# THE USE OF EXISTING RAIL RIGHTS-OF-WAY IN THE DEVELOPMENT OF BRITISH AND NORTH AMERICAN LIGHT RAIL TRANSIT SYSTEMS: EXCELLENT OPPORTUNITY OR POTENTIAL PROBLEM?

BY

STEVEN HOBSON

A Thesis
Submitted to the Faculty of Graduate Studies
in Partial Fulfillment of the Requirements
for the Degree of

MASTER OF ARTS

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## ABSTRACT

In North America and the United Kingdom, a renewed interest in the potential ability of rail transport to solve urban transport problems has partially manifested itself in support for Light Rail Transit (LRT). For many of the LRT lines that have been constructed/will be constructed, existing rail rights-of-way have been/will be a vital ingredient in the planning and construction process. This can be attributed to the simplified task of construction and lower construction costs afforded by their use. Experience gained with the Miami "Metrorail" rapid transit system, however, suggests that existing rail alignments do not necessarily serve the best interests of the travelling public. The thesis examines the Calgary LRT and the planned "Vancouver-Richmond Rapid Transit Project" and argues that in each case, greater emphasis upon a streetcar style of operation might be a better recipe for LRT success than simply using existing rail alignments for engineering and financial simplicity.

## ACKNOWLEDGEMENTS

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# CHAPTER ONE:

# INTRODUCTION

# Introduction

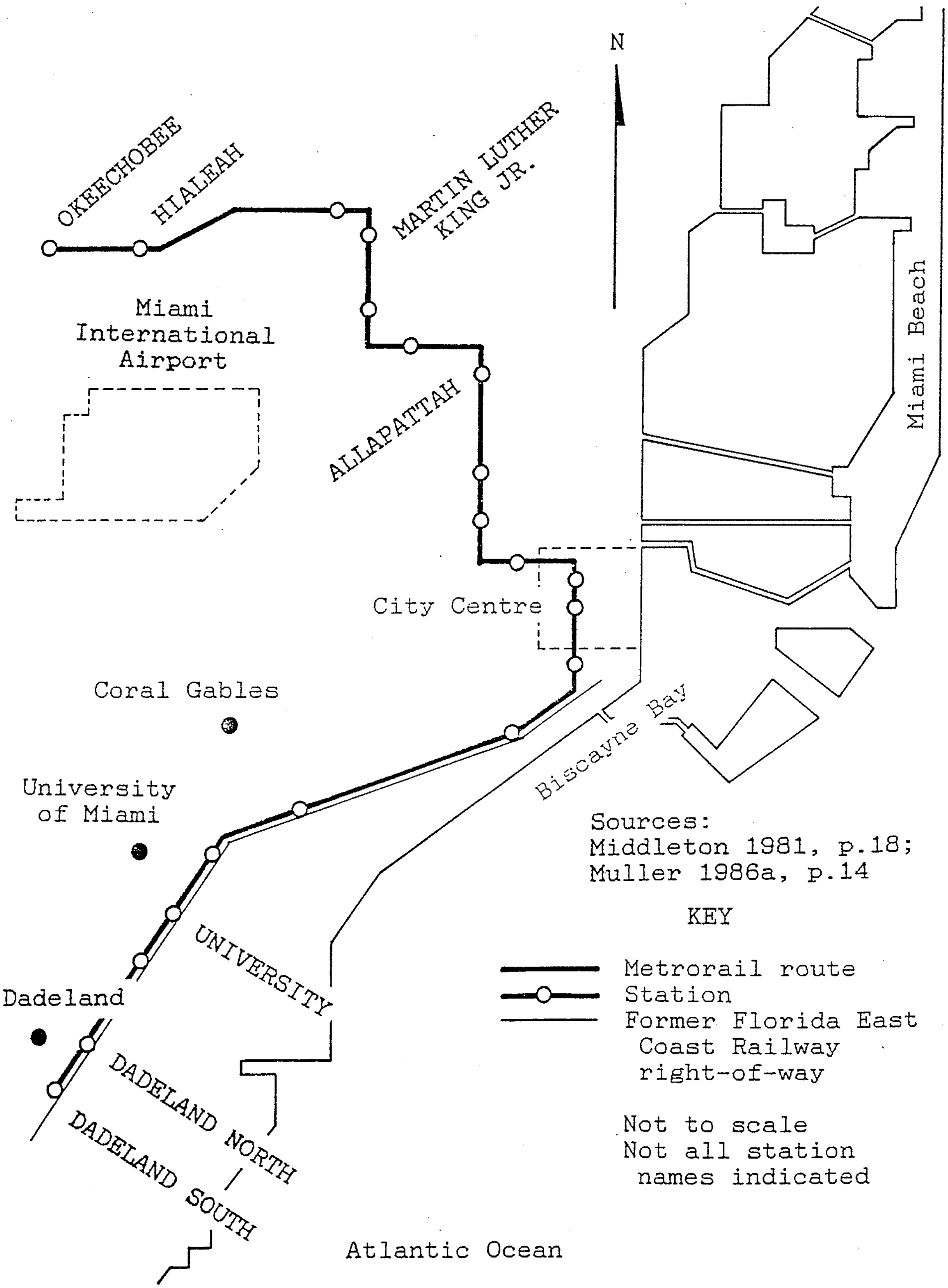
Since the late 1970s, but particularly from the mid 1980s, there has been a renewed interest in rail based urban public transport in North America and the United Kingdom. It has evolved from a growing belief that "the auto alone cannot satisfy [the] transportation needs of cities for physical, social, economic, and environmental reasons" (Vuchic, 1981, p.460). Indeed, a publication by the United States Department of Transportation states that "an integrated, efficient, well-managed public transit system is the sine qua non of the more energy-efficient, less auto- and oil-dependent city of the future" (Peirce 1980, p.9). A dissatisfaction with the existing urban transportation mix of car usage on a large scale and an inadequate public transport system (often bus only) has prompted many British and North American cities to reconsider the value of rail transportation. There is now increasing recognition that some form of electrified rail system can alleviate road traffic congestion and remove some noise and air pollution from city streets.

The fact remains, however, that it is very difficult to persuade motorists to leave their vehicles at home and use public transport instead. In 1967, for example, two nationwide surveys were conducted in the United States that asked the question: "The auto pollutes air, creates traffic, demolishes property, and kills people. Is the contribution the auto makes to our way of life worth this?" In 80% of the responses the answer was "yes" (Demaree 1970, p.126). This is not really surprising. At the heart of the debate lies the notion of "freedom" and the tenacity with which we hold on to it. A car permits the individual to move beyond the confines of the fixed routes and fixed schedules of public transport. The problem of promoting the increased use of public transport as a solution to the transportation problems that currently plague our cities is the problem of persuading individuals to forfeit some of their freedom for the sake of the common good. The problem might, however, be ameliorated through improvements to both the quality and quantity of public transport available. It is possible that an attractive and relatively inexpensive transportation alternative to the private car could compensate for the loss of freedom that we experience by leaving our car at home, or by not driving altogether. Therefore, if there is to be a substantial modal shift from the car to public transport systems, then those systems must prove themselves in the eyes of the public. Part of any success must rest with the selection of those public transport routes which best serve the needs of the travelling public. A poorly selected route will probably result in low ridership, will ultimately be reflected in the route´s degree of success or failure, and can mar the chances of other lines and systems that are in the planning stages of gaining funding/voter approval. In short, a poorly selected route can impact negatively upon public transport.

An example of a public transport system which has not been successful is the "Metrorail" rapid transit system in Miami. Opened in 1984 to help alleviate problems of traffic congestion, the system has been "a resounding failure", with dismally low ridership figures. The southern portion of the system in particular, running out to Dadeland, had the potential to draw passengers from a number of large activity centres, including the University of Miami and the "leading" suburb of Coral Gables, but the route selected was inappropriate (Figure 1). Because of the decision to use a "cheaply available, abandoned railroad corridor", the stations intended to serve Dadeland and the University were poorly sited and Coral Gables was bypassed altogether (Muller 1986a, p.14).

From the standpoint of the transportation planner, it is easy to see why an existing rail right-of-way (whether disused or active with freight/passenger traffic) would be given serious consideration for a new public transport project like Metrorail. It offers a readily available corridor through a built-up urban area, which translates

Figure 1. Miami "Metrorail" - System Map



into a relatively simple, and thus relatively inexpensive construction project. The alternatives are to build underground or create a new transportation corridor on the surface, either elevated or at grade. Both options are expensive when compared to the cost of using an existing rail right-of-way and, particularly in the case of the latter, prone to oppostion from area residents. Although costs will vary according to local conditions, Table 1 gives an indication of the relative costs per route-kilometre for several types of "light rail" alignment. The costs are derived from experience in the United Kingdom, but they are likely to be equally valid elsewhere. The attraction held by existing rail corridors is clearly evident.

Table 1. Light rail construction costs per route-kilometre

| ALIGNMENT | COST* |
|---|---|
| Conversion of existing right-of-way | 1.0-3.0 |
| New light rail at grade | 2.0 |
| New light rail on structure | 5.0 |
| Cut-and-cover tunnel in city centre | 15.0 |
| Bored tunnel | 15.0 |

* Pounds Sterling (millions), 1986 prices

Source: Railway Development Society 1990, p.23.

The issue of route selection is an important one because Miami´s Metrorail, in terms of using an existing rail right-of-way, is far from being an isolated case. Many of the systems which have arisen, and are arising from the resurgence of interest in urban rail, appear to be following Metrorail´s example, incorporating active and abandoned rail alignments. This is particularly true of "Light Rail Transit" (LRT) projects. Because of the sheer cost associated with "heavy rail" systems such as the San Francisco Bay Area Rapid Transit (BART) and the Washington (DC) METRO, several cities have turned to Light Rail Transit, which is seen as a "cheaper and more flexible means of obtaining [some of] the benefits of rapid transit" (Hellewell 1979, p.49). Nowhere is this being pursued with greater enthusiasm at the moment than in the United Kingdom. Although there is not currently (March, 1992) an LRT system ready to accept fare paying passengers, the first phase of Manchester´s "Metrolink" is almost complete, and systems for Sheffield ("Supertram") and the West Midlands ("Midland Metro") are in the advanced planning stage. A list of additional urban areas for which LRT has been strongly recommended includes: Avon (Bristol), Croydon, Edinburgh, Strathclyde (Glasgow) and West Yorkshire (Leeds). In fact, "interest has now reached such a pitch that there is hardly a self-respecting urban area in the British Isles which does not have a glimmer of an idea for its own light rail system" (Glover 1989, p.69).

North America, too, is sharing in the enthusiasm for LRT. Lines have already been constructed in Buffalo, Calgary, Edmonton, Los Angeles, Portland, Sacramento, San Diego and San Jose, with old streetcar systems having been upgraded to LRT in Boston, Cleveland and Pittsburgh. Many of these lines and systems are also scheduled for expansion. Proposals for new LRT networks exist for several other areas in North America, including: Baltimore, Denver, Minneapolis-St.Paul and California's Orange County. A planned LRT system for Dallas is about to enter its initial construction phase. In Winnipeg, several proposals for an LRT system have been floated over the years and it is an issue which periodically surfaces in the context of the city's transportation plans.

As indicated above, a large proportion of the LRT systems proposed for North America and the United Kingdom, along with a substantial amount of the North American systems which have already been constructed (including their expansion plans), intend to use/have used, existing rail rights-of-way. There is a danger that any repeat of the Miami Metrorail episode will cast a shadow upon LRT and slacken the momentum of what appears to be a worthwhile solution to some of the transportation problems of our cities. As Glover has observed, "the new-found belief in the efficacy of light rail to solve urban transport problems...is fragile, and the industry professionals can ill afford an engineering, operational or financial fiasco" (1989, p.69). Therefore, the aim of this thesis is to examine the degree to which the availability of existing rail rights-of-way has been a factor/will be a factor in the planning and construction of North American and British Light Rail Transit lines/systems, and the degree to which reliance upon those existing rail rights-of-way has affected/is likely to affect the subsequent success/failure of those lines/systems.

At this point it is necessary to review the existing literature of Light Rail Transit, in order to determine the extent to which the subject of route selection has been explored, and to see how this thesis can contribute to an understanding of the subject.

## Literature Review

In contrast to the body of academic literature devoted to heavy rail rapid transit systems, there has been relatively little written upon the subject of Light Rail Transit, beyond numerous brief articles in the railway industry press. This is largely explained by the short history of this form of transport in the English-speaking world. In the wake of the post-war decimation of light rail (streetcar/tram) systems in British and North American cities, it was not until the late 1970s that similar systems, in the form of LRT, had begun to re-emerge, initially in Canada and the United States and now in the United Kingdom. Continental Europe, on the other hand, has a wealth of experience in the arena of LRT, as a consequence of its staunch, long-term support of light rail. It seems reasonable to assume, therefore, that a large body of academic literature exists, which is not easily accessible to an English-speaking LRT researcher. However, it may still be possible to identify some dominant themes in the available literature and place into context the issue of right-of-way and route selection for LRT projects.

The most dominant theme of the literature devoted to LRT is that of cost. Much of the writing in the railway industry press that deals with cost comes down strongly in favour of LRT, whilst academic research is often critical of the initial and subsequent operating costs which LRT systems incur. In the former vein, for example, Middleton (1989) has argued that, in terms of construction costs, LRT is "substantially more economical" than heavy rail rapid transit systems and often costs no more than an express busway. It is only for an "extremely high-capacity" need that heavy rail is a more appropriate option (p.LR3). Middleton also points out that, although buses are cheaper to purchase than Light Rail Vehicles (LRVs), the latter are able to carry more passengers per vehicle and thus higher vehicle costs can be offset by greater productivity. This in turn can be accentuated by LRT´s ability to exploit multiple unit train operation (p.LR5).

Several North American LRT systems have been praised for using a low cost, no frills approach. Sacramento´s "RT Metro" is a case in point. Matoff (1989) claims that the LRT system represents a "low cost application" for a city with a low overall population density. The key elements cited for the RT Metro´s low cost design philosophy are: the use of available rights-of-way, minimum initial investment, the use of proven equipment, and a system designed for cheap operation (p.6). In a city that "represented an unfriendly environment for public transportation", the introduction of the LRT system "has greatly enhanced the public acceptability of transit" (p.11). In the United Kingdom, the first LRT system will be introduced in Manchester. Known as "Metrolink", it will knit together the city´s two heavy rail networks. Young (1988) argues that after 150 years of trying, Manchester, thanks to the "affordable prices" associated with LRT, will benefit from a valuable cross city rail link (p.8).

In contrast to, and as a result of, the body of writing in support of LRT costs, several authors have been highly critical of this aspect of LRT. Gomez-Ibanez (1985) conducted research into the cost aspect of LRT systems in San Diego, Calgary and Edmonton. He sought to dispell the belief that LRT is no more expensive to operate than a conventional bus system whilst at the same time offering an improved service. Gomez-Ibanez found that LRT systems require "substantially higher capital outlays" than the bus systems that they replace, and cost "slightly more" to operate. The higher operating expenses arise from a variety of maintenance costs associated with the LRVs, the track, and the electrification and signalling systems. Furthermore, the research found that transit ridership increased only modestly after the introduction of LRT service. He suggests that other cities contemplating LRT "should be skeptical of claims that light rail will reduce transit costs...or increase ridership significantly" (pp.349-350).

When Calgary's Northeast LRT line was under construction, Taylor and Wright (1983) conducted an economic evaluation of the project and concluded that it was "not in the public interest." They prepared a cost benefit analysis, based upon the benefits likely to arise from the opening of the LRT line, and the construction and operating costs (over a 30 year period) that the project would incur. They concluded that continued use of the former express bus service and an increase in private vehicle occupancy rates would represent a more "efficient use of resources" (pp.351-352, 357). Kain (1988) supports the argument that bus rapid transit combines a higher performance with lower costs per passenger trip than LRT, and would be a more appropriate transportation option for United States "Sunbelt" cities like Dallas and Los Angeles. In both of these cities, argues Kain, "the decision to build LRT systems was made with little or no consideration of more cost-effective bus rapid transit systems" (p.211).

In common with the cost issue, much has been written upon the subject of LRT´s ascension in North America and the United Kingdom. Beginning with the Edmonton LRT, which opened in 1978 and was the first all new LRT system to be constructed in North America, there are now (March, 1992) 11 North American urban areas using LRT. With so much railway construction concentrated in a relatively short period of time, and with more to come, several articles have been written which discuss this "phenomenon". Those written by Kizzia (1980b), Gilman (1983) and Bernstein (1984) are typical. On a similar theme, but rather more interesting from a geographical point of view, are several studies which examine the role of LRT in the cities of the eastern United States. The introduction of LRT to the North American city has largely been confined to the western half of the continent, where it has signalled the return of urban rail public transport to those cities in question. Much of the literature concerned with the birth of North American LRT neglects the fact that, although the eastern portion of the continent plays host to several heavy rail rapid transit systems, LRT also has a role to play there. In this respect, Middleton (1986) and Carrington (1988) provide valuable insight into an often overlooked aspect of LRT in North America. From a British perspective, Glover (1989) has also written upon the subject of the rising interest in LRT, and publications by the Light Rail Transit Association offer an "in-depth" review of developments in the United Kingdom (Taplin & Fox 1991, for example).

Since urban transportation is "intrinsically related" to land use (Soberman 1976, p.52), a significant quantity of heavy rail rapid transit literature, particularly in the discipline of geography, has been concerned with this interrelationship. The principle applies also to LRT, although the body of work is considerably more modest. LRT, for example, has been heavily promoted as a catalyst for urban renewal. Cervero (1984) states that, "like heavy rail rapid transit", LRT "has the inherent potential to influence urban growth, affect land uses, promote redevelopment, and increase nearby property values" (p.133). Although LRT´s impact upon urban land use might be less than that of a heavy rail system, observes Cervero, the strongest development potential of LRT is likely to be in the city centre. LRT projects are often integrated with city centre transit malls, as in Buffalo and Portland, for example. However, Gomez-Ibanez (1985) is critical on this point also. Based upon his research of the San Diego, Calgary and Edmonton LRT systems, he argues that the insufficient service improvement (compared to the former bus only transit service) is likely to hinder city centre redevelopment plans, along with redevelopment aspirations for suburban station sites. He concludes that LRT "has only modest prospects for promoting downtown development in rapidly growing metropolitan areas, and virtually no prospects in slowly growing or declining ones" (p.350).

It has been argued that a change in city parking policy can be used as a tool to promote the use of LRT systems, with a resultant impact upon land use, both in the city centre and at suburban station sites. Part of the planning context for Calgary´s LRT system has involved the reduction of city centre spaces, "relative to downtown growth", in an effort to encourage LRT (and bus) use throughout the city (Bolger 1985, p.3). At the same time, parking has been provided at suburban stations to encourage motorists to leave their vehicles at outlying sites rather than in a city centre parking space. Cervero (1985) claims that "parking policies have been as instrumental as any other factor in orienting commuters to LRT" in both Calgary and Edmonton. However, he does observe that "the lid on downtown parking is about to be uncapped" in Calgary, leading to an increase in parking supply and a possible decrease in demand for public transport (p.640).

Unfortunately, with little more than a decade of service experience for Edmonton's LRT system, and considerably less for the majority of other systems/lines, research into the relationships between LRT and land use in North American cities is, understandably, inconclusive. As Cervero (1985) notes, for example, the early history of LRT in Alberta was "overshadowed" by economic recession. Long-term experience is vital in order to support satisfactory research into this aspect of LRT.

In contrast to the literature devoted to LRT costs, the rising popularity of LRT, and the relationships between LRT and land use, much less has been written upon the subject of route selection and right-of-way. The majority of research has been pertinent to a single system and sometimes to a single LRT route. Schumann (1989), for example, observes that Sacramento "was blessed with existing [rights-of-way] that were available, in reasonable locations for a functional LRT system", contributing to an "affordable" solution to some of that city's transportation problems (pp.389, 407). Likewise, when the "San Diego Trolley" was in its early planning stages, Hebert (1978) noted that LRT would be appropriate for the city "since it would travel over an existing right of way yet serve desired concentration centers, including downtown San Diego" (p.42). With respect to the LRT systems in Calgary and Edmonton, Guillot (1983) compares and contrasts Calgary's surface transit mall with Edmonton's underground city centre alignment. Her research reveals that underground alignments do not necessarily enable a faster passage for LRVs, and "more significant time savings through downtown" might be achieved through improvements in fare payment and ticket inspection procedures (p.353).

The bulk of the literature that considers the issue of LRT route selection and right-of-way deals with the "versatility" aspect of LRT. Middleton (1988) argues that "the greatest strength of the LRT mode is the exceptional diversity in route location and configuration that it permits" (p.LR5). With a capacity for negotiating steep gradients and short radius curves, LRVs can use rights-of-way ranging from "streetcar-type running in mixed street traffic to high-speed, grade-separated elevated or subway operation" (p.LR5). As a consequence of this flexibility and adaptability, LRT has the potential to be located in most urban areas in a "relatively unobtrusive" fashion. This is particularly important where community "acceptability" is likely to be a key element of a new public transport project (Middleton 1989, p.LR5).

In summary, the body of literature devoted to LRT is small when compared with that which is concerned with heavy rail rapid transit systems. However, in the literature that does exist, the dominant themes are the cost of LRT systems and the ascension of LRT in British and North American cities. To a lesser degree, the issue of the interrelationship of LRT and land use, and the subject of route selection, also have a place in the literature. There is clearly a need for additional research which examines the relationship between route selection and the subsequent ability of a Light Rail Transit system to fulfil its initial promise. It is against this backdrop that the thesis has been written, with the intention of making a useful contribution to the subject.

## Thesis Limitations

There are some limitations to this thesis and at this point it is appropriate to draw attention to them. It is not the intention of the author to use or develop any statistical methods of measuring the relationship between route selection and the success/failure of an LRT route/system. Rather, the method used throughout the thesis is largely synthesis of data, information and criticism, combined with the author's personal observation and interpretation.

In addition to those LRT systems which are operational, and in some cases have been for at least a decade, the thesis draws upon examples of projects which are in the advanced planning or construction stage. All of the existing North American LRT systems, and those in the United Kingdom and North America which are either under construction or are about to enter the construction phase are examined in the thesis, subject to the definition of LRT. The proposals of other British and North American urban areas have been omitted from the thesis because in most cases the plans are embryonic and therefore potentially subject to radical change, or cancellation.

## Definition of Terms

The term "Light Rail Transit" (LRT) is clouded in ambiguity and is thus difficult to define. In order to construct a working definition for the purposes of this thesis, and with a view to making a contribution to the terminology debate surrounding the subject, it was considered appropriate to devote a significant portion of the succeeding chapter to a discussion of the term and the ambiguities associated with it. For introductory purposes, however, it is sufficient to state that LRT is a rail based urban transportation tool (although it can be used for inter-urban and rural purposes) which combines the operational flexibility of the traditional streetcar (tram) with some of the performance characteristics of a heavy rail system.

The term "rail right-of-way" refers to any existing path through an urban area which can be used in the planning and construction of an LRT route. The right-of-way can either be disused prior to the introduction of LRT, or it can be active, served by freight and/or passenger trains. In the latter case, the right-of-way could be subsequently shared by Light Rail Vehicles (LRVs) and conventional trains, or the former rail traffic could be accommodated elsewhere.

Finally, for the purposes of this thesis, the degree of "success/failure" of an LRT system, or individual route, is gauged in one of two ways, or a combination of both. It can be gauged either in terms of its cost recovery through the farebox, or the transfer of motorists to public transport in order to reduce road traffic congestion and road vehicle emissions. An increasing search for "green" urban transport solutions appears to favour the latter as the most realistic measure of LRT's success or failure.

## Methodology and Data Sources

Data for the thesis have been drawn from three sources: books and professionaljournal articles, articles published in the railway industry press, and material supplied by public transport agencies. Three railway industry journals were used. Railway Age and Mass Transit provided valuable information concerning North American LRT projects, whilst Modern Railways helped to piece together the British picture. Before arriving at a working definition of Light Rail Transit for the thesis, a list of "candidate" systems was compiled from the railway industry journals, and the relevant operating/future operating agencies were contacted by letter. A general request for information was made to the following agencies:

Canada
BC Transit (Vancouver)
City of Calgary Transportation Department
City of Edmonton Transportation Department
Toronto Transit Commission

United States
Dallas Area Rapid Transit
Greater Cleveland Regional Transit Authority
Los Angeles County Transportation Commission
Massachusetts Bay Transportation Authority (Boston)
Metropolitan Transit Development Board (San Diego)
New Jersey Transit (Newark)
Niagara Frontier Transportation Authority (Buffalo)
Port Authority of Allegheny County (Pittsburgh)
Sacramento Regional Transit District

San Francisco Municipal Railway
Santa Clara County Transportation Agency (San Jose)
Southeastern Pennsylvania Transportation Authority (Philadelphia)
Tri-County Metropolitan Transportation District of Oregon (Portland)

United Kingdom
Greater Manchester Passenger Transport Executive
South Yorkshire Passenger Transport Executive (Sheffield)
West Midlands Passenger Transport Executive/Centro (Birmingham)

The response was good and in only two cases was a request for information ignored. Material supplied included publicity literature, maps and planning documents. An unrelated field trip to Vancouver revealed the possibility of using the planned Vancouver-Richmond Rapid Transit Project as a subject for detailed examination in the thesis. Consequently, the City of Vancouver was contacted, in addition to the future operating agency, BC Transit. The Office of the City Clerk supplied relevant extracts from the minutes of City Council meetings concerning the project's route selection process.

The Calgary LRT and the Vancouver-Richmond Rapid Transit Project were selected as "case studies" and subjected to a much greater examination than the other LRT systems. This was necessary so that meaningful conclusions could be drawn. Both systems also afforded the opportunity of greater study in a Canadian context. Following the decision to select the Calgary LRT and the

Vancouver-Richmond Rapid Transit Project as case studies, several subsequent requests for specific information were made to the City of Calgary Transportation Department and BC Transit.

In order to examine the degree to which the availability of existing rail rights-of-way has been a factor/will be a factor in the construction of LRT projects, the survey of systems in Chapter Three is the principal tool by which this is achieved. With the aid of the case studies, the thesis attempts to illustrate the degree to which reliance upon existing rail rights-of-way has affected/is likely to affect the success of LRT.

With respect to the geographic study area, North America and the United Kingdom were chosen, for two reasons. First, the flurry of interest in LRT has largely been concentrated in the United Kingdom, Canada and the United States. This is because so much urban rail was lost in these countries following the Second World War that there has been a much greater opportunity for new systems than in Continental Europe, for example. Secondly, it was decided not to restrict the study simply to North America or the United Kingdom. This is because North America possesses the operating experience, whilst the United Kingdom has the richer harvest of advanced plans for LRT. It was also considered important to include systems that are in the advanced planning/construction stage, so that the degree of future, as well as current reliance upon existing rail rights-of-way could be examined. Hence the inclusion of LRT projects destined for Dallas, Manchester, Sheffield and the West Midlands.

## Thesis Organisation

The core of the thesis comprises four chapters. Chapter Two, entitled "Understanding Light Rail Transit", is divided into three sections. The first section provides a brief history of urban transportation, allowing LRT to be placed into context. Then follows a discussion of the term "Light Rail Transit", culminating in a working definition of the term. This section includes several definitions drawn from academic sources as well as those offered by public transport agencies. The last section of Chapter Two discusses reasons why LRT has been introduced into several North American cities, and why more schemes are under consideration, both for North America and the United Kingdom.

Chapter Three is a survey of 14 British and North American LRT systems. The purpose of this chapter is to determine how prevalent the use of existing rail rights-of-way is when it comes to establishing LRT lines/systems. The chapter provides a map for each of the systems discussed. It also offers a selected list of 23 urban areas in Canada, the United States and the United Kingdom for which LRT is under serious consideration.

The aforementioned case studies are the subject matter of the next two chapters. Chapter Four features "Case Study A", which examines the Calgary LRT system. There are three LRT routes in the city - the "South Corridor LRT", the "Northeast LRT" and the "Northwest LRT" - and each one is discussed, both individually and as part of a single system. Chapter Five is devoted to "Case Study B", which examines the Vancouver-Richmond Rapid Transit Project. The chapter focusses primarily upon the issue of route selection in the residential Vancouver section of the project corridor, for which an existing rail right-of-way is available.

Finally, Chapter Six draws together several conclusions derived from the core of the thesis, and offers suggestions for further research into the issue of LRT route selection.

# CHAPTER TWO:

# UNDERSTANDING LIGHT RAIL TRANSIT

# A Brief History of Urban Transportation

The purpose of this section is to briefly examine the history of urban transportation, in order to place Light Rail Transit into context. It is not intended to be an exhaustive review of all urban transportation phases and modes, but a selective one. Where possible, a chronological sequence of developments has been followed. However, several forms of transportation evolved (and continue to do so) more or less simultaneously and the sequence of their introduction varies according to the individual city in question. This is particularly true of comparisons between the United Kingdom and North America. It should also be noted that, since Light Rail Transit is a form of passenger transportation, no mention is made of urban freight movement in this brief history.

## The Pedestrian City

In North America and the United Kingdom prior to the nineteenth century the dominant method of travel within the city was on foot. The horse was only used for transporting heavier goods and as a personal conveyance for the wealthier citizens. With an overwhelming reliance upon walking, the geographical extent of the "pedestrian city" was governed by the distance that people were willing to walk in order to reach work, shops and places of recreation. For most cities this meant a walking time of less than 30 minutes for a journey from the centre of the city to any given urban location. Consequently, the pedestrian city was a "highly compact settlement... requiring people and activities to tightly agglomerate in close proximity to one another" (Muller 1986a, p.10).

## The Horse-drawn Omnibus

Although horses were employed in the pedestrian city, it was not until the advent of the horse-drawn omnibus that they were used in any organised fashion for the conveyance of people. The omnibus (which derives its name from the Latin word omnis=all) was a higher density, intracity version of the stagecoach. These "long stagecoaches" were first used in urban areas in France, where Stanislaus Baudry established the first omnibus service in Nantes in 1826 (Vuchic 1981, p.12). The new form of transport quickly spread to other parts of Europe and to North America. In 1829 an omnibus service was introduced in London by George Shillibeer and the first service in the United States was operating in New York by 1827. The first public transport in Toronto was the omnibus route along Yonge Street established in 1849 by local cabinetmaker and undertaker, Burt Williams (TTC 1989, p.6).

As a result of the unsanitary conditions in the compact pedestrian city, which led to frequent epidemics, and the noise, there was a strong (largely unfulfilled) desire to dwell beyond the pedestrian city´s morphological limits. The reason for this desire can be illustrated by the following descriptions, which refer, respectively to York (now Toronto) in 1832 and Glasgow, Scotland in 1840:

> ...stagnant pools of water, green as leek, and emitting deadly exhalations, are to be met with in every corner of the town - yards and cellars send forth a stench from rotten vegetables sufficient almost of itself to produce a plague... (Godfrey 1968, p.20; cited in Hodge 1986, p.76).

> In many houses there is scarcely any ventilation; dunghills lie in the vicinity of the dwellings; and from the extremely defective sewerage, filth of every kind accumulates (Ashworth 1954, p.49; cited in Hodge 1986, p.76).

The principal function of the horse-drawn omnibus was to move people around the already built-up city. However, it also allowed a small number of people to move just beyond the city limits (the wealthy had always had that facility, since they owned horse-drawn vehicles), making the first changes to the morphology of the compact pedestrian city. Although the impact was modest, due to the low speeds and capacity of the vehicles, it nevertheless paved the way for the horse-drawn tram (horsecar), the cable car and, in turn, the electric tram (streetcar).

The Horse-drawn Tram (Horsecar)

The first "street railway", using horse-drawn vehicles, was opened in New York in 1832, running from Harlem to lower Manhattan. By using rails rather than crude roads, the horse- drawn "tram" or "horsecar" was able to overcome many of the problems that had plagued the omnibus. Using the technology of rail guidance meant that the tram had a low rolling resistance, which in turn gave it several advantages over the omnibus: improved passenger comfort, a higher capacity, and a more efficient use of horse power (Vuchic 1981, p.14). Consequently, the new trams represented "the first meaningful breakthrough toward establishing intracity "mass" transit" (Muller 1986b, p.30). For the morphology of the city it meant some expansion beyond the former city limits, particularly along radial routes.

The success of the horse-drawn tram led to its introduction into several cities throughout North America and Europe. In Buffalo, for example, the horsecars introduced by the Buffalo and Black Rock Land and Railroad Company in 1834 represented the first form of urban public transport in that particular city (NFTAa, p.4). In Canada, the horsecar was introduced later in the nineteenth century, in 1861 in Toronto, with vehicles running along Yonge Street. Two decades later, on 20th October, 1882, the

Winnipeg Street Railway Company inaugurated the first horsecar system in Winnipeg. For 10c passengers could ride along the Main Street route, and the service was "deemed successful from the very beginning" (Baker 1982, p.10).

## The Cable Car

The first mechanised form of public transport to achieve widespread commercial success, and the approval of the travelling public, was the cable car. Invented by the American, Andrew Hallidie, in 1873, the cable car is a rail-guided vehicle employing auxiliary traction, with a system of cables, pulleys, and a gripping device mounted on the car. The origins of the system can be traced back to the eighteenth century, where rail-guided wagons were hauled up steep inclines in British mines. The principal advantage of the system was its ability to negotiate very steep gradients, and the world´s first cable-operated street tramway was opened, in 1873, on Clay Street Hill, San Francisco.

Although the most famous system to survive is undoubtedly that which is operated by the San Francisco Municipal Railway, cable car operations were initiated by many cities around the world. In the United States, for example, the largest network was in Chicago, and Melbourne, Australia could boast the largest network in the world.

However, the higher operating speeds and superior safety of the electric streetcar led to the demise of most cable car systems (Vuchic 1981, pp.17-18;619-620).

## The Electric Tram (Streetcar)

Although the horse-drawn tram represented a major improvement upon the omnibus, the horse remained a liability. Horses are expensive to maintain, they grow old, and are always susceptible to injury and disease. In 1872, for example, the "great epizootic", stemming from an equine respiratory disease, killed over 2,250 horses in less than a month in Philadelphia (Yeates & Garner 1980, p.190). To improve the efficiency of urban transportation, another form of motive power was required.

The electrical industry that evolved in the nineteenth century provided the means for the successful introduction of an electrically powered, rail-guided vehicle, on city streets - the electric tram or streetcar. It was first used successfully by Frank Sprague, an American ex-naval officer, on the Richmond Union Passenger Railway in Richmond, Virginia in 1888. Sprague was awarded a contract to supply electrical equipment and vehicles for a 19km line serving the city of Richmond. The ability to run a reliable service over track that was poorly laid and often steeply graded was a measure of Sprague's achievement

(Vuchic 1981, p.20) and represented a major turning point in urban transportation.

Within a year the system was adopted by two dozen other American cities and by the early 1890s was "the dominant mode of intraurban transit" (Muller 1986b, p.32). In Philadelphia, for example, the first streetcars were introduced by the Philadelphia Traction Company on 15th December, 1892. They proved so successful that within five years the horsecar was abolished from a track network in excess of 130 miles (SEPTA 1982, p.3). Canadian cities were also quick to embrace the new technology. On 27th January, 1891, almost two years prior to Philadelphia, the Winnipeg Street Railway Company provided the first streetcar service in Winnipeg.

In Europe the widespread introduction of electric street railways lagged behind North America, with the so-called "tramway revolution" occurring between 1890 and 1910. The reasons are twofold. First, a greater emphasis was placed upon the aesthetic aspects of city development in Europe. This led to an (ultimately) unsuccessful search for an alternative to the "untidy web of overhead wires" used for current collection in North American cities. Secondly, more stringent legislation was a strong deterrant to private investment, and large-scale electrification was subsequently undertaken, to a large degree, by municipal authorities (Vuchic 1981, pp.23-25).

In terms of its impact upon the morphology of the city the most important aspect of the streetcar was the rapid development of the urban fringe. The incorporation of the new "streetcar suburbs" created, in many cities, a distinctly star shaped urban form. The phenomenon occurred on both sides of the Atlantic but to a much greater degree in North America where the streetcar was introduced earlier and systems were more extensive (Ward 1964, p.477).

## The Motor Bus

The bus, the first public transport vehicle to be powered by the internal combustion engine, was developed at the turn of the century. Initially, buses were powered by petrol engines, but after the original invention of Rudolf Diesel, a German engineer, was refined, the diesel engine became almost the exclusive source of power for the bus. The introduction of diesel-powered buses spread rapidly in the 1930s, particularly in the United Kingdom, which had seen its first diesel bus introduced in Nottinghamshire less than a decade before.

The history and fortune of the bus varies greatly from city to city. In some cases the bus directly replaced the horse-drawn omnibus. In the United States the first city to do so was New York. Between 1905 and 1908 the Fifth Avenue Coach Company introduced 35 double-decker buses to replace its entire fleet of horse-drawn omnibuses. However, the role of the bus grew rapidly when it replaced the streetcar. The period 1945-1965 saw the wholesale conversion of American streetcar routes into bus routes (Vuchic 1981, pp.36-37). In Canada and the United Kingdom the story was the same. The last streetcar ran in Winnipeg, for example, on 19th September, 1955, and in Birmingham (England) the streetcars were gradually replaced by diesel buses during the period 1936-1953.

## The Trolley Bus

In some cities the streetcar was partially replaced by the trolleybus (operating alongside the diesel bus), which is an

> electrically propelled bus which obtains power via two trolley poles from two overhead wires along routes. It can travel a limited distance on battery power or auxiliary ICE [internal combustion engine] (Vuchic 1981, p.651).

However, in many cases the trolleybus suffered the same fate as the streetcar, and was itself replaced by the motor bus. In Winnipeg, the trolleybus began to replace streetcars on some routes in 1938, but by 1970 the trolleybus era had come to an end for the city. Likewise, the trolleybus became extinct in the United Kingdom, a country that had formerly been one of its greatest users. Notable examples of North American cities which still operate the trolleybus include Seattle and Vancouver.

## Other Rail Transport

Alongside the development of the streetcar, larger cities started to employ rail technology for faster services on wholly or partially segregated rights-of-way. Three distinct modes were to emerge, and they can be referred to as: "suburban rail", "rapid transit", and "interurban".

"Suburban rail" can be defined as

> regional passenger service usually provided by railroad agencies which consists of electric or diesel-powered trains on grade-separated railroad lines... Characterized by very high performance and service quality (Vuchic 1981, p.649).

Originally suburban rail service evolved from the intercity railway and because of similarities between the two (the use of steam locomotives at the outset, for example) it is difficult to determine exactly when the former was first introduced. The first large-scale use of suburban trains, however, was in London. Most of the city´s extensive suburban rail network was constructed between 1840 and 1875. Other British cities introduced such services several years later - Liverpool, for example, in 1886 and Glasgow in 1887. In the United States, the Boston and West Worcester Railroad is thought to be the first "commuter" railway, introducing regular commuter trains between Boston and West Worcester in 1843 (Vuchic 1981, p.42). In Chicago, the first suburban rail service was inaugurated in 1856.

The electrification of the suburban railway began around 1900 and intensified after the Second World War. In the case of London, the vast majority of suburban trains (which are now all operated by the British Rail sector, Network SouthEast) are electrically powered. Significant portions of the suburban rail networks in the West Midlands (Birmingham), Merseyside (Liverpool), Greater Manchester, and Strathclyde (Glasgow) have also been electrified, with further projects in the pipeline. In North America, however, much of the suburban rail fabric is operated by diesel trains. In Chicago, for example, the extensive suburban rail system operated by Metropolitan Rail (Metra) has a single electrified line, that running south to University Park from the city centre. Other networks are entirely operated with diesel powered rolling stock: GO Transit (Toronto), Massachusetts Bay Transportation Authority (Boston), Caltrain (San Francisco - San Jose), and Tri-Rail (Miami).

Parallel with the emergence of suburban rail networks, larger cities began to construct "rapid transit" systems. Rapid transit can be defined as a

> generic class of electrically powered transit modes which...have high speed, capacity, reliability and safety [and operate on a right-of-way] used exclusively by vehicles of the same mode. It is fully controlled by the operating agency, and entry or crossing by other vehicles or pedestrians is physically impossible (Vuchic 1981, pp.385, 649).

London was the first city in the world to build a rapid transit line, in an attempt to provide a fast service free from street congestion. On 10th January, 1863, the Metropolitan Railway opened its 3.75 mile Paddington-Farringdon line to the public. As with many other rapid transit lines (the elevated lines in New York, for example) the service was initially operated with steam locomotives, with electrification to follow. Since the Metropolitan Railway was built near the surface, largely constructed by the "cut-and-cover" method, the use of steam locomotives was possible, if not entirely desirable. However, the construction of "deep tube" tunnels, using tunnelling shields, necessitated the use of electric trains. The first such railway was, again, introduced in London, when the City and South London Line opened in 1890, running under the Thames to Stockwell. Other "subway" lines were opened in Merseyside and Glasgow, in 1886.

In North America, the first rapid transit service was the elevated line constructed above Greenwich Street in New

York. The line was opened in the late 1860s, to be followed by three more in the 1870s and 1880s. The famous Chicago elevated line was opened to the public in 1892. However, it was the underground rapid transit lines which proved to be a better tool for solving the transport problems of the large American cities. The first subway line was opened in New York in 1904 and was followed by Philadelphia (1907) and Boston (1908). Subsequent additions to the list include: Chicago (1943), Toronto (1954, the first in Canada), and the San Francisco Bay Area Rapid Transit or BART (1972).

In addition to the development of suburban rail and rapid transit, the "interurban" emerged as another distinct form of rail transport. It can be defined as

> electric rail transit service between cities and towns in close proximity to each other... This mode usually has [a separate right-of- way] which excludes other traffic running along the tracks but has at-grade crossings ..., high speed and comfort (Vuchic 1981, pp.385, 647-648).

Although an interurban line was built in Northern Ireland in 1883, it was in the United States that the large-scale development of this mode took place. In 1893 two lines were opened: one in Oregon, linking Portland and Oregon City, and the other in Ohio, the Sandusky, Milan and Norwalk Electric Railway. In terms of line construction the period of greatest activity was 1901-1908. The network of interurban lines was so extensive that it was possible to travel from New York to Boston simply by changing from one interurban or streetcar line to another. The most intensely used and extensive systems were to be found in Los Angeles, Chicago, and in the states of Ohio, Indiana and Michigan. Of all the American systems, the most famous was the Pacific Electric. Focused upon Los Angeles, "The World´s Greatest Interurban Railway" (Middleton 1991a, p.29) provided service on a network in excess of 1,000 miles. In Manitoba, the era of the classic interurban was ushered in by the Winnipeg, Selkirk and Lake Winnipeg Railway Company in 1904, which linked Selkirk, Stony Mountain and Stonewall with Winnipeg.

Only two interurban lines have survived in the United States: the Norristown Line in Philadelphia, now under the aegis of the Southeastern Pennsylvania Transportation Authority (SEPTA), and the Chicago South Shore and South Bend line, which runs between Chicago´s Randolph Street station and South Bend, Indiana.

As with the streetcar, all three modes - suburban rail, rapid transit, and interurban - promoted the radial growth of the city. Furthermore, since they were more expensive to establish than streetcar service (due in large part to the need for a separate right-of-way) they were only introduced along the most heavily used corridors. Consequently, the radial growth that characterised the streetcar suburb was accentuated with the introduction of these advanced forms of urban rail transport (Yeates & Garner 1980, p.203). There was, however, a new form of transport on the horizon which would have far reaching implications for urban transportion and the city.

## The Automobile (Motor Car)

There is little need to define the automobile, or car, suffice to say that it provides personal transportation and, beyond the taxi cab, is divorced from public transport.

The first automobile was built in Germany in 1886 by Carl Benz of Mannheim, and by the end of the nineteenth century internal combustion engine-powered vehicles were being constructed in large numbers in Germany, France and the United Kingdom. With the evolution of the streetcar into interurban service, and the development of suburban rail and rapid transit systems, there was a widespread belief that the car had a limited future. However, the various forms of rail transport had promoted and made possible the suburbanisation of the city, and widespread car ownership further developed the phenomenon (Yeates & Garner 1980, pp.203-204).

The popularity of the car can be attributed to the perception of "freedom" held by the motorist. A car permits the individual to dispense with the fixed routes and fixed schedules of public transport and to travel wherever and whenever he/she chooses. Consequently, the rise in car ownership went hand in hand with the decline of public transport, virtually eliminating the streetcar from North American and British streets. In the United States, for example, the number of passenger car registrations (in millions) had risen from 0.5 in 1910 to 142.4 by 1990 (Muller 1986b, p.36; US Department of Transportation 1990). An inevitable outcome of this trend was the establishment of new suburbs away from the streetcar arteries. The classic radial growth pattern that evolved during the streetcar era was transformed by these new "infill" suburbs.

The degree of change experienced by the city as a result of widespread car ownership, and the timetable associated with those changes, varies from city to city, and particularly between North America and the United Kingdom. In the United States, for example, accommodation of the car was "carried to the extreme" (Vuchic 1981, p.110), particularly with respect to the "freeway". The construction of "high-speed, limited-access expressways" or "freeways" represented the "coming of age of the automobile culture" (Muller 1986b, p.40). With a willingness to permit the decline of good (in some cases, excellent) public transport systems, and the evolution of the car from a luxury recreation tool into a transportation "necessity", the freeway became a logical development. The 1956 Interstate Highway Act gave impetus to this trend and the freeway reshaped the city. In the same way that the streetcar had pushed the city limits outwards from the city centre in a pattern of radial growth, so the limited access freeway repeated the process but on a much larger scale.

In addition to promoting urban sprawl and reducing demand for public transport, the car and the freeway effectively turned the city inside out. Historically, the city centre or Central Business District (CBD) had been the focus of the city and the public transport system. With widespread car ownership and a network of limited access roads, the economic activity of the city started to drift out to peripheral locations, where land was cheaper and more abundant. As a result the city centre declined in importance. Meanwhile the urban public transport system retained its city centre focus and this remains the case today. Even bus routes which, unlike rail routes, can be changed virtually overnight, are still largely concentrated upon the city centre. In terms of the total number of buses/seats provided per route the concentration is even more pronounced. In some cases, however, the city centre remains a very viable focus for economic activity. This is true of British cities and larger cities in North America, but these cities have also experienced their share of economic and recreational migration to the urban periphery.

Today, the task of moving people around the city is shared by some form of public transport and the private car. The quality and success of the public transport system differs greatly between cities, and the same applies to the effectiveness of the traffic system in facilitating the free flow of private vehicles. No city is without its transport problems and no city is a model of urban transportation efficiency. In all cases the solution is probably a package of remedies, but one tool that is looked upon favourably in many quarters is Light Rail Transit (LRT). What Light Rail Transit is, forms the subject of the next section.

## What is Light Rail Transit?

For the purposes of this thesis it is essential to have a working definition of "Light Rail Transit" in order to eliminate those urban rail systems in North America and the United Kingdom that are not true LRT systems, although they might appear to be so at first glance. Although the term is frequently used in such a fashion that one is expected to fully understand its meaning (indeed, a definition often appears to be deemed unnecessary), confusion and contradiction frequently take the place of simple definition. The literature of LRT is littered with a bewildering array of labels, including: "Light Rail Transit"(LRT), "Light Rapid Transit"(LRT), "Light Rail Rapid Transit"(LRRT), "Automated Light Rapid Transit"(ALRT), "Pre-Metro", "Light Rail", and "Conventional Light Rail Transit". Furthermore, the names selected for the individual systems: "Supertram"(Sheffield), "Metrolink"(Manchester), "San Diego Trolley" and "Metropolitan Area Express", or "MAX"(Portland), for example (essentially products of advertising agencies), only serve to cloud the issue. In order to illustrate the contradiction and confusion which surround the issue of LRT and any attempts to define the term, two examples will be appropriate.

In British Columbia´s Lower Mainland Region, "SkyTrain" provides rail service along a 25km route linking Vancouver, Burnaby, New Westminster and Surrey. The first phase of SkyTrain went into revenue service in 1986 and extensions to the route are currently in the engineering and design stages. SkyTrain is regarded as an "Automated Light Rapid Transit"(ALRT) system by its operator, BC Transit, and is seen as something quite distinct from LRT.

BC Transit is planning to construct a rapid transit link between Vancouver and Richmond, and is currently evaluating three types of public transport. According to BC Transit, the three types under consideration are "SkyTrain", "Conventional Light Rail Transit" and "Busway" (BC Transit 1990a). Meanwhile, other sources regard SkyTrain as an LRT system. In the United Kingdom, a report by the Passenger Transport Executive Group, entitled Light Rail Transit, refers to SkyTrain as such a system. The trade journal Mass Transit periodically publishes a survey of the world´s "LRT" systems, and its listing for 1984 included the Vancouver system, which at that point was under construction (Goldsack, Tomlinson & Wiese , p.20). However, the Mass Transit survey of the following year contained an entry for Vancouver, describing SkyTrain as an "intermediate capacity transit system (not LRT)" ("LRT: By any name it´s a fast growing technology", p.16) and the 1987 survey omitted Vancouver altogether (Carrington 1987). Finally, the 1990 worldwide guide to LRT systems reinstated the entry for Vancouver, referring to SkyTrain as an "advanced LRT" system (Carrington 1990, p.40).

For those cities which have retained a "streetcar" system and embarked upon some form of upgrading, whether simply new vehicles or an expansion of the network, the terminology is often confusing. Toronto is a case in point.

The legacy of Toronto's original streetcar system is a network of 45.6 miles, operated by a fleet of new and rehabilitated cars. On 22nd June, 1990, the Toronto Transit Commission (TTC) opened the 1.3 mile "Harbourfront LRT" line, which is designed to serve the newly redeveloped waterfront area of the city centre. The Harbourfront line is widely referred to as a "streetcar line" (TTC 1989, p.22; "TTC Notes", p.5; "Harbourfront contract signed"), and is operated by streetcars, including the classic PCC (Presidents' Conference Committee) vehicles. This suggests that the term "LRT" can be applied to a streetcar operation, but as with SkyTrain, the inclusion of Toronto in LRT surveys lacks consistency. The <u>Mass Transit</u> surveys of 1984 and 1985, published a few years prior to the opening of the Harbourfront Line, contain entries for Toronto, making reference to the 45.6 mile original streetcar system. However, in the 1987 listing, Toronto has been omitted, and although it reappears for the 1990 survey, reference is made only to the Harbourfront line and the Scarborough Rapid Transit line (which is very similar to SkyTrain and links Scarborough city centre to the TTC's Kennedy subway station). Now the implication is that LRT is something more than the traditional streetcar operation, but apart from an underground section, the Harbourfront line is the same as the city's extensive streetcar system.

Those two examples not only serve to illustrate the confusion which surrounds the term "Light Rail Transit", but also they imply that LRT occupies a place between the extremes of SkyTrain (a fully automated system using linear induction motors) and the conventional streetcar. Whether or not those extremes can be placed under the banner of "LRT" remains to be seen, but they do provide valuable guidelines. The next step is to examine the literature from a variety of sources to see how the term "Light Rail Transit" has been variously defined. The public transport (transit) operator serves as a convenient starting point.

The City of Calgary Transportation Department has defined Light Rail Transit as:

> an urban transportation concept utilizing medium-capacity electric rail vehicle technology in innovative combinations of exclusive or shared rights-of-way, as well as in mixed traffic (Calgary Transit, p.2).

The City of Edmonton Transportation Department:

> Light Rail Transit (LRT) is not to be confused with the traditional North American concept of the subway...LRT can utilize existing railway rights-of-way and median strips with grade crossings. Street operations are also possible on this system ...its implementation and operation are more flexible (Edmonton Transit, p.1).

Strathclyde Passenger Transport Executive (Glasgow):

> The term light rail has been applied to a range of public transport systems. It generally refers to a rail-based system

> exhibiting the following characteristics -
>
> - Light weight vehicles capable of negotiating sharper bends and steeper gradients than conventional rail vehicles enabling better acceleration and easier incorporation into a built-up environment at lower cost than conventional rail.
>
> - Much less signalling than conventional rail with the ability to respond to road traffic control arrangements.
>
> - Simple low cost, closely spaced stops.
>
> - Wholly or partially segregated or completely unsegregated track.
>
> - Driver or fully automated operation (if completely segregated).
>
> The much greater flexibility of light rail compared with conventional rail enables a wide range of opportunities to be explored and within the range of these characteristics two extreme systems can be identified as follows -
>
> (1) A totally segregated system which could be fully automated...
>
> (2) An on-street driver controlled tramway system with no special signalling arrangements and no segregation from other traffic (SPTE 1989, p.13).

The West Midlands Passenger Transport Executive (Centro) considers Light Rail Transit to be "a segregated system using lightweight vehicles" (WMPTE), and states that its own evolving LRT system, the "Midland Metro"

> will not be a railway train on the street. Nor will it be a tram of the past. Aesthetically and practically it will be a new mode of transport - a 21st century tram... (Tarr 1989, p.6).

For Sheffield, the South Yorkshire Passenger Transport Executive proposes the "Supertram":

> a modern, attractive, lightweight single deck electric tram...it runs on rails which are built flush with the surface of the street, or on its own separate roadway. It has...space for over 100 seats and space for another 100 standing passengers... (SYPTE 1988).

Santa Clara County Transportation Agency, responsible for the Guadalupe Corridor Light Rail system (which serves Santa Clara and San Jose), claims that:

> the term "light" refers not to weight, but rather to the system's simplicity, relative lower cost and vehicle capacity. Each vehicle can carry up to 167 passengers, and will operate in one, two or three car units (SCCTA 1990).

Other clues to understanding LRT come from Dallas Area Rapid Transit, which defines LRT as an "overhead wire system with some street crossings [and] can be elevated or in subway" (DART 1990, p.8); the Tri-County Metropolitan Transportation District of Oregon: "light rail is the modern version of the streetcar" (Tri-Met 1988a); and the Sacramento Regional Transit District, which regards that city's LRT project as "typical of European LRT design in which major structures are mimimized by utilizing existing rights-of-way and at-grade crossings" (SRTD).

Although public transport operators yield a wealth of valuable information, any attempt to understand Light Rail Transit should look to other sources of information as well. This is because the comments of the former are often (understandably) applied to a specific system/project and do not necessarily offer a broader view of the subject. Also, to a substantial degree, the statements represent attempts to "sell" individual systems to the public. The series of definitions which follow, therefore, are intended to provide a broader view, while at the same time complementing the above statements made by various public transport operators.

In a paper presented to the Manchester Branch of the Institution of Civil Engineers, at the University of Salford, Young had this to say about Light Rail Transit:

> The term "tramway" still has mixed connotations, especially in Britain, but generally refers to street running systems. The term "Light rail transit" (or LRT) has evolved to describe the modern equivalent of the tramway, a blend of the characteristics of the old style street tram and the rapid transit railway or metro system. Thus LRT can operate on-street especially through shopping centres, but is more frequently found on segregated tracks, either within or adjacent to the highway, or on private right of way.
>
> Light rail transit is the predominant mode within the classification of "Light Rapid Transit". "Rapid Transit"

> is the term to describe an urban railway with high frequency service such as the London Underground or Paris Metro. It includes other segregated modes such as rubber tyred metro or even monorail. "Light" rapid transit is the corresponding term for systems which are not necessarily fully segregated, and which employ lighter forms of construction. Light rapid transit includes light rail transit, busways, guided busways, and some monorail or peoplemover systems (Young 1989, p.3).

An article by Glover entitled "The prospects for Light Rail Transit in Britain" offered this definition of LRT:

> Light Rail Transit is generally considered to be duo-rail electric traction service. System operational and service performance falls in a range between local surface service (ie: trams) and grade-separated rail rapid transit, or Heavy Rail Transit (HRT). In addition, LRT service must fall into (or at least in part) a majority of the following categories, for all or a portion of the operation:
>
> 1. Lightweight construction of rolling stock, approximately 1120 - 1420 kg/m length.
>
> 2. Low-level (at grade) passenger loading.
>
> 3. Street running (with or without automobile segregation).
>
> 4. Overhead current collection (trolley or pantograph variations).
>
> 5. One-man, single-car operation (in, but not confined to, base hours).

> 6. Reserved-way operation (whether or not grade separated).
>
> 7. Train operation in peak periods of not more than three vehicles. (Glover 1980, p.201).

According to Taylor, "Light rail transit is a subject in search of a definition", but might be defined as follows:

> Light rail is an evolutionary mass transit mode, based on established technology, offering the opportunity to provide a variety of services and a more effective means to control operating costs. It offers rapid, reliable, safe and attractive transportation. The community gains a plausible alternative to the automobile that is compatible with its environment and can be upgraded or expanded on an incremental basis with modest public resources (Taylor 1975, p.7).

In the preamble to its 1985 survey of LRT systems, Mass Transit observes that "in North America, the terms streetcar, trolley car and light rail (LRT) are often used interchangeably, depending on the age of the system". Amongst the definitions discussed in the introduction to the survey, that offered by the International Light Rail Commission is noteworthy. They defined LRT as follows:

> A form of rail transport that can be developed by stages from a modern tramway to an express transport system running on its own track below or above ground. Each development stage may be complete in itself, but should make it possible for development to continue to the next higher stage ("LRT: By any name it´s a fast growing technology",p.13).

In 1988 the Passenger Transport Executive Group published a report entitled Light Rail Transit, which was intended to establish guidelines for future LRT developments in Britain. For the purposes of the report, LRT was defined as:

> any system exhibiting the following characteristics:
>
> - driver only, manual operation.
> - standard gauge, steel wheel on steel rail vehicles.
> - wholly or partially segregated rights of way, or completely unsegregated from road traffic.
> - simple low cost, closely spaced stops.
> - minimum signalling.
> - lighter vehicles built to less onerous end loading and other design criteria, which are capable of negotiating sharper bends and curves and steeper gradients than conventional rail vehicles.
>
> (PTEG 1988, p.2).

One final definition of Light Rail Transit can be taken from Vuchic´s comprehensive book, Urban Public Transportation, in which the author defines LRT as a:

> transit mode utilizing predominantly [right- of-way] category B, sometimes A or C on different network sections. Its electrically powered rail vehicles operate in 1- to 4-car [units]. The mode has a wide range of [level of service] and performance characteristics (Vuchic 1981, p.648).

The author recognises three categories of right-of-way (R/W):

- Exclusive R/W or Category A, used exclusively by vehicles of the same mode. It is fully controlled by the operating agency, and entry or crossing by other vehicles or pedestrians is physically impossible.

- Separate R/W or Category B, which excludes other traffic running along the tracks but has at-grade crossings. This category, typical for LRT, includes a variety of physical layouts: from curbed street medians to high-speed tracks in independent alignments with a few controlled crossings.

- Shared R/W or Category C,representing street operation in which track areas are also used by other traffic. (Vuchic 1981, p.385).

From the preceding sample of LRT definitions it is possible to see where the confusion arises in defining the term. All forms of urban rail transport can be placed upon a spectrum. Guided by such parameters as cost and vehicle capacity, they range from streetcar systems to suburban rail and rapid transit operations. Some definitions see LRT as something which encompasses everything from the streetcar to any fully segregated system that (for whatever reason) is not regarded as a suburban rail or rapid transit operation. Those definitions put forward by Glover (1980), Mass Transit ("LRT: By any name it´s a fast growing technology") and the Strathclyde Passenger Transport Executive (SPTE 1989) typify this view. An alternative approach to the subject is to regard LRT as something which occupies a narrower portion of the spectrum. Young (1989), for example, defines LRT as a form of rail transport which blends some of the advantages of the streetcar with those of systems at the higher end of the spectrum. At first glance this approach to a definition of LRT is more compelling, since it appears to offer an explanation as to why LRT is currently in vogue. It points towards a transportation tool that can offer some of the speed and capacity of a system such as the Toronto subway, and possesses the ability to use existing streets if necessary, in common with the streetcar.

Notwithstanding the confusion that arises from a sampling of LRT definitions, it is still possible to identify some common threads which run through those definitions. The first relates to cost. According to the definitions, a common feature of LRT is the use of "simple" stations and signalling systems, and "light-weight" vehicles - hence the "light" in "Light Rail Transit". That lightness, relative to the more ambitious rapid transit and suburban rail systems (so-called "heavy rail"), translates into lower costs, other things being equal. The ability to introduce a system with some of the attributes of a heavy rail service, but at a significantly lower cost, is part of LRT´s appeal.

A second feature shared by all LRT systems may be summed up in a single word: flexibility. Unlike streetcar and heavy rail systems, LRT utilises a variety of right-of-way categories, from street running to exclusive right-of-way. The above definition by Vuchic (1981) elaborates upon the categories that are available to the LRT planner. Their availability means that the implementation and operation of an LRT system is more flexible than other forms of rail transport. Coupled with the LRT vehicle's ability to negotiate sharper bends and steeper gradients than a conventional rail vehicle, it allows an LRT system to be easily incorporated into the existing built environment.

For a system to be classified as LRT, however, it must fall into more than one category of right-of-way. A rail operation which employs large amounts of street running is simply a streetcar system, and this applies, for example, to the network of "light rail" routes operated by the Toronto Transit Commission. On the other hand, neither can a rail operation which employs only exclusive right-of-way be regarded as an LRT system. This type of operation, typified by the Vancouver SkyTrain, can employ such features as high-level platforms at all stops/stations, automatic train control, and a third-rail power supply. Although LRT can employ all three right-of-way categories (and the ability to do so is one of its characteristics) it often relies upon the intermediate category, whereby all other traffic is excluded from the right-of-way, except at grade crossings.

Another guide to defining LRT is the vehicle itself, widely referred to as a Light Rail Vehicle (LRV), although each has a specific manufacturer's designation. Here, however, one runs into the danger of blurring the boundaries of LRT and streetcar systems. As a result, examining the attributes of a vehicle in order to determine whether or not the operation is LRT can present difficulties. It should remain simply a guide, to be used in conjunction with the common threads of cost and flexibility outlined above. Broadly speaking, though, the performance of an LRV, regardless of the parameter chosen, is superior to that of a streetcar.

In some cases it is possible to draw a sharp distinction between an LRV and a streetcar. The Canadian Light Rail Vehicle (CLRV) built by Hawker-Siddeley and operated by the Toronto Transit Commission is, notwithstanding its name, a streetcar. It can seat 46 people and accommodate a "crush load" of 132. By contrast, the Siemens-Duwag U2 LRVs which operate on the LRT system in Calgary provide seating for 64 passengers and can carry a maximum of 250. Unfortunately, not all contrasts are as sharp. The problem is that the improvements in technology which have facilitated the birth of LRT have at the same time been adapted by the streetcar. The design of Toronto´s CLRV, for instance, provided a stepping stone to the Articulated Canadian Light Rail Vehicle (ALRV). Although it operates on Toronto´s streetcar system it can seat 61 passengers and accommodate as many as 205 under crush load conditions.

Other vehicle parameters such as speed, braking performance, and acceleration can also be a source of confusion when defining LRT. Nevertheless, when used alongside the LRT characteristics of cost and flexibility, the performance of the vehicle in question can assist in the definition of "Light Rail Transit".

Although it is not the purpose of this thesis to produce a definitive definition of Light Rail Transit (and in view of the confusion clouding the subject it would be presumptuous to make any such claim), the above discussion does permit the production of a working definition. For this thesis, Light Rail Transit can be regarded as:

> an electrified urban passenger rail system, employing various combinations of completely unsegregated and wholly or partially segregated rights-of-way, largely (in many cases) reliant upon the latter. It uses medium-capacity vehicles which are not only capable of negotiating sharper bends and steeper gradients than a conventional rail vehicle, but on wholly or partially segregated sections of track they can approach the speed and comfort of such

vehicles. LRT represents a medium cost transport tool which is more expensive to implement than the traditional streetcar operation but considerably more affordable than a conventional heavy rail alternative.

Applying these criteria, and bearing in mind the geographical framework of the thesis, Light Rail Transit systems have been identified for the following cities:

<u>Canada</u>
Calgary
Edmonton
Vancouver* **

<u>United States</u>

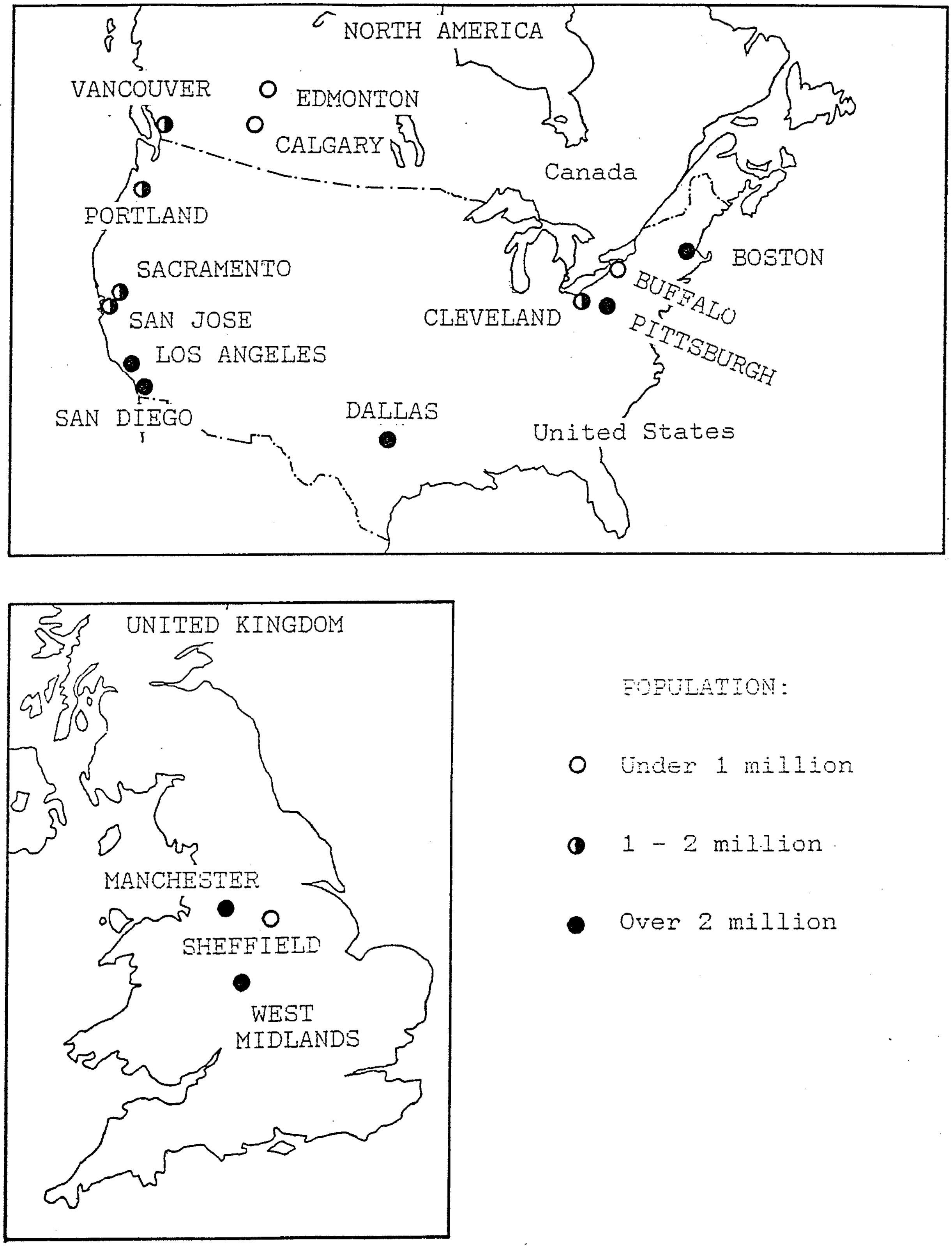
| | |
|---|---|
| Boston | Pittsburgh |
| Buffalo | Portland |
| Cleveland | Sacramento |
| Dallas* | San Diego |
| Los Angeles | San Jose |

<u>United Kingdom</u>
Manchester*
Sheffield*
West Midlands (Birmingham)*

* in the advanced planning/construction stage
** other technology choices also under consideration

Each system will be studied in the following chapter, with the exception of the Calgary LRT and the proposed Vancouver- Richmond Rapid Transit Project. They will be the subject of detailed analysis in Chapter Four and Chapter Five respectively. The British and North American cities in which LRT has found a niche (Figure 2) are all of substantial size, each with a population in excess of 500,000. The range is considerable, however, and some

Figure 2. Light Rail Transit in North America and the United Kingdom



cities such as Dallas, Greater Manchester and Los Angeles possess populations in excess of 2 million. Several other cities crop up in the literature of LRT from time to time, but their systems will not be included in this thesis, for the following reasons:

<u>Canada</u>

Toronto

- Much of Toronto´s "LRT" system is really a conventional streetcar operation, comprising a network of 45.6 route miles.
- The recently opened 1.3 mile "Harbourfront LRT" resembles a short LRT line, with its separate right-of-way along Queens Quay, but the Toronto Transit Commission will operate the route with streetcars.
- The Scarborough Rapid Transit (SRT) line, linking the Kennedy subway station with Scarborough city centre, uses an exclusive right-of-way and cannot be regarded as LRT.

Vancouver

- BC Transit´s SkyTrain, which connects Vancouver city centre with Burnaby, New Westminster, and Surrey, also employs an exclusive right-of-way.

<u>United States</u>

Newark

- The 4.3 mile Newark City Subway, which largely occupies the bed of the old Morris Canal, is the last vestige of the city´s streetcar system. Although the line has been substantially upgraded it still remains a streetcar operation.

Philadelphia

- The Southeastern Pennsylvania Transportation Authority (SEPTA) operates one of the largest streetcar systems in the world but none of its operation can be regarded as LRT.

San Francisco

- San Francisco´s Muni Metro system, although updated with new vehicles, stations, and track, remains a streetcar operation, with extensive street running beyond the Market Street Subway.

United Kingdom

London

- An important component in the redevelopment of Docklands, in the East End of London, has been the Docklands Light Railway (DLR). The railway is often referred to as an LRT system, but since it utilises exclusive right-of-way throughout, it will not be covered by this thesis.

Newcastle

- What was once referred to as "Britain´s first and last adventure in light rail" (Goldsack 1982), the Tyne & Wear Metro, is frequently labelled LRT. However, the system, which absorbed much of British Rail´s dilapidated suburban rail system in the Newcastle area, is virtually all grade-separated and cannot be included in this study of LRT.

Before turning to the next chapter, and a study of individual LRT systems in North America and the United Kingdom, the question of why LRT has been chosen in some cities over other transport "solutions" needs to be addressed.

## Why Light Rail Transit?

There are several reasons why LRT has been introduced into many cities (and why more schemes are in the planning and design stages) and they can be conveniently grouped under one of two headings. "General" reasons are those which apply to all urban rail systems, including LRT. The principal advantages of LRT in this category are: the ability to reduce road traffic congestion; the environmental benefits; and the ability of LRT to act as a catalyst in urban renewal schemes. Additionally, there are those advantages which are "specific" to LRT and which go a long way to explaining why several cities have opted for this transport tool. The two principal advantages in this category are: the "flexibility" of LRT; and its cost-effectiveness as a transport "solution". Since these "specific" factors helped to define "LRT" in the previous section they will not be expounded upon here.

One of the biggest headaches facing residents and city planners alike is the road congestion that afflicts city streets and freeways. The problem essentially has two components. Part of the problem stems from the fact that a significant portion of our urban road system was designed in an era when large-scale car ownership did not exist. Consequently, many of the streets are simply not "built" for current traffic levels. Furthermore, where infrastructure has been purposely built for large volumes of road traffic (in particular, the limited access freeway) its advantages have been quickly negated by rising traffic levels. Quite simply, it has become a victim of its own success. Any trend towards increased car ownership simply exacerbates the problem.

LRT schemes, along with other rail-based projects, promise to reduce road congestion by offering the motorist an alternate and desirable means of travel. In the West Midlands, for example, "traffic peaks are now occupying a greater proportion of the day, with traffic jams moving quickly to grid-lock whenever the normal flow is disrupted". Consequently, one of the objectives of the "Midland Metro" LRT is "to offer the traveller a real and attractive alternative to battling through traffic congestion" (Tarr 1989, pp.2,4). In Calgary, LRT was selected for the so-called "South Corridor" in an attempt to solve a "major deficiency" in transportation capacity along that axis. Given the existing political and financial constraints, it was believed that road improvements could not accommodate travel demand in the long term (Kuyt & Hemstock 1978, p.7). The same is true of Portland, where "MAX" ("Metropolitan Area Express") is part of a balanced transportation system, designed to "reduce air pollution and relieve traffic congestion" (Tri-Met 1988b). The first "MAX" line (and currently the only line, although more are proposed) was built between Portland and Gresham in order to relieve the most congested transportation corridor in the metropolitan region: the Banfield Freeway (Interstate 84).

A strong driving force behind the formulation and implementation of plans for urban rail systems, is the desire to reduce vehicle emissions, and car emissions in particular. The burning of fossil fuels by transportation vehicles plays a large part in the build up of "greenhouse" gases in the atmosphere (Transportation Research Board 1990). Those gases include methane ($CH_4$), carbon dioxide ($CO_2$), chlorofluorocarbons (CFCs) and nitrous oxide ($N_2O$). According to the Canadian Urban Transit Association, the average car (per year) produces 34.4 kgs of hydrocarbons, 4029.3 kgs of $CO_2$, and 29.6 kgs of $N_2O$. In 1989, there were 12,811,318 cars registered in Canada. A 1985 inventory completed by Environment Canada revealed that of the 1.9 million tonnes of nitrogen oxide produced by all Canadian sources, 912,000 tonnes (48%) could be attributed to the automobile (CUTA 1990; Statistics Canada 1990).

A "green" urban transport policy seeks to reduce vehicle emissions through the promotion of "communal" means of movement (public transport) over the excessive use of low-occupancy vehicles (cars) (Lowe 1989, p.28). Vehicle emissions/passenger-km are significantly reduced through the use of public transport and are reduced still further if the public transport vehicle is an electric one. Therefore, green urban transport policy favours the use of electrified rail systems such as Light Rail Transit. One of the objectives of "Midland Metro", for example, is "to improve the environment of the area [the West Midlands] by offering transport which is totally free of noxious fumes or emissions" (Tarr 1989, p.4). Similar sentiments exist in Manchester, where the "green" benefits of the "Metrolink" LRT scheme have been extolled. Councillor Jack Flanagan, Chair of the Greater Manchester Passenger Transport Authority's Metrolink Members' Working Party, had this to say about the LRT system:

> Once Metrolink becomes operational early in 1992 we will be offering thousands upon thousands of motorists the alternative to travel in and around the city centre in a clean environment. Therefore it is important that the motorists get the message. They can each play their part in reducing pollution by leaving their cars at home and by starting to use a new, fast and efficient means of public transport (GMPTE 1990).

At this stage, however, a note of caution should be injected into the discussion. LRT is not a utopian solution to urban transport problems. LRT vehicles do remove harmful emissions from the city street, but the power station that provides the electricity is still a potent source of pollution, if fossil fuels are burnt. Although it is true that alternatives exist, they also come with their own "price tag". Atomic energy produces radioactive waste material, and the production of hydro electric power involves the flooding of land and interferes with the flow of rivers. Both forms of energy, therefore, are shrouded in controversy.

The nagging question also remains: "to what degree can motorists be induced to leave their cars at home and use LRT?" Despite these cautionary notes, however, the fact remains that the widespread use of rail transport will reduce harmful emissions into the atmosphere, and this is one of the forces behind the push for LRT.

A third advantage of urban rail projects is their ability to act as an urban renewal catalyst, attracting private investment to the route. Although this is particularly marked at station sites, a new rail transport project can help to regenerate all of the area in question. In the case of Buffalo´s "Metro Rail" LRT, the desire to bolster a flagging western New York state economy was a prime reason for the implementation of the city´s LRT system. The Niagara Frontier Transportation Authority once stated: "the reasons to build this system are many...[but] perhaps the greatest will be the dramatic changes that will come about to enhance the area´s economic vitality" (NFTA 1985, p.4). In Sheffield, the second phase of "Supertram" will serve the Lower Don Valley, "to act as a catalyst in the regeneration of this area" (Jackson 1990). A similar scenario exists in Portland with respect to the "Metropolitan Area Express". It is claimed that some $800 million (US) in development has taken place along the 15 mile route since construction began, and another $400 million is "on the drawing boards" (Tri-Met 1990a).

Light Rail Transit is a transportation tool which promises to reduce traffic congestion, to enhance urban air quality, and to attract economic activity, all at a cost significantly lower than conventional rail alternatives. To couple this with the flexibility which is unique to LRT (and which is responsible in part for the lower implementation costs of LRT projects) provides a powerful incentive for the sponsorship of LRT.

# CHAPTER THREE:

# A SURVEY OF NORTH AMERICAN AND BRITISH

# LIGHT RAIL TRANSIT SYSTEMS

The primary purpose of this chapter is to determine the extent to which LRT systems in North America and the United Kingdom have employed, or propose to employ, existing rail rights-of-way. This will be achieved by examining each of the sixteen systems listed in the previous chapter, with the exception of those for Calgary and Vancouver, which will be dealt with in Chapters Four and Five. Each entry includes, wherever possible, background information, future plans and a map of the system. Following the system survey a listing is included, for information purposes, of those urban centres in North America and the United Kingdom which have expressed a need for some form of LRT system.

## Canada

### Edmonton

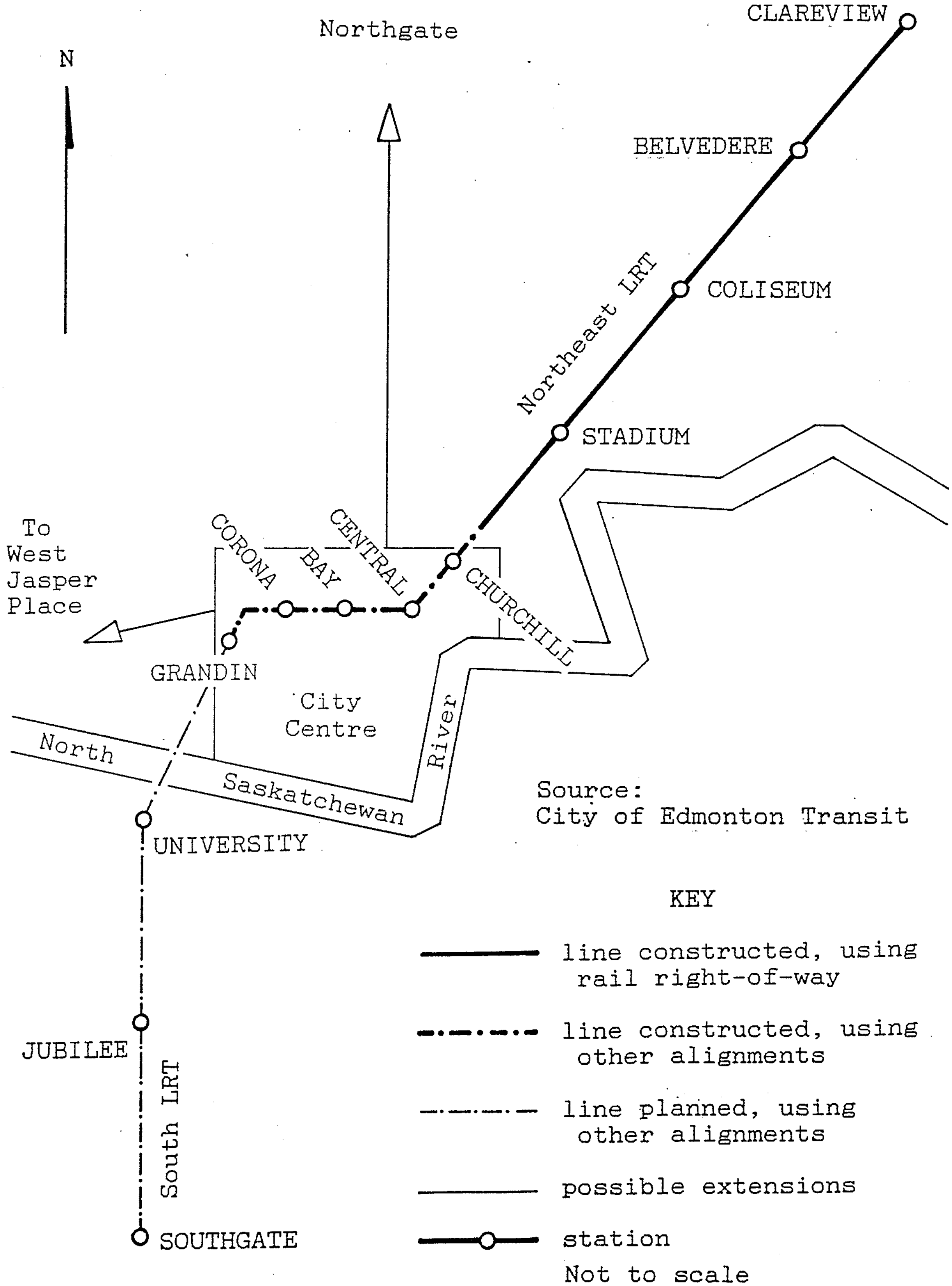
In April 1978, the city of Edmonton officially opened LRT Route 101, in time for the 1978 Commonwealth Games, and became the first city in North America to introduce a brand new light rail system. The reason why Edmonton decided to embark upon the construction of an LRT system can be found in the tremendous growth experienced by the city after the Second World War. In particular, Edmonton (along with Calgary) grew rapidly in the 1970´s, as a beneficiary of the western Canadian oil boom. Edmonton experienced an annual growth rate of appoximately 2% throughout much of the 1970´s and in excess of 5% per annum in the early 1980´s, until the 1982 "bust". As a result of prolonged and marked growth Edmonton began to experience severe transportation problems, particularly with the daily commute between the city centre and the northeast suburbs. Since Edmonton possesses a densely-developed and viable city centre there is a large concentration of employment there and a concomitantly large demand for commuter travel (Cervero 1985, pp. 635-636).

In an effort to solve Edmonton´s transportation problems the city decided to redress (albeit partially) the imbalance that favoured the private car, opting for a policy of "balanced transportation" (Park 1978, p.10). On the one hand, it was thought that a freeway system would only provide a temporary solution (quickly becoming clogged with cars) and on the other hand, an increase in the supply of transit buses would only add to the congestion. Spurred by a healthy support of public transport (between 1975 and 1979 patronage of Edmonton transit had risen by 40%, whilst the city´s population over the same period had increased by 25%) the city of Edmonton selected LRT (Edmonton Transit, p.5).

The first phase of the project to be opened was the 4.5 mile/7.2 kilometre segment between Central and

Belvedere stations, known as the Northeast line, or Route 101 (Figure 3). This alignment was chosen because of an identified need to improve transportation facilities between the city centre and the northeast suburbs, and because a CN Rail (Canadian National Railways) right-of-way offered a "ready-made" route (Park 1978, p.13). Of the 4.5 miles/7.2 kilometres opened in April 1978, 0.94 miles/1.5 kilometres are underground and 3.6 miles/5.7 kilometres share the CN Rail alignment. A further 1.4 miles/2.2 kilometres of surface line, again utilizing the CN right-of-way, were opened in April 1981, with the extension of service to Clareview station. The 1983 opening of Bay and Corona stations added another 0.6 miles/0.9 kilometres to the underground portion of the LRT system. In September 1989 another underground station, Grandin, was opened for service. Grandin station is part of a 1.5 mile/2.4 kilometre extension from the city centre to the University of Alberta. Apart from a bridge over the North Saskatchewan River the extension is being constructed underground. University station is scheduled to open in September 1992. Known as the South LRT (although it is physically a continuation of the Northeast line) it is planned to continue the southward push to Jubilee and Southgate. If the necessary funding is forthcoming then Jubilee station could be opened in 1996 and LRT trains could reach

Figure 3. Edmonton LRT - System Map



Southgate by 1999. There are also plans for additional lines, to serve West Jasper Place and Northgate, although a firm timetable has yet to be decided upon.

During the first four years of its operation, the number of passengers using LRT increased from 4.265 million to 6.820 million, rising to 7.200 million by 1983. Total ridership for 1989 was 6.405 million. Along the LRT corridor Edmonton has been successful in promoting the use of public transport, particularly around the outlying station areas, where mode shifts to public transport have been in the order of 7% (Cervero 1985, pp.645 - 647). However, concern has been raised with regards to the cost of Edmonton´s LRT, and LRT systems in general. Research has shown that LRT systems require significantly higher capital outlays than the bus systems that they replace (although this is perhaps not surprising) and also cost significantly more to operate (Gomez-Ibanez 1985, p.349). Furthermore, on a per capita basis, total public transport ridership in Edmonton has fallen during the LRT era when compared to the pre-LRT period. Population gains have outstripped ridership gains and it is clear that Edmonton has yet to solve the transportation problems that gave rise to LRT in the first place (Cervero 1985, p.645).

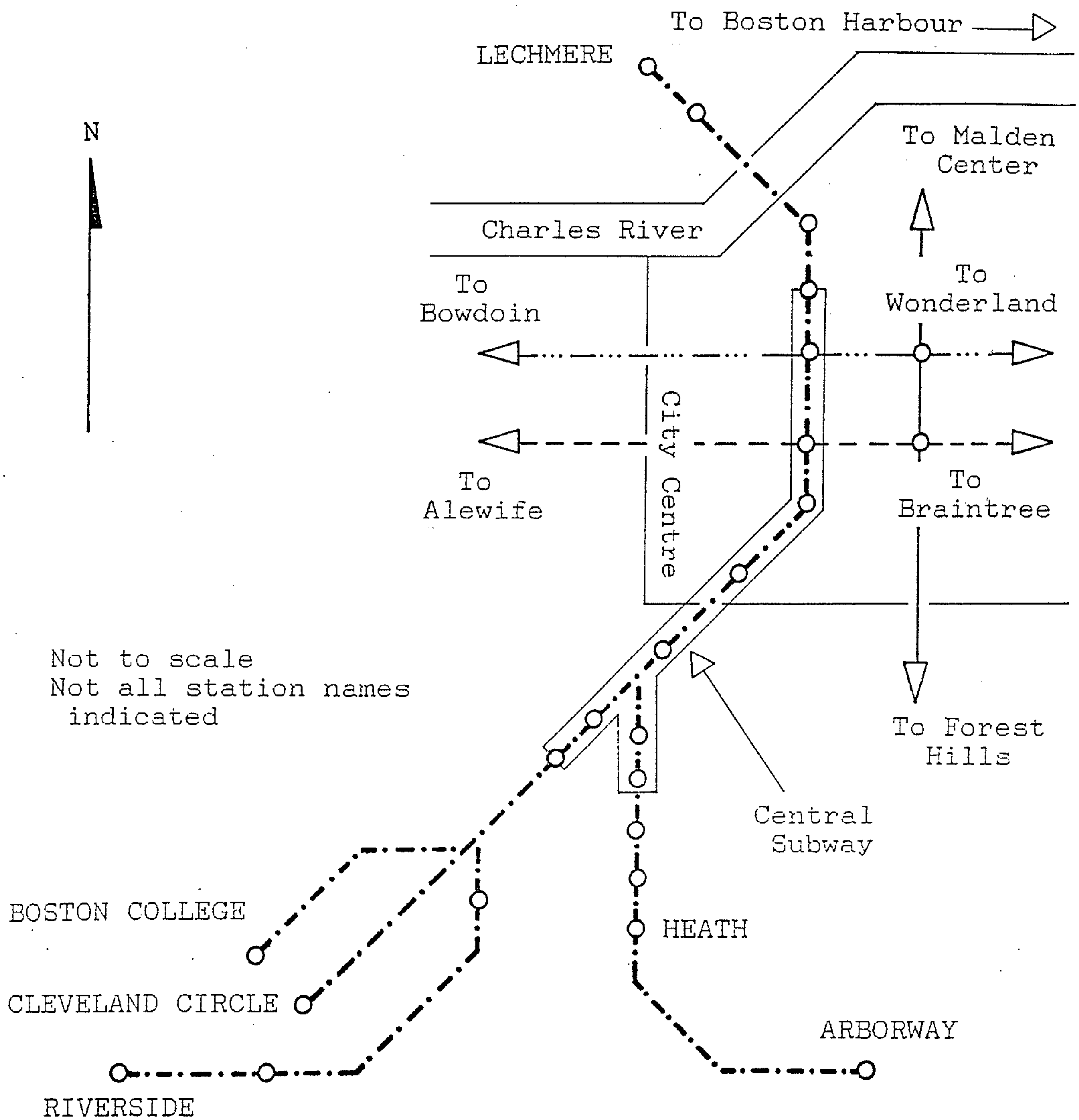
## United States

### Boston

Much of the interest expressed in LRT has been focussed upon new systems, but in the eastern United States a handful of systems exist which date back to the original streetcar era. Thanks to major modernisation programmes and strong financial commitment, significant portions of the old surface rail networks in Boston, Cleveland and Pittsburgh have effectively been turned into brand new LRT systems. The reasons why these older systems survived can mainly be attributed to the large population densities and strong commitment to public transport that have existed in such cities as Boston. In addition, most of the surviving systems (whether existing today as LRT or as modern streetcar systems) possessed operational advantages over buses using public streets. The streetcar system in Boston, for example, made use of a long subway alignment in the congested city centre (Middleton 1986, pp.71-72).

In addition to suburban rail and rapid transit operations, the Massachusetts Bay Transportation Authority (MBTA) operates the Green Line LRT (Figure 4), a remnant of Boston´s old streetcar system. The 35 mile/56 kilometre line consists of five branches - to Lechmere, Boston College, Cleveland Circle, Riverside and Arborway - feeding into a central subway, part of which is the oldest transit

Figure 4. Boston "Green Line" LRT - System Map




Source: Parsons Brinckerhoff Quade and Douglas 1989, p.2

KEY

- line constructed, without using rail right-of-way
- Blue Line rapid transit route
- Orange Line rapid transit route
- Red Line rapid transit route
- station

tunnel in the United States. Beyond the city centre subway, alignment is a combination of dedicated right-of-way (Riverside), partial reservation along the street (Boston College and Cleveland Circle) and elevated (Lechmere). In addition to extensive renovations of the 5 mile/8 kilometre subway, recent projects have included work on the Arborway branch. This section of line, closed for a road rebuilding project, was reopened as far as Heath in late 1989 using a partially reserved alignment. The out of service portion from Heath to Arborway currently consists of rail laid along the street.

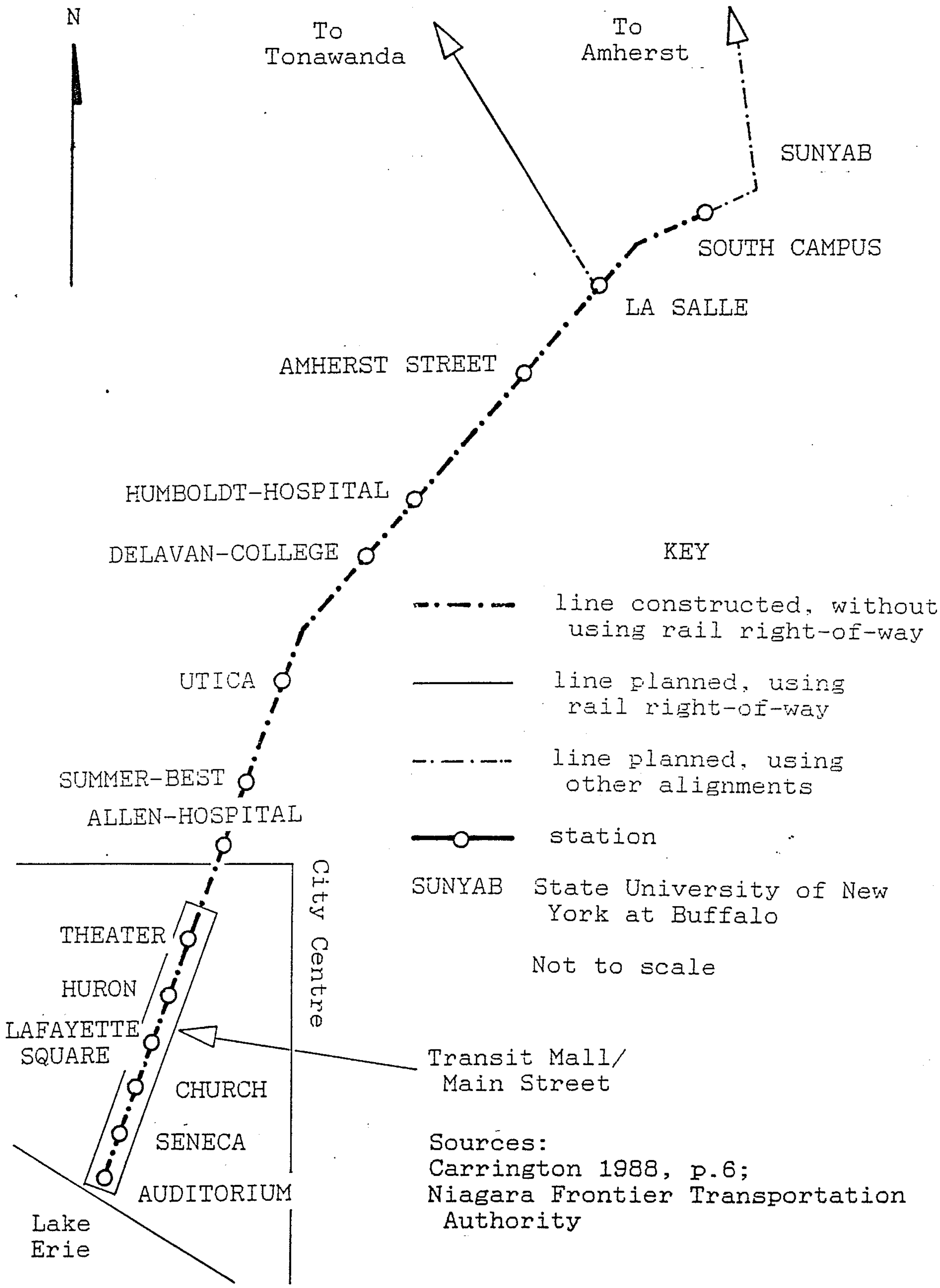
Other improvements have included a new LRV maintenance depot, opened at Riverside in 1976, track and station modernisation, and an order for new LRVs. The new vehicles were constructed by Kinki Sharyo of Japan and will allow MBTA to start withdrawing its Boeing LRVs. The Boeing Standard Light Rail Vehicles (SLRVs) have proved difficult and expensive to maintain and MBTA refused delivery of the final 40 vehicles of a 170 vehicle order, opting instead for a $35 million (US) cash refund and $27 million in spare parts (Kizzia 1980c, p.21). Boston has no plans to expand its LRT system (with new initiatives focussed upon MBTA´s Orange, Blue and Red rapid transit lines, and upon its commuter rail operations) although modernisation of the existing system continues.

## Buffalo

In the late 1960s, under the direction of the newly formed Niagara Frontier Transportation Authority (NFTA), planning took place for transportation improvements in Buffalo´s principal urban corridor - along Main Street between the Buffalo city centre and the suburb of Amherst (NFTAb, p.2)(Figure 5). The original 1972 plan called for a 12.5 mile/20 kilometre "heavy rail" ("rapid transit") line, with a subway in the city centre and an elevated alignment for the rest of the route. Objections to both the underground and elevated portions of the route plunged NFTA into a long and controversial planning process. The experience gained through that planning process has made NFTA a leading expert in developing community participation in transit planning. On the one hand, the city centre merchants objected to the disruption and loss of sales that would stem from tunnelling and on the other hand, suburban residents objected to the idea of elevated tracks, which they perceived would be visually obtrusive and noisy (Carrington 1988, p.9).

Cost was also an objection, particularly in the eyes of the federal government, which backed out of the project. Instead of abandoning its plans NFTA embarked upon a series of community meetings - ultimately establishing firm relations with the Community Rapid Transit Interaction

Figure 5. Buffalo "Metro Rail" LRT - System Map




Sources:
Carrington 1988, p.6;
Niagara Frontier Transportation Authority

Panel - and hammered out a plan that was acceptable to the opposition. The new plan called for LRT, not heavy rail rapid transit, with a surface transit mall in the city centre and twin tunnels running under Main Street for the suburban alignment (Carrington 1988, pp.9,11; NFTA 1985, p.5). The substitution of a tunnel for the elevated alignment increased the cost of the project and therefore the length of the line had to be reduced. The original 12.5 mile/20 kilometre route from the city centre to Amherst became a 6.4 mile/10.2 kilometre line truncated at the South Campus of State University (NFTAb, p.2). This was regarded as the "minimum viable" length for the project to succeed and the Urban Mass Transportation Administration (UMTA) grudgingly released the construction funds necessary for the $550 million (US) line (Carrington 1988, p.11).

Following UMTA funding approval in 1978, construction began in April 1979, and a limited public service (along the transit mall) was offered from the 9th October, 1984. A full service between Auditorium Station in the city centre and Amherst Street Station in the suburbs was started in May 1985, and extended to South Campus by November of the following year.

In terms of its construction Buffalo's "Metro Rail" can be divided into three segments. The city centre transit mall is served by six surface stations and at 1.2 miles/1.9

kilometres is one of the longest transit-pedestrian malls in the world (NFTAb, p.3). The mall is a key element in the Metro Rail project and is regarded as a vital component in the economic revitalisation of Buffalo's city centre. North of Theater Station the line descends underground. The first 1.7 mile/2.7 kilometre section includes three stations and was constructed using the cut-and-cover method, a normal practice for rail tunnels situated near to the surface. The final section of the route, the 3.5 miles/5.6 kilometres to South Campus was constructed through rock using a tunnel boring machine. The combination of a surface operated transit mall and an underground suburban route is unusual for an LRT system.

As a measure of Metro Rail's success, much of the city centre redevelopment and investment currently enjoyed by Buffalo is "directly traceable to the commitment and progress" that the LRT line represents. However, Metro Rail, thanks to the truncation of the original plan, has not been able to fulfill the important objective of uniting the two campuses of State University (Carrington 1988, pp.11,13). A proposed extension to Amherst would resolve this problem. Also under consideration is a 4 mile/6.4 kilometre branch to Tonawanda, using an existing rail right-of-way. In the original Metro Rail project provision was made at La Salle station for the "Tonawanda Turnout", a junction to provide access to the Conrail right-of-way. Firm commitments have yet to be made for the Amherst and Tonawanda extensions, known collectively as the "Northern Corridor" (NFTA 1985, p.21).

## Cleveland

In common with Boston, the city of Cleveland has retained part of its original surface rail network and subsequently converted it into a modern LRT system. The combination of a separate right-of-way in the city centre and long suburban alignments in central street reservations, allowed the Shaker Heights Rapid Transit (SHRT) to survive the wholesale closure of the city´s streetcar routes (Carrington 1988, p.6).

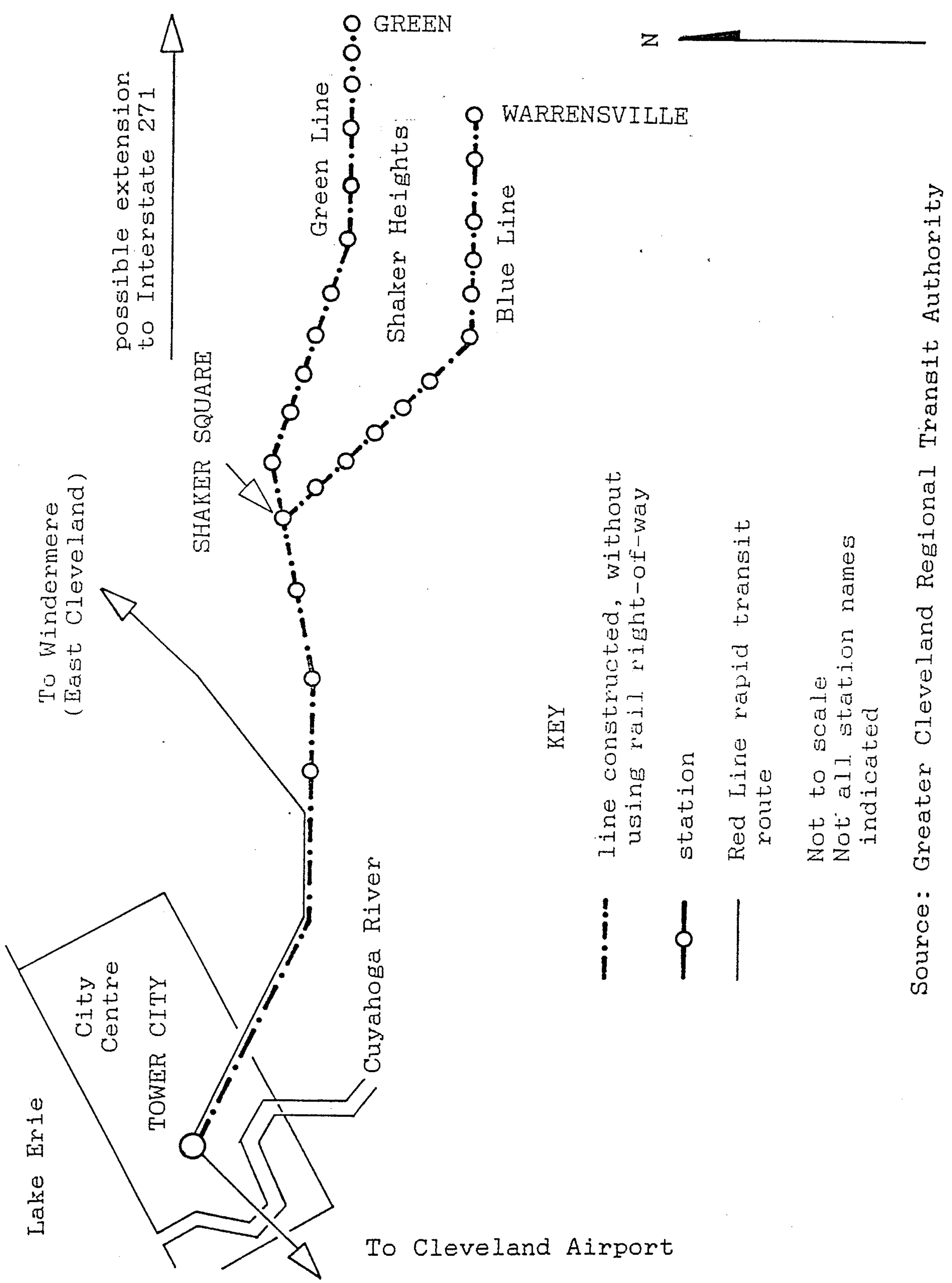
The Shaker Heights line was opened in 1920 as an integral part of the development of Shaker Heights, now a wealthy inner suburb of Cleveland. Thanks to the "Rapid", Shaker Heights has long enjoyed a close connection with the city centre (Carrington 1988, p.13) and has clung tenaciously to the line. In 1975, the Cleveland Transit System (CTS) merged with Shaker Heights Rapid Transit, along with several other regional agencies, to form the Greater Cleveland Regional Transit Authority (RTA). In return for merging itself into the newly founded authority, Shaker Heights Rapid Transit obtained a promise that the line would be rebuilt, that new cars would be ordered, and that the service would never be replaced by buses (Kizzia 1980a, p.46). Shaker Heights Rapid Transit officials claimed that buses could not match the speeds attained by their rapid transit vehicles (Silver 1975, p.12).

The promises were kept and between 1980-1982 a $100 million (US) rebuilding of the system was undertaken, one section at a time. Stations were rebuilt, track and overhead electrical equipment were replaced and new LRV´s (from Breda of Italy) were purchased. The Shaker lines were renamed by the RTA as the Green (Shaker Boulevard) and Blue (Van Aiken) lines and the system can be divided into four segments (Figure 6). On the approach to the city centre the Green and Blue lines share track and electrical equipment for 3 miles/4.8 kilometres with the RTA Red Line. This is a heavy rail line (opened in 1955) serving East Cleveland and the International Airport. For another 3 miles/4.8 kilometres the Green and Blue lines run together, and at Shaker Square they separate, with the 3.8 mile/6.1 kilometre Green branch running to Green Station and the Blue branch extending 3.3 miles/5.3 kilometres to Warrensville.

Given the stable population of Shaker Heights and its already high commitment to public transport, there has been little room for the Cleveland LRT to boost ridership.

Figure 6. Cleveland "Green Line/Blue Line" LRT - System Map





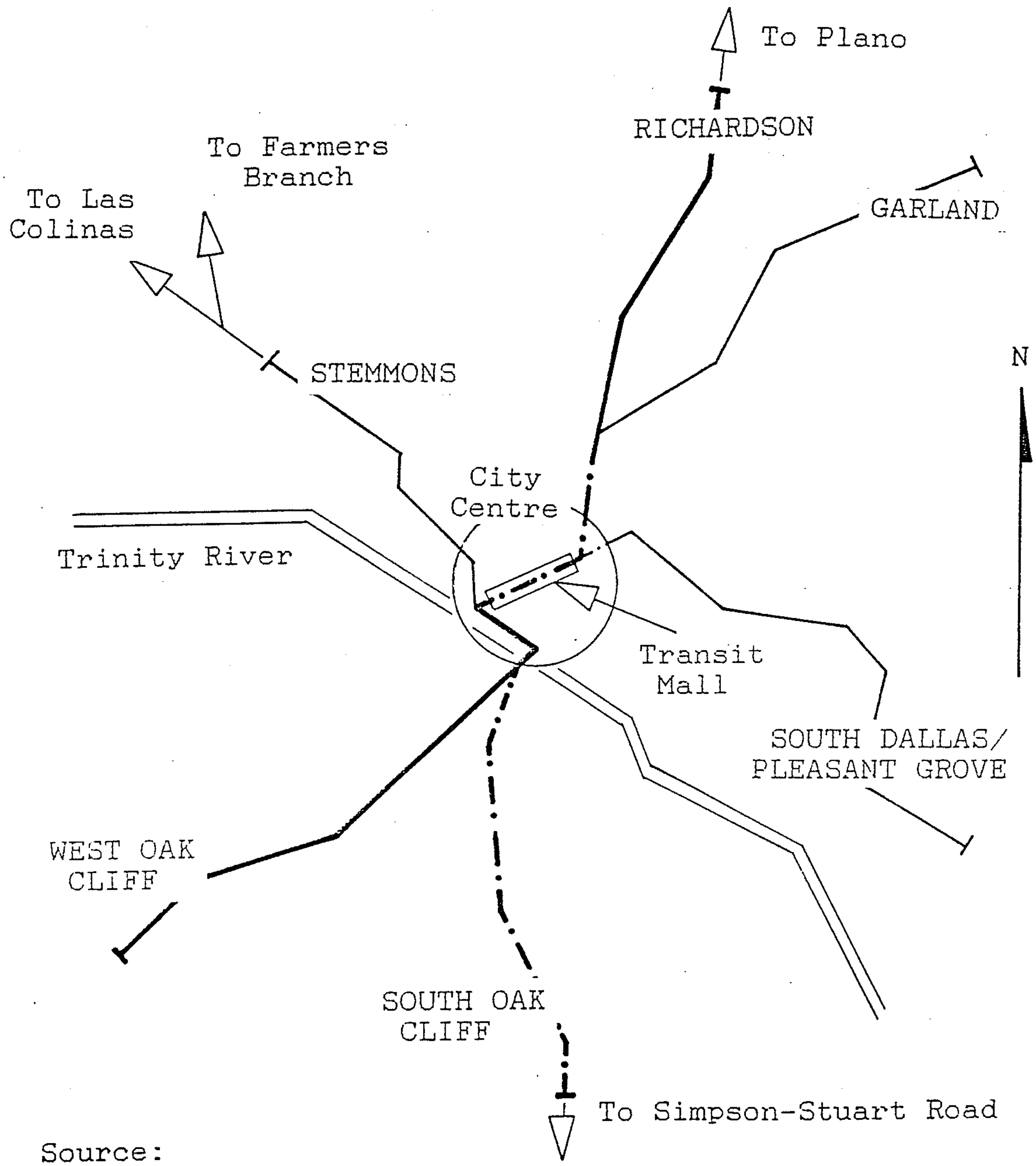
However, it is important to note that despite the long disruption during reconstruction and a tripling of fares, before and after passenger counts have been almost constant. Excess capacity still exists though, and of the 48 LRV´s ordered from Breda only 28 are currently needed to cover rush hour services (Carrington 1988, p.13). There are plans to expand the LRT and heavy rail rapid transit systems, although final decisions have yet to be made. One proposal calls for a $39 million (US), 1.8 mile/2.9 kilometre extension of the Green Line to Interstate 271. According to Leonard Ronis, general manager of RTA (in 1980) "the [economic] future of [Cleveland] depends on having a complete rapid transit system, not a partial one" (Kizzia 1980a, p.48).

## Dallas

Faced with severe traffic congestion along the roads and freeways of Dallas, the city´s residents voted in 1983 in favour of a sales tax increase to raise money for mass transit. It was originally proposed to build a 160 mile/256 kilometre rail system over a 27 year period, as part of an ambitious $8.7 billion (US) regional transit plan drawn up by Dallas Area Rapid Transit (DART). In the interim, however, reality has eroded the ambitiousness of the plans. Even a scaled down proposal for a 93 mile/149 kilometre regional rail system was defeated in a 1988 DART bond referendum. There was community-wide consensus that if a transit plan was to be approved then it would have to be more affordable, provide some immediate relief to transport problems, and look more realistically at the economic future of Dallas in the "post energy-boom era". Consequently, in August, 1988, DART decided to embark upon a programme of "New Directions", outlined in its June 1989 "Transit System Plan" (DART 1989, p.3).

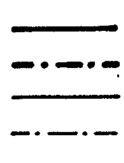
The DART "Transit System Plan" is "designed to provide a balanced combination of transit services and facilities custom-tailored to meet the range of mobility needs throughout a growing region." In addition to a 67 mile/107 kilometre LRT system, the $2.4 billion (US) plan calls for 18 miles/28.8 kilometres of suburban rail, and 37 miles/59 kilometres of high occupancy vehicle (HOV) lanes within existing freeways, along with improvements to regional bus and paratransit services (DART 1989, p.10). It is intended that all elements of the plan will be in place within 20 years. The LRT system will consist of six routes radiating from the city centre to serve the districts of Richardson, Garland, South Dallas/Pleasant Grove, South Oak Cliff, West Oak Cliff and Stemmons (Figure 7). A "substantial" portion of this network will be built in existing railway rights-of-way. Planning and residual

Figure 7. Dallas LRT - System Map




Source:
Dallas Area Rapid Transit

KEY



Starter Line, using rail right-of-way
Starter Line, using other alignments
Planned extension, using rail right-of-way
Planned extension, using other alignments
Possible future extension

Not to scale

land acquisition for a 20 mile/32 kilometre "starter line" are now under way and a formal groundbreaking ceremony was scheduled for 17th January, 1992. The starter line will consist of branches serving South and West Oak Cliff, a city centre transit mall and a branch north to Richardson. Revenue service is scheduled to begin in 1996 (Middleton 1990, p.55; "Dallas awards first light rail contract", p.23; Johnson 1991).

In addition to the initial 20 mile/32 kilometre system, a further 35 miles/56 kilometres of LRT is planned for construction during the period 1997-2005, with the balance of the proposed system to be in place by the year 2010. Possible additions to the LRT network include a continuation of the Richardson branch to Plano, an extension of the South Oak Cliff route to Simpson- Stuart Road, and the provision of service beyond Stemmons to Farmers Branch and Las Colinas.

## Los Angeles

In 1940 the city of Los Angeles completed the limited access Arroyo Seco Parkway, a high speed highway linking the city centre of Los Angeles with Pasadena. That single 6 mile/9.6 kilometre freeway was the prototype for a California freeway system that now totals 4,047 miles. In parallel with the growth of its freeway system the population of California has grown from 6.9 million in 1940 to just under 30 million in 1990. Today 12% of all Americans live in California. In part because of the need to accommodate this population growth rate, and in part because of the decentralising effect of the freeway upon urban development, California has become remarkable for the sheer areal extent of its low density residential suburbs. Los Angeles, for example, has been referred to as "91 suburbs in search of a city" (Rawling 1990, p.650). Throughout much of the period in which this remarkable growth has occurred, the state´s passenger rail systems have declined. The almost unlimited freedom of the private car simply eclipsed public transportation and led to the demise of systems like the Pacific Electric Railway.

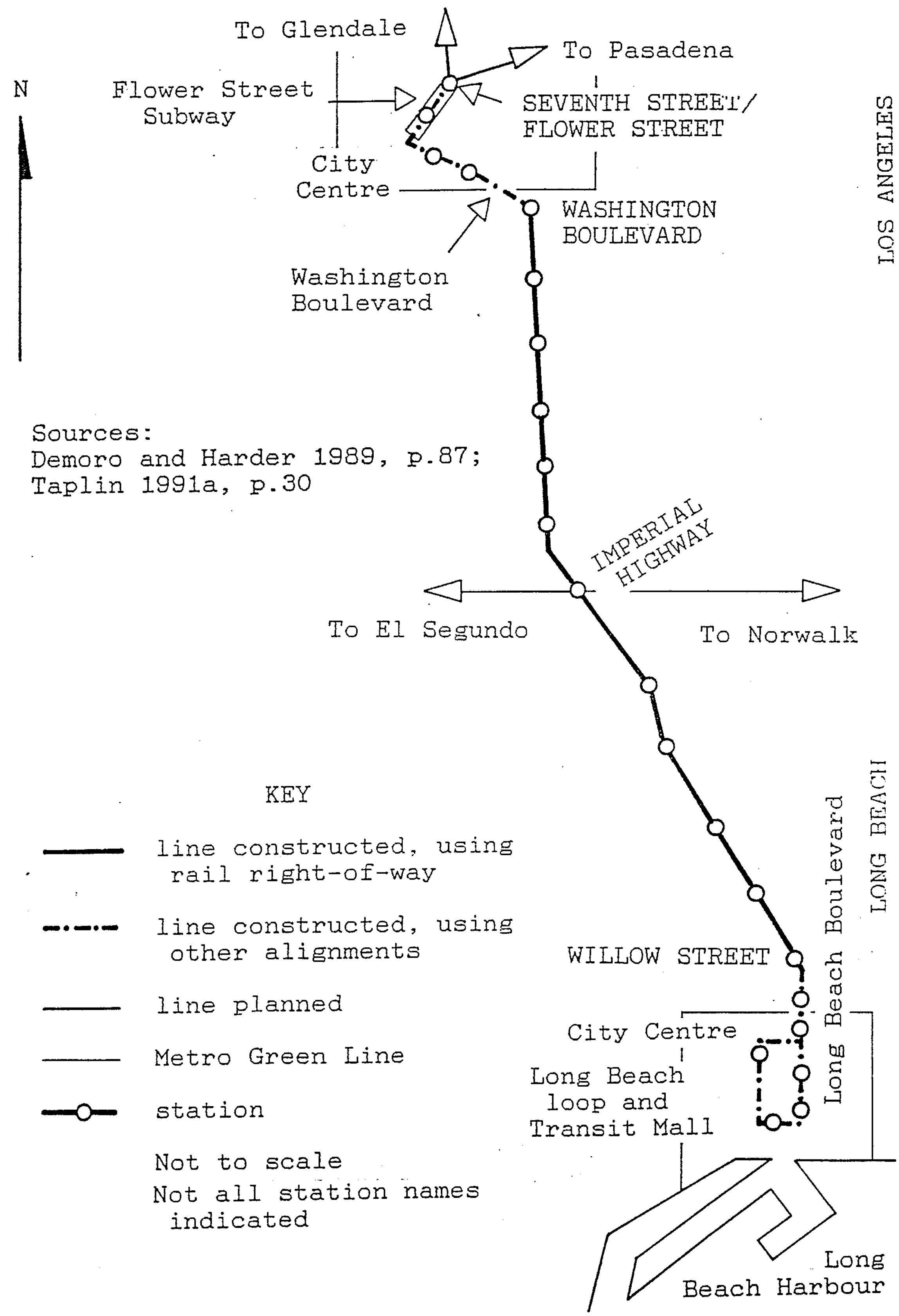
The last few decades, however, have witnessed the automobile begin to fall from grace as California´s prime transportation tool. Even before the Pacific Electric closed for business in 1961, and the last train operated along a Los Angeles street in 1963, it was realised that in the city centre of Los Angeles, 28% of the land was occupied by roads and freeways and another 38% by loading zones and parking spaces. At some point in the future the construction of new freeways and the expansion of existing ones would have to cease. The city would simply run out of space (Taplin 1991a, p.27). Because of the now widely recognised destructive effects of new urban freeway construction, coupled with its prohibitive cost, road building in Los Angeles has fallen far behind rising traffic levels. Furthermore, despite the strict emission control standards that exist in California, the Los Angeles area has the poorest air quality in the United States, stemming in large part from automobile usage (Middleton 1991a, p.29). The automobile can no longer single-handedly cater for the transportation requirements of Los Angeles without destroying the city that it purports to serve.

Against this background the Los Angeles County Transportation Commission (LACTC) began planning in the 1970´s for the return of urban passenger rail to the county. In 1980 a referendum was held in which voters approved "Proposition A", a 0.5% increase in the county sales tax, in order to raise money for transportation projects. An ambitious transit plan calls for the construction of a 150 mile/240 kilometre, largely LRT, rail system. From a "shopping list" that identified 13 corridors with the potential for LRT, the LACTC in 1982 selected the Los Angeles-Long Beach corridor for its starter line. The final choice was made on the basis of cost, the availability of right-of-way, and potential ridership.

Ironically, the Metro Blue Line, as the Los Angeles-Long Beach LRT is officially referred to, largely duplicates the alignment used by the Pacific Electric's interurban line to Long Beach, the last Pacific Electric route to be closed (Figure 8). The 22 mile/35.2 kilometre Blue Line LRT makes extensive use of a Southern Pacific rail right-of-way (the Pacific Electric Railway was owned by the Southern Pacific) under an arrangement which saw the freight traffic routed elsewhere. At Willow Street the LRT leaves the rail right-of-way and loops around the streets of Long Beach, including a reserved right-of-way in the centre of Long Beach Boulevard and a short LRT/bus transit mall on First Street. In Los Angeles, the Blue Line leaves the rail right-of-way at Washington Boulevard and uses city streets to reach the short subway section in Flower Street where the line terminates at the Seventh Street-Flower Street station. The official opening of the Blue Line took place on 14th July, 1990, with the Flower Street subway and Long Beach loop coming into use the following year.

In 1984 a second LRT route was selected, the Green Line from Norwalk to El Segundo, but it was subsequently recommended that the line lent itself to more advanced technology. A fully automated system is scheduled to accept passengers in 1994. The next LRT line planned is an extension of the Blue Line to Pasadena, which should be open in 1996, and a second Blue Line extension, to

Figure 8. Los Angeles "Metro Blue Line" LRT - System Map



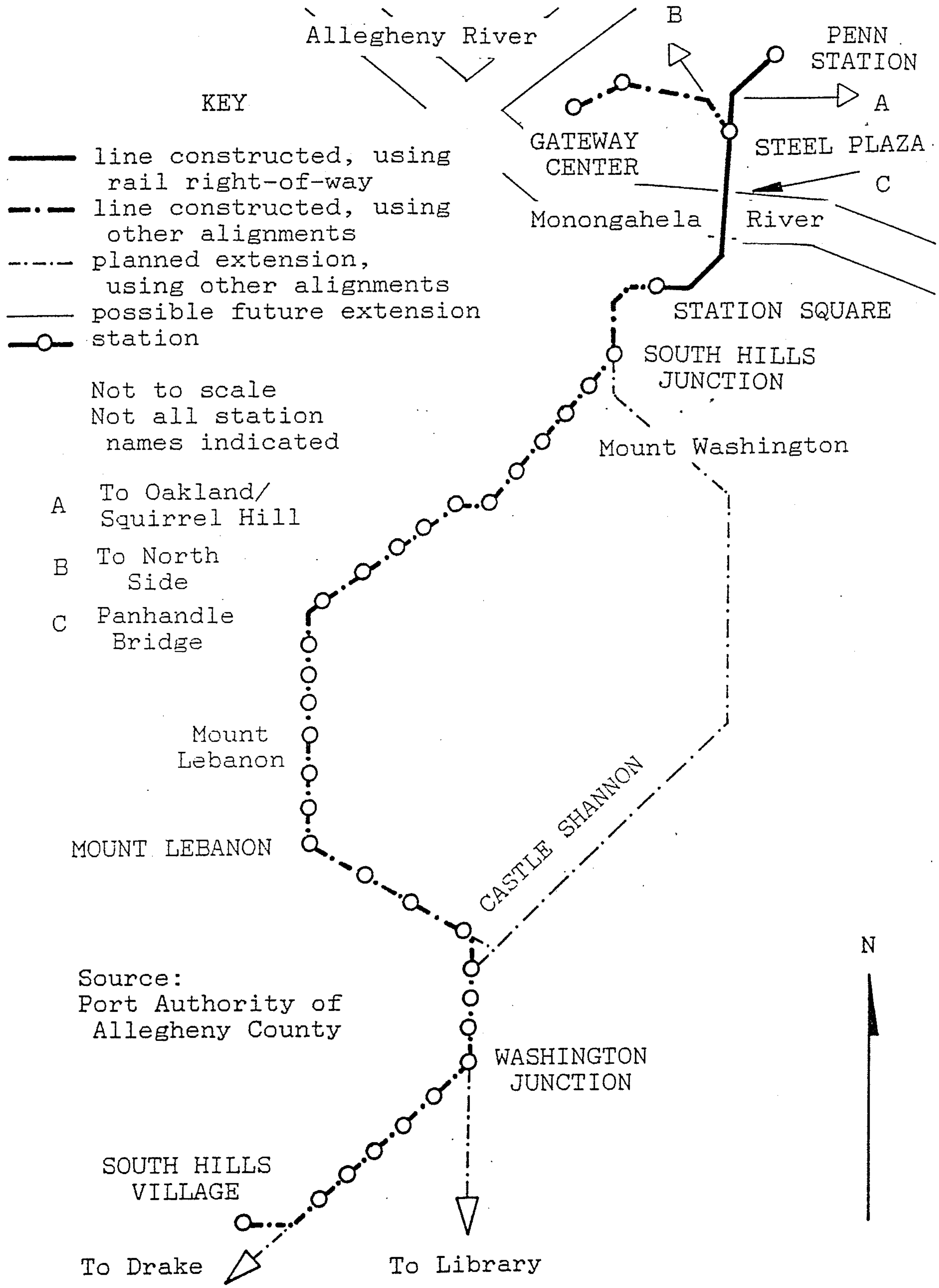
Glendale, is also in the planning stages.

## Pittsburgh

At one time Pittsburgh was the centre for an extensive streetcar and interurban system, but by the 1960s only the lines south of the Monongahela River were still in use. Their survival is largely attributed to the 3,500 ft (1,075m) Mount Washington tunnel access to the city centre, which allowed the streetcar system to alleviate much of the pressure on the existing road system (Carrington 1988, p.7). In the 1960s, the newly formed Port Authority of Allegheny County (PAT) entertained the idea of building "Skybus" (a rubber-tyred guideway system, similar to the French VAL system used in Lille) to enhance transportation between the Pittsburgh city centre and South Hills. Following the ultimate rejection of Skybus, PAT decided to embark upon a programme of upgrading half of its existing streetcar system to LRT.

Stage 1 of PAT´s LRT project was a combination of new construction, rehabilitation of existing railway facilities, and reconstruction of sections of the old South Hills streetcar system. A total network of 10.5 miles/18.8 kilometres of LRT has been created from the 26 mile/41.6 kilometre South Hills legacy of Pittsburgh´s original streetcar system (Figure 9). A key element of the new LRT

Figure 9. Pittsburgh LRT - System Map



system is the city centre subway. It uses an existing railway tunnel and new construction to reach two terminals, Gateway Center station and Penn station, in the "Golden Triangle" city centre redevelopment zone. New construction was used for the Steel Plaza to Gateway Center branch, but the line to Penn station, including the core tunnel south of Steel Plaza station, utilises an existing railway tunnel. The use of existing railway right-of-way also includes the Panhandle Bridge over the Monongahela River (acquired from Conrail), the north and south approaches to the bridge, and Station Square, the redeveloped Pennsylvania and Lake Erie Railroad station. South of Station Square the LRT project has entailed the complete rebuilding of the line to South Hills Village, including a new 3,000 ft tunnel at Mount Lebanon.

Construction for the Stage 1 LRT project was divided into three sections. At the southern end of the route, where a new LRV maintenance facility has been built at South Hills, work began in 1980. Although some work on the city centre subway began in 1980-1981 it was not until January 1982 that construction began in earnest. The subway opened in July, 1985. Finally, the intermediate 5.8 mile/9.3 kilometre section, the former Mount Lebanon/Beechview streetcar route, was closed for rebuilding in 1984. The complete Stage 1 LRT was formally opened by PAT on 22nd May, 1987.

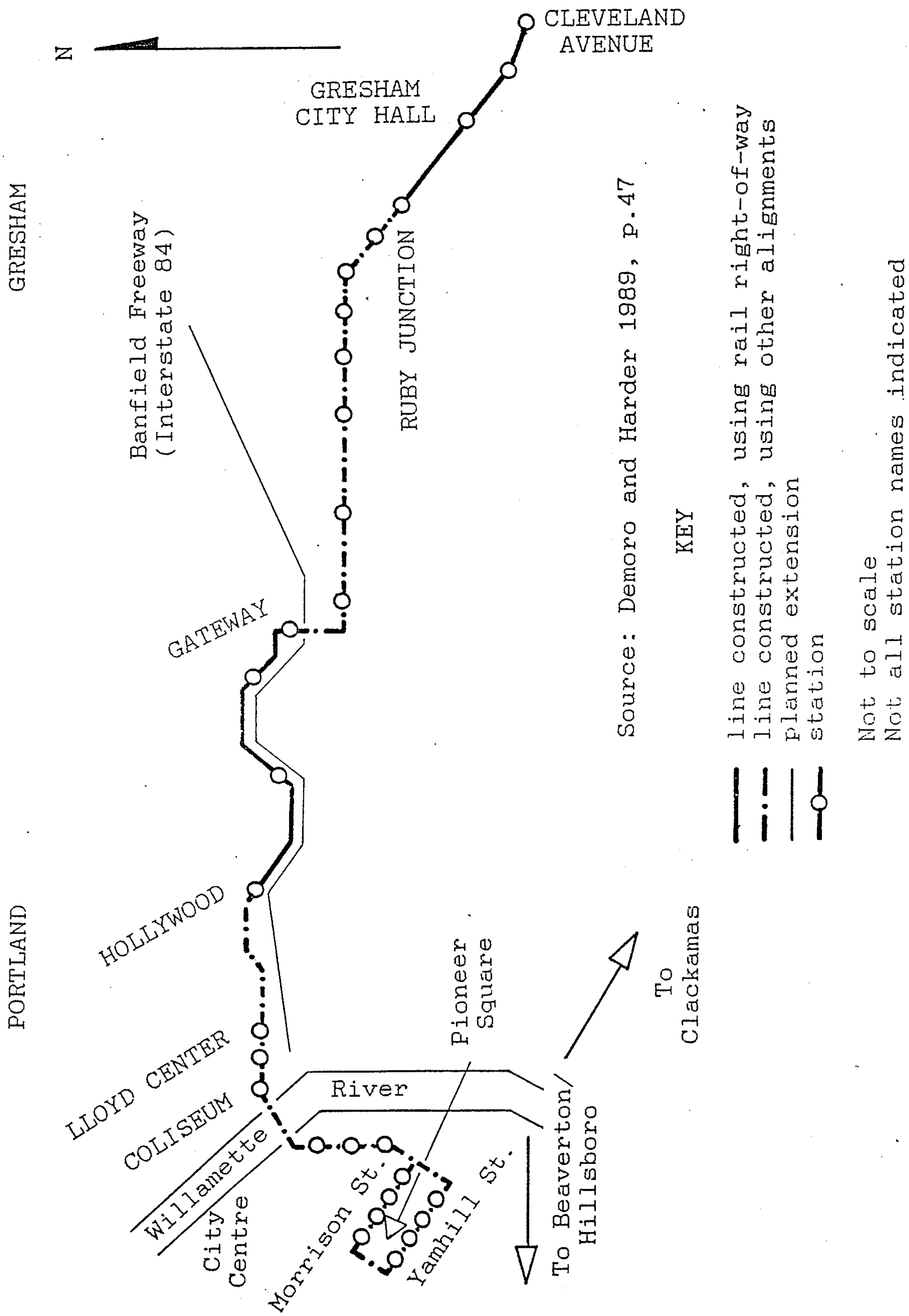
What of Stage 2? The Port Authority has placed a proposal before the Urban Mass Transportation Administration and "prospects are good that [the] light rail system will grow" (Middleton 1987, p.48). Stage 2 covers the modernisation of the remaining South Hills streetcar system, which includes the South Hills Junction-Castle Shannon route and the branches to Drake and Library. North of the Monongahela River, a proposed Spine Line Corridor could extend the LRT network across the Allegheny River into the North Side, and east to Oakland or Squirrel Hill. PAT is currently evaluating these plans (Middleton 1987, p.48).

## Portland

By the mid-1970s, in common with many North American cities, local governments in the Portland metropolitan region began to realise that road traffic congestion could not be solved simply by constructing new freeways and expanding the existing ones. In 1974, as a result of community opposition, a proposal to construct the Mount Hood Freeway in southeast Portland was voted down by the Portland City Council. With freeways becoming increasingly expensive to construct, and the large quantities of land that they require unavailable in the Portland region (without destroying established neighbourhoods), an alternative transport solution was needed. In the same year that the Mount Hood Freeway was rejected, the then governor of Oregon (Tom McCall) formed a task force to determine whether mass transit in some form could be substituted for the freeway (Tri-Met 1988c, pp.1-2).

As a result of potential pollution problems in Portland´s city centre, the effect of the Arab oil embargo, and the expected labour savings, LRT was chosen over some form of busway. The city centre transit mall was originally designed to handle 200 buses in the rush hour, not the 500 buses that a busway was expected to generate. In selecting LRT the Tri-County Metropolitan Transportation District of Oregon (Tri-Met) received the approval of local and regional agencies and, most important of all, general citizen support (Tri-Met 1988c, pp.3-4). At the same time (1975) Gresham, to the east of Portland, had become the region´s fastest-growing community, and the Banfield Freeway the most congested transportation artery (Figure 10). As a result it was decided to introduce a package of transportation remedies for this corridor, to be known as the Banfield Transitway Project. The project combined the $214 million (US) LRT line with the reconstruction of 4.3 miles of the Banfield Freeway (Interstate 84) at a cost of $107 million. Tri-Met´s 15 mile/24 kilometre LRT line

Figure 10. Portland "Metropolitan Area Express" LRT - System Map



linking Portland and Gresham (which has been dubbed "MAX" or "Metropolitan Area Express") is part of a regional strategy striving for balanced transportation (Tri-Met 1988b, p.1).

The LRT line was opened for revenue service on the 8th September, 1986 and is a combination of separate right-of-way and street running, with the former constituting the bulk of the route. In the centre of Portland the line makes a loop along Yamhill and Morrison Streets, bisecting the Portland Mall bus transit mall, to create useful interchange points at Pioneer Square. For a distance of 5.3 miles/8.5 kilometres, between Hollywood and Gateway stations, the LRT alignment follows the Banfield Freeway and shares right-of-way with the Union Pacific railway. In Gresham, the final 2.5 miles/4 kilometres of the line, from Ruby Junction to the Gresham/Cleveland Avenue terminus, occupies the path of a former interurban. The line saw diesel powered freight service into the 1980s.

Portland´s "MAX" is widely regarded as one of the "major success stories of modern light rail development" (Middleton 1990, p.57). In addition to fulfilling its promise of efficiency and lower operating costs (a single LRV can carry the same number of passsengers as 6 diesel buses), the LRT has brought economic and environmental benefits to the region. In a 1988 survey of businesses adjacent to the MAX route, 66% believed that the LRT system had helped their business. Substantial sales increases have been reported for shops in both the city centre of Portland and Gresham. Furthermore, the construction of an LRT line, as an alternative to the Mount Hood Freeway, has allowed the money saved to be used for other road needs in the region (Tri-Met 1988c, p.4; 1990a, p.3). Expansion of "MAX" forms part of Tri-Met´s Regional Transportation Plan, which calls for LRT service in six congested corridors. A line serving Beaverton and Hillsboro ("Westside MAX") is seen as a "top priority" by Tri-Met, followed by a line to Clackamas County (Tri-Met 1990b).

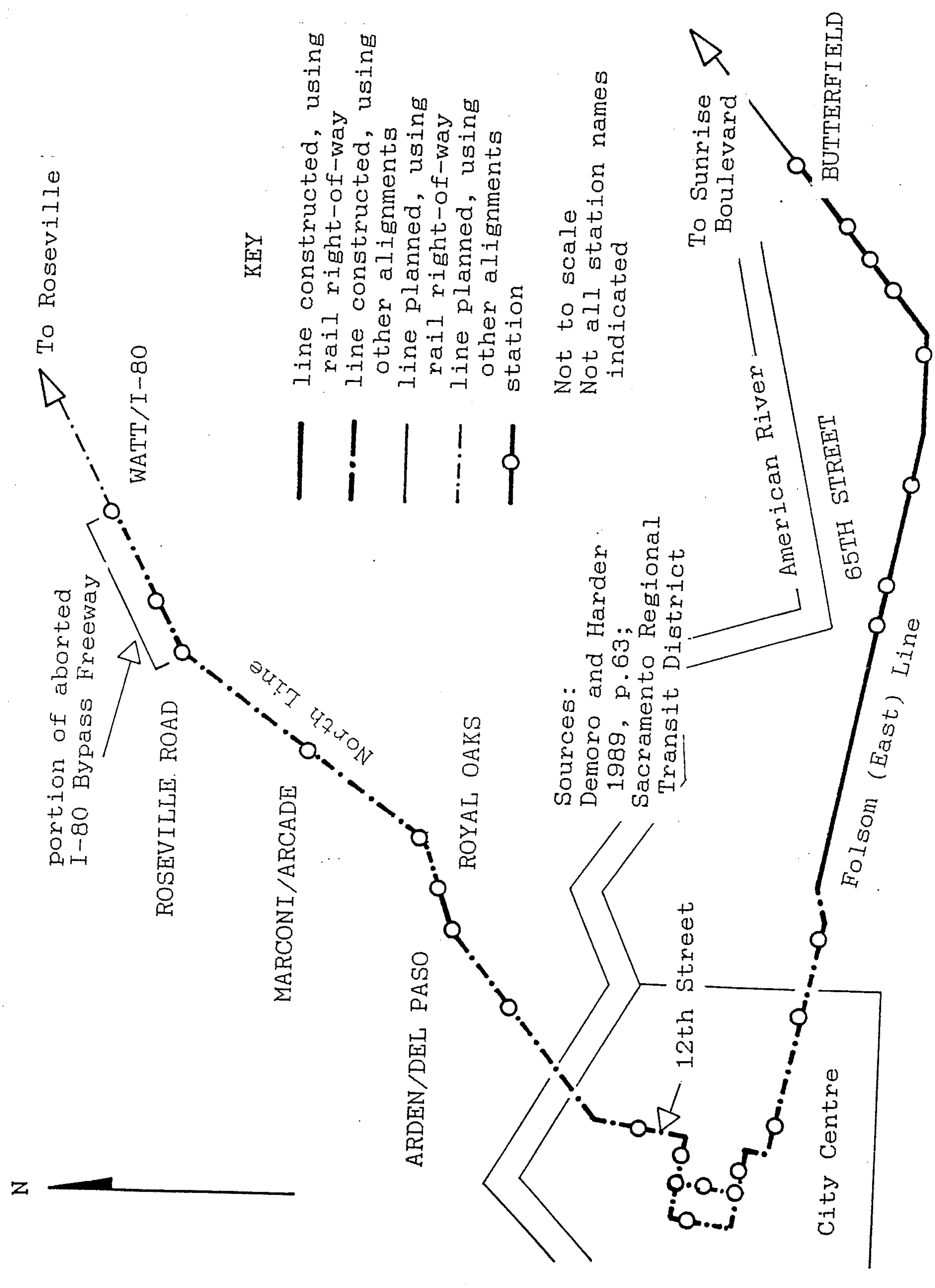
### Sacramento

In August, 1979, the Sacramento City Council voted not to proceed with the Interstate 80 "bypass freeway", and following a two-year study of alternative transport solutions found that LRT was the "locally preferred alternative". The Sacramento Transit Development Agency (STDA) was formed to build the system and the Sacramento Regional Transit District (RT) was assigned the job of operating the new LRT: the "RT Metro" (SRTD, p.2).

The design philosophy for the Sacramento LRT stressed the importance of economy, and the 18.3 mile/29.3 kilometre "starter line" which opened in 1987 was constructed at minimal cost, while simultaneously preserving the flexibility for future expansion of the system. The design philosophy´s economy motif was based upon four principles: the maximum utilisation of existing rights-of-way; the use of proven technology for all aspects of the system; the construction of simple, functional stations; and the integration of the LRT system with Regional Transit´s existing bus system in order to "optimize service and reduce operating costs" (SRTD p.7).

In order to serve the two major transportation corridors in Sacramento the RT Metro was built as a C-shaped system with lines running out of the city centre to Watt Avenue and Interstate 80 (Figure 11) in the northeast, and to Butterfield station in the east. The latter route is known as the Folsom or East line (9.3 miles/14.9 kilometres) while the former is usually referred to as the North line (9 miles/14.4 kilometres). With a design philosophy stressing economy, it is perhaps not surprising that the starter line has made substantial use of existing rail rights-of-way. Between Royal Oaks and Del Paso on the North line the RT Metro follows the long abandoned Swanston branch of the Sacramento Northern Railway (a former interurban carrier). However, the Folsom line makes a much greater use of rail right-of-way. From the Sacramento city centre to 65th Street the LRT uses the

Figure 11. Sacramento "RT Metro" LRT - System Map 



alignment of Southern Pacific´s former Placerville branch which was relinquished by the freight railway as part of the RT Metro project. East of 65th Street the Southern Pacific line is still active and runs parallel with the LRT. Interestingly, most of the North line alignment between Watt/I-80 and Roseville Road uses the right-of-way that was earmarked for the aborted I-80 bypass freeway. Since the freeway was replaced by the LRT project, this portion of the RT Metro is somewhat apt.

As part of its economical approach to the LRT project, the STDA constructed 63% of the route as single track and this has limited the capacity, and hence success, of the system. The first priority for expansion, therefore, has been to eliminate as many of the restrictive single track sections as possible. The first double tracking project, between Marconi Avenue and Roseville Road, was completed in 1989 and a second project, along 12th Street, was completed in December 1990. Similar projects are slated for the period 1991-1993. At the same time, several extensions to the LRT route map have been identified. The Regional Transit District is just completing a Systems Planning Study that will establish priorities for route expansion. The list of "most likely" candidates includes an extension of the North line to a new terminus in Roseville, and continuation of Folsom line service to Sunrise

Boulevard (Middleton 1991b, pp.43-44).

## San Diego

Although the greater part of San Diego´s post-war growth has taken place alongside the city´s growing reliance upon the automobile (San Diego discarded its streetcar system in 1949), a rekindled interest in mass transit occurred in the 1970s. Following a programme of fleet modernisation, for example, San Diego experienced a "remarkable resurgence" in its all-bus transit system. Between 1972 and 1975 the number of passengers using the system grew by 110% to 3 million monthly passengers by May 1975 (Middleton 1975, pp.56, 60). Against a backdrop of renewed interest in mass transit, and with a desire to sustain the economic growth of the San Diego region, planners and community leaders recognised the need to look beyond bus transportation and introduce some form of rail-based mass transit.

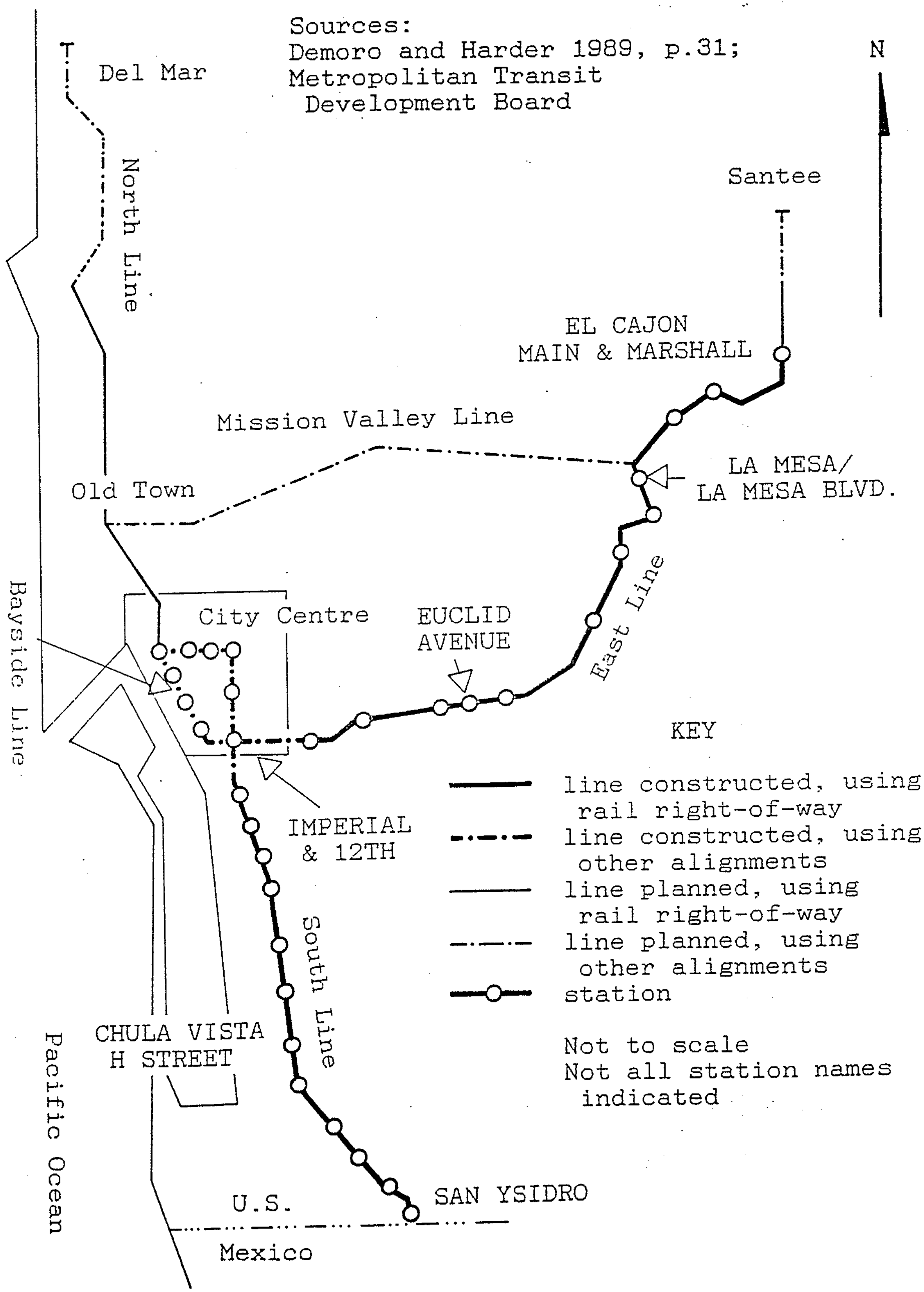
In 1975, the San Diego Metropolitan Transit Development Board (MTDB) was established, with an emphasis upon rail transit development. Since the legislation that created the MTDB made it clear that San Diego could not justify a "high capital-intensive system" (based upon the city´s population and expected transit ridership demands), LRT was selected as the basis for a mass transit programme.

With a "strong, clear legislative directive" to follow, the MTDB developed a pragmatic approach to its LRT programme that closely resembles the model used by Sacramento, although the MTDB opened its first LRT route six years ahead of Sacramento. The MTDB´s pragmatic approach included using off-the-shelf technology, establishing a system that could be developed upon an incremental basis, and using existing rights-of-way where possible (Larwin 1989, p.19).

Much of the "existing rights-of-way" for the "San Diego Trolley" has so far come from the San Diego and Arizona Eastern Railway (SD&AE), which was purchased and rebuilt for LRT operation by the MTDB. The SD&AE is now a subsidiary of the MTDB, along with San Diego Trolley Inc. which operates the city´s LRT. In July, 1981, the 15.9 mile/25.4 kilometre South Line was opened, linking the San Diego city centre with the Mexican border at San Ysidro, and between 1986 and 1989 the 17.3 mile/27.7 kilometre East Line was progressively extended to El Cajon (Figure 12). Both lines were built largely in the SD&AE right-of-way. The short (2 mile/3.2 kilometre) Bayside Line along the San Diego waterfront was opened in 1990.

The San Diego LRT has been able to combine a cost-effective approach to all aspects of construction (the San Diego Trolley was presented with a "Special Civil Engineering Achievement Award" in 1982 by the American

Figure 12. San Diego "Trolley" LRT - System Map



Society of Civil Engineers, for "Cost-effective public transit"), with a steady increase in ridership, from 11,000/day in 1981 to a current daily figure of 55,000. The success of the system is largely undisputed and funding from San Diego County´s successful 1987 "Proposition A" vote will enable further planning and construction to occur (Middleton 1991b, p.42). Preliminary engineering and environmental studies have been undertaken for a 3.6 mile/5.8 kilometre extension of the East Line to Santee. Planning is also in progress for the North Line, which will progressively extend LRT service to Del Mar. Construction has begun on the Old Town portion of the route which will be in service by 1994. In addition, plans are well advanced for an 11.3 mile/18.1 kilometre east-west Mission Valley Line, which would link Old Town on the North Line with the East Line at La Mesa. It is anticipated that all of these extensions will be either under construction or in the advanced design stage by 1995 (Middleton 1991b, pp.42-43).

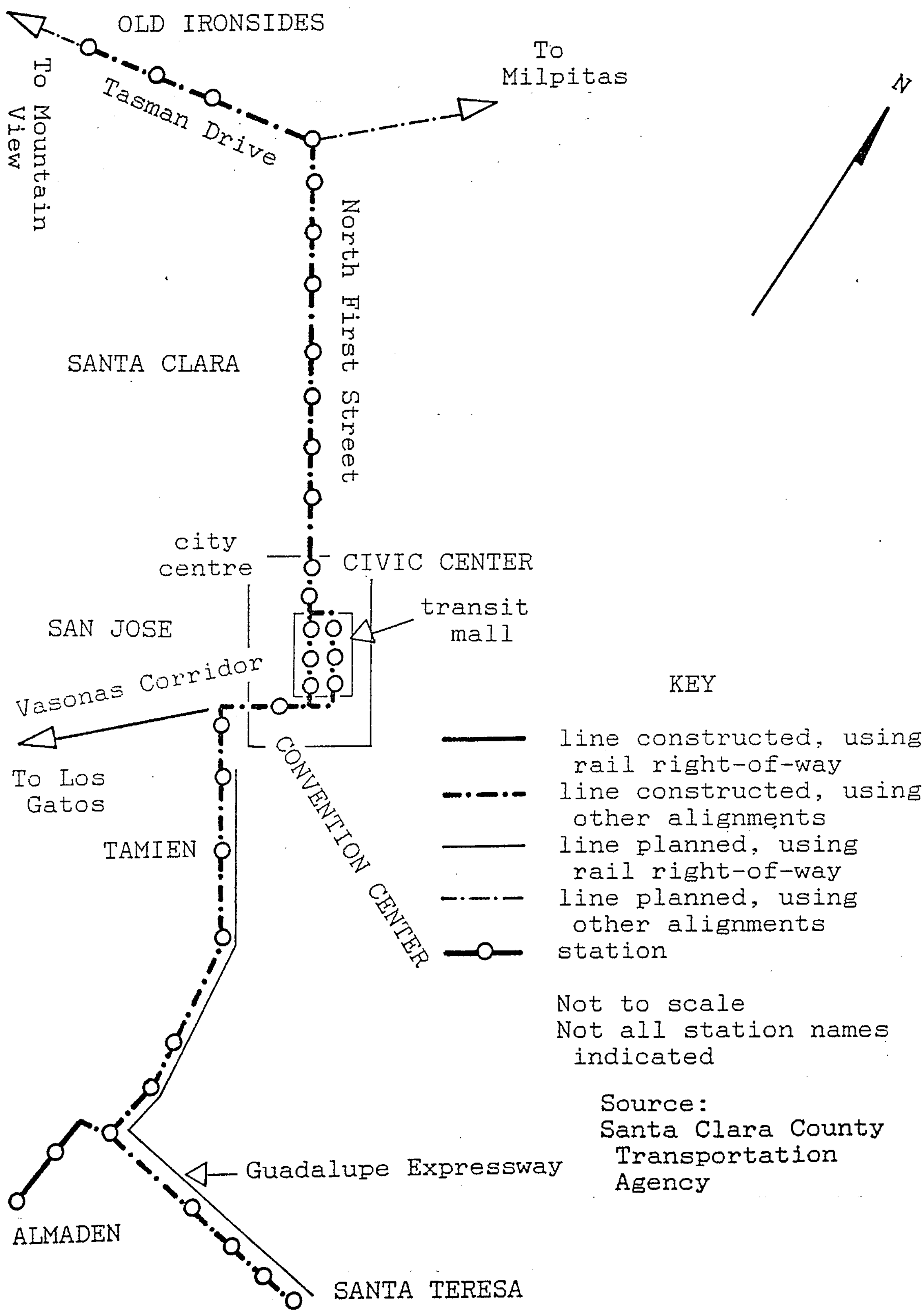
### San Jose

The dramatic industrial development that has created California´s "Silicon Valley", and its associated population growth, have produced some "monumental" transportation requirements for the northern Santa Clara County area. To help meet some of those requirements the

Santa Clara County Transportation Agency (SCCTA) grew into a major bus operator in less than a decade, and its bus network now carries roughly 120,000 riders per day. However, despite this initiative and an extensive programme of freeway construction it became clear by the mid-1970s that some form of rail-based mass transit would also be required. In particular, much of the area´s transportation demand exists in the Guadalupe Corridor, a 16 mile NW-SE strip of land that roughly parallels the Guadalupe River and includes the cities of Santa Clara and San Jose (Figure 13). In view of this it seems logical that any rail transit programme would have begun with this corridor, and a study released in 1976 recommended that an LRT "starter line" be constructed to serve Santa Clara and San Jose ("San Jose light rail may be next", p.40).

As part of a package of transportation improvements in the Guadalupe Corridor, the Guadalupe Corridor Project includes a 9 mile/14.4 kilometre freeway (the Guadalupe Expressway) and a transit mall in the San Jose city centre, in addition to a 20 mile/32 kilometre LRT line. The line has been opened in several stages, starting in 1987. On 11th December of that year service was inaugurated over the northern portion of the line from Old Ironsides to the San Jose Civic Center. With the bulk of the LRT´s projected passengers living in the southern suburbs of San Jose, the

Figure 13. Santa Clara County LRT - System Map




Source:
Santa Clara County Transportation Agency

first phase of the Guadalupe Light Rail Project carried less than 1,000 riders per day. On 17th June, 1988, LRT service was extended to the San Jose Convention Center via the city´s new transit mall, and two years later the August 1990 opening of Tamien station (near Alma Avenue, and originally to be called Alma) brought LRVs into San Jose´s southern suburbs. On 25th April, 1991, full LRT service was introduced, when the final segments to Almaden and Santa Teresa were opened to the public. With the completion of the Guadalupe Corridor line, the SCCTA had expected to cater for 20,000 passengers per day by the end of the first year of operation. However, that figure was surpassed the next month, when average weekday ridership for May reached 21,624, and by June the figure had climbed to 23,000 (Middleton 1991b, pp.44-45; Middleton 1991c, p.64; Demoro & Harder 1989, p.77).

In terms of its right-of-way the Guadalupe LRT has largely employed existing road and rail rights-of-way, with on-street running through the San Jose transit mall. North of the San Jose city centre the line uses the North First Street and Tasman Drive medians. In the southern suburbs of San Jose the line uses what will become the median of the Guadalupe Expressway, the freeway component of the Guadalupe Corridor Project. The branch to Almaden uses an old Southern Pacific rail alignment.

For the period 1985-2005 it is projected that Santa Clara County will experience a 20% growth in population and an even higher growth in employment. As a consequence, SCCTA is planning for a "major expansion" of LRT, along with new road and bus projects (Middleton 1991b, p.44). According to Rod Diridon, chairman of the Santa Clara County Transit District Board of Supervisors, "now that this entire line is open for service, we can set our sights toward additional routes that will ultimately tie into a network of light rail lines crisscrossing the entire county" ("New LRT routes for Santa Clara?"). Two extensions are currently in the planning stages. A proposed east-west extension (9-14 miles/14.4-22.4 kilometres) along Tasman Drive would bring LRT service to Mountain View and Milpitas. Construction is slated to begin in 1993 with passenger service to be introduced in 1996. A second project would serve the Vasonas Corridor, with a 7 mile/ 11.2 kilometre line running from the San Jose city centre to Los Gatos, along an old rail right-of-way (Middleton 1991b, pp.44-45). In common with the Guadalupe Corridor LRT, all planned extensions are to be fully integrated into the existing transportation fabric. Along with the provision of park-and-ride spaces at LRT stations and the realignment of bus routes, to the mutual advantage of bus and LRT, the SCCTA plans to connect with Caltrain and BART stations where possible. The planned expansion of LRT service to Mountain View, for example, will connect with the Caltrain station of the same name. The BART network does not extend to Santa Clara/San Jose, but there are plans for it to do so (Middleton 1991c, pp.63, 68A).

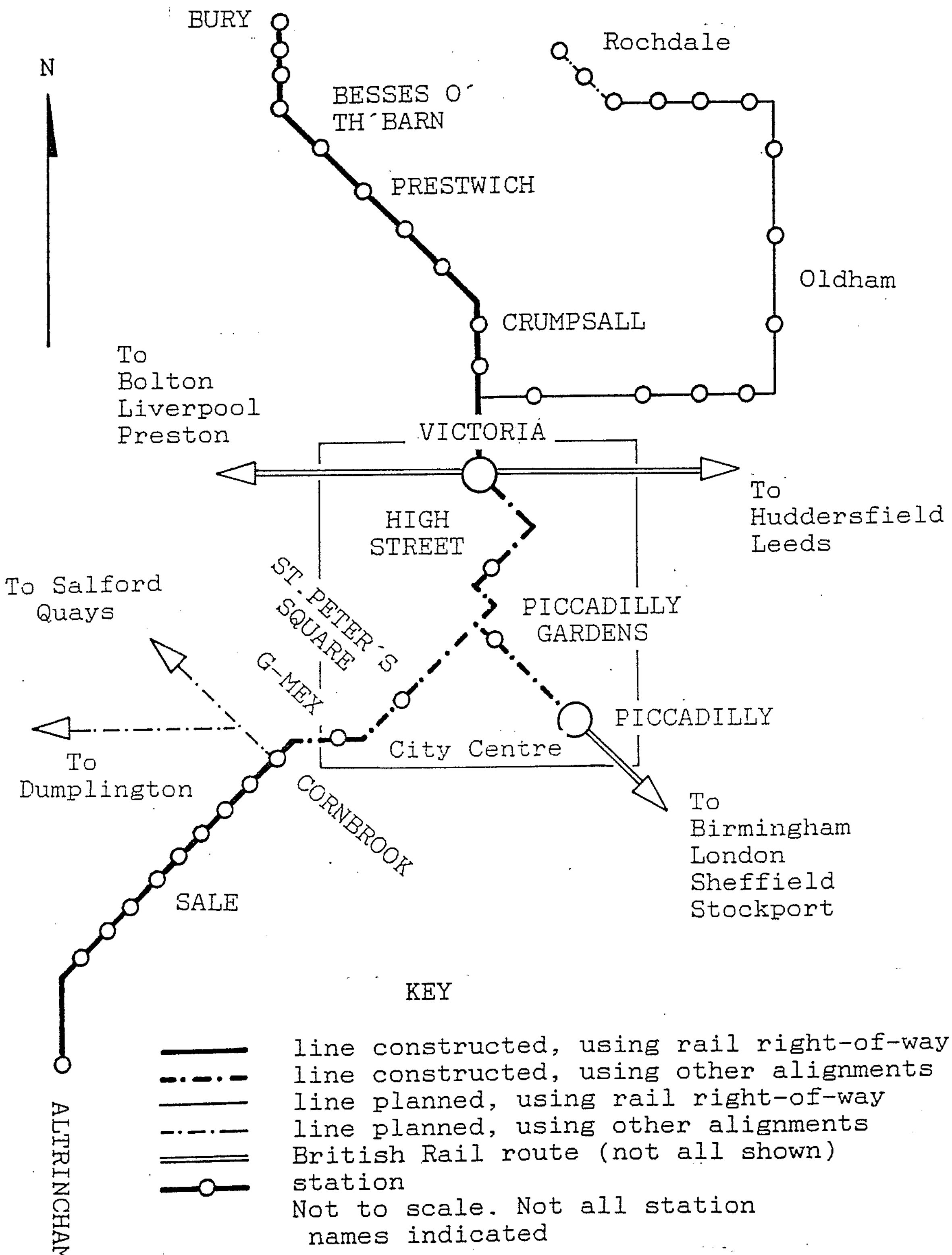
## United Kingdom

### Manchester

The genesis of Manchester´s new LRT project, which will operate under the "Metrolink" banner, can be traced back to the nineteenth century when the city attracted railways from all parts of the country. Because of the inability to plan a comprehensive rail system in a competitive Victorian economy, Manchester has inherited an extensive, but divided, rail system. One half of the network is served by Victoria station on the northern edge of the city centre, whilst to the south, Piccadilly station serves as the focus for the balance of the system (Figure 14). The full potential of Manchester´s rail system has never been realised because of the lack of cross city links and an inability to penetrate the city centre (Glover 1988, p.576; Young 1989, p.6).

Attempts to solve the problem date back almost to the beginning of the city´s railway history, when a proposal for a Piccadilly-Victoria rail tunnel was mooted in 1839.

Figure 14. Manchester "Metrolink" LRT - System Map 




Not to scale. Not all station names indicated

Source: Greater Manchester Passenger Transport Executive

In the interim a series of schemes have all failed to reach maturity, including the most recent proposal for a "Picc-Vic" tunnel. The project gained parliamentary approval in 1972 but was subsequently abandoned in 1977 on the grounds of cost. Meanwhile the fabric of Manchester´s suburban rail network was visibly deteriorating. In 1982, the then Greater Manchester Metropolitan County Council initiated a joint study with the Greater Manchester Passenger Transport Executive (GMPTE) and British Rail to examine a range of options for the development of the local rail network. Clearly with an eye upon cost, LRT emerged as the preferred option, with street running to provide access to the city centre. On 19th January, 1988 the Secretary of State for Transport gave approval (in principle) to Phase 1 of the Metrolink project, and in September 1989 a contract to design, build and operate the new LRT was placed with the GMA consortium. With all funding details resolved by the end of the following month, construction was able to go ahead. On 21st February, 1992, Metrolink LRVs were scheduled to enter revenue earning service (Young 1989, p.6; "Manchester Metrolink", pp.6-7; "Opening date for Metrolink").

Whilst many new LRT projects make use of existing rail rights-of-way, the emphasis has primarily been upon converting freight lines to LRT use or the revival of abandoned lines. With Metrolink, Manchester has taken things a stage further, the conversion of viable suburban rail lines to LRT operation. Phase 1 of Manchester´s LRT involves the conversion of the Piccadilly-Altrincham and Victoria-Bury suburban lines for LRT use. The focal point of the system will be Piccadilly Gardens, where the lines from Bury/Victoria station, Piccadilly station and Altrincham converge. The 1.6 miles/2.5 kilometres of street running in the city centre will permit a much greater integration of Manchester´s rail network and allow (some) passengers a simple journey to the heart of the city. The February, 1992, opening day was supposed to see Metrolink LRVs take over from British Rail on the Manchester Victoria-Bury segment, with street running to Piccadilly station and the G-MEX exhibition centre scheduled for 20th March, 1992. Completion of Phase 1 is due to take place on 17th April, 1992, when service will be extended beyond G-MEX to Altrincham ("Opening date for Metrolink").

Looking ahead to Phase 2 and beyond, the GMPTE has been investigating the possibility of converting the (British Rail) Oldham and Rochdale line to LRT, with unsegregated street running in both town centres. Other plans call for an extension of Metrolink to serve the Salford Quays redevelopment area and a major new shopping centre planned for Dumplington (Holt 1991a).

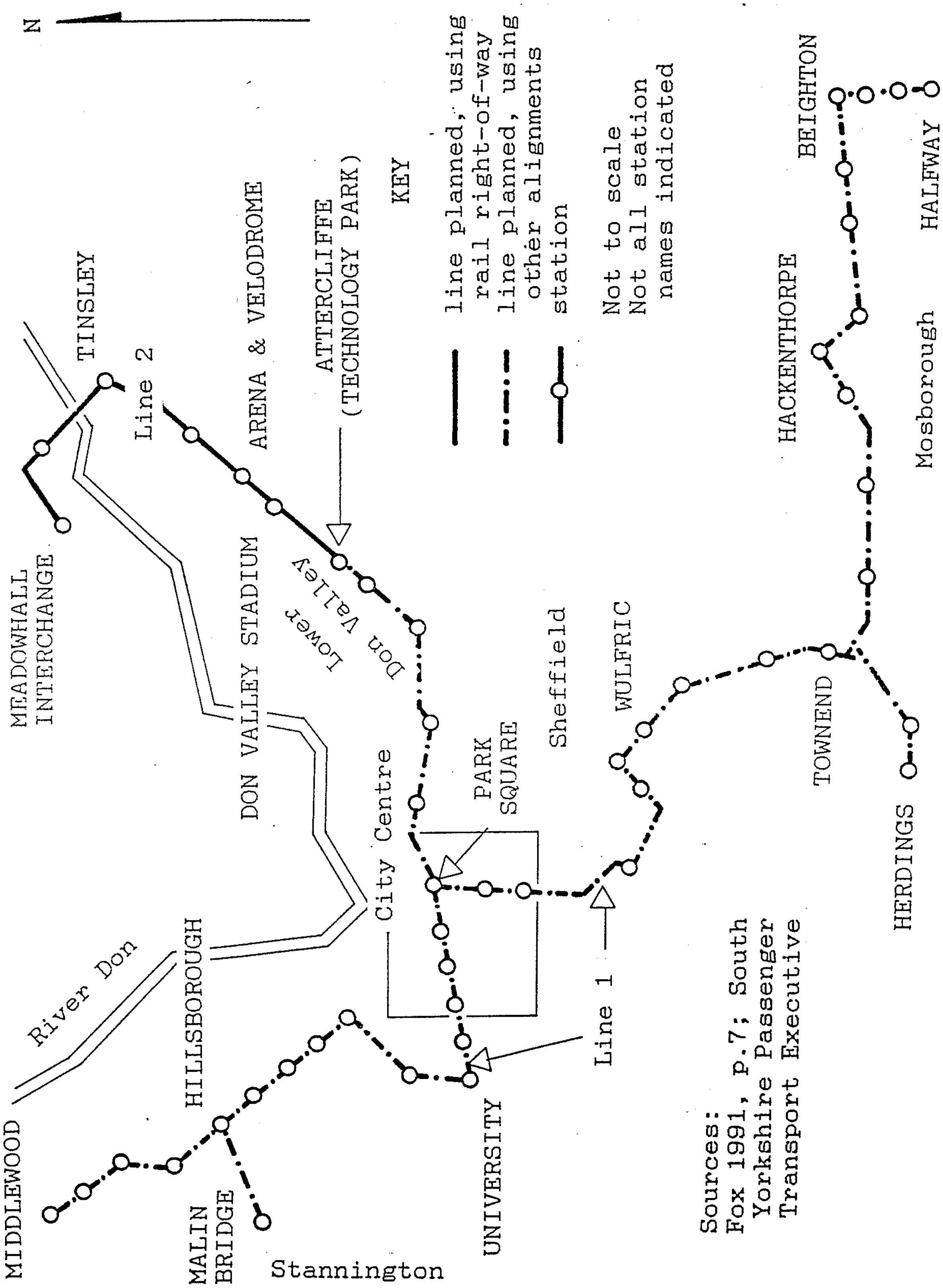
The ensuing months will reveal much about the performance of Metrolink and the wisdom of selecting British Rail´s Bury and Altrincham lines as the bedrock for Phase 1. Already, however, much criticism has been launched against the project, including concern over the ability of Metrolink to match the present British Rail service on the Bury and Altrincham routes. This concern has focussed upon the reliability of the Bury line (which is currently self-contained and enjoys an enviable on-time performance) once its trains start to negotiate the traffic congested streets of Manchester´s city centre. There is also concern that Metrolink will not be able to provide capacity comparable to that which is currently offered by British Rail. Although capacity is only partly a function of seats per vehicle, Altrincham passengers will forfeit their British Rail Class 304 Electric Multiple Units (234 seats/unit), and Bury line passengers their Class 504 Electric Multiple Units (178 seats/ unit) in return for LRVs which can only carry 180 people, including standees (<u>British Rail Motive Power 1989</u>, pp.80, 150; GMPTEa). It has been argued that with Metrolink Manchester is attempting to run its electrified railways "on the cheap" and that if it was serious about investing in a modern LRT system then it should have built alongside major roads with no complementary rail service. Therefore, "there is a real danger that in its existing form Metrolink will be a fiasco and that its failure will be used to blight other, more-deserving, LRT projects elsewhere" (Holt 1991b).

## Sheffield

Sheffield was the last English city to dispense with its trams, on 8th October, 1960, and the first indication that some form of modern equivalent would return to the city's streets was in 1974, when the Sheffield and Rotherham Land Use Transportation Study was issued. A network of LRT routes was one of the options under consideration to meet the region's transportation requirements for the 1990s and steps were taken to safeguard rights-of-way outlined in the document. In the early 1980s a Segregated Passenger Transport System Working Group was established to develop proposals and determine demand in the corridors under study. The group selected the Hillsborough and Mosborough corridors for detailed examination (Figure 15), and decided that LRT would be the most cost-effective transport mode. In November, 1985 a Bill was placed before Parliament. Entitled "South Yorkshire Light Rail Transit Bill", it sought powers to build a 15.6 mile/25 kilometre line from Middlewood/ Stannington to Halfway (Mosborough)/Herdings. Following local opposition the branch to Stannington was later cut

Figure 15. South Yorkshire "Supertram" LRT - System Map





back to Malin Bridge (Jackson 1990; Fox 1991, p.3).

Due to a lack of any definite commitment on the part of Sheffield City Council the Bill encountered difficulties at the House of Commons Committee stage and proceedings were adjourned on two occasions. The delay, however, allowed City Council to consult with the public (throughout September 1987) before giving full support to the project, subject to several provisos. The most important stipulation required the South Yorkshire Passenger Transport Executive (SYPTE) to submit a second Bill, in November 1988, seeking powers for an LRT route in the Lower Don Valley. This route, which will terminate at the Meadowhall complex (Europe´s largest shopping centre), is intended to help regenerate Sheffield´s east end, an area of derelict and semi-derelict steelworks. It was also hoped that the line would serve sites for the World Student Games, which were held in Sheffield in July 1991. Royal Assent for the initial Bill was granted on 27th October, 1988, and the second Bill was passed fourteen months later (Jackson 1990; Fox 1991, p.3).

The stage is set for South Yorkshire´s "Supertram" but the final hurdle, financing the scheme, has yet to be cleared. Financing is supposed to include a "substantial" grant from central Government (along with contributions from the SYPTE and the private sector), but in February

1990 the Government announced that money would not be available for a 1990 construction start. Thus Supertram could not begin operations in time for the World Student Games the following year (Taplin 1991b, p.39; Whitehouse 1991a, p.7). The Government has since agreed to pay its share (agreement given in November 1990), but wants cash contributions from the four district councils affected by Supertram: Sheffield, Barnsley, Doncaster and Rotherham. Although it is anticipated that the full Supertram system will be in operation by the mid-1990s, progress is currently stalled as discussions continue (Whitehouse 1991b; 1991c, p.423).

In terms of the type of right-of-way to be used, the Sheffield Supertram contrasts sharply with Manchester's Metrolink. Whilst the latter is essentially a connection between two former British Rail routes (hence the label "Metrolink"), Supertram is planned to be the "first completely new street-based LRT system" in the United Kingdom. "Supertram" was considered an appropriate name for an LRT system that will primarily employ street running and partially reserved right-of-way alongside existing streets (Fox 1991, p.5). The only use of rail right-of-way will be along Line 2, that which serves Meadowhall Interchange. Between Attercliffe (Technology Park) and Tinsley, Supertram will share the trackbed of a lightly used British

Rail freight line. For the final segment to Meadowhall Interchange an abandoned rail right-of-way will be reactivated. The minimal use of existing rail alignments means that Supertram will have the opportunity of complementing the existing SYPTE-funded suburban rail services (operated by British Rail), rather than replacing them with, what is after all, a medium-capacity transportation mode.

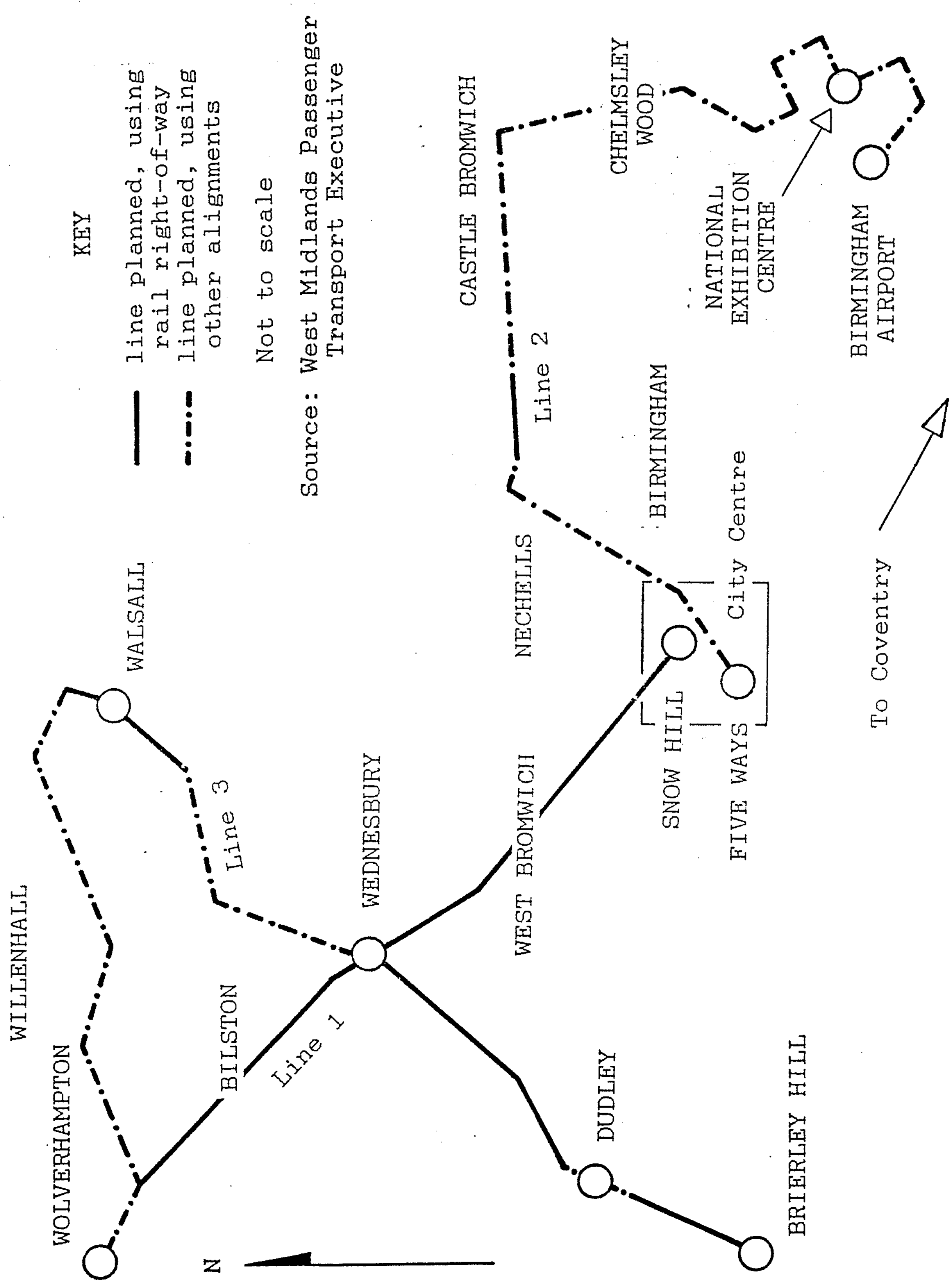
### West Midlands (Birmingham)

Along with Manchester´s Metrolink and the Sheffield Supertram, the "Midland Metro" is one of a trio of British LRT systems that have either entered the construction stage or are waiting to do so, subject to the resolution of funding details. The origins of the proposed Midland Metro, which is being sponsored by Centro (the new corporate identity of the West Midlands Passenger Transport Executive), can be traced back to 1981, when the then West Midlands Metropolitan County Council released its "Structure Plan" for the county.

In the early 1980s, the West Midlands was suffering under a "near collapse" of its manufacturing industry and had one of the lowest levels of economic growth in the country. At the same time, public transport ridership figures were declining, and the problems of a less mobile population were compounding those on the economic front. Since the County Council saw rapid transit as a potential solution to these problems, the "Structure Plan" endorsed the development of a modern transit system for the region. However, the first proposal, prepared by 1985, was rejected on the grounds that it would entail extensive demolition of residential property, and it received a great deal of public opposition. The idea of a rapid transit system was re-launched in September, 1987, under the "Midland Metro" banner, and the revised plans call for a network of LRT lines serving the principal traffic corridors in the West Midlands. Midland Metro is designed to relieve traffic congestion and is seen as vital to the "economic, social and environmental well-being" of the region (Tarr 1989, pp.1-2).

From the outset Centro has recognised a need to develop a network of lines, integrated as closely as possible with the existing road, rail and bus systems, and there are currently three LRT routes in the advanced stages of planning. Line 1 (Figure 16) will be a 13 mile/21 kilometre route running between Birmingham city centre (from British Rail's Snow Hill station) and Wolverhampton, serving West Bromwich, Wednesbury and Bilston. Most of the route will employ the disused Great Western Railway right-of-way with some street running in the Wolverhampton

Figure 16. West Midlands "Midland Metro" LRT - System Map



city centre. Parliamentary approval for the line was received in November, 1989, but as with Sheffield's Supertram, financing currently presents a stumbling block. In the same month Centro submitted a second, "more ambitious", Bill to Parliament, for Lines 2 and 3.

Line 2 will run from Birmingham, Five Ways (one of the city's principal commercial centres), through Birmingham city centre, and out to the National Exhibition Centre (NEC) and Birmingham International Airport, via Nechells, Castle Bromwich and Chelmsley Wood. Although the line is to be 16 miles/26 kilometres in length, only a small (0.6 mile/1 kilometre) segment will use existing rail right-of-way. The vast majority of the route will utilise a brand new segregated alignment, including a tunnel through the city centre of Birmingham.

Midland Metro (No.2) Bill also seeks permission to construct Line 3. This line, which is also to be 16 miles/26 kilometres long, will link Wolverhampton, Walsall, Wednesbury and Dudley. Much of the route will comprise new segregated alignments, but 3.2 miles/5.2 kilometres of Line 3 will share the trackbed of an existing British Rail freight line. Centro has subsequently agreed to promote a further Parliamentary Bill to extend Line 3 to Brierley Hill, largely in the right-of-way of the afore- mentioned freight line (Tarr 1989, pp.6,8,10; "Midland Metro grant sought"; "Design, build, operate for Midland Metro").

Lines 1-3 represent the first 45 miles/73 kilometres of a planned 125 mile/200 kilometre LRT network for the West Midlands county. Whilst awaiting Department of Transport financial approval for the first of these lines, Centro is currently working with local authorities in the region to determine the alignments for additional routes. There are also proposals for LRT lines in Coventry (a city near the southeastern boundary of the West Midlands county), although they would be physically isolated from the bulk of Centro´s planned LRT system ("Midland Metro grant sought").

## Other Systems

In addition to the fourteen systems discussed in the previous pages, there are numerous other North American and British urban areas with aspirations for their own LRT system. For information purposes, the following is a selected list of those urban areas that are giving serious consideration to this form of rail transport.

<u>Canada</u>
Vancouver

<u>United States</u>
Baltimore
Montgomery County, MD
 (Washington DC suburbs)
Denver
Minneapolis-St.Paul
Norfolk-Virginia Beach, VA

Ogden-Salt Lake City-Provo
Orange County, CA
St.Louis
Seattle
Tucson

United Kingdom
Avon (Bristol)
Belfast
Cambridge
Cardiff
Cleveland (Stockton-Middlesborough)
Croydon
Edinburgh
Norwich
Nottingham
South Hampshire (Fareham-Portsmouth)
Strathclyde (Glasgow)
West Yorkshire (Leeds)

## Conclusions

The primary purpose of this chapter has been to determine how prevalent the use of rail rights-of-way is in North America and the United Kingdom when it comes to planning and constructing LRT lines. Of the fourteen systems discussed, only the Green Line LRT in Boston and Cleveland´s Shaker Heights Green and Blue lines have not made use of existing rail rights-of-way. However, those systems have a long history and were established when right-of-way acquisition was not, generally speaking, the problem that it is now. Today, any new transportation project that involves large-scale demolition of property will be controversial and is likely to be killed or substantially amended in the planning stage. Consequently there is a strong incentive to use "ready made" corridors such as active and disused rail rights-of-way. This is supported by the findings of this chapter.

The LRT systems established in Edmonton, Los Angeles, Portland, Sacramento and San Diego, and those planned for Dallas, Manchester and the West Midlands, have all used/propose to use existing rail rights-of-way on an extensive basis. In particular, the San Diego Trolley and Manchester´s Metrolink have a very close relationship with such rail corridors. Much of the present LRT network of San Diego Trolley Inc. has been established along the trackbed of the San Diego and Arizona Eastern Railway Co., and in turn, both organisations are subsidiary corporations of San Diego County´s Metropolitan Transit Development Board. In Manchester, Phase 1 of the Metrolink scheme entails the conversion of two existing and operational heavy rail suburban lines to LRT operation, with further conversions under consideration.

There are also those LRT projects which have used rail rights-of-way on a moderate basis. They include the Santa Clara County and Pittsburgh LRTs, along with the proposed Sheffield Supertram and extensions to Buffalo´s Metrorail. Furthermore, reports indicate that the majority of cities currently aspiring to LRT also propose to make use of existing rail alignments. This is certainly true for

18 (78%) of the 23 urban areas listed above. It is quite clear then that in North America and the United Kingdom, Light Rail Transit has relied upon, and proposes to rely upon, existing rail rights-of-way to a significant degree.

# CHAPTER FOUR:

# CASE STUDY A - THE CALGARY LRT

In the previous chapter a total of 14 existing and planned LRT systems were examined in order to determine the extent to which they have incorporated/intend to incorporate existing rail rights-of-way. The sheer number of urban areas covered, however, precluded in depth examination of any one LRT system. Hence the need for "case studies": expanded treatment of individual systems. This chapter is devoted to an examination of the Calgary LRT and Chapter Five is concerned with the proposed Vancouver-Richmond rapid transit link.

Before selecting a Light Rail Transit system for Case Study A, the following criteria were established. The system chosen must: be in existence (rather than in the advanced planning stages), because system experience is vital; have more than a single route, to allow for the comparison of different routes within a single system; be the subject of critical appraisal from various sources; and be a Canadian system. The last criterion was considered appropriate since this thesis is being prepared in Canada as part of a Canadian university programme. The only system that could satisfy all four criteria was the Calgary LRT.

Calgary is situated on the Bow River in the Rocky Mountain foothills of southern Alberta. In addition to being the centre of the Canadian oil and gas industry, its economy retains a strong agricultural base. The city has a population of 670,000.

## Background to the Calgary LRT

> The problem with urban mobility in simple terms was understood as the negative impact of accumulated automobile use, a requirement for balance in the transportation system was fashionable, and revitalized transit was suggested as a potential solution (Bolger 1985, p.1).

The above quote sums up the position of transportation in the North American city of the 1960s, and Calgary was no exception. As a result, the city began planning for some form of rapid transit in 1966, with a series of studies conducted by Simpson and Curtin Ltd. In the following year the city council opted for a policy of "balanced" transportation and proposed to construct a system of freeways and heavy rail lines over the following 20 years. The emphasis was placed upon freeways, with budgets for roads and public transport established at a ratio of 5.6:1. However, factors beyond the control of city council conspired to radically alter these plans. The plan for a network of freeways was to fall foul of local opposition, and in the light of revised population growth and population density figures the capital costs for a heavy rail rapid transit system were considered unrealistic for a city of Calgary's size (Bolger 1985, p.2; Kuyt & Hemstock

1978, pp.2-3).

In 1975, the city of Calgary undertook two studies designed to identify, and plan for, major transportation requirements in the city. The reports were published the following year. The Transportation Improvement Priority Study examined Calgary's future transport needs and compared an "all roads" to a "roads plus mass transit" proposal. Light Rail Transit for Calgary was a study of alternative mass transit technologies. Both reports identified the need for rapid transit in the "South Corridor": a strip of land extending 10 miles south from the city centre. Not only had major transportation deficiencies been identified in the corridor, but studies also indicated that it would be impossible to satisfy long term travel demands solely by financially and politically acceptable road schemes. City council ultimately adopted a "roads plus LRT" option (Bolger 1985, p.6; Kuyt & Hemstock 1978, pp.3,7).

Before finally selecting LRT as the "mass transit" component of a "roads plus mass transit" policy, three transit alternatives were canvassed: exclusive bus lanes, LRT and busways. Heavy rail rapid transit had already been rejected on the grounds of cost. The alternatives were judged against several criteria, including: impact upon existing traffic; flexibility to increase capacity;

level of service and capacity; and cost. In terms of traffic impact, LRT and busway were found to be far superior to exclusive bus lanes, but in the city centre a busway would suffer from congestion and capacity problems. LRT promised a higher level of service and capacity than the bus alternatives and would provide the greatest flexibility for future increases in capacity, essential in fulfilling long term transit goals. Although annual costs were found to be significantly lower for bus lanes than either busway or LRT (Table 2), monetary savings were negated by the impact of exclusive bus lanes upon existing traffic, stemming from the loss of road space to buses. LRT was found to be slightly more costly than a busway. However, since most of the annual cost of LRT is debt repayment, and the annual cost of a busway contains a large labour component (due to the need for a larger number of bus drivers than LRV operators for a given level of service), LRT offers some protection against wage-related inflation. Consequently, LRT was recommended as the transit mode best suited to the requirements of the South Corridor (Kuyt & Hemstock 1978, pp.8-15).

Table 2. Comparison of annual costs for bus lane, busway and LRT systems*

| | BUS LANES | BUSWAY | LRT |
|---|---|---|---|
| Structures | 5,280 | 52,620 | 53,310 |
| Equipment & vehicles | 7,380 | 6,800 | 22,450 |
| Property & demolition | 2,520 | 12,520 | 13,420 |
| Utility relocation | - | 3,770 | 6,870 |
| Engineering | 790 | 6,480 | 9,270 |
| Contingency | 160 | 8,222 | 10,530 |
| TOTAL CAPITAL COST | 17,570 | 90,410 | 115,850 |
| ANNUAL CAPITAL COST | 1,820 | 7,870 | 10,360 |
| ANNUAL OPERATING COST | 3,710 | 3,360 | 1,900 |
| TOTAL ANNUAL COST | 5,530 | 11,230 | 12,260 |

* expressed in 1976 dollars (thousands) and based on capacity provision for 4,200 persons per hour per direction

Source: Kuyt & Hemstock 1978, p.12.

## The system

### South Corridor LRT

Implementation of the South Corridor LRT project began on 25th July, 1977 with the purchase of 27 "U2" LRVs from Siemens-Duwag of Germany. On 25th May, 1981, the system was formally opened to the public. With economy and ease of implementation two of the cornerstones of Calgary's LRT planning philosophy (Kuyt & Hemstock 1978, p.28), it is perhaps not surprising that the South Corridor LRT largely employed an existing rail right- of-way for its alignment. The original 8 mile/12.9 kilometre line, linking Anderson station in South Calgary with the city centre (Figure 17), used part of the CP Rail (Canadian Pacific Railways) Macleod Subdivision for a distance of 4.6 miles/7.4 kilometres (57.5% of the LRT route), between Anderson and 39 Avenue stations. There is ample room for CP Rail and the LRT to share the rail right-of-way and freight trains continue to use the route. The remaining 2.2 miles/3.5 kilometres of suburban alignment is a combination of reserved right-of-way along existing roads, and short subway sections. In the city centre the LRVs run along (rather than underneath, as in Edmonton) Seventh Avenue, which was opened as a transit mall in April, 1981. In addition to providing a new transport link between South Calgary and the city centre, the South Corridor LRT serves the Exhibition and Stampede Grounds, and the Saddledome (via Stampede station).

## Northeast LRT

In spite of the recession which hit Calgary around the time of the South Corridor LRT´s inauguration, and in spite of a reduction in municipal spending (including cutbacks in transit service), the Calgary city council has remained committed to the development of the LRT system. Construction of the "Northeast LRT" began in 1981 and the line was opened to the public on 29th April, 1985. The

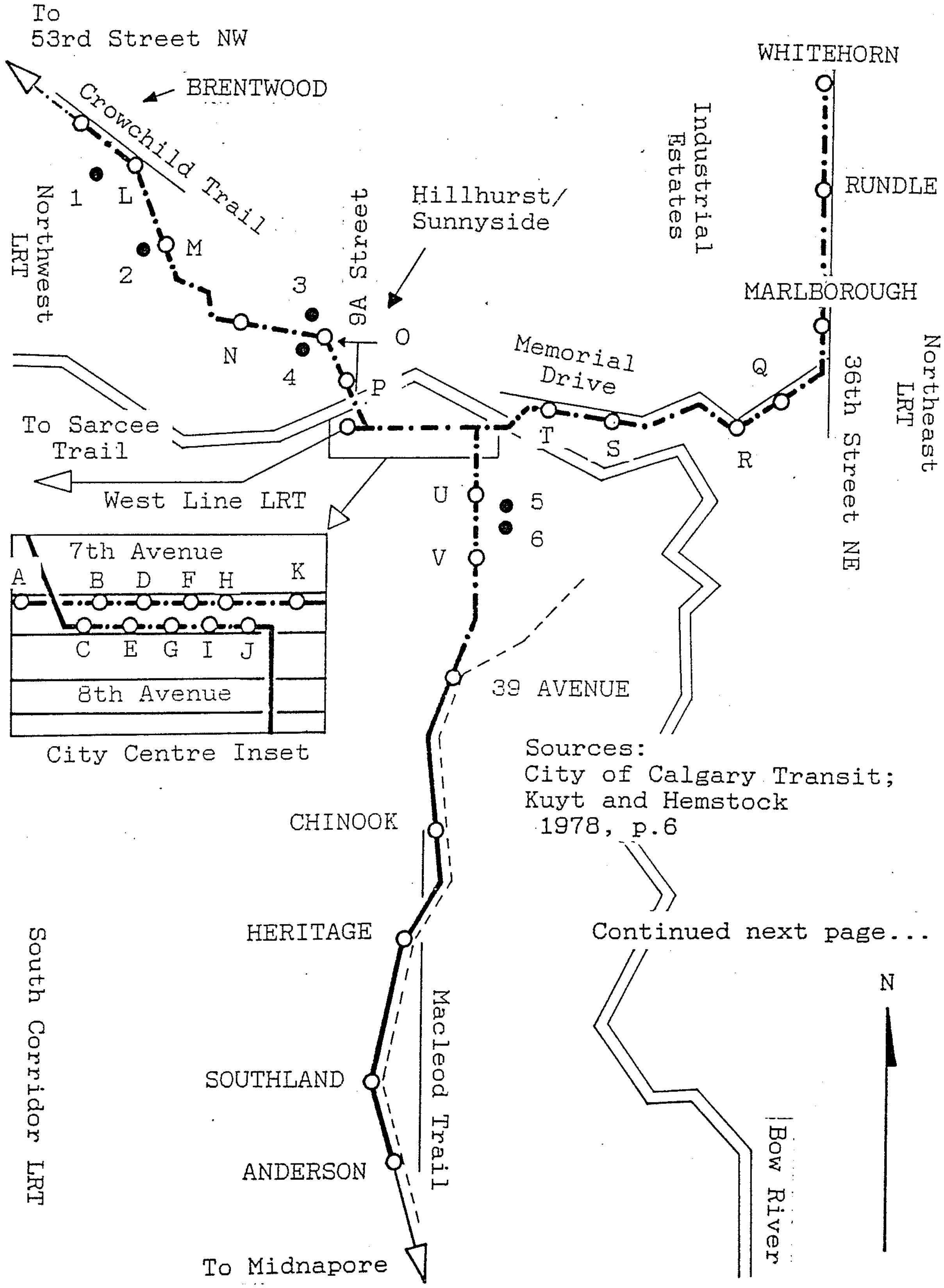

To
53rd Street NW
BRENTWOOD
Crowchild Trail
WHITEHORN
Industrial Estates
RUNDLE
Northwest LRT
Hillhurst/
Sunnyside
9A Street
MARLBOROUGH
Memorial Drive
Northeast LRT
36th Street NE
To Sarcee Trail
West Line LRT
7th Avenue
8th Avenue
City Centre Inset
39 AVENUE
Sources:
City of Calgary Transit;
Kuyt and Hemstock
1978, p.6
CHINOOK
HERITAGE
Continued next page...
N
South Corridor LRT
Macleod Trail
SOUTHLAND
ANDERSON
Bow River
To Midnapore

Figure 17. Key to Map

KEY

Line constructed, using rail right-of-way
Line constructed, using other alignments
Line planned, using rail right-of-way
Line planned, using other alignments
Possible future extension
CP Rail Macleod Subdivision

Station:

| | |
|---|---|
| A | 10TH STREET SW |
| B | 7TH STREET SW |
| C | 8TH STREET SW |
| D | 4TH STREET SW |
| E | 6TH STREET SW |
| F | 1ST STREET SW |
| G | 3RD STREET SW |
| H | OLYMPIC PLAZA |
| I | CENTRE STREET |
| J | CITY HALL |
| K | 3RD STREET SE |
| L | UNIVERSITY |
| M | BANFF TRAIL |
| N | LIONS PARK |
| O | SAIT/ACA/JUBILEE |
| P | SUNNYSIDE |
| Q | FRANKLIN |
| R | BARLOW/MAX BELL |
| S | ZOO |
| T | BRIDGELAND/MEMORIAL |
| U | STAMPEDE |
| V | ERLTON |

Place of interest:

| | |
|---|---|
| 1 | University of Calgary |
| 2 | McMahon Stadium |
| 3 | Southern Alberta Institute of Technology (SAIT) |
| 4 | Jubilee Auditorium |
| 5 | Olympic Saddledome |
| 6 | Exhibition and Stampede Grounds |

Not to scale

project involved the construction of a 6.1 mile/9.8 kilometre line to Whitehorn station in the northeastern suburbs, and a short extension along the Seventh Avenue transit mall to 10th Street SW (Bolger 1985, p.7).

Unlike the South Corridor LRT, the line to Whitehorn does not use any existing rail right-of-way. Instead, it runs in the median of two major roads, Memorial Drive and 36th Street NE, in order to reach the Whitehorn terminus. However, both lines share a degree of "remoteness" from the suburbs that they serve. In the case of the Northeast LRT, the use of 36th Street as a right-of-way means that all of the residential property between Marlborough and Whitehorn stations lies to one side of the LRT alignment. A series of industrial estates flank the Whitehorn route along its western edge.

## Northwest LRT

Further confirmation of city council´s support of the Calgary LRT came in the form of the Northwest LRT, which was opened as far as the University of Calgary on 7th September, 1987. The 0.6 mile/1 kilometre Brentwood extension opened in the autumn of 1990, bringing the total length of the Northwest LRT route to 3.5 miles/5.6 kilometres. In addition to the University, major activity centres along the LRT alignment include the Southern

Alberta Institute of Technology (SAIT) and the Jubilee Auditorium (both served by SAIT/ACA/Jubilee station), and the McMahon Stadium (via Banff Trail station). The University line was deliberately opened in 1987 in order to be ready for the 1988 Winter Olympics. Several of the venues employed for the Olympics are situated adjacent to the LRT route.

The alignment for the Northwest LRT has been rather controversial because it penetrates residential areas to an extent not achieved by the other LRT routes. In particular, there was a great deal of opposition voiced by the residents of the Hillhurst/Sunnyside community over the proposed alignment through that particular inner city neighbourhood. The issue will be examined in greater depth at a later stage in this chapter. In order to access the northwestern suburbs of Calgary, the Brentwood route largely employs a dedicated right-of-way along the centre of existing roads.

Although the Calgary LRT consists of three radial lines sharing a common city centre transit mall, the system (which is known as "C-Train") is operated as two routes by Calgary Transit. Route 201 links the original South Corridor LRT and the recently completed Northwest LRT, with trains running between Anderson and Brentwood. The

Northeast LRT line to Whitehorn and the city centre extension to 10th Street SW are operated as Route 202. Presently the C-Train network comprises 17.7 miles/ 28.3 kilometres, of which 4.6 miles/7.4 kilometres (26%) has incorporated existing rail alignments. Table 3 provides a summary of individual route mileage and the proportion of each route that can be attributed to existing rail right-of-way.

**Table 3. Distance breakdown of the Calgary LRT**

| ROUTE | EXISTING RRW* | NON-RRW (MILES/PERCENTAGE) | TOTAL |
|---|---|---|---|
| SC LRT | 4.6/67.8 | 2.2/32.2 | 6.8/100 |
| NE LRT | - | 6.1/100 | 6.1/100 |
| NW LRT | - | 3.5/100 | 3.5/100 |
| MALL | - | 1.3/100 | 1.3/100 |
| TOTAL | 4.6/26.0 | 13.1/74.0 | 17.7/100 |

* RRW=rail right-of-way
SC=South Corridor; NE=Northeast;
NW=Northwest; MALL=Transit Mall

## Future Plans

Looking to the future of the Calgary LRT, there are several extensions at the planning stage. A proposed 2.5 mile/4 kilometre extension of the Northwest LRT to 53rd Street NW, and a 3.7 mile /5.9 kilometre extension of the South Corridor beyond Anderson to Midnapore, are "tentatively scheduled" for the late-1990s. The latter extension will use the CP Rail right-of-way while continuation of Northwest LRT service beyond Brentwood will be in the median of existing roads. Other plans call for the construction of a West Line LRT to the Sarcee Trail along Bow Trail and 17th Avenue, and an underground alignment through the city centre, replacing the transit mall (Bolger 1991; Middleton 1990, p.57; "Transit in Calgary", p.32).

## Criticism

The South Corridor, Northeast and Northwest LRT lines represent an interesting collection of routes, offering as they do, the opportunity to examine three different types of alignment. In terms of the physical integration of each line into its respective community, the South Corridor and Northeast routes share a marked degree of "remoteness" from the communities that they purport to serve. Although the South Corridor mainly employed an existing rail right-of-way, and road medians were used to construct the Northeast line, both routes traverse large tracts of industrial and open land. Thus the vast majority of LRT riders must either park their cars at C-Train stations or use a Calgary Transit feeder bus. By contrast, the Northwest line to Brentwood runs through the centre of established neighbourhoods such as Hillhurst/Sunnyside, and in that sense it resembles a conventional bus or streetcar route.

Ideally it would be useful to have data which document the impact of the degree of physical integration of an LRT route in a community upon its subsequent ridership performance. It would then be possible to compare the three radial routes of Calgary's C-Train system to determine whether, for example, the alignment of the South Corridor route along an existing rail right-of-way (which has left it physically removed from the surrounding community) has impacted negatively upon its ridership. Unfortunately, according to the City of Calgary Transportation Department, such data do not exist (Bolger 1991). However, constructive criticism of individual C-Train routes is available, in addition to critical comment pertinent to the system as a whole, which permits several conclusions to be drawn concerning the selection of LRT right-of-way in Calgary.

## South Corridor LRT

Following the opening of Calgary's South Corridor LRT in 1981, a household survey conducted by the Calgary Transportation Department found the response from C-Train passengers to be "largely positive" (Bolger 1985, p.6). Over 30% of the combined peak/off-peak passengers were new to Calgary Transit and in the peak period over 20% were former car users. The most dramatic increase registered was in Calgary Transit's share of journeys between locations in the South Corridor and the city centre: from 42% to 52% in the morning peak and from 31% to 42% during the off-peak period. However, Calgary Transit's share of non-city centre trips to or from points in the LRT corridor dropped from 20% to 18% during the morning peak, and from 6% to 3% during the off-peak period. The drop in market share for non-city centre travel was large enough that transit's share of <u>all</u> trips to or from points in the South Corridor rose only slightly in the morning peak (26.2% to 28.4%) and actually fell during the off-peak period, from 8.5% to 6.9% (Bolger 1985, p.6; Gomez-Ibanez 1985, p.344). For the purposes of this thesis, it has to be assumed that this is also the situation today (1992), since the City of Calgary Transportation Department does not have figures more recent than those provided by the household survey (Brown 1991).

In one sense the South Corridor LRT has been a success. Calgary has a "well-defined, densely-developed, and viable" city centre, and because of the large concentration of city centre workers transit is heavily relied upon during the rush-hour periods (Cervero 1985, p.636). In combination with the provision of parking facilities and feeder bus connections at suburban LRT stations, the South Corridor LRT has improved transportation between the corridor and the city centre, and greatly increased Calgary Transit´s share of rush-hour, city centre-oriented travel. In another sense, however, the performance of the South Corridor LRT has been dissappointing. The drop in Calgary Transit´s share of non-city centre trips implies that suburban travel via LRT is not as convenient as city centre travel. An analysis of office trips along the South Corridor revealed that transit´s modal share declined from 9%, pre-LRT, to 5% in 1984. The LRT project was coordinated with development/redevelopment along the LRT corridor. In order to induce commercial development around suburban station sites the city reduced the minimum parking requirement to 2 spaces/1,000 sq.ft. for new buildings. With an unexpected fall in transit use for suburban office trips, the relaxation of parking space requirements resulted in an overflow of vehicles on to residential streets (Cervero 1985, p.649; Gomez-Ibanez 1985, p.349).

Given the "burgeoning growth" in suburban office parks (Cervero 1985, p.649) and the general economic and recreational migration to the urban periphery in cities like Calgary, the inability of the South Corridor LRT to effectively serve suburban office trips is disturbing. Furthermore, if LRT is to improve transportation in a given corridor then it is fair to expect an enhancement in service to existing suburban locations, not just station redevelopment sites. A passenger travelling between suburban stations (whether on the same route or travelling across the city from another route), and using park-and-ride facilities at the station of origin, will obviously require the destination LRT station to be within walking distance of the journey's goal. In using CP Rail's right-of-way, the South Corridor LRT has been placed in the median of freight trackage serving industrial sidings east and west of the core CP Rail line. As a result, the suburban LRT stations are as much as 0.5 kilometres from the nearest commercial thoroughfare in the South Corridor, Macleod Trail, and with stations an average of approximately 1.5 kilometres apart, many commercial sites are even farther removed. Where public transport routes are concerned, it is often easy to forget that proximity to a station/stop is what counts, not just proximity to the route.

In the case of Calgary's South Corridor LRT it may have been more appropriate to use one of the principal roads in the corridor as a right-of-way in order to better serve non-city centre requirements. The LRT tracks could have occupied the centre of Macleod Trail, for example, in the same way that the Northwest LRT serves the

Hillhurst/Sunnyside neighbourhood. Alternatively, a modern streetcar system, as a mid-range solution between buses and LRVs, could have been constructed for the South Corridor.

The drawbacks of mixed-traffic running, typical of streetcar operations, tend to have been overstated. Research has found that on-street delays in LRT or streetcar operations can be attributed to several causes, not just road traffic congestion. A 1977 study of San Francisco's streetcar system, for example, found that the main cause of delays was due to passenger boarding and alighting. An earlier study conducted in Toronto revealed that boarding and fare collection accounted for 40% of all delays to Toronto Transit Commission (TTC) streetcars, almost as much as traffic signals at 50%. Street conflict caused by traffic congestion, pedestrians, construction etc. accounted for a mere 10% of delays. Therefore, "it may be invalid to readily assume poor service performance from new LRT surface options" (Guillot 1983, pp.346-347). If passenger boarding can be speeded up, with passengers purchasing tickets before boarding, coupled with random onboard ticket checks, then on-street running by LRVs could offer a viable and acceptable alternative to the use of rail (and expressway/freeway) rights-of-way.

However, inadequacies aside, the South Corridor LRT, in combination with park-and-ride facilities and feeder buses, has made a marked positive contribution to city centre oriented travel from the corridor.

## Northeast LRT

The C-Train line to the northeast Calgary suburbs of Whitehorn, Rundle and Marlborough, opened in 1985, has been located in the median of existing roads. For much of the route length (51%), between Franklin and the suburban terminus at Whitehorn, the line runs along the eastern edge of a belt of industrial estates. All of the residential, and much of the commercial/recreational development in the area, lie to the east of the LRT line. As a result, a station can be as much as 4 kilometres from a point within the northeast suburbs. A combination of park-and-ride and feeder bus facilities at suburban stations ensures that the line can effectively cater for trips to and from the city centre, but, as with the South Corridor line, the Northeast LRT is not well equipped to handle non-city centre travel. An LRT line could have been built through the heart of the northeastern suburbs, rather than skirting their western edge, allowing greater access to the area. If a suitable alternative, in engineering terms, to the present alignment could not have been found, then an alternative to LRT could have been considered. A conventional streetcar system can offer many of the advantages of LRT, and the superior capacity and performance of LRVs could have been relinquished in return for greater access to northeast Calgary.

Concern has even been expressed over the construction of an LRT line serving the city centre and, in a wider context, over the wisdom of an entire LRT system focussed upon the city centre. An economic evaluation of the Northeast LRT, conducted when the line was still in its early construction phase, observed that

> the greatest long run risk [in building the line] is probably the danger that a centrally oriented mass transit system will become obsolete if, as many expect, the economic structure of the society is reoriented to emphasize the movement of information rather than employees (Taylor & Wright 1983, p.354).

The last point may be a contentious one, but critics are justified in raising doubts over an LRT line/system that is only effective in catering for city centre-oriented travel.

## Northwest LRT

Unlike the Northeast and South Corridor LRT routes, the Northwest C-Train line (which was opened in two stages, in 1987 and 1990) runs in close proximity to the commercial, recreational and residential areas for which it offers transport service. Using a combination of dedicated right-of-way along the centre of existing roads and trackage located in the median of divided highways, LRVs penetrate the heart of communities in Calgary´s northwest suburbs. The Northwest LRT line is more of a "walk on/walk off" transport facility than the other LRT routes, in common with bus and streetcar operations. Only Banff Trail and Brentwood stations, for example, offer park-and-ride facilities.

In the "Northwest Calgary Transit Service Area" (essentially the northwest quadrant of the city), Calgary Transit carries approximately 37,000 trips each weekday. Of this total, about 20,500 trips (55%) are made on the LRT line. A trip is defined by Calgary Transit as "an uninterrupted journey in one direction between the place of origin and the travel destination" (Calgary Transit 1989, p.20). Since October, 1987, the City of Calgary Transportation Department has conducted five surveys in the Transit Service Area, allowing the degree of success of the Northwest LRT to be gauged. They represent the most recent ridership information available from the Transportation Department for the line. The surveys are:

- <u>Northwest LRT Impact Study - Onboard Survey</u>, October 1987, Transportation Planning Division.

- <u>Northwest LRT Impact Study - University of Calgary and S.A.I.T. Travel Surveys</u>, October 1988, Transportation Planning Division.

- <u>Northwest Household Survey</u>, March 1989, Heffring Research Group.

- Northwest Onboard Survey, March 1989, Calgary Transit and Transportation Planning Division.

- Northwest Transit Operator Survey, March 1989, Calgary Transit.

In October, 1987, comments concerning the recently opened Northwest line "generally reflected approval" for the addition of LRT to the Transit Service Area. The Northwest LRT Impact Study - Onboard Survey found that LRT passengers liked the C-Train facility "due to its comfort, speed, frequency of service, direct connection to other areas of the city, accessibility, reliable operation, and economy of travel". When comparing travel behaviour before and after introduction of the Northwest LRT, it was revealed that 17.8% of LRT travellers in the morning peak had previously used a car rather than transit, and 73% of LRT passengers had a vehicle available to make the trip (Calgary Transit 1989, p.23).

The overall level of satisfaction with Transit service in the area, and with LRT in particular, would seem to indicate that the Northwest LRT has lived up to the expectations of Calgary´s Transportation Department. Furthermore, the surveys reveal a latent demand for public transport that could (in theory) be realised given certain improvements to the existing public transport system in the area. With the exception of the Northwest LRT Impact Study - University of Calgary and S.A.I.T Travel Surveys, all surveys identified deficiencies in the connections between feeder buses and LRT. Transfers were not considered to be well coordinated. Similar criticism has also been directed against the LRT/bus interchanges at stations along the Northeast LRT route. The Northwest surveys also revealed a desire for improvements to the LRT line, in the form of additional park-and-ride spaces and an extension farther into the northwest suburbs. A package of enhancements to the existing transit service would, according to the surveys, attract one third of current non-users and entice almost half of the existing transit users to make greater use of the system (Calgary Transit 1989, pp.23-26; 1988, pp.28-29).

Although placing an LRT route in close proximity to commercial, recreational and residential areas is advantageous in terms of maximising the route's accessibility, it can spark conflict with the community in question. Such conflict is often absent where an LRT line employs an existing rail right-of-way or the median of a major road, expressway or freeway. The Northwest LRT has been controversial with respect to its route through the Hillhurst/Sunnyside community.

Located just across the Bow River from the city centre (Figure 17), Hillhurst/Sunnyside is a well established and stable inner city neighbourhood dating back to 1909. In an effort to retain that stability, the Hillhurst/Sunnyside residents have tried to resist those "modernizing" forces which they perceive to be detrimental to their community. The proposed Northwest LRT was seen as a product of "insensitive transportation planning" and it sparked collective community resistance. It was the planned alignment of the Northwest LRT through the neighbourhood, "more than any single issue", which was seen as a threat to the very survival of the community. An original proposal by city council to demolish residential property in order to allow LRVs to pass through the community was defeated in the courts. The court challenge was mounted by the "9A Street" group and it demonstrated the resilience and resourcefulness of the community association. Council ultimately voted to install LRT tracks in the road-bed of 9A Street and this is the alignment now used by the Northwest LRT (Dyson 1984, pp.30-33).

Following the decision by city council to adopt a modified 9A Street alignment, the 9A Street group sponsored a city-wide petition calling for a plebiscite on LRT routing, with reference to the Hillhurst/Sunnyside issue in particular and concerning LRT routing through Calgary in general. The petition called for measures which would ban the construction of LRT lines through residential property, residentially zoned areas and parkland "where existing transportation corridors can accommodate the system." According to the 9A Street group, the onus should be on city council "to select a route which will keep LRT within existing transportation rights-of-way or place it underground." With an estimated starting price of $28,471,000 for an underground route through Hillhurst/Sunnyside, in contrast to an on-street alignment costing $11,514,000 at the outset, the tunnel option was abandoned. The call for a plebiscite was also abandoned and the 9A Street routing issue resolved through a series of public hearings with City Council (Dyson 1984, pp.32-33; Brown 1991).

The Hillhurst/Sunnyside episode illustrates the importance of sensitive planning with respect to LRT and other transport projects, sensitivity, not only with respect to selecting LRT alignments through individual communities, but also in terms of proper liaison with community associations and community interest groups. That was the lesson learnt by Buffalo´s Niagara Frontier Transportation Authority (NFTA) in the 1970s. Where "ready made" LRT alignments in the form of rail (and indeed expressway/ freeway) rights-of-way are to be shunned in favour of alignments which penetrate the heart of existing commercial/recreational/ residential areas, then the lessons of Hillhurst/Sunnyside need to be understood.

However, the 9A Street routing issue is not without irony. The Hillhurst/Sunnyside district developed into a residential community in 1909 when the municipal streetcar system crossed the Bow River. It is therefore ironical that the 9A Street group attempted to resist LRT, a modern derivative of the transportation mode that was influential in creating the neighbourhood in the first place. Perhaps it was simply an example of the NIMBY (Not In My Back Yard) syndrome at work. If LRT has the potential to reduce road traffic congestion and bring environmental benefits to our cities, then sensitive planning for an LRT route should be embraced and not hindered by community organisations.

## Transit Mall

Opened in April, 1981, the Seventh Avenue transit mall (also referred to as "Transit Avenue") is the hub of Calgary´s C-Train system. The mall, which covers twelve city centre blocks, is reserved for LRVs, buses and emergency vehicles. Currently, the transit mall is considered adequate for transit demand in the "short to mid-term", but future expansion of the transit system (primarily LRT) will require new additional capacity. That extra capacity will probably come in the form of an LRT subway under 8th Avenue, one block south of the present transit mall. The ratio of surface to subway construction cost per mile of line typically ranges from 1:4-1:8 according to local conditions. However, in spite of the cost involved, underground alignments are considered desirable because they permit LRVs to operate free of traffic congestion, particularly in the city centre. As with Calgary, it is also possible to construct an underground city centre alignment at a later date. A surface transit mall can then serve as a "starter line" until the LRT system expands and matures (Guillot 1983, pp.352-353).

## Conclusions

At present, Calgary's C-Train LRT system comprises 17.7 route miles/28.3 kilometres, of which 4.6 miles/7.4 kilometres have been constructed using an existing rail right-of-way. At 26% of the total route mileage, the rail right-of-way component represents a significant portion of the C-Train network. In terms of the different types of alignment used in the system, there are essentially three: alignment incorporating existing rail right-of-way; alignment using the median of a divided highway; and on-street alignment with LRT rails installed in the road-bed. The South Corridor LRT has largely been constructed using existing rail right-of-way; the Northeast LRT makes extensive use of highway medians; and a combination of on-street running and highway medians constitutes the right-of-way for the Northwest LRT.

The primary purpose of this chapter has been to better understand the relationship between the use of existing rights-of-way (and rail rights-of-way in particular) for the construction of LRT routes, and the subsequent degree of success/ failure of that route. Using the Calgary C-Train system as a case study it has been possible to draw several conclusions concerning this relationship.

The experience of Calgary Transit clearly indicates that LRT is able to make a marked positive contribution to rush-hour, city centre-oriented travel. Commuter travel within this category appears to be largely influenced by the provision of feeder bus and park-and-ride facilities at suburban stations, rather than the precise alignment of the LRT route. Criticism directed against Transit service in northwest Calgary has repeatedly focussed upon the deficiencies of feeder bus connections at LRT stations in the area. It has been suggested that enhancements to the Transit service (including improvements to the feeder bus service, additional park-and-ride facilities, and LRT line extensions) would realise a substantial quantity of latent demand.

Although Calgary's LRT has been a success for city centre-oriented travel, the same cannot be said of suburban travel via LRT, particularly along the Northeast and South Corridor lines. An over reliance upon existing rail right-of-way (South Corridor) and the median of existing roads (Northeast) has left both routes largely traversing tracts of industrial and open land. Consequently, both routes share a marked degree of "remoteness" from the suburban commercial, recreational and residential areas that they are intended to serve. It is argued that even in cities such as Calgary, which possesses a viable city centre, suburban locations have increasingly shaped travel patterns and new transportation projects like C-Train need to address those demands. LRT routes which can only effectively serve new suburban centres, in the form of station development sites, cannot be expected to make a dramatic impact upon overall suburban travel patterns.

A solution to this predicament might be found in the greater use of on-street running by LRVs along established commercial thoroughfares. A "ready made" path through an established urban area, such as a rail right-of-way, can be appealing in planning, engineering and economic terms, but it is unlikely that it could match the high degree of accessibility afforded by a major city street. Experience with Calgary's transit mall and studies of North American streetcar systems suggests that the "drawbacks" of mixed-traffic running may have been overstated. If LRT systems can achieve a greater degree of physical integration into the areas for which they offer service, then the results for non-city centre travel may well be brighter than those achieved by Calgary's C-Train thus far.

For the LRT planner, one distinct advantage of selecting a rail (or expressway/freeway) right-of-way, is that the choice of routing is not usually controversial for local residents. A change of policy that favours greater on-street running is a policy that places rails and LRVs in much closer proximity to housing and commercial establishments. In this respect, the Northwest LRT in its planning stage came into conflict with the residents of the Hillhurst/Sunnyside community. The episode illustrated the need for sensitive LRT planning and the importance of proper liaison with the community in question. A diplomatic approach could well avoid controversy and ensure the smooth implementation of similar LRT projects.

Finally, there is a parallel that can be drawn between Calgary's "starter line", the South Corridor LRT, and the city centre transit mall. It has been argued that a transit mall can serve as a relatively inexpensive city centre hub until the LRT system expands and matures. At that point the transit mall can be replaced by an underground alignment for LRVs and the on-street rails removed. This is the likely scenario for Calgary. The implication is that Calgary would like to have constructed a subway at the outset but could not justify the cost. A transit mall would suffice as an interim solution. Perhaps the same can be said of the South Corridor LRT "starter line"? By using an existing rail right-of-way the City of Calgary was able to introduce LRT in a relatively inexpensive fashion. Although the alignment may not have been perfect it may have been the only way to launch LRT in Calgary within acceptable financial and political guidelines.

# CHAPTER FIVE:

# CASE STUDY B -

# THE VANCOUVER-RICHMOND RAPID TRANSIT PROJECT

In contrast to the previous chapter, which explored the issue of route selection for a complete urban rail system, this chapter examines the selection of a single route, for the "Vancouver-Richmond Rapid Transit Project". The project has been established to design and construct a rapid transit link between Vancouver and the Municipality of Richmond in British Columbia's Lower Mainland Region. Within this broad remit there is scope for several combinations of route and technology, including LRT. The project sheds valuable light upon the issue of route selection and the choice between a readily available rail right-of-way and alternative alignments. Principally for this reason, the Vancouver-Richmond Rapid Transit Project has been chosen as the subject of Case Study B. It was also selected for two other reasons. Since the thesis examines the degree of future as well as current dependence upon existing rail rights-of-way, this chapter addresses the need for a project which is still firmly in the planning stage, in contrast to Calgary's operational system. Also, in common with the Calgary LRT, the selection of the Vancouver-Richmond Rapid Transit Project is intended to contribute to a better understanding of Light Rail Transit in Canada.

Vancouver is the third largest city in Canada and the financial, commercial and industrial centre of British

Columbia. Located in the Fraser River delta, it is the Canadian gateway to the Pacific and the Orient, symbolized by its large and comprehensive port facilities. Greater Vancouver, with a population of 1.6 million, comprises 21 municipalities and unincorporated communities, including Vancouver, North Vancouver, Burnaby, Richmond and Surrey.

## Background to the Vancouver-Richmond Rapid Transit Project

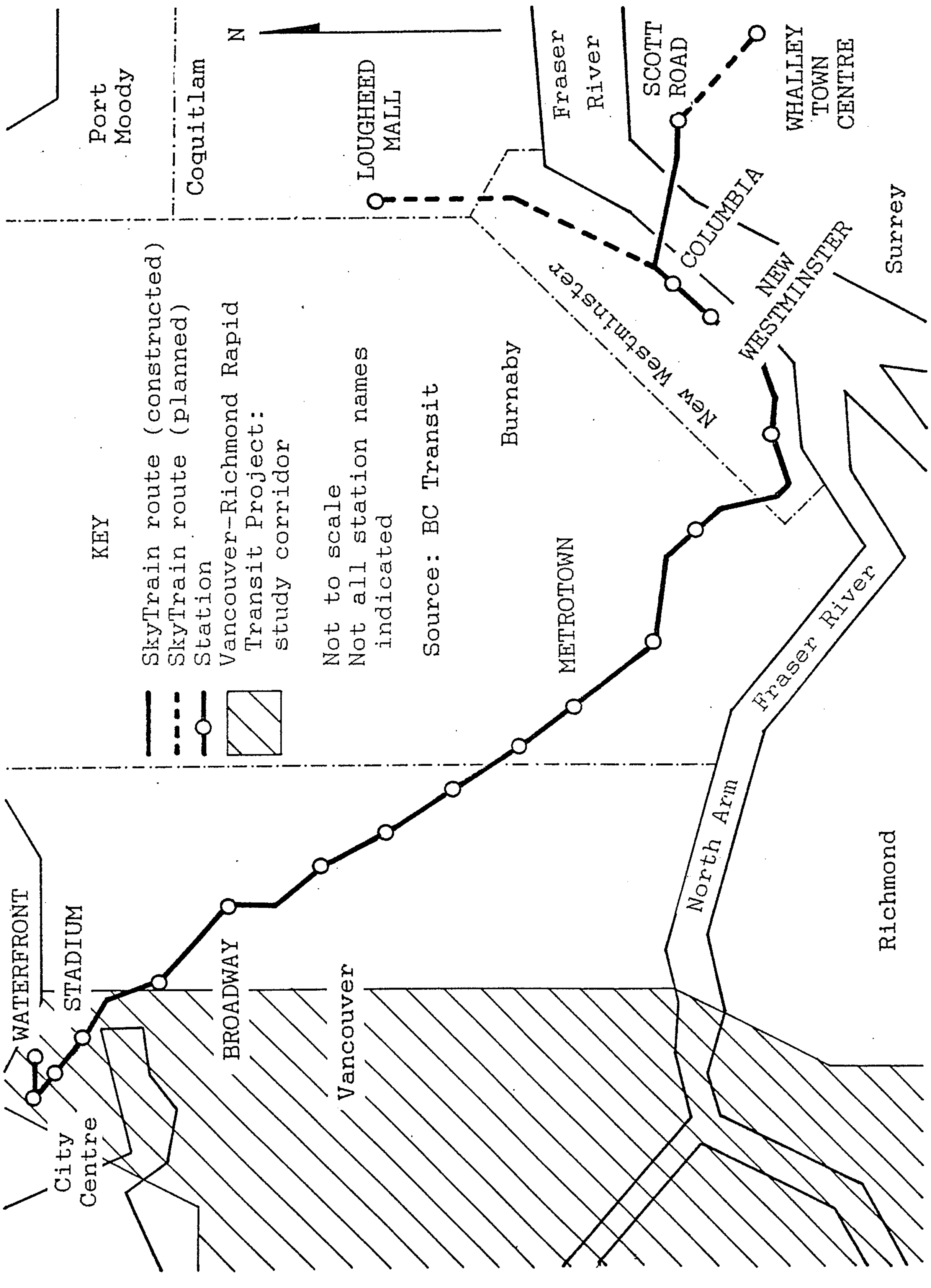
The seeds of rapid transit in the Vancouver region were sown in 1967, when the Greater Vancouver Regional District (GVRD) was formed by the Government of British Columbia. The GVRD is a partnership of the aforementioned municipalities and unincorporated communities and has a mandate to provide "essential" services to the residents in the region. In 1975 the GVRD attempted to answer the question: "How can Greater Vancouver´s unique quality of life be enhanced in balance with continued growth?" The "answer" was the "Livable Region" planning strategy. This planning blueprint, which has been "revived" under the banner "The Livable Region, A Strategy for the 1990s", is based upon several goals. One of those goals is the "creation of improved accessibility for [the] transportation of goods and people" (GVRD 1989). Improvements to the transit system are seen as essential in order to reduce air pollution in the region. It is estimated that motor vehicles account for as much as 80% of the air pollution in the Greater Vancouver area. In addition, rapid transit can play an important role in the economic development of the region (BC Transit 1990a).

The 1969 plan for the Vancouver Metropolitan area proposed to connect the Vancouver city centre with the four "regional town centres" of Burnaby, New Westminster, Port Coquitlam and Surrey using a rapid transit system (Figure 18). That system was "SkyTrain", a fully automated railway that is operated with driverless trains using linear induction propulsion. Phase One began revenue service in 1986, to coincide with EXPO 86, and by 1990 trains were running between Vancouver and Surrey. Further extensions to the system are currently in the engineering and design stages. SkyTrain service will be extended to Whalley Town Centre (Surrey) by 1993 and to Lougheed Mall in Port Coquitlam by 1995.

In addition to the construction of a rapid transit system linking Vancouver with Surrey and Port Coquitlam, the GVRD has for some time regarded the establishment of a rapid transit link in the Vancouver-Richmond corridor as a priority. The 1989 report of the Greater Vancouver Transportation Task Force referred to the proposed link as "one of the highest priority transportation improvements to

Figure 18. Rapid Transit in the Greater Vancouver Region





address growing traffic congestion" in the corridor (BC Transit 1990a). The proposed goal of the project is

> to increase the use of transit in moving people in the designated corridor (Vancouver-Richmond) and to do so in an environmentally responsive, aesthetically attractive and cost effective way and in a manner which is compatible with land use objectives and which has general public support (BC Transit 1990c).

On 31st July, 1989, the then Premier, William Vander Zalm, announced a $1 billion programme of rapid transit projects for the Greater Vancouver area. This programme includes the planning, design and construction of the line to Richmond, along with the Whalley and Coquitlam SkyTrain extensions. Target date for the completion of the Vancouver-Richmond Rapid Transit Project has been set for 1995 (BC Transit 1990a).

## The Project

### Introduction

Beyond the need to link Richmond and the Vancouver city centre, the terms of reference for the rapid transit project permit a large degree of flexibility with regards to the choice of route and technology. Several combinations of the two are currently being evaluated. Within the broad study corridor (Figure 18) a number of alignments are under consideration. The following sections of this chapter will examine the issues surrounding route selection for the project. In terms of the technology to be used, three types of rapid transit have been proposed: SkyTrain, Light Rail Transit and Busway. However, Vancouver City Council has gone on record as being opposed to any form of elevated alignment. This is a result of the negative response from residents living along the existing SkyTrain route, a system that uses extensive portions of elevated right-of-way (BC Transit 1990a; City of Vancouver 1989b, p.3). In addition to the generally unwelcome visual intrusion of the elevated portions of the route, the wheelsets of moving SkyTrain vehicles have produced excessive levels of noise. A 1990 survey conducted by BC Transit found that SkyTrain detractors regarded the system as "noisy, expensive and visually unappealing" (BC Transit 1990e). Presumably, then, the balance is tipped in favour of LRT or busway, since SkyTrain, as an automated system and one which employs a "third rail" system of current collection, must use an exclusive right-of-way. The only alternative to an elevated SkyTrain route is one which makes extensive use of underground alignments, if the impact upon existing road vehicle and pedestrian traffic is to be kept to a minimum. In this respect both LRT and busway offer much greater flexibility to the planner.

Identification of the best route and technology represents Phase One of the project, which in turn will be a four stage planning process:

Stage 1 - "Determine all feasible routes and develop appropriate screening criteria."

Stage 2 - "Select 10 best of the feasible routes/ technologies for initial evaluation."

Stage 3 - "Select best 3 out of 10 feasible routes/ technologies for detailed evaluation."

Stage 4 - "Select best route/technology" (BC Transit 1990d).

The estimated timetable for all phases of the project is as follows:

Phase 1 (1990-1991) - Selecting the route and choosing the technology.

Phase 2 (1991-1992) - Designing the system.

Phase 3 (1992-1994) - Constructing the system.

Phase 4 (1995) - Commissioning thesystem (BC Transit 1990b).

Although the first phase of the project will examine all potential alignments, both the GVRD and the City of Vancouver have expressed a preference for using the so-called "Arbutus Corridor" (also referred to as the "Arbutus Rail Line" and the "Arbutus Right-of-Way"). The GVRD has proposed operating a route in the corridor with LRT technology, whilst Vancouver City Council favours using the alignment for a busway (BC Transit 1989; 1990a). As a result, the label "Arbutus Corridor" has often been used synonymously with the project.

## The Arbutus Corridor

Although Phase One of the project is concerned with selecting a route between Richmond and the Vancouver city centre, including the crossings for the Fraser River and False Creek, this thesis is concerned with the section between those two bodies of water, since this is the portion of the project corridor for which a rail right-of-way is available. The Arbutus Corridor is a CP Rail right-of-way which runs parallel to Arbutus Street and, farther south, is sandwiched between West and East Boulevard (Figure 19). Because the railway line links False Creek and the Fraser River along a general north-south alignment, it is understandable that this readily available right-of-way has been touted for the rapid transit project. In the well documented view of the Vancouver City Planning Commission, the Arbutus Corridor possesses many advantages over alternative (i.e. road right-of-way) alignments. It already exists as a "complete transportation corridor"; it involves fewer crossings (i.e. conflict with east-west road traffic); and it has a resultant lower cost (City of Vancouver 1989a). Between 9th-17th January, 1990, BC Transit conducted "formal opinion research" among residents of potentially affected areas of Vancouver and Richmond, in order to determine public opinion concerning various aspects of the rapid transit project. For Vancouver

Figure 19. Vancouver-Richmond Rapid Transit Project
Study Corridor: Residential Vancouver Component

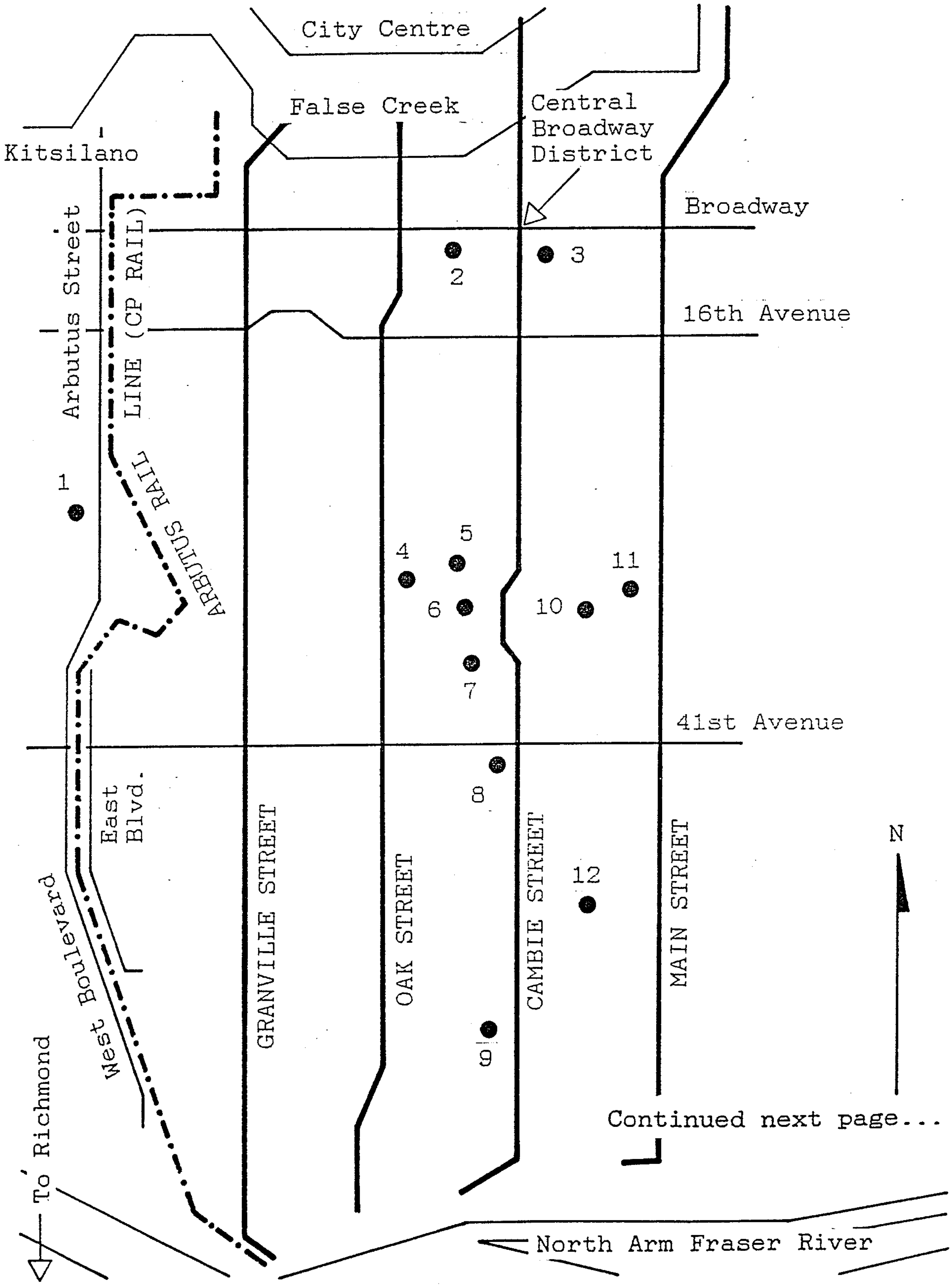



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Figure 19. Key to Map

## KEY

| | |
|---|---|
| ——— <br> —·—·— | Alignments considered for the Vancouver-Richmond Rapid Transit Project |
| ● | Potential traffic generator: |
| 1 | Arbutus Village Shopping Centre |
| 2 | Vancouver General Hospital |
| 3 | City Hall |
| 4 | Grace and Children's Hospital |
| 5 | Shaughnessy Hospital |
| 6 | St. Vincents Hospital |
| 7 | RCMP Barracks |
| 8 | Oakridge Shopping Centre |
| 9 | Pearson TB Hospital |
| 10 | Queen Elizabeth Park |
| 11 | Nat Bailey Baseball Stadium |
| 12 | Vancouver Community College |

Not to scale

Sources: Allmaps Canada;
American Automobile Association

residents, the most popular choice of alignment was the Arbutus Corridor.

> An Arbutus/W.Boulevard route was preferred by these residents largely because it is seen to be able to easily accommodate a rapid transit line. Respondents reason that as there is already a rail right-of-way along this route, it would be the least disruptive to build (BC Transit 1990e).

The "popularity" of the Arbutus Corridor among Vancouver residents does, however, require qualification. Although the survey conducted by BC Transit revealed more support for the Arbutus Corridor than for any other alignment, response to all potential routes was low. Furthermore, the survey was not able to determine whether any support for the Arbutus Corridor was forthcoming from residents living in close proximity to the route. As with support for potential alignments, opposition to all routes was low, but the largest percentage of opposition was reserved for the Arbutus Corridor (BC Transit 1990e). Nevertheless, the arguments in favour of the corridor, as revealed in the BC Transit survey, neatly summarise the reasons why support for the alignment has been strong in some quarters.

In common with the experiences of Calgary Transit with respect to the Calgary neighbourhood of Hillhurst/Sunnyside, much concern has been expressed by residents living in the vicinity of the Arbutus Rail Line, should the corridor be selected for the rapid transit project. Some residents fear that by converting a lightly used railway freight line into an intensively used rapid transit link, the present essence of neighbourhoods in the Arbutus Corridor, Kitsilano for example, will be degraded. Vancouver City Council has stated that "regardless of what corridor is ultimately selected, there should not be a disruptive impact on the neighbourhood". Council also proposed that BC Transit

> design a system that doesn't impact negatively on the Vancouver neighbourhood selected from the perspective of the people who live there and so that any commonsensical person driving or walking through the selected neighbourhood will know that here is a neighbourhood with integrity and pride (City of Vancouver 1989b; 1989d).

The problem is that terms such as "disruptive impact" and "impact negatively" are difficult to quantify and will depend upon whose point of view is considered. The Vancouver City Council, BC Transit and the GVRD all publicly acknowledge that a rapid transit system can be a powerful economic tool, and experience with SkyTrain supports this. Much of the commercial development at Metrotown (Burnaby) and New Westminster may not have taken place without SkyTrain. The pattern of development which occurs in any given area is strongly governed by its street network, and major arterial roads and transit corridors are "even more instrumental" (BC Transit 1990a; City of Vancouver 1989a). It is difficult to see how a rapid transit link could not have a significant physical impact upon the Arbutus Corridor, or any other alignment. Each station site, for example, is likely to exert a strong economic influence upon the area in its immediate vicinity.

There have already been moves to rezone land along the Arbutus Corridor in Kitsilano, in the vicinity of Broadway (Figure 19). As a result, City Council faces a series of dilemmas in attempting to establish rezoning policies for the area. Property owners, for example, generally favour higher densities than those favoured by the residents. Residents prefer development with lower heights and a Floor Space Ratio (FSR) ranging from 0.75 - 2.0. The FSR is an index of building bulk that relates the floor area of a structure to the site area. An FSR value of 1.0 is equal to a single storey building covering the entire lot. An economic land development analysis of the area suggests that residential development with an FSR of 1.45 or less will offer only marginal economic returns. In addition, residents have called for a 40 foot height limit, but the "livability" of residential development at FSRs in excess of 1.45, combined with such a height restriction, can be "significantly reduced". It may not be possible to achieve a consensus of opinion among residents and property owners/ developers with respect to rezoning policies in the area. Furthermore, if the Arbutus Corridor is selected for the rapid transit link, a station and possibly some form of bus interchange will be required in the Kitsilano area. This may well lead to further conflict between parties (City of Vancouver 1989e; Hodge 1986, p.156).

The announcement of the rapid transit project and suggestions that the Arbutus Corridor would be given serious consideration as a suitable right-of-way, led to the submission of several briefs to the Mayor of Vancouver and members of Council by concerned residents of the area. The Kitsilano Citizens´ Planning Committee is one such organisation that is active in this respect. The Committee has passed several motions stemming from "general concerns" about the rapid transit project and from the aspirations which Kitsilano residents hold for the Arbutus Corridor. In order to "minimize impacts on the local neighbourhoods", regardless of which route is finally selected, a motion was passed urging that the rapid transit system be placed underground, rather than construct an elevated or surface alignment. The Committee also passed a motion requesting the City to reserve the Arbutus Corridor solely for transportation use and that the City "recognize bicycle ways, pedestrian ways, rapid transit [and] utilities as legitimate forms of transportation". In this way it is hoped to make the corridor available for all transport requirements, including those that are at present unanticipated. Essentially, the Kitsilano Citizens' Planning Committee would like to see a rapid transit link buried underground, if the corridor is selected for the project, and the surface right-of-way devoted to a pedestrian/bicycle route linking False Creek and the Fraser River. The Committee recommends that the Arbutus Corridor be "set aside as a pollution-free zone" (McCall 1990).

As with the protestations of the 9A Street group in response to Calgary Transit's Northwest LRT, it is difficult to ascertain whether community groups such as the Kitsilano Citizens' Planning Committee genuinely support a move towards "green" urban transportation, or whether they are simply illustrating the NIMBY syndrome. Certainly, the bulk of the Committee's motions address a desire to remove railway freight traffic from the Arbutus Corridor and supplant it with a bicycle route and pedestrian walkway. However, the sincerity and aims of community groups with respect to urban transportation are beyond the intended scope of this thesis. Besides, although it would be wrong for the planner to simply take the path of least resistance, and build where community opposition is at a minimum (or non-existent), the early stages of the

Vancouver-Richmond Rapid Transit Project have revealed deficiencies with the Arbutus Corridor, and advantages associated with alternative alignments.

The Vancouver City Planning Commission has been constantly informed that a direct correlation exists between the success of public transport and the population density of the area that it serves. There is a hierarchy of urban transportation modes which are "appropriate" at different densities, ranging from the taxicab and dial-a-bus service for the lowest density developments, to expensive "heavy rail" rapid transit systems such as BART or the Washington (DC) METRO, for which high density land development is considered vital. Higher density cities have tended to support transit better than those of lower densities. Of the proposed alignments through Vancouver - the alternatives will be identified and discussed in the following section - the Arbutus Corridor offers virtually the lowest densities of all. This would not necessarily be a problem in itself if the corridor could be redeveloped to a higher density in the future. However, the Vancouver City Planning Commission believes that "residential densification" would be more appropriate elsewhere. It favours redeveloping "single-family enclaves" adjacent to locations with institutional uses (City of Vancouver 1989a; Pushkarev & Zupan 1977). Presumably, the Kitsilano

Citizens' Planning Committee, and other community groups active in the Arbutus Corridor, would attempt to resist any plans designed to further increase residential density in the corridor.

Before examining the issue of alternative alignments for the rapid transit project there is one more drawback to the Arbutus Corridor that is often overlooked, but is worth mentioning. Any cost comparisons between the Arbutus Corridor and alternative paths must include the cost of purchasing the rail right-of-way from CP Rail. The alternative alignments would use existing road rights-of-way, at least between False Creek and the Fraser River, and since these are owned by the City of Vancouver, no right-of-way purchase cost would be incurred by the project along this portion of the route should one of these be selected. It might be possible for the City to lease the right-of-way from CP Rail or obtain it in exchange for another parcel of land. Either option would, however, result in a cost to the City, whether a direct cost or the lost opportunity of selling the alternative parcel of land (City of Vancouver 1989a; 1989d).

## Alternative Alignments

Although the Arbutus Corridor offers a readily available rail right-of-way (which would make the rapid transit project relatively simple to construct in engineering terms, and thereby keep project costs down) pressure has forced the terms of reference to be amended so that other routes between False Creek and the Fraser River can be evaluated. Therefore "alternative alignments will be considered in the broad corridor between Arbutus Street on the west and Main Street on the east" (BC Transit 1990b). There are four alternatives to the Arbutus Corridor: Granville Street, Oak Street, Cambie Street and Main Street (Figure 19).

In its report to Vancouver City Council of 31st July, 1989, the Vancouver City Planning Commission expressed "strong misgivings" concerning the project's terms of reference. The Planning Commission was "dismayed" that the Transit Corridor Study would "limit itself to the Arbutus Corridor" in Vancouver. Although the Planning Commission acknowledged the engineering and construction advantages associated with the Arbutus route, it argued that these advantages "might be outweighed in the longer term" by other benefits that could only be derived from the road alignments. The arguments of the Planning Commission centred on the issue of whether or not the rapid transit link should be designed to serve intermediate points between Richmond and the city centre of Vancouver. According to the Planning Commission

> if it is the opinion of Council that the north-south rapid transit line should function primarily as an inter-city service to bring people back and forth between Richmond and the central business district of Vancouver, then the Arbutus Corridor probably has no rivals.

If, however

> there are important benefits to be gained for the city by serving directly more people and employment destinations along the Vancouver portion of the route, by selecting a corridor with the promise of optimizing Vancouver ridership and by creating more land use options, then the other north-south routes through the city should be included in the scope of the report (City of Vancouver 1989a).

Setting aside the objections that community organisations such as the Kitsilano Citizens' Planning Committee might raise, the Arbutus Corridor would seem to be an ideal route to select, if the only role that the rapid transit link should fulfill is the effective movement of people between Richmond and the Vancouver city centre. However, by selecting one of the alternative routes, Cambie Street/Oak Street for example, the new public transport facility would provide direct access to a much greater selection of employment destinations in Vancouver, particularly public institutions. The latter could generate large numbers of passengers in the form of institution employees, visitors and students. The following public institutions could be served by a rapid transit link in the

Cambie Street/Oak Street corridor (Figure 19):

Vancouver General Hospital
Grace and Children's Hospital
Shaughnessy Hospital
St. Vincents Hospital
Pearson TB Hospital
City Hall
Vancouver Community College
RCMP Barracks

There are also major commercial activity centres in the corridor, including the Oakridge Shopping Centre, at the corner of Cambie Street and 41st Avenue, and the Central Broadway District in the vicinity of the Broadway and Cambie Street intersection. A rapid transit link along this corridor could also usefully serve Queen Elizabeth Park (and conservatory) and the Nat Bailey Baseball Stadium. By contrast, the only notable "destination" in the Arbutus Corridor (with the exception of schools, churches, parks and small shopping areas, which are present in all of the study corridors) is the Arbutus Village Shopping Centre, located on the west side of Arbutus Street.

If an alternative to the Arbutus Rail Line is selected, the Oak Street/Cambie Street corridor for example, then the much greater range of employment, shopping, educational and recreational destinations that can be effectively served by the rapid transit link will presumably translate into much greater ridership and revenue (City of Vancouver 1989a). Since the Arbutus Rail Line is approximately 1.25 miles/2 kilometres from the various travel destinations mentioned above, it is not realistic to expect a rapid transit route located in the corridor to be regarded by the travelling public as an effective means of accessing those destinations. Cambie Street, on the other hand, is located approximately 0.2 miles/0.32 kilometres from the principal destinations in the study corridor and is thus better placed to effectively serve them. Therefore, although the Arbutus Corridor represents a simpler route in engineering terms, and as such, has remained popular with the Vancouver City Council, strong arguments in favour of alternative routes forced Council to alter the project´s terms of reference to include those alignments.

On 15th August, 1989, Coucil approved a delegation request by a group of interested citizens to be heard at a future Finance and Priorities Committee meeting. The meeting was held on 31st August, 1989, and there were nine delegations present to address the Committee. In view of the large number of people present to hear the debate on the "Transit Corridor Study" the agenda was altered to make this the first item of business. Furthermore, over 70 letters from the public were available for the Committee´s consideration. The delegations and correspondence relating to the Vancouver-Richmond Rapid Transit Project conveyed a selection of views, but all were "in opposition to any pre-selection of the Arbutus Corridor without a comprehensive review of altervatives being undertaken." The Chairperson subsequently explained that City Coucil "had no intention of restricting the choice of transit corridor to Arbutus, but would request B.C. Transit to undertake a full and objective study of all routes" (City of Vancouver 1989b).

The presence of several major traffic generators in close proximity to routes such as Cambie Street and Oak Street is a persuasive argument for widening the scope of study beyond the Arbutus Corridor, but there are other factors which further strengthen the case in support of the road alignments. Those factors relate to residential density in the project study area, available space within each corridor, and shifts in the economic centre of gravity of the Greater Vancouver region. As mentioned previously in this chapter, higher residential densities than those which currently exist in the Arbutus Corridor are likely to be necessary in order to make the rapid transit link viable. This is particularly true in view of the fact that the corridor is largely residential (with some industrial use, although this has been subject to a "marked exodus" in recent years) and contains only a single major traffic generator. In contrast, the road alternatives to the east serve areas of higher residential density. Furthermore, if pressure (from whatever source) forces "residential densification" to occur within the chosen rapid transit corridor, then it seems likely that it will take place in one of the road alignments rather than in the Arbutus Corridor. This is because, in addition to staunch community opposition to higher densities in the Arbutus Corridor, particularly in the Kitsilano neighbourhood, the City believes that densification would be more appropriate in one of the road corridors. The Vancouver City Planning Commission has argued that higher density development could be more "sensibly" accommodated in pockets of single-family development around public institutions, such as the Shaughnessy Hospital (City of Vancouver 1989a; 1989c). It is possible that the Planning Commission would find it easier, and thus prefer, to "squeeze out" lower density development in these areas, rather than tackle the thorny issue of a significant rezoning of the Arbutus Corridor. However, residential densification or not, the higher existing densities present in the road corridors suggest that they would be more appropriate for rapid transit than those of the Arbutus Corridor.

Another factor which favours a road alignment is the corridor width required for a double-track rapid transit route. The CP Rail line is only single-track and north of 16th Avenue it has been suggested that insufficient corridor width exists for the project, a situation that would of course be exacerbated at station sites (City of Vancouver 1989d). One of the criticisms that has been directed at the automobile is the relatively large amount of land required for a given traffic volume, in comparison to public transportation, and rail transportation in particular. Consequently, major roads like Cambie Street offer more than enough room for a rapid transit link, whether busway or some form of rail based transport is chosen. The selection of a road alignment would be more disruptive at the construction stage, because of the need to temporarily reduce (or even eliminate) road capacity, but it would remove any obstacles associated with the width required for a rapid transit line. It also weakens, to some degree, City Council´s arguments in favour of the Arbutus Corridor as the best option from an engineering standpoint.

Finally, the projected long term development trends of the Greater Vancouver region have been used in the debate over the choice of route for the Vancouver-Richmond Rapid Transit Project. With the region hemmed in by mountains to the north and the sea to the west, the overall direction of expansion for the built-up area is southeast, along the valley of the Fraser River. The Vancouver City Planning Commission has argued that with the region´s economic centre of gravity moving eastward, the Arbutus Corridor, already "remote" from major centres of employment, recreation and education, will be left with an increasingly peripheral role to play. In this respect, therefore, any one of the road alignments to the east of the Arbutus Corridor represents a more attractive proposition (City of Vancouver 1989a).

## Project Footnote

The consultants responsible for the Vancouver-Richmond Rapid Transit Project have made progress in narrowing the list of route/technology options associated with Phase One. Although a busway was originally the preferred technology choice of City Council, the final decision will now be made from the two rail based options: LRT and SkyTrain. Both technologies are better suited than busway to provide the higher capacity likely to be required in the growing Lower Mainland Region. For the residential Vancouver portion of the route, between False Creek and the Fraser River, a final decision will now be made between the Arbutus Corridor and Cambie Street. The other road options (Oak Street, Granville Street and Main Street) were eliminated because they were not considered to be wide enough to accommodate a rapid transit line at grade and still be able to function as effective arterial roadways.

With a wide centre boulevard, Cambie Street can, in theory, cater for the anticipated volumes of both road and rail traffic. There are in fact 10 route options for the project, dictated by the uncertainty surrounding the Richmond and Vancouver city centre alignments, but all options use either the Arbutus Corridor or Cambie Street. Unfortunately, Phase One of the project has been delayed due to the provincial election and "the requirement to brief the new government on the status of the project." Phase One is now likely to be completed this year (1992) (BC Transit 1991; Chan 1991a; 1991b).

## Conclusions

The Vancouver-Richmond Rapid Transit Project, currently in the planning and design stages, is an example of a rapid transit system which has the opportunity of using an existing rail right-of-way, which, if selected, could provide approximately 50% of the project´s required route. Phase One of the project is concerned with selecting the route and choosing the technology for the system, and is scheduled to be completed in 1992. The route selection component of the project´s first phase is the context within which this chapter has been written. A final choice of technology will be made between LRT and SkyTrain.

The Arbutus Corridor is the label which has been attached to the railway line running between False Creek and the Fraser River that CP Rail would be willing to sell, should it be required by the rapid transit project. Since the Arbutus Corridor is a readily available right-of-way it represents a relatively simple and relatively inexpensive route option, in engineering and construction terms, for the residential Vancouver portion of the project. Consequently, both the Greater Vancouver Regional District (GVRD) and the City of Vancouver have expressed a preference for this route option. Indeed, in the earliest stages of the project it was almost a foregone conclusion in some quarters that rapid transit vehicles would supplant CP Rail freight trains in the Arbutus Corridor. However, concern expressed by residents living in the corridor, coupled with suggestions that deficiencies associated with the CP Rail route might not be present in alternative alignments, forced City Council to amend the project's terms of reference. Between False Creek and the Fraser River, the study corridor was expanded to include Granville Street, Oak Street, Cambie Street and Main Street. Subsequently, the choice has been narrowed to the Arbutus Corridor and Cambie Street.

Central to the discussion of route selection for the project is the issue of whether the rapid transit link should be designed to serve intermediate points between

Richmond and the Vancouver city centre, or whether its primary role should be to provide "inter-city" service between the two. If the project were to assume the latter role then the Arbutus Corridor would probably be unrivalled, ignoring for a moment the concerns and pressures of community groups active in the corridor. However, the accepted view now is that the rapid transit link should serve as many intermediate traffic generators as possible, thus maximising ridership and revenue, and benefitting a larger segment of the Greater Vancouver population. SkyTrain, the "model" for rapid transit in the region, has demonstrated that service to intermediate points can be combined with acceptable end to end journey times.

If the volume of intermediate traffic generated by the rapid transit line is to be maximised, then Cambie Street is a superior choice of route. The use of Cambie Street as a right-of-way would place the rapid transit line close to City Hall, several hospitals, a college and two major commercial activity centres. All can be expected to generate substantial quantities of traffic. The Arbutus Corridor, on the other hand, can boast only a single notable travel "destination", in the form of a shopping centre. Furthermore, since the Arbutus Corridor is "remote" from the travel destinations in the Cambie Street corridor, it is unrealistic to expect a rapid transit facility located in the corridor to effectively serve them.

In addition to its proximity to several major traffic generators, there are further arguments in favour of Cambie Street as a viable alternative to the Arbutus Rail Line. Of all the route options in the study area, the Arbutus Corridor offers virtually the lowest residential densities. Since it is reasonable to assume that, other things being equal, the corridor with the highest residential density is likely to offer the greatest number of riders, it would be prudent to select that corridor. Cambie Street not only has a higher residential density, but it also has the greater potential for future density increases. Another factor which favours the Cambie Street alignment is the corridor width needed for a double-track railway line and the space required at station sites. The Arbutus Rail Line is only single-track and doubt has been expressed regarding the corridor´s ability to accommodate a rapid transit facility. Cambie Street, by contrast, offers more than enough corridor width. It also has to be remembered that the Arbutus Corridor is a privately owned right-of-way, unlike Cambie Street which is the property of the City of Vancouver. Therefore, if the Arbutus Rail Line were to be selected for the project, the choice would incur the cost of purchasing land from CP Rail. Finally, with the Greater

Vancouver region's economic centre of gravity shifting eastward, Cambie Street will occupy a more central location than the Arbutus Corridor.

This chapter has attempted to illustrate the point that, although an existing rail right-of-way is desirable for the transit planner, from an engineering and construction standpoint, it is not necessarily the route which will best serve the interests of the travelling public. Using the Vancouver-Richmond Rapid Transit Project as an example, it can be argued that

> selecting the cheapest, least problematic and cost-effective route would be the correct short-term engineering solution. Selecting the route which maximizes the more long range benefits to the public, the economy, the fare structure and the urban development of the city would be the correct planning solution (City of Vancouver 1989a).

It is also worth observing that the "correct planning solution" to rapid transit route selection will probably involve, if not actively solicit, public opinion. Community groups in Vancouver have been influential in attempts to alter the terms of reference for the rapid transit project, forcing City Council to consider alternatives to the Arbutus Corridor. Although public opinion is (and should be) important to the transit planner, it becomes difficult to separate constructive criticism from self-interested opinion. It remains to be seen to what extent community opposition to a surface rapid transit link in the Arbutus Corridor will affect the ultimate choice of route in residential Vancouver.

# CHAPTER SIX:

# SUMMARY AND CONCLUSIONS

Starting in the late 1970s, and gathering momentum during the 1980s, there has been a resurgence of interest in urban rail transport in North America and the United Kingdom. An over reliance upon the automobile as a transport "solution" has burdened many of our cities with intolerable levels of air and noise pollution and created traffic congestion which, in many cities, can only be "solved" by financially and politically unacceptable road expansion measures. Increasingly, by contrast, urban rail projects are being viewed as an effective antidote to at least some of these transportation problems. Light Rail Transit (LRT) is one form of rail transport that has been part of this resurgence and has been embraced by many cities in Canada and the United States, with other cities, including several in the United Kingdom, set to follow suit.

Consensus upon what exactly is Light Rail Transit appears to be elusive, but for the purposes of this thesis it is regarded as a transport tool which combines much of the operational flexibility of the streetcar (the ability to negotiate sharper bends and steeper gradients than can be accomplished by a conventional rail vehicle) with some of the performance and passenger capacity of "heavy rail" rapid transit trains. As a result of its operational flexibility, LRT can take advantage of a variety of potential route alignments, from exclusive right-of-way to mixed traffic operation along city streets. The attraction of LRT lies in its apparent ability to reduce road traffic congestion and enhance urban air quality, at a price that is lower than conventional rail alternatives, whilst simultaneously offering a flexibility in implementation and operation that is unique to LRT.

Although several types of alignment are potentially available to the LRT planner, the author noted that many lines seem to have relied heavily upon the use of existing rail rights-of-way, whether disused or active with conventional rail traffic. Such alignments provide a readily available and thus relatively inexpensive corridor through a built-up urban area. In that respect it is easy to understand why existing rail rights-of-way have been prominent in the planning and construction of LRT routes. The alternatives are to build underground or to create a new corridor on the surface, either elevated or at grade. Both options are expensive and, particularly in the case of the latter, subject to potential opposition from area residents. However, experience with the "Metrorail" rapid transit system in Miami serves as a warning. The railway has been plagued by low ridership figures because of the decision to use an abandoned rail right-of-way to construct the line, a decision which has resulted in

Metrorail trains bypassing several large activity centres in Miami.

This thesis resulted from concerns that a repetition of the Metrorail example in the sphere of Light Rail Transit could seriously mar the latter's contribution to rail transport's urban resurgence. Consequently, the thesis has attempted to ascertain the extent to which LRT lines have used/will use existing rail rights-of-way, and in turn, the degree to which reliance upon those rights-of-way has affected/is likely to affect the success of an LRT project.

Based upon the definition of Light Rail Transit provided in Chapter Two, the thesis has identified 16 lines/systems in North America and the United Kingdom which are operational, under construction, or in the advanced planning stage. The LRT lines/systems in question have been constructed/will be constructed in the Canadian cities of Calgary and Edmonton; in the American cities of Boston, Buffalo, Cleveland, Dallas, Los Angeles, Pittsburgh, Portland, Sacramento, San Diego and San Jose; and in the British conurbations of Manchester, South Yorkshire (Sheffield) and the West Midlands (Birmingham). With the exception of the Calgary LRT and the proposed Vancouver-Richmond Rapid Transit Project, all 16 LRT systems were examined in Chapter Three. The aim of this chapter was to ascertain the degree to which the availability of existing rail rights-of-way has been a factor (or will be a factor) in the planning and construction of North American and British LRT systems.

Of the 14 urban areas discussed in Chapter Three, only the Boston and Cleveland LRT systems were found not to have made any use of existing rail rights-of-way. However, those systems were established in the late nineteenth century/early twentieth century, in an era when right-of-way acquisition was much less of a problem than it is today. As a new form of rail transport, LRT construction has to address the task of threading new railway lines through old established urban areas. The LRT lines in Boston and Cleveland have been rebuilt (the same is also true of Pittsburgh´s LRT network) from old streetcar and rapid transit systems respectively. Chapter Three revealed that 8 of the 14 systems surveyed (57%) have used or propose to use existing rail rights-of-way on an extensive basis. Those systems have been constructed in Edmonton, Los Angeles, Portland, Sacramento and San Diego, and are planned for Dallas, Manchester and the West Midlands. Other LRT projects which have also used existing rail alignments, albeit on a moderate basis, are the San Jose and Pittsburgh systems, in addition to the planned "Supertram" in Sheffield and extensions to Buffalo´s "Metro Rail" LRT.

Similar results were observed for the Calgary LRT (Chapter Four) and the Vancouver-Richmond Rapid Transit Project (Chapter Five). The Calgary "C-Train" system comprises three routes radiating from the city centre, and of those three routes, the "South Corridor" line was constructed largely along an existing rail right-of-way. In terms of route mileage, the rail right-of-way represents 67.8% of the South Corridor line and 26% of the complete C-Train network. An existing rail right-of-way also represents one of the route options through residential Vancouver for British Columbia's planned rapid transit link between Richmond and Vancouver. In this case the existing rail alignment would, if selected, provide 50% of the required route. Finally, in addition to the aformentioned constructed and planned LRT systems, Chapter Three provides a selected list of 23 British and North American urban areas which are seriously examining LRT. Of the list, reports indicate that 18 (78%) of the cities plan to make use of existing rail alignments. Clearly, in Canada, the United States and the United Kingdom, Light Rail Transit has relied upon/proposes to rely upon existing rail rights-of-way to a substantial degree.

Having established that Light Rail Transit and existing rail rights-of-way are inextricably linked, the extent to which reliance upon those rights-of-way has affected or is likely to affect the subsequent success (or failure) of LRT systems is addressed. The two "case studies", Chapter Four´s examination of the Calgary LRT and the discussion of the Vancouver-Richmond Rapid Transit Project that constitutes Chapter Five, are the means by which the thesis tackles this issue. Although the Calgary LRT was opened to the public in 1981 and the Vancouver-Richmond Rapid Transit Project is currently at the planning stage, there is a striking similarity between the findings of the two case studies.

As noted above, the incorporation of an existing rail alignment in Calgary´s C-Train network has been confined to the system´s initial line, the South Corridor LRT. An over reliance upon CP Rail´s "Macleod Subdivision" has meant that the South Corridor route traverses tracts of industrial and open land. As a consequence, the line exhibits a marked degree of "remoteness" from the suburban commercial, recreational and residential areas that it is intended to serve. The suburban stations along the line are as much as 0.5 kilometres from the nearest commercial street, and since the average distance between stations in the south Calgary suburbs is 1.5 kilometres, many commercial locations are even farther away from the LRT line. In residential Vancouver, another CP Rail freight line, the Arbutus Rail Line, has been proposed for the

Richmond rapid transit link. However, the freight line can only realistically be expected to "serve" a single notable travel destination within the "Arbutus Corridor", a shopping centre. There are several hospitals, a community college, Vancouver City Hall and other activity centres in residential Vancouver which could potentially generate traffic for a rapid transit link, but they are located approximately 2 kilometres from the Arbutus Rail Line.

In the case of Calgary´s South Corridor LRT, there is evidence to suggest that the line has not lived up to initial expectations. Although it is generally acknowledged that the C-Train system as a whole has been successful in serving city centre-oriented travel needs, the same cannot be said of suburban travel on LRT. A combination of feeder bus and "park-and-ride" facilities at suburban stations has enabled LRT to boost transit´s share of travel to and from the city centre. For non-city centre trips though, Calgary Transit´s passenger count dropped significantly in the South Corridor after the inauguration of LRT. Suburban travel in the corridor using LRT is clearly not as convenient as city centre travel. The thesis attributes much of the poor performance of the South Corridor LRT in this respect to the line´s "remoteness" from major suburban activity centres in the area. Given the fact that in the majority of North American cities, suburban locations have played a major role in shaping travel patterns, the inability of the South Corridor LRT to effectively cater for those travel demands is disappointing.

Although the Vancouver-Richmond Rapid Transit Project is only in the planning stages, it is realistic to argue that the findings derived from the study of the Calgary LRT are equally valid for Greater Vancouver´s proposed system. The Arbutus Rail Line represents a readily available right-of-way for the rapid transit link, but in common with Calgary´s South Corridor LRT, the alignment would be markedly removed from the major activity centres in residential Vancouver. An alternative route, and one still considered to be a viable option, is to use the right-of-way of Cambie Street, with trains running either below ground or at street level. The advantage of using Cambie Street, despite the higher costs incurred by tunnelling and the considerable disruption to road traffic during the construction period, is that the road corridor runs in close proximity to the vast majority of the important activity centres in the area. Therefore, a Vancouver-Richmond rapid transit line using the Cambie Street route can be expected to effectively serve those traffic generators in a way that is simply not possible from the Arbutus Corridor.

In addition to the findings outlined above, there are a number of subsidiary points which have arisen from the thesis. Since they are pertinent to the planning and implementation of LRT projects they should be reiterated as part of the concluding observations that form this final chapter. First, a thread that has been common to both the Calgary LRT and plans for the Vancouver-Richmond Rapid Transit Project is the role of the community's voice in the planning process. Input from the community, either on a group or an individual basis, represents an important factor that needs to be taken into consideration by the LRT planner. Although it may not be possible to satisfy all parties, to embark upon the planning and construction of an LRT route without seeking and addressing community opinion is to invite problems that might otherwise be avoided.

A second factor that can influence the effectiveness of a new LRT route (or any other rapid transit route) is that of residential density. There is a correlation between the success of a rapid transit line and the residential density of the corridor that it serves. Therefore, other things being equal, the greater the density, the more riders a line will attract. Since patronage is an important component in the success of public transport it follows that, given a choice of corridors, an LRT line should be constructed in that which offers the greatest residential density.

Thirdly, the ability to successfully integrate LRT into the rest of the urban transport fabric is a factor which needs to be considered when selecting a route alignment. Apart from the travel habits of some individuals, an LRT system is unlikely to be a success if it cannot be coordinated with other forms of transport. Therefore, the need to provide "park-and-ride" and feeder bus facilities at station sites should not be overlooked when planning for LRT. Surveys conducted in Calgary, for example, suggest that improvements in the provision of such facilities would realise a latent demand for LRT service.

A fourth factor is the common practice of using the median of major roads and expressways/freeways in the construction of LRT routes. Here a parallel exists with the central theme of the thesis. A large proportion of the San Jose LRT has been constructed in such a fashion and this is also true of Calgary's "Northeast LRT". Extensive use of the major roads linking the northeast suburbs of Calgary with the city centre has left the Northeast line remote from major activity centres in the area. In construction and cost terms, a road median offers an attractive right-of-way for an LRT route, but if the end result is a transportation facility geographically remote from the area that it is intended to serve, then the attractiveness is diminished.

What then are the implications for the principal findings of this thesis? A propensity to incorporate existing rail rights-of-way into LRT projects means that the planner risks a repetition of the problems encountered with the Calgary LRT and the possible future problems facing the Vancouver-Richmond Rapid Transit Project. It is also possible that the problems will be of a magnitude similar to those which have plagued the Metrorail system in Miami. If such a scenario were to occur then the current enthusiasm for LRT, and urban rail transport in general, could be dampened to a substantial degree. Without widespread support for urban rail, in both the political arena and in the eyes of the general public, many of the transportation problems present in our cities will persist and probably worsen. Proponents of public transport face a major hurdle in attempts to get motorists to leave their cars at home. Because our society equates the car with freedom it has proven very difficult to encourage the individual to forfeit some of that freedom in exchange for greater participation in public transport. A repeat of Metrorail would simply raise that hurdle and strengthen society's resolve to cling to the automobile.

Light Rail Transit routes should be constructed along those alignments which bring the greatest possible benefits to the travelling public. Existing rail rights-of-way should be used where they offer such a benefit, but not simply because they offer a cheap and simple solution to construction problems. Where a useful rail alignment is unavailable it may be possible to make greater use of mixed traffic running along city streets. Research suggests that the "drawbacks" to this type of operation, a characteristic of streetcar systems, might have been exaggerated. Should this be the case, LRT has the potential to effectively reach those residential, commercial and recreational locations to which the individual traveller requires access. An LRT system reflecting the needs of the travelling public is in a strong position to nurture the current support of urban rail transport and effect a real change in our travel habits. Without that change it is unlikely that we can solve the transportation problems of our cities. How much freedom will we have then?

Finally, the thesis suggests some directions for possible future research. Since LRT has a short history in North America and the United Kingdom, many studies have by necessity been based upon a limited service experience. Much research that examines the Calgary LRT, for example, has been based upon household surveys conducted by Calgary Transit shortly after the opening of each route. As a consequence, the surveys compare the performance of Calgary Transit before and after the introduction of LRT, rather than the longer term performance of the transit system with LRT. The South Corridor line has been in operation since 1981 and it would be useful to repeat those household surveys, particularly with a view to ascertaining the performance of the route with respect to suburban travel. In Manchester, much criticism has been directed against the decision to convert some heavy rail suburban passenger lines to LRT operation. There is concern that LRT represents an inferior form of rail transport when compared to existing heavy rail lines. Once "Metrolink" has been in service for several months, research into the performance of Britain´s first LRT system would make a valuable contribution to the subject. There is also a need to systematically examine the extent to which the medians of freeways and other major roads have been incorporated into LRT networks. With a parallel to be drawn between the use of such alignments and those represented by existing rail rights-of-way, some work in this field could be of benefit. Finally, more study needs to be conducted into the performance of streetcar systems in order to determine whether or not the LRT planner could realistically make greater use of mixed traffic running by routing LRVs along existing city streets. A comprehensive approach to the issue could incorporate past research into the streetcar systems of Toronto and San Franciso, along with any work pertinent to Continental Europe´s numerous street railway systems and the extensive networks in Philadelphia, and Melbourne, Austrailia. British planners in Sheffield are willing to gamble upon a street-based LRT, in the form of "Supertram", and it will be interesting to observe the outcome. Perhaps the steel rail can be returned to the street, not as an alternative, but as a complement to existing rail rights-of-way.

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