THE DEVELOPMENT OF AUTOMATED LIGHT RAPID TRANSIT IN VANCOUVER: THE POTENTIAL FOR SIGNIFICANT COMMUNITY CHANGE

by

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Abstract

The development of the Automated Light Rapid Transit (ALRT) system in Vancouver, first proposed in the 1970's, has been touted as a solution to the contemporary urban problems of increasing traffic congestion, access to the downtown core, and limited affordable housing near the city centre. Recent concerns have been expressed that the development of the ALRT will be accompanied by significant change in the neighbourhoods along the route. This thesis aims to assess the potential for significant change occurring in the suburban Vancouver City neighbourhoods along the ALRT route after the construction is completed.

The increased accessibility to the city centre anticipated as an outcome of the development of the ALRT is regarded as the factor most likely to produce significant change in neighbourhoods along the route. This expectation arises from the understanding provided by literature from the fields of urban economics and urban ecology. Discussions of the bid-price curve in the work of Alonso and other urban economic writers attributes much of the market value of land, and by inference the residential density of land, to the effect of accessibility to the city centre. Further discussions in the urban ecology literature, including the work of the factorial ecology school, outline the relationship between accessibility to the city centre and the distribution in urban areas of social rank and of household types. From the relationships indicated in the literature, it is expected that the improved accessibility which
will result from the construction of the ALRT could significantly change neighbourhoods along the route.

Using Census data, the thesis explores the strength of the existing relationships between accessibility to the city centre and each of the social characteristics identified in the literature. The strength of each relationship was determined using a rank-order correlation between relative accessibility to the city centre and z-scores associated with indicators for each of the social characteristics. The relationship between accessibility to the city centre and social rank was examined using the highest level of education attained by the over 15 year old population as a proxy for social rank. The proportions of the various household types, including family and non-family households, single-person and multiple-person non-family households, were used to provide insights into variations in this aspect of urban life which is affected by accessibility to the city centre. Finally, the relationship between accessibility to the city centre and the distribution of dwelling types was examined by looking at variations in the distributions of single-detached, multiple-dwelling, and apartment units along the ALRT route.

Social rank was found to be not strongly correlated with the level of accessibility to the city centre. Instead, the distribution of social rank was seen to have been more strongly influenced by other factors, such as the historic pattern of development. The distribution of dwelling types and of the various household types were demonstrated to be related to
accessibility to the city centre. As the level of accessibility to the city centre increased, the proportion of apartment units in an area and the proportion of non-family households were seen to increase.

The development of the ALRT was not expected to significantly affect the distribution of social rank along the route. Expectations that significant change would follow the development of the ALRT was supported for both the spatial pattern of the various dwelling types and the spatial pattern of the household types. The spatial distribution of both of these social indicators would be expected to change significantly following the completion of the ALRT.
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I. INTRODUCTION

1.1 Broad Urban Context

The development of a light rapid transit system, the precursor of the Automated Light Rapid Transit (ALRT) system, was first proposed in the early 1970's as a solution to Vancouver's problems of traffic congestion and efficient access to the downtown. The Greater Vancouver Regional District, in the 1973 Livable Region Plan, pointed three issues relating to the development of a light rapid transit system. These were:

i. the desire for a reduction in the time and effort involved in the journey to work,

ii. a concern about the high cost of housing,

iii. a willingness to use fast, frequent and convenient public transit. (GVRD 1973,7) The statements of issues indicates that the public would support the idea of a rapid transit system.

Though the decision to build a light rapid transit system has been made, and construction is well under way, new problems are anticipated as a result of the new transit system. Included are the concerns that there will be:

i. increases in the development pressures on land along the ALRT route accompanied by increases in housing costs;

ii. increases in the proportion persons of higher social rank moving into established neighbourhoods along the transit corridor; and
iii. changes in the household structure in the neighbourhoods along the ALRT route.

This thesis provides an empirical assessment of the likelihood for these three types of changes to occur based on the theories and methods of two bodies of literature, urban land economics and urban social ecology. The development of the ALRT system is expected to have a major effect on accessibility to the city centre for those neighbourhoods along the route. A number of relationships between social characteristics and accessibility to the city centre are suggested by the urban land economics and urban social ecology literature. In this thesis, the strength and significance of three of these relationships is examined. The findings from this examination are anticipated to provide insights which could guide policy decisions for the suburban Vancouver section of the ALRT route.

1.2 The Development Of The ALRT

The development of Vancouver's ALRT has been heralded as a solution to problems of limited access to the downtown and of traffic congestion within the core area. The ALRT is being developed with the realization that while major potential for office development in the core still exists most of the residential capacity which exists under present zoning has already been developed. Unless residential land use intensification opportunities can be created within Vancouver, future residential development will be limited to adjacent suburban communities.
The possibility of a continued employment concentration in the city centre and an accelerated residential development in the suburbs would potentially undermine the business efficiency and the quality of life of the core area. The ALRT is believed to be a solution to these transportation and growth problems. The City of Vancouver Planning Department expects that the development of the ALRT system create "hot spots of accessibility" which will in turn, encourage new housing and population growth near the stations and along the corridor (City of Vancouver 1983b, 2).

In keeping with the City of Vancouver's ongoing public participation policy, the citizens of the neighbourhoods surrounding the four suburban stations have been invited to participate in the planning process for each of the impacted neighbourhoods. Public planning projects have been initiated in the neighbourhoods surrounding: the Broadway Station; the Nanaimo and the 29th Avenue Stations; and the Joyce Station (City of Vancouver 1983b, 1983c, 1983d). The major focus of this planning process is on the detailed nature of the anticipated impacts of the ALRT on each of these neighbourhoods.

This thesis is concerned with one section of the ALRT route, from Main Street to Boundary Road. The empirical analysis examines the strength and significance of existing relationships between social characteristics of these neighbourhoods and accessibility to the city centre.
1.3 The Problem Statement

The development of the ALRT is expected to have a significant impact on the Lower Mainland, and particularly on the City of Vancouver. Immediately following the construction of the transit line, a strong connection will be made between the outlying areas and the city centre, encouraging travel, particularly, to the established centres, such as downtown Vancouver. Later, once the development of other centres in outlying areas is completed, such as Metrotown in Burnaby, it is possible that journeys focused on other centres could become a more significant aspect of movement in the region. The aim of this thesis is to understand some of the likely changes in the social characteristics of neighbourhoods along the ALRT route expected to result from improved accessibility.

According to urban land economics and urban social ecology, change in social characteristics can be estimated from the existing relationships between accessibility and the social characteristics. These existing patterns can provide a basis for developing estimates of the potential impacts of increased accessibility to the city centre on the pattern of social differentiation in the ALRT corridor. This thesis will concentrate, in particular, on the change in the social dimensions of family status and economic status. These elements are key components in the analysis which characterizes the factorial ecology approach to the study of urban areas. In addition, the urban economic literature suggests a third dimension, dwelling type, which is related to the level of
accessibility to the city centre.

The empirical tests carried out by this thesis involve exploratory data analysis of the relationship between the relative accessibility to the city centre and three dimensions of social differentiation: social rank, family status, and dwelling type.

1.4 The Research Method

The literature from urban land economics and urban social ecology provides two related approaches to the analysis of urban structure. Accessibility to the city centre is a fundamental concept in both theoretical approaches. The development of the ALRT is expected to significantly change accessibility to the city centre for neighbourhoods along its route; it is, therefore, important to understand what impact such changes have on the social characteristics of neighbourhoods along the route. The relationship between accessibility and the various social characteristics indicated in the urban land economic and urban social ecology literature suggests that the development of the ALRT could lead to change in the social characteristics of the neighbourhoods along the route.

Both the urban ecology literature and the urban economic literature identify accessibility to the city centre as a critical factor in the spatial distribution of many of the attributes of neighbourhoods. This thesis examines specifically the relationships between accessibility and three social characteristics: social rank, family status, and dwelling type.

The first of these, social rank, is determined on the basis
of the level of education attained. Three categories are used as measures: high school, post-secondary (non-university), and post-secondary (university). Each category is significant and distinctive and represents a major educational alternative. In addition, these categories can be arranged in an ordered sequence reflecting the relative social rank of each grouping of highest level of education attained, (following the lead provided by Blishen and McRoberts, 1976).

In the discussion of family status, a distinction is made between family and non-family households. Following this, a second level of distinction is made within the family and the non-family distinctions. Within family households, the distinction is made between single-family and multiple-family households; within non-family households, the distinction is made between single-person households and non-related multiple-person households.

The dwelling type indicators used are: single-detached house, multiple-dwelling unit, and apartment unit. Each of these indicates a distinct measure of residential density; they can readily be arranged in an ordered scale.

The thesis focuses on the geographical area contained within the Census Tracts along the Main Street and Boundary Road section of the ALRT route. Data from both the 1976 and 1981 Census were used. The study area from the 1981 Census is shown on the map (Figure 1). The geographic extent of the study area was identical for the 1976 Census; however, some of the Census Tracts were not yet divided.
Each of the indicators, social rank, family status, and dwelling type, along the ALRT corridor are analysed to determine their existing relationships in terms of accessibility to the city centre. This analysis is confined to the Census Tracts within the City of Vancouver. The strength and significance of the relationship between accessibility to the city centre and each of the social characteristics is determined from rank-order correlations of each of the relationships using the Kendall's tau b correlation coefficient and its test of statistical significance.
Figure 1 - Map of the ALRT Corridor

Inner Suburban Section
Outer Suburban Section

ALRT Route
1.5 The Anticipated Results

Improved accessibility to the city centre anticipated from the development of the ALRT system is expected to affect the future distribution of social characteristics. Before the potential for change can be discussed, the existing relationship must be determined. The literature from urban land economics and urban social ecology suggests likely distributions for each of these dimensions based on extensive empirical research. The theoretical distributions provide hypotheses which this research can test. The anticipated results of indicators for each social dimension are discussed below.

The social rank of neighbourhoods along the route is expected to be affected by the development of the ALRT. The relationship between the bid-price for land and the level of accessibility to the city centre suggested by the urban land economics literature creates the expectation that improved accessibility to the city centre will affect the spatial distribution of social rank along the ALRT route. In addition, it is expected that the social rank of the residents of the Census Tracts along the ALRT route will increase as a result of improved accessibility to the city centre.

The improved accessibility to the city centre is expected to lead to changes in the spatial distribution of family status, as indicated by different household types. Household types presently concentrated in the highly accessible neighbourhoods near the city centre are expected to locate there in the future. More households of the same type would be expected to locate in
neighbourhoods which became equally accessible following the development of the ALRT.

The improved accessibility is also expected to affect the spatial distribution of dwelling types. Improved accessibility along the route is expected to force up the bid-price for housing along the ALRT corridor. The increase in the bid-price is expected to result in an increase in the development of denser residential structures, such as apartments, where accessibility to the city centre is improved.

1.6 Overview

The literature from urban land economics and urban social ecology suggests three social dimensions, social rank, dwelling type and family status, which are related to the level of accessibility to the city centre. The relationship between the development of the ALRT system and these theoretical relationships is discussed in Chapter II.

Chapter III details the method used to test the strength and significance of the relationships between the social dimensions and accessibility suggested by these literatures. Correlations between indicators of the social dimensions and accessibility to the city centre are computed; the findings from this analysis indicate how accurately the theoretical relationship is represented along the ALRT corridor. The findings from this analysis are presented at the end of Chapter III. The relevance of these findings to the questions raised in this thesis are discussed in Chapter IV. Finally, in Chapter V, the conclusions from this research are discussed. The main
findings and conclusions from this study are summarized below.

Social rank was found to be not strongly correlated with the level of accessibility to the city centre. Instead, the distribution of social rank was seen to have been more strongly influenced by other factors, such as the historic pattern of development. The distribution of dwelling types and of the various household types were demonstrated to be related to accessibility to the city centre. As the level of accessibility to the city centre increased, the proportion of apartment units in an area and the proportion of non-family households were seen to increase.

The development of the ALRT was not expected to significantly affect the distribution of social rank along the route. Expectations that significant change would follow the development of the ALRT was supported for both the spatial pattern of the various dwelling types and the spatial pattern of the household types. The spatial distribution of both of these social indicators would be expected to change significantly following the completion of the ALRT.
II. THEORETICAL FOUNDATIONS

2.1 Introduction

In the context of this thesis it is necessary to examine earlier transit corridor studies (Metropolitan Transportation Commission 1979, Dvett et al 1979, Dewees 1976, and others) as well as theoretical literature which can provide insights into the relationship between accessibility to the city centre and social characteristics of neighbourhoods.

The earlier studies of the land use effects of rapid transit (Toronto, Philadelphia, and San Fransisco) have been frequently referenced to provide support for new rapid transit initiatives (De Leuw, Cather and Company in Altshuler 1979, 398). Recently, the conclusions reached by these studies have been criticized for attributing too much of the subsequent development to the construction of these rapid transit projects (Webber 1977). Other factors, including land use regulation and related policy instruments, have been found by some studies (Altshuler 1979, 404; Knight and Trygg 1977, 235; Knight 1980, 8) as being critical in shaping land use change following the development of rapid transit systems.

The significance which land use regulations and related policy instruments have in affecting the extent of the land use change which follows the development of a rapid transit project attests to the need for a well considered estimate of the potential consequences in an unregulated market. Such an estimate will enable regulatory responses which are consistent with the goals of the community to be developed in advance of
the completion of the transit project. In this way, new development can be encouraged in locations at which greater social benefits can be realized, and discouraged in other locations.

In order that these estimates of potential consequences are reasonable, it is important that they are developed from well established theory. The relationship between accessibility to the city centre and the distribution of several neighbourhood characteristics has been widely discussed in the literature, notably, in the urban land economics contributions of Alonso (1964) and Wingo (1961), in the factorial ecology school following Shevky and Bell (1955) and, in factorial ecology studies of Vancouver (Wolfforth 1966 and Patterson 1974). These theoretical literatures provides the foundation for the research method of this study.

These key sources were selected because they represent the established literature in their fields, and because they focus on the distribution of social characteristics within an urban setting. Alonso and Wingo examine relationships between accessibility to the city centre and the distribution of land prices; this discussion continues as fundamental elements of urban land economics. The Alonso model provides the basis for more recent work in land economics and regional analysis (Grigg 1984, and Werczberger 1984). Replications of the landmark work done by Shevky and Bell (Van Asdol, Jr., Camilleri, Schmid 1958, Schwirian and Matre 1969, Murdie 1969), including studies done in Greater Vancouver (Wolfforth 1966 and Patterson 1974), attest
to the continued vitality of this body of theory and its applicability in the City of Vancouver.

In the following sections of this chapter, the literature which provides the analytical perspective of this thesis is discussed. For the reasons just noted, the discussion has two major components, the urban land economics and urban social ecology literatures. Chapter III will build on this chapter by applying the theory reviewed and selected in Chapter II.

2.2 Urban Land Economics

2.2.1 Origins Of The Urban Land Economic Literature

Urban land economic theory (Alonso 1960, Muth 1969, Wingo 1961) has explained the pattern of residential location as the outcome of trade-offs between transportation costs and the cost of land. Sociologist, Leo Schnore (1954) made the assumption that "rent or the cost of occupancy of a site, declines with distance from an activity centre but transportation costs are assumed to increase with distance" so that "the maximum distance from significant centres of activity at which a unit tends to locate is fixed at that point beyond which further savings in rent are insufficient to cover the added costs of transportation to these centres" (Schnore 1954, 342).

These earlier discussions of the theoretical relationships between rent and accessibility to the city centre were further examined by economists, Hoover and Vernon (1959). Their argument was that residential location decisions resolved the trade-offs between easy access to the city centre and spacious living away from the core.
These early discussions provided the basis on which Alonso (1964) and Wingo (1961) developed their more rigorous versions of the theory to explain the relationship between land costs and accessibility. The conclusion that land values decreased as distance from the city centre increased was developed from their theoretical analysis. Wingo focused his investigation on the effect of changes in the transportation system on urban land use; while Alonso was more concerned with the determinants of urban land use and land rents. The early works of Alonso and Wingo have continued as the foundation of urban land economics. The critical relationship between accessibility to the city centre and land costs is expected to be significantly affected by the development of the ALRT system.

2.2.2 The Fundamental Urban Land Economics Model

The essential element of Alonso's analysis of the trade-off between land cost and commuting costs to the city centre is a bid-price curve which provides a useful model of this relationship. The bid-price curve depicts the price which an individual household would pay for the use of residential land at each location on the urban surface. The graph of this relationship illustrates how the bid-price for residential land decreases as distance from the downtown core increases. (see Figure 2)
At the outset of his analysis, Alonso makes a number of assumptions. First, he makes the simplifying assumption that all work-places are located at the city centre; in fact, while not all jobs in the contemporary post-industrial city are located in the city centre, it is by far the largest single employment concentration. Second, the journey-to-work was seen to be the most significant journey in the daily travel pattern of the household. Each household was assumed to make only economically rational decisions. Within the parameters of these assumptions, the individual household was expected to select its optimal residential locations; each household was expected to reach this goal by balancing the cost of their residential land with their cost of commuting to work in the city centre. Accessibility to the city centre, because of the importance of
the journey-to-work to the individual household was seen to be critical to their residential location decision. Alonso's bid-price curve describes the critical relationship between accessibility to the city centre and the cost of residential land which is expected to change as a result of the construction of the ALRT.

2.2.3 Application Of The Model

The resolution of the trade-off between accessibility to the city centre and the cost of residential land is greatly influenced by the particular characteristics of individual households. To be useful for modelling purposes, suitable data to test this relationship would have to be available in a form compatible with the census data. Two of these characteristics which are seen to influence the spatial distribution of households are the family structure of the household (including household size and composition), and household income. The location decision for a particular household comes out of applications of such parameters to their individual set of bid-price curves.

The particular dwelling space demands of a household are affected by the number of members in the household, and the age structure of the household. The bid-price curves for a particular household are influenced by both, the income of the household and any particular requirements which the individual household may have. The particular requirements of the individual household would include any unique factors specific to the household.
Evans (1973) assumes that the residential location decision for the individual household minimizes its total locational costs (Evans 1973, 30). These costs include the rental value of the home, and the cost of the journey-to-work, including both the actual price of the transportation to work and the value of the time involved.

The relationship depicted by the bid-price curve has implications for variations in the density of dwellings and for the spatial distribution of households. As land costs increase with improved accessibility to the city centre, the housing market generally responds with more intensive development of the land. Alonso's bid-price model was extended by Muth (1969) to explain the spatial distribution of different household types. Different types of households would vary in their dwelling space requirements. Single-person households would need less space than family households; while family households with young children would need smaller homes than family households with older children.

For households with similar incomes, the household with a higher dwelling space requirement would be expected to locate further from the city centre than those requiring less space. Following from the relationship indicated by the bid-price curve, households with a higher space requirement should be able to obtain the addition dwelling space that they require for a price similar to the price they would have paid for less space closer to the city centre. This point is illustrated in Figure 3. Muth (1969), (referenced in Evans 1973, 168), found that
household size was positively correlated with distance from the city centre.
The generalized spatial distribution of households indicated in Figure 3 (after from Muth 1969), is derived from the independent decisions of the households in a city. Each decision is affected by variations in the household composition. The optimal location for each household is determined by locating the point on their bid-price curve where the cost of
commuting is in equilibrium with the cost of acquiring the necessary dwelling space. The exact bid-price curve for a particular household will vary with the income of that household. A higher household income will be generally imply a higher and steeper bid-price curve for housing. In Figure 4, the shift from AB to CD indicates the outcome of an increase in household income on the bid-price curve for housing.
Figure 4 - The Optimal Location Of The Household

Redrawn from Evans 1973, fig.6.1.
Initially, it would be expected that after an increase in income, a household would be more willing to allocate a larger amount of the household income for an equivalent amount of dwelling space. At the same time, they would likely want a larger amount of dwelling space. The location for a household with an increased housing budget would come from the resolution of the choice between a location with more dwelling space and a more expensive site. Within the understanding which a strict application of the theory provides, the household would attempt to select a location which would be both more spacious and more costly. The more spacious location would most likely be found further from the city centre; while the more costly location would be found closer to the core. The conflict which this discussion suggests is usually resolved by the household selecting a residential location which combines a change in distance from the centre with an increase in the amenity level.

2.2.4 The Effects Of A Change In Accessibility

The basic model of urban land economics, Alonso's bid-price curve, presents an analysis of the interaction between accessibility to the city centre and the cost of urban land. The expectation that the construction of the ALRT will affect the level of accessibility to the city centre along the transit corridor raises questions of how such a change might affect land costs in this area. As noted above, the desire to minimize location costs is fundamental to the residential location decision for households. One of the most significant factors affecting the location costs of urban land is its accessibility.
to the city centre. This relationship is examined by Wingo; he notes that "the quality of location, or 'accessibility' is the dominant factor in determining the uses of the land or their intensities." (Wingo 1961). Accessibility is defined by Wingo as a relative quality accruing to a parcel of land by virtue of its relationship to a transportation system operating at some specified level of service (Wingo 1961, 26).

This point is key to understanding the relationship between accessibility and the cost of urban land.

Alonso, on the other hand chooses to avoid some of the mathematical uncertainty implied by the subjective nature of the term "accessibility". Instead, he uses physical distance in his analysis because of the relative ease with which it can be measured. The unfortunate consequence is that some of the fuller, albeit less rigorous, meaning which "accessibility" includes is lost from the analysis. In this thesis, the term "accessibility" will be used to refer to an ordered measure of the effect of distance from the city centre. Thus, the accessibility of one location can be discussed relative to the accessibility of another location.

Less expensive commuting and shorter commuting times are two of the effects which, Alonso (1964, 111) notes, would be expected to follow an improvement in transportation technology. Initially such changes would give the bid-price curves for affected areas much flatter slopes. Alonso also notes that initial responses to the technological change would begin with a lowering of the price structure for the affected area. (see
This initial decrease is depicted in the diagram by the shift from AB to A'B. Following this initial increase in the accessibility to the city centre, the price of the land in the area OM would be much lower than the initial price under AB, the price structure would then re-adjust and would stabilize at A"B". The outcome of a change in transportation technology which improved accessibility to the city centre would be lower
land costs in central locations; while higher land costs would be the case in locations further from the centre.

A second interpretation of the effect of improved accessibility to the city centre comes from Wingo; it can be summarized in the following diagram (see Figure 6). The change in the price structure which would be expected to accompany an improvement in the transportation technology is indicated in Figure 6. The dotted line, \( b - M_1 \), represents the initial bid-price curve under the pre-existing transportation technology. The new bid-price curve which would follow an improvement in the transportation technology is indicated by the solid line, \( e - M_2 \). The corresponding effect of a change in transportation technology on the density of residential development is indicated by shift from \( a - M_1 \) to \( c - M_2 \) in the lower curve. The area between \( e \) and \( m_2 \) in Figure 6 represents the area which would experience an increase in the price of land as the result of an improvement in the transportation technology.
Figure 6 - Effect Of An Improvement Of Transportation On The Price Structure
The literature from urban land economics suggests a significant relationship between accessibility to the city center and the bid-price for land. An improvement in accessibility, such as would be anticipated after the construction of the ALRT, would be expected to affect the cost of land along the transit corridor. The application of this theory is postponed to the next chapter, after development of
social ecology.

2.3 Urban Social Ecology

The literature of urban social ecology is extensive; in spite of the extent of the literature and the wide variety of the methods which have been applied to the study of urban social differences, there has been a consistency to the findings. Studies of the urban social ecology of North American cities indicate that three sources of variation, socioeconomic status, family status, and, ethnicity/segregation, originally suggested by Shevky and Bell (1955) are needed to distinguish urban social areas. The three social dimensions were developed with a view to established sociological theory and available data sources.

Each of the social dimensions noted by Shevky and Bell arises from observations of the changing character of societies. Change which could be readily measured using census data was seen in the distribution of skills, the structure of productive activity, and in the composition of the population. These indicators of social differences can also be used to indicate differences between urban sub-areas (Herbert and Evans 1974). The changing distribution of skills which affects the functional arrangement of occupations in the society can be measured by variations in the social rank dimension of the population. Similarly, changes in the structure of productive activity of the society can be indicated by variations in the family status dimension. The changing composition of the population is indicated by Shevky and Bell using the ethnic status or ethnicity dimension.
Substantial differences have been noted in the composition of the third variable, ethnicity or segregation, between the Canadian and American contexts (Schwirian and Matre 1969). In Canada, the ethnic dimension was seen by Schwirian and Matre to be best identified when it included national and cultural heritage; while in America, it referred to race, and specifically, the proportion of the population which is Negro. Anderson and Egeland (1961) indicate that the distribution of the ethnicity dimension varies considerably between cities; for this reason, they did not include ethnicity in their study of the spatial aspects of social area analysis.

The three dimensions, social status, family status, and to a lesser extent in Canada, ethnicity, allow distinctions to be made in the social character between urban areas. The spatial patterns displayed by the major dimensions (Anderson and Egeland 1961, Berry 1965, Berry and Kasarda 1977, Murdie 1969, Rees 1979, Schwirian and Matre 1969, Schwirian and Smith 1971) has suggested that each dimension has a distinctive spatial distribution. Social rank is distributed in a predominantly sectoral pattern; while family status is distributed in a predominantly concentric ring pattern. While some authors (Anderson 1962, Boal 1976) have suggested that ethnicity is distributed sectorally; results in other studies (Patterson 1974) have not indicated a conclusive pattern. The distribution of ethnicity varies between cities. In some cities, differentiation along racial or linguistic lines does not occur (Pederson 1967, in Berry and Karsarda 1977, 131). Where ethnic
differentiation is a factor, it can be distributed either by sectors or by concentric rings. Patterson (1974) concludes that the distribution of ethnicity in metropolitan Vancouver had "a unique pattern unlike any of the urban models". Berry (1977) and others have highlighted the similarity between the distribution of the other social dimensions and the classic models: social rank (Hoyt's sectoral model), and family status (Burgess's concentric ring model).

The literature of contemporary urban social ecology is viewed as a "field of inquiry that deals with form, structure and process regarding social systems ... (which provides) ... a theoretical basis for our understanding of urban social organizations from a residential perspective" (Perle 1983). Recent urban geographic thought (Ley 1983) supports this contention and points to the value of social area analysis as a method for analysing social characteristics of urban areas. Ley (1983) reminds us that the factorial ecology method can provide the insights into the distribution of social characteristics which might well allow the reconciliation of the Burgess and Hoyt models of land use and social areas.

2.3.1 Origins Of The Contemporary Models Of Urban Social Ecology

Contemporary understanding of urban social ecology (Berry and Rees 1969, and Murdie 1976) is derived from both factorial ecology and the classic social ecology models. The mathematical rigour of the factorial ecology studies identifies the dimensions of urban social differences; while the classical urban social ecology models provide descriptions of the spatial
distribution of the dimensions. Classical urban social ecology research has provided two models (Burgess 1925, and Hoyt 1939) which are basic to the understanding of land use change. More recent factorial ecology studies (Wolforth 1965, Murdie 1969, Patterson 1974, and Rees 1977) have again demonstrated the insight into land use change which the classical models of urban ecology have provided. While the explanations which were developed by Burgess and Hoyt attempted to provide a comprehensive portrait of the social processes shaping the land use patterns of the city, more recent studies (Murdie 1969, Rees 1969) suggest that the greatest value of these classic studies is in showing how these processes have differentially molded the urban landscape of the contemporary Western city.

The Burgess (1925) model provides a framework which describes the location of activities in urban areas. The "concentric-zone theory" (see Figure 7) viewed the city as a series of five concentric zones: the loop or central business district, the transition zone, the zone of workingmen's homes, the residential zone, and commuter's zone.

The growth of the metropolitan area was regarded by Burgess as the outcome of an urban expansion which developed from the construction of new homes for the higher-income populations at the periphery of the city. As higher-income populations moved to new homes in the outer rings, the homes which were abandoned by the higher-income groups were then occupied by lower-income households. This filtering process was seen as the source of the homes for the lower-income households. A major feature of
the Burgess hypothesis was the concentric-ring pattern of residential location taken by the various socioeconomic groups in the city. The lower-income households were located near their places of work in the city centre, while the higher-income households sought newly constructed homes near the outskirts of the city.

Figure 7 - Burgess's Concentric Ring Model

1. Central Business District
2. Zone of Transition
3. Zone of Workingmen's Homes
4. Zone of Better Residences
5. Commuters' Zone

Adapted from Burgess 1925 in Chapin 1965, fig.2.

The Burgess model has been criticized for being a
"generalized description of the residential structure of one city at one point in time" (Senior 1973, 171), and for this reason it was seen as having little applicability to other cities. The extension of the Burgess hypothesis as an explanation of urban structure was questioned earlier by Schnore (1963, 1964) following his analysis of the socioeconomic patterns of a number of American cities. While he did find that some cities were patterned like the concentric-ring model of Chicago as depicted in the Burgess model, Hoyt found that there were many other cities whose form differed significantly from the Burgess model. More recent works (Berry and Rees 1969, and Murdie 1976) in factorial ecology indicate the value of the Burgess model in describing the distribution of the family status dimension.

The second classic spatial model is the sectoral model of Homer Hoyt (1939). Hoyt derived the sectoral model from an analysis of the locational patterns of different rental areas in a number of American cities. In each municipality he found that each distinct socioeconomic group occupied a discrete sector. The amenities of these locations and other characteristics of the site were found to be particularly important in the residential location decisions made by the higher-income group. Hoyt felt that those who could pay the high rent which was demanded for high amenity locations would pay the price demanded. From Hoyt's analysis, the high-income households were expected to seek accommodation along "the best existing transportation lines", on "high ground - free from risk of
floods" and on "land along lake, bay, river and ocean front where such water fronts are not used for industry" (Hoyt 1939, 117-19). The theory holds that the various income classes in a city will be found segregated in separate wedge-shaped sectors, focused on the city centre (see Figure 8). The wedge-shaped sectors would be arranged so that households of higher socioeconomic status would be found in the higher amenity areas; while households of lower socioeconomic status would occupy the remaining residential lands between the high amenity areas. Recent work (Berry and Rees 1969, and Murdie 1976) concludes that the social rank dimension is distributed sectorally.

Figure 8 - Hoyt's Sector Concept Model

1. Central Business District
2. Wholesale and Light Manufacturing
3. Low-Class Residential
4. Middle-Class Residential
5. High-Class Residential

Adapted from Hoyt 1939 in Chapin 1965, fig.2.
Some earlier studies of urban structure (Berry 1965) have concluded that the classical models provide conflicting and contradictory descriptions of the internal structure of the city. Other studies (Anderson 1961, Berry and Rees 1969, Murdie 1969, and Murdie 1976) suggest that the classic models of Burgess and Hoyt complement one another, with each model describing a separate aspect of social differentiation within a city. The concentric ring model which Burgess used to describe the distribution of socioeconomic status in the city more accurately describes the spatial distribution of the family status variables, such as, family or non-family households. Hoyt's sectoral model, particularly in light of the results from factor analysis of the urban ecological structure (Berry and Rees 1969, Murdie 1969, Murdie 1976 and Patterson 1974), provides the more accurate picture of the spatial distribution of socioeconomic status, particularly when the analysis is focused on the central city in a larger urban agglomeration. The correspondence between the classic models is illustrated in Figure 9.
Figure 9 - The Urban Ecological Structure

Reprinted from Murdie 1969, fig.2.
2.3.2 Application Of The Urban Ecological Models

Recent urban ecological research has focused on the growth and development which is a major feature of the process of urban expansion. Three aspects of this research are particularly relevant to the focus of this thesis; they are the residential location decision, the distribution of household types and the level of accessibility to the downtown core.

Residential Location Decision

The concentric-ring concept has been particularly useful in relating the residential location decisions to household income and the cost of housing, stage in the life cycle, and type of dwelling. The significance of each factors varies with the distance from the city centre. The insights provided by the concentric-ring concept parallels the understanding provided by the bid-price surface concept of land-use. Both the bid-price curve and the concentric-ring model indicate how variation in accessibility to the city centre is related to other components of the residential location decision.

The sector concept provides insights into the more subtle aspects of the residential location decision which arise from socioeconomic differences in the population. Factorial ecology studies (Wolfforth 1965, Murdie 1969, Patterson 1974, Rees 1977) have demonstrated that in Western cities social rank is distributed sectorally. The existing spatial pattern of social rank in the city has an influence on the residential location decision as households generally seek locations which contain others of similar social rank. Income and wealth are correlated
with social rank and affect the residential location outcome by placing limitations on the range of the possible trade-offs between household income and cost of housing. In addition, the life-style preference and the community characteristics considerations which are fundamental to the residential location decision are affected by the social rank of the household.

The Distribution Of Household Types

The spatial distribution of the various household types is affected by differences in the housing requirements of different households. The life-style and stage in the family life-cycle limit the accommodation which is appropriate for the household. Studies of the distribution of different household types (Abu-Lughod and Foley 1960) have examined the importance of these factors in the distribution of the various household types. Household life-style includes the choices made among the major adult goals, raising a family, pursuing a career, and enjoying the 'good life'. While these goals are not mutually exclusive, each household must make its choice amongst them. The choices which affect individual residential location have a further effect on the broader pattern of household types.

A major distinction can be made between households for whom the raising of a family is the major focus, and households for whom pursuing a career or living the 'good life' is the major focus of their life. None of these life-styles is necessarily exclusive; a specific household would be expected to make decisions based on the importance they attach to these factors. Family households will have specific needs, and these needs
would differ from those of the career-oriented or 'good life' oriented household. Differences in household needs will affect the residential location decisions of each household type; each household types would locate in neighbourhoods which contain the most suitable accommodation. Variations in shelter needs of households arising from life-style differences obscure the categories of family status and social rank. Life-style differences affect the residential location decision but these differences cannot be readily distinguished by using census data.

In addition to the influence of their life-style choices, the residential location decisions of family households are further influenced by household composition. Generally, family households evolve through a series of life-cycle stages which mirror the physical development of the offspring. Each stage has broader implications for the residential location decision of the household and consequently for the distribution of the various household types. As expected, family households are found in much higher numbers in those areas which contain suitable accommodation, particularly, single-detached houses, which are most frequently found away from the city centre in the suburbs.

Like household life-style, the stage in family life-cycle influences its shelter needs. The family household passes through a number of stages which imply different residential space requirements. Prior to the birth of the first child, the residential needs of a family household are similar to those of
a non-family households; although in anticipation of starting a family, the household may choose a larger home. As the family household grows in size, and particularly after the children are born, the family household's desire for larger accommodation grows. Often, the family household will forego easy accessibility to the city centre for the more spacious, less expensive accommodation which can be found in the suburbs. Later, as the children begin to reach adulthood, the household again feels a need for still more spacious housing to accommodate the increase in the number of adult members and to meet the additional social demands faced by the household. Once the children leave home, the household no longer needs the large family home, but often it is maintained to accommodate family visits. Following the death of one of the household heads, the surviving spouse may seek accommodation of a more manageable size. The size of the residential accommodation required by a particular household is seen to change as the size and composition of the household changes (A fuller discussion of this subject can be found in Abu-Lughod and Foley 1960).

The differing spatial demands of both non-family and family households at the various stages in the family life-cycle affects their housing needs. These differences in housing needs affects the choice of residential location made by the household. As noted above, the relationship between distance from the city centre and the cost of residential accommodation depicted by the bid-price curve, has an impact on the selection of a residential location. The distribution of different
dwelling types is affected by variations in the cost of land. Each households seeks a suitable residence from the available accommodation.

**Accessibility To The City Centre**

Recent research in urban ecology has examined the significance of accessibility on the residential location decision. Accessibility to the city centre has been the basis for the classical models of urban ecology, particularly, the models developed by Burgess and Hoyt. The importance of accessibility in the residential location decision was criticised by Wolforth (1965) and Stegman (1969) who contend that other factors, such as neighbourhood quality, were more influential. Earlier work on stages in family life-cycle (Abu-Lughod and Foley 1960) undermines this dismissal of the importance of accessibility to the city centre in the residential location decision. While the results of the survey done by Stegman suggest that the accessibility assumptions are no longer valid because most suburban families are more concerned about neighbourhood quality than accessibility. Family households with children are key to Stegman's conclusions are indicated by Abu-Lughod and Foley as the household type which would be least concerned with the level of accessibility to the city centre. Accessibility to the city centre is basic to many residential location models including the model developed by Kain (1961). The major premise of these models is that family households will locate at a point away from the city centre where the costs of appropriate accommodation is balanced.
with their need for accessibility to the city centre. In making their residential location decision, the households will trade-off the increased costs of commuting with the benefits in the amount of residential space which they can obtain in the suburbs.

Stegman (1969) contends that the accessibility assumptions upon which the residential location models are founded are no longer valid. His study concludes that neighbourhood quality was a more important factor in the residential location decision of new suburban residents than was accessibility to the city centre. His evidence includes his findings that a similar proportion of central core households and suburban households drove to work, suburban families and central core families held similar values and so the neighbourhood character would not be different, and freeways often resulted in the suburban neighbourhoods having better accessibility to the core than those living in the central core neighbourhoods.

Johnston (1971) suggests that this dismissal of the role of accessibility in residential location decisions might be "too sweeping". However, Johnston does note the earlier conclusion of Wolforth (1965) that the level of accessibility to the city centre is not a crucial factor in residential location decisions. Wolforth's findings suggested that with the exception of a limited number of workers, distance from work was not a crucial factor in the residential location decision. Distance from work was important in the residential location decision of females working in clerical positions in the CBD,
married women who worked, plant workers in peripheral workplaces where a sufficiently large quantity of low-cost housing was available (Wolforth 1965, 75). The availability of adequate affordable housing near the workplace was more frequently mentioned as a crucial factor in the residential location decision than was accessibility to the city centre.

In their discussions of the relationship between family cycle and residential choice, Abu-Lughod and Foley (1960) suggested that family households are the household type least concerned with accessibility to the city centre. This finding is not inconsistent with the findings which Stegman presents. It is at odds with the conclusions which Stegman draws, particularly, his outright dismissal of residential location theory. Stegman suggests that the suburban family is "more concerned with neighbourhood quality than with accessibility to other parts of the metropolitan region" (Stegman 1969, 22) and concludes from the findings from this sample that residential location theory should be dismissed. The earlier research of Abu-Lughod and Foley suggests that the suburban family household would have a minimal need for access to the city centre. Accessibility to locations other than the city centre would be expected to be more important for family household than for non-family households.

The salient point from Abu-Lughod and Foley which counters this argument is that different households, because of their varying housing demands, will place differing levels of importance on accessibility to the workplace. Only those
households for whom the journey-to-work is the most important daily trip would be expected to locate their residences to reconcile the trade-off between the cost of appropriate shelter and the cost of commuting to the workplace. All other households would locate their residences based on other criteria.

2.4 Synthesis

Previous studies of rail transit corridors have not provided clear insights into the relationship between accessibility to the city centre and the social characteristics of neighbourhoods along the routes. Many of the studies have measured changes in selected social dimensions after the completion of rapid transit projects; but few have applied theoretical understanding to the prediction of impacts. A major conclusion from these studies has been that land use regulations and other policy instruments are usually more critical in determining the extent of the land use change which results from the development of a rapid transit project than is the change in accessibility to the city centre. Because of the impact which land use regulations and other policy instruments will have on the development which follows the construction of a rapid transit project, it is crucial that these policies are conceived with an understanding of potential outcomes so any subsequent development can be socially beneficial.

The literature from urban land economics and from urban social ecology provides a strong theoretical basis for predicting the potential for unregulated response to the
development of the ALRT. The fundamental relationship between accessibility to the city centre and the cost of land described by the bid-price curve is anticipated to be altered by the construction of the rail transit system. Urban land economic theory describes a relationship in which highly accessible land is more expensive. Because of the higher cost, such land is more likely to be developed as multiple-dwelling units or apartments. The construction of a rapid transit system is expected to increase the accessibility to the city centre for neighbourhoods along its route leading to higher land costs along its route. Within a suitable zoning regime, the housing market would be expected to respond to the higher costs of land by the construction of more multiple dwellings.

The relevant literature from urban social ecology includes material from the classical models, and from the factorial models. The relevant classical models include the concentric zone model (Burgess 1925), and the sector model (Hoyt 1939). These classical models suggest two competing hypotheses about the spatial distribution of social characteristics in the city. The factorial model distinguishes the basic organizational dimensions of the society which allow social change to be measured. The social area analysis technique, developed by Shevky and Bell (1955), indicates three dimensions which can be used to identify social change, social rank, family status, and ethnicity. Earlier research (Berry and Rees 1969, and Schwirian and Matre 1969) indicates that the distribution of the two dimensions, social rank and family status, is consistent for
many cities. Social rank is distributed by sector; while family status is distributed by concentric zone.

Some urban social ecology research (Schwirian 1974, Sweetser 1969) has suggested that the factorial, concentric zone, and sector models can be used jointly to provide insights into urban social differentiation. Factor analysis is often used to distinguish social differences and to identify suitable social dimensions. The concentric zone and sectoral models are used to indicate differences in the spatial patterning of the social dimensions in relation to the city's centre and to each other. The urban land economic literature provides a further model which parallels the concentric-ring model and can be used to further the insights provided by the urban social ecology literature.
III. DATA AND ANALYSIS

The aim of this research is to determine how the construction of the ALRT system might affect the social characteristics of Vancouver residential areas along the transit corridor. Several theoretical relationships between accessibility and social characteristics have been suggested in the literature from urban land economics and urban social ecology. A major transportation initiative, such as the construction of the ALRT would be expected to alter existing relationships between accessibility and social characteristics, such as social rank, dwelling type and family status. Testing the significance of these relationships along the ALRT route was undertaken using readily available data from Statistics Canada. The extent and presentation of the Statistics Canada variables limited both the choice of the variables and the scale of the analysis which could be used in this analysis. The early sections of the chapter details the methods used in this research and points to its foundation in the theoretical literature. The final sections examine the actual indicators used in the testing of the theoretical relationships and the findings which this analysis provides.

3.1 Theoretical Foundation Of Research Method

Improved accessibility to the city centre for those living in or near the transit corridor will be an immediate outcome of the development of the ALRT. Chapter II reviewed established theory in urban land economics and factorial ecology which suggests that the anticipated improvement in accessibility to
the city centre could precipitate change in the social characteristics of neighbourhoods along the ALRT right-of-way. In this research, the relationship between accessibility to the city centre and a number of social characteristics is explored in order to estimate potential consequences of the development of the ALRT on neighbourhoods along the suburban section of the route through Vancouver.

The urban land economic literature indicates a significant relationship between accessibility to the city centre and the bid-price for residential land. The anticipated improvement in accessibility to the city centre in neighbourhoods along the ALRT route would be expected to affect the cost of land in locations experiencing improved accessibility. In addition, the literature on urban social ecology suggests two further relationships which can also be affected by the level of accessibility to the city centre. The Burgess concentric ring has been found by the factor ecology school to accurately represent the spatial pattern of family status in urban areas; it is anticipated that the change in accessibility will affect the distribution of family status. The sector model of Homer Hoyt has been noted by the factor ecology school to accurately represent the spatial distribution of social rank in urban areas; it is not expected that a change in the level of accessibility would dramatically affect this pattern. The original sector model of Homer Hoyt relies on the location of major transportation arteries for the orientation of the sectors. The construction of the ALRT will provide an
additional transportation arterial which could affect the orientation of social rank sectors in the city. However, this consequence of the theoretical relationship between accessibility and social rank was not tested in this research.

The urban land economic theory summarized in Alonso's bid-price curve and the theory from urban geography and factorial ecology describe relationships between the level of accessibility to the city centre and a number of social characteristics. These theoretical relationships predict that the improvement in accessibility to the city centre coming from the construction of the ALRT would affect social characteristics of neighbourhoods along the ALRT. The social characteristics expected to be affected by the improved accessibility to the city centre include the relative social rank, family status, and the spatial distribution of the various dwelling types. An increase in accessibility to the city centre would be expected to affect the distribution of these characteristics along the ALRT corridor.

3.2 Summary Of Research Method

The geographic focus of this study is the residential neighbourhoods along the ALRT route from Main Street to Boundary Road. The most appropriate data for this study was the Census Tract data from Statistics Canada; for this reason, the residential neighbourhoods have been operationally defined as the Census Tracts which the ALRT crosses along this section of the route through Vancouver. Level of education, dwelling type, and household structure variables, were selected from the 1976
and the 1981 Census which corresponded to the social dimensions, social rank, dwelling type, and family status, indicated in the literature review. Details of the research methods are discussed below, followed by presentation of the findings.

3.2.1 Study Area

The study area for this research includes all of the Census Tracts through which the ALRT will pass between Main Street and Boundary Road. This area was selected because it is expected to be the residential area most directly affected by the change in accessibility. The extent of the Study Area is shown on Figure 11.

A comparison of the Census Tracts for the 1976 and 1981 Censuses which were in the Study Area are included in Table 1. The same geographical area is included for both census dates.
Table 1 - Study Area - 1976 and 1981

<table>
<thead>
<tr>
<th>Census Tract Number</th>
<th>1976</th>
<th>1981</th>
</tr>
</thead>
<tbody>
<tr>
<td>Closest to CBD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>050.00 *</td>
<td>050.01</td>
<td></td>
</tr>
<tr>
<td>037.00</td>
<td>037.00</td>
<td></td>
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<td>032.00</td>
<td>032.00</td>
<td></td>
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<td>035.00</td>
<td>035.00</td>
<td></td>
</tr>
<tr>
<td>017.00</td>
<td>017.00</td>
<td></td>
</tr>
<tr>
<td>016.00 *</td>
<td>016.01</td>
<td>016.02</td>
</tr>
<tr>
<td>Farthest from CBD</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* divided into two Census Tracts for the 1981 Census

Data from the 1976 and 1981 Censuses, provide the substance for the testing of the model of change anticipated to follow from the construction of the ALRT. The Census Tract was selected as the most appropriate geographic unit for this analysis. Much of the data used in this study was available at this level. In some cases, however, the necessary data was available only at the enumeration area level. In those cases, some initial manipulation of the data was necessary prior to the analysis, so that all data was at the Census Tract Level.
Figure 10 - Map of the Study Area
3.2.2 Research Methods

The methods used to test the relationships between accessibility and social dimensions suggested by the theoretical literature are discussed below. The data base for this study was assembled from the 1976 and 1981 Census, User Summary Tape files, available from Statistics Canada. Detailed information for the City of Vancouver was available for 76 census tracts from the 1981 Census and for 72 census tracts from the 1976 Census. A number of Census Tracts defined for the 1976 Census were sub-divided into two Census Tracts for the 1981 Census. From the available data, information was selected on the highest level of education attained, the dwelling type, and the household type.

Variables were selected from the available data which represented the relationships indicated in the literature. The three dimensions of the problem, social rank, dwelling type, and family status, were indicated by the three variables, highest level of education attained, dwelling type, and household type. Two of these variables, social rank and dwelling type, were comprised of a set of ordered categories, as detailed below (see Figures 12 and 13). The third variable, family status, was composed of a set of nested dichotomous categories (see Figure 14).

Some manipulations of the data were required to allow for comparisons between the two Census dates; some variables had to be combined into categories which allowed the data for both dates to be compared. These were converted into percentages of
the Census Tracts population in each category, e.g. the Census Tract population over 15 years of age with high school graduation or less education was converted into a percentage by dividing by the total Census Tract population over 15 years of age. The calculated percentages of Census Tract population were subsequently transformed into z-scores.

A useful characteristic of the distribution of z-scores or standardized score is that its mean is 0 and its standard deviation is 1. The z-score is calculated for each value of the variable by first subtracting the mean from the raw score and then dividing the standard deviation.

\[
\text{z-score} = \frac{\text{Raw Score} - \text{Mean}}{\text{Standard Deviation}}
\]

A given z-score is directly interpretable as indicative of the number of standard deviations that a score is above or below the mean. Z-scores provide a common basis of measurement which is useful in making comparisons between distributions. The z-score transformation allowed the relative status of the individual scores in the distribution to be readily compared. In addition, this transformation allowed easy comparisons to be made between the relative positions of corresponding items, in this case, Census Tracts, in different distributions.

After the data was transformed to z-scores, the strength of the relationships between accessibility to the city centre and the three variables of social rank, dwelling type and family status was tested. This was accomplished by computing a ranked-
order correlation coefficient (Kendall's tau b) between the z-score for the categories of each variable and accessibility to the city centre. The Kendall's tau b indicated the strength of the relationship between accessibility and the three social dimensions.

3.3 Indicators Of The Social Characteristics

The review of the literature from urban land economics and urban social ecology has explored some of the relationships between accessibility and a number of social characteristics, social rank, family status, and dwelling type. Each of these social characteristics can be distinguished by different variables. It was important that the variables used for the analysis were available in a census tract format and could provide uncluttered measures of the social dimensions.
Figure 11 - Theoretical Origins Of The Social Indicators

Suitable variables were selected from the Census Tract data which allowed the relationship between accessibility and the social characteristics identified in the literature to be tested. The indicators of the social rank dimension was developed from the highest level of education attained. The family status indicator was derived from the number of family and non-family households in different areas of the city. Variations in the distribution of dwelling types provided the third indicator of social characteristics, and allowing further insights into the family status dimension and into variations in residential density.

3.3.1 Social Rank

Social rank is most commonly measured using one of the following variables: level of education completed, level of income, or type of occupation. For this study, the highest level of schooling attained was used as a measure of the level of social rank. The level of income was not collected for the 1976 Census and so it could not be used for this study. Additional problems with using level of income are implied because the available income data is average household income.
for the Census Tract and does not indicate the range of values; other problems include the difficulty of standardizing for family size and for family composition.

Problems arise when the attempt is made to order the social rank using the occupational groupings which are provided by Statistics Canada. Much of the difficulty arises from the broad range of social ranks which each of the occupational categories include. The occupational data available from Statistics Canada is comprised of a small number of occupational categories. In contrast with the large number of distinct categories used by Blishen, each of these categories contains a wide range of occupations representing a wide range of social rankings. Each of the Statistics Canada occupational categories could contain members from a numerous social rankings; in each geographic area, the composition of each occupational category could easily vary significantly. To avoid complications of this sort, the highest level of education attained was chosen to indicate social rank. The educational variables present a more straightforward structure for ordering the categories of data, based on the number of years of education and the distinction between academic and non-academic programs. The decision to use the highest level of education attained was taken for these pragmatic reasons and because of the considerable support for the validity of the level of education attained as a measure of social rank in the sociological literature. The highest level of education attained was seen to be the most direct measure for social rank available for the time period under consideration.
In addition, the highest level of education attained provides an accurate indicator of social rank which is not subject to the difficulties which other indicators provide.

The determination of the relative ranking of the social rank of the Census Tracts was made using the highest level of education attained by the over 15 year old population. The highest level of education attained variable was available for both the 1976 and the 1981 Census periods. There were however, differences between the educational categories of the two years. This inconsistency was overcome by combining the categories to obtain equivalent groups. The variability of the education variable between sub-areas became more apparent after the highest level of education attained variables were combined into the three comparable categories, high school, post-secondary (non-university), and post-secondary (university). Each category represents a broad range of educational background which is closely related to social rank. The high school category includes all persons over the 15 years old who have as their highest level of educational attainment: less than grade 9, some high school, or high school graduation. The post-secondary (non-university) category includes all persons over the 15 years old who have as their highest level of educational attainment: trade certificates, some non-university post-secondary training, non-university post-secondary training with a trade certificate, or non-university post-secondary training with a diploma or a certificate. The post-secondary (university) category includes all persons over the 15 years old
who have as their highest level of educational attainment: some university level training without a diploma or a certificate, some university level training with a diploma or a certificate, or a university graduate at the Bachelor's degree level or higher. The relationship between the educational categories can be seen in Figure 12.

Figure 12 - The Educational Indices

<table>
<thead>
<tr>
<th>TOTAL POPULATION OVER 15 YEARS</th>
</tr>
</thead>
<tbody>
<tr>
<td>High School Index</td>
</tr>
<tr>
<td>*Less than Grade 9</td>
</tr>
<tr>
<td>*Some High School w/ no Certificate</td>
</tr>
<tr>
<td>*Some High School w/ Certificate</td>
</tr>
<tr>
<td>*High School Graduate</td>
</tr>
<tr>
<td>Post Secondary (No University) Index</td>
</tr>
<tr>
<td>*Trade Certificate</td>
</tr>
<tr>
<td>*Non-University w/ no Certificate</td>
</tr>
<tr>
<td>*Non-University w/ no Certificate</td>
</tr>
<tr>
<td>Post Secondary (University) Index</td>
</tr>
<tr>
<td>*University w/ no Certificate</td>
</tr>
<tr>
<td>*University w/ Certificate</td>
</tr>
</tbody>
</table>

The percentage of the Census Tract population was calculated for each category of social rank, high school, post-secondary (non-university), and post-secondary (university). These values allowed comparisons to be made between Census Tracts along the ALRT route. Each of the percentages were converted to z-scores which enabled further comparisons to be made within each category. The strength of the relationships between accessibility and the categories of the social rank dimension was tested by computing the rank-ordered correlation coefficient (Kendall's tau b) for each
relationship.

3.3.2 Dwelling Type

The dwelling type variable is available directly from the Census data. The variables were reasonably comparable for both Census dates. However, the data collection method changed from the data being reported by the Census-taker in the 1976 Census, to the data being reported by the householder in the 1981 Census. This change resulted in some data problems being noted by Statistics Canada. These problems were particularly evident in the assignment of certain multiple dwelling types into the Statistics Canada categories. Statistics Canada includes a cautionary note in their documentation suggesting that these problems can be overcome by combining some of the multiple dwelling categories. The fine-grained data which is available from the 1981 Census was not needed for the purposes of this analysis, so the combining of the data in this fashion did not limit the analysis which followed.

For this analysis, three categories of dwelling type were designated, the single-detached house, the multiple-dwelling unit and the apartment. Each of the categories represented an increase in density of residences from single-detached to apartment. The single-detached house category referred to the single houses attached to no other dwelling or non-residential premises. The multiple-dwelling category included dwellings in side-by-side duplexes, over-under double houses, and row houses. Finally, the apartment category included dwellings in high-rise apartments, low-rise apartments, and suites in structures other
than duplexes, double houses, and row houses. The decision to separate the multiple-dwelling category from the apartment category was taken when a preliminary investigation indicated that the distribution of the multiple-dwelling category might differ from that of the apartment category.

### Figure 13 - The Dwelling Type Categories

<table>
<thead>
<tr>
<th>TOTAL DWELLINGS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Detached</td>
</tr>
<tr>
<td>Multiple-Dwelling</td>
</tr>
<tr>
<td>Apartment</td>
</tr>
<tr>
<td>*Single House</td>
</tr>
<tr>
<td>*Double House</td>
</tr>
<tr>
<td>*Duplex</td>
</tr>
<tr>
<td>*Row House</td>
</tr>
<tr>
<td>*House Attached To A Non-Residential Structure</td>
</tr>
<tr>
<td>*Apartment-less than 5 storeys</td>
</tr>
<tr>
<td>*Apartment-over 5 Storeys</td>
</tr>
<tr>
<td>*Suites in Buildings not included in the Multiple Dwelling Category</td>
</tr>
</tbody>
</table>

The Census Tract data included a count of the dwellings in each category of dwelling type. This data was combined to create three dwelling type categories, the single-detached house, the multiple-dwelling unit, and the apartment (See Figure 13). The single-detached house category referred to residential structures which are attached to no other dwellings or non-residential premises. The multiple-dwelling unit category included residential units in duplexes, double houses, row houses, and residential units attached to non-residential premises. The apartment category included dwellings in high-rise apartments, low-rise apartments, and suites in structures other than duplexes, double houses, and row houses.

After the data was combined into these three categories the
percentage of the total number of dwellings in each Census Tracts was calculated for each category; this allowed comparisons to be made between Census Tracts. Finally, these percentages were transformed into z-scores. The z-score transformations allowed further comparisons to be made within each category. The strength of the relationships between accessibility and the categories of the dwelling type dimension was tested by computing the rank-ordered correlation coefficient (Kendall's tau b) for each relationship.

3.3.3 Family Status

The family status data from Statistics Canada included the number of family and non-family households in each Census Tract. The family households data was further disaggregated into single-family households and multiple-family households. The non-family household data was broken down into single-person households and multiple-person non-related households. The household variables could be used without having to combine any of the categories used by Statistics Canada (See Figure 14).
The percentage of the Census Tract population was calculated for the following household types, family and non-family, single-family and multiple-family, and single-person and multiple-person non-related. These values allowed comparisons to be made between Census Tracts along the ALRT route. Each of the percentages were converted to z-scores which enabled further comparisons to be made within each category. The strength of the relationships between accessibility and the categories of the family status dimension was tested by computing the rank-ordered correlation coefficient (Kendall's tau b) for each relationship.

3.4 Specific Findings

The analysis of the relationship between accessibility to the city centre and the social characteristics identified in the literature was undertaken in two phases. In the initial phase of the analysis, the percentages of the Census Tract population which each variable in the data category were transformed into z-scores. This transformation enabled the relationships between
accessibility and the social characteristics to be determined and allowed comparisons to be made between the variables. In the second phase, the strength of the relationships between accessibility and the social characteristics of neighbourhoods along the route was examined. The strength of these relationships were determined by calculating the rank-order correlation coefficients (Kendall's tau b) between accessibility and the variables.

3.4.1 Social Rank

In the initial phase of this analysis, comparisons were made between the z-scores for the percentage of the over 15 year old population in each social rank variable, high school, post-secondary (non-university), and post-secondary (university). The z-scores for the social rank variables in the 1981 Census are summarized in the Table 2. For each Census period, these z-scores were compared with the z-scores of the other Census Tracts along the ALRT corridor.

In 1981, the data for most Census Tracts along the ALRT route indicated that a higher proportion of the over 15 year old population were in the high school category than the mean for the City of Vancouver. Within the study area, the z-scores for the high school variable ranged from .272 to 1.231 with most z-scores greater than 1.000. In contrast, the z-scores for the post-secondary (university) variable in 1981 ranged from -.390 to -1.096, with most z-scores less than -1.000. The z-scores for the post-secondary (non-university) variable in 1981 ranged from .314 to -.905.
The highest level of education attained data from the 1976 Census demonstrated a similar relationship with accessibility, although, with less extreme variation in z-scores. The z-scores for the social rank variables in the 1976 Census are summarized in Table 3. For the high school variable, the z-scores ranged from .486 to 1.138, with more scores falling between the low point, .486, and 1.000. On the other hand, the z-scores for the post-secondary (university) variable ranged from -.575 to -1.126, with most scores between the high point, -.575, and -1.000. The z-scores for the post-secondary (non-university) variable ranged from .069 to -.799, with most scores between -.553 and -.799.
Table 3 - Z-Scores: 1976 Social Rank Variables

<table>
<thead>
<tr>
<th>Census Tract</th>
<th>High School</th>
<th>Post-Secondary (non-university)</th>
<th>Post-Secondary (university)</th>
</tr>
</thead>
<tbody>
<tr>
<td>050.00</td>
<td>.486</td>
<td>.069</td>
<td>-.575</td>
</tr>
<tr>
<td>037.00</td>
<td>.660</td>
<td>-.355</td>
<td>-.649</td>
</tr>
<tr>
<td>032.00</td>
<td>.899</td>
<td>-.761</td>
<td>-.801</td>
</tr>
<tr>
<td>034.00</td>
<td>1.008</td>
<td>-.553</td>
<td>-.987</td>
</tr>
<tr>
<td>035.00</td>
<td>1.138</td>
<td>-.799</td>
<td>-1.062</td>
</tr>
<tr>
<td>017.00</td>
<td>1.167</td>
<td>-.696</td>
<td>-1.126</td>
</tr>
<tr>
<td>016.00</td>
<td>.971</td>
<td>-.417</td>
<td>-.985</td>
</tr>
</tbody>
</table>

In the second phase of the analysis, rank-order correlation coefficients (Kendall's tau b) were computed for the relationship between the three social rank variables, high school, post-secondary (non-university), and post-secondary (university), and accessibility to the city centre. The rank-order correlation coefficients were computed first for the inner suburban section of the ALRT route, from Main Street to 29th Avenue; and then, the rank-order correlation coefficients were computed for the entire suburban section of the route, from Main Street to Boundary Road. In the 1976 Census, stronger rank-order correlations were indicated for the inner suburban section of the route. The results of the rank-order correlations of the social rank variables for the 1976 Census are indicated in Table 4.

There was a perfect correlation between the high school variable and accessibility in the 1976 Census (Kendall's tau b = -1.00, significant at less than the 0.05 level); as accessibility decreased, the proportion of the Census Tract population with high school graduation or less decreased. There was a perfect correlation between the post-secondary (university) variable and
accessibility (Kendall's tau b=1.00, significant at less than the 0.05 level); as accessibility decreased, the proportion of the area population with some post-secondary, university level education or a completed university programme increased. The correlation between the post-secondary (non-university) variable and accessibility in the 1976 Census was weaker than it was for the other two variables (Kendall's tau b=-.80, significant at less than the 0.05 level).

The correlation between both, the high school variable and the university variable, and accessibility for the entire suburban section of the ALRT route was not as strong as it was for the inner section, (Kendall's tau b=.71, significant at less than the 0.05 level for the high school variable and Kendall's tau b=-.71, significant at less than the 0.05 level for the post-secondary (university) variable. When the entire suburban section of the ALRT route was viewed, the correlation between the post-secondary (non-university) variable was also not as strong as it was for the inner section of the route (Kendall's tau b=-.33, significant at less than the 0.05 level).
Table 4 - Rank-Order Correlation: 1976 Social Rank Variables

**Kendall Correlation Coefficients**

<table>
<thead>
<tr>
<th></th>
<th>Inner Suburban CT's (n=5)</th>
<th>Entire Suburban CT's (n=7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>High School</td>
<td>(\text{tau}_b = -1.00)</td>
<td>(\text{tau}_b = .71)</td>
</tr>
<tr>
<td></td>
<td>(&lt;0.05)</td>
<td>(&lt;0.05)</td>
</tr>
<tr>
<td>Post-Secondary</td>
<td>(\text{tau}_b = -0.80)</td>
<td>(\text{tau}_b = -0.33)</td>
</tr>
<tr>
<td>(non-university)</td>
<td>(&lt;0.05)</td>
<td>(&lt;0.05)</td>
</tr>
<tr>
<td>Post-Secondary</td>
<td>(\text{tau}_b = 1.00)</td>
<td>(\text{tau}_b = -0.71)</td>
</tr>
<tr>
<td>(university)</td>
<td>(&lt;0.05)</td>
<td>(0.147)</td>
</tr>
</tbody>
</table>

For the 1981 Census, the social rank variables were not as strongly correlated with accessibility as they were for the 1976 Census. For both the inner suburban section and the entire suburban section of the ALRT route, the social rank variables were not as strongly correlated with accessibility, as they were for the 1976 Census.

For the 1981 Census, the correlations between accessibility and the social rank variables were weak and not particularly significant for the inner section of the route (for the high school and the post-secondary (university) variables, Kendall's \(\text{tau}_b = .20\), significant at the 0.287 level; for the post-secondary (non-university) variables, Kendall's \(\text{tau}_b = -.20\), significant at the 0.287 level) For the entire section of the ALRT route in 1981, the relationship between accessibility and the social rank variables were marginally stronger, (for the high school variable, Kendall's \(\text{tau}_b = -.33\), significant at less than the 0.05 level; and for the post-secondary (university)
variable, Kendall's $\tau_b = -0.28$, significant at the .149 level).

Table 5 - Rank-Order Correlation: 1981 Social Rank Variables

**Kendall Correlation Coefficients**

<table>
<thead>
<tr>
<th>Inner Suburban CT's (n=7)</th>
<th>Entire Suburban CT's (n=9)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>tau</strong> b</td>
<td><strong>sig.</strong></td>
</tr>
<tr>
<td>High School</td>
<td>.20</td>
</tr>
<tr>
<td>Post-Secondary (non-university)</td>
<td>-.20</td>
</tr>
<tr>
<td>Post-Secondary (university)</td>
<td>.20</td>
</tr>
<tr>
<td></td>
<td>-.33</td>
</tr>
<tr>
<td></td>
<td>-.28</td>
</tr>
</tbody>
</table>

3.4.2 *Dwelling Type*

In the first phase of this analysis, comparisons were made of the percentage of the dwellings in each category of dwelling type for the Census Tracts along the Main Street to Boundary Road section of the ALRT route. For each Census period, these z-scores were compared. This comparison indicated two distinct relationships between accessibility and the proportion of dwellings of a particular type. A higher proportion of apartments were found in the Census Tracts closest to the city centre; while a higher proportion of single-detached houses were found in the Census Tracts which were further from the city centre. The z-scores for the dwelling type variables are summarized in Tables 6 and 7.
Table 6 - Z-Scores: 1976 Dwelling Type Variables

<table>
<thead>
<tr>
<th>Census Tract</th>
<th>Single-Detached</th>
<th>Multiple-Unit</th>
<th>Apartment</th>
</tr>
</thead>
<tbody>
<tr>
<td>050.00</td>
<td>-1.073</td>
<td>-1.063</td>
<td>1.057</td>
</tr>
<tr>
<td>037.00</td>
<td>-.452</td>
<td>2.085</td>
<td>-.077</td>
</tr>
<tr>
<td>032.00</td>
<td>.581</td>
<td>.742</td>
<td>-.750</td>
</tr>
<tr>
<td>034.00</td>
<td>.701</td>
<td>.417</td>
<td>-.756</td>
</tr>
<tr>
<td>035.00</td>
<td>.928</td>
<td>.049</td>
<td>-.881</td>
</tr>
<tr>
<td>017.00</td>
<td>.997</td>
<td>-.034</td>
<td>-.945</td>
</tr>
<tr>
<td>016.00</td>
<td>.730</td>
<td>.156</td>
<td>-.771</td>
</tr>
</tbody>
</table>

Table 7 - Z-Scores: 1981 Dwelling Type Variables

<table>
<thead>
<tr>
<th>Census Tract</th>
<th>Single-Detached</th>
<th>Multiple-Unit</th>
<th>Apartment</th>
</tr>
</thead>
<tbody>
<tr>
<td>050.01</td>
<td>-1.230</td>
<td>1.269</td>
<td>.854</td>
</tr>
<tr>
<td>050.02</td>
<td>-.956</td>
<td>1.257</td>
<td>.495</td>
</tr>
<tr>
<td>037.00</td>
<td>-.512</td>
<td>1.689</td>
<td>-.332</td>
</tr>
<tr>
<td>032.00</td>
<td>.463</td>
<td>.129</td>
<td>-.675</td>
</tr>
<tr>
<td>034.00</td>
<td>.733</td>
<td>-.409</td>
<td>-.697</td>
</tr>
<tr>
<td>035.00</td>
<td>.959</td>
<td>-.648</td>
<td>-.850</td>
</tr>
<tr>
<td>017.00</td>
<td>1.069</td>
<td>-.774</td>
<td>-.946</td>
</tr>
<tr>
<td>016.01</td>
<td>.687</td>
<td>-.689</td>
<td>-.689</td>
</tr>
<tr>
<td>016.02</td>
<td>.687</td>
<td>-.517</td>
<td>-.575</td>
</tr>
</tbody>
</table>

When successive Census Tracts along the ALRT route were examined, the relationship between accessibility and the proportion of a specific dwelling type became more evident. At each successive Census Tract along the ALRT route, as accessibility decreased, the proportion of apartments decreased. In contrast, the proportion of single-detached houses increased as the accessibility decreased. For the 1981 Census, the relationship between accessibility and the proportion of single-detached houses was not constant over the entire ALRT route; at a certain distance from the city centre, the proportion of single-detached houses began to decrease with decreasing accessibility. One explanation of this reversal could be that
at this point the influence of other second-order centres increased and affected the demand for residential space in this area. The pattern demonstrated by the multiple-unit variable was less consistent than the patterns of the other dwelling type variables. This was particularly evident in the 1976 Census.

In the second phase of the analysis, the strength of the relationships between accessibility and the dwelling type variables was tested by computing the rank-order correlations coefficients between the z-scores for the dwelling type variables and accessibility. The strength of these relationships were tested for both the inner suburban section and the entire suburban section of the ALRT route.

Table 8 - Rank-Order Correlation: 1981 Dwelling Type Variables

<table>
<thead>
<tr>
<th>Kendall Correlation Coefficients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inner Suburban CT's (n=7)</td>
</tr>
<tr>
<td>Single Detached</td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td>Multiple Unit</td>
</tr>
<tr>
<td>Apartment</td>
</tr>
</tbody>
</table>

The rank-order correlations computed between accessibility along for the Main Street to Boundary Road section of the ALRT route and the single-detached house variable indicated a strong relationship, (Kendall's tau b = .81, significant at less than the 0.05 level in 1976, and Kendall's tau b = .65, significant at less than the 0.05 level in 1981). When the rank-order
correlation was confined to the Main Street to 29th Avenue section of the route, the correlation was perfect, (Kendall's \( \tau_b = 1.00 \), significant at less than the 0.05 level in both 1976 and 1981). This confirmed the earlier suspicion that the influence of the city centre on the proportion of single-detached homes diminished beyond a certain distance from the city centre where the influence of other second-order centres became more important.

Table 9 - Rank-Order Correlation: 1976 Dwelling Type Variables

Kendall Correlation Coefficients

<table>
<thead>
<tr>
<th>Inner Suburban CT's (n=5)</th>
<th>Entire Suburban CT's (n=7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Detached</td>
<td></td>
</tr>
<tr>
<td>( \tau_b )</td>
<td>( \tau_b )</td>
</tr>
<tr>
<td>1.00</td>
<td>0.81</td>
</tr>
<tr>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Multiple Unit</td>
<td></td>
</tr>
<tr>
<td>-0.20</td>
<td>-0.24</td>
</tr>
<tr>
<td>0.312</td>
<td>0.226</td>
</tr>
<tr>
<td>Apartment</td>
<td></td>
</tr>
<tr>
<td>-1.00</td>
<td>-0.81</td>
</tr>
<tr>
<td>&lt;0.05</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

The rank-order correlations between accessibility along the Main Street to Boundary Road section of the ALRT route and the z-scores for the apartment variable indicated a strong negative relationship, (Kendall's \( \tau_b = -0.81 \), significant at less than the 0.05 level in 1976, and Kendall's \( \tau_b = -0.61 \), significant at less than the 0.05 level in 1981). Similar to the findings for the single-detached homes, when the rank-order correlation was computed for the Main Street to 29th Avenue section of the route, the correlation between accessibility and their dwelling type variable was stronger. In this case, the correlation was
perfect, (Kendall's tau b = 1.00, significant at less than the 0.05 level in both the 1976 and the 1981 Census).

The rank-order correlation between accessibility and the z-scores for the multiple-unit variable were almost identical for the inner section of the ALRT route in both Censuses. The major distinction was between the two Census dates, (for the inner section of the route, Kendall's tau b = -0.20, significant at the .312 level in 1976, compared with Kendall's tau b = -0.73, significant at less than 0.05 in 1981; for the entire section, Kendall's tau b = -0.24, significant at the .226 level in 1976, compared with Kendall's tau b = -0.72, significant at less than 0.05 in 1981).

3.4.3 Family Status

In the initial phase of this analysis, comparisons were made of the family status variables for the Census Tracts along the ALRT route. For each Census, the z-scores for each family status variable were compared. The focus of the distribution of family status variables on the downtown core was not as strong as anticipated. In addition, the distribution also differed between the two Census dates.

The data from the 1976 Census indicated a definite pattern in which the Census Tracts closer to the city centre contained a higher proportion of non-family households than the Census Tracts further from the city centre. Each successive Census Tract along the route from Main Street to 29th Avenue had a higher proportion of the family households than the preceding Census Tract (See Table 10). The data from the 1981 Census
demonstrated a similar pattern (See Table 11); although, the relationship between accessibility and the proportion of family households was not as clearly defined as it was in the 1976 Census.

Table 10 - Z-Scores: 1976 Family Status Variables

<table>
<thead>
<tr>
<th>Census Tract</th>
<th>Family/Non-Family</th>
<th>Family</th>
<th>Non-Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>050.00</td>
<td>-.768</td>
<td>-.148</td>
<td>.148</td>
</tr>
<tr>
<td>037.00</td>
<td>-.481</td>
<td>.251</td>
<td>-.251</td>
</tr>
<tr>
<td>032.00</td>
<td>.227</td>
<td>.627</td>
<td>-.627</td>
</tr>
<tr>
<td>034.00</td>
<td>.826</td>
<td>.780</td>
<td>-.780</td>
</tr>
<tr>
<td>035.00</td>
<td>.884</td>
<td>.792</td>
<td>-.792</td>
</tr>
<tr>
<td>017.00</td>
<td>.764</td>
<td>.768</td>
<td>-.768</td>
</tr>
<tr>
<td>016.00</td>
<td>.717</td>
<td>.759</td>
<td>-.759</td>
</tr>
</tbody>
</table>

Table 11 - Z-Scores: 1981 Family Status Variables

<table>
<thead>
<tr>
<th>Census Tract</th>
<th>Family/Non-Family</th>
<th>Family</th>
<th>Non-Family</th>
</tr>
</thead>
<tbody>
<tr>
<td>050.01</td>
<td>-.854</td>
<td>-.609</td>
<td>.609</td>
</tr>
<tr>
<td>050.02</td>
<td>.652</td>
<td>.795</td>
<td>-.795</td>
</tr>
<tr>
<td>037.00</td>
<td>-.848</td>
<td>-.598</td>
<td>.598</td>
</tr>
<tr>
<td>032.00</td>
<td>.697</td>
<td>.814</td>
<td>-.814</td>
</tr>
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<td>034.00</td>
<td>.885</td>
<td>.887</td>
<td>-.887</td>
</tr>
<tr>
<td>035.00</td>
<td>1.399</td>
<td>1.047</td>
<td>-1.047</td>
</tr>
<tr>
<td>017.00</td>
<td>.970</td>
<td>.918</td>
<td>-.918</td>
</tr>
<tr>
<td>016.01</td>
<td>.769</td>
<td>.844</td>
<td>-.844</td>
</tr>
<tr>
<td>016.02</td>
<td>1.081</td>
<td>.955</td>
<td>-.955</td>
</tr>
</tbody>
</table>

In the second phase of the analysis, a rank-order correlation was computed to determine the strength of the relationship between accessibility and the z-scores for the family status variables. The correlations between accessibility and the family status variables are summarized in Table 12 and 13. The first relationship which was assessed was that between accessibility and the ratio of family to non-family households. The family to non-family household ratio provided similar
insights to those which could have been determined from either the family or non-family variable. When the inner section of the ALRT route, the Main Street to 29th Avenue section, was considered, the results for the family/non-family ratio indicated a perfect correlation in the 1976 Census, and a strong correlation in the 1981 Census, (Kendall's tau b = 1.00, significant at less than the 0.05 level in 1976 compared with Kendall's tau b = .87, significant at less than the 0.05 level in 1981). When the entire suburban section of the ALRT route was considered, the relationship was not as strongly correlated as it was for the inner suburban section of the route. For the entire suburban section of the route, the rank-order correlation was stronger in the 1981 Census, (Kendall's tau b = .61, significant at less than the 0.05 level for the 1981 Census, compared with Kendall's tau b = .52, significant at less than the 0.05 level for the 1976 Census).
Table 12 - Rank-Order Correlation: 1981 Family Status Variables

Kendall Correlation Coefficients

<table>
<thead>
<tr>
<th>Variables</th>
<th>Inner Suburban CT's (n=7)</th>
<th>Entire Suburban CT's (n=9)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>tau b</td>
<td>sig.</td>
</tr>
<tr>
<td>Family</td>
<td>.87</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Non-Family</td>
<td>-.87</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Family/Non-Family</td>
<td>.87</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>One-Person</td>
<td>-.73</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Multi-Person/Non-Family</td>
<td>-.60</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Single-Family</td>
<td>.73</td>
<td>&lt;0.05</td>
</tr>
<tr>
<td>Multiple-Family</td>
<td>.60</td>
<td>&lt;0.05</td>
</tr>
</tbody>
</table>

In addition to the basic distinction between family and non-family households, a second level of family status variable can be distinguished. The proportion of single-family households and the proportion of multiple-family households is also associated with accessibility to the downtown core. As could be expected from the relationship between the ratio of family to non-family households and accessibility, the proportion of both single-family and multiple-family households was seen to increase with the level of accessibility to the city centre.

The correlation between the single-family household variable and accessibility was stronger in the 1976 Census for both, the inner suburban section and the entire suburban section of the ALRT route. The z-scores for single-family households,
generally increased as accessibility decreased. The correlation was stronger for the Main Street to 29th Avenue section of the ALRT route, (Kendall's tau b =1.00, significant at less than the 0.05 level in 1976 and Kendall's tau b=.73, significant at less than the 0.05 level in 1981). Although, a strong correlation was noted for the Main Street to Boundary Road section in the 1976 Census, (Kendall's tau b =.90, significant at less than the 0.05 level in 1976), the correlation was somewhat weaker for the 1981 Census, (Kendall's tau b=.50, significant at less than the 0.05 level in 1981).

Table 13 - Rank-Order Correlation: 1976 Family Status Variables

Kendall Correlation Coeffecients

<table>
<thead>
<tr>
<th>Inner Suburban CT's (n=5)</th>
<th>Entire Suburban CT's (n=7)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Family</td>
<td>Tau b</td>
</tr>
<tr>
<td></td>
<td>1.00</td>
</tr>
<tr>
<td>Non-Family</td>
<td>-1.00</td>
</tr>
<tr>
<td>Family/Non-Family</td>
<td>1.00</td>
</tr>
<tr>
<td>One-Person</td>
<td>-1.00</td>
</tr>
<tr>
<td>Multi-Person Non-Family</td>
<td>-.60</td>
</tr>
<tr>
<td>Single-Family</td>
<td>1.00</td>
</tr>
<tr>
<td>Multiple-Person</td>
<td>1.00</td>
</tr>
</tbody>
</table>

The relationship between accessibility and the multiple-family household variable was similar to the pattern found for the family household variable. When the inner suburban section
of the ALRT was considered, stronger correlations were observed, particularly for the 1976 Census, (Kendall's $\tau_b = 1.00$, significant at less than the 0.05 level in 1976 and Kendall's $\tau_b = 0.60$, significant at less than the 0.05 level in 1981). When the entire suburban section of the ALRT route was examined, the rank-order correlations were not as strong, (Kendall's $\tau_b = 0.62$, significant at less than 0.05 level in 1976, and Kendall's $\tau_b = 0.56$, significant at less than 0.05 level in 1981).

The relationship between the non-family households and accessibility discussed above included at a second level, the two further relationships between accessibility and the single-person household variable and the multiple-person non-family household variable. As noted above, these household types were more predominant in the residential neighbourhoods close to the city centre. As accessibility decreased, the proportion of single-person households and multiple-person households was found to decrease.

The correlation between accessibility and the z-scores for the single-person household variable was stronger along the inner suburban section of the ALRT route, particularly in the 1976 Census, (Kendall's $\tau_b = -1.00$, significant at less than the 0.05 level in 1976 compared with Kendall's $\tau_b = -0.73$, significant at less than the 0.05 level in 1981). When the Main Street to Boundary Road section of the route was examined, the correlation was not as strong, (Kendall's $\tau_b = -0.33$, significant at less than the 0.05 level in 1976, and Kendall's $\tau_b = -0.56$, significant at less than the 0.05 level in 1981).
When the Main Street to 29th Avenue section was considered, the correlation between accessibility and the z-scores for the multiple-person non-family household variable was not as strong as that for the single-person household variable, (Kendall's tau b = -.60, significant at the 0.07 level in 1976 and Kendall's tau b = -.60, significant at less than the 0.05 level in 1981). For the ALRT route from Main Street to Boundary Road, the correlation was stronger for the 1976 Census, (Kendall's tau b = -.81, significant at less than the 0.05 level in 1976 and Kendall's tau b = -.28, significant at the 0.15 level in 1981).

3.5 Summary

The literature from urban land economics and urban social ecology suggests several theoretical relationships between accessibility and social characteristics which might be altered by the development of the ALRT system. Theoretical relationships with accessibility were noted for three social characteristics, social rank, family status, and dwelling type. These relationships with accessibility were tested using indicators for each social characteristic, social rank (highest level of education attained), family status (household type), and dwelling type (three categories of dwelling type). Rank-order correlations were calculated between the indicators for the social dimensions and relative accessibility to the city centre. Strong correlations were indicated between accessibility and two social characteristics, family status and dwelling type; while social rank, on the other hand, was less strongly correlated with relative accessibility. The
implications of these finding for future development in the Vancouver section of the ALRT corridor are discussed in the following chapter.
IV. DISCUSSION OF FINDINGS

4.1 Summary Of The Findings

Potential impacts of the construction of Vancouver's ALRT were tested by comparing theoretically predicted relationships between accessibility to the city centre and three variables of social differences. It was hypothesized that if the three variables (social rank, dwelling type and family status) were related to accessibility to the city centre that the construction of the ALRT would affect the distribution of the three variables.

The bodies of literature used in this study suggested two alternative distributions for social rank. The urban land economic literature suggested that the distribution of social rank would be affected by the variations in the bid-price for land; under the urban land economic perspective, the bid-price for land would vary with accessibility to the city centre. On the other hand, the urban social ecology literature suggested that social rank was distributed sectorally and thus would not be related to accessibility to the city centre. The spatial distribution of dwelling type was indicated, by both the urban land economic and the urban social ecology literature, as being affected by the level of accessibility to the city centre. Finally, both the urban land economics and urban social ecology literatures indicated that the distribution of family status is related to the level of accessibility to the city centre. The strength of the relationship suggested by each of the hypotheses was tested statistically, and the significance and strength of
these associations are reported in the next three sections.

4.2 Social Rank

The urban land economic and the urban social ecology literature suggests several possible relationships between accessibility to the city centre and social rank. The urban land economic literature indicates that land cost is tied to accessibility to the city centre; for this reason under this theory, the neighbourhoods near the city centre would be expected to be occupied by persons of higher social rank. A second competing hypothesis under urban land economic theory is that the persons of higher social rank would be expected to reside away from the city centre because of their better ability to pay the higher costs of commuting to suburban locations. In either case, the spatial distribution of social rank would be expected to be affected by accessibility to the city centre.

The literature of urban social ecology suggests that the distribution of social rank is not strongly related to the level of accessibility to the city centre. The hypothesis which comes from this perspective is that the spatial pattern of social rank is independent of accessibility to the city centre.

For this study, the highest level of education attained by residents of the Census Tracts was used to indicate the level of social rank of the population. The analysis of the Census Tracts along the suburban section of the ALRT route indicated little variation in social rank. This finding is consistent with the findings of Patterson (1974) which indicate that the Vancouver neighbourhoods along the ALRT route are populated by
persons of the lower quartile of socioeconomic status. In fact, only a weak correlation was found between the distance from the downtown core and the indicator of social rank along the ALRT corridor. Within the ALRT corridor, distance from the downtown does not substantially affect the indicator of social rank.

Contrary to the hypothesis from urban land economics, in this part of Vancouver social rank is not related to accessibility to the city centre. This leads to the speculation that another factor, such as the pattern of historical development of the city, is more strongly related to the distribution of social rank in Vancouver than was accessibility to the core. The distribution of social rank observed in this corridor in 1981 is consistent with a variety of past results, (Van Ardosol, Camilleri and Schmid 1958, Anderson and Bean 1961, Schwirian and Matre 1974, Latif 1971, Berry and Rees 1969, Berry and Spodek 1971, Sweetser 1965). Because of the consistency of this finding, both over time and in a variety of locations, it was expected that the change in accessibility to the city centre resulting from the development of the ALRT system would affect the future distribution of social rank in Vancouver.

The sectoral pattern demonstrated by social rank in earlier studies of Vancouver (Wolforth, 1969 and Patterson, 1974), has also been noted in many other jurisdictions (Van Ardosol, Camilleri and Schmid 1958, Anderson and Bean 1961, Schwirian and Matre 1974, Latif 1971, Berry and Rees 1969, Berry and Spodek 1971, Sweetser 1965). One of the earliest references is the discussion of socioeconomic status in the Chicago area by Homer
Hoyt (1939). Factors, such as the aesthetic features of the location and neighbourhood characteristics, were noted by Hoyt as being more frequently related to the social rank of an area than is the proximity or the accessibility to the downtown core.

4.3 Dwelling Type

The urban land economic literature (Alonso, 1961; Wingo, 1964) suggests that the areas furthest from the city centre would be the least densely developed and that those areas closest to the city centre would be the most densely developed. The development pattern in the study area was expected to follow the classical pattern of the Alonso's bid-rent curve. An extension of the urban social ecology findings on the spatial distribution of dwelling type as a measure of family status leads to the expectation that more single family dwellings would be located in the suburban areas, while more apartments and other multiple-dwelling would be located nearer the city centre. To test these expectations, the relationship between distance from the downtown core and the dominant dwelling form in the Census Tracts along the ALRT route was analysed. In this analysis, the dwelling types found in Vancouver were categorized into three groups: single-detached houses, multiple-dwelling units, and apartments.

The analysis indicated that there was a significant relationship between the relative distance from the downtown core and the spatial distribution of the concentrations of two dwelling types, single-detached houses and apartments. The proportion of single-detached houses increased as the distance
from the city centre increased; in contrast, the proportion of apartments decreased as distance from the city centre increased. While the proportion of both apartments and single-detached houses were found to be strongly correlated with the distance from the downtown core, the proportion of other multiple-dwellings, such as duplexes and suites in houses, was found to be weakly correlated with distance from the city centre. The relationship between the proportion of households in the apartment and single-detached house categories and distance from the downtown core was consistent with the relationship predicted by the classic model of the bid-rent curve.

Several conclusions can be drawn from these findings. The more intensive development of inner city land as apartments suggests that land costs are related to distance from the downtown core. In combination with the controlling influence of the zoning pattern, accessibility to the city centre has helped to shape the physical development of the city. More apartments than single-detached houses have been constructed near the city centre where the land cost would be higher. On the other hand, more single-detached homes have been constructed in less accessible areas where the land costs have been traditionally been lower away from the city centre. This pattern of development reflects the most rational market response to the opportunities which the property market has presented. The high cost of the inner city land has come in part as a property market response to the easy access to the downtown core which is characteristic of the central area. The influence of distance
from the central downtown on the residential development pattern was observed to diminish beyond a certain range from the core. In the absence of contrary zoning restrictions, it is expected that the increase in accessibility resulting from the construction of the ALRT would affect the future form and pattern of residential development.

Formerly, the outlying areas, the less accessible parts of the city away from the centre have been characterized by lower land costs which, in turn, have made lower density developments economically feasible. A higher proportion of single-detached houses are found in neighbourhoods at a distance from the core. Under the rubric of Alonso's trade-off theory, the residents of this area accept decreased accessibility to the central city in exchange for a lower land cost. Following the construction of the ALRT system, the existing relationship between land costs and accessibility will be altered. Areas made more accessible to the city centre will susceptible to more intensive residential development if the zoning bylaws were to permit such development.

4.4 Family Status

The findings of factorial ecology studies (Abu-Lughod 1961; Johnston 1974) suggest that neighbourhoods nearest the core would have a higher proportion of single-person households than the neighbourhoods further from the core. These findings further suggest that a higher proportion of single-family households would be located in the neighbourhoods further from the core than would be found in the neighbourhoods of the inner-
city. In other words, it was anticipated that the proportion of non-family households would be larger in the inner-city neighbourhoods and that the proportion of family households would be larger in the neighbourhoods further from the city centre. The distribution of dwelling types suggested by the urban land economic literature has implications for the distribution of household types. The single family dwelling which urban land economic literature suggests would be developed in the suburbs is a more suitable residence for family households and, therefore, a high proportion of families would be expected to settle in these neighbourhoods. Similarly, the higher concentration of apartments in the inner-city would be expected to attract a higher proportion of non-family households. Within the family status variable, a number of dichotomous relationships have been identified. They include: family/non-family households, single-family/multiple-family households, single-person/multiple-person non-family households. The multi-faceted nature of the family status variable has meant that a series of relationships were anticipated between the various sub-components of the variable and the distance from the downtown core.

An analysis of the relationship between accessibility to the city centre and the components of the household variable was completed. The results indicate that, in fact, a higher proportion of single-person households were located in neighbourhoods near the downtown core than in neighbourhoods away from the downtown. The proportion of single-family
households, as expected, was higher in neighbourhoods further from the city centre. Finally, a higher proportion of the non-family households were located in centre city neighbourhoods, although this relationship was weaker than the relationships discussed above.

Initially, accessibility to the downtown core would appear to be the main factor affecting these relationships. A detailed understanding of the distribution of dwelling types in these Census Tracts helps to provide a fuller and more plausible explanation. More single-families are to found in those areas which are dominated by single-detached houses; single-detached houses are more appropriate accommodation for single-family households. Conversely, more single-person households are found in those areas which are dominated by apartments; this type of accommodation better meets the needs of the single-person household. A more thoughtful conclusion would be that the proportion of a particular dwelling type is related to the distance from the downtown core for the reasons indicated above; and the distribution of the dwelling types, in turn, affects the distribution of the various household types throughout the region.
V. CONCLUSIONS

Changes in development, at the scale of the transit corridor, caused by the development of the ALRT are the main interest of this thesis. Zoning may limit, indeed prevent, development. Zoning is, however, a necessary but not sufficient condition for development to occur. Prediction of what would be changed if the zoning bylaw were to allow it is one among many factors which should be considered by those making decisions about changes in the zoning bylaws. That sort of prediction is the rationale behind the selection of the questions used in this thesis.

This thesis set out to examine how improved accessibility to the city centre arising from the development of the ALRT system will affect the social characteristics of neighbourhoods along the route. Before this question could be answered, it was necessary to understand the theoretical relationships between neighbourhood characteristics and accessibility to the city centre. An examination of the literatures of urban land economics and urban social ecology provided a number of specific neighbourhood characteristics which were believed to be related to accessibility. The literature further suggests that changes in the social character of neighbourhoods could be measured along three social dimensions, social rank, family status, and dwelling type. Once these specific dimensions of social change were identified, the significance and strength of their relationship with the level of accessibility to the city centre could be tested.
Logically, the relationships between the social characteristics and accessibility could range from very strong to very weak or non-existent. If there were a strong relationship between accessibility and a specific social characteristic, then the development of the ALRT system would be expected to affect the future distribution of that social characteristic. If on the other hand, the relationship between accessibility and a particular social characteristic were found to be weak or non-existent, then the development of the ALRT system would not be expected to affect the distribution of that social characteristic. Statistical testing of the relationship between accessibility to the city centre and indicators of the social dimensions was undertaken. The results of these tests indicated that two indicators of the social dimensions, dwelling type and family status, were strongly correlated with the level of accessibility to the city centre and would be expected to be affected by the improvement in accessibility resulting from the development of the ALRT system. The third dimension, social rank, was found to be weakly correlated with the level of accessibility to the city centre and would not be expected to be affected by the improvement in accessibility.

The literature demonstrates that the relationship between the indicators of the social dimensions and the level of accessibility to the city centre has been consistent both over time and in different locations. For this reason, it is not anticipated that these relationships will change dramatically. It is expected that any improvement in the level of
accessibility to the city centre will affect the spatial distribution of those social dimensions which are strongly related to the level of accessibility to the centre. Specifically, the development of the ALRT system would be expected to improve accessibility to the city centre for those neighbourhoods along the ALRT route. The improvement in the level of accessibility to the city centre would lead to increases in the bid-price for land along the ALRT route. The urban land economics literature suggests that the higher bid-price for land in more accessible areas of the city would be capitalized into land value resulting in more intensive development of the land if the zoning bylaw permitted such intensification. If the zoning bylaw does permit the intensification, the expectation is that more apartments and multiple-unit dwellings would result.

Changes in the distribution of dwelling types have implications for the distribution of the family status variable. More intensive development, such as apartments, would likely be accompanied by an increase in the number of single-person and non-family households in these areas. Households of this type would find these multiple-unit dwellings more suited to their life-style and needs than would family households. A higher proportion of single-person and non-family households would be expected to settle in areas which contain large numbers of multiple-unit dwellings.

The redevelopment of the land along the ALRT route is by no means guaranteed; rather, such development is simply encouraged
by natural market dynamics due to the improved accessibility to the city centre. Zoning regulations and other development policy instruments play a significant role in controlling the form and extent of new development which would take place. Such controls can intercede to constrain or prohibit development which might otherwise be appropriate according to the logic of land market dynamics. The key role of the planner in this process is to provide advice to the decision-makers. Such advice could indicate potential consequences of a wide range of alternative decisions. Provision of this advice early in the decision-making process could lessen the possibility of undesirable outcomes. Careful consideration needs to be given to the related social and economic factors which will influence the eventual success or failure of any redevelopment efforts.

The extent of the actual change induced by the development of the ALRT cannot be definitively determined; however, an indication of the direction in which the change will likely take place has been established. The findings of this thesis point to a number of speculations about the future of the neighbourhoods along the ALRT corridor. Findings of the strength and significance of the relationships between accessibility and the social dimensions, social rank, dwelling type and family status, suggest potential changes for these neighbourhoods which could result from the construction of the ALRT system. Some of these changes are discussed in the following section of this chapter.

The finding that accessibility is not strongly related to
social rank along the Vancouver section of the ALRT corridor suggests that little change would be expected in the social rank of this area as a result of the development of the ALRT. The residential location decisions of individuals moving to neighbourhoods along the ALRT route are not anticipated to be significantly influenced by differences in the social rank of the neighbourhoods along the route. Once the decision to live in this section of Vancouver has been taken, subsequent decisions between specific locations within the area are unlikely to be further influenced by the relative social rank of these locations. Instead, other factors such as the location of suitable dwellings would be expected to be more influential in these residential location decisions. Social rank differences between neighbourhoods would be expected to have a minimal influence on the location decision of individuals selecting residences in neighbourhoods along the ALRT route.

While the social rank dimension is not related to the level of accessibility along the ALRT route, the dwelling type dimension is affected by accessibility. The urban land economics literature suggests that an increase in the bid-price for land would encourage more intensive residential development on such land if the zoning bylaw were to permit such intensification. It is expected that the development of the ALRT will improve accessibility to the city centre for the residents of neighbourhoods along the route. This improvement in accessibility is expected to result in a concommitant increase in the bid-price for land in these areas. Such change
would be expected to make intensive residential development more likely and thereby increase the development pressures on land along the route. While the precise timing of the increases in development pressure is uncertain, it is expected to result in pressure to change the zoning bylaw to permit the development of more apartment and multiple-dwelling units along the route.

The impact of improved accessibility on the distribution of different dwelling types will also have an impact on the distribution of the different household types included in the family status dimension. One explanation of the distribution of household types focuses on the residential location decisions made by the individual households. Under this paradigm, each household makes its location decision by making the trade-offs, suggested by Alonso, between the lower land costs (and thus lower overall housing costs) in neighbourhoods further from the city centre, and the higher costs of commuting to the downtown core from these less accessible areas. Households of lower social rank have fewer housing choices because the price range of the more spacious accommodation in the suburbs is beyond their financial reach. Households of lower social rank must make their optimal residential location decision constrained by the location of affordable accommodation. Because of these constraints, they are unable to make a more comprehensive decision based solely on the trade-off between the cost of transportation to the downtown core and the cost of suitable accommodation. Their decisions are restricted instead to accommodation which is within their limited accommodation and
transportation budgets.

The households in neighbourhoods along the ALRT route are not expected to relocate elsewhere following the construction of the ALRT. Their residential location decisions will continue to be limited to the physical location of affordable, suitably large accommodation. Some households which are wholly dependant on public transit for their journey-to-work could be expected to relocate in housing stimulated by the construction of the ALRT. A major consideration for these households would be the affordability of the accommodation.

The actual impact which the construction of the ALRT will have on households in the neighbourhoods along the ALRT route will depend on the degree to which individual households rely on the public transit system. For those households which do not rely on the public transit system, the construction of the ALRT would be unlikely to influence their residential location decisions. But, for those residents who regularly use public transit to travel to work in the city centre, the construction of the ALRT system -- accompanied by the development of appropriate, affordable housing along the suburban ALRT route -- could result in increased demand for suitable accommodation in these neighbourhoods by the public transit dependent households.
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