

***Light Rail Transit in Calgary
The First 25 Years***

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**Presented at the 2006 Joint International Light Rail Conference
St. Louis, Missouri
2006 April 8 - 12**

LIGHT RAIL TRANSIT IN CALGARY – THE FIRST TWENTY-FIVE YEARS

ABSTRACT

In the past 25 years, The City of Calgary has invested approximately \$1 billion (Canadian dollars) in developing a three leg, radial LRT system that is closely integrated with an extensive bus network. Currently, the LRT system consists of 42.1 km of double track, 116 light rail vehicles and carries over 220,000 boarding passengers each weekday.

This paper will examine the impact of LRT on travel behaviour in Calgary and the planning and operational lessons learned over 25 years of operation. The lessons encompass systems planning and design, market segmentation and access mode planning, transit oriented development, and personal security, in addition to overall experience gained with LRT operations.

INTRODUCTION

Calgary is Canada's fourth largest city with a population of approximately 1 million people. The city has a diversified, robust economy which is based on its position as the headquarters for Canada's energy industry, and as a growing business and financial centre and intermodal transportation hub within Western Canada. During the past decade, Calgary's population has increased by 23 percent while Calgary Transit annual ridership increased by nearly double this rate (45 percent) to over 82 million annual revenue trips. As a result of this rapid growth, existing LRT and bus services are operating near capacity during peak travel periods and The City of Calgary is embarking on a ten year, \$1 billion dollar capital investment program (Canadian dollars) to extend existing LRT lines and expand its LRT and bus fleet.

It is projected that Calgary's population will grow to 1.25 million over the next 20 years because of its economic potential, geographic position and desirability as a place to live. In managing future growth, The City has committed to follow "smart growth" principles in its decision making processes to ensure its urban form and transportation system are sustainable from an environmental, social and economic perspective.

Urban Form and Governance

The urban form of Calgary's development is a concentrated city centre bounded on the north, west and south by a large crescent of low density residential suburbs. A band of industrial land extends along the east side of the city.

There is a distinct pattern of employment location in Calgary. Approximately 24 percent of city employment is located in the downtown, 34 percent in the east industrial area and 42 percent is distributed throughout the remainder of the city. Strategic policies have encouraged the concentration of employment in the downtown to support a high level of transit service. However, suburban development trends have created strong cross-city travel patterns between low density residential development on the west side of the city and industrial areas on the east side, which are difficult to serve efficiently with public transit service. With the limited number of expressway standard, east-west roads, cross-city traffic congestion is a problem for many Calgarians.

Calgary is a "uniCity" in the sense that it is an urbanized area surrounded by agricultural or country residential areas. This situation allows City Council to exercise almost complete control over its urban environment, including its transportation system. The consolidation of land use, roadway and transit planning functions within The City administration also facilitates the integration of transportation modes and coordination of land use and transportation planning decisions. These factors have contributed to the development of a successful, integrated LRT and bus system.

SYSTEM DEVELOPMENT

Discussion

The concept of a balanced transportation strategy encompassing roads, transit, walking and cycling has provided the context for transportation planning in Calgary since the mid-1960s. Although the definition of "balance" has varied since the term was first introduced, the concept of utilizing each mode to its best advantage has remained constant over the years.

In 1968, the first comprehensive transportation plan was prepared for The City of Calgary, incorporating a balanced plan of freeways and four heavy rail transit lines that were to be implemented over the next 20 years (1). The proposed road plan included new freeways on the north and south sides of the Bow River and ten new river crossing bridges, most of which would connect directly into the downtown. The high priority rapid transit corridors in the south and northwest were approved in principle by City Council, which allowed protection of the right-of-way and commencement of land acquisition. However, components of the proposed freeway network plan quickly encountered strong public opposition.

In 1973, a report entitled "A Balanced Transportation Concept for The City of Calgary" was completed. Its primary function was to develop a policy combining and coordinating transportation improvements. A road construction program on a much smaller scale than envisioned in the 1968 plan was proposed. The report also recommended a change in direction of transit planning toward consideration of options for an intermediate capacity, rapid transit system. With a population of less than 470,000, it was concluded that Calgary could not support an extensive, grade separated rapid transit system. Instead, The City began to look more closely at the surface-running street car and light rail systems in Europe as a model for implementing a higher capacity transit service in Calgary.

To position the city for eventual implementation of a rapid transit system, a new "Blue Arrow" express bus service was recommended, paralleling the proposed rapid transit lines. The Blue Arrow expresses included complimentary park and ride and feeder bus routes to mimic the characteristics of the future rapid transit system that was envisioned. Within the downtown, steps were taken to develop the centrally-located 7th Avenue corridor as a future rapid transit route by increasing bus route density and augmenting bus throughput by implementing a peak period contra-flow bus lane in a one-way, mixed traffic operation. This action established a foundation for eventual conversion of 7th Avenue to exclusive transit operation.

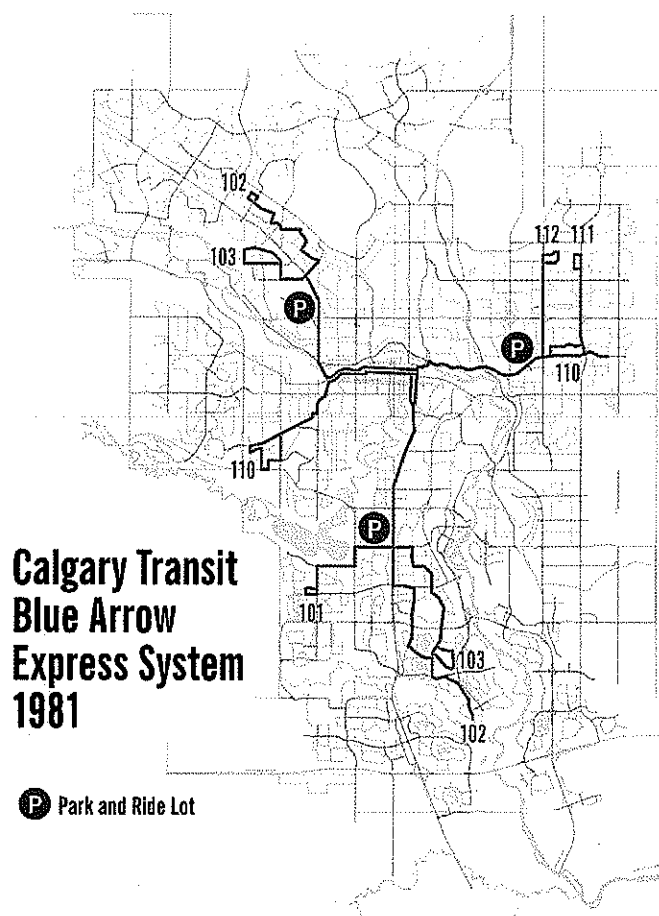
Figure 1 illustrates the Blue Arrow Express system that was in place in 1981, prior to the implementation of LRT.

Between 1975 and 1977, several studies were undertaken to evaluate rapid transit options for Calgary and to analyze the impact of transit versus roadway expansion in south Calgary (2)(3). The studies concluded that forecast growth in south Calgary could not be accommodated by road improvements alone and implementation of a high capacity transit service was essential. A detailed comparison of LRT versus curbside bus lanes and a dedicated busway was conducted for the south corridor. The analysis concluded that the capital cost of a LRT and busway system would be similar but that LRT offered significant advantages over the other options in regard to speed and service reliability, reduced operating costs, impact on the downtown road system and urban environment, and ability to achieve a more compact urban form.

In 1976, City Council approved the LRT concept in principle, which included plans for a possible five-leg LRT network, and directed the Administration to proceed with functional planning for a south LRT line. However, following the 1976 municipal election, the new City Council requested that an independent review be undertaken to verify the appropriateness and costs of LRT in the south corridor. This review endorsed the construction of the proposed south LRT line. As a result, City Council in 1977 gave approval to proceed with the implementation of LRT.

The initial 12.9 km (7.7 mi) south LRT line, extending from Anderson Road to downtown, opened for revenue service in 1981 May, on schedule and within budget, and soon achieved its forecast ridership target of 40,000 boarding passengers per day. Based

Figure 1



on the positive ridership results and strong public acceptance of the LRT concept, City Council directed that planning studies be undertaken to finalize the route for the second priority LRT leg which would serve two major post-secondary education institutions and communities in northwest Calgary. However, significant public opposition was encountered in regard to the recommended LRT alignment through the inner-city community of Sunnyside, located immediately north of downtown. While extensive community consultation on this issue was taking place, implementation priority was shifted to the northeast line whose right-of-way had been protected in the median of arterial roadways planned in this area. The 9.8 km (5.9 mi) northeast line opened in 1985, sharing a downtown section with the south line.

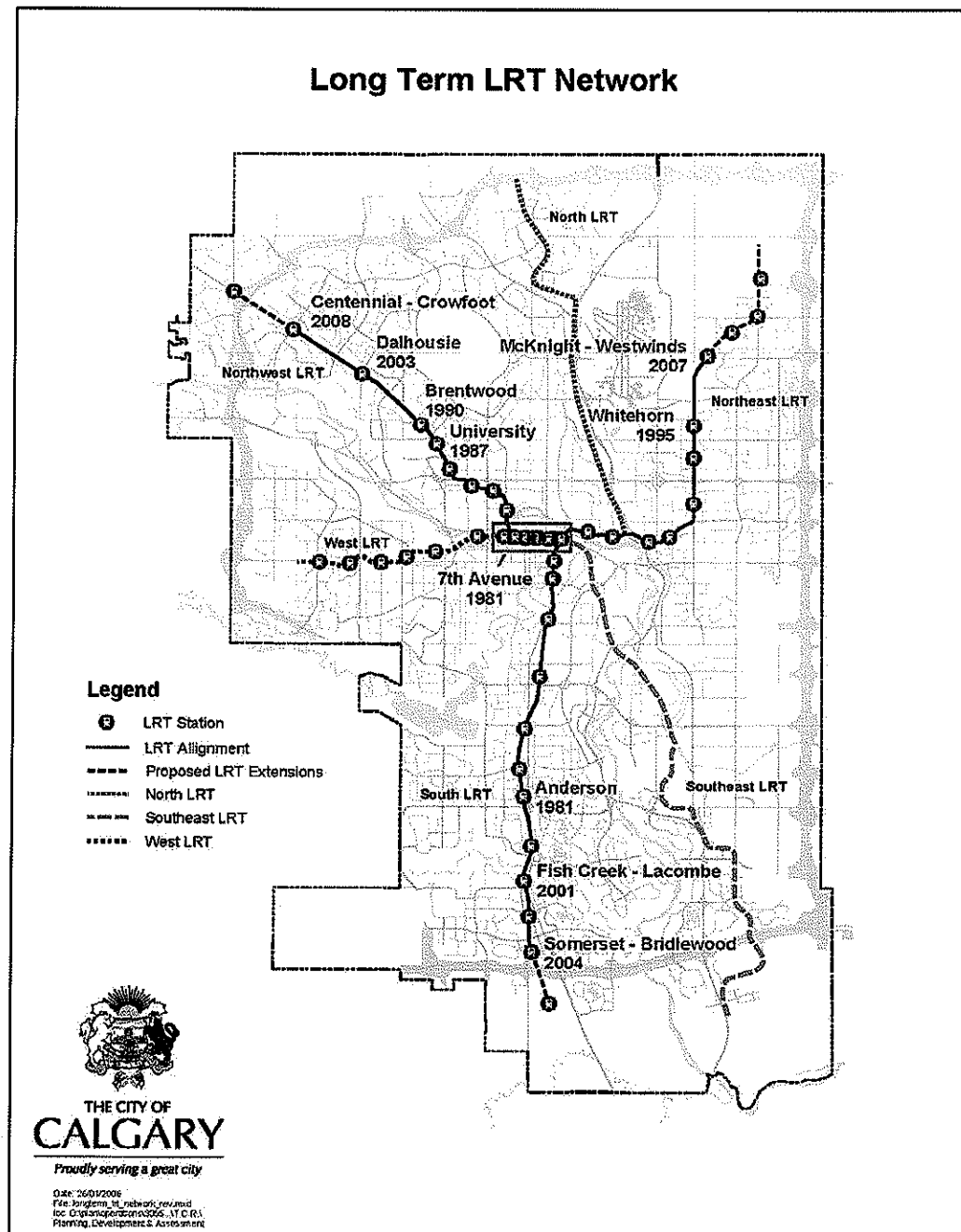
The impending 1988 Winter Olympics gave impetus to resolving community opposition to the northwest line, which served important venues at the University and McMahon Stadium for the games. The 5.8 km (3.5 mi) line was opened in 1987 and connected to the south line. A further 0.8 km (0.6 mi) extension of the northwest line to Brentwood opened in 1990, providing improved terminal connections and park and ride facilities.

Following 1990, plans for further LRT expansion were suspended for a nearly a decade as a result of an economic downturn and reduction in urban funding grants from The Province of Alberta. However, a new cycle of strong population growth in the mid-1990s resulted in significant growth in roadway and transit use and increased public perception of the need for investment in new transportation infrastructure. In 2000, The Province of Alberta agreed to allocate 5 cents per litre from the existing Provincial tax collected on gas and diesel fuel consumed in Calgary toward new transportation infrastructure. This new funding enabled The City to revive its LRT expansion program by approving a multi-phase extension of the south LRT line to Fish Creek-Lacombe Station (2001) and Somerset-Bridlewood Station (2004) and Dalhousie Station in the northwest (2003).

The resulting LRT system which is in place today consists of two lines – south to northwest (Somerset to Dalhousie) and northeast (Whitehorn to downtown) (see Figure 2). Over the past decade, LRT ridership has increased by 120 percent to over 220,000 weekday boarding passengers (611 boarding passengers per revenue operating hour), including 25,000 passengers within the downtown free-fare zone on 7th Avenue.

In 2004, The Province of Alberta announced a new Alberta Municipal Infrastructure Program worth \$886 million over five years for The City of Calgary. City Council has determined that 70 percent of this funding (\$620 million) will be allocated to transportation infrastructure upgrades in Calgary. As well, the Government of Canada has introduced a new Gas Tax Fund for “environmentally sustainable” urban infrastructure totaling \$141 million and an additional \$48 in special funding for transit projects in Calgary. When this new investment is combined with other funding sources such as the Provincial fuel tax, City parking revenue, developer funded acreage assessments for new suburban growth, and City debt financing, \$1.8

Figure 2



billion in funding will be available for new transportation infrastructure in Calgary over the next decade.

One of the key policies of the Calgary Transportation Plan is that "The City investment in transit and roads will be approximately equivalent." The proposed city capital budget for 2006 to 2015 includes 47 percent funding for roads and 53 percent funding for transit. The approved transit investment strategy includes plans to accelerate completion of the primary LRT network by extending the northeast line to McKnight-Westwinds Station (2007) and the northwest LRT line to Centennial-Crowfoot Station (2008). Additional investments are planned to commence expansion of the LRT platforms to accommodate four-car train operation, construct a new LRT maintenance facility, expand the LRT fleet by 40 percent (40 cars) and the bus fleet by 42 percent (330 buses).

Recent planning studies (4) (5) have identified that a network of six LRT lines will be necessary to accommodate a future city population of 1.5 million. A conceptual representation of this network is presented in Figure 2.

Lessons Learned

1. **Find Champions.** Strong and consistent support from senior administration and politicians is essential to long term success. Elected officials must be made aware of the benefits of investing in public transit and develop budget guidelines for appropriate funding levels for roads and transit expansion. Effective stakeholder engagement is essential to build and maintain public support for transit investment.
2. **Build the Right Project.** Develop "rock solid" ridership and cost estimates and choose the appropriate transit technology. Calgary Transit has accurately estimated LRT ridership by drawing on experience with the "Blue Arrow" Expresses, which formed a prototype for the LRT service. Realistic ridership estimates have been based on output from The City's regional transportation model and experience with earlier LRT extensions. Strict adherence to a philosophy of using basic, proven technology (e.g., LRT cars are without automated diagnostics, automated passenger counting, air conditioning) and utilitarian design (e.g., primarily surface operation) has minimized the cost and risks associated with system development and has enabled the LRT extensions to be delivered on time and within budget.
3. **Build the Project Right.** Adhere to your vision for LRT development and take advantage of LRT design flexibility by developing surface operations wherever possible. Work with Traffic Engineers to integrate surface LRT operations within road rights-of-way and determine an appropriate level of transit priority for your LRT system. A comprehensive, integrated approach to transportation and land use planning, which Calgary has achieved through "uniCity" governance and administration, is critical to the success of LRT.

4. **Identify and protect future land requirements.** Long range plans should be developed to protect LRT right-of-way, including station areas and land for park and ride, feeder bus facilities and TOD development.
5. **Develop the Corridor Concept.** Use express buses or Bus Rapid Transit and park and ride to develop ridership in future LRT corridors.
6. **Think 50 to 100 Years Ahead.** Design, construct and maintain vehicles and infrastructure in consideration of life cycle expectations. Understand the logistics and impact of system maintenance and expansion during current operations.
7. **Strategic Operating and Staffing Decisions.** Understand that the skill sets and interests of planners, designers and builders are fundamentally different than operators and maintainers. Create separate position classifications and seniority for LRT and bus operators and mechanics. Minimize dependence on performing maintenance and system expansion during non-revenue hours. Learn to conduct right-of-way maintenance work under traffic.

TRANSIT ORIENTED DEVELOPMENT (TOD)

The City of Calgary has adopted many policies that relate to transportation choices, transit use, quality of life and urban form. The Calgary Plan (1998), Calgary Transportation Plan (1995), Sustainable Suburbs Study (1995), Transit Friendly Design Guidelines (1995) and Transit Oriented Development Guidelines (2004) contain policy directions to encourage transit use, make optimal use of transit infrastructure and improve the quality of the urban environment.

The focus of many of Calgary's land use policies over the past 20 years has been to preserve the downtown's unique role as a major employment centre and to attract new high density residential development within the downtown and within close walking distance of LRT stations and major bus corridors. In response to growing traffic congestion, The City has incorporated direction in its strategic land use and transportation policy plans to encourage a shift in the location new suburban employment from the east to the west side of the city and existing and proposed LRT stations. This strategy is aimed at moving jobs closer to residential areas and decreasing commute distances, encouraging greater use of walking, cycling and transit for work trips, and making more efficient use of the off-peak direction of travel on transit and roadways.

Performance of Downtown TOD Policies

Calgary has a well-defined, intensively developed downtown incorporating 120,000 jobs, 12,000 residences, 32 million sq. ft. of office space, plus hotels and retail spaces, within only 3.6 km² (approximately 1.4 mi²).

Calgary's present transportation policies are designed to alter the modal split in favour of public transit, with the long term objective of accommodating 50 percent of downtown work travel by LRT and bus services. The cornerstone of the policies for downtown transportation is the gradual reduction in the availability of long term parking

relative to downtown growth. The current Land Use Bylaw requirements for office buildings specify one parking stall per 140 m² (1,500 ft²) of net floor area. For the downtown core area, which has restricted vehicular access because of the 7th Avenue LRT corridor and restricted road access on the 8th Avenue pedestrian mall, The City has a cash-in-lieu program of on-site parking. The Calgary Parking Authority, operated by The City, uses funds collected through this program to construct parking structures in designated corridors on the periphery of the downtown core. These structures are connected to the office and retail core by an extensive, elevated walkway system known locally as the Plus 15 network.

Figure 3 summarizes the changes in parking supply, employment, and modal split to the downtown between 1964 and 2004. The total number of long term parking stalls has continued to decline in relation to downtown employment growth, which has increased monthly parking costs to an average of \$250 – the highest rate in Canada. The interaction of downtown parking policies with strategic decisions to expand LRT and bus service instead of expanding downtown road access has resulted in a significant increase in the transit modal split from 37 percent in 1996 to over 42 percent in 2005. There has also been an increase in walking and cycling to downtown with the construction of new high density residential development within and close to downtown and both transit passengers and auto drivers are traveling before and after the peak hours. All these changes enabled the downtown workforce to grow by 18,000 jobs since 1992 without building any new roads into downtown.

Figure 3

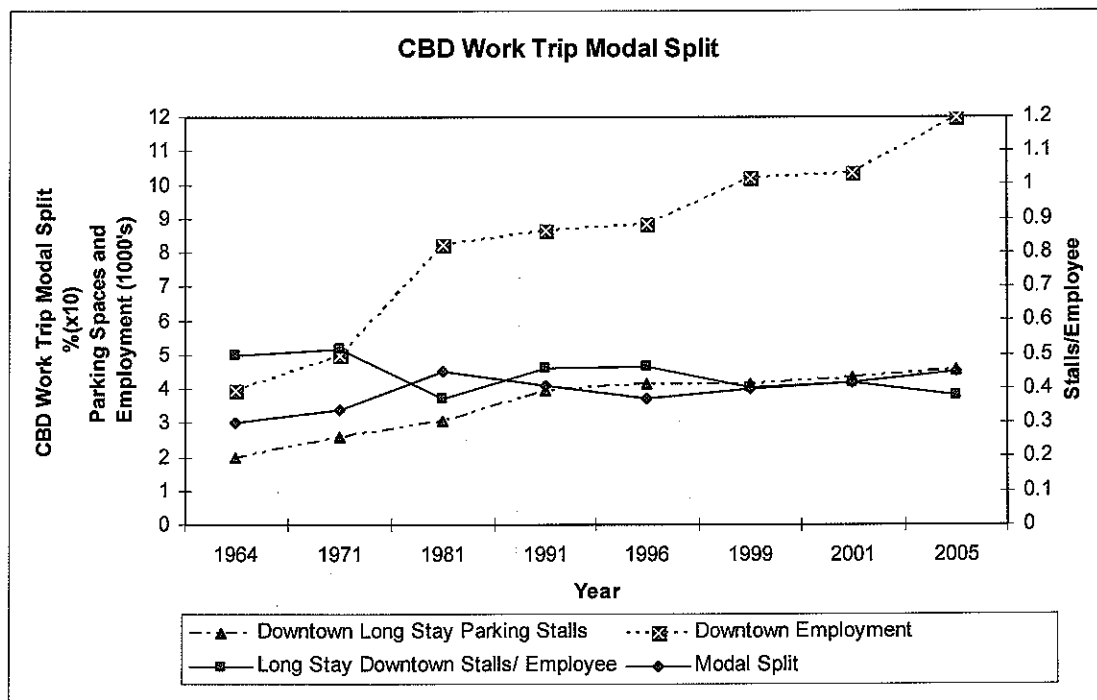
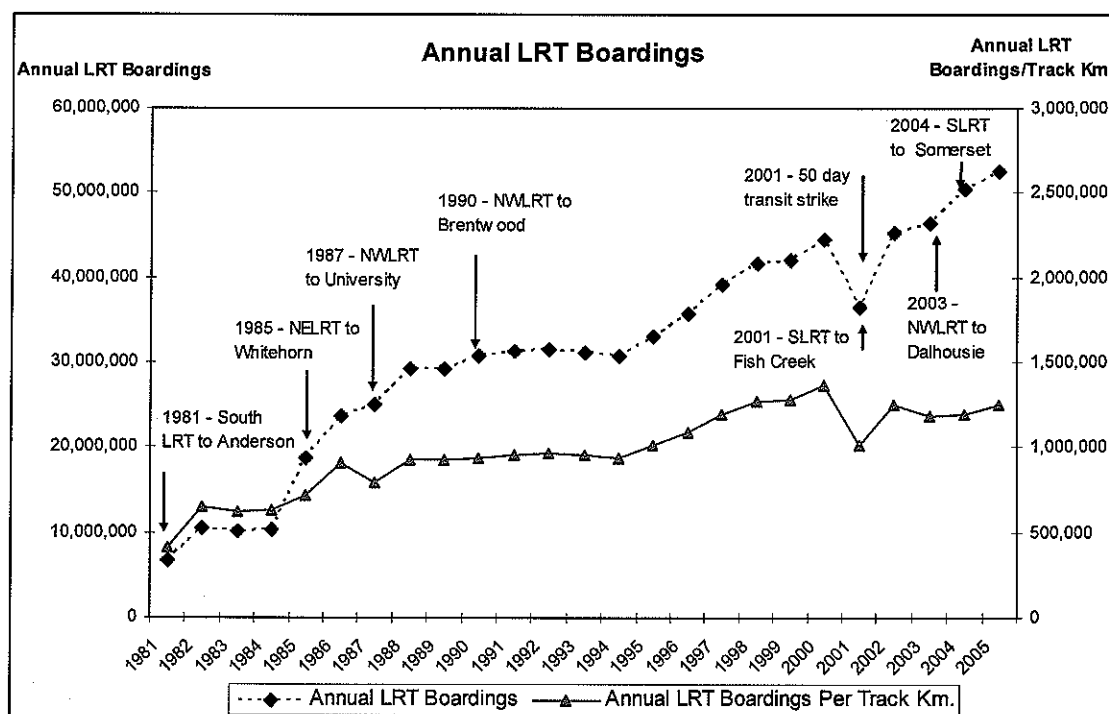


Figure 4 illustrates the 25 year growth trend in LRT system ridership. Over the past decade, LRT ridership has increased from 33.1 million to 52.6 million annual boarding passengers (+59 percent). Current weekday LRT ridership has surpassed 220,000 boarding passengers day. On average, the three LRT lines carry 130,000 people in, out and through the downtown, about 17,000 in the peak hour alone. Since the inception of LRT service, each new LRT line or LRT extension has produced a 15 to 20 percent increase in corridor ridership, resulting from the diversion of previous auto drivers to transit. Annual LRT boardings per track km. have increased from 1 million to 1.2 million since 1995. Further ridership growth is constrained by system capacity limitations; however, 33 new cars have been ordered to address this problem.

Currently, the average hourly operating cost of LRT is approximately \$163, including operating, maintenance and utility costs. With an average of 600 boarding passengers per revenue operating hour, the average cost per LRT passenger is only \$0.27. In comparison, the average cost per bus passenger boarding is approximately \$1.50, or almost six times the cost of carrying an LRT passenger.

Figure 4



Performance of Suburban TOD Policies

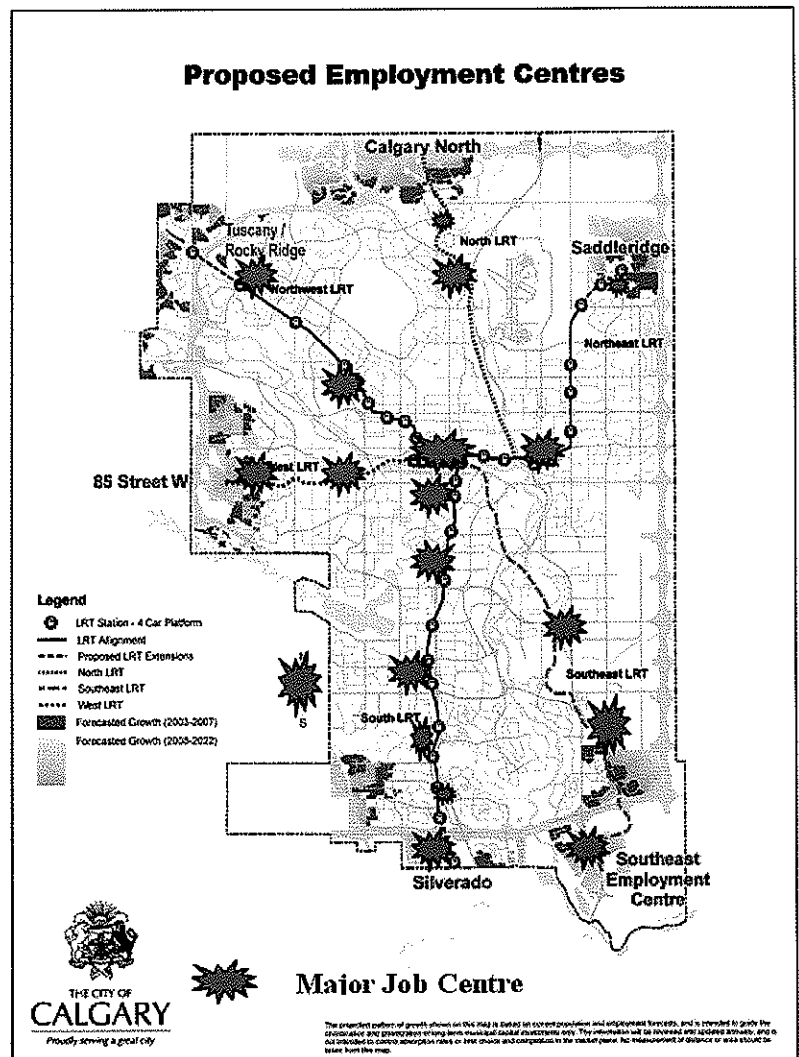
In contrast to its experience with downtown TOD policies, The City has had mixed success in its efforts to shift the location of new suburban employment to proposed employment centres and promote more compact development in new suburban communities.

Major employment centres which were identified in the 1995 Calgary Transportation Plan in the south and northwest are now fully developed as "big box" retail areas with little or no office space (see Figure 5). The recent job growth numbers show that employment growth continues to be focused on the east side of the city, which is exacerbating east-west roadway congestion.

Some positive trends have been seen in regard to new residential development. In the past five years, approximately one-third of all new housing starts in Calgary have been multi-family. While new suburban home development continues to be primarily single-family homes, approximately half of new multi-family housing starts have occurred in new communities. As a result, most communities are achieving the approved minimum density targets of six to eight units per acre and some developers are seeking approval to increase the density ranges.

Figure 5

Some high density residential, office and retail development has occurred adjacent to existing LRT stations at Lions Park (northwest), Stampede/Elton (South), Southland (South) and Franklin (Northeast). However, expectations of substantial new developments at the LRT stations have not been achieved and developer interest in pursuing TOD at the stations has only recently started to gain momentum as traffic congestion increases and citizens start to recognize the value of living and working close to the LRT system. The limited success achieved to date in achieving new employment centres and TOD at LRT Stations is due in part to the lack of an implementation strategy. For example, The City was presented with a opportunity in the mid-1990s to acquire property for an employment centre in south Calgary but declined due to reluctance to front-end the cost



of land acquisition and hold it until a market for higher density developed. Other opportunities have been lost due to market dynamics, which have created an immediate demand for retail development in areas that were identified as employment centres. Public opposition to higher density land uses adjacent to established residential areas has also eliminated opportunities for higher density development in some areas.

Fortunately, The City has learned from this experience and is planning or undertaking new TOD developments by utilizing some of its own land holdings in LRT station areas. One such development is "The Bridges", which will occupy a 37 ac. (15 ha) site adjacent to Bridgeland/Memorial Station, providing up to 1,500 new residential units as well as new retail and office uses. The City is also partnering with Provincial and Federal Government and the development industry to revitalize the east end of downtown, adjacent to the LRT system, through strategic use of city-owned land and Tax Increment Funding development fees. Other city properties located adjacent to several of the south LRT stations (i.e., Heritage, Anderson, Fish Creek-Lacombe and Shawnessy) will also be marketed for mixed-use TOD in the near future. The City has also prepared reports on TOD best practices and development guidelines to guide development and educate the public and elected officials of the benefits of intensifying land uses adjacent to the LRT stations (6) (7).

Lessons Learned

1. **Plan an integrated policy solution.** Develop integrated land use, development (TOD), road, parking and transit policies. LRT has had a positive impact on increasing the modal split for downtown work travel when supportive policies are working together to manage the supply of long term downtown parking, road capacity and transit service.
2. **Achievement of TOD requires political commitment and collaboration with private sector developers.** Proactive land acquisition and land banking by The City can facilitate development or protect future options for employment centres. In most cases, developed land uses are very long term, therefore, the cumulative impact of incremental, poor land use decisions is significant. It is critical that cities show leadership in supporting TOD by locating some of its business functions in these developments, expediting approval of TOD and consideration of financial incentives (i.e., business tax breaks for TOD tenants, Tax Increment Financing).

SYSTEM DESIGN AND OPERATIONS

Calgary's LRT system currently consists of 42.1 km (26.3 mi) of double track, of which 87 percent is surface operation, 5 percent is on grade-separated bridges and 8 percent is underground. Surface LRT operations have been adapted to operate in city streets (e.g., downtown Calgary), within an existing railway corridor (e.g., the south corridor), in the median of an expressway and major arterial roadway (e.g., the northeast and northwest corridor), and within existing communities and educational institutions on an exclusive right-of-way or parallel to existing local streets (e.g., the northwest corridor).

Outside the downtown, train movements are controlled by an automatic block signal (ABS) system that allows only one train to occupy each section of track. At grade level crossings outside the downtown, trains pre-empt the normal operation of traffic signals to allow uninterrupted movement between stations. Grade level roadway and pedestrian crossings are protected by LRT gates, bells, flashing lights, pedestrian crosswalk heads and gates, which is consistent with leading safety measures. Currently, the gate warning time is about 22 seconds, with an additional 10 to 15 seconds for the gates to ascend and the warning lights and bells to turn off. In the northeast corridor, the operation of the traffic signals at the 10 grade level intersection crossings on 36th Street is designed so that preempted traffic movements (e.g., north and south left turns) are reserviced if a preset green time has not been met once the train clears the intersection. The maximum operating speed of trains along 36th Street is 80 km/h, whereas the posted roadway speed is 60 km/hr.

Within the downtown, the LRT operates along the 7th Avenue transit corridor, in a line-of-sight operation, with buses and emergency vehicles. The maximum LRT operating speed on 7th Avenue is 40 km/hr. Cross-street traffic and train and bus movements are controlled by conventional traffic signals which operate in a 90 second fixed-time cycle, which allows sufficient time for trains to stop and unload at a platform and travel to the next station. This operation facilitates the movement of trains between stations on 7th Avenue in synchronization with other traffic signals located throughout the downtown.

Transit Safety

Providing a safe journey for our customers is the number one priority of Calgary Transit. Each weekday, there are nearly 500,000 individual boardings on Calgary Transit's 828 buses and 116 LRT cars. To deliver customers to their destinations, Calgary Transit buses travel over 140,000 kilometers on city streets each day, stopping at some of the more than 5,000 bus stops. LRT cars travel over 12,000 kilometers daily to serve passengers traveling between the 36 stations.

Calgary Transit has a rigorous program aimed at accident prevention and investigation. Reporting of all accidents is a requirement of all staff. Reports are completed each time that a transit vehicle makes contact with another vehicle, pedestrian or object. Passenger injuries (mostly trips, slips and falls while boarding or alighting) are recorded.

The following table provides information on the rate of reported vehicle and pedestrian accidents. The rates of vehicle collisions per million kilometers of travel and the number of passenger injuries per million boardings are very low. It should be noted that these data do not segregate accidents or injuries by severity. In general, the safety record of the LRT system is more favourable than bus.

Table 1 – Calgary Transit LRT and Bus Collisions and Passenger Accidents

	1995	2005
Collisions per million km		
Bus Collisions	23.0	17.8
LRT Collisions	11.3	10.3
Passenger Accidents per million boardings		
Bus Passenger Accidents	5.6	1.6
LRT Passenger Accidents	.40	0.06

Lessons Learned

- 1. Surface LRT operations can be safely and effectively integrated within city streets by using conventional traffic, pedestrian and railway controls.**
- 2. LRT signal pre-emption in arterial streets provides reduced transit travel time without compromising roadway safety.**
- 3. LRT is safer than bus.** On the basis of Calgary Transit's experience, LRT vehicle collision and passenger accident rates are significantly lower than those for the bus system.
- 4. Systems fail – Manage failure.** Design your LRT system with replacement in mind and embrace formal asset management principles as soon as possible. Five to ten year forecasts of resources necessary to ensure stable infrastructure are mandatory for good management of the system. Key maintenance people should be in place during the system design and construction stages. Numerous design and construction deficiencies can be avoided with this approach. In Calgary's operating and weather environment, the need for major infrastructure replacement increased exponentially during the 20 to 25 year age window. Good ride quality and wear characteristics in the LRT environment demand track tolerances well beyond those in the typical mainline heavy rail environment. Track designers and constructors with bona fide LRT experience should be engaged in design and construction, wherever possible. Locate facing point switches and bi-directional interlocked signaling to facilitate maintenance and failure management.

STATION DESIGN

The experience gained from construction and operation of each of the LRT lines has resulted in changes in the scale and design of Calgary's LRT stations.

The initial south LRT line included six center-load stations which can be accessed by enclosed stairways and a single set of escalators at the north end of the platforms. No provision was made in the station design for elevators or ramp facilities to accommodate persons with disabilities.

The design of the northeast LRT leg incorporates the LRT tracks in the median of an expressway and a major arterial roadway. The seven center-load stations on this line are fed by overhead pedestrian bridges which are accessible by stairways and ramps. An elevator, two escalators and stairway are provided in the station to accommodate access between the fare processing area and the LRT platform. Access to the platforms incorporates alternate end loading at successive stations. Placement of the access points at opposite ends of alternate platforms improved the evenness of passenger loads in the three-car train sets, resulting in better equipment utilization and passenger comfort compared with the same end-loading pattern on the south LRT.

The design of the northwest LRT line incorporates several sections of in-community track alignment parallel within and parallel to local residential streets and presented an opportunity to design low scale "local stations" with grade-level pedestrian access crossing both the inbound and outbound tracks to the platforms. Each station reflects the local character of the community in scale, design and materials. To accommodate customer access, railway signals, staggered pedestrian bedstead barriers and pedestrian gates are used. Large signs warn customers to look both ways for approaching trains.

The low scale platform design and grade-level pedestrian access provide significantly improved customer access in relation to the other station designs. Positive customer feedback led Calgary Transit to incorporate new at grade crossings at each of the south LRT platforms to improve accessibility. For safety reasons, the new pedestrian crossings allow pedestrians to cross the southbound track only, in front of the stop position for trains. Pedestrian access is controlled by railway signals and staggered bedstead railings.

Similar grade-level connections have been incorporated at several new LRT platforms. For safety reasons, Calgary Transit encourages the practice of allowing grade-level crossings of both tracks in front of a station platform to avoid conflicts between pedestrians and approaching trains or staggering the location of side-load stations to provide connections at the stop position between the platforms.

Lessons Learned

- 1. Minimize station access time where possible with grade level access to stations.**
- 2. Integrate the scale and design of stations with adjacent land uses.**
- 3. Design to the highest barrier-free accessibility standards possible.**
- 4. Invest time, effort and funds to ensure the station design function well, is intuitive, understandable and creates a "significant place" in the community from a customer perspective.**
- 5. Alternate end loading should be incorporated at successive centre-load stations to balance customer loads between cars in the train consist and achieve more efficient use of available capacity.**

6. **Manage customer confidence by using Crime Prevention through Environmental Design (CPTED) principles, visible security presence, security monitoring equipment, lighting, good information and positive messaging to manage customer confidence.**

ACCESS MODE PLANNING

Access mode planning for Calgary's LRT system accommodates a comprehensive range of access modes (i.e, walking, cycling, auto, feeder bus); however, first priority is given to ensuring effective integration of feeder bus networks with the LRT. At suburban LRT stations, over 50 percent of customers typically access the station by feeder bus. Together, the LRT system and connecting feeder bus network form a highly integrated system which services the demand for downtown work trips and cross-town travel to suburban employment, educational and shopping destinations.

To allow reasonable opportunities for private vehicle access to the LRT stations, park and ride and auto passenger drop-off facilities are provided at suburban stations. The amount of parking provided at LRT stations is set to comply with established policies which specify that 15 to 20 percent of projected ridership be accommodate by the park and ride access mode. The calculation of park and ride demand considers the number of residents living within the catchment area of the station; the number of transit trips made external to the community by the residents, the percent of transit trips which access the station by auto and the efficiency of the parking lot. External parking demand generated by residents outside of Calgary is also considered. Currently there are a total of 11,200 park and ride stalls at 17 stations throughout the LRT system, with an estimated overall utilization rate of 95 percent.

The actual calculation for park and ride demand is based on the following formula:

Park and Ride Demand =

	<u>Park and Ride Catchment Population</u> - based on full build-out
X 0.35	<u>Transit Trip Generation Rate</u> - each resident is estimated to make 0.35 trips per weekday
X 0.8	<u>External Trips</u> - 80 percent of trips will leave community
X 0.5	<u>One-way Travel Factor</u> - one stall is required for round trip
X 0.15 - 0.2	<u>Park and Ride Access Share</u> - 15 to 20 percent will use park and ride
/1.2	<u>Auto Occupancy Factor</u> - on average there will be 1.2 persons per auto using park and ride
/0.95	<u>Parking Lot Efficiency Factor</u> - some stalls may not be available due to poor parking
/1.2	<u>Stall Turnover Rate</u> - stalls may have more than single use per day.

APPENDIX G: OPERATING AND MAINTENANCE COST ESTIMATES

OPERATING AND MAINTENANCE COSTS

Introduction

Annual operating and maintenance costs include the ongoing costs to operate and maintain the transit system. These costs typically include administration, labor (operations and maintenance), vehicle maintenance, fuel, and insurance. For purposes of this study, the annual operating and maintenance costs were estimated in year 2003, current year, dollars and then escalated to year 2010, the anticipated year of expenditure. An escalation rate of 4.0 percent per year was used, which is consistent with the escalation rate used in *Central Corridor 2002 Draft Environmental Impact Statement (DEIS)*.

The total estimated annual operating and maintenance cost is the sum of the feeder bus costs, rail costs and, in the case of DMU the lease payment to the private railroad companies.

Feeder Bus

The operating and maintenance cost estimate for the feeder bus system is a calculation of the estimated change in platform hours (i.e., revenue hours, deadhead hours, and vehicle preparation hours) over the existing service provided by the existing bus system. A unit cost of \$89.96 (year 2003) per platform hour is the regional standard for estimating the cost per platform hour. This \$89.96 figure includes the cost of labor, materials, fuel, utilities, insurance, taxes and benefits.

Light Rail Transit

The model used to estimate LRT operating and maintenance costs for the Southwest rail transit line was originally developed for the Hiawatha LRT line. It is based on actual financial and operating data for the following eight LRT systems: Baltimore, Dallas, Denver, Portland, Sacramento, San Jose, San Diego, and St. Louis.

The model includes the following categories:

Rail Transportation – This applies to operations personnel such as the director, assistant manager, clerk, train operators, fare inspector, police officers, materials and supplies, and propulsion power.

Rail Vehicle Maintenance – This applies to vehicle maintenance personnel such as the director, clerks, mechanics, materials and supplies, and fuel and lubrication.

Rail Facilities Maintenance – This applies to facility maintenance personnel such as the director, manager, technicians as well as the costs for maintenance of the tracks, power, signals, station platforms and yards and shop.

Rail Administration and Support – This applies to administrative personnel such as the assistant general manager of rail operations, director of bus/rail safety, budget analysts, engineers, marketing, customer service, taxes, insurance and utilities.

In addition, the model also factors in the operating characteristics (i.e., the number of vehicles, the service frequency, the system miles, the number of maintenance facilities and stations) to calculate the annual operating and maintenance costs.

To reflect potential LRT costs in this region, the model uses Metro Transit's current annual average earnings for comparable job positions and fringe benefit rates. The model also reflects Metro Transit's allocation of labor overhead, as reported in the National Transit Database. The

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overhead allocation is intended to represent functions not directly associated with operations, such as marketing and customer service.

Diesel Multiple Unit

Since the Colorado Rail Car Company's Aero DMU vehicle is not currently in operation there is no system data upon which to base an annual operating and maintenance cost estimate. To develop an operations and maintenance cost estimate, the LRT model was modified slightly for application to the Diesel Multiple Unit system.

Information provided by DMU manufacturers and from European experience indicates that DMU costs are likely to differ from LRT costs in the following areas:

Vehicle Maintenance – Operating and maintenance costs for DMUs are similar to LRV costs for items such as axles, wheels, body and paint. However, the cost to maintain the power train is comparable to a transit bus. Each powered DMU typically contains two diesel engines, each with the power output (horsepower) similar to a diesel engine of one standard transit coach. This results in the need for a greater number of diesel engine mechanics than the number of electro mechanics required for LRT. The cost to maintain power-related elements of DMUs will also be higher. Based on prior research conducted for Denver's Regional Transit District, vehicle maintenance labor and material costs for two diesel engines¹ are expected to be approximately 20 percent higher than comparable LRT costs, on a vehicle-mile basis.

Facility Maintenance – Costs for overhead catenary maintenance are not required by DMUs. The cost of labor, materials and contracted services for the catenary expense category in the LRT cost model have been removed from the DMU cost model.

Fuel – Another major area of difference is fuel cost. The Colorado Rail Car Company provided an average fuel consumption rate of 1.2 miles per gallon per car for their Aero DMU vehicle. This information is used in the DMU cost model.

Track Maintenance – Track maintenance costs have been assumed to be 20 percent higher than those identified in the LRT cost model. This is based on the assumption that shared use with freight trains will result in higher maintenance costs.

Annual Lease Payment

In addition to the annual operating and maintenance costs, the DMU option also requires an annual lease payment to the private freight rail companies for use of their tracks.

Typically, the transit agency would purchase rights to operate passenger rail transit service on the private railroads tracks. In return, the private rail companies generally require capital improvements to the existing rail tracks and a long-term lease agreement that includes payment for access fees, real estate taxes, track retention, special or extra train service fees, incentives (e.g. to maintain passenger rail service reliability/on-time performance) and contingencies.

For purposes of this study, the following two methods of estimating the annual lease agreement costs were used:

Method 1: Payments to railroads based on cost per Directional Route Mile (DRM = the number of route miles of revenue track, excluding yard and tail track). One route-mile of double track equals two directional route-miles.

¹ Each Colorado Railcar DMU powered car includes two Detroit Diesel Series 60 engines.

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Method 2: Payments to railroads based on Daily Hours of Track Use. This method is based on what portion of the service day the agency intends to utilize the track, and what portion of the day remains for the railroad to utilize the track. These costs can be low or high depending on how active existing freight service is on the host railroad.

Historically, existing railroads have been used (track lease agreement) to operate commuter rail type service versus a more frequent passenger rail service, like LRT or DMU. Because commuter rail service typically operates less frequently (peak hours only or very limited midday service), railroads have been willing to sell or lease use (time) of their tracks, provided they can still maintain their existing and planned use of the railroad line.

