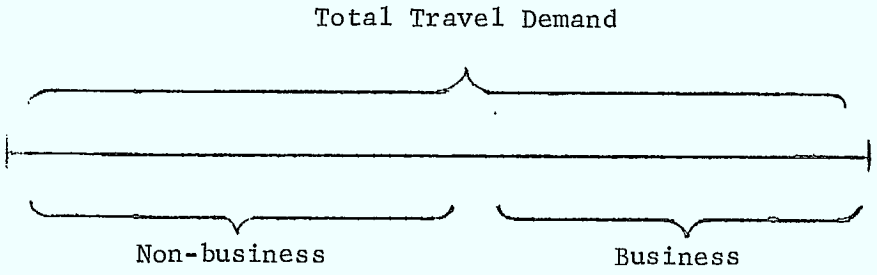
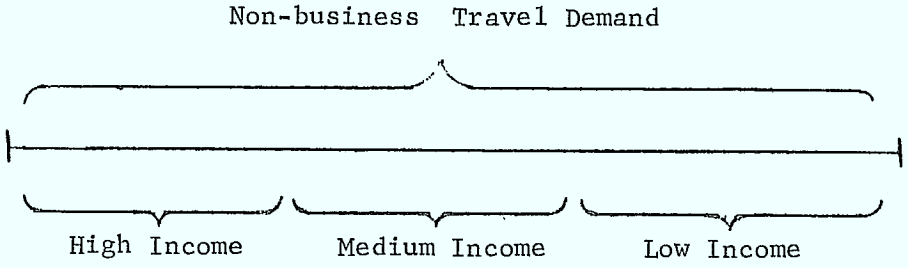
* "Application of a Modal Split Model to Travel Estimates for the Washington Area" by T.B. Deen, W.L. Mertz, N.A. Irwin, Highway Research Bulletin No. 347, 1963.

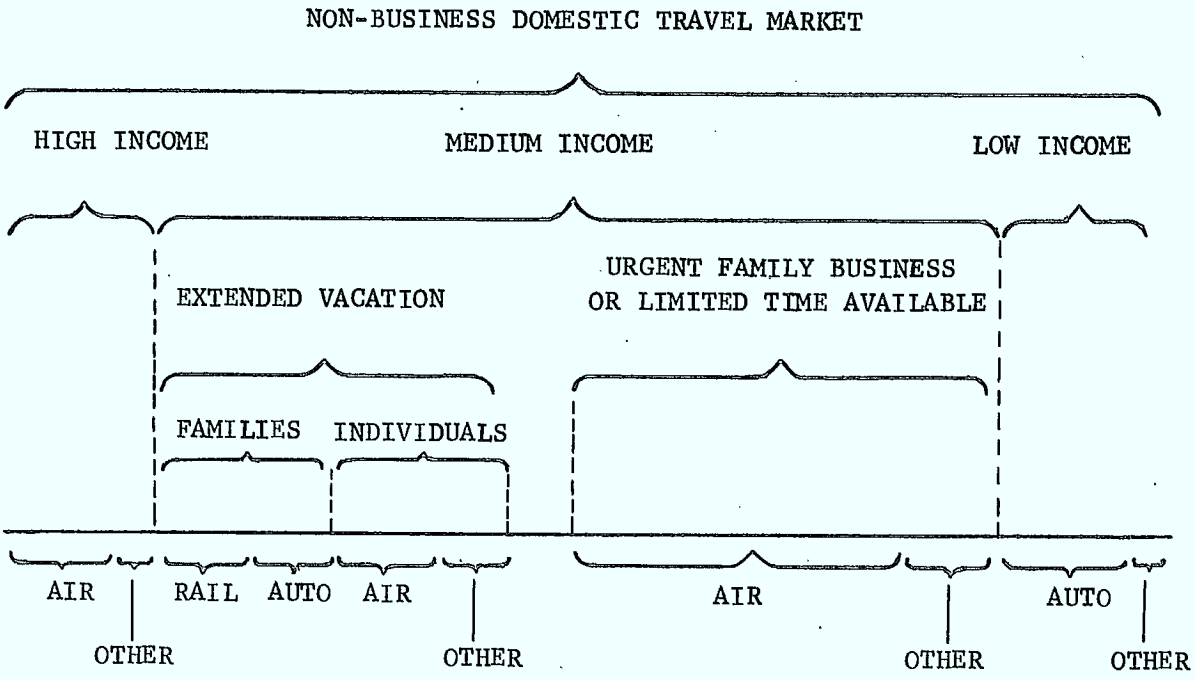


The next step is to divide each of these segments into still smaller segments. This can be done by stratifying by another variable such as family income.



Consequently, by successive stratifications by different variables the entire travel market can be broken down in small segments.

Example of Segmented Market Analysis

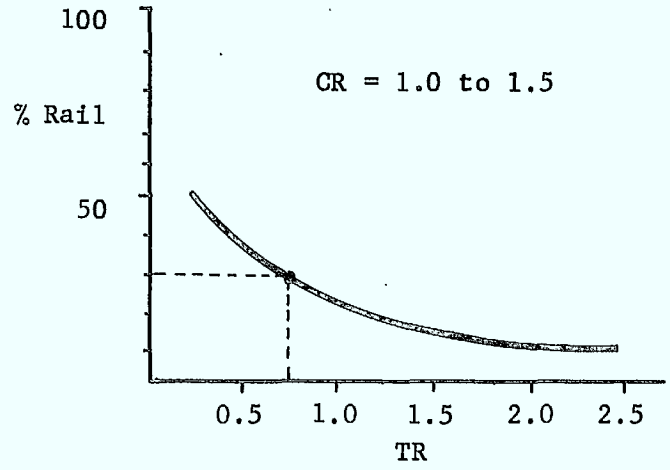


The idea is to divide the travel market into components small enough that no more than two travel modes are competing for that segment of the market. In fact, in many cases, it will be possible to obtain certain market segments where travel by only one mode is significant.

The next step in the modal choice analysis procedure is to determine what will be the percentage split between two modes of travel in a market segment given the characteristics of service on these competing modes.

There is no limit to the variables permitted to describe the difference in service characteristics (e.g. travel time, cost, comfort

index, etc.). The percentage split between the pairs of travel modes is then determined by diversion curves such as the following:



Where TR = Travel time ratio (rail travel time divided by auto travel time)

CR = Cost ratio (rail travel cost divided by auto travel cost)

In this particular example we are concerned with the percentage split between rail use and auto use and we are assuming (for simplicity) that two variables, travel time and travel cost, are sufficient to represent the differences in service characteristics between these two modes. The particular market segment that this (auto vs. rail) diversion curve could be applied to might be for a market segment consisting of medium income families travelling between Toronto and Vancouver on an annual vacation. Thus, in this hypothetical example, if the rail travel cost were 20 per cent higher than the auto travel cost, and rail travel time were 25 per cent less than the auto travel time, then the percentage of travellers in this market segment expected to travel by rail would be 30 per cent.

The scope and exact specification of the diversion curves is obtained using all the information available on the magnitude of the travel market by mode, the attitudes of travellers and transportation system characteristics.

The adaptation of this type of model to TRANSCOM System problems will depend on whether the choices between communications media and/or transportation modes can be reduced to two for a particular application.

(ii) Discriminant Function Model*

The choice between different types of transportation or modes of travel may be considered a question of classification. It is hypothesized that there may be a unique set of characteristics which will, with reasonably high probability, classify a traveller or group of travellers as choosing one mode over another. If this is the case, then discriminant function analysis can be applied as an alternative approach in developing a modal split model.

Essentially, the problem of classification occurs when the research worker makes a number of measurements of a traveller and wishes to classify the traveler into one of several categories on the basis of

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* "Calibration of a Discriminant Function Model of Interurban Modal Split" by A.P. Mongini, Traffic Research Corporation, March 1966.

Warner: Stochastic Choice of Mode in Urban Travel, Northwestern University Press, 1962, p.11.

"Some Aspects of Discriminant Functions and Other Interurban Modal Split Models" a report submitted to NECTP, National Bureau of Standards, by Traffic Research Corp., October 1965, p.6.

these measurements. This problem of classification is recognized as being similar to a problem of "statistical decision functions". The investigator has a number of hypotheses for assigning the mode to the travel, where each hypothesis is that the choice of the traveller is a given mode. One of these hypothesis must be accepted and the others rejected.

In constructing the procedure of classification, it is decided to minimize the probability of misclassification, or more specifically, to minimize the average of the bad effects of misclassification of travellers, by type of mode of travel.

For a description of the Discriminant Function Model we refer to the literature.

(iii) Cross-Elasticity Model

This model introduces the economic concept of cross-elasticity of demand for two competing projects or (in this context) travel modes. It uses this concept to relate a "demand weight" for a given mode of travel (proportion of total trips on a given origin-destination segment using the mode in question), to transportation system variables relating the time, cost convenience, etc., of one mode to another. For a description of the cross-elasticity model we refer to the literature.*

The latter two methods have an advantage over the Diversion Curve Approach because they can theoretically account for more than two modes. However, they are substantially more complex.

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* "Analysis of a Market Split Model" by A.J. Goldman, J.M. McLynn, P.R. Meyers, R.H. Watkins, November, 1966.

4. Assignment

Assignment of trips to specific facilities follows the determination of modal split. Once the mode is chosen, the best alternative facility (such as a route) between two points is selected, either on a least-time, a least-cost or least-time/cost basis.

The assignment algorithms load the available alternative facilities between network points in such a way as to avoid excessive loading of a particular one. This occurs in reality as a result of individual decisions to switch from an overloaded or higher-cost facility to a faster or less expensive one; this process continues until sufficient individuals switched from the original facility so that it becomes equal in performance to the others.

It is interesting to note that one of the first assignment algorithms, now used in transportation, was developed by Moore of the Bell Laboratories for telephone networks.

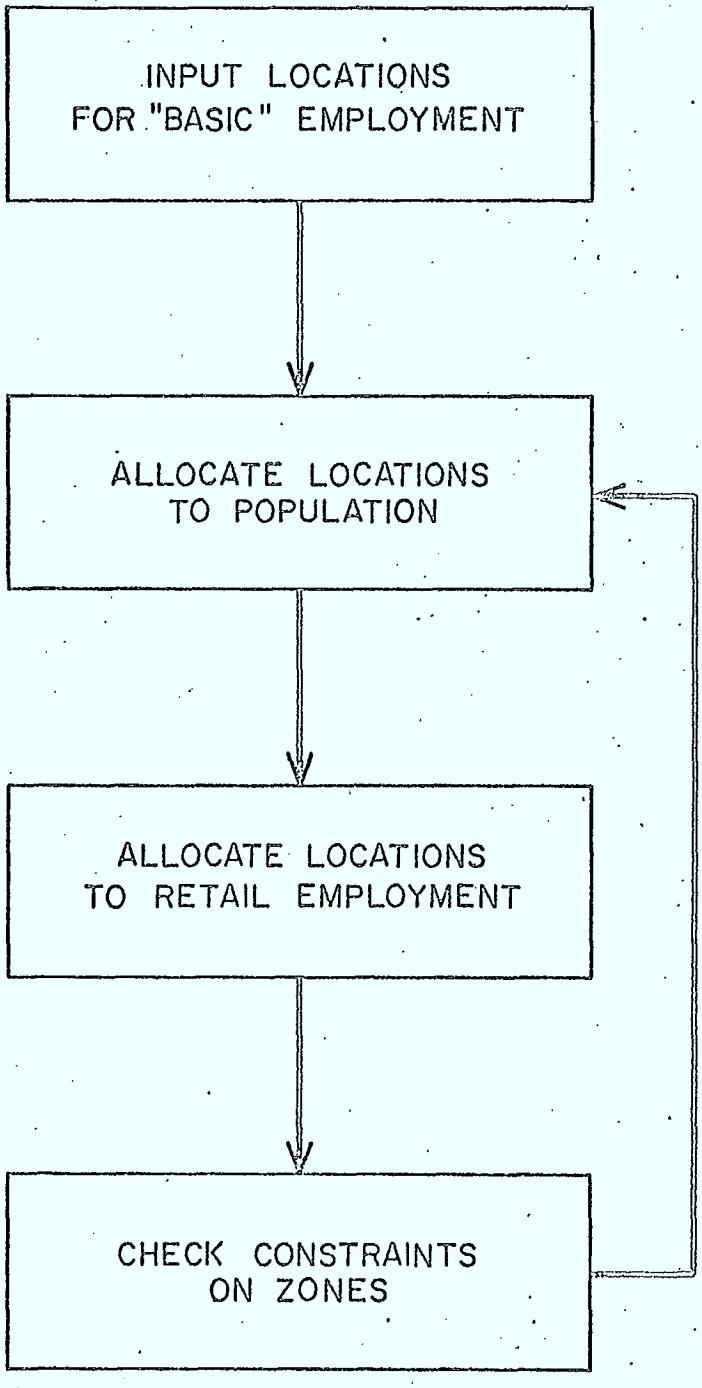
ALLOCATION MODELS

In this section, we shall describe three examples of models used in land-use allocation type problems:

- the Lowry-Rand Model
- the Penn-Jersey Model
- the Empiric Model (Simultaneous Multiple Regression).

FIGURE 12

LOGICAL FLOW IN THE LOWRY-RAND MODEL



NOTE: FOR SOURCE SEE APPENDIX F

Lowry-Rand Model

This model was used in the Pittsburgh Area Transportation Study.*

The operation of this model, outlined in Figure 12 opposite, depends on the allocation of the so-called "basic" employment (i.e., employment which operates essentially to produce goods and services that are exported from the region under study).

This employment must be allocated outside the model by hand, i.e., exogenously, to the various zones. The model then uses measures of accessibility to determine where households will wish to locate, and then where service industries will locate with respect to patterns of residential and basic industry location.

More details of the relationships and identities used in the Lowry model are given in Figure 13 overleaf. The solution of the equations representing the factors shown in Figure 13 was performed by

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*: Lowry, I.S., Residential Location in Urban Areas, unpublished Ph.D. thesis, University of California, Berkley, 1959.

Lowry, I.S., "Design for an Intra-Regional Locational Model", Working Paper No. 6, Pittsbrugh Regional Planning Association, September, 1960.

Lowry, I.S., A Model of Metropolis, Rand Corporation Memorandum, RM - 4035 - RC, Santa Monica, August, 1964.

Kain, J.F., The Journey to Work as a Determinant of Residential Location, University of California, December, 1961.

Kain, J.F. and J.R. Meyer, "A First Approximation to a Rand Model for Study of Urban Transportation", Rand Corporation Memorandum, November, 1961.

FIGURE 13

EQUATIONS OF THE RAND MODEL

1. Total available land in each zone equals the sum of land in each use.

$$A_j = A_j^U + A_j^B + A_j^R + A_j^H$$

2. Total regional and service employment by category is a function of the number of households in the region.

$$E^{Rk} = a^k(N^H)$$

3. Zonal retail and service employment by category is proportional to an accessibility measure weighting households and employment access.

$$E_j^{Rk} = b^k \sum_{i=1}^{n} \left[\frac{c^k N_i^H + d^k E_i}{T_{ij}} \right]$$

4. Total retail and service regional employment by category equals the sum of zonal employment in the category.

$$E^{Rk} = \sum_{i=1}^{n} \left[\frac{c^k N_i^H + d^k E_i}{T_{ij}} \right]$$

5. Total employment in each zone equals the sum of exogenously located employment plus employment in the endogenous categories.

$$E_j = E_j^B + \sum_{k=1}^{m} E_j^{Rk}$$

6. Land used by each employment category is proportional to the employment in that category and the sum of land in each use in each category in a zone equals the total land in use in that zone.

$$A_j^R = \sum_{k=1}^{m} e^k E_j^{Rk}$$

7. Regional household population is a function of total employment.

$$N^H = f\left(\sum_{j=1}^{n} E_j\right)$$

8. Number of households in each zone equals the total area available for residential use times accessibility to employment times a scale factor.

$$N_j^H = A_j^H \cdot g \cdot \sum_{i=1}^{n} \left(\frac{E_i}{T_{ij}}\right)$$

9. Number of households in the region equals the sum of the number of households in each zone.

$$N^H = \sum_{j=1}^{n} N_j^H$$

NOTE: FOR SOURCE SEE APPENDIX F

a repetitive or iterative technique where one solution was tried, the fit of this to the equation was determined, and then a better solution proposed, and so forth. There is no theoretical analysis available of the condition under which this procedure will in fact converge to a stable solution. Lowry expresses some doubts about possible instabilities caused by constraints. For example, there is no constraint on maximum density of retail establishments. Theoretically, the model could assign retail employment to a zone without available land. Lowry interprets this as a possible mixed use of multi-storey buildings.

This type of model is based on a series of hypothesized equations which constrain the possible solution of the model.

Models of this type are very hard to calibrate and there may be more than one solution. For this reason, they are not recommended for TRANSCOM.

The Penn-Jersey Model

This model is perhaps the ultimate approach so far, using the direct method of analysis, to the problem of urban systems. This is the complex and conceptually brilliant work that was done by the group of researchers on the Penn-Jersey Transportation Study.* The model was never made operational in its full form. It was, however, implemented in a simplified form, and the actual use of the data and of the insights gained

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*: Herbert, J.D., and B.H. Stevens, "A Model for the Distribution of Residential Activity in Urban Areas", Journal of Regional Science Fall, 1960.

Harris, B., "Some Problems in the Theory of Intra-Urban Location". P.J. Paper No. 3, Penn-Jersey Transportation Study, April, 1961.

from the modelling efforts was of considerable value in the planning process in that region.

The model operates recursively in time by making a prediction for a five-year base. It then uses the results of the first prediction as a basis for the next five-year prediction, and so on. The heart of the model is the simulation of the residential location based on the economic theory that individual households tend to maximize their locational advantage, and that land is allocated to that group of households which can bid the highest price for it. There are several inputs to the activity distribution base of the model for each recursive prediction. These fall into three main categories.

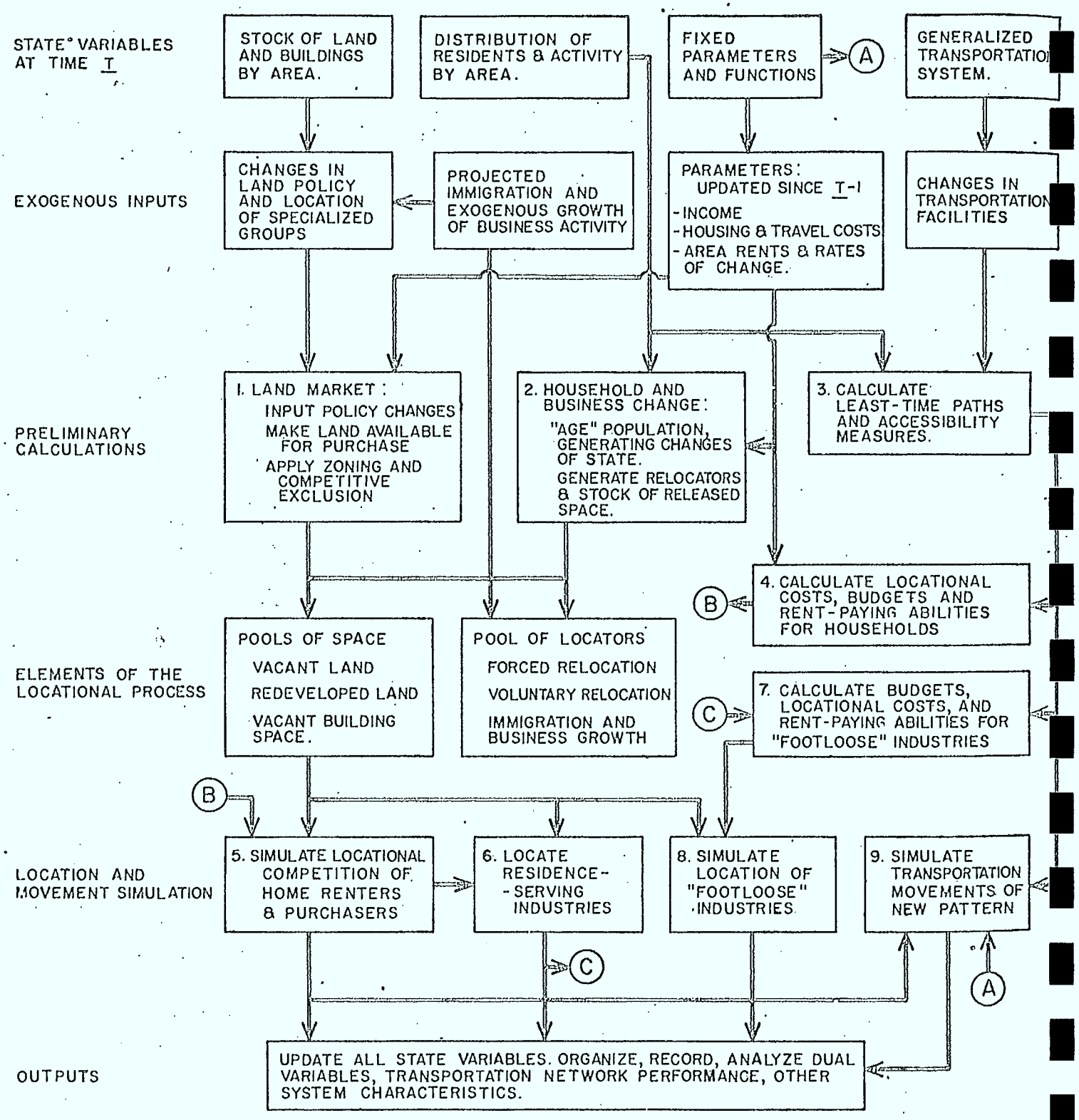
1. Inputs describing the state of the system, i.e., population location and characteristics; activity location by industry or other activity category; accessibility of opportunities by each area, as determined from a transportation flow model; etc.

2. Data reflecting assumptions and policies, i.e., reservation of public open space; land development controls and public service policies including transportation.

3. Subsidiary models provide parameters and relationships related to land availability; household and population increases over time; probabilities of households of different types moving from initial locations before end of recursion period; relationships summarizing the desirability of different zones for residents, in terms of household budgets to be devoted to locational factors such as cost of housing, cost of transportation, etc.; formulae for computing cost of transportation and housing of different types, for households of different types; location preferences of other industries based on zone characteristics and accessibility.

FIGURE 14

FLOW CHART OF THE PENN-JERSEY MODEL



NOTE: FOR SOURCE SEE APPENDIX F

The output of the model is a spatial distribution of different types of industrial and commercial activities with the corresponding amount of land used and a spatial distribution of household types, housing types and land rents. A transportation flow model is used as part of the regional growth model, taking inputs from the activity distribution phase to determine how many trips will be generated and to what areas they will go.

Figure 14 opposite shows the flow chart of one iteration of the regional growth and transportation model. The blocks shown indicate the various stages and calculations involved in this extremely complex model.

Because of the complexities inherent in this type of model, it cannot be recommended at this early stage in the development of a model system for TRANSCOM.

Simultaneous Linear Multiple Regression Technique

Simultaneous linear multiple regression is an extension of linear multiple regression that is powerful in determining cause and effect and has been used in many urban regions as a land use allocation model.

FIGURE 15

SIMULTANEOUS MULTIPLE REGRESSION

EXAMPLE EQUATIONS:

1. GROWTH OF ZONE POPULATION + 0.1 x GROWTH OF ZONE RETAIL EMPLOYMENT
   = 0.5 x USED LAND AREA + 0.1 x WATER INDEX - .5 x ACCESSIBILITY
   - 0.2 x INCOME AVERAGE.

2. GROWTH OF ZONE MFG. EMPLOYMENT - 0.9 x GROWTH OF ZONE POPULATION
   + .8 x GROWTH OF ZONE RETAIL EMPLOYMENT + .4 x GROWTH OF ZONE
   OTHER EMPLOYMENT
   = 0.2 x RETAIL EMPLOYMENT + .1 x POPULATION DENSITY
   - .2 x MFG. EMPLOYMENT.

3. GROWTH OF ZONE RETAIL EMPLOYMENT + 0.9 x GROWTH OF ZONE OTHER
   EMPLOYMENT - 0.2 x GROWTH OF ZONE MFG. EMPLOYMENT
   = 0.1 x RESIDENTIAL AREA - -.3 x RETAIL EMPLOYMENT.

4. GROWTH OF ZONE OTHER EMPLOYMENT + 0.2 x GROWTH OF ZONE RETAIL
   EMPLOYMENT
   = 0.1 x NET OTHER LAND AREA + 0.1 x POPULATION + 0.1 x MFG. EMPLOYMENT.

NOTE: FOR SOURCE SEE APPENDIX F

We frequently find that one variable can be expressed as a function of several other variables but the degree of fit to reality is small. We often find that different combinations of independent variables describe several of the projected variables taken together better than a single one alone. In order to determine this type of inter-relationship, we must use a technique of simultaneous multiple regression. This procedure is illustrated in Figure 15 opposite.

Here we have several variables that we wish to predict, and several variables that we can observe. All of the observations are allowed to influence all of the predicted variables. This calls for a mathematical technique that is only feasible with modern computing hardware and software.

The major problem of linear regression for projective planning purposes is that statistical regression techniques, unless they are set up with some care, will not be sensitive to policy and other types of planning input, and will reproduce only the patterns of the past in an incremental fashion.

Experience has shown that it is possible to develop very useful planning models of this type. An example is the Empiric Growth Allocation

Model developed in the United States by Traffic Research Corporation Ltd., a predecessor of Kates, Peat, Marwick & Co.*

An example of the use of the Empiric program is a study carried out for the City of Winnipeg.**

The Winnipeg activity allocation model is based on the concept that changes in the patterns of population and employment distribution at the small area level are the results of the locational decisions by family units and by commercial and industrial establishments, and that these decisions are functions of public development policies as well as of existing patterns and trends. The growth allocation model does not

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* Irwin, N.A., "Review of Existing Land-Use Forecasting Techniques", Highway Research Record, No. 88, Highway Research Board, Washington, 1965.

Hill, D.M., "A Growth Allocation Model for the Boston Region", Journal of the American Institute of Planners, Vol. 31, No. 3, March, 1965, pp 111-119.

Hill, D.M., and D. Brand, "Methods for Developing Activity Distribution Models by Linear Regression Analysis", HRB Record, #126, Highway Research Board, Washington, 1966.

Hill, D.M., D. Brand and W.B. Hansen. "Prototype Development of a Statistical Land Use Prediction Model for the Greater Boston Region", HRB Record, #114, Highway Research Board, Washington, 1966.

Lakshmanan, T.R., "An Approach to the Analysis of Intraurban Location Applied to the Baltimore Region", Economic Geography, Vol. 40, 1964, pp 340-370.

Lakshmanan, T.R., "A Model for Allocating Urban Activities in a State", Socio-Economic Planning Sciences, Vol. 1, #3, July, 1968, pp 283-295.

** Kates, Peat, Marwick & Co., Developing a Growth Allocation Procedure for Forecasting Land Use in a Metropolitan Region, Canadian Council of Urban and Regional Research and Metropolitan Corporation of Greater Winnipeg, December, 1969.

TABLE 2

THE COEFFICIENTS OF THE WINNIPEG MODEL

EQUATION	DEPENDENT VARIABLE		DEPENDENT VARIABLE 1 GROWTH OF POPULATION	2 GROWTH OF MFG. & CONST. EMPLOY.	3 GROWTH OF WHOLES. & RETAIL EMPLOYMENT	4 GROWTH OF OTHER EMPLOYMENT	INDEPENDENT VARIABLE 5 USED LAND AREA (UA) (TOTAL-UNDEVELOPED) AT TIME T-1	6 NET RESIDENTIAL Land AREA (NAP) AT TIME T-1	7 NET OTHER LAND AREA (NAO) AT TIME T-1	8 QUALITY OF WATER INDEX AT TIME T	9 WEIGHTED QUALITY OF WATER INDEX AT TIME T	10 POPULATION CAPACITY INDEX (NAP/GA) x (GA - UA) AT TIME T-1	11 MFG. CAPACITY INDEX (NAM/GA) x (GA - UA) AT TIME T-1	12 NON-MFG. CAPACITY INDEX (NAO/GA) x (GA - UA) AT TIME T-1	13 POPULATION AT TIME T-1	14 MFG. & CONST. EMPLOYMENT AT TIME T-1	15 WHOLES. & RETAIL EMPLOYMENT AT TIME T-1	16 OTHER EMPLOYMENT AT TIME T-1	17 INCOME AT TIME T	18 WEIGHTED POPULATION DENSITY AT TIME T-1	19 WEIGHTED ACCESS TO POPULATION AT TIME T	20 POPULATION DENSITY UNWEIGHTED AT TIME T-1	STANDARD ERROR OF EQUATION	UNBIASED MULTIPLE CORRELATION (R)
1	GROWTH OF POPULATION	COEFF.	1.00		.0823		.556			.0957		.00273	-.0177	.0132			.0251		-.0574		-.510	-.0980		
		t VALUES			1.426		6.106			1.494			2.094	1.145			1.499		1.081		6.158	4.014	.00187	.733
		BIVAR. CORR.	1.00		.068		.183			-.142		.524	.105	.420			-.029		.206		-.013	-.461		
2	GROWTH OF MFG. & CONST. EMPLOYMENT	COEFF.	-.906	1.00	.759	.393							.0292				-.248	.217	.0468		.105		-.155		
		t VALUES	2.872		2.752	1.089							1.322				4.273	2.665	1.194		2.696		2.669	.00384	.434
		BIVAR. CORR.	.028	1.00	.141	.100							.063				-.264	-.099	-.090		.142		-.143		
3	GROWTH OF WHOLESALE AND RETAIL EMPLOYM'T	COEFF.		-.261	1.00	.979		.117										-.242							
		t VALUES		1.181		3.559		2.637										15.656						.00466	.878
		BIVAR. CORR.		.141	1.00	.311		.105										-.880							
4	GROWTH OF OTHER EMPLOYMENT	COEFF.			.204	1.00			.0562		-.154					.0717	.0591	.0493	-.0606						
		t VALUES			1.376				2.213		2.977					1.849	1.681	1.114	2.846					.00286	.483
		BIVAR. CORR.			.311	1.00			.005		-.022					.117	.249	-.173	-.203						

NOTE: FOR SOURCE SEE APPENDIX F

indicate the overall metropolitan growth. This must be provided independently outside the model. The mathematical technique predicts the zonal development patterns of urban activities based on observations of various independent and causal factors that occurred over an historical time interval. In the development of the model itself, there is a continuous loop of iteration between the processes of observation of the variables concerned, developments of hypotheses that explain the inter-relationship of the variables, testing of this structure of the hypotheses in terms of equations, and the revision of the hypotheses in the light of the discrepancies observed.

Table 2, opposite, shows the actual coefficient table of the Winnipeg model. The table indicates the dependent and independent variables used.

In the context of TRANSCOM Systems particular reference should be made to policy variables. These are variables whose future locations and intensities are controllable by the planner, and thus are subject to public policy decisions. Examples of such variables would be transportation facilities, public open space and land use restrictions. Of these, it is perhaps the transportation facilities through which the regional planner can exert the greatest influence upon shaping the allocation of other activities. Transportation variables are expressed in the activity allocation model in terms of zone-to-zone accessibilities. Accessibility factors are calculated to represent the accessibility of each zone in the urban area to each of the different activities that take place in the urban area. For an individual zone, the accessibility

factor to a particular activity will be the sum of the amounts of activity available in all other zones multiplied by a factor which decreases as the travel time between the zones increases.

The calculation of accessibility factors is straight-forward for the base year, since the travel times are known, and the amounts of activity by zone are known. For a forecast year, however, the calculation of accessibilities requires measures of the distribution of future activities, which is exactly what the model is attempting to predict. Consequently, forecast year accessibilities are computed using base year activity levels with forecast year travel times.

The simultaneous linear multiple regression technique has some drawbacks:

(i) Data Requirements

This type of procedure requires a large amount of data about the region under study such as land use and availability, population, transportation use, etc. Some of this information is required for at least two points in time which are separated by several years, preferably ten.

(ii) Identification of Variables

It is not always possible to identify all the variables at work and there is a risk that some important process that causes growth or decay in a region may be left out.

(iii) Marginal Effect of Transportation and Communication

There are many factors at work causing people to move from one region to another besides transportation and communication. Therefore it will often be hard to identify the effect of TRANSCOM System variables and the model will be very sensitive to random variations in the data or to missing variables.

GOVERNMENT OF CANADA
DEPARTMENT OF COMMUNICATIONS

TRANSPORT AND COMMUNICATIONS AS INSTRUMENTS OF NATIONAL POLICY

APPENDIX E

BIBLIOGRAPHY

BIBLIOGRAPHY

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GOVERNMENT OF CANADA
DEPARTMENT OF COMMUNICATIONS

TRANSPORT AND COMMUNICATIONS AS INSTRUMENTS OF NATIONAL POLICY

APPENDIX F

SOURCES OF EXHIBITS

SOURCES OF EXHIBITS

Figures 1a to 1d have been based on maps by Weir, T.R., "Population Changes in Canada, 1867-1967", Geographical Approaches To Canadian Problems, R.L. Gentilcore, Editor, Prentice Hall, Toronto 1971, pages 12, 14 and 16.

FIGURE 1a - Road Network Coverage

1. Philips Historical Atlas of Canada, 1966, page 25.

FIGURE 1b - Rail Network Coverage

1. Philips Op. Cit., page 27, 28 and 37.

FIGURE 1c - Telephone Grid Coverage

1. Historical Atlas 1927.
2. Rounthwaite, "The Task Force Committee on Communications", Mid-Canada Development Conference, May 1970, page 37.

FIGURE 1d - Telegraph Network Coverage

1. Philips Op. Cit., page 25.

FIGURE 2a - Airline Routes

1. Acres, "The Mid-Canada Development Corridor: Implementation", A Mid-Canada Development Corridor, A Concept, Toronto, June 1967, Section 19.

FIGURE 2b - Micro-Wave Network

1. Tele Commission Committee, Instant World - Report on Telecommunications in Canada, Ottawa, 1971, page 60.

FIGURE 2c - Television and Community Antenna Coverage

1. CRTC, Annual Report, 1969/70, page 26 and 27.

FIGURE 3a - The Unconstrained Future

1. A graphical interpretation of the potential growth of Canada's urban centres as foreseen by Lithwick, N.H., Urban Canada, Ottawa, 1970, page 133.

FIGURE 3b - An Alternate Future Developing the Mid-Canada Corridor

1. This is a modified interpretation of the Mid-Canada Corridor Development scheme by Acres, Op. Cit., Section 21.

FIGURE 6a - Inter-Provincial Travel by Car

1. Inter-Provincial Travel Survey by Kates, Peat, Marwick & Co., 1964.

FIGURE 6b - Inter-Provincial Travel by Air

Ibid.

FIGURE 6c - Inter-Provincial Travel by Air

Ibid.

FIGURE 6d - Inter-Provincial Travel by Bus

Ibid.

FIGURE 7 - Number of Urban Complexes of 5,000 and Over, By Size Group, Canada, 1871 to 2001

1. Stone, L.O., "110 Years of Canadian Urban Population Increase and Urbanization", Urban Development In Canada, Dominion Bureau of Statistics, Ottawa, Canada, 1967, page 72.

FIGURE 8a - Percentage of Gross National Expenditures on Inter-City Transportation and Communication

1. Urquhart, M.C., Editor, "Population and Migration", Historical Statistics of Canada, the MacMillan Company of Canada Limited, Toronto, 1965, pages 130, 304, 537, 551, 558, 560 and 561.

2. Lessard, J-C., Transportation in Canada, Royal Commission on Canada's Economic Prospect, Ottawa, November, 1956, pages 15, 19, 101 and 103.

3. Systems Research Group, Canada Transportation Projections to the Year 2000, Toronto, 1970, page 18.

4. Kates, Peat, Marwick & Co., A Blueprint for Change, Canada Post Office, November 1969, page A8.

FIGURE 8b - Cumulative Percentage of Gross National Expenditures on Inter-City Transportation and Communication

Sources as above.

FIGURE 9a - Per Cent of Population in Principal Regions of Metropolitan Development

1. Stone, L.O., Op. Cit., page 133.

FIGURE 9b - Growth of Nine Major Canadian Cities

1. Stone, L.O., Op. Cit., page 177.

2. N.D. Lea & Associates, Urban Transportation Developments in Eleven Canadian Metropolitan Areas, Toronto, 1968, page 86.

3. Lithwick, N.H., Op. Cit., page 133.

FIGURE 9d - Cumulative Population Distribution in Canada 1901 to 2001

This exhibit was compiled from the following:

1. Stone, L.O., Op. Cit., page 42.

2. Urquhart, M.C., Op. Cit., page 14.

3. Lithwick, N.H., Op. Cit., page 133.

4. N.D. Lea & Associates, Op. Cit.

FIGURE 10a - Number of Trips of Messages per Capita by Major Transportation and Communication Media, Inter-City

1. Urquhart, M.C., Op. Cit., pages 14, 529 to 531, 535, 551, 553 and 559.

2. Canada Post Office, Environmental Forecast, March 1971.

3. Kates, Peat, Marwick & Co., Op. Cit., page A7.

4. Dominion Bureau of Statistics, Passenger Bus Statistics, 1960.

FIGURE 10b - Historical Trends of Costs Per Passenger or Message Mile for Major Inter-City Transportation and Communication Media

1. Urquhart, M.C., Op. Cit., page 304, 535, 537, 553 and 560.

2. Lessard, J-C., Op. Cit., page 14, 15 and 101.

3. Systems Research Group, Op. Cit., page 18.

4. Canadian Transport Commission Research Branch, Inter-City Passenger Transport Study, Ottawa, September 1970, page 30.

FIGURE 10c - Historical Trends of Cost Per Message for Selected Communication Media

1. Dominion Bureau of Statistics, Canadian Statistical Review, Historical Summary, Ottawa 1963, page 43.

2. Urquhart, M.C., Op. Cit., page 559 to 561.

FIGURE 12 - Logical Flow in the Lowry-Rand Model

1. Irwin, N.A., "Review of Existing Land-Use Forecasting Techniques", Highway Research Record, No. 88, Highway Research Board, Washington, 1965.

FIGURE 13 - Equations of the Rand Model

1. Irwin, N.A., Op. Cit.

FIGURE 14 - Flow Chart of the Penn-Jersey Model

1. Irwin, N.A., Op. Cit.

TABLE 2 - The Coefficients of the Winnipeg Model

1. Kates, Peat, Marwick & Co., "Developing a Growth Allocation Procedure for Forecasting Land Use in a Metropolitan Region", Canadian Council on Urban and Regional Research and The Corporation of Greater Winnipeg, December 1969.

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