A PROPOSED GOALS ORIENTED URBAN TRANSIT MONITORING SYSTEM

by

JOHN ROGER MORTON
B.A., York University, Toronto, 1973

A THESIS SUBMITTED IN PARTIAL FULFILLMENT OF
THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE

in

THE FACULTY OF GRADUATE STUDIES

School of Community and Regional Planning

We accept this thesis as conforming
to the required standard

THE UNIVERSITY OF BRITISH COLUMBIA
September, 1977

Department of Community and Regional Planning

The University of British Columbia
2075 Wesbrook Place
Vancouver, Canada
V6T 1W5

Date Sept 7, 1977

ABSTRACT

In recent years, the scope and role which urban transit is expected to play in our cities has been expanded substantially. This renewed interest in transit has coincided with a greater awareness of the impacts of widespread automobile use and concerns over the future availability and price of petroleum products. Policy makers are also more sensitive to the needs of groups who may be experiencing mobility hadicaps.

The purpose of this thesis is to develop a systematic urban transit monitoring program designed to generate information on the efficiency and effectiveness of transit services. A major emphasis has been to suggest a methodology which is explicitly goal oriented and which provides useful feedback to transit planners and management.

The thesis first determines which goals are apparently being pursued by governments in their expanded transit programs. This review consists of an analysis of present transit related legislation,policy statements by senior Ministers, and a review of recent urban transportation planning studies. It is noteworthy that many senior government transit goals are only indirectly related to transportation.

A second major task of the thesis is to critically examine the potential of transit systems to contribute to the achievement of goals that are frequently stated as reasons for providing transit service. This has been accomplished through a review of relevant theoretical and empirical literature.

The third section of the thesis documents the criteria and procedures presently used to monitor transit services and describes the procedures by which decisions are made concerning the allocation of transit resources to different areas. The principle sources of information in this section were obtained through a survey of Canadian and American transit operators, the published reports of industry conferences, and a review of transit evaluation procedures utilized by senior governments.

The major conclusions of the thesis are set out in the form of a proposed monitoring system suitable for use in medium to large metropolitan areas. Unlike current monitoring procedures, the proposed system is explicitly goal oriented and would facilitate transit resource allocation decisions. Furthermore, implementation of such a system should foster more precise definitions of operational objectives by transit management. Hence, it is conceivable that the conclusions of the thesis could contribute to the evolution of more cost-effective urban transportation systems.

ACKNOWLEDGEMENT

In the preparation of this thesis, I received a great deal of help from faculty at the University, fellow students, and friends. I would like to express my special thanks to my advisers and friends, Professors Poulton and Horn. Their many criticisms and suggestions caused me much anguish but in the end helped me to produce a vastly improved final draft. More importantly, they taught me to be more critcal of the subject matter at hand.

In the course of my studies at U.B.C., I received financial assistance from several sources to which I wish to express my gratitude. These include the B.C.Telephone Company, The Roads and Transportation Association of Canada, and the Centre for Transportation Studies, U.B.C.

Finally, I would like to thank Beverly for her help in typing this thesis and for her perserverance and patience in the many earlier drafts. Without her constant encouragement, I have my doubts as to whether I would ever have finished this work.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

PROLOGUE

On November 21, 1861, some six years before the formation of the Canadian Confederation, an important event occurred in old Montreal Town. On that day, the Montreal City Passenger Railway Company opened it's first horse-drawn public transportation system. The new system was generally well received by the citizenry although accounts of the event note that the official opening ceremonies were marred by a public demonstration by irate cab drivers, fearful that they might lose business.

The first cars of the new system were constructed at a cost of $1500 each. The early company expanded at a good rate despite high fares which were set at 8 tickets for 25¢ during peak hours. By 1875, the company owned some 400 horses and over 100 vehicles.(Hayes, 1963, p.3)

On June 17, 1977, on the Vancouver, British Columbia waterfront, an event of similar fanfare, if not importance, occurred with the opening of the Burrard Inlet Ferry public transportation system. The passenger-only ferry was designed to link up two urban areas of Metropolitan Vancouver without the necessity of a new bridge crossing the formidable Burrard Inlet. The new " Seabus " system, consisting of two ferries and allied port facilities was reported to have cost in excess of 46 million dollars. Press accounts suggest the new system was also well received by the public although a demonstration by bicycle club members, angry because the system could not accomodate cycles, was held at the official ceremonies. First day ridership for the ferry system was high, perhaps due in part to the low fares of 35¢ charged by the system. (The Vancouver Sun, June 17, 1977, p.1)

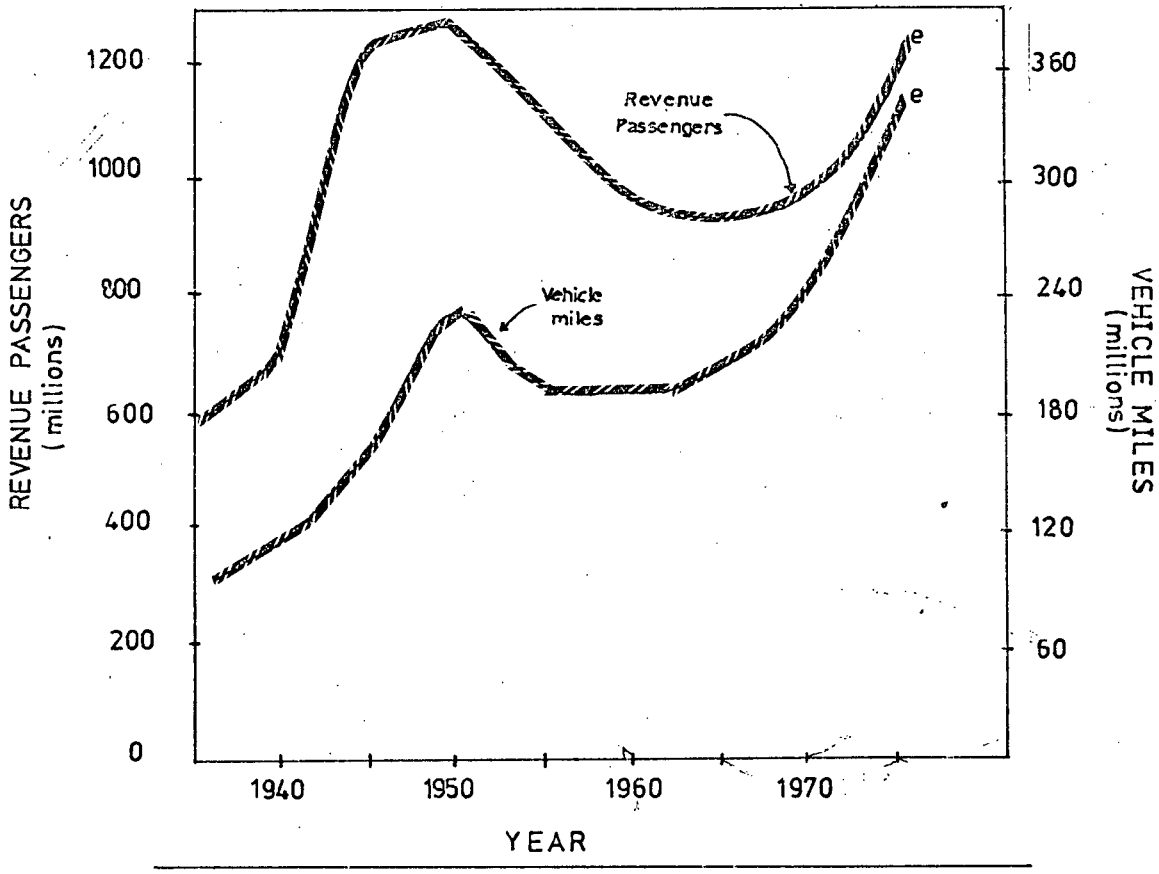
That the opening of public transit systems like the Montreal tramway and the many technological improvements which were to follow were events of great civic importance is not disputed. The new technology of transit provided a means for the middle and upper income groups to escape the squalid conditions of the densely populated industrial

FIGURE 1.1

Trends in Total Ridership

and Vehicle Miles

CANADIAN TRANSIT PROPERTIES



source: Canadian Urban Transit Association, Transit Fact Book (Ottawa, 1975)

e: 1976 estimate based on Statistics Canada, Urban Transit (Publication 53-003, Dec., 1976)

cities which were emerging in the 1800's. The effect of transit was to greatly increase the importance and influence of the central core by making it accessible to a greater area. The new lines were often quickly followed by new residential development and it was observed that central city densities generally declined. The importance of transit was explicitly recognized by Burgess and Hoyt in the early models of the internal structure of the city. Hence, the impact of transit upon the nineteenth century city was far greater than a simple transportation improvement. Rather, the effect of early transit is known for it's social impact; especially for the suburbanization and segregation of the middle classes. (Yeates and Garner, 1971, pp217-221.)

The nature of early transit's relationship with urban development, however, is not straightforward. It is commonly assumed that the new lines were simply extended into the hinterland somehow causing new development to occur autonomously. Warner (1962) argues convincingly, that a close co-operation existed between the early transit companies and the developer-speculators of the time. It was the developer who actually determined the areas where new residential development should

occur. Having already decided on a land use plan, the transit company then strategically laid out new lines through the preplotted subdivision thereby guaranteeing future traffic and profits. The importance of transit in this symbiotic relationship was clearly of only secondary nature.

The various private companies and systems continued to expand their networks and these were generally followed by similar rises in patronage and revenues. The fortune of most transit companies however, as a high growth industry was short-lived. Ridership levels in most North American cities peaked during the 1920's especially when measured on a per-capita basis. There followed a long term decline that has continued virtually to this day. While there have been many reasons cited as responsible for the decline, the availability of mass produced automobiles must be recognized as the chief determinant. Others have also cited a general profit squeeze caused by escalating costs and the general rise in affluence of the populace.

For a number of reasons, to be explored in detail later, public attitudes about transit began to change in the middle sixties. Increasingly, governments at all levels were prepared to subsidize various aspects of transit's operations. The chief reasons associated with this re-emergence of transit has been a new perception of the external social costs of widespread automobile use, and, in some cases, a belief that transit is required to support densely developed commercial areas. In addition, there is concern for groups of people in society who may be handicapped through lack of access to an automobile.

For whatever the reasons, the aggregate effect of new public support has been to increase the supply of transit services available. This increased supply of transit has apparently been responsible for a modest but significant increase in national patronage levels which have been observed in recent years. The public cost of these improvements has been great. In 1976, it is estimated that total operating expenses of Canadian transit properties* exceeded operating profits by some $200 million.[1]

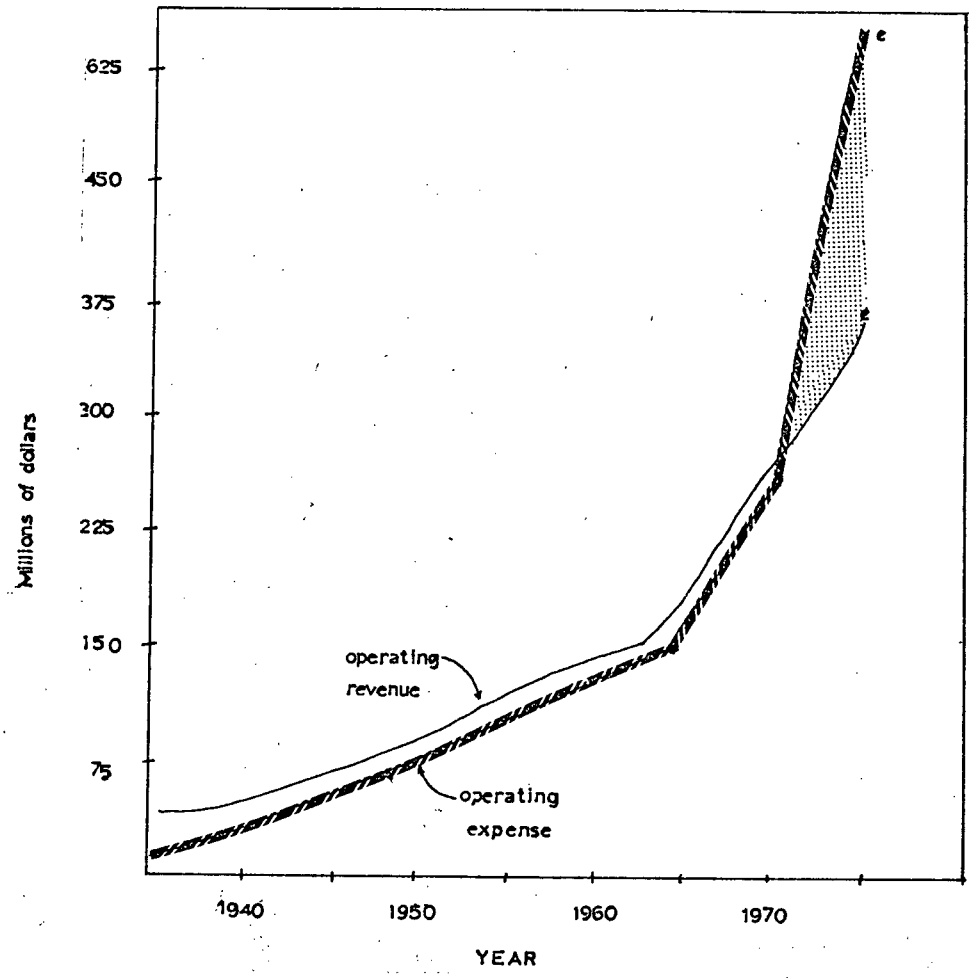
---

1) estimate based on Statistics Canada, URBAN TRANSIT (publication 53-003, December 1976)

* The term transit "property" is used throughout the industry and refers to that organization which actually operates transit systems whether such systems are public or private.

FIGURE 1.2

Trends in Costs and Revenue
Canadian Transit Properties



source: Canadian Urban Transit Association, Transit Fact Book (Ottawa, 1975)

e 1976 estimate based on Statistics Canada, Urban Transit (Publication 53-003, Dec., 1976)

The re-emergence of transit, however, has not been without heated debate by those who question whether benefits accruing from transit are worth the costs. If current projects bear an uncanny resemblance to transit's antecedents, one should not assume they can be evaluated in the same manner. Issues and urban conditions are not the same. Public goals and objectives have changed. A fundamental dilemma for transit managers, public planners and elected officials has thus emerged. Like most public issues, the benefits derived from transit do not lend themselves to quick metrification. While there is general agreement that profits cannot be used as indicators of the worth of a system or of it's component parts or routes, little concensus has been reached as to an acceptable alternative mechanism. There is a need for a systematic methodology through which trade-offs between economic efficiency and the furthering of community objectives can be facilitated. The purpose of this thesis is to suggest a conceptual framework by which these trade-offs can be made explicit.

CHAPTER 2

RESEARCH OBJECTIVES

2.1 INTRODUCTION

The re-emergence of transit as a potent urban institution has been accompanied by a host of new objectives which in the past have been largely ignored by the urban transportation planning process. This re-emergence has also required increasingly large injections of public monies to keep pace with rising costs and to finance increased service. The magnitude of deficit financing which is apparently necessary to keep transit viable is so great that it has caused substantial debate. Hilton (1974), for example, in his scathing review of American transit policy, questions the desirability of a transportation policy which accepts continuing annual deficits as a matter of fact.

A particular problem for those charged with administering and managing new rpograms of transit assistance stems from the difficulty of evaluating the effect of the various programs. When transit was a private, albeit sometimes regulated industry, this evaluation was simple. The ultimate test was whether a system or a component part of the system was profitable. Admittedly, the process may have been complicated by a regulatory body whose concerns were more than simple profit and loss statements.

Nor is the evaluation methodology employed in the traditional transportation planning process appropriate for many transit allocation decisions. The traditional model views evaluation as the culminating step in what is essentially a design process. After several alternatives have been formulated, evaluation attempts to rank alternatives with respect to some exogenously determined normative criteria. Decision makers are then free to choose that alternative which best meets their own perceptions of what values and concerns are important. This alternative is then implemented.

It is noteworthy that the model just described evolved in a period when urban transportation planning was almost entirely concerned with the construction of new streets and highways. If forecasted levels of traffic proved to be wrong, there was little that could be done to correct past errors. If, following construction, community tastes or demands changed, the roadway was not expected to respond to this change. Hence, there was little need for a continuing evaluation of the worth of the roadway.

Beginning sometime in the mid-sixties, criteria reflecting new social and environmental considerations were integrated into the urban transportation planning process. In addition, the range of alternatives considered in the strategic planning process was broadened. Comprehensive programs emphasising public transportation were explicitly considered along with the more traditional highway programs. From this process, a number of metropolitan areas opted for transit oriented programs designed to solve their long-term transportation problems.

The decision to adopt a particular transit alternative is based on a favourable evaluation of it's effectiveness in meeting certain goals. Such a decision is made based on an "a priori" evaluation relying on forecasts of anticipated consequences which may never be realized. Failure to properly anticipate consequences may result because of a lack of understanding of dynamic processes or because of lack of control over other relevant variables. Because transit programs are usually incremental in nature and, compared to highway projects, require a greater proportion of public expenditures to cover operating costs, a much greater reliance is placed on a system of continued monitoring.

2.2 OBJECTIVES OF THE THESIS

The objective of this thesis is the development of an improved conceptual model of performance monitoring appropriate for use by transit operators and planning organizations. The implementation of an improved system of transit monitoring is not of course, an end in itself. Monitoring the effect of past actions is important to insure that apparticular action is causing the anticipated outcome. Hence, it is important that a transit monitoring system develop the type of information which is related to preferred policy outcomes.

An underlying premise of the thesis is that the development of more explicitly goal oriented measurement techniques and criteria will enable and foster the development of more realistic and precise objectives for transit. An important aspect of precise operational objectives, however, is specification of the

means by which they may be measured. The development of an appropriate mechanism to do so is the main objective of the thesis.

Better information should also improve transit marketing strategies. With such information, transit marketing could adopt a stance more akin to that of most consumer industries. Service could be offered to meet the special needs of segmented portions of the transit market. Unlike private firms who seek to maximize economic profit, the driving force of the transit marketing program should be the maximization of social profit as revealed through a communities' goals and objectives.

Clearly, the economic viability of transit investments will always be an important aspect of all communities' transit programs. It does not follow, however, that maximizing economic profit, revenues, or passengers (given a budget constraint) will be the best means to achieve community goals. Transit resources might better be allocated to specific groups, to specific spatial

areas or to specific temporal periods.

Moreover, differing conditions and aspirations between urban areas are likely to give rise to differing objectives for transit. A major effort has been the development of a goal-oriented monitoring strategy. The intent of the thesis is not to suggest which goals are appropriate for all communities. Rather, an attempt has been made to delineate the main recurring objectives suggested for transit and to integrate those goals which are likely to be influenced through the service function (i.e. specification of routes, schedules, and service policy) into a systematic measurement system.

The implementation of such a system is likely to be of particular value to those in a position to allocate the available resources to different spatial areas (i.e. a transit planning organization). Information generated by such a system should also be of value to higher levels of planning such as urban transportation planning and

urban/regional planning. If the conditions and circumstances where transit is working and where it does not seem to work become explicit, planners should be in a better position to influence the evolution of a more cost-effective urban transportation system.

2.3 NEED FOR RESEARCH

Existing methods of performance monitoring for urban transit rely upon a variety of operational measures of transit performance collected and usually compiled by local transit operators. Generally such measures are collected on a route by route (link) basis and are often aggregated into system wide (urban) indices. The statistival reports of transit operators typically present information on inputs, outputs, and some ratio of inputs to outputs. Measures of transit performance at the zonal (or area) level are particularily lacking.

Basic marketing information is also notably lacking. For most firms, markets are broken down into segments to meet the specialized needs of different groups of people. Transit, however, is one of the few industries still producing an essentially standardized product. (Reed, 1976, p.9). Moreover, little is known about the travel behaviour of individual passengers nor the characteristics

of individuals and groups who currently make up the transit market. Smerk (1974, p. 231), commenting on the lack of specific data collected by transit operators concluded...

> "(F)ew transit operators can give day-by-day, trip-by-trip information on patronage or on the origins or destinations of patrons, or can provide a data profile of it's patrons. Few can, as a matter of course, detail the cost of a given trip, or the revenue contributions such routes or trips make, or the benefits conferred to the public by such trips. Much of the federal program is based on the assumption that there are overspill benefits from transit sufficient to warrant the subsidy of transit operations yet there is no definitive, standardized method of calculating the benefits."

Likewise, methodologies designed to quantify the attributes of the transit system or the"level of service" are crude.[1] Conventional methodology expresses level of

---

1) No suitable definition of level of service directly applicable to transit has been found. For highway planning, the most authoritative source, the Highway Capacity Manual, defines it as follows: "Level of service is a term which broadly interpreted, denotes any one of an infinite number of differing conditions that may occur on a given lane or roadway when it is accomadating various traffic volumes. Level of service is a qualitative measure of the effect of a number of factors , which includes speed and travel time, traffic interruptions, freedom to maneuver, safety, driving comfort and convenience, and operating costs. In practice, selected specific levels are defined in terms of particular limiting values of certain of these factors." (1965, p.7)

service in terms of link frequency of service. The most notable reference in this area is the manual published by the National Commitee for Urban Transit (1958). More recently, attempts have been made to define level of service more precisely. A promising approach utilizes a concept of accessibility. (ITE Technical Committee 6y -1, 1976).

A substantial body of literature suggests measures of transit level-of-service are appropriate criteria for periodic evaluations of transit programs. (Botzow, 1974; Weiner, 1972). The relationship of level of service to the achievement of urban objectives is found in the classic ends-means paradigm. Rice (1972), however, is concerned that overreliance on these criteria will lead to faulty policy evaluations since they actually measure inputs to a policy rather than outputs. The best of plans do not always work. Hence, the use of level of service criteria is more applicable to the systematic monitoring of the progress made implementing a plan rather than the policy outcome of implementation.

A related segment of the relevant level of service literature seeks to utilize quantifiable measures of level of service to set specific transit planning standards. In reality, such standards set the lower limits below which transit services will not be offered. Some attempts have been made to integrate general transit planning objectives to the application of these standards.[2] While standards can play an important role in the management of transit systems, they are not substitutes for more realistic measures of transit performance or effectiveness. Furthermore, the environment in which transit operating decisions are made is complex. Operators must respond to rapidly changing levels of demand which occur both temporally and spatially. Standards which are formulated are broad and general. Adherence to such standards may lessen the propensity to introduce inovation into a transit system. Heathington, (1975,p.3) argues...

> "(P)lanners, on the other hand, in the search for hard to define goals and objectives, have turned their attention to widely applicable 'service standards'. At times these service standards have been used blindly. If goals are stated, they frequently are formulated to satisfy funding requirements and are broad and general."

---

2. Several transit o-erators have made notable strides in the development of operating standards which are "ends oriented". See, for example, Massachusetts Bay Transportation Authority, Service Policy for Public Transportation (unpublished, Boston, 1975)

> "Operators faced with rapidly rising deficits, declining ridership, and lack of specific direction from local authorities often feel that continuing existing operating procedures is the safest course to follow."

In summary, the available literature which is relevant to transit monitoring suggests a variety of methodologies are employed by transit properties to monitor the performance of their operations. Existing techniques are characterized as being crude. Often there is a lack of basic information from which criteria can be constructed. Operators and transit planning organizations often utilize similar criteria to both construct qualitative level of service standards and as a performance measurement technique. In a subsequent chapter, much more detail will be devoted to techniques currently in use by transit operators.

2.4 OVERVIEW OF THE THESIS

The thesis is divided into four main themes. In chapter Three, the conceptual goals of transit are uncovered. This is accomplished through an analysis of relevant policy statements by senior ministers and officials of goverment and a review of the articulated goals of recent land use/transportation studies. A survey is also conducted of the relevant legislation and administrative machinery set up by provincial governments to administer their transit policies. The main recurring goals responsible for the renewed interest in transit are then synthesized from these various sources and presented.

Chapter Four examines the characteristics of transit which appear related to the goals or issues areas identified in Chapter Three. Both the theoretical rationale for transit and the accumulating empirical evidence of transit's actual performance are reviewed through the literature. While the thesis is not presumptuous enough to reach definitive conclusions as to transit's potential

in meeting the various goals set out for it, a better understanding of the many constraints faced by transit is gained. Further, it is clear that there are alternative means of meeting many of the broad objectives. This Chapter then, provides the framework by which existing evaluatory criteria can be assessed.

In Chapter Five, a detailed review of the criteria and techniques currently used to monitor transit is presented. The review draws from several different sources and vantage points. These include several surveys of transit operators and planning organizations, procedures utilized in several recent and progressive transit development plans, and methodologies suggested by academicians. It was found that commonly employed criteria often related to the internal efficiency of transit operations or are crude in nature. Criteria seldom related to the apparent goals as identified in Chapter Three.

Finally, Chapter Six deals with the development of a systematic methodology with which to monitor the effectiveness of transit operations in meeting community objectives.

Recurring goals, as identified in Chapter Three, are first grouped into four thematic areas which are likely to be affected thrugh similar operational mechanisms. Specific methodologies to monitor both inputs and outputs are described and several practical illustrations of possible use are presented. Where forseen, the limitations of the proposed methodology are also discussed. Finally, the implications of the proposed system to transit planning are discussed and areas where future research appears warranted are set out.

In summary, then, the thesis attempts a far more ambitous task than simply identifying an array of possible indicators which are in some way, shape, or form related to the urban transportation system. Rather, a conceptual methodology, albeit untested and unrefined, is suggested through which a comprehensive program of public transportation can be monitored and evaluated in terms of specific operational objectives. The methodology will be most beneficial to the transit planning organization which must make allocative decisions concerning transit resources.

CHAPTER 3

CONCEPTUAL GOALS

3.1 INTRODUCTION

A plan may be viewed as a statement of programs recommended as best for achieving a certain set of goals given a set amount of resources available. The decision to adopt a certain sequence of programs over other possible programs is facilitated through the process of evaluation. Whether one is monitoring the effectiveness of past allocative decisions or attempting to predict the consequences of proposed actions, the central questions of evaluation remain the same. This question involves making a judgement as to the extent to which goals have been met through a particular organization of available resources.

In theory, the actual evaluation will be conducted by accountable decision makers. The role of the planner in this process, is that of a technical specialist. It is the planner's task to generate timely and relevant information to facilitate the choice between alternative courses of action.

The planner's role is therefore paradoxical. He is charged with providing information to facilitate accountable decision makers' evaluation; yet he receives little guidance to indicate what type of information is relevant and feasible. Policy statements which may have been made are apt to be vague. A local goal to increase transit ridership may be operationally measurable, but reveals little as to what purpose is to be served by the increased ridership. Likewise, a local goal to promote "balanced transportation" reveals even less as to what issues are foremost in policy maker's minds. Specifying the <u>actions</u> which policy makers wish to take rather than the <u>goals</u> which they hope to accomplish is apt to lead planners to generate only information concerning that action. An attempt must be made to uncover the issues which have caused policy makers to promote public transportation

over other alternatives and then to relate evaluatory information generated to these issues.

The pupose of this Chapter is to explicitly document the issues which appear foremost in policy makers minds. To accomplish these ends, several techniques were employed. First, a review of important policy statements concerning transit made by senior officials of government is presented. These statements are analyzed to reveal the fundamental issues. Secondly, a survey of government administrative machinery and of the review processes of the provinces concerning their transit programs was conducted to determine the degree and manner in which government enunciated policy has actually been translated into action programs. Finally, recent transportation studies were reviewed to document common goals at the operational level.

3.2 THE POLICY STATEMENTS - SENIOR LEVELS OF GOVERNMENT

The Federal government, for the most part, does not directly become involved in local urban transportation decision making. Some projects are funded through the Transportation Development Agency - the research arm of the Federal Transport Ministry - but usually only for demonstration purposes.[1] Local transportation under the B.N.A. Act, is a provincial responsibility. It is not inconceivable, however, that the Federal role could become significant in the future.

The Provincial Government's role in transit is extensive. In recent years the provincial governments have been assuming an increasing share of municipal transit deficits. In 1976, Provincial grants to local transit programs for operating assistance was over $200 million.[2] What were the events which caused government to assume such great deficits?

---

1) The Vancouver 'Turn Down Traffic Volume' project, for example, is funded as a demonstration project through T.D.A.

2) Estimate based on Statistics Canada, Urban Transit (pub. # 53-003, December 1976.)

In Ontario, the most urbanized province and also the province with the largest transit program, government policy was changed in 1972 following the provincial government's decision to cancel the Spadina Expressway - a major urban freeway. A statement issued by the Premier provided the basis for a new urban transportation emphasis stressing transit instead of highways. In his statement, Premier Davis indicated concern for environmental quality, social impacts of highways, the efficiency of alternative systems and the mobility problems of certain segments of society. The statement began by articulating the qualities important in cities. The city...

> "... should be a place that is rich in variety of employment, housing, and leisure activities."
>
> "... should be a place where it is possible to move quickly and with safety from one place to another. It is a place where children and the old people and those without a private automobile should be able to move about safely and conveniently. " (Davis, 1972, p.1 emphasis mine.)

This provides a general framework which Ontario is apparently using to guide it's transit program. The Premier believes expressways provide a safe and effective means of inter-urban movement. They are not suitable for

urban areas however, because...

> "... unrestricted use of cars and trucks during peak hours is causing our urban transportation problems to become critical."
>
> "... as a means of solving our urban transportation problems, expressways are not only too expensive for the traffic moved, but because of their accompanying intrusion, noise, and air pollution, they have become unacceptable in residential neighbourhoods." (p.3, emphasis mine.)

Ontario also has aspirations to use transit as a tool to help implement the overall development objectives of the region. There is a belief that investment in transit as opposed to urban freeways ...

> "... will encourage moderate density residential areas which may bring about a new sense of community belonging, not unlike the cities of the past which also evolved around major public transit systems." (p. 19, emphasis mine.)

It is not clear, however, whether development is expected to spontaneously evolve around transit facilities or whether development will be consciously planned to support new transit systems.

> "It may be necessary to plan the siting of large buildings more consciously in the future than has been the case in the past. Such commercial development should offset most of the expense of the original land acquisition and bring people close to the transportation system." (p.19, emphasis mine.)

In Alberta, a similar concern about the environmental consequences of urban freeways is expressed. In order to give urban systems in Alberta more 'balanced transportation' ...

> "(A) new emphasis is being placed on modern transportation services for the urban centres of Alberta. The emphasis not only relates to the efficient movement of people; it also reflects a determination to avoid the adverse environmental implications of improperly planned transportation." (Government of Alberta Human Settlement Policies, 1976, p.21.)

Alberta's objectives are being pursued by extensive upgrading of municipal transit systems. This is expected to cause people to change their travel habits. Reduction in the number of people who travel by automobile will...

> "... alleviate the pressure which results from private automobile travel." (p. 21)

In British Columbia, where transit services have been greatly expanded in recent years, a similar concern about the need for 'balanced transportation' has been expounded. In addition to the concerns noted in other provinces, the government has a somewhat stronger view about the income distributional consequences of alternative investments. In a 1973 policy statement, the minister responsible for transit stated:

> "As a result of our efforts in public transportation, we would see the accrual of benefits in the form of greater mobility for persons and more efficient use of existing road space by enabling more people to travel over the same roads. We see our efforts decreasing the dependency of persons on movement by private automobiles and removing the pressures to build more roads, parking facilities, and bridges with the attendant loss of land and livability in our communities. Furthermore, we will be using transit planning as a positive tool to shape future development of our communities in directions suited to the needs of present and future residents. (Lorimer, 1973, p.11, Emphasis mine.)

It is unclear whether Mr. Lorimer's statement indicates a belief that transit will influence land-use developments or whether criteria and measures will be adopted in the land use planning process so as to promote

development which will support a regional transit system.

The Minister's statement also sheds some light on what type of evaluation is considered appropriate to compare alternative transit systems. Evaluation...

> "... not only looks at the monetary costs and revenues, but also considers such aspects as pollution, the distibution of costs and benefits on various subgroups in society (ie. who benefits and who pays) and the impact upon community land use planning." (p.11, emphasis mine.)

3.3 LOCAL GOVERNMENT POLICY STATEMENTS

Local government statements concerning the role of transit generally reflect concerns similar to those held by more senior governments. Emphasis upon particular objectives, however, may differ substantially. As a general rule, Municipal concerns reflect a more narrow viewpoint as to the objectives which transportation in general, and transit in particular is expected to achieve. Local governments tend to emphasize immediate problems. Transit is envisioned as one component of an overall traffic management strategy. Understandably, the major goal of municipal government is the efficient movement of traffic to areas in which the existing street system is inadequate.

Where secondary objectives and impacts are of concern to local governments, they may not necessarily be the same as those held by senior government. An emerging viewpoint from provincial governments, for example, is to pursue a goal of social equity. In this case, transit subsidies are justified, in part, because of the perceived effect upon the redistribution of income. It is clear that transit subsidies are seen to be a means to affect the distribution from rich to poor. Yet, local goals may be to equalize transit service to all parts

of the region. The effect of such a policy upon the distribution of income is not clear. Indeed, a policy that vastly increases the service in suburban areas may be regressive.

While municipalities generally share equal concern over the concomitant impacts which result from urban freeway building, they are equally sensitive to the impacts which result from expanded transit systems. The introduction of an urban bus line onto a formerly quiet street, as is commonly found in suburban areas, can substantially lower the livability of that street in the eyes of local residents. Likewise, parking restrictions introduced in business/commercial areas, can be a matter of serious inconvenience to local businesses. The odor of diesel fuel seems more foul to the nose than automobile exhaust.

Whereas the direct impacts resulting from urban freeways are large and localized, and hence vigorously opposed, the impacts from transit are smaller, yet more pervasive. Provincial governments, who typically are not the implementing agency, may be better insulated from public controversy which may erupt. For this reason, local governments tend to become more involved in matters of detailed route design than do their provincial counterparts.

Statements of policy concerning transit and it's role in municipalities do not normally emerge from local councils. There is not the same need to disseminate information to other levels of government as there is in provincial governments. While a great deal of transit policy making is conducted by local councils, it is rare for councils to articulate the higher level objectives which they hope to accomplish through transit. Where such policy statements are made, they tend to be masked in generalities. In Vancouver, for example, during the 1976 civic election campaign, all parties generally supported transit. The Electors Action Movement (TEAM) proposed to:

1. "Continue improvements of the bus system - including a free bus service in the downtown area in order to alleviate the serious traffic congestion."

2. "The start of a light rapid transit service in the Greater Vancouver area is an absolute essential in the next five years."[1] (emphasis mine)

Statements by regional governments in Vancouver exhibit a broader concern than those shown by municipal governments but less broad than those shown by provincial governments.

---

1. The TEAM Record., (TEAM Campaign '76 Headquarters, Vancouver, October, 1976, p. 1)

A statement by the Greater Vancouver Regional District Board to the provincial Minister of Municipal Affairs indicated that increased emphais upon public transportation will ...

> " ... meet the growing requirements for personal travel between parts of the region and between major activity centres by transit rather than by improving road capacity for greater automobile usage. This strategy should economize on travel costs, reinforce the Regional Town Centres' Program, reduce through traffic in sub-regions, conserve energy and control pollution." [2]
> (emphais mine)

The GVRD hopes to finance its plans for new rail transit, in part, through higher user fees on automobile licences. According to the GVRD, automobile taxes are justified, because automobile users will benefit through a reduction in congestion, gasoline expenditures and insurance costs. In addition, municipalities will be asked to levy higher property taxes to beneficiaries of the rail system. No specific criteria has been suggested to enable municipalities to determine what additional property levies were equitable.[3]

---

2. Statements on the Next Stage of Public Transportation Improvements., (Communication from the GVRD Board of Directors to the Minister of Municipal Affairs, Sept. 26, 1974)

3. The Sun (Vancouver) Dec. 10, 1976, p. 1)

In Edmonton, where the provincial government requires periodic formal statements of municipal goals, the City Council made an attempt to articulate the transit goals of the city. The expansion of the Edmonton Transit System to serve suburban areas...

> "... (E)ven operating at a substantial deficit ... has the potential to save a great deal of expenditures on freeways, arterial roads, and central city parking. The operation of express busses ... at short intervals thereafter, with convenient transfer provision, would probably result in a significant decrease in the number of one passenger cars now commuting." [4]
> (emphasis mine)

---

4. Edmonton City Council, A Statement on the Future of the City., (Submission to the Minister of Municipal Affairs, Province of Alberta, 1973)

3.4 PROVINCIAL ADMINISTRATIVE MECHANISMS

Provincial administrative mechanisms to guide and promote the greater use and role of transit in urban areas differ widely between provinces and regions. Almost all provinces make some financial contribution to assist local transit systems. In general, the more urbanized and prosperous the province, the greater likelihood that funding mechanisms are determined by some ascertainable criteria. Most provinces, however, retain some discretionary control over transit assistance funding.

In Ontario, the province provided over $133 million to assist municipalities to acquire and run public transportation systems in fiscal year 1976, under authority of the Public Transportation and Highway Improvement Act (R.S.O. 1970, c 701 as amended). Prior to January 1, 1977, the province provided 75 percent provincial financing of transit capital costs and 50 percent financing of operating deficits. The province has now adopted a formula whereby operating costs incurred by local transit properties (municipally owned) are eligible expenses and may be subsidized up to 25 percent by the province. The change came after complaints were received from municipalities unhappy with the old formula. Under the old formula, fare increases were, in effect, shared with the province.[5]

5. Personal communication with R.B.McEwan, Manager, Administration, Transit Office, Ministry of Transportation & Communication, Province of Ontario.

In Alberta, the province administers capital improvement grants for municipal transit systems as a trust fund. Under Alberta's Urban Transportation Policy, initiated in June, 1974, the province automatically deposits capital grants to special municipal accounts. Ten cities and urban areas are currently eligible for the grants. Eligible cities which do not have transit systems are allowed to collect interest on the funds until such time as a system is developed. Six Alberta urban areas currently have some form of transit service operating. Under terms of the program, Edmonton and Calgary each receive $7.5 million annually for transit capital costs. Eight other Alberta cities share a total of $1,130,000 annually. Transit operating subsidies are also financed up to 50 percent of the operating deficit subject to a maximum provincial contribution of $3.33 per capita per year. In addition, the province will also fund up to 2/3 of the cost of transit research and development projects.[6]

Transit assistance to Quebec cities is administered according to a complex formula. The province will pay up to 30 percent of capital costs for buses manufactured within the province and 10 percent for buses manufactured elsewhere.

---

6. Personal communication with Mr. Leo L. LeClerc, Assistant Minister, Urban Transportation Policy Development, Alberta Transportation, Nov. 9, 1976

Municipalities acquiring private transit systems can apply for provincial grants for up to 1/3 of the cost of acquisition. In the case of the Montreal Urban Community, the province financed 60 percent of the acquisition cost.

The province also provides operating assistance to municipally owned public transit properties or to private concerns operating transit service under contract to municipalities. The size of the operating grant varies according to population of the city but generally ranges between 45 to 55 percent of the total operating deficit. The province will also provide 100 percent of the cost of urban transportation studies.[7]

In British Columbia, provincial transit policy is still evolving and has not been codified to the extent it has in some other porvinces. In the past, the provincial government has financed 100 percent of the cost of new buses and absorbed 50 percent of the cost of some operating expenses. The B.C. situation is unique among Canadian Provinces in that the B.C. Hydro and Power Authority, a provincial Crown corporation, provides transit service in the two largest cities. Financial assistance to B.C. Hydro is largely discretionary. A special grant of $32.5 million was given to the company in 1976 to offset its deficit.

---

7. Personal communication with M. Jacques Simard, Directer of Public Transportation, Ministere des Transports, Province of Quebec.

Provincial assistance toward municipal transit operations in other Canadian cities differs widely in form and magnitude of assistance. In Saskatchewan, for instance, the province will finance up to 50 percent of capital costs toward the purchase of new buses and up to 75 percent of certain other capital costs pertaining to transit operations on roadways (eg. roadway turn-ins, bus shelters, etc.). The province also provides operating assistance to municipally run transit systems up to a maximum of 3¢ per revenue passenger carried. The program is open to all urban areas having a population over 1000 and is administered by the provincial highways department.[8]

In Newfoundland, the province will contribute up to $4.00 per capita subject to a maximum contribution of $385,000 per year toward the operation of the municipally run transit system of St. Johns. No other city in the province has municipally operated transit service. The special grant is administered by the provincial Department of Transportation and Communications and is completely discretionary.[9]

---

8. personal communication with Mr. John M. King, Urban Transportation Engineer, Department of Highways and Transportation, Province of Saskatchewan.

9. personal communication with the Honourable James Morgan, MPA, Minister of Transportation and Communication, Government of Newfoundland.

In New Brunswick, no assistance is available which is directly attributable to municipal transit programs. The province does make available unconditional grantss to all municipalities. These grants are based on a prorata proportion of all municipal expenditures. Provincial authorities estimate this indirect grant provided about $215,000 in 1976 toward the operation of two municipal transit systems.[10]

A summary of the various provincial programs is shown in TABLE 3.1

.10 personal communication with Mr. G.B. Hawkins, Director, Municipal Services Branch, Department of Municipal Affairs, Province of New Brunswick

TABLE 3.1

PROVINCIAL ASSISTANCE TO LOCAL TRANSIT SYSTEMS

PROVINCE	FORMAL TRANSIT PROGRAM	TYPE OF ASSISTANCE		
		OPERATING	CAPITAL	OTHER
NEWFOUNDLAND	no	assistance to one city. Annual grant of $4.00/capita/ annum to maximum of $385,000/year.	no distinction made	no distinction made
NEW BRUNSWICK	no	unconditional grants to municipalities based on prorata municipal expen. Grants to two cities estimated to be $215,000 in 1976.	no distinction made	no distinction made
ALBERTA	yes	50% operating subsidy to maximum of $3.33/capita/year for 10 Alberta cities eligible. 1976 grants estimated to be $3.5 million.	$16,130,000 annual grants to ten Albt. cities. ($7.5 million to Edmonton and Calg. Funds need not be used in any one year.	2/3 costs of transportation studies and demonstration projects to maximum contribution of $800,000/year.
ONTARIO	yes	between 13½% to 25% grants toward public transit operating costs (not deficits)	75% capital subsidy for eligible capital expenses.	
QUEBEC	yes	between 45% to 55% subsidy toward operating deficits dependent upon population of service area.	between 10% and 30% subsidy for purchase of transit buses. Up to 1/3 financing of acquistion costs of private firms. 60% financing of Montreal metro.	100% financing of transportation studies.

3.5 TRANSPORTATION PLANS

A number of recent transportation plans in Canada which emphasis transit were reviewed. In general, most of the plans indicate that several alternative transportation and, in some cases, land use, alternatives were formulated and then assessed against a number of criteria. There exists considerable variation between studies in terms of the actual objectives which the transportation system is designed to meet and also the process by which objectives were determined. Recent studies do reflect the widening of basic transportation goals. There is however, no universally accepted manner of choosing objectives or criteria. On this point, Hutchinson (1974, p.303) notes ...

> " ... A generally accepted method of evaluation for urban transportation projects does not exist at the present time."

In Vancouver, the "Kelly Report" in 1972 formed the basis for the recent expansion in Vancouver's regional transit services. The technical study for the report was undertaken by a consultant. Specific objectives for the technical report were apparently formulated by the technical staff.

The report noted ...

> " ... it is necessary to specify what objectives the programme seeks to optimize. The reasons most frequently cited for government investment in transit include:
>
> -provision of more efficient means of moving people in medium and high density traffic situations than the auto affords;
>
> -assurance of a reasonable minimum level of mobility for those without full-time access to cars;
>
> -minimize the impact of transport activities on the landscape; and
>
> -utilize the potential development impact of transportation systems to influence land use." [11]

Strategic or long-range transportation studies, which seek to determine the level of investment between different modes, are guided by a similar set of objectives. In Halifax, for example, a recently developed plan sets out a preferred land use plan and formulates a transportation system capable of accomadating that land use plan. Specific objectives which guided the formulation of alternatives included:

---

11. Brian E. Sullivan, Preliminary Plan for the Immediate Improvement to Public Transportation in Greater Vancouver., (Vancouver, Spatial Dynamics, 1972)

1a. To achieve a strong urban core of high environmental quality, pedestrian in nature and human in scale.

1b. To achieve a compact urban area.

1c. To create a diverse suburban environment with secondary focuses

2 . To promote efficient movement of people at the least public and private cost.

3. To maintain present levels of noise and air pollution. .12

In Toronto, no attempt was made at the onset of a recent study to explicitly define the objectives which would guide the study. It was felt that the very general goals which typically are formulated in such studies were not necessarily meaningful. Instead, planners and engineers formulated four alternative transport systems, three of which emphasised transit. Assessment of each alternative involved estimating the performance and impact implications of each alternative against a multi-faceted list of issue areas. No attempt was made to weight particular aspects of the evaluatory criteria. The intent of the study was to present a number of feasible land use/transportation options to accountable representatives, together with appropriately presented information and allow them to make implicit tradeoffs

---

12. Halifax, Nova Scotia, Metro Area Planning Committee, Proposed Transportation Policy and Plan (Halifax-Dartsmouth Metro Area, 1973)

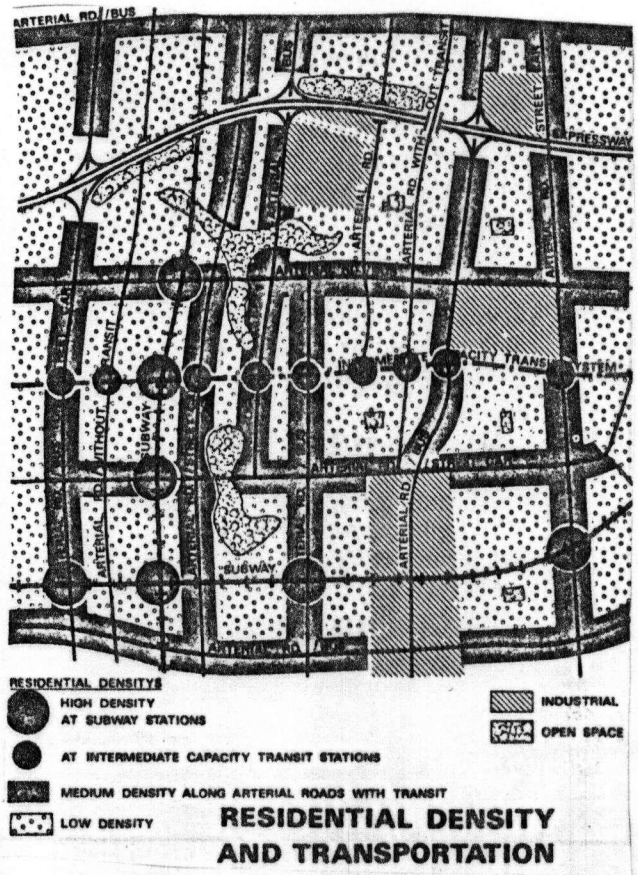


FIGURE 3.1

ELEMENTS OF RECOMMENDED LAND USE PLAN IN TORONTO

SOURCE: Canadian Institute of Planners, FOURUM, (Ottawa, February, 1977, p.9)

between alternatives based on their individual values systems. Evaluatory information is to be generated in the following areas :[13]

Description

1. Land use alternatives
2. Transportation alternatives
3. Land use/Transportation combinations

13. Royal Commission on Metropolitan Toronto, Transportation Organization in Metropolitan Toronto (Background Report, April, 1975)

Performance

1. Travel Demand
2. Demand/Capacity Analysis
3. Performance of land use/transportation combinations

Costs

1. Public Costs
2. Private Costs
3. Public Revenue
4. Net Public Costs

IMPACTS

1. Landuse/transportation interactions
2. Socio-Economic Effects
3. Environmental Effects

3.6 SUMMARY

The conventional wisdom underlying the resurgence of urban public transit begins with the assumption that public transit can readily be a substitute for a significant number of automobile trips. Investment in public transit, according to this viewpoint, has, in the past, been less than optimal due to the failure of analysts and public policy makers to appreciate the magnitude of social costs attributable to widespread urban automobile use and to incorporate these factors into formal evaluation processes. Following this line of reasoning, increased investment in transit is expected to reduce the total volume of traffic in urban areas (or, at least to slow its growth). This reduction in traffic is predicted to:

1. result in more livable cities through reduction in the concomitant impacts of automobiles such as air pollution, traffic noise and unsightly highway and parking facilities.

2. reduce the need to construct expensive automobile facilities such as bridges, urban highways, and arterial streets. The savings from not building these facilities is often believed to more than offset the public cost of supporting transit.

3. save energy since transit is more energy efficient.

4. reduce the disruption caused through the construction of new highway facilities in established urban residential and commercial areas.

The new emphasis upon public transit will also enable social

objectives to be furthered. Specifically, it is expected that:

5. the subsidization of transit by the public sector will result in substantial benefits to accrue to lower incomed groups.

6. Those people without access to an automobile or who do not wish to operate an automobile will be guaranteed some minimum level of mobility.

Finally, the planning of public transportation facilities can be consciously integrated with urban land use planning. Transit can be used, it is believed, to influence physical land development through the provision of massive and focused accessibility to certain areas. A typical public goal seeks to:

7. Protect established land values, investment, and dominance of the central area and/or promote compact developments, both residential and commercial, in other parts of the urban region.

These then, are the underlying factors which appear responsible for the renewed interest in public transportation How is transit expected to meet these lofty and laudable goals? What has transit's track record been in the past? These are the questions of Chapter Four to which we now turn.

CHAPTER 4

TRANSIT AND TRANSIT GOALS: THE ACCUMULATING EVIDENCE

4.1 INTRODUCTION

In Chapter Three, contemporary objectives for transit, as seen by public policy makers and revealed in recent transportation studies were articulated. Current goals for transit require that it successfully compete with private automobiles in the urban travel market. In this way, it is hoped the perceived impacts from automobiles can be reduced. Furthermore there is an implicit feeling among policy makers that increased investment in transit is the least costly means to meet future urban travel demands. It is hoped the conscious planning of transit facilities can be accomplished so as to focus service to particular groups who are perceived to be in greatest

need of service. Finally, policy makers assume it is possible to influence regional land use developments through particular transit route configurations.

In this Chapter, the characteristics of mass transit are explored. A good deal of evidence has been accumulated. What does this have to say about transit's ability to meet current objectives? Such an understanding is not purely of academic interest. A better appreciation of the circumstances and situations where transit appears to work and where it does not facilitates a critical review of criteria which are currently being used to monitor and evaluate transit.

The Chapter is divided into three main sections. The first section examines transit and it's relationship to social objectives. A second section gives critical attention to the effect of transit upon urban development. Finally, the question of transit and it's role in a national energy conservation strategy is reviewed.

4.2 TRANSIT AS A SOCIAL SERVICE

> " There is an imperative need to redefine the fundamental nature of urban mass transit services and to redefine the systems that provide these services as systems that deliver essential social services to the users and to the rest of the community." (Tomazinis, 1972, p.46)

In Chapter Three, it was demonstrated that transit was perceived to be a worthwhile welfare device by policy makers. Large public subsidies are supported, in part, on these grounds. The provision of transit services, it is believed, will cause substantial benefits to accrue to less fortunate members of society in the form of increased mobility and access to a wider range of urban opportunities. Some believe that transit will affect a positive redistribution of income. It is to these issues which we now turn.

The benefits and costs of transportation in general and transit in particular are not evenly spread geographically but tend to be localized. A policy which increases aggregate accessibility does not necessarily lead to improvements for all groups. Indeed, incremental improvements in the transportation system can actually worsen

the condition of those groups most in need of improvement. Perhaps the most often cited case where this is said to have taken place is where urban freeways carve up inner city neighborhoods.(Wheeler, 1974, Chapter 4)

The Concept of Transporation Equity

The demand for transportation is a derived demand. The benefits obtained from urban transportation are primarily derived from the ease or cost with which an individual can travel from a given origin to a desired destination. Increasing the ease with which individuals can overcome the "friction of space" also increases the range of opportunities open to those individuals. In economic evaluation, these benefits are typically expressed in terms of time savings or improvements in accessibility.

The inherent nature of transportation, however, is to link up parts of the urban space. Hence, benefits are not spread evenly over the urban space. Figure 4.1 illustrates this point. Here, it is assumed that economic costs are spread equally throughout the society. Major benefits accrue to those living close to the facility.

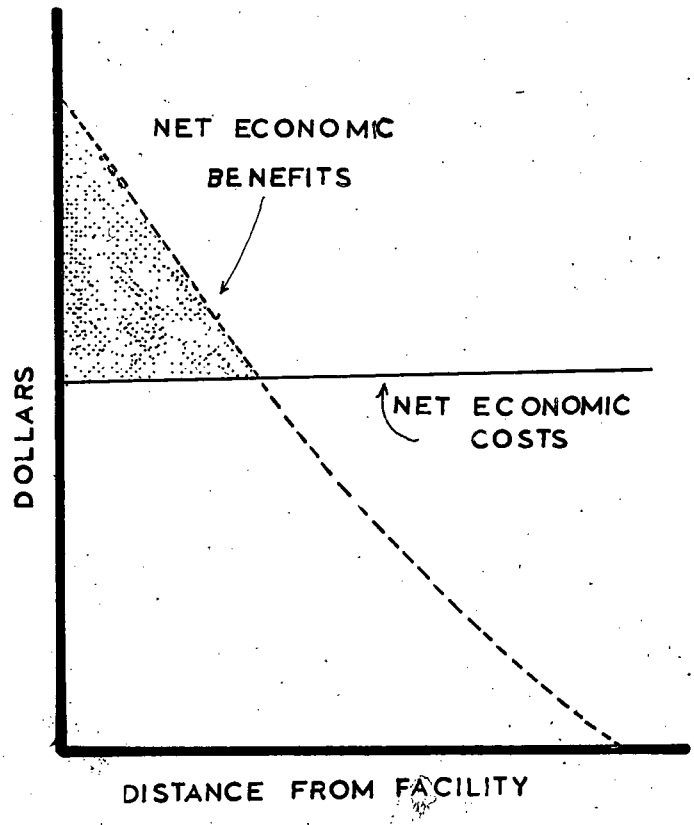


FIGURE 4.1

HYPOTHETICAL COSTS AND BENEFITS
OF TRANSPORTATION FACILITY

source: adapted from James O. Wheeler, The Urban Circulation Noose., (New York, Duxbury Press, 1974, p. 94)

In reality, the costs of urban transportation are not spread equally over the urban area. A complex arrangement of user charges and public subsidies cause groups and individuals to pay differing amounts towards the maintenance of the system. Finally, the poorly understood operation of the urban land market makes an ultimate determination of costs and benefits difficult.[1] Despite these formidable theoretical and operational difficulties, attempts have been made by some to estimate the magnitude of the distributional consequences of transportation.[2] Explicit recognition of these costs and benefits and the manner in which they are distributed has come to be known as transportation equity.

The case can be well made that the distributional consequences of transportation decisions should be considered in the planning process. For a complex set of reasons - many of which are institutional and non-transportation related - a number of groups have become disadvantaged.

---

1. For a review of elementary urban land economics see Section 4.3.
2. See, for example, Bergman, Joel, etal. , Development of a Methodology for an Assessment of BART'S Impact Upon Economics and Finance Plan. (Metropolitan Transportation Commission, Berkeley, 1975); J.S. Dajani, "Income Distributional Effects of the Atlanta Transit System", TRANSPORTATION RESEARCH RECORD,(Washington, Research Record No. 516, 1974, pp.35-46); John K. McKoy, Transportation and Equity: Toward a Framework for Distributional Analysis,(Association for Bay Area Governments, 1973)

in terms of their ability to move quickly throughout the urban region. This group includes the young, the elderly, the poor, the physically handicapped and those without access to an automobile. The direct results of low mobility are a reduced range of urban opportunities accessible. The more indirect, but far more serious consequences may be increased crime, unemployment, and social instability.[3]

Clearly, transportation has only limited potential in dealing with what are fundamental problems of society. The mere provision of accessible transportation will not guarantee that disadvantaged groups will gain employment. Nor should it be considered a solution to complex social problems. At best, it can only be considered a short-term measure designed to alleviate existing inequities and make further progress feasible in other sectors.

---

3. Inadequate public transportation was claimed to be one of the main contributing factors preventing black inner city residents from obtaining jobs and education. A direct link was suggested between the availability of public transportation and the Watts riots. See, J.M.McCone, Violence in the City - An End or a Beginning, (Governor's Commission on the Los Angeles Riots, Sacramento, 1965.)

The documented evidence that a significant portion of society suffers from a transportation disadvantage is large. In the United States, a group estimated between 70 and 100 million are said to be transportation disadvantaged. According to the 1971 U. S. census, 20 percent of all households were without an automobile. For those with incomes under $3000 peraannum, 46 percent of households were carless. (Saltzman and Ameedee, 1976, pp. 1-2)

In Chapter 3, it was demonstrated that policy makers expect transit to provide a measure of mobility to the transportation disadvantaged in urban areas. Hence, the case for explicit recognition of the distributional implications of transit planning is even greater than in conventional transportational planning.[4]

It is not sufficient merely to provide transit service in an urban area and expect the needs of the transportation disadvantaged to be met. Existing services may not be tailored to meet the needs of lower income people.

---

4. Some have made quite persuasive arguments that the most cost-effective method of providing mobility for the transportation disadvantaged would be to provide them with private vehicles. For one such argument, see, Douglas B. Gurin, "Improving Job Access for the Urban Poor", HIGHWAY RESEARCH RECORD, (Washington, Report No. 473, 1973, pp. 16-27)

Wohl notes that much of the rapidly increasing levels of public subsidy are being used to finance costly suburban transit services designed to carry affluent workers to downtown offices - a group which at best represents five to ten percent of the population. (Wohl, 1970, pp. 21-45) A similar conclusion has been reached by Webber in his study of the BART impact in San Francisco. Although the poor pay a larger share of their income to support BART, ridership is skewed toward the wealthy.

> "The percentage of income paid to provide tax support for each ride taken is 40 times greater for an individual in the lowest income group than for one in the highest income group." (Webber, 1976,p.23.)

TABLE 4-1
INCOMES OF BART RIDERS

FAMILY INCOME	% DISTRIBUTION OF BART RIDERS	% DISTRIBUTION IN BART DISTRICT	RIDERS AS A % OF POPULATION IN BART DISTRICTS IN INCOME GROUPS
Under $5,000	10.5	22.9	2.62
$5,000- 6,999	6.8	9.8	3.98
$7,000- 9,999	12.6	16.9	4.07
$10,000-14,999	21.6	25.6	4.83
$15,000- 24,999	30.6	19.3	9.12
Over $25,000	17.8	5.6	18.26
	100.0	100.0	

SOURCE: Webber, 1976

Why is existing transit service not utilized to a greater extent by the transportation disadvantaged? In many cases, the low density of places of low skill employment prevents economically efficient service even allowing for large operational deficits. Manufacturing employment has been decentralizing to suburban areas. What service is available in these areas is often oriented toward suburban residences rather than employment centres. Historically, transit management has seen it's task as providing radial service to downtown areas. Hence, much of the transportation disadvantaged are not given the opportunity to utilize transit. Some have suggested the problem is one of a management failure to pursue appropriate goals. (Falcocchio,1973.) Others suggest the poor have no political clout. Decision makers largely ignore these groups. (Wheeler,1974.) Still others claim the problem is largely technological. (Saltzman and Ameedee,1976.)

Having indicated that the overall effect of transit on income distribution could be regressive, and that there is a good possibility that transit may not be serving those most in need of service, what would be an appropriate policy for transit management or policy makers?

At the least, some crude accounting of the gross costs and benefits attributable to various groups would be called for. Armed with this information, policy makers could make reasoned decisions concerning appropriate pricing and subsidy issues. (McKoy,1973.)

Secondly, a concerted effort could be made to identify "left-out" groups and to plan improvements with a view to providing these groups with immediate benefits. (Appleyard,1971.) In some cases this might call for extensions of regular service. It might also require a policy which called for the acquisition of more accessible transit vehicles. In some cases, it might call for specialized service.

Whatever strategy is tried, it is clear that some type of monitoring will be required to assess the effectiveness of various measures. Clearly, this will involve more than simply counting passengers. Yet, as will be demonstrated, in Chapter Five, this is now the norm. Before we arrive at that point, however, we must explore other facets of transit's new goals.

4.3 TRANSIT AND THE URBAN STRUCTURE

> "... in the final report of the Transportation Plan Review, considerable emphasis is placed on encouraging decentralized forms of land use development (that is the creation of regional sub-centers that tend to reduce the overriding importance of the central area) and transportation systems that would encourage the implementation of such development policies. Wherever possible, the Transportation Plan Review emphasized increasing dependence upon public transportation and to a large extent gave low priority to road improvements and the construction of new urban expressways." (Ontario Royal Commission on Metropolitan Toronto, 1975,p.9.)

Increasingly, transit investment is often justified based on it's expected impact upon urban development patterns. According to the normally glossy reports, transit is to be used as a "positive development tool" by those responsible for broad brush, metropolitan land use planning.

The argument that transit has a major role to play in land use planning is complex. On the one hand, a presumption is made that public policy makers and planners can realistically define a desirable land use pattern - at least in a broad manner. Secondly, it assumes that

land use developments are sensitive to the transport system and that these linkages can be forseen. Finally, and most relevant to this thesis, it assumes that particular forms of urban development can be expected to evolve dependant on the mode of transport emphasized. In the case of transit, it is generally supposed that a relatively more compact form of development will evolve than would evolve if private automobile transport was emphasized. These last two arguments will be the subject of this section.

LOCATION THEORY

Theoretical work suggests the link between land use developments and transport is explained by location theory. A large body of empirical evidence, however, suggests transport is only one of a myriad of factors responsible for urban development. Furthermore, different types of development (eg. residential vs commercial vs industrial) are influenced by different factors. In the case of residential development, for example, recent evidence suggests environmental factors such as neighborhood amenities are far more important than transport as an explanatory variable through which residential development

can be explained and predicted. (Michelson, 1972; Richardson, 1971, Chapter 1.) With these provisos, the importance of classical and neo-classical location theory to the genesis of current thought and emerging land use plans cannot be understated. What follows then, is the theoretical, albeit simplified, foundation of modern location theory.

In the classical theory, firms and households are seen as competitors for an unusual commodity which is called location. In the theory's early development dealing with agricultural patterns of spatial organization, von Thünen presented the elementary case where site rents were exclusively a function of a location's proximity to markets.(Hall, 1966.) In the classical model, the maximum distance from the market where production will take place is that distance where transportation costs just equal economic profit.

$$d_{max} = \frac{p_m - p_c}{r}$$

where: p_m = market price

p_c = production cost

r = transport rate

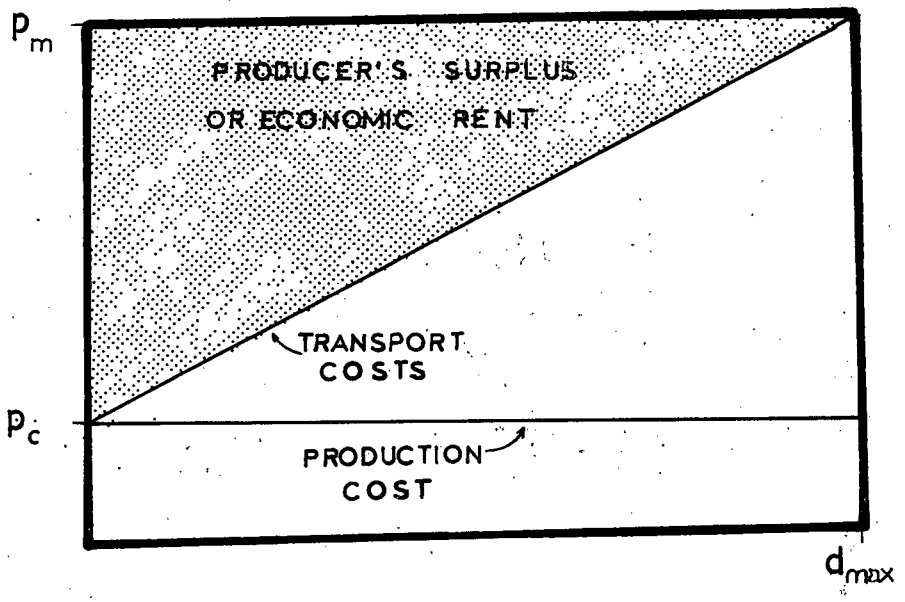


FIGURE 4.2

DIAGRAMMATIC REPRESENTATION OF CLASSICAL LOCATION THEORY

source: conceptualization by author

Since sites closer to market are more profitable, owners will be able to demand and obtain higher economic rents for their use (for simplification, linear transport charges are assumed). In the one commodity market, the resulting rent structure is cone shaped as represented in Figure 4-3.

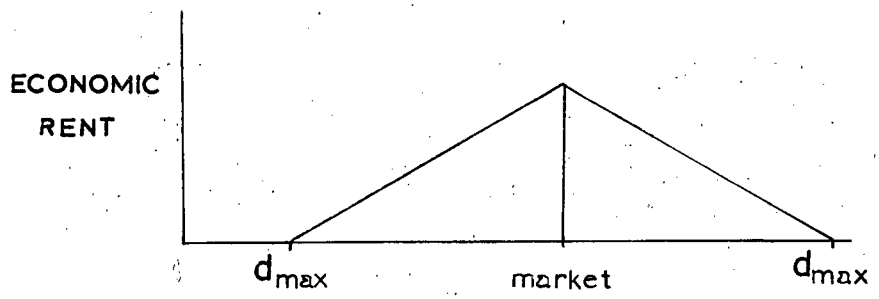


FIGURE 4.3

RENT CONE IN PURE ONE COMMODITY MARKET

From this simple model, several empirically observed phenomena can be deduced. First, an increase in transportation efficiency will cause the rent cone to flatten out as areas further from the market become competitive. Secondly, if output per unit of land is allowed to vary, then locations closer to market will presumably have higher intensities of land use.

If more than one type of crop is assumed, the classical model predicts that those crops which can yield the

highest profit will be produced at a given location. The particular location of one type of crop in relation to another will be determined by the slope of the rent curve and the market price. Those crops with steep rent curves will always displace crops with more shallow rent curves provided market price is high enough. Hence, market forces will generate a series of land uses as shown in Figure 4-4.

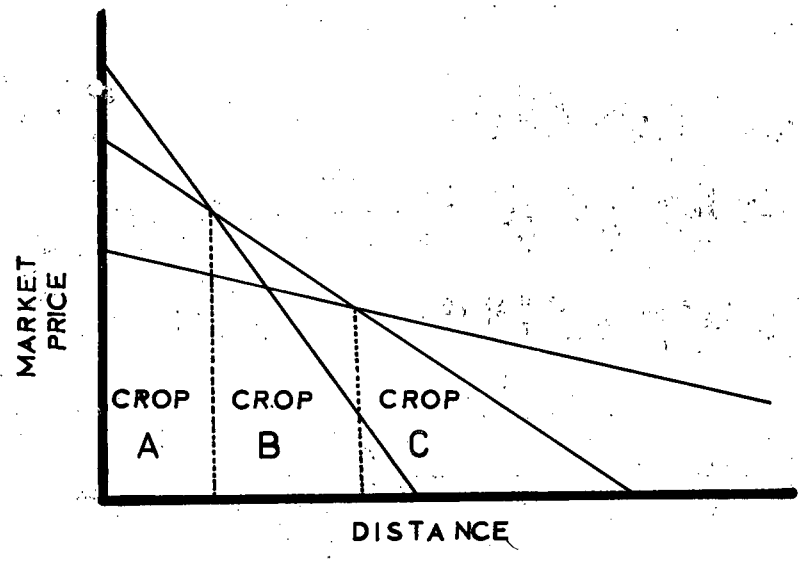


FIGURE 4.4

ECONOMIC RENT CURVES FOR COMPETING LAND USES

The elementary theory has been expanded substantially by many. Perhaps the most satisfactory theory is presented by Alonso. (1960) In this model, a family of bid-rent curves exist for each user of land such that each is indifferent to location anywhere along the curve. Equilibrium rent is determined by comparing bids of potential users and choosing the highest. For non-profit maximizing users (eg. residential land use), bid-rent functions will reflect individual satisfaction rather than profits. Alonso presents the case where individual's value of space is traded off against transport costs to determine residential location. Empirical observation suggests the process is considerably more complex.[5] The theoretical model offered by Alonso, however, has not been nullified. In it's pure sense, the model is not restricted to a single attribute. Nor does it attempt to shed any light on the nature of specific attributes. Rather the Alonso model is an important statement as to the principles of the urban land market.

---

5. For a critique of the theoretical basis for the Alonso model and other tradeoff models, see, Harry W. Richardson, Urban Economics (Penguin Books, 1971,pp.19-24.)

A substantial body of literature supports the general observations of the Alonso model. Clark(1951) has observed that residential density declines in a logarithmic function from the center of the city supporting the notion that "close-in" locations will have more intensive land use. Land values follow much the same pattern. Berry (1971) has shown land values in Chicago radiate out from the C.B.D. along major transportation corridors with peaks at important interchanges. Business centers have developed at these peaks.

One attempt to conceptualize the transit induced development process, utilizing much of elementary location theory has been formulated by Hamburg (1970). In his model, Hamburg assumes the stock conditions and assumptions of economic theory. He begins with a flat even plain with no development. The region is divided into a series of equal sized zones. Each zone is assumed to have equal attractiveness in terms of non-transportation factors (site, neighborhood, and institutional characteristics). Alternative transport systems are then superimposed upon the region. Development is then allocated to each zone based on the nature of the accessibility offered by alternative transport systems. Sub-

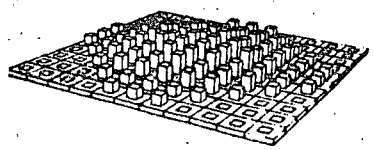
stantial differences are predicted to occur if the urban transport is either entirely dependent upon automobiles or upon transit. (Figures 4-5a and 4-5b)

Once a city has developed an automobile network, however, the existence of radial transit systems are predicted to cause little development impact.(Figure 4-5c). The model suggests there are reasons to doubt whether conditions which historically were associated with transit are still applicable to modern conditions. This warning, moreover, is given solely based on accessibility factors.

LOCATION THEORY - SUMMARY

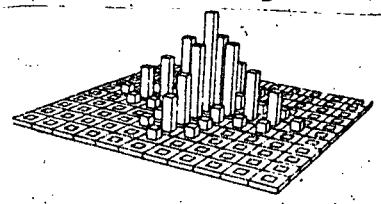
While there is empirical support for some of the more general observations of neo-classical location theory, there has been only limited success in attempts to "operationalize" such models. A host of factors account for the complex workings of the urban development process; transportation is only one of these factors. Other variables such as site, neighborhood and institutional characteristics are difficult to integrate into the various models although they are not incompatible with the various

figure 4.5(a)



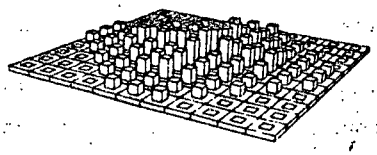
Development pattern for population of 1,500,000 served by automobile network

figure 4.5(b)



Development pattern for population of 1,500,000 served by transit network

figure 4.5 (c)



Development pattern for population of 1,500,000 served first by transit then by automobile network

FIGURE 4.5

CONCEPTUAL IMPACT OF TRANSPORT UPON URBAN DEVELOPMENT

SOURCE: Paul Drewe, Impact of the Structure and Extent of Urban Development on the Choice of Modes of Transport: The Case of the Medium Size Conurbation., (European Conferences of Ministers' of Transport, OECD, Paris, 1975, p. 39)

theories. Commenting upon the shortcomings of the existing theories, a recent review concluded...

> "... the inconclusive nature of the work in this area can be attributed to the myriad of significant problems concerning not only what factors to incorporate into the analysis but the precise way in which to do so." (Alcaly, 1976 p.51.)

Existing statements of classical location theory begin with simplified assumptions. The most workable statements of existing theory assume unrealistically simplified conditions: a centralized city with a single nucleus of employment, perfect land markets and homogenous site conditions. Agglomerating forces and institutional constraints are ignored. Existing theories give no guidance as to how heterogenity between different types of land use (residential, retail, office, manufacturing) should be handled. However, even when all the simplified conditions are assumed theoretical work suggests the implementation of rapid, modern transit in contemporary urban areas (with mature automobile networks in place) is likely to have little development impact.

EMPIRICAL EVIDENCE

Earlier portions of this Chapter demonstrated the complex theoretical relationship between transport and accessibility and between accessibility and land use. Some general principles were developed which allow some inference to be made concerning the nature of this relationship. How well does historical evidence substantiate these general principles? It is to these questions which we now turn.

Empirical evidence clearly attests to the effect particular transport technologies have had on city development. The technology of the railroad and streetcar facilitated the development of suburbs at a time when crowded cities made urban life intolerable. Yeates comments...

> "(T)he electric streetcar consequently made it possible for the population of urban areas to spread out and thereby to decrease residential densities. For the population to spread out, however, land had to be provided and serviced, and homes ahd to be built. The innovations of the trolly therefore led to great increases in land sales, land values, and land speculation, particularly along the areas adjacent to the main transportation arteries." (Yeates and Garner, 1971,pp. 218-219.)

Similarly, the development of the internal combustion engine gave further impetus to the decentralization of cities. Whereas the streetcar facilitated the radial growth of the cities, the automobile made possible an even greater expansion of the city and permitted the spread of population between major corridors. Further, the decentralization of the city has not been limited to residential land use. Increasingly, commercial activity and industry have also migrated away from the central core.

While the new technology of transit and automobile facilitated major changes in the internal structure of the city, they were not sufficient conditions. Rising real incomes and the new process of mass production made such developments economically feasible. New transportation technologies simply made such developments technically feasible.

The importance of viewing the historical context in which a type of development occurred should not be understated. Recent statements (see Chapter Three) by policy makers imply that the provision of a particular type of accessibility will give rise to development patterns

which were associated with that same provision in the past. Such statements may be invalid. With particular reference to rapid transit, Lash warns...

> "By the time a metropolitan area begins to seriously consider adding a rapid transystem, much of it's transportation system, in the form of an extensive network of roads and streets is established... Thus the network may be less of a controlling influence in determining the form of urban development than is sometimes imagined..." (Lash, 1967, p.193)

Blumenfeld has made substantially the same observation. Noting that density distributions in Hamburg, Germany are practically identical with those in Metropolitan Toronto despite the increased transit orientation of the former, he concludes...

> "(W)ith all parts of a metropolitan region accessible to motor vehicles, presence or absence of other means of transportation have only marginal impact upon development patterns." (Blumenfeld, 1974, p. 192)

While an increased transit orientation is not likely to affect a large change in development patterns, clearly it will have some impact. What can we expect will be the nature of that impact? Richardson (1971,pp.15-16.) has put forth the thesis that access in areas with mature

urban transport systems takes on a secondary role; a limiting constraint. Injections of additional increments of accessibility will have an effect only if the improvement is substantial and only if other non-transport factors are favourable for development. Batty (1974), for example, believes improvements of radially focused transit accessibility will have an effect only if congestion is severe in central areas. Paradoxically, the nature of the impact will be more sprawl and a greater growth in regional demands for travel. This will result through increased concentrations of firms which can take advantage of central agglomeration economies and, at the same time, increased decentralization of residential land uses.

Similar conclusions have also been reached by Putnam (1974) and by Dewees (1974).

Meyer, after comparing empirical records of land use in a number of American cities could find no difference between cities with highly developed transit systems and those without. In his words...

> "... the patterns of land use, population growth, employment location and residential choice recorded in recent years by the most transit oriented American cities have essentially mirrored those of other cities with strong highway orientation." (Meyer, 1964 p. 360)

TRANSIT IMPACT STUDIES

Changing the nature of the transportation system may have far reaching consequences. Impact studies attempt to sort those consequences which can be attributed to the system change from those that would happen without the change. A clear understanding of both the transportation and the larger urban system is therefore prerequisite to proper impact estimation. In many cases, this level of understanding does not exist.

Impact studies can be conducted 'a priori' - before the system change - or 'ex post' - after the change has been introduced. If the study has been conducted 'a priori', then the analyst attempts to predict consequences. If the study is conducted 'ex post', then the analyst attempts to document effects. Impact studies are commonly conducted before projects. Indeed, a lengthy report

detailing the anticipated consequences of specific projects has become an integral part of the project planning process. Ex post studies are rare. They are usually conducted as academic exercises.

In recent years, little attempt has been made to document the effects of transit upon the internal structure of the city after a particular change has been made. What studies have been conducted are typically concerned with rapid transit; an extreme and atypical form of public transportation. Moreover, rapid rail impact studies are of dubious authorship; often they are conducted by agencies with vested interests in the outcome. On the bright side, a major effort is now underway to document the effects of the BART system in San Francisco.

Of the North American studies concerned with the impact of transit upon urban development, perhaps the Toronto study is most frequently cited. The study, conducted by the Toronto Transit Commission, was concerned with the effect of the Commission's subway upon urban development in Toronto. Records of real property values, as indicated through assessed valuation, were compared for properties adjacent to the subway with the city as

a whole. For taxation purposes, the city is divided into 40 districts, 14 of which are adjacent to the subway. Changes in the amount and rate of growth of assessed value were then compared over time. Table 4-1 presents the study findings.

	TOTAL CITY		ADJACENT TO SUBWAY	
YEAR	INCREASE	%	INCREASE	%
1950-53	$101,426,000	7.5	$48,557,000	9.2
1954-56	127,721,000	8.5	69,846,000	12.1
1957-59	212,253,000	13.5	121,521,000	18.8

TABLE 4-2

LAND VALUE INCREASE IN TORONTO

SOURCE: Toronto Transit Commission, Transit in Toronto (Toronto, 1967, p.32.)

Subsequent investigation by independent researchers confirmed the T.T.C.'s general findings. Heenan (1965, p.217.) claims that 48.5% of all high rise apartments and 90% of all new office concentration occurred within a five minute walking distance of subway stations. Bourne's research(1970, p.30.) indicated the bulk of the city's

new development was limited to 5 of the 40 taxation districts, 4 of which were adjacent to the subway. These five areas (which included the CBD) accounted for 83% of all new office buildings and 51% of all new apartments.

The difficulty of separating development effects which have been induced by a new transit facility from those that would have occurred anyway have already been alluded to. On this point, Lash is emphatic.

> "The benefits attributable to urban transportation facilities through increased real estate values are often oversimplified and misleading. Such benefits can be determined only after searching analysis and not simply through the sales experience of properties located along the new facility." (1967,p.192.)

In the case of the Toronto facility, there are several factors which on the surface would appear to be at least as important as the subway. The bulk of office and commercial development occurred within the historical commercial center of Toronto. Similar construction booms have been noted in other Canadian cities. There is reason to believe such construction booms could be attributed to a general increase in service employment. Between 1950

and 1960 (about the same period as the Toronto study) white collar employment in North America increased by about 33%. The growth in blue collar employment amounted to only 5%. (Danials,1975,p.31.) In Great Britain, office employment increased by 40 percent between 1951 and 1961 in a period when total employment grew by only 7 percent. (Goddard, 1973, p.4.)

In San Francisco, a similar boom in downtown office construction has been attributed to the effect of the BART system. During the 12 year period following the decision to build BART, 35 high rise office buildings were constructed in the San Francisco CBD comprising some 18.5 Million square feet of office space. (Webber, 1976,p.13.) New evidence from the BART Impact Study, however, questions the role of BART in influencing the decisions of developers building offices. On a per capita basis other cities have experienced similar construction booms in new office buildings. Houston, for example, a city decidedly oriented toward automobile travel, experienced a greater boom on a per capita basis. (Figure 4-6)

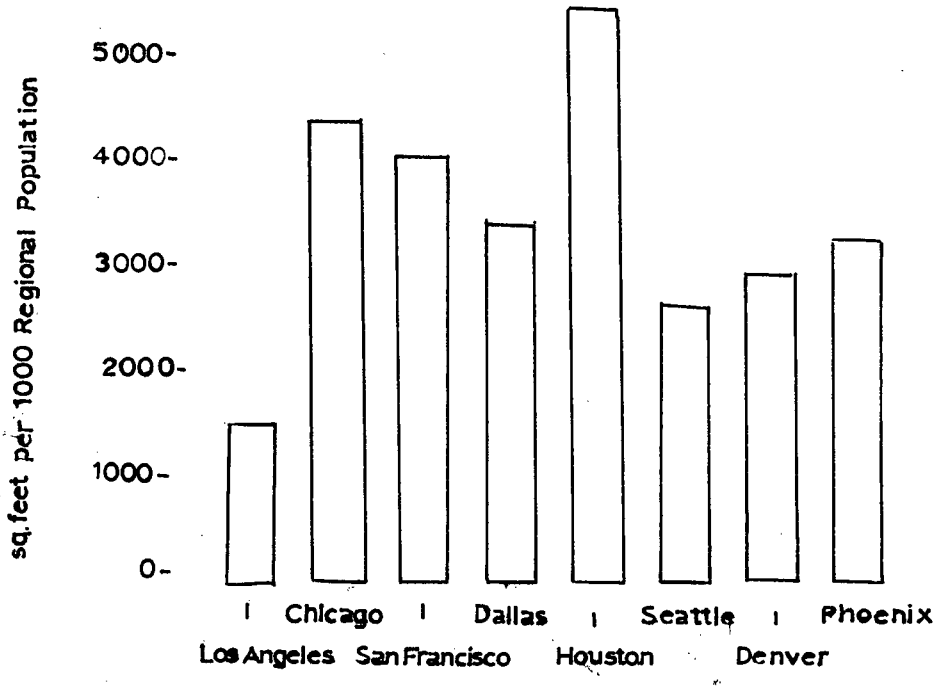


FIGURE 4.6

PER CAPITA OFFICE CONSTRUCTION
IN SELECTED AMERICAN CITIES

---

source: adopted from Melvin M. Webber, The BART Experience - What Have We Learned. Berkeley, Univ. of California, Institute for Urban and Regional Development, 1976, p. 12)

In Philadelphia, Gannon and Dear (1975), attribute the observed decentralization of offices in the Philadelphia SMSA to the effects of the Lindenwold Rail Transit line. Evidence in this case is shaky. The authors note an increase in office employment in adjoining suburbs not served by the facility was greater than areas served but are at a loss to explain why.

> "It is important to note that the speedline is not located within Montgomery County. This study did not investigate the reasons for the high annual rate of growth in office space in this county." (Gannon and Dear, 1975,p.231.)

In both Toronto and San Francisco, suburban commercial development has occurred in only a few areas. There is not a widespread tendency toward suburban commercial development around stations although in the case of the San Francisco facility, this was a major goal. (Webber, 1976,p.15.) Decisions to cut construction costs, led BART planners to locate stations in areas apart from existing commercial centers and to surround the station with large parking lots. Potential developers, who may have wished to locate near BART, were faced with the prospect of large walking distances from the stations. Rather than locate near the transit station, they have apparently

opted to locate within the existing commercial area.

In the case of residential development, there is even less reason to believe that focussed transit accessibility has any effect on development patterns. Little residential development has occurred in the proximity of transit stations in either San Francisco (Webber,1976, p.16.) or Philadelphia (Gannon and Dear,1975,p.223.) In Toronto, substantial claims have been made concerning the effect of the city subway upon apartment developments. There has been no clear demonstration of any actual causality, however, and some doubt the claims of the T.T.C. Hutchinson, for example, notes...

> "In Toronto, the subway is also cited frequently as a major determinant in urban form. The cluster of high density apartments concentrated around the Yonge Street subway station is pointed to as evidence of the desirable impact of subway construction on urban development...."
>
> "A recent study by the Metropolitan Toronto Planning Board has shown that the change in residential density in each of the sixteen planning districts observed over two recent two year periods may be explained almost exclusively by the amount of unused land available at the start of the analysis period. This observation simply reflects the fact that major apartment developers are interested only in the locations where relatively large tracts of land may be assembled which may be zoned for high density development." (Hutchinson, 1972,p.192)

Does transit then, have any real impact upon the internal structure of the city? The accumulating evidence appears to be inconclusive in that, given different situations and circumstances either answer can be at least partially substantiated. While it is clear that transit has little impact upon residential location, (other factors such as neighborhood amenities being far more important), it has been shown to be of some importance to office and retail location. Classical and Neoclassical location theory suggest some general principles which are relevant, but due to their generality and inconclusiveness, they do not lend themselves to rigorous testing or definition. On the whole, the greatest body of relevant literature appears to support the position that the overall effect of transit upon the spatial structure of cities is likely to be small.

The role of transit in regional land use planning is seen then as supportive. Other more traditional land use implementing policies such as zoning, subdivision control, etc., are far more important. The relevance of the theory developed to date, however, has significance to transportation planning and to transit management. What is called for, is a means to insure that the developing transit infra-structure in cities is consistent

with the furtherance of regional land use policies. A mechanism whereby this co-ordination between transit service orientation and land use policies can be objectively measured is desirable. This subject, however, must remain until Chapter Six. There are multiple goals guiding our emerging transit policy. In the next section we shall examine another.

4.4 TRANSIT AS AN ENERGY CONSERVATION MEASURE

INTRODUCTION

Explicit recognition of the energy implications of transportation has only recently been considered in transportation planning. The need for such consideration has been underscored by the current uncertainties over the future availability and cost of energy in general and petroleum in particular. The implications of future energy shortages will affect virtually every facet of life.[6] This section will concern itself with the short term potential (say the next 20 years) of public transportation as one component of an energy conservation strategy.

The present patterns of energy use in urban mobility are the result of complex interactions between national policy, technological development, and long term economic trends. For many years, North America has followed a policy of cheap and plentiful energy. This policy

---

6. See, for example, current proposals which call for a shift to a conserver society. Such a society would ultimately involve fundamental shifts in values and lifestyles.

has been intimately linked with the rapid growth which has characterized the Canadian economy in post war years. That this growth was made possible, in part. by a technology that made relatively inefficient use of energy, is now generally accepted. The dilemma for the future is to find ways to use remaining energy reserves more efficiently without sacrificing social and economic progress and to exploit new sources of energy which are economically viable and environmentally sound.

It is within this contextcthat transit is now popularly seen as one of the strategies with which we can conserve valuable energy. Furthermore, Chapter Three documented that this belief was widely held among policy makers. In this section, the potential of transit as an energy conservation measure is the subject of critical review.

THE DEMAND FOR TRANSPORTATION ENERGY

The demand for transportation energy is a function of the demand for trasnportation services and the energy efficiency of the modes performing these services. There are two aspects of modal energy efficiency. First, diff-

erent modes will utilize differing amounts of energy per vehicle mile of operation. Secondly, the relative efficiency of different modes will be a function of the degree of utilization in terms of passenger miles per vehicle mile of operation. Both of these factors should be clearly recognized in any transit monitoring mechanism.

In Canada, energy expenditures for all types of transportation comprise about 25 percent of total energy use.[7] Virtually all transportation energy used is obtained from petroleum products. Transportation consumption comprises about 55 percent of all domestic petroleum demand. (Yunker and Sinha, 1975.) Road transportation accounts for almost 77 percent of transportation energy use.[8] Of the total gasoline used in Canada about 32 percent is sold in retail trade in Canada's twelve largest metropolitan areas where slightly less than half of Canada's population lives.[9] This amount represents

---

7. Based on Statistics Canada, Detailed Energy Supply and Demand in Canada (Publication #57-207,1973) Canadian energy use totalled 5,779,030 BillioBTU, Total Transportation use accounted for 1,460,920 Billion BTU.

8. Statistics Canada (Pub. #57-207, 1973) Road Transportation accounted for 1,120,137 Billion BTU.

9. Statistics Canada, Energy Statistics, Retail Gasoline Sales By Metropolitan Area (Pub. #57-002,Vol.9,No.56,1973) Retail gasoline consumption in 12 Canadian Metro Areas consisted of 2,228,86 Million Gallons. Total Road Gasoline used in Canada consisted of 7,029.37 Million Gallons.

about 6 percent of total Canadian Energy Use or about 23 percent of the transportation energy used.[10]

Urban mass transit in Canada currently consumes about 47.5 million gallons of petroleum products and about 403 million kilowatt hours of electricity.[11] This amount of energy is equivalent to about 2 percent of the gasoline sold in the twelve largest metropolitan areas.[12]

In recent years, the demand for petoleum products has been growing at an annual rate of about 6.6 percent.[13] Furthermore, most projections of future transportation energy demand predict a continued rapid rate of growth. (Yunker and Sinha, 1975, p.572.) As domestic and global reserves are depleted, future supply of fuel available may become problematic.

---

10. BTU equivalent for this amount of gasoline is approximately 341,498 Billion BTU.

11. Statistics Canada, Urban Transit (Publication # 53-003, Vol.23, No.12).

12. BTU equivalent for this amount of energy is approximately 9,297 Billion BTU.

13. Statistics Canada, (Publication # 57-207.), Average growth rate for petroleum products for period 1960-1969.

MODAL ENERGY EFFICIENCY

The energy used by the different transportation modes is comprised of capital energy used in the manufacture of vehicles and guideways, and operating energy used to propel vehicles. In some cases, the amount of capital energy used to construct a transportation system may be as significant as the amount used to operate. It is reported, for example, that the energy used to construct the BART system in San Francisco is equivalent to about 44 percent of the energy used to operate it for the next fifty years.[14]

Estimates of the total energy requirements for various modes are shown in Table 4-3.

Comparisons of modal efficiency must also account for the differing degrees of utilization of the various modes. A city bus, for example, uses much more energy per vehicle mile than does an automobile but also carries a greater average number of passengers. Hence, at some load factors, a bus maybbe more energy efficient than

---

14. See, Office of Technology Assessment, Energy, the Economy and Mass Transit (United States Congress, Washington, D.C., 1975.)

TABLE 4-3

TOTAL ENERGY CONSUMPTION PER VEHICLE MILE FOR

SEVERAL URBAN TRANSPORTATION MODES

(expressed in K.W.H.)

SOURCE:
M.F. Fels, Comparative Energy Costs of Urban Transportation Systems, (Transportation Report 74-TR-2, Transportation Program, Princeton University, 1974, p.30)

Individual contribution to energy use	AUTO 3600 lb	AUTO 2000 lb	CITY BUS	RAPID RAIL	PRT	BICYCLE	WALK
OPERATION	3.19	1.63	9.57	16.7	5.92	.042	.063
VEHICLE MANUFACTURE	.39	.21	.30	.4	.40	.042	--
GUIDEWAY MANUFACTURE	..03	.03	.09	.7	.02	.014	--
TOTAL ENERGY PER VEHICLE MILE	3.61	1.87	9.96	17.8	6.34	.10	.063

a typical automobile. As the load factor of the urban bus declines, there is some point where an average loaded automobile becomes more energy efficient. For this reason, comparisons of energy efficiency are commonly expressed in terms of energy use per passenger mile. Typical ranges of the operating energy requirements of three modes are presented in Figure 4-7.

For policy purposes, the incremental change in modal efficiency should be distinguished from an average measure of efficiency. As long as the service elasticity of transit demand is less than one, a given increase in transit service will bring about a smaller percentage increase in passenger demand.

The need to consider the incremental energy use as opposed to the average useccan best be illustrated by way of example. In 1972, Canadian transit systems carried some 1,041 Million annual riders and produced 261 Million miles of service.[15] By 1975, ridership had risen to 1,133 Million riders while service miles had increased to 303 Million miles.[16] If the increase

---

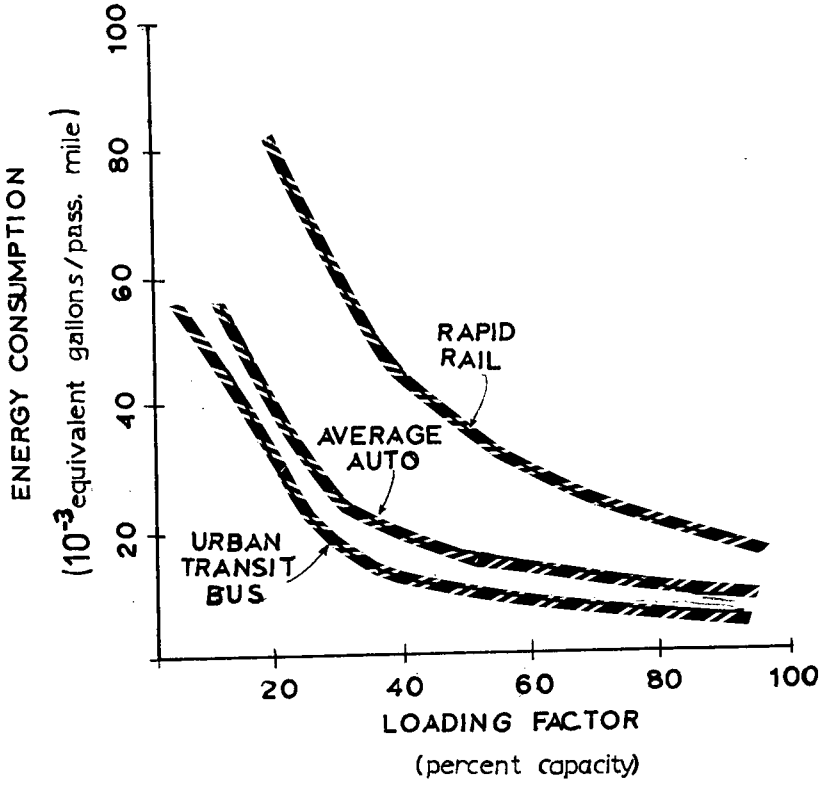
15. Statistics Canada, Urban Transit (Publication # 53-003, 1972.)

16. ibid, 1975

FIGURE 4.7

MODAL ENERGY EFFICIENCY

VS. VEHICLE UTILIZATION



source: adopted from Kenneth R. Yunker and Kumares C. Sinha, "Energy Considerations in Urban Transportation Planning", TRAFFIC QUARTERLY (Volume 29, 1976, p. 585)

in service level was chiefly responsible for the increase in passengers, then 92 Million additional passengers were attracted at the cost of 42 Million additional service miles. The marginal energy cost of this increase would then be about 44 passenger miles per equivalent gallon of fuel.[17] (414 Million passenger miles ÷ 9.33 Million equivalent gallons of fuel) During the same period, the average energy cost per passenger mile would decline from 81 (4,684 Million passenger miles ÷ 58 Million equivalent gallons of fuel) to 75.7 (5,098 Million passenger miles ÷ 67.3 Million equivalent gallons of fuel). This represents a decline of only 6.2 percent.

Further exploratory calculations indicate that transit has only limited potential in the short run as an energy conservation measure. Assume transit, through a doubling of current service, was able to double it's present ridership. Assume further, that the increased ridership accrued from former automobile drivers. The savings in gasoline use would be on the order of 33,000 Billion BTU.[18] Transit systems would use an addition-

---

17. Assumes an average trip length of about 4.5 miles per gallon and modal energy consumption of 4.5 vehicle miles per equivalent gallon of fuel.

18. Based on current energy use patterns.

al 9,300 Billion BTU. Net energy savings would be about 24,000 Billion BTU. This amount of energy represents about .5 percent of total Canadian Energy use or about 6 percent of gasoline sold in retail trade. Yet, favourable conditions for transit were assumed in the calculations.

On the other hand, consider the short term potential of measures designed to enhance the energy efficiency of automobiles. Present Canadian standards require that all new automobiles sold in 1980 must be capable of getting 24 miles per gallon. By 1985 this requirement increases to 33 miles per gallon. Similarily, measures to increase the utilization of automobiles can bring dramatic results in terms of energy efficiency. While transit may play a part in Canadian energy it is clear that it is not a panacea.

4.5 CLOSURE

A host of institutional, economic and technological factors exist within the urban transit environment which tend to reduce the potential of transit in meeting articulated urban objectives. Local areas which plan to emphasize the role and scope of transit will require careful planning to insure the recommended network best serves local aspirations.

The planning model utilized by local areas will likely place heavy emphasis upon a monitoring system which generates relevant information. Moreover, the type of information generated would best reflect the broad goals which local areas are attempting to meet. Hence, it is not unlikely that different areas will require different types of information.

What types of monitoring systems are now used by public transport agencies? Can any inferences be made as to the apparent goals which monitoring systems now in use appear to reflect? This is the subject of Chapter 5.

CHAPTER 5

TRANSIT MONITORING: CRITERIA NOW IN USE

5.1 INTRODUCTION

> "The changing role of public transit in North America has generally not been accompanied by improvements in the state-of-the-art of data collection and analysis. Most public transit agencies and operators do not have measurable objectives that specifically relate transit service and performance to broader community goals and objectives..." (Horn,1977, p.29)

It is surprising that critics of current transit programmes cite a lack of information as a major problem. Few organizations require as much data to insure efficient operation as do local transit operators. Transit service that is not immediately consumed cannot be stored; it is an infinitely perishable product. Careful study is required to insure the supply of transit offered to consumers is closely related to the amount demanded.

To further complicate matters, demand is in no way static. Rather it is in a constant state of flux both temporally and spatially. To cope with these complex operating conditions, a good deal of resources are devoted to the generation of information. In Vancouver, 23 full time positions have been created by B.C. Hydro transit to collect detailed ridership information.[1]

With the increasing trend toward public ownership within the transit industry has come a similar broadening of the type of decision-making information required to adequately assess transit's new role. This is due to the substitution of social profit maximization as the operational decision making criteria for the economic profit making criteria historically utilized. Agencies are now expected to assess social well-being along with fiscal viability. A fundamental dilemma for public properties stems from the lack of generally accepted criteria and procedures through which this trade-off can be axcertained.

In this chapter, the type and nature of information available and used by transit operators will be reviewed. The chapter will draw from several sources including surveys of transit operators and planning organizations, a review of liter-

---

1. Interview with Mr. V. Sharman, Director, Operational Planning, B.C. Hydro Transportation, July 18, 1976

ature and several recent and progressive transit development studies.

5.2 A TAXONOMY OF URBAN TRANSIT CRITERIA

A variety of criteria relating to urban transit is presently being used in North America. It is clear that there are different levels of criteria, each corresponding to a specific use. There have been a number of attempts to classify criteria along several different dimensions. For example, Rice, (1972), attempted to stratify criteria according to interest group (user vs operator vs community) Others,,have attempted to stratify criteria along the dimensions of efficiency and effectiveness. Presumably, efficiency relates to economic viability while effectiveness relates to the furtherance of social well-being. A third methodology attempts to stratify criteria along the lines of system performance and system impact. This appears closely related to efficiency and effectiveness.

In this study, an attempt will be made to treat transit as a continuing urban programme rather than a comprehensive project. The emphasis here will be on programme management rather than project design. Transit will be considered a system rather than the sum of component parts. With these considerations a three tiered classification system is proposed.

Operational efficiency refers to criteria which relate operational inputs to operational outputs. This is a suitable definition for internal efficiency. Operational inputs refer to resources (eg. labour and capital) used to produce operational outputs (eg. bus miles). Measures of this type would include such criteria as the number of employees per transit vehicle or the cost per vehicle mile.

Program efficiency refers to criteria which relate to the manner of organization of operational outputs. This set of criteria will be used extensively in the planning of service. The chief means by which community transit goals can be met, for example, will stem from the manner in which resources are allocated to different spatial areas and time periods and the linkage between them. This is commonly defined as the level of service.

This set of criteria will seek to quantify the means by which a particular plan is expected to contribute toward the attainment of some higher level goal. The quantification of level of service will be known as program input. Program efficiency, then, becomes the ratio of operational inputs to program inputs. It seeks to

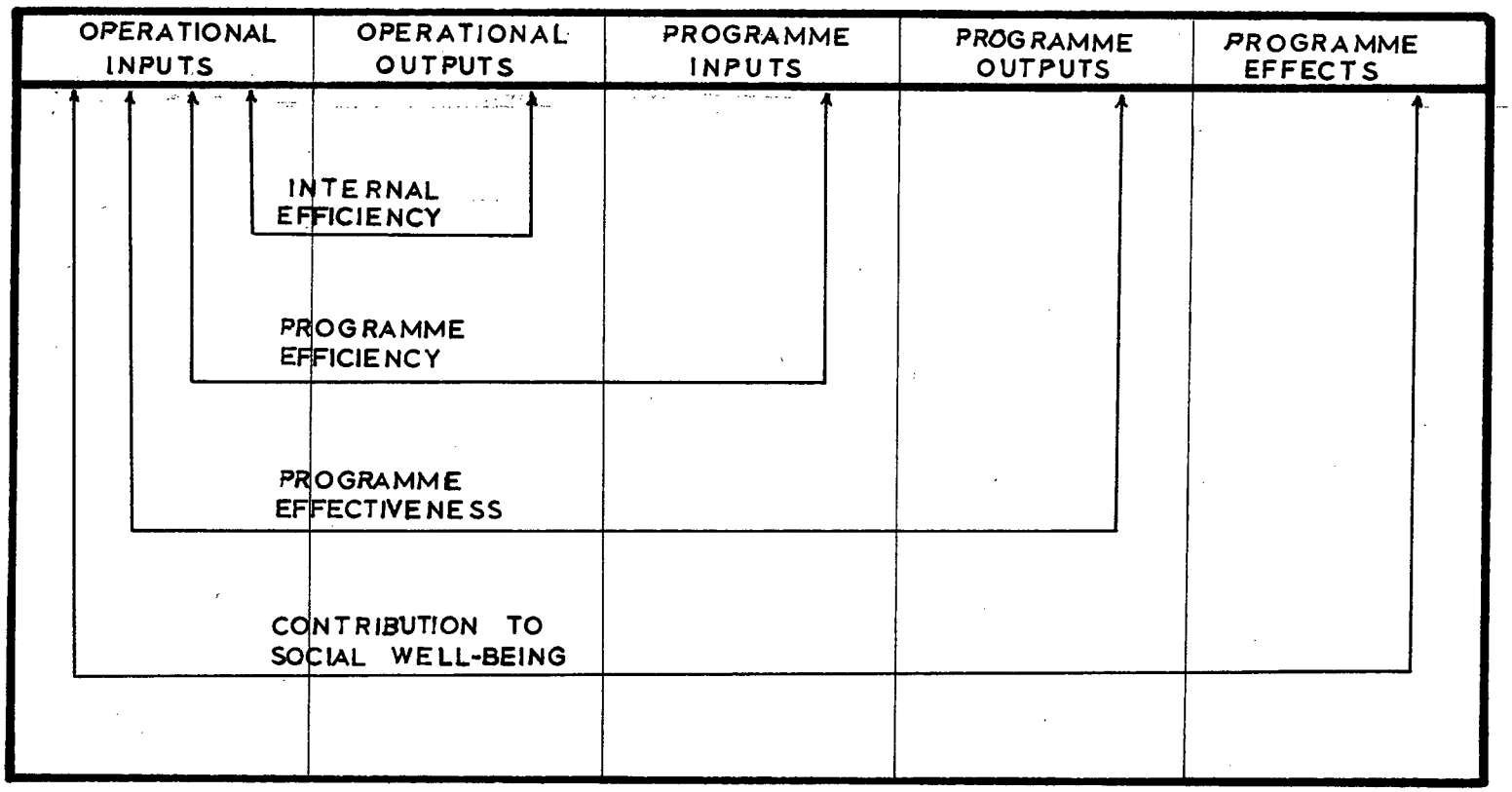
measure how efficiently a particular alternative or plan has been mounted to meet a specific operational objective.

There is a danger, however, in overreliance on measures of program efficiency. Policy evaluation involves the relation of policy inputs to policy outputs. The conceptual measure of program efficiency suggested here seeks only to measure and quantify policy inputs. The relationship between policy inputs and policy outputs is derived from the conceptual model of the rational planning process. Policy inputs are the means through which desired policy outputs are expected to be generated.

Finally, program effectiveness will refer to the extent to which a continuing program of public transportation appears to be meeting community objectives. This set of criteria will facilitate the trade-offs that public transit operators and planning organizations must make between fiscal viability and social profit maximization. The quantification of this measure will be defined as program outputs. Like program inputs, this measure should be goal oriented. It will not however indicate the actual contribution of the community transit system toward social well-being or program effects. Rather, program outputs are in reality indicative meas-

FIGURE 5.1

DIAGRAMATIC REPRESENTATION OF LEVELS OF TRANSIT CRITERIA



ures of such effect. They attempt to measure the degree to which operational objectives are being met. The distinction between operational objectives and community goals cannot be understated. The actual program effect of transit could only be estimated in a much broader context following very searching analysis. This level of analysis is clearly beyond the legitimate functions of transit management or transit planning organizations.

Finally, it is also useful to consider three different levels of planning; the urban area as a single unit; the zonal components which comprise the urban area and; the various links of the transportation system connecting the parts to the whole.

5.3 CRITERIA RELATING TO OPERATIONAL OUTPUTS

A variety of statistical measures, often derived from accounting records, are commonly used by urban transit properties. These indicators usually measure some physical unit of actual work produced by the transit work functions. Measures of this sort include the aggregate total of bus miles (or bus hours) operated. This type of data is widely reported in government statistical reports (see, Statistics Canada Pub. # 53-003) and in special reports compiled and disseminated by industry organizations such as the American Public Transit Association. This data is useful for comparisons between different transit operators and between different time periods. It is common to construct ratios of operational inputs to operational outputs. This measure then becomes a measure of operational efficiency. It is common to express this ratio in terms of cost per vehicle mile. A survey of transit operators (Horn, 1977), revealed that approximately 77 percent of transit operators responding (N=28), expressed this measure on a route by route (or link) basis.

Various other measures, such as the number of employees per vehicle mile, or the average annual vehicle mileage per fleet coach, are commonly computed. All of these measures attempt to give some indication of the relative efficiency (vis a vis other operators or some other time period). Moreover, they are commonly used in the preparation of annual budgets.

The relative uniformity of such measures between different properties is not surprising. The current uncertainties within the transit industry stem from the absence of an ascertainable methodology with which to handle social well-being.

Operational output measures, and measures of operational efficiency, have historically been employed by the private, for profit, transit properties. In the metamorphosis from private to public ownership, this well developed system, already utilized to measure operational outputs, was not discarded.

5.4 CRITERIA RELATING TO PROGRAM EFFICIENCY

Measures of program efficiency, as defined here, relate to the manner in which resources are organized to meet objectives and the implications such an organization of resources has to operational inputs (See Figure 5.1). Our chief task in this section, will be to review the various measures of program inputs now utilized within the transit industry.

Most transit properties utilize some measures of program inputs although they are usually known by some other name. In Horn's survey of transit operators (1977) for example, fully 84 percent of repondents indicated they collected information on the degree of schedule adherence. Although crude, this measure gives some indication of the quality of service. In general, measures of program input will seek to measure the level of service.

Despite the fact that the level of service is the chief means through which urban transit policy can be operationalized, it's measurement, for the most part, remains an imprecise science. Furthermore, most measures

refer to either links in the transit system or general urban scale measures. Program input (or level of service) measures at the zonal level are seldom used. This paucity of information tends to complicate analysis. A recent analysis of the Toronto, Canada public transportation system, for example, concluded:

> "In examing strengths and weaknesses of public transportation in Metropolitan Toronto, attention has (had) to be given to the whole at the expense of the detailed discussions on the parts." (Parkinson and Chan, 1973, p. 7)

Procedures followed by the bulk of transit operators follow guidelines set out by the National Committee for Urban Transportation (1958). This publication, however, is more a discussion of qualitative transit planning standards and less a rigorous methodology by which service level can be measured. It's emphasis is decidely on isolated links (routes) in the transit system rather than attributes of the system in whole. Measurement of service level, as suggested by this manual, is largely restricted to determination of route frequency.

Perhaps more disturbing, is the lack of any guidance from the manual as to how to handle social goals (as defined in Chapter 4). This is understandable given the vintage of the manual, yet it's suggested standards are apparently still utilized by many properties.

A more recent manual by the Urban Institute (1972), suggests that a measure of accessibility is more appropriate as a definition of level of service. Two measures are suggested. The first measure attempts to estimate the "percent of residents not within 'x' minutes of public transit services or more than one hour from key destinations."[1] It is suggested that a residence is accessible to a surface transit line if it is within a five to ten minute walking distance from a bus stop or station. No guidance is given as to what constitutes a "key" destination. A further refinement of this technique is suggested whereby the percent of residents without access to an automobile is estimated based on secondary zonal data on automobile ownership and demographic information.

---

1. Richard Winnie and Harry P. Hatry, Measuring the Effectiveness of Local Government Services: Transportation. (Urban Institute, Washington,D.C., 1972, p.17.)

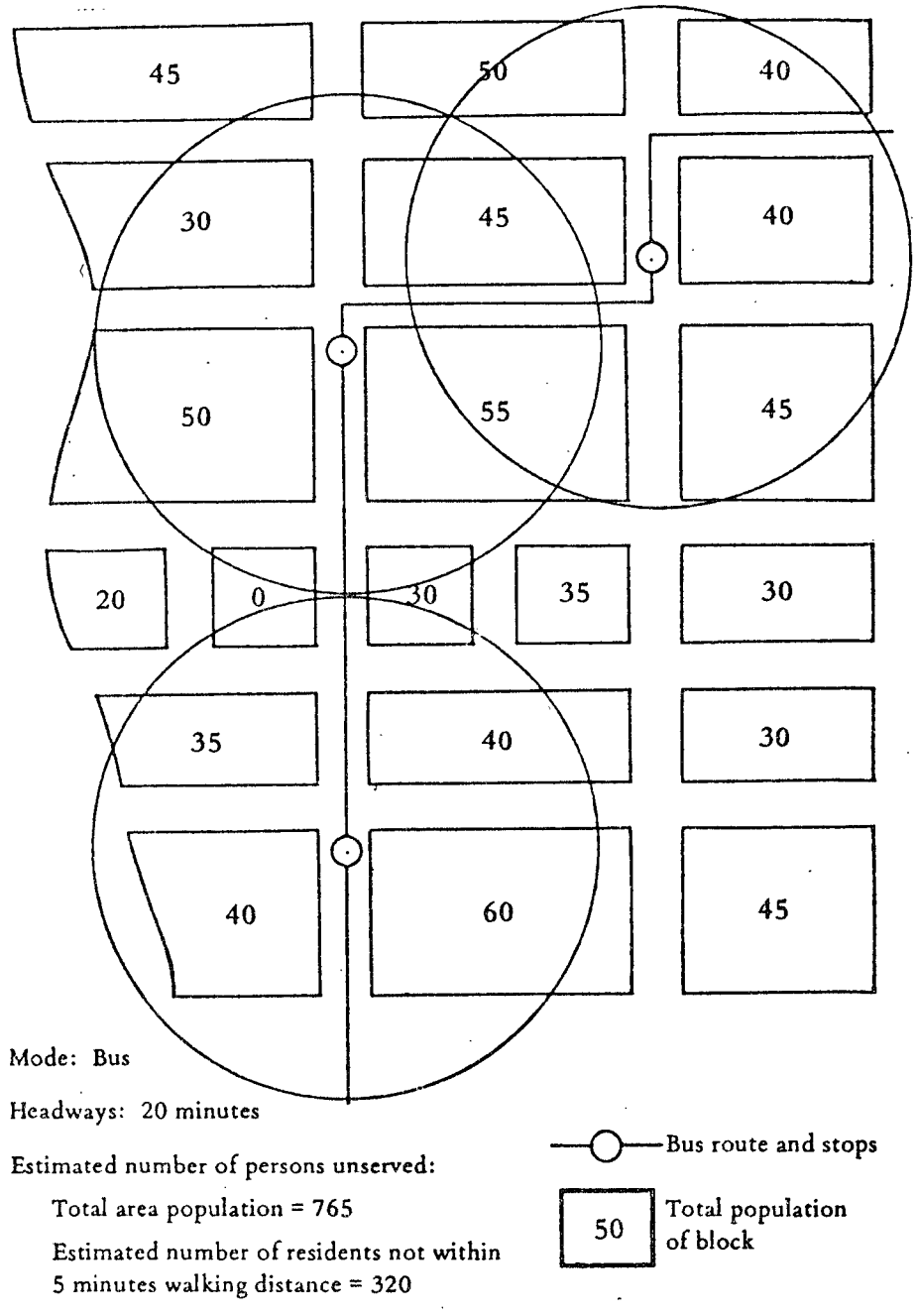


FIGURE 5-2

ILLUSTRATIVE MAPPING PROCEDURE TO DETERMINE TRANSIT ACCESSIBILITY

source: Winnie and Hatry, Measuring the Effectiveness of Local Government Services:Transportation (The Urban Institute, Washington, D.C., 1972, p 20

The second level of service measure recommends that the "time required to travel between major origins and destinations " be monitored on an annual basis. In an "average sized city", the report estimates that about 15 to 30 origin-destination links would be adequate to derive an urban level measure. It further recommends that other links should be included which, though not presently travelled with high frequency, are nevertheless "socially desirable". As an example of such a link, it cites a route portion which connects a low income neighborhood experiencing high unemployment with an employment center which could conceivably use the type of labour available in the neighborhood.

Criteria of this type are commonly used by many of the larger transit organizations, though they are more frequently utilized as local standards rather than measurement procedures. In Toronto, for example, local objectives have been developed which define the percent of population, stratified by automobile ownership, which it would be desirable to serve.

POPULATION CLASS	DESIRABLE PERCENT ACCESSIBLE *
Low car ownership	90
Medium car ownership	70
High car ownership	60

* defined as within 1000' of a surface line or subway station.

TABLE 5.1

LEVEL OF SERVICE STANDARD UTILIZED IN TORONTO

SOURCE: PARKINSON and CHAN, 1973

A further criteria, defined as "connectivity" is measured in terms of the travel time (vehicle only) from origin to downtown. This criteria would be applicable to urban areas which aspired toward C.B.D. preservation or enhancement. A third criteria used in Toronto to measure level of service utilizes transit/auto travel time ratios, though again only for travel to the C.B.D. Total door to door travel time is considered in this measure.

Similar criteria have been recommended in Portland,[2] and in Cleveland.[3]

---

2. Tri-Met Transit Authority (portland, Oregon) Goals (unpublished, 1975, Portland, Oregon)

3. Alan M. Voorhees & Associates, 5 County Transit Study-Service standards and Level of Service Criteria (Unpublished draft report, Cleveland, Ohio, 1973)

In Boston, local standards have been developed whereby average spacing of surface routes is also a function of population density.[4] This measure has been refined, however, so as to express level of service in terms of the miles of transit routes per square mile of development. This measure is the reciprocal of route spacing.

Pop./Sq. Mile (thousands)	Average Spacing Feeder	Crosstown	Route Miles/ Sq./Mile
Over 12	.4	.6	4.17
100- 12	.5	.75	3.33
8 - 10	.6	.9	2.67
6 - 8	.8	1.2	2.00
4 - 6	1.00	1.5	1.67
2 - 4	1.0	---	1.00
Under 2	2.00	---	.50

TABLE 5.2
LEVEL OF SERVICE STANDARD UTILIZED IN THE BOSTON METROPOLITAN AREA[4]

Scheibe and Schultz use a somewhat similar measure but also consider the frequency of service. Their criteria is the one way hourly bus miles per square mile. This measure equals the reciprocal of the spacing distance times the frequency of service. For design purposes, it has the added advantage that total bus miles can be used as a surrogate measure of cost.

4. Massachusetts Bay Transportation Authority, Service Policy For Public Transportation. (Unpublished, Boston, 1975)

A conceptually superior, but far more complicated measure has been suggested by the Institute of Transportation Engineers (1976). This measure seeks to define the "percent of opportunities (y) that can be reached in minutes (t) or at cost (c) by population group (x)."

where:

y_1 = jobs

y_2 = classrooms

x_1 = low income residents

x_2 = high income residents

t = local standard

c = local standard

It is further suggested that spatially disaggregated accessibility indices could serve to indicate whether the local public transportation system is compatible with local land use plans. Presumably, accessibility should be high for the designated growth areas whether this is the C.B.D. or some other activity area.

A similar analysis has been carried out in the preparation of the five year transit development plan by the Comprehensive Planning Organization of the San Diego Region. In that study, the criteria used to measure level of service was the " % of population able to reach % of jobs in the San Diego Region within 45 minutes (door to door) using the bus transit system."[5] The San Diego Study further stratified the above measure by income group and spatial proximity to the C.B.D.

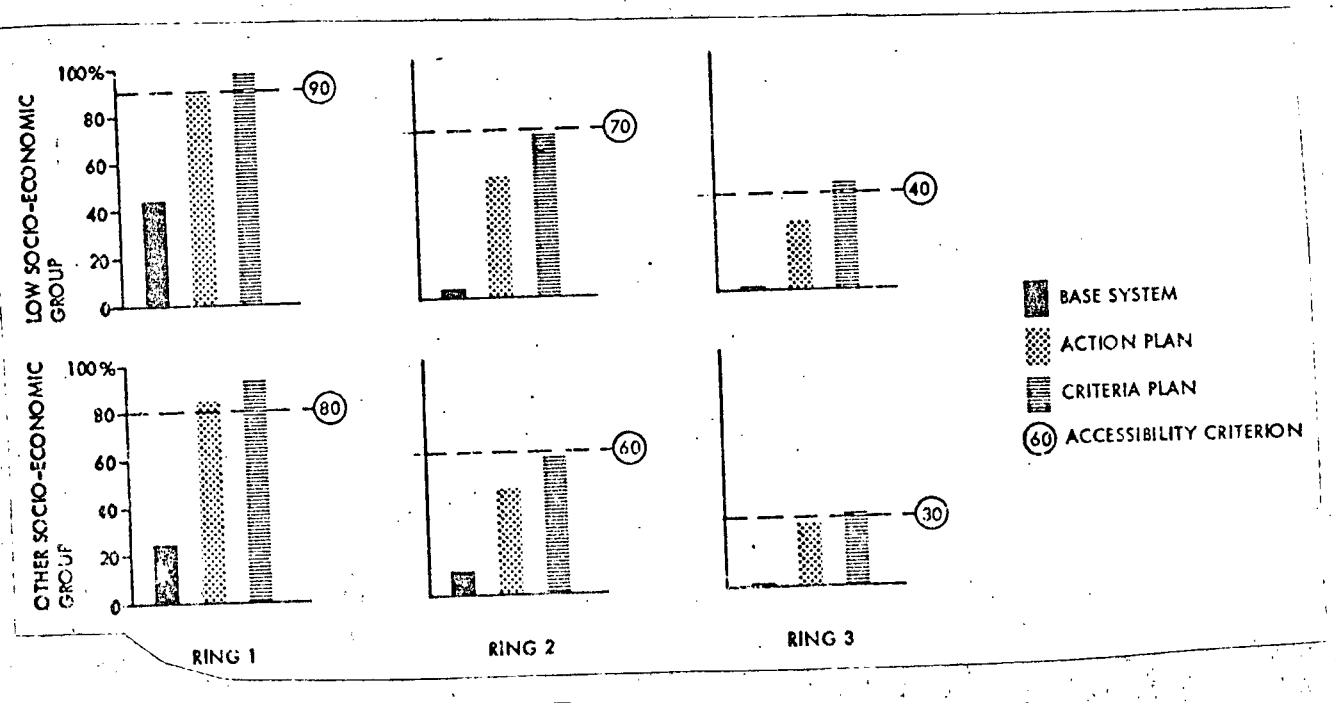


FIGURE 5.3

LEVEL OF SERVICE OF ALTERNATIVE TRANSIT PLANS IN SAN DIEGO

5. Comprehensive Planning Organization of San Diego, Transit Development and Management Plan, (San Diego, 1975)

Type of Activity	Ring	Socio-Economic Group	Standard	
Employment			% of population able to reach % of jobs in the San Diego Region within 45 minutes (door-to-door) using the bus transit system:	
			% Population	% Jobs
	Inner	Low	90	40
		Other	80	40
	Intermed.	Low	70	30
		Other	60	30
	Outer	Low	40	15
		Other	30	15
Shopping or Health Services			% of population able to reach a major shopping area (greater than 300,000 square feet) or major health clinic within 30 minutes using the bus transit system:	
			% Population	
	Inner	Low	90	
		Other	80	
	Intermed.	Low	70	
		Other	60	
	Outer	Low	40	
		Other	30	

TABLE 5.3
LEVEL OF SERVICE CRITERIA
IN SAN DIEGO

source: Comprehensive Planning Organization of the San Diego Region, Transit Development and Management Plan., (San Diego C.P.O., 1975)

A variant of the I.T.E. measure has been suggested by Rice (1973). This measure involves calculating the

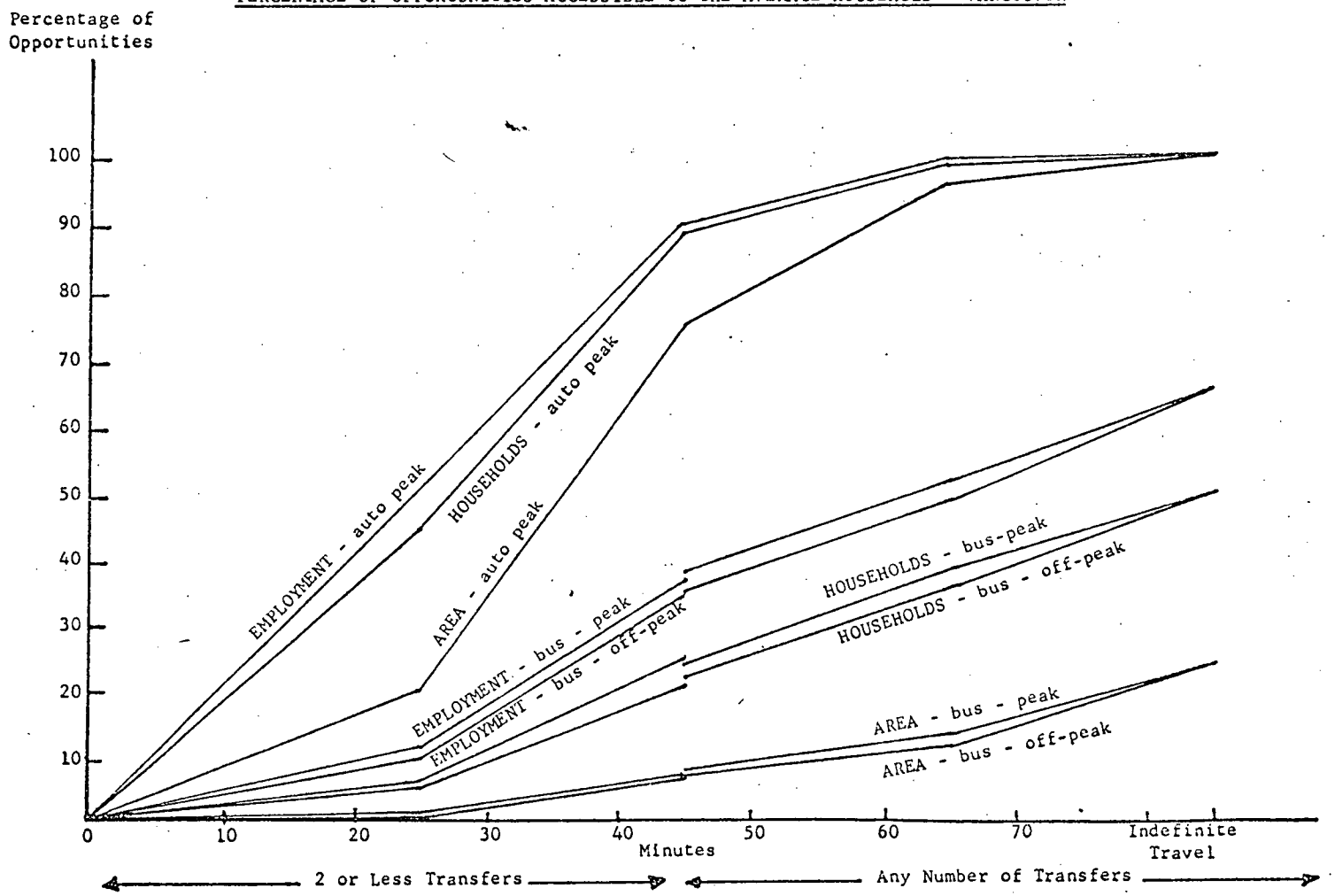
percentage of employment in urban areas which can be reached by public transit within 40 minutes (door to door) from each analysis zone. This measure is superior to the measures discussed earlier in that it is disaggregated to a finer spatial mesh. This should allow for a more explicit and objective-oriented planning process.

Kates, Peat, Marwick & Company (1973), have made use of a similar measure in their study of the public transportation systems in Vancouver, Edmonton and Winnepeg. Their measure, which was defined as connectivity, calculated the number of households and employment centers accessible from spatially disaggregated analysis zones. The measure was calculated for both automobile travel and for public transit travel. A household was defined as accessible to an urban opportunity (ie. employment) if a trip could be completed within 35 minutes (door to door travel time) and within two transfers. Representative Output from the study is shown in Table 5-4 and Figure 5-4.

The study suggests that it would be conceptually superior if zonal population was stratified by income (say low income and other income classes) and employment

FIGURE 5-4

PERCENTAGE OF OPPORTUNITIES ACCESSIBLE TO THE AVERAGE HOUSEHOLD - VANCOUVER



source: Kates, Peat, Marwick & Co., Transportation Service Measures (Vancouver, Greater Vancouver Regional District, 1973)

TRANSPORTATION SERVICE MEASURES

CONNECTIVITY MEASURES - PEAK HOUR

	VANCOUVER 1967 Number	%	WINNIPEG 1967 Number	%	EDMONTON 1971 Number	%
HOUSEHOLDS						
Number Accessible to Average Household:	276,056	100	158,919	100	133,259	100
- By Transit at All	135,518	49	114,834	72	107,995	81
- By Transit in 35 Minutes, 2 Transfers	40,964	15	47,899	30	39,263	29
- By Automobile in 25 Minutes.	122,378	44	143,320	90	125,206	94
Number Accessible from City Centre:						
- By Transit in 45 Minutes	157,193	57	128,945	81	119,117	89
- By Transit in 35 Minutes, 2 Transfers	114,979	42	117,156	74	106,083	80
- By Automobile in 25 Minutes.	152,478	55	153,974	97	133,259	100
JOBS						
Number Accessible to Average Household:	336,113	100	196,582	100	167,127	100
- By Transit at All	219,851	65	167,106	85	143,140	86
- By Transit in 35 Minutes, 2 Transfers	80,142	24	85,649	44	71,998	43
- By Automobile in 25 Minutes.	163,998	49	143,320	73	161,386	97
Number Accessible from City Centre:						
- By Transit in 45 Minutes	251,948	75	190,044	97	159,306	95
- By Transit in 35 Minutes, 2 Transfers	209,212	62	158,806	81	150,455	90
- By Automobile in 25 Minutes.	219,903	65	194,865	99	167,073	100
AREA (Square Miles)						
Area Accessible to Average Household:	445.1	100	170.3	100	88.5	100
- By Transit at All	100.6	23	72.1	42	51.6	58
- By Transit in 35 Minutes, 2 Transfers	17.9	4	19.6	12	16.5	19
- By Automobile in 25 Minutes.	91.8	21	142.0	83	79.7	90
Area Accessible from City Centre:						
- By Transit in 45 Minutes	81.5	18	66.4	39	55.3	62
- By Transit in 35 Minutes, 2 Transfers	52.1	12	54.9	32	48.1	54
- By Automobile in 25 Minutes.	64.6	15	158.4	93	86.9	98
ESTIMATED 1971 POPULATION	1,100,000		535,000		460,000	
Number who Return in Peak 5 Holiday Hours:	-		91,600 *		116,000	
Number for whom there is Highway Capacity:	195,000		256,000 *		206,000	
Utilization, as % of Population:			17 *		25	
Capacity Available, as % of Population:	18		48 *		45	

* From Recreational Routes Only

TABLE 5-4

source: Kates, Peat, Marwick & Company, Transportation Service Measures, (Vancouver, Greater Vancouver Regional District, 1973)

was stratified by skill (ie. low skill jobs vs other jobs). This has also been suggested by Falcocchio and Cantilli (1975).

A second level of service indicator utilized in the K.P.M. study sought to quantify time and convenience. One hundred trips were randomly sampled from origin-destination tables. From these sampled trips, estimates were made of the average trip time, the normal maximum time travelling by public transportation, the average time spent outside of vehicles, etc. A measure of this type is appropriate as an urban level indicator but less useful for work requiring greater detail.

In summary, level of service is an elusive concept measurable with varying degrees of accuracy and sophistication. The available literature indicates that most transit operators and regional transportation planning agencies define level of service in a rather crude fashion. Connectivity of the total transit system is seldom considered.

As goals for urban transit become more specific, and the role transit is expected to play increases, it

is clear that level of service must be more precisely defined. The procedures are complex and special care must be taken to insure that these procedures are understood by professionals who may have had no involvement in their preparation. These and other problems will be taken up in Chapter Six.

5.5 CRITERIA RELATING TO PROGRAM EFFECTIVENESS

Program effectiveness refers to the degree to which operational objectives are being met through a comprehensive programme of public transportation. Measurement of program effectiveness will involve a combination of operational input measures and of program output measures. Unlike program efficiency, which is essentially concerned with service level, (ie. supply), programme effectiveness is concerned with impacts. In most cases, this will involve some measurement of actual consumer demand.

All transit operators generate some form of information concerning programme outputs although it is usually known by some other name. In general, information generated concerning actual passenger demand is a form of programme output. A major problem with information now available relates to the manner and scale with which it is collected.

Perhaps the most basic impact measure now collected is a simple tally of passengers riding the transit system. Nearly all transit operators collect this information.

The typical methodology employed, involves conducting a sample survey of passengers entering transit vehicles and expressing this figure as a function of farebox revenues so that:

$$R = \sum_{i=1}^{n} P_i \; F_i$$

Where: R = Total Revenue

P_i = Total Passengers in Fare Class i

F_i = Fare of Passengers in Class i

Using this expression, total passengers can be estimated given total revenue. Aggregate information of this sort is routinely available in published industry reports.

A refinement of this basic methodology involves utilizing the transit route as the basic unit of data collection. This requires segregation of vehicle revenue on a route by route basis. Horn's survey (1977) of transit operators indicated that 75 percent of respondents (N=28) segregated revenue on a route by route basis (p19).

Another commonly employed transit survey involves conducting a spot check at a screenline point or some

other point where the load is known to be the greatest. In Horn's survey, fully 100 percent of respondents indicated that they conducted such surveys. These surveys are utilized by operational management to insure supply of transit along a route matches the demand. The survey results, however, are alternatively used as impact measures. In Portland, for example, a major goal is to increase the daily average ridership to the Central Business District.[6] The technique employed to measure this would be the spot survey. Likewise, a number of transit properties commonly have available the modal split to the downtown area. In Horn's survey, 66 percent of respondents had this information available. The transit component of this measure is typically determined utilizing the spot survey (Another agency usually supplies the auto component).

Surprisingly, few properties were able to supply estimates of the number of passenger miles of travel (13 properties out of 26). This figure, when expressed as

---

6. Tri-County Metropolitan Transportation District of Oregon, Goals,(Portland, Oregon, December, 1974.)

a ratio of vehicle miles, provides an indicator of the overall productivity of the transit route. Moreover, this estimate is not affected by differences in the average length of the ride. The indicator has special relevance in considerations of pricing and equity issues.

Other commonly collected impact measures, as revealed by Horn's survey, included a tally of senior citizen passengers and a variety of on-board boarding and alighting surveys.

Basic information relating transit performance to social goals is collected less frequently. While many of the transit proponents fervently believe it's impact will be greatest among lower income groups, basic demographic profiles, stratifying ridership by levels of income are seldom collected. Horn's survey indicated that only 15 operators out of 27 respondents had such data available.

Moreover, properties which had such data do not appear to collect it systematically. Properties surveyed indicated such data was collected randomly (5), every few years (3), or seldom(3). (p. 17)

Likewise, basic information concerning the transportation impact was rare. Few properties (9 out of 26), could estimate the percentage of passengers who had an automobile available for their trip. (p. 17). Such information sheds some light on the number of "choice" passengers carried. For new or improved service, 16 out of 25 respondents indicated some type of information was collected concerning the former mode of patrons. Like other information of this sort, however, the data appeared to be gathered infrequently.

The lack of relevant information on transit impact usually forces senior government transit aid administrators to rely on crude measures of success. In the United States, for example, the Urban Mass Transportation Administration advises it's applicants...

> "...ridership impact is employed as a measure of merit in several places in these guidelines. Affecting ridership therefore appears to be an objective, but ridership in reality is a measure of success (or potential success) in working toward an objective like affecting congestion through various means..." [7]

---

7. Department of Transportation (U.S.), Urban Mass Transportation Administration, External Operating Manual, (Washington D.C., 1972, p.IIB - 16.)

Smerk (1974, p. 231.), claims the lack of appropriate criteria is one of the major problems confronting the transit industry today.

> "Much of the Federal program is based on the assumption that there are overspill benefits from transit sufficient to warrant the subsidy of transit operations, yet there is no definitive, standardized methods of calculating these benefits. The lack of information is probably a major cause for the evident lack of success in boosting patronage."

At one point, the U.M.T.A. attempted to introduce specific criteria for grant administration but withdrew it's proposal in the face of widespread industry opposition. (Smerk, 1974, p.254.) Operators cited the extra cost that would necessarily be expended to comply with the proposed new regulations.

An emerging methodology employed by larger operators involves a detailed survey of ridership for those routes which fall below some specified level of revenue. In such cases, a detailed demographic profile of passengers' socio-economic characteristics and travel demand is determined. In cases where the transportation disadvantaged (however defined) comprise a significant proportion of

passengers, minimun standards are reduced.[8]

While this methodology allows some integration of "social well-being" objectives into the transit decision making framework, it does not permit the systematic tracking of the extent to which these new goals are being met. Routes chosen for special analysis are always the marginal components of the system.

---

8. See for example, Tri-Met Transit Authority, Goals, (Portland, Oregon, 1975; Massachusetts Bay Transportation Authority, Service Policy For Public Transportation, (Boston, 1975.)

5.6 SUMMARY

In the metamorphosis from private to public ownership, the urban transit industry and transit planning organizations have had considerable difficulty reconciling the various social (ie. not profitable) objectives of transit with the stark fiscal realities of a world with only limited financial resources. Much of the present crisis appears to stem from the failure of management to develop appropriate criteria through which "need" can be objectively determined, and by which "progress" can be objectively charted.

Criteria can be classified into three main areas. A first area deals with criteria developed to measure the internal operating efficiency of the transit system. Criteria developed while transit was a private enterprise is still appropriate today. By and large, most properties utilize similar types of indicators and these are still relevant.

A second area deals with criteria utilized to measure the level of service. Most properties appear to utilize generally accepted service guidelines expressing service in terms of route spacing, headway (or frequency),

hours of operation, etc. It is not unusual for such guidelines to be subjectively tempered with considerations for special public groups such as the elderly and the handicapped. Increasingly, properties are developing minimum standards of route productivity which must be met for a given route to be continued.

Zonal measures of transit level of service are rare. A few properties and cities have made notable attempts to measure service level in different spatial areas of the city. An emerging methodology employs a measure of accessibility to express service level although only a few cities have progressed to this stage.

The measurement of transit impact is often expressed more crudely than level of service. Typically, aggregate ridership is the only information available by which a transit programme can be assessed. Little is known about the characteristics of riders, or their trip purpose. Basic information such as area (zone) of origin and destination is often not available. What information is collected is normally done so on a route by route basis.

The lack of basic information available on transit performance prevents even the most rudimentary assessment of the success or failure in meeting transit's apparent goals. Until such information is available the current debate over the wisdom of present policies is likely to continue. One possible methodology is suggested in the next Chapter.

CHAPTER 6

A PROPOSED GOALS ORIENTED URBAN TRANSIT MONITORING SYSTEM

6.1 INTRODUCTION

In this chapter, a conceptual model of an urban transit monitoring system is presented. In the first part of the chapter, the intended role, scope, and limitations of the envisioned system are set out. A methodology to monitor operational outputs is suggested. This portion of the proposed system provides a means whereby physical units of output can be systematically recorded. Operational outputs, as defined here, are not goal related. Rather, they provide a linkage between physical resources and the measurement of programme inputs. Their purpose is to facilitate the comparison of system costs to the level of service of the transit system to various areas of the urban region.

A second portion of the chapter reviews the goals of transit as uncovered in Chapter three. Programme inputs and programme outputs are then related to these goals. Programme inputs seek to measure the attributes of the transit system.

This is the means by which objectives are to be met by transit. Its concern is with system performance. Frequently, this has been referred to as the level of service.

Programme outputs seek to measure system impact. It seeks to determine the extent to which individuals react to a community transit programme. Like programme inputs, its measurement is directly related to goals.

Finally, specific indicators of programme inputs and program outputs are presented. These indicators are grouped along major thematic goal areas. Hypothetical examples of the use of such measures is also illustrated. These indicators become the major conclusions of the thesis.

Implementation of such a system will provide the disaggregated data on transit performance and impact which will allow for a more reasoned evaluation of the degree to which transit is contributing to specific community objectives over time. With such information, it is hoped allocative decisions concerning the level of transit expenditures and the distribution of service between different spatial areas can be more objectively determined.

6.2 THE ROLE OF TRANSIT MONITORING

Effective transportation planning requires sufficient and timely information about the change in the spatial structure of economic and social activities in the urban areas. The present generation of urban transportation planning studies have resulted in "end state" plans. Means of reaching these states have been based on consideration of past trends and current objectives and needs. Urban areas, however, are constantly undergoing change in development patterns and socio-economic conditions within specific parts of the urban region. These changes may manifest themselves in changing consumer attitudes and preferences. Because of the degree of uncertainty surrounding future urban conditions, "end state" plans may not be relevant after even relatively short time spans. To cope with these uncertainties, a continuing planning process is called for which has as it's purpose the continual re-evaluation of community objectives and the methods and means to achieve them.

Within the transit planning and management process the need for a continuing planning process is even greater.

A small shift in community travel patterns may have comparatively little impact on a mode which serves 85 percent of the urban travel market. The impact is much greater, however, for the minority mode which transit has become. Further, since a good deal of resources must be devoted to operating the transit system, detailed attention must be given to how well it performs.

Likewise, there exists a need for detailed information on areas and situations in which transit appears to be working well. Such information will provide the basis for future decisions on transit's role in the community, and provide a basis for making adjustments to the existing system. Monitoring the existing transit system and the changing social and economic conditions within urban areas provides a basis for the description and maintenance of the current status of urban activities.

The role of transit monitoring is therefore twofold. On the one hand, information is required to allow an assessment of the effectiveness of past decisions. A framework to systematically measure the effectiveness of transit operations may lead to a transit management atmosphere more cognizant of community concerns. A second purpose,

is to provide the tools to allow a more accurate prediction of the effectiveness of proposed actions.

Simply put, a transit monitoring process seeks to determine the extent to which community objectives are being met through a continuing program of transit services, and to quantitatively measure the effect of marginal changes of resource allocation over time. Ultimately, the implementation of a transit monitoring system may facilitate program evaluation and allow for more rational trade-offs to be made between different objectives and programs.

There appears to be five central questions relevant to transit monitoring:

1. What are the goals of Transit?
2. What are the inputs to the production function and the means to measure them?
3. What are the operational outputs to transit programs and the means to measure them?
4. What are the program outputs and the means to measure them?
5. What are the program effects of transit and the means to measure them?

Under the process envisioned, a start-up phase would establish base values of inputs and outputs. The base period is an important parameter of the system as shifts in inputs and outputs would be compared against these base measures. Conceivably, indices could be constructed to compare one period to another.

LIMITATIONS OF PROPOSED TRANSIT MONITORING PROCESS

Ideally, a transit monitoring system would seek to measure the direct effect of transit in meeting community objectives. In practice, however, objectives are often only indirectly linked to the transportation system, and not easily measurable. This may best be illustrated by means of an example.

One objective of a transit system might be to increase employment of low-skilled individuals. A realistic measure of transit's effectiveness would then be the number of individuals who obtained employment as a consequence of transit. Even if it were possible to measure this effect (and it probably would not be) it might turn

out that workers who secured employment, immediately purchased an automobile. Hence, transit's apparent and lasting effect could be quite limited.

In view of these problems one is forced to utilize indirect indicators of the particular goal achievement. In this study, indicators which are directly associated with the activity of individuals (ie. individuals' travel patterns and their interface with the transit system) will be utilized as surrogate measures of goal achievement.

In some cases, a more direct measure would be appropriate for a higher level monitoring system. A hypothetical example illustrates this point. Assume a community objective is to reduce downtown air pollution through a number of measures including increased transit use. The transit monitoring system would generate information as to the marginal increase in passengers carried downtown and the marginal change in pollutants attributable to transit. A regional monitoring system, however, would utilize direct measurement of downtown air quality.

A second problem relates to output indivisibility. Basically, the same production function (ie. bus miles) is utilized in transit to achieve multiple onjectives. It is extremely difficult to relate inputs to specific outputs. No attempt has been made in this report to do this. For this reason, it is difficult to measure real efficiencies over time within any specific goal area. For example, it is difficult to separate resources devoted to accomplish social objectives from those allocated to accomplish energy or transport efficiency goals.[1] Consequently, it must be stressed that the proposed output measures reflect trade-offs that cannot be technically isolated.

---

1. Conceivably, a very complicated procedure involving the weighting of many factors could be initiated. It is doubtful however, whether such a process would improve the decision-making process.

RELATIONSHIP OF TRANSIT MONITORING TO HIGHER LEVEL MONITORING PROGRAMS

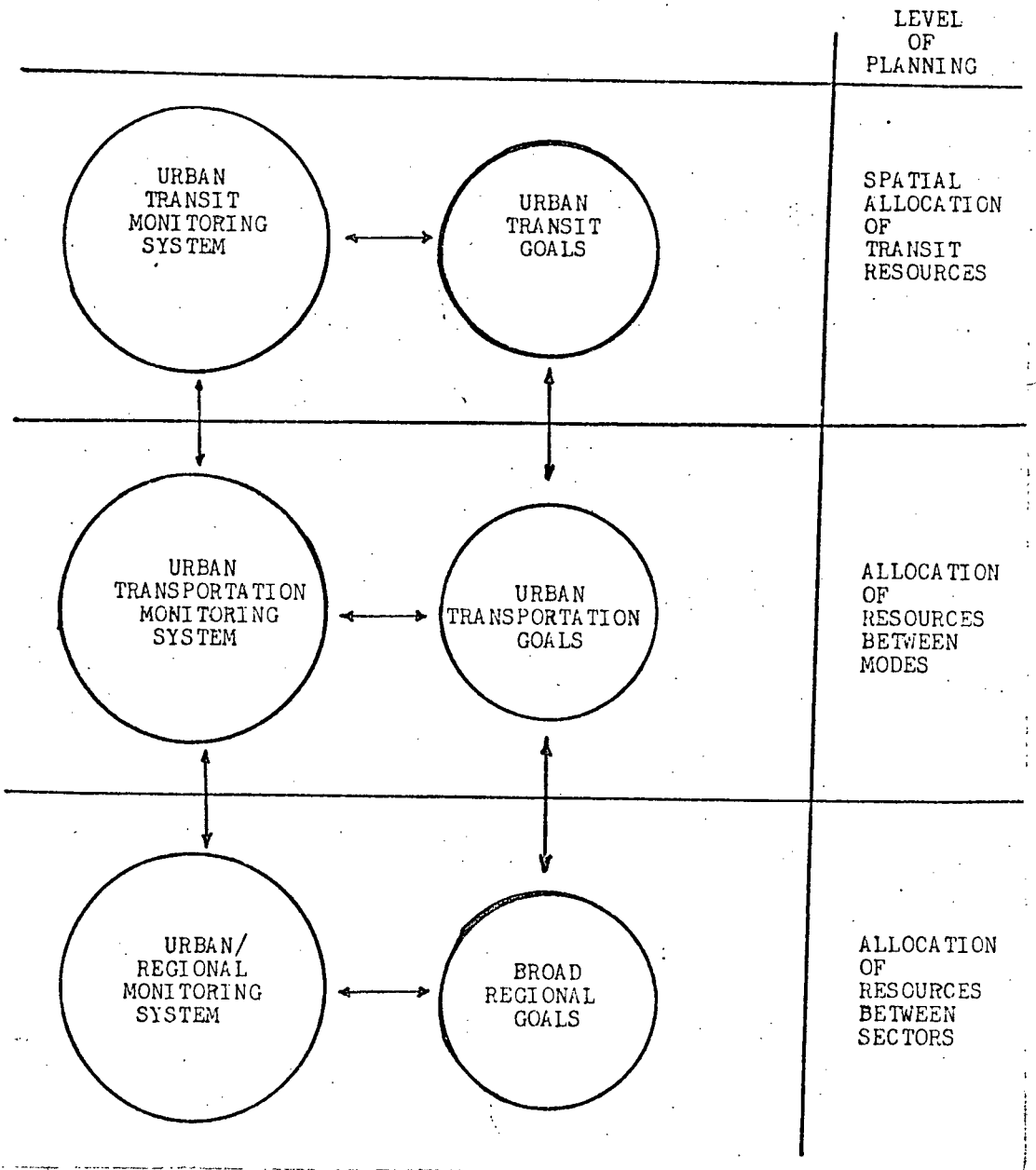
Transit monitoring is not an end in itself; rather it is a means to an end. Given that the goals of a community are such that a decision has been made to use transit to achieve certain objectives, it seeks to answer how effectively these goals are being accomplished. Within the transit sector, this information may be useful to predict the effects of alternative courses of action.

The usefullness of a transit monitoring system extends well beyond the evaluation of transit. On a broader scale, information generated by a transit monitoring system may be used to evaluate the effectiveness of urban transportation in general, and assist in the reformation of regional transportation goals. Similarly, resource allocation decisions between alternative modes would be facilitated if timely information on the efficiency and effectiveness of current programs was available.

Likewise, information from an urban transportation monitoring system would be useful for the setting of broad regional priorities to facilitate decision making in different sectors. The siting of a new hospital, for example, might conceivably be made considering the attributes of the public transportation system.

FIGURE 6.1

RELATIONSHIP OF TRANSIT MONITORING TO HIGHER LEVEL MONITORING PROGRAMS



6.3 SPECIFICATION OF OPERATIONAL OUTPUT MEASURES

Despite the diverse nature of community objectives for transit, there is a common pool of resources from which all program outputs and effects are generated. Therefore, similar kinds of operational outputs can produce numerous and distinct types of program outputs. These in turn can generate a host of program effects.

As has been stated earlier, this thesis will not attempt to formulate a link between operational inputs and operational outputs. Hence, our task here is to suggest an appropriate parameter for operational outputs.

A severe problem concerning the specification of operational outputs for transit, centers around the inherent transportation function of the operation. This study will deal with the impact of transit on specific zonal units so as to foster a more goal-oriented transit planning process which can explicitly account for spatial differences of population, and by inference, transportation needs. The consumption of transportation services however, does not respect arbitrary zonal boundaries. It is therefore difficult to specify a unit of measurement

of operational output which has any relationship to operational inputs. In practice, the link between inputs and outputs is manifested in demand. Longer trips will consume more resources.

A second problem concerns the extent of an area served. Clearly, transit only serves a small area on either side of a station or stop. Individuals, however, will differ in the degree to which they will utilize a service necessitating a walk of the same distance. Hence, some means must be established to arbitrarily determine the extent to which an area is served. This problem will be more fully discussed in the next section.

A variety of measures could conceivably be used as a surrogate of operational outputs in discrete areas. Ideally, a measure would indicate the real output that could be consumed in a zone. Passenger Seat Miles Available, for example, would potentially measure a gross estimate of the extent of resources devoted to an area. The measure, however, is not readily available and can be estimated only through extensive operational surveys.[2]

---

2. The use of automatic vehicle monitoring techniques however might facilitate use of such a measure.

A less satisfactory method of measuring operational output would be to utilize a measure of bus miles or bus minutes of service. This measure has the advantage that it can be easily calculated and has some relationship to operational inputs.[3]

A further refinement of this measure would be to express bus miles in terms of the area served, as has been suggested by Scheibe (1977). This measure is then related to both route spacing and frequency of service. It's derivation can be illustrated by way of example.

Assume an area two miles by one mile (a traffic zone, planning area, etc.), is served by two bus lines; one running East-West, and one running North-South. During the two AM peak hours, the East-West line has a headway of 6 minutes and the North-South line has a headway of 30 minutes. If the area served by the bus lines is arbitrarily set at 1200 feet from either side of the route,* then the total area served will be 1.16 square miles. The East-West line will supply

---

3. According to responses to Horn's (1977) transit survey, bus miles are used as a standard method for calculating operating budgets of transit systems.

* These standards will be discussed further in Section 6.5.

80 bus miles of service to the area (2 miles length X 10 bus trips per hour X 2 hours X 2way travel). The North-South line will supply 8 bus miles of service. Hence the number of bus miles per square mile served will be 76.12.

EFFECT OF CHANGES IN THE FREQUENCY OF TRANSIT SERVICES

If service on the East-West line is reduced (say the headway is increased to 10 minutes), the indicator of operational output will decline. Using the assumptions from the example above, the case is presented in Table 6.1.

EFFECT OF CHANGES IN THE SPACING OF TRANSIT SERVICES

While the number of bus miles per square mile provides one measure of the physical amount of service provided to an area, it is important to recognize that it is very sensitive to the spacing of routes. Moreover a reduction in service can have perverse effects on the mag-

TABLE 6.1

EFFECT OF CHANGES IN HEADWAY
ON OPERATIONAL OUTPUT INDICATOR:
HYPOTHETICAL SERVICE AREA "Y"

PERIOD	AREA OF ZONE	AREA SERVED BY TRANSIT	NUMBER OF BUS MILES	BUS MILES/ SQ. MILE
BASE PERIOD	2 SQ. MILES	1.156	88	76.1
BASE PERIOD + 1	2 SQ. MILES	1.156	56	48.4
CHANGE	---	---	-32	-27.7

TABLE 6.2

EFFECT OF CHANGES IN ROUTE SPACING
ON OPERATIONAL OUTPUT INDICATOR:
HYPOTHETICAL SERVICE AREA "Y"

PERIOD	AREA OF ZONE	AREA SERVED BY TRANSIT	NUMBER OF BUS MILES	BUS MILES/ SQ. MILE
BASE PERIOD	2 SQ. MILES	1.156	88	76.1
BASE PERIOD + 1	2 SQ. MILES	.909	80	88.0
CHANGE	----	-.247	- 8	+11.9

nitude of the number. In cases where new service routes are added or where routes are terminated, the change in bus miles per square mile can be in the opposite direction of the change of service. Consequently, it is important to consider changes in the area served and changes in the amount of service. This can again be illustrated using the data from the case above. Assume the North-South route was terminated. Changes in the measure of operational output is then illustrated in Table 6.2.

SUMMARY

A methodology, albeit crude, has been outlined to provide for the systematic measurement and recording of the gross output of a transit operation which is allocated to different spatial areas of the city. There are some serious drawbacks to the method outlined. For example, it is difficult to establish a direct relationship between operational output measures and input costs. A second problem concerns the difficulty of quantifying trade-offs between route spacing and frequency of service. Despite these difficulties, this methodology represents a signi-

ficant improvement over measurement practices currently in use. This is largely because the proposed measure can be related to a specific area rather then a route segment. The physical resources then devoted to the area can be related to basic demographic information of the area as is commonly available from secondary data sources such as land use surveys or census information.

It must be emphasised again, that measurements of the operational output of a transit operation are not goal oriented. A more qualitative measure of transit service is required. Nor do measures of operational output allow any inference to be made as to the utility of the community transit system. It is to these matters which we now turn.

6.4 INDICATORS OF PROGRAM INPUTS

Whereas operational output indicators, as defined in this study, are not oriented toward the achievement of any specific goal, program inputs and program outputs are both related to achieving specific ends. The link between operational outputs and program inputs lies in the manner in which resources are organized and integrated toward specific ends.

Another way of distinguishing between operational outputs and program inputs lies in the scale of the measurement technique. For any particular zone or area, the measurement of operational output is independent of any other area. The measurement of program inputs, however, explicitly considers the allocation of resources to all parts of the region. It seeks to quantify the ease with which an individual can travel from one area to another area. Program input, then, is concerned with the attributes of the transit system in specific spatial areas. This may alternatively be defined as the level of service.

The chief technique proposed to measure program inputs is through a measure of accessibility. Accessibility of the transit system, however, is not as pervasive as the accessibility of automobiles. In particular, the fixed route characteristics of most transit operations, sharply focusses accessibility both temporally and spatially. Accessibility, however, is an elusive concept. It seeks to measure the effective nearness of potential opportunities. Hence, arbitrary standards must be utilized to define what constitutes an opportunity.

Because accessibility seeks to quantify the effective nearness of opportunities and activities, it's measurement defines the interface between the transportation system and the land use system. Changes in either the land use system or the transportation system then, will change the accessibility of all areas and activities within the region. Practically, however, small changes are not likely to cause any significant impacts. Moreover, the suggested measurement techniques are too crude to record such small changes.

MEASUREMENT OF ACCESSIBILITY

In order to develop accessibility measures which are related to goal achievement, it is necessary to construct indices which relate to a specific goal. It should be stressed that there will be a strong interrelationship between accessibility measures oriented toward alternative goals. Hence, it is not appropriate to consider measures which relate to different goals to be additive in any way.

In general, the proposed measures seek to quantify the number of opportunities related to objective "y", which are accessible to a region "within a reasonable time period". The term "within a reasonable time period" is a local standard but should represent realistic conditions. Lengthening the time considered reasonable will obviously increase the degree of accessibility measured. However, unreasonable time standards will produce unreasonable measures of accessibility which will be of doubtful utility. All parts of the transit system can likely be reached within a three hour period. If this was established as the local standard, every area served by transit would have identical accessibility.

Further, "a reasonable time period" should attempt to measure the door to door travel time, not only the vehicle travel time. Refinements of the technique might seek to weight "out of vehicle" time more heavily as is often done in modal split studies.

Another requirement will be to quantify the number of activities and opportunities within a "reasonable walking distance" from the transit stop or station.[4] The term, "a reasonable walking distance" is similar to a local time standard. Most evidence indicates that ridership drops off rapidly with distance from the transit stop or station. Hence, the choice of a standard should reflect realistic conditions.

The quantification of opportunities will be the most difficult task in the construction of measures. Even small areas are not homogenous in density of development. Hence, a direct proportional estimate of total area land use characteristics of the area served by transit will not be sufficient. In as much as most land use information will come from another agency, it would be desirable if the source agency adopted an information system capable of disaggregation to the block face level.

---

4 .In some cases another type of measure would be appropriate as would be the case if a park & ride type operation was operated.

In the absence of such a system, it would be necessary for field observers to make estimates based upon professional judgements and land use information disaggregated to the planning area level.

The question of what activities to consider in the construction of an accessibility measure is a serious one. On the one hand, inclusion of a greater number of categories may better illuminate the actual level of service of the transit system. On the other hand, inclusion of too many measures would unnecessarily increase the cost of the proposed measurement system without necessarily increasing the quality of decision making.

In this study, only employment and households have been included in accessibility measures. This tends to bias the measures towards employment trips. It is felt, that for bus system transit, shopping and recreation type trips would be very closely correlated with employment, simply because of the spatial structure of the city. This may not be true for all transit systems. In cases where exclusive right of way are utilized, as in the case of rail transit, system orientation may not focus on other activities. Hence, it may be appropriate for some local areas to consider more than employment opportunities.

It is proposed that zone to zone travel time be computed using a network model. In areas where headway is great, assumptions might be made concerning the average wait time.

The total time required to travel between activities would then consist of; walking time, vehicle time, transfer time, and walking time.

6.5 PROGRAM OUTPUTS

Immediate impacts from a community transit system will consist of the riders who actually patronize the system. It has been shown that most evaluations of transit service utilize this measure of a system's worth. An underlying premise of this thesis is that not all transit trips are homogenous. Hence, systematic measurement of the characteristics of individual trips will provide an indication of the degree to which goals are being achieved.

It is important to again distinguish between program output and program effect. The actual output of a transit system provides indicative information as to the degree to which objectives are being met. A direct link to program effect (ie. the actual degree of goal achievement) is usually not possible. This is due to the difficulty of closely measuring actual goal achievement and the high degree of externalities associated with transit. This may best be illustrated by way of example.

Assume a goal for community transit has been established which seeks to redistribute wealth from high

socio-economic groups to lower socio-economic groups. As an operational objective, the transit operators increase the ease with which lower socio-economic groups can reach appropriate employment. After some time, measurement indicates that the number of employment trips by lower socio-economic groups increases by 20 percent.

While this might provide some indication that the operational objective was being met, it says nothing about achievement of the community goal to redistribute wealth. Even if it can be demonstrated that a greater proportion of resources (largely subsidized by the higher socio-economic group), was devoted to the lower group, it is not possible to make any link to the higher level goal. It may well be that the transit investment precipitated higher rent payments. Hence, the overall effect on the broad goal is indeterminant.

MEASUREMENT OF PROGRAM OUTPUT

Detailed monitoring of the trip behaviour of individuals will require a major commitment from transit operators. A systematic on-board passenger survey will

be required. Are these requirements excessive? The survey of 26 Canadian and American transit operators (Appendix A) revealed that five operators already administer annual transit origin-destination type surveys. Another nine operators reported that they conducted boarding and alighting surveys at least once a year.[5] In addition, other transit surveys requiring on-board observers are common. B.C.Hydro, for example, reports that they administer average fare surveys at least twice a year on all routes.[6] If origin-destination type surveys were systematically administered, there would be no need for these other surveys.

The current practice for those operators who already administer origin-destination type surveys is to administer all surveys on a single day or within the span of a few days. Consideration should be given to survey administration on a route by route and area by area basis. In this way, staff could more easily be spread out throughout the year. Organizationally, the tasks of impact monitoring would become more routinized. Staff could

---

5. A boarding and alighting survey determines where passengers board and alight but does not tie an individual passenger origin to a destination.

6. An average fare survey determines the fare paying characteristics of passengers. From these surveys, operators estimate patronage on the basis of farebox receipts.

more easily digest increments of new information and make desirable changes with less effort than would be the case if a large scale system-wide survey was conducted.

Another consideration when implementing such a system would be the length of the review period. A majority of firms who have established systematic origin-destination sampling do so on an annual basis. This period seems more of an astrological coincidence than a reasoned decision. For most parts of the transit system, a review period of 24 months may be as effective.

6.6 THE GOALS OF TRANSIT

The goals of transit have been extensively researched and reviewed and are documented in Chapter 3. Goals are important to the proposed transit monitoring system. Selection of input and output measures has been guided by the twin criteria of relevancy and feasibility. The criterion of relevancy demands that proposed measures have a demonstrable relationship to the specific objective being sought. Considerations of budget and measurement limitations preclude inclusion of all relevant measures. More importantly, the decision making process is not likely to be significantly enhanced beyond a certain level of information.

Not all goals have been considered in this report. In general, the criterion for selecting goals has been dependent upon the degree to which they are relevant to the service function of transit planning.

Nor will all local areas hold similar goals. It is doubtful whether one local area would effectively utilize every measure suggested. Moreover, some goals,

which may be relevant in certain areas may not have been included in this report. In still other cases, it may be desirable to modify proposed measures to reflect unique local conditions.

While the goals of transit differ widely between areas, a taxonomy of goals and objectives has been formulated. This classification groups goals which may be met by the same transit function. Four thematic goal areas have been identified.

1. Goals Which Relate to Social Objectives

This set of goals is primarily concerned with the provision of mobility to groups who may be experiencing a transportation handicap, primarily because they do not have access to an automobile. Identified groups include the poor, the young, the old, the handicapped, and those who simply do not have access to the family car. The provision of mobility to the poor has been especially emphasized. A minority of policy makers expressed the belief that transit could be used to effect a redistribution of income.

2. Goals Which Relate to Land Use Objectives

This set of goals is primarily concerned with the coordination of transit planning and regional land use planning. In some cases, transit is expected to play a leading role in the implementation of regional land use plans. In other cases, transit's role is seen as supportive. A major theme of this goal is that transit will promote more compact urban settlement patterns. Many areas stress the role transit may have supporting the Central Business District. A minority of areas plan to use transit to promote concentrated cores of retail and office type employment apart from the C.B.D..

3. Goals Which Relate to a Reduction of Traffic Congestion

This is the traditional goal of transit. Reducing or slowing the rate of growth of traffic congestion can reduce the need to construct new automobile facilities. A recurring thought is that transit is the least costly means of meeting future travel requirements.

4. Goals Relating to Energy and Environmental Objectives

Generally, it is believed that the higher capacity modes are more energy efficient that the private automobile. In addition, air pollution, on a per person basis, is believed to be less from transit than from automobiles. Consequently, this objective seeks a general diversion of automobile traffic to transit. Another aspect of this objective seeks to promote safer urban areas and to reduce injury due to traffic accidents.

6.7 PROPOSED INDICATORS RELATING TO SOCIAL OBJECTIVES

The notion that transit can provide significant benefits to individuals suffering from some form of transportation disadvantage is central to this objective. Yet, as has been noted in Chapter 4, transit's potential is severely constrained by a host of non-transportation factors.

In cases where transit is intended to be used as a transportation mode by those with some form of functional disability,(ie. the elderly and handicapped), architectural barriers and the requirement that individuals undertake lengthy walks to gain access may render transit inaccessible.

Where it is intended to enable disadvantaged groups to gain wider employment opportunities, transit often does not effectively serve areas where these opportunities are available. Moreover, the low density characteristics of low skill employment places does not lend itself to efficient mass transit.

Transit is considered by some as an income redistribution device, yet it is not clear empirically or theoretically what the ultimate effect of subsidies may be. In a local area where transit is used to support long distance travel between suburban residential areas and the central city, the effect may be regressive. In addition, theoretical evidence suggests the benefits of increased transit service may induce spill over effects on other sectors. Hence the benefits from transit may be reduced somewhat by, say, increased rental rates.

These arguements are reiterated only to expose the inconclusive theoretical and empirical foundations of the work to date and to place the objectives oriented toward the promotion of social welfare in the proper perspective.

Suggested Operational Objectives

Where specific operational objectives are given in this thesis it is done only to be illustrative of the type of objective that might be pursued by transit management. Obviously, operational objectives will depend

on the type of goal held by the community at large. The following examples, then, are representative of the types of goals uncovered in Chapter 3.

1. Provide increased employment opportunities, accessible by transit, to lower socio-economic groups.

2. Provide increased employment opportunities, accessible by transit, to individuals without access to an automobile. This group specifically includes the young, the old, and the handicapped.

3. Reduce the total cost of travel (user charge + time cost) for all socio-economic groups.

4. Effect a redistribution of income from higher socio-economic groups to lower socio-economic groups through transit.

Table 6.3 presents specific proposals to measure program inputs and program outputs related to the obtainment of social objectives.

TABLE 6.3

Programme Inputs and Programme Outputs
Related to the Achievement of
Social Objectives

PROGRAMME INPUTS	PROGRAMME OUTPUTS
The number of low income households, accessible to transit, which can reach (x) percent of low skill jobs, accessible to transit, within a reasonable travelling time.	The number of employment trips per day made by low income residents.
The number of adults, over age 16, accessible to transit, who do not have regular access to an automobile and who can reach (x) percent of total employment opportunities within a reasonable travel time.	The number of 'other' transit trips per day made by low income residents.
The number of young people, below age 17, who are accessible to transit.	The operating profit (loss) per person, per transit trip, per socio-economic group to the transit system.
The number of elderly people who are accessible to transit.	The total 'generalized cost' (time costs + user fare), per person, per socio-economic group.

Data Requirements for Measurement of Inputs and Outputs

This set of measures will require a suitable definition of several terms. The following examples are given for illustrative purposes. Actual choice of terms will be a matter for local choice and the availability of local land use information.

low skill jobs	Employment opportunities which conceivably might be accessible to lower socioeconomic groups in terms of institutional constraints. This set of jobs might include manufacturing, processing, retail sales and clerical employment. It might be worthwhile to consider industrial type of employment separately. Empirical work (Wohl, 1970; Falocchio, 1973.) suggests these types of jobs are least served by transit.
low income household	The intent of including low income households is to insure that those individuals most in need of mobility are considered in the planning process. Hence, it would be desirable to set a relatively low cutoff point in the definition of this term. A cutoff point which included households in the first quartile of family incomes, for example, might be appropriate.
transit dependent	Those individuals who do not have access to an automobile. This question would likely be asked on a passenger survey

	and might be estimated on the basis of demographic information and the incidence of automobile ownership in a planning area.
operating profit (loss) per socio-economic group	That portion of costs and revenues that can be allocated to specific groups. This allocation could be made on the basis of passenger surveys. It would be best to express this measure in terms of passenger miles of travel rather than the average cost per passenger carried as is standard industry practice. This measure would not be affected by unusually high numbers of transfer passengers and is sensitive to the length of trip. It is noteworthy that some respondents to Horn's survey (1977,p.19) indicated that route revenue was unacceptable in integrated networks.
total generalized cost	The total of direct user costs and the cost of time travelled. It is not clear from empirical work what the actual cost of time travelled is, although estimates range from $1.50 to $4.50. Time costs could be computed from the zone -to-zone travel time matrix derived from the program input measures.

Hypothetical Example of Use

Through the program input measures, it is noted that the regional transit system is heavily oriented toward skilled jobs. In particular, industrial jobs are very poorly served. About 55 percent of the low income households are accessible to at least 14 percent of industrial jobs. However, only 15 percent of low income households are accessible to at least 30 percent of industrial jobs.

An attempt is made to better serve industrial locations. Four new transit routes are added providing a direct link between a central city low income neighborhood and suburban industrial sites. Vehicles normally assigned to a suburban express route are utilized. These vehicles normally "deadhead" from the central city to the suburban residential neighborhood. In addition to the route additions, small changes are made in the scheduling of several small feeder routes so as to enable easy transferring.

In subsequent periods, the following changes are noted in program inputs and program outputs. (See Table 6.4)

Note: This hypothetical example has been purposely simplified for the purposes of illustration. It is doubtful whether actual conditions would be as uncomplicated and unconstrained as has been portrayed.

Closure

It is important to remember that the fact that more low income people are riding transit says nothing about the higher level goal to increase employment opportunities to low income residents. Rather, there is some evidence that the operational objective to increase the accessibility of industrial jobs to low income households is being met. Further it appears that the extension is having some positive impact.

The distinction between achieving an operational objective and meeting a community goal cannot be overstated. The degree to which a community goal is being

TABLE 6.4

Changes in Programme Inputs and Programme Oututs Related to Hypothetical Example

(Aggregated Urban Scale Measures)

PERIOD	PROGRAMME INPUTS	PROGRAMME OUTPUTS
BASE	14 percent of low income households accessible to at least 30 percent of 'low skill' jobs.	1040 daily employment trips by low income residents, per day.*
BASE + 1	26 percent of low income households accessible to at least 30 percent of 'low skill' jobs.	1830 daily employment trips by low income residents, per day. **
BASE + 2	29 percent of low income households accessible to at least 30 percent of 'low skill' jobs.	2375 daily employment trips by low income residents, per day. ***

* system daily ridership :150,000
** system daily ridership :158,000
*** system daily ridership :162,000

met can only be determined in a much broader context.

Finally, an ultimate determination of the worth of the new transit routes would necessarily involve considerations of the efficiency of the new route. The trade-off between efficiency and effectiveness, however, should be facilitated with the type of information presented here.

6.8 PROPOSED INDICATORS RELATING TO LAND USE OBJECTIVES

Current objectives to utilize transit as a land use shaper differ widely in the role which transit is expected to play. Objectives to support the CBD see transit responding to a demand whether this demand is latent or manifest. In addition, the competitive advantage of the automobile is likely to be lessened in the face of widespread traffic congestion. Objectives to influence the development of secondary centers and to influence the pattern of residential development see the role of transit to be one of essentially creating demand. Clearly, the difference between types of land use objectives will have different implications as to the potential of transit to meet them.

The link between land use and transportation is found in urban land economics. Transportation, however, is only one aspect of a myriad of relevant factors responsible for changes in the internal structure of the city. Furthermore, in urban areas where a basic transportation network consisting of a series of streets and highways is already in place - and this includes most areas in North America - the addition of improved facilities will likely have less and less of an effect.

The effects of transit, which carries only a small percentage of daily person trips and no goods, is likely to be even less. It's greatest potential would appear to be it's possible effect upon the location of activities requiring great numbers of people or dependent upon a large volume of people passing. This would include retail trade and office employment. With reference to the effect of transit upon residential development patterns, the accumulating evidence suggests it's impact is minimal (See Richardson, 1971; Michelson, 1972).

There is some theoretical evidence which suggests that the net effect of transit on development will be to increase sprawl (Batty, 1974). The supply of transit services will enable natural agglomeration economies to come into play and promote the centralization of specialized retail and control activities. At the same time, individuals will be able to choose peripheral, low density housing and will be able to commute into the central city within a reasonable time. If such a scenario were actually the case, the provision of transit services might actually fuel the growth in regional travel demands.

Current attempts to use transit to influence the development of concentrated employment centers plan to increase and sharpen the focus of transit accessibility on designated areas. There has been little success in attempts to influence the pattern of residential development through the use of transit accessibility.[7] In many cases, however, the placement of large residential developments are consciously planned considering the availability of transit service. In still other cases, transit responds to the placement of new development.

Past attempts to monitor the impact of transit upon development patterns have usually utilized records of real property assessments and made inferences based on the different rates of growth of assessed value in small spatial areas. An alternative approach has been to actually monitor changes in land use in small spatial areas through existing record systems such as building permits or through more direct means. A serious problem relates to the difficulty of separating the effects of transit from all other factors. Attempts to measure

---

7. Of course, in the strategic land use planning process, the spatial allocation of transportation routes and services in general, has a profound effect on residential patterns. The use of focused transit accessibility, appears to have minimum effects.

the effect of transit on gross residential patterns typically employs cross sectional analysis between cities having varying degrees of transit orientation.

In this report, it is proposed that a direct transportation measure would be appropriate for use by a transit planning organization. The ultimate test of the worth of a transit oriented land use plan which seeks to promote a concentrated employment center will be the number of people who actually utilize the transit service and are employed in the area. Moreover, inferences about land use can be made on the basis of trip generation. Hence, some measure of the degree to which a transit oriented land use plan is successful over time can be inferred from records of actual trip behaviour.

No suitable indicator of the impact of transit upon gross residential pattern has been formulated. Batty (1974), argues the overall effect of transit may be to increase the separation between place of employment and residence. It is therefore suggested that information concerning the average length of employment trip by transit be collected by small spatial area and compared over time.

The information suggested to be collected concerning the nature of transit trip behaviour between different

spatial areas will be useful to ascertain the degree to which operational objectives are being met. Beyond this level of planning, however, information of this sort, together with information concerning automobile trip behaviour could be of substantial value to regional planning organizations.

Suggested Operational Objective

Increase the number of households accessible to designated growth areas.

Closure

Does the fact that employment trips made to the area by transit are increasing indicate that the regional goal to influence development is working? Clearly, it does not. Rather some evidence is presented that transit's supportive role is having some impact. Combined with other information concerning the use of automobiles, and direct development activity, however, a regional planning organization would be able to make a more reasoned assessment of the success of a particular land use plan.

TABLE 6.5

Programme Inputs and Programme Outputs
Related to the Achievement of
Land Use Objectives

PROGRAMME INPUTS	PROGRAMME OUTPUTS
The number of households which are accessible to a designated growth area by transit.	The number of employment trips per day, by transit, made to a designated growth area. The number of transit shopping trips per day, which are being made to a designated growth area. The average length of employment trips by transit to designated growth areas. The average length of employment trips by transit (regional average)

6.9 PROPOSED MEASURES RELATING TO LEVELS OF TRAFFIC CONGESTION

Strategies to reduce congestion follow a similar theme as strategies which seek to influence land use. In general, service is emphasized toward areas where levels of congestion are high. Where automobile congestion is great on particular links of the transportation system (ie. bridges, main arteries, etc.) a general diversion of potential automobile trips to transit is sought. The employment trip is particularly relevant in this measure. Congestion levels are usually greatest and cause the most severe problems during peak hours.

This objective is the traditional transit goal. Perhaps for that reason, transit's effectiveness in reducing congestion is more consistently monitored than other transit objectives.

The objective to reduce congestion has many ultimate ends. It is believed that a successful transit program will reduce the need to construct new automobile facilities. Hence, there will be less need to disrupt existing neighborhoods. A reduction of congestion may also lead to more environmentally attractive and safer areas.

The potential for transit to reduce congestion is perhaps it's most clearly obtainable goal. In this instance, transit is responding to demand. Existing level of service for automobiles is not likely to be great; hence, the competitive advantage of automobiles is likely to be lessened. Moreover, the density of trip ends is likely to be great - an important factor for transit.

Despite these advantages, there are some potential constraints. Some theoretical work indicates that trips which transit is able to divert will be quickly replaced by automobile drivers who did not formerly make the trip. Furthermore, it is possible that many of the individuals which transit does carry would, in the absence of transit, simply obtain rides from other individuals who do drive.

Hence, it is difficult to assess the effect of transit on congestion levels without also considering it's effect on other parts of the transportation and urban systems. It is clear that any assessment of transit's impact on regional congestion objectives can only be made through analysis of many factors.

Present monitoring techniques usually employ screenline surveys of aggregate transit trips. While such

techniques are valuable, they do have some serious drawbacks. Many urban transit systems have route structures focused on the downtown and other congested areas. Individuals who might wish to travel from point "A" to point "B" by transit may find that it necessitates a downtown trip solely because of route orientations. These individuals then, are not evidence of transit impact on downtown congestion.

Suggested Operational Objective

Increase the number of households accessible to transit in area "A" which are accessible to employment opportunities in area "B" during peak travel hours.

Where: area "A" generates a high number of employment trips to congested area "B".

TABLE 6.6

Programme Inputs and Programme Outputs Related to the Acheivement of Congestion Reduction Objectives

Program Inputs	Progam Outputs
The number of households accessible to to transit in area 'A' which can travel to 'X' percent of total employment opportunities in area 'B'. *	The number of employment trip ends in congested area 'B' by transit in time period 'Y' The number of transit trip ends in congested area 'B' in time period 'Y'

* where area 'A' is known to generate a high number of employment trips to congested area 'B' during peak hours.

6.10 PROPOSED MEASURES RELATING TO ENERGY AND ENVIRONMENT OBJECTIVES

Objectives to meet national energy conservation goals and to reduce regional air pollution through transit are both met through the same transportation function. Essentially, what is sought is a general diversion of potential automobile drivers to transit.

It has been shown in Chapter 4 that transit's impact on national energy consumption is likely to be small even assuming the most favourable conditions for transit. The greatest potential for public transportation in this area is transit's ability to utilize alternative energy sources.

An important aspect of total transportation energy use was shown to be "capital energy" utilized in the construction of vehicles and guideways. This is particularily relevant when areas are considering fixed guideway type rapid transit systems.

Of all the modes, both public and private, the

urban transit bus is the most efficient in terms of both absolute and present load factors,(Fels, 1974; Yunker and Sinha, 1975). Technological advancement in the design of more energy efficient automobiles, however, is progressing much faster then the design of more energy efficient transit vehicles. In the immediate future, national legislation designed to increase the energy efficiency of automobiles will be far more significant than the energy conservation impact of transit.

An important aspect of modal energy efficiency is the average load factor or utilization rate. Trends in Canadian transit operations indicate the marginal energy efficiency of enhanced transit programmes is much less than the average energy efficiency.

Emissions of air pollutants by transit vehicles are not directly related to energy consumption. There is, however, a strong relationship between the utilization rate or load factor of transit and per-person emissions of pollutants.

Operators should initiate or continue systematic

monitoring of individual vehicle emissions in their maintenance programs. Data collection problems, however, preclude inclusion of direct emission monitoring criteria within the service monitoring framework suggested. Rather, it is proposed that utilization rate be chosen as the surrogate measure of vehicle emissions over time.

For individual transit projects, the most relevant indicator of transit's impact would seek to measure the diversion of present day automobile passengers along a certain corridor to transit. This type of indicator has not been included here as it fails to account for growth and is most suited to project evaluation rather than program monitoring.

More seriously, the suggested indicators fail to account for the effect that generated traffic may have on the indices. If, for example, low fares were responsible for some additional traffic, the effect would be to inflate the indicators. Nevertheless, even given these theoretical objections, inclusion of the measures put forth here would serve to alert management if a policy was actually regressive (ie. if, over time, transit is less utilized in specific areas).

Suggested Operational Objectives

1. Provide a high level of transit service throughout the region.
2. Attempt to increase utilization rate of vehicles.

TABLE 6.7

Programme Inputs and Programme Outputs
Related to the Acheivement of
Energy and Environmental Objectives

PROGAM INPUTS	PROGAM OUTPUTS
	The number of passenger miles on the transit system per day.
The number of households accessible to transit which can reach 'Y' percent of total regional employment opportunities.	The number of passengers per day carried by the transit system.
	The utilization rate of transit operations. *
The number of households accessible to transit.	The average number of passenger miles per unit of energy.
	The marginal number of passengers miles per unit of energy. **

* $\frac{\text{passenger miles}}{\text{vehicle miles}}$

** This review period compared to last review period.

6.11 SUMMARY AND CONCLUSIONS

The implementation fo the proposed transit monitoring system as set out here will require a major commitment from transit operators. Horn's work (1977) suggests the planning departments of most operators are understaffed and oriented toward operational factors such as vehicle scheduling. While work of this nature will continue to be required, questions as to the extent to which transit is actually meeting local objectives must be explicitly addressed. The proposed system is intended to fill this need.

A fundamental premise of this thesis holds that the lack of relevant information in the transit planning process is a serious constraint to effective service planning. The ultimate test of the legitamacy of this hypotheses will require actual implementation of the proposed system in a real world situation and careful evaluation after a suitable time period.

The cost of implementation of the monitoring process suggested here has not been objectively determined but Horn's work (1977) and interviews with local transit operators suggest that personnel required to operate the system are already available but are engaged in data collection tasks which would be rendered obsolete if the proposal were to be implemented. The main problems appears to be in the effective

reorganization fo existing staff.

Given the current conditions characterized by a lack of relevant information, informal allocative decision-making and the mounting levels of public subsidies, however, the relevant questions do not center around the incremental costs of implementation. Rather, it is whether we intend to allocate available transit resouces rationally in response to real community needs and objectives or wheter these resources will be allocated according to political whim.

REFERENCES

Alcaly, Roger E., "Transportation and Urban Land Values: A Review of the Theoretical Literature", LAND ECONOMICS, (Vol.52, Feb. 1976)

Alonso, William, "A Theory of the Urban Land Market", in Larry S. Bourne (ed.), Internal Structure of the City., (New York, Oxford University Press, 1971, pp. 154 - 159)

American Public Transit Association (APTA), Transit Fact Book, 1976., (Washington, D.C., 1976)

Appleyard, Donald, Social and Environmental Policies for Transportation in the 1970's., (Berkeley, Institute for Urban and Regional Development, University of California at Berkeley, 1971)

Batty, Michael, The Impact of Fare Free Public Transport upon Urban Land Use and Activity Patterns., Department of Geography, University of Reading, 1974)

Beesley, M.E., Urban Transport: Studies in Economic Policy., (London, Butterworth & Company, 1973)

Bergman, D.K., Development of Urban Public Transportation System Standards and Evaluation Criteria.,(Bureau of Transportation, Michigan Department of Commerce, Lansing, Mich., 1972

Bergman, Joel, et. al., Development of a Methodology for an Assessment of BART's Impact upon Economics and Finance Plan (Berkeley, Calif., Metropolitan Transportation Commission, 1975)

Berry, Brian J., "General Features of Urban and Commercial Structure.", in Larry S. Bourne (ed.), Internal Structure of the City., (New York, Oxford University Press, 1971, pp. 361-367)

Botzow, Herman, "Level-of-Service Concept for Evaluating Public Transport", TRANSPORTATION RESEARCH RECORD., (Washington, D.C., Transportation Research Board, report 519, 1974, pp. 73 - 84)

Bourne, Larry S., "Trends in Urban Redevelopment - The Implications for Urban Form", APPRAISAL JOURNAL (January, 1970, pp 24 - 36)

Canadian Urban Transit Association, Transit Fact Book (Ottawa, 1975)

Clark, Collin, "Urban Population Densities", JOURNAL OF THE ROYAL STATISTICAL ASSOCIATION., (London, 1951, pp. 490 - 495)

Comprehensive Planning Organization of the San Diego Region, Transit Development and Management Plan., (San Diego, Calif., 1975)

Danials, P.W., Office Location., (London, 1975)

Davis, Honourable William G., Premier of Ontario, An Urban Transportation Policy for Ontario,(Toronto, Queens Park, 1972)

Dazani, J.S., "Income Distributional Effects of the Atlanta Transit System", TRANSPORTATION RESEARCH RECORD., (Washington, D.C., Report 516, 1974, pp 35-46)

Dewees, Donald N., The Effect of Mass Trasnit on Driving and Land Use., (Toronto, The University of Toronto Press, Policy paper # 11, 1974)

Edmonton City Council, A Statement on the Future of This City., (Submission to the Minister of Municipal Affairs, Province of Alberta, 1973)

Falcocchio, J., et. al., "Criteria for Planning a Home-to-Work Public Transportation Demonstration Project for Low Income Workers: A Case Study.", TRANSPORTATION RESEARCH RECORD,(Washington, D.C., Transportation Research Board, Report 473, 1973, pp 1-17)

Falcocchio, J., and Edmund J. Cantilli, Transportation and the Disadvantaged (New York, Lexington Books, 1974)

Fels, M. F., Comparative Energy Costs of Urban Transportation Systems (Princeton University, Transportation Program, Transportation Report 74-TR-2, 1974)

Gannon Colin A., and Michael J. Dear, "Rapid Transit and Office Development", TRAFFIC QUARTERLY (Eno Foundation for Traffic Safety, Vol. 29, 1975, pp 223-242)

Goddard, J., Office Linkages and Location: A Study of Communications and Spatial Patterns in Central London., (London, Vol. 1, 1973)

Government of Alberta, Human Settlement Policies (A Submission to the United Nations Conference on Human Settlements, Vancouver, 1976)

Greater Vancouver Regional District Board, Statements on the Next Stage of Public Transportation Improvements (Submission to the Minister of Municipal Affairs, Province of British Columbia, Sept. 26, 1973)

Gurin Douglas B., "Improving Job Access for the Urban Poor", HIGHWAY RESEARCH RECORD , (Washington D.C., Highway Research Board, Report 473, 1973, pp. 16-27)

Hall, Peter, Von Thunen's Isolated State (Oxford, Pergamon Press, 1966)

Hamburg, J.R., "Impact of Transportation Facilities on Land Development", HIGHWAY RESEARCH RECORD,(Washington, D.C., Highway Research Board, report 305, 1970)

Hayes, Bernard, Montreal '62., (London, The Omnibus Society, 1963)

Heathington, Kenneth W., "The Need for Evaluation", Research Needs for Evaluating Urban Public Transit., (Washington, D.C., Transportation Research Board, Special report 155, 1975)

Hilton Georgee, Federal Transit Subsidies: The Urban Mass Transportation Assistance Program. (Washington D.C., American Enterprise Institute for Public Policy Research, 1974)

Horn, Kevin H., Managerial Decision-Making Criteria in Urban Mass Transit., (Centre for Transportation Studies, University of British Columbia, 1977)

Hutchinson, B.G., "Some Urban Transportation Myths", Roads and Transportation Association of Canada, Annual Conference (Ottawa, 1972)

_____., Principles of Urban Transport Systems Planning (Washington, D.C., McGraw Hill, 1974)

Institute of Transportation Engineers (ITE), Technical Committee 6Y-1, "Levels of Service Provided by Urban Transportation Systems", TRAFFIC ENGINEERING (January, 1976)

Kates, Peat Marwick & Company, Transportation Service Measures., (Greater Vancouver Regional District, 1973)

King, Alan J., "Identifying Community Transportation Concerns", TRAFFIC QUARTERLY (Eno Foundation For Transportation, July, 1975, pp. 317-331)

Lash, M., "Exploring the Benefits of Improved Mass Transit" in, W.S. Homburger (ed.) Urban Mass Transit Planning., (Berkeley, University of California at Berkeley, 1967, pp. 87-95)

Lorimer, Honorable James G., Minister of Municipal Affairs, Government of British Columbia, Policy Statement: Public Transportation for British Columbians. (Victoria, B.C., April 6, 1973)

Massachusetts Bay Transportation Authority, Service Policy For Public Transportation (Boston, unpublished, 1975)

Meyer, Harold M., The Spatial Expression of Urban Growth , (Washington, D.C., Associations of American Geographers, 1969)

McCone, J. M., Violence in the City: An End or a Beginning (Governor's Commission on the Los Angeles Riots, Sacramento, Calif., 1965)

McKoy, John H., Transportation and Equity: Toward a Framework For Distributional Analysis., (San Francisco, California Association for Bay Area Governments, 1967)

Metro Area Planning Committee (Halifax, Nova Scotia), Proposed Transportation Policy and Plan (Halifax-Dartsmouth Metro Area, 1973)

Meyer, John R., J. F. Kain and M. Wohl, The Urban Transportation Problem, (Cambridge, Mass., Harvard University Press, 1964)

Michelson, William, Environmental Choice: A Draft Report on the Social Basis of Family Decisions on Housing Type and Location in Greater Toronto., (Ottawa, Canada, Ministry of State for Urban Affairs, 1972)

Ministry of Treasury, Economics and Intergovernment Affairs, Regional Planning Branch, Toronto Centered Region: Program Statement., (Toronto, Queen's Park, 1976)

Morgan, Thomas R., "Measuring Transportation System Performance", Transportation Engineering Journal (ASCE, August, 1975, pp. 437-454)

National Committee for Urban Transportation, "Recommended Standards, Warrants, and Objectives for Transit Facilities and Service", Better Transportation For Your City (Procedural Manual 8A, Chicago, Public Administration Service, 1958)

National Cooperative Highway Research Program, Strategies For the Evaluation of Alternative Transportation Plans., (Washington, D.C., Transportation Research Board, report 96, 1970)

National Cooperative Highway Research Program, Transportation Decisions Making: A Guide to Social and Environmental Considerations., (Washington, D.C., Transportation Research Board, report 156, 1976)

National Research Council, Highway Capacity Manual , (Washington, D.C., Special report 87, 1966)

Nikalus, John L., Criteria Used by Transit Operators and Planning Agencies in Several Cities to Extend Service to Newly Developed Areas., (Tulane Urban Studies Center Report No. 2, Tulane University, undated)

Northwestern University Transportation Centre, Development of an Experimental Methodology for Evaluating Mass Transit Demonstrations: An Application to the Seattle Bus Service Demonstration Project., (Washington, National Technical Information Service, U.S. Dept. of Commerce, report PB 235 509-510, 1971)

Office of Technology Assessment, United States Congress, Energy, the Economy and Mass Transit., (Washington, D.C., U.S. Government Printing Office, 1975)

Office of Technology Assessment, United States Congress, Assessment of Community Planning for Mass Transit., (Springfield, National Technical Information Service, U.S. Dept. of Commerce, report PB 253 641, 1976)

Parkinson, Tom, and Cecil Chan, Metropolitan Toronto Transportation Review, "Strengths and Weaknesses: Part 1: Public Transportation, (Toronto, Ont., Vol. 18, 1973)

Paaswell, R. E., and W. W. Recker and V. Milone, "Profile of the Carless Population", TRANSPORTATION RESEARCH RECORD. (Washington, D.C. Transportation Research Board, report 578, 1976, pp 16-28)

Putnam, Stephen H., "Preliminary Results from an Integrated Transportation and Land Use Models Package", TRANSPORTATION (Vol. 3, No. 3, 1974, pp 193-229)

Reed, Richard and Kenneth R. Ingram, "Starting the Transit Industry on a Search for the Affluent Markets", TRANSPORTATION RESEARCH RECORD (Washington, D.C., Transportation Research Board, 1976, pp. 9-13

Reynolds, D.J.,"The Urban Transportation Problem in Canada", in, Urban Canada: Problems and Prospects., (Ottawa, Information Canada, 1971)

Rice, R. G., and D. Peterson, The Development of Level-of-Service Standards for Public Transport Systems., (unpublished, presented at the annual conference of the Roads and Transportation Association of Canada, Halifax, Nova Scotia, Oct. 9-12, 1972)

Richardson, Harry,W., Urban Economics., (Harmondsworth, England, Penguin Educational, 1971)

Royal Commission on Metropolitan Toronto, Transportation Organization in Metropolitan Toronto,(Background Report,Toronto, Ontario, 1975)

Saltzman, Arthur and George Ameedee, "Serving the Transportation Handicapped with Demand Responsive Transportation", TRANSPORTATION RESEARCH RECORD., (Washington, D.C., Transportation Research Board, report 599, 1976)

Scheibe, Mark H., and Gordon W. Shultz, A Design Synthesis Transit Planning Approach (unpublished, draft report prepared for the 56th annual meeting of the Transportation Research Board, January, 1977)

Schermer, Julie H., "Interest Group Impact Assessment in Transportation Planning", TRAFFIC QUARTERLY (Eno Foundation for Transportation, Volume 29, Jan. 1975, pp. 29-50)

Science Council of Canada, Cities For Tomorrow., (Ottawa, Information Canada, 1971)

Shortreed, J.H., Urban Bus Transit: A Planning Guide., (Waterloo, Ont., The University of Waterloo, 1974)

Smerk, George, Urban Mass Transportation: A Dozen Years of Federal Policy,(Bloomington, Indiana, 1974)

Stuart, Darwin G., Systematic Urban Planning., (New York, Praeger Publishers, 1976)

Stuntz, Mayo S., and Eric Hirst, "Energy Conservation Potential of Urban Public Transit", TRANSPORTATION RESEARCH RECORD (Washington, D.C., Transportation Research Board, report 599, 1976, pp. 46-51)

Sullivan, Brian E., Preliminary Plan for the Immediate Improvement to Public Transportation in Greater Vancouver. , (Vancouver, B.C., Spatial Dynamics, 1972)

Teuscher, J.J. and D.R. Wilson, Secondary Use of Census Data in Model Formulations of the Social Impact of Transportation upon a given area., (Sacramento, Calif., Department of Transportation, 1974)

Tomazinis, Anthony, New Concepts in Urban Transportation., (University of Pennsylvania, Institute for Environmental Studies, 1972)

Toronto Transit Commission, Transit in Toronto (Toronto, 1967)

Tri-Met Transit Authority, Goals (unpublished, Portland, Oregon, 1975)

Urban Institute, Measuring the Effectiveness of Local Government Services: Transportation (Washington, D.C., 1972)

Urban Mass Transportation Administration, Department of Transportation, External Operating Manual (Washington, D.C., U.S. Government Printing Office)

Voorhees, Alan M. and Associates and Colin Buchanan & Partners, Transit Immediate Action : Tyne Wear Plan., (NewCastle upon Tyne, England, 1970)

Voorhees, Alan M. & Associates, An Integrated Island Wide Bus System,(Honolulu, Hi., prepared for the City and County of Honolulu, Hi., 1971)

_____., 5 County Transit Study- Transit Service Standards and Level of Service Criteria. (Cleveland, Ohio, 1973)

Warner, S.B. Jr., Streetcar Suburbs: The Process of Growth in Boston., (Cambridge, Harvard University Press, 1962)

Webber, Melvin M., The BART Experience - What We Have Learned. (Berkeley, Institute of Urban and Regional Development, Univ. of California at Berkeley, Monogram no. 26, 1976)

Weiner, Edward, "Public Transportation Operating Standards", in, Issues in Public Transportation (Washington, D.C., Transportation Research Board, Special report 144, 1972, pp. 124-140)

Wheeler James O., The Urban Circulation Noose., (New York, Duxbury Press, 1974)

Wohl, Martin, "Users of Urban Transportation Services and Their Income Circumstances", TRAFFIC QUARTERLY., (Eno Foundation for Transportation, vol. 24, 1970, pp 21-45)

Yeates, Maurice H. and Berry J. Garner, The North American City., (New York, Harper and Row, 1971)

Yunker, Kenneth R., and Kumares C. Sinha, "Energy Considerations in Transportation Planning", Eno Foundation For Transportation, Volume 29, 1975, pp. 571-592