Edmonton Light Rail Transit Experience

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Edmonton's light rail transit (LRT) line has now been in operation for more than 17 years. A summary of Edmonton's LRT experience in terms of system design, ridership, service, incident management, system performance, underground versus surface, staffing and security, fare payment, accessibility, and operating costs is presented. The experiences shared relate the lessons learned as well as the many improvements and quality initiatives undertaken. Edmonton's light rail operations are fully integrated with the city's overall transit network. Ridership has climbed from 12,000 passengers a day in 1978 to 36,000 today. The line is 12.3 km long, 4.7 km underground. There are six underground and four surface stations, several park-and-ride lots, and a fleet of 37 cars based at a modern maintenance department.

The city of Edmonton is located 670 m (2,200 ft) above sea level at 53½ degrees north latitude in the province of Alberta, Canada. Edmonton is the provincial capital and the center of the province's public administration.

Although government is Edmonton's major "business," the energy and petrochemical industries are of comparable importance. Large coal reserves and many producing oil wells exist within a short distance of the city. The refining of crude oil is centered in "refinery row" east of the city.

The Edmonton area is composed of a number of communities surrounding the city of Edmonton. They include the city of St. Albert; the counties of Strathcona, Leduc, and Parkland; and the municipal district of Sturgeon. The combined population within the Edmonton area is approximately 810,000, and the 1993 city of Edmonton population is 627,000.

Annual temperatures in Edmonton can vary substantially between winter and summer. The warmest monthly average for July was 19°C (66°F), with the warmest recorded summer temperature being 37°C (98°F). During winter, cold spells of −37 to −43°C (−34 to −45°F) lasting several days can be experienced. The lowest recorded average temperature for January was −27.7°C (−18°F). Average annual rain and snowfall are approximately 450 mm (17.5 in.). During December the city receives approximately 203 mm of snow (8 in.); the maximum recorded snowfall in December was 813 mm (32 in.).

Edmonton Transit Overview

Edmonton Transit began operations on November 1908 as the Edmonton Radial Railway with a fleet of seven streetcars and 12 route-mi of track. By 1938 the Radial Railway had expanded to 74 streetcars and 54 route-mi. Annual passenger volumes reached 14.2 million.

Beyond 1938, the street railway system gradually downsized as motor buses and electric trolley buses replaced streetcars. The first motor bus service was introduced in 1932, and electric trolley bus service began in 1939. As more and more trolley and motor buses became part of the public transit network, the name of Edmonton Radial Railway was changed in 1947 to its current name, the Edmonton Transit System. By the end of 1951, streetcars ceased to be a part of Edmonton Transit.

Edmonton Transit continued to expand as the city grew from a population of approximately 159,000 in 1951. By the early 1960s the city's population had grown to 337,000, bringing with it growing traffic congestion. During the following years various transportation studies were conducted to address this growing congestion. One of these studies, prepared in 1972, encouraged the use of a modern European-style light rail transit (LRT) system. In 1973 city council approved the construction of the Northeast Rapid Transit Line as approved by the Utilities and Engineering Committee. Construction began on September 30, 1974.

On April 22, 1978, Edmonton became the first city in North America of under 1 million residents to open a new LRT system (Figure 1).

LRT System Overview

This year marks the 17th anniversary of Edmonton Transit's light rail line. When it opened on April 22, 1978, there were 6.9 km of double track and five stations, served by 14 light rail vehicles (LRVs). Today, after three extensions, the line is 12.3 km long, 4.7 km of which is underground. There are six underground (Figure 2) and four surface stations (Figure 3), several park-and-ride lots, and a fleet of 37 cars based at a

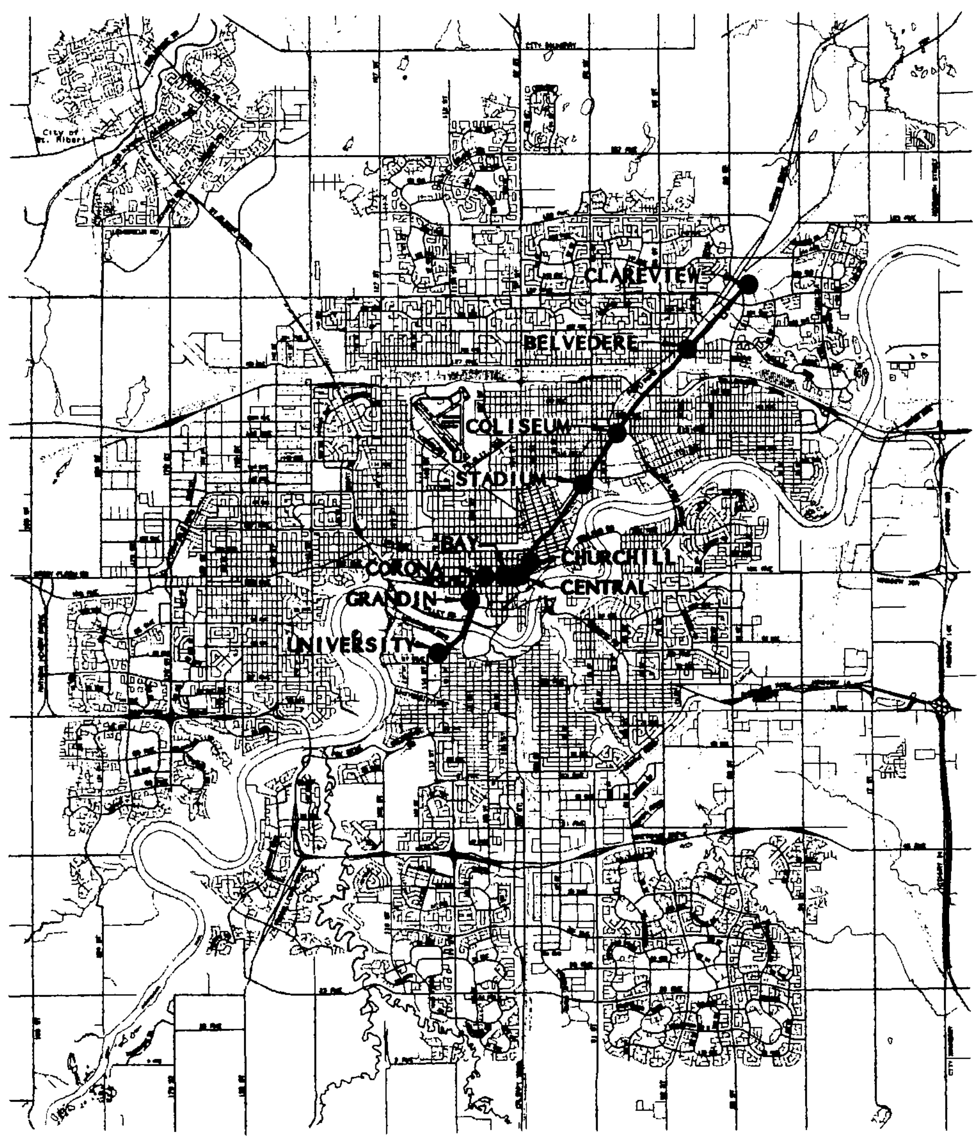

FIGURE 1 City map with LRT line superimposed.

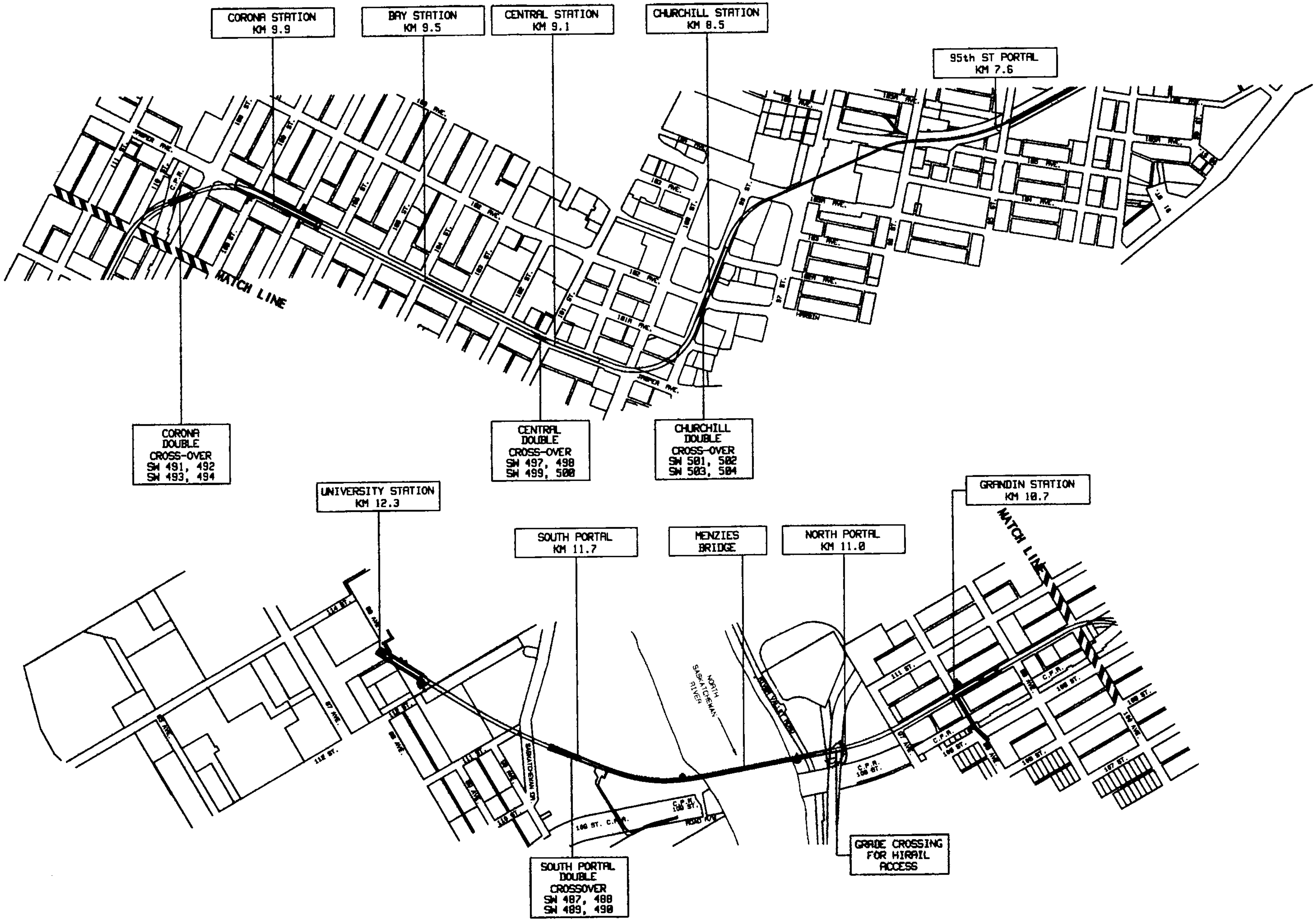

FIGURE 2 Underground track, Edmonton Transit.

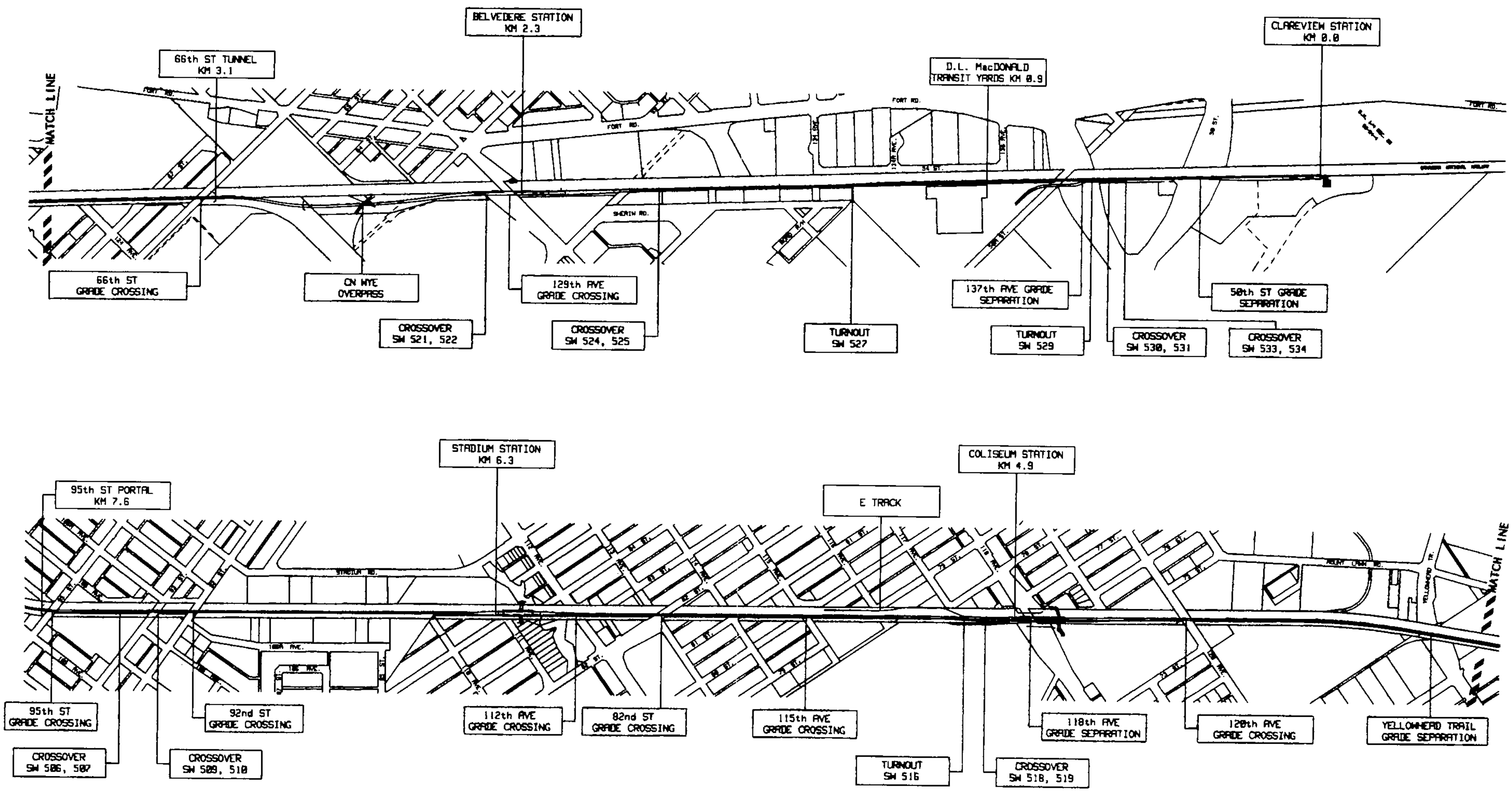

FIGURE 3 Surface track, Edmonton Transit.

modern maintenance depot. Total capital investment has reached approximately $343 million (Canadian dollars).

Starting from Clareview in the northeast, the light rail line runs on the surface parallel to Canadian National (CN) Rail tracks toward the city center (Figure 4). A tunnel through the central downtown area leads to a bridge over the North Saskatchewan River, which brings the route to an underground terminus beneath the University of Alberta. There are eight level crossings on the surface section, equipped with federally approved protection. Also situated along the surface route is the Northlands Coliseum, home of the National Hockey League's Edmonton Oilers, and Commonwealth Stadium, which is the venue for the city's professional football team and various other special events.

The last extension was completed in 1992 to the University of Alberta. Construction of the 2.5-km extension from Corona to the university began in 1986. Approximately 20 prime contractors and 100 subcontractors were involved in this highly technical project, which included tunneling under high-rise structures through a variety of soil conditions and building a bridge across the North Saskatchewan River. A combination of tunnel boring and sequential excavation was used on the section between Corona and the north bank portal, including Grandin (Government Center) station, which opened in September 1989.

The Dudley B. Menzies Bridge, which parallels the High Level Bridge, was constructed from precast concrete segments. Although built exclusively for the light rail line, it incorporates a suspended footway and cycleway connection across the river. The south portal and tunnel under the university were built using sequential excavation.

University station was built by the tangent pile cut-and-cover method used for the earlier city center stations. Given the elevation of the single track leaving the southern end of the bridge, the station is the deepest in Edmonton, with the platform 23 m below road level. The station was opened in August 1992, completing the 6-year, $150 million extension.

Edmonton Light Rail Experience

Over the past 17 years Edmonton Transit has gained a great deal of experience, some of which the author would like to share. The experiences have been both good and bad, but for the most part good.

Ridership

Light rail operations are fully integrated with the city's overall transit network. The network is designed on a

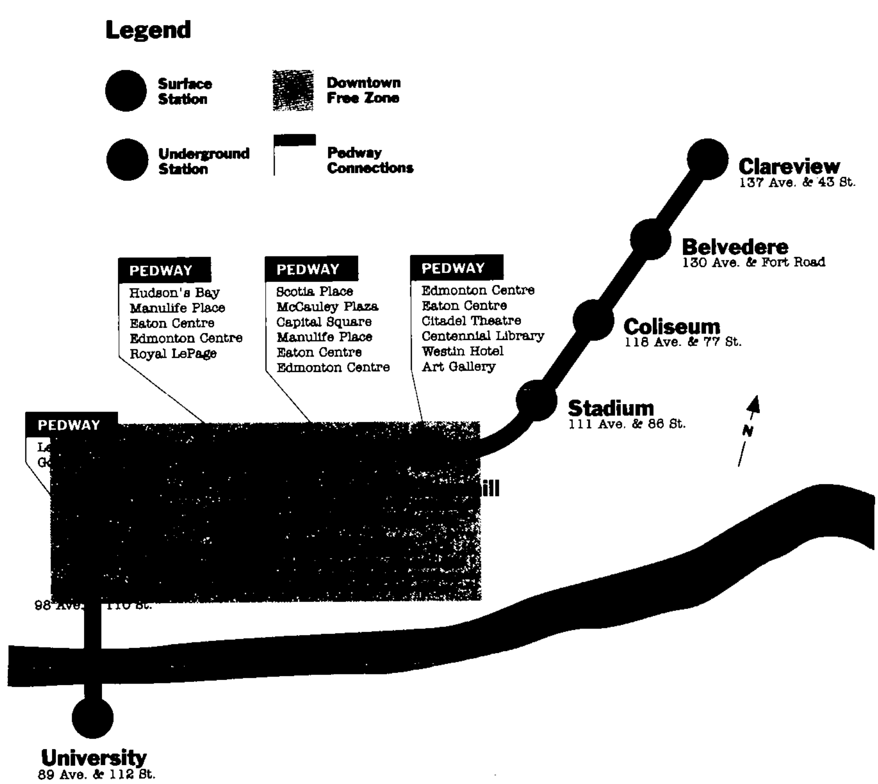

FIGURE 4 LRT link and route map.

hub-and-spoke basis, with transit centers (including the LRT stations) acting as hubs. Buses from residential areas feed into the hubs and provide direct links between transit centers; timed transfers allow connections onto other buses and light rail services.

During the first 15 years, light rail ridership rose from 12,000 to 36,000 passengers a day; two-way peak-hour demand currently stands at 5,300 (i.e., a.m. peak-hour ridership is 4,440 in the southbound direction and 860 in the northbound direction).

The opening of the university extension in 1992 brought a 50 percent increase in ridership, which can be attributed to two factors. First, bus services in the area were realigned, with direct services from the university to the central area eliminated in favor of transfers onto the light rail line. More significant, new riders have been attracted by the convenience of light rail. University students have the opportunity to live in lower-priced accommodations farther from campus while maintaining quick and direct access via the LRT. Since the extension opened, demand for park-and-ride lots has exceeded the capacity of 2,000 spaces.

Service

The basic light rail service operates every 10 min, with 5-min headways at weekday peak hours and 15-min intervals in the evenings and on Sundays. Trains of up to three articulated units can be accommdated at all stations, although there is provision for extension to five-car sets should this be warranted in the future. Formations are adjusted to match capacity to demand and optimize operating costs and customer satisfaction.

Incident Management

Incident management is an important element in the design and operation of an efficient light rail system, and Edmonton Transit is fortunate that the track layout provides a degree of flexibility in operations. Unforseeable incidents can and do happen that render certain sections of track impassable and risk stranding large numbers of passengers in trains or at stations. By designing the track layout so that services can be operated around any trouble spots, the incident management objective is to maintain at least a 10-min headway at all times.

Organization and Staffing

The light rail section of Edmonton Transit employs 111 staff, of which 58 cover operations: motormen, inspectors, fare agents, and dispatchers. Another 28 are employed in vehicle maintenance, 5 in fare equipment maintenance, 14 in plant maintenance, and 6 in administration and engineering.

System Performance

System performance factors are recorded and reported monthly (Figures 5 and 6). Factors measuring the reliability of the LRVs, signal system, traction system, track, motorman performance, and miscellaneous system performance are combined into an overall system performance measurement. Overall system performance is based on the number of runs delayed more than 5 min within a given month. Experience to date has been outstanding: schedule adherence averages 99.6 percent throughout the year. When delays do occur, they generally result from LRV or traction system problems (Figure 7). Traction system problems usually involve the overhead catenary snagging the vehicle pantograph; this usually occurs two to three times a year and can cause considerable system delay.

LRV problems occur more often and usually involve two factors, mechanical or electrical component failure and operational training. In most situations a mechanical or electrical component failure on the LRV will not render it immobile, as most LRVs are designed with considerable redundancy. With the right training, operational staff should be able to assess the problem quickly and decide whether to operate the vehicle or remove it from the line. However, often what occurs is that too much time is spent trying to fix the problem rather than concentrating on maintaining scheduled service.

Rolling Stock

Edmonton has 37 light rail vehicles of the Frankfurt U2 type, similar to the vehicles used in Calgary, San Diego, and Sacramento. The cars were purchased in three separate orders: the first 14 in 1977, the next 3 in 1980, and the remaining 20 in 1983. The reliability of these vehicles has been remarkable. Each of the first 14 cars underwent a major inspection at 500 000 km, the result of which showed no significant problems. Most of these cars have exceeded the 1 000 000-km mark, with most of the vehicles still using the original major components, such as traction motors, camshaft controller, gear boxes, and couplers. Because of this experience, major inspections have been increased to 750 000 km. Routine inspections are carried out every 10 000 km.

To track vehicle reliability, a computerized job costing system has been developed. The system maintains

	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DEC	YTD	PIB	PREV.YR.
SYSTEM PERFORMANCE															
SHEDULE ADHERENCE															
INCIDENTS > = 5 & < 10 MINS.															
INCIDENTS > = 10 MINS.															
SYSTEM DELAYS > = 5 & < 10 MINS.															
SYSTEM DELAYS > = 10 MINS.															
INCIDENT SEVERITY															
CUSTOMER SATISFACTION															
VEHICLE PERFORMANCE															
INCIDENTS > = 5 & < 10 MINS. DUE TO LRV															
INCIDENTS > = 10 MINS. DUE TO LRV															
SYSTEM DELAYS > = 5 & < 10 MINS. DUE TO LRV															
SYSTEM DELAYS > = 10 MINS. DUE TO LRV															
SIGNAL SYSTEM PERFORMANCE															
INCIDENTS > = 5 & < 10 MINS. DUE TO SIGNALS															
INCIDENTS > = 10 MINS. DUE TO SIGNALS															
SYSTEM DELAYS > = 5 & < 10 MINS. DUE TO SIGNALS															
SYSTEM DELAYS > = 10 MINS. DUE TO SIGNALS															
TRACTION SYSTEM PERFORMANCE															
INCIDENTS > = 5 & < 10 MINS. DUE TO TRACTION SYSTEM															
INCIDENTS > = 10 MINS. DUE TO TRACTION SYSTEM															
SYSTEM DELAYS > = 5 & < 10 MINS. DUE TO TRACTION SYSTEM															
SYSTEM DELAYS > = 10 MINS. DUE TO TRACTION SYSTEM															
TRACK PERFORMANCE															
INCIDENTS > = 5 & < 10 MINS. DUE TO TRACK															
INCIDENTS > = 10 MINS. DUE TO TRACK															
SYSTEM DELAYS > = 5 & < 10 MINS. DUE TO TRACK															
SYSTEM DELAYS > = 10 MINS. DUE TO TRACK															
OPERATIONS PERFORMANCE															
INCIDENTS > = 5 & < 10 MINS. DUE TO OPERATIONS															
INCIDENTS > = 10 MINS. DUE TO OPERATIONS															
SYSTEM DELAYS > = 5 & < 10 MINS. DUE TO OPERATIONS															
SYSTEM DELAYS > = 10 MINS. DUE TO OPERATIONS															
MISC. SYSTEM PERFORMANCE															
NUMBER OF SIGNAL PENALTY STOPS															
TRAINS STOPPED DUE TO SPEED CHECKS															
LRV PASSENGER INCIDENTS															
STATION PASSENGER INCIDENTS															
INCIDENTS > = 5 & < 10 MINS. DUE TO ACCIDENTS / INCIDENTS															
INCIDENTS > = 10 MINS. DUE TO ACCIDENTS / INCIDENTS															
ESCALATOR / ELEVATOR REPAIR CALLS															
SERVICE COMPLAINTS															
VANDALISM															
STATION INCIDENTS															
LRV INCIDENTS															

COMMENTS

FIGURE 5 LRT system performance report.

TIME INCREMENTS

INCIDENTS > = 5 MINS.	5 minutes represents peak hour LRT freqency.
INCIDENTS > = 10 MINS.	10 minutes represents the LRT incident management Service Frequency Objective.

SYSTEM PERFORMANCE

SHEDULE ADHERENCE	SHEDULE ADHERENCE	= (number of runs - (number of incidents + number of delays)) / number of runs - expressed as a percent.
INCIDENTS > = 5 & < 10 MINS.	INCIDENTS > = 5 & < 10 MINS.	= An incident effecting a single train within a local area.
INCIDENTS > = 10 MINS.	INCIDENTS > = 10 MINS.	= An incident effecting a single train within a local area.
SYSTEM DELAYS > = 5 & < 10 MINS.	SYSTEM DELAYS > = 5 & < 10 MINS.	= An incident effecting all trains causing the LRT Line to stop for 5 to 10 minutes or scheduled service can not be maintained to within 5 minutes of the published schedule. ie. 5 minute service reduced to 10 minute service.
SYSTEM DELAYS > = 10 MINS.	SYSTEM DELAYS > = 10 MINS.	= An incident causing all or part of the LRT Line to stop or regular scheduled service can not be maintained to within 10 minutes of the published schedule. ie. 5 minute service reduced to 15 minute service.
INCIDENT SEVERITY	INCIDENT SEVERITY	= (number of system delays / (number of incidents + system delays) expressed as a percent.
CUSTOMER SATISFACTION	CUSTOMER SATISFACTION	= 1 - (number of service complaints / number of platform hours) expressed as a per cent. measurement base: 34,620 annual platform hours & 36,000 passengers per day = 1

VEHICLE PERFORMANCE

INCIDENTS > = 5 & < 10 MINS. DUE TO LRV	An incident caused by a Light Rail Vehicle.
INCIDENTS > = 10 MINS. DUE TO LRV	An incident caused by a Light Rail Vehicle.
SYSTEM DELAYS > = 5 & < 10 MINS. DUE TO LRV	A system delay caused by a Light Rail Vehicle.
SYSTEM DELAYS > = 10 MINS. DUE TO LRV	A system delay caused by a Light Rail Vehicle.

SIGNAL SYSTEM PERFORMANCE

INCIDENTS > = 5 & < 10 MINS. DUE TO SIGNALS	An incident caused by the Signal System.
INCIDENTS > = 10 MINS. DUE TO SIGNALS	An incident caused by the Signal System.
SYSTEM DELAYS > = 5 & < 10 MINS. DUE TO SIGNALS	A system delay caused by the Signal System.
SYSTEM DELAYS > = 10 MINS. DUE TO SIGNALS	A system delay caused by the Signal System.

TRACTION SYSTEM PERFORMANCE

INCIDENTS > = 5 & < 10 MINS. DUE TO TRACTION	An incident caused by the Traction System.
INCIDENTS > = 10 MINS. DUE TO TRACTION	An incident caused by the Traction System.
SYSTEM DELAYS > = 5 & < 10 MINS. DUE TO TRACTION SYSTEM	A system delay caused by the Traction System.
SYSTEM DELAYS > = 10 MINS. DUE TO TRACTION SYSTEM	A system delay caused by the Traction System.

TRACK PERFORMANCE

INCIDENTS > = 5 & < 10 MINS. DUE TO TRACK	An incident caused by the Track.
INCIDENTS > = 10 MINS. DUE TO TRACK	An incident caused by the Track.
SYSTEM DELAYS > = 5 & < 10 MINS. DUE TO TRACK	A system delay caused by the Track.
SYSTEM DELAYS > = 10 MINS. DUE TO TRACK	A system delay caused by the Track.

OPERATIONS PERFORMANCE

INCIDENTS > = 5 & < 10 MINS. DUE TO OPERATIONS	An incident caused by Operations.
INCIDENTS > = 10 MINS. DUE TO OPERATIONS	An incident caused by Operations.
SYSTEM DELAYS > = 5 & < 10 MINS. DUE TO OPERATIONS	A system delay caused by Operations.
SYSTEM DELAYS > = 10 MINS. DUE TO OPERATIONS	A system delay caused by Operations.

MISC. SYSTEM PERFORMANCE

NUMBER OF SIGNAL PENALTY STOPS	Number of signal system penalty stops.
TRAINS STOPPED DUE TO SPEED CHECKS	Number of trains stopped due to speed checks.
LRV PASSENGER INCIDENTS	Number of LRV passenger incidents.
STATION PASSENGER INCIDENTS	Number of station passenger incidents.
INCIDENTS > = 5 & < 10 MINS. DUE TO ACCIDENTS / INCIDENTS	An incident caused by an accident or other non specified incident.
INCIDENTS > = 10 MINS. DUE TO ACCIDENTS / INCIDENTS	An incident caused by an accident or other non specified incident.
ESCALATOR / ELEVATOR REPAIR CALLS	Number of escalator and elevator repair calls.
SERVICE COMPLAINTS	Number of customer service complaints as compiled by the Customer Service Section

VANDALISM

STATION INCIDENTS	Number of station vandalism incidents.
LRV INCIDENTS	Number of LRV vandalism incidents.

FIGURE 6 LRT system performance definitions.

records of all faults and repairs on each vehicle. It also keeps track of major components, wheel wear records, and scheduled inspections (as well as payroll records). The data base was put into operation in 1982 and provides an invaluable history of vehicle performance.

Stations

Edmonton has 10 stations, 6 underground and 4 on surface. The physical plant includes the tunnels, track, signal system, traction power, and communications. Underground station maintenance has proved to be a very expensive proposition. On average underground stations cost approximately $300,000 in annual maintenance, which includes custodial services, utilities, and general maintenance.

The major station maintenance problem is escalators. Edmonton Transit's experience with escalators has not been good. They stop frequently, inconveniencing passengers; are expensive to repair; and require constant

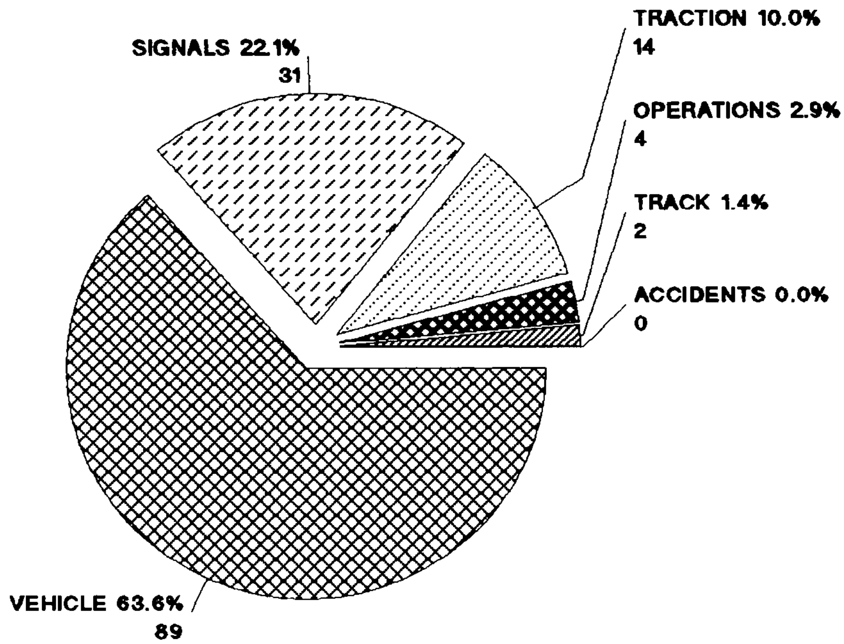

FIGURE 7 LRT system delay incidents, 1994.

maintenance. The root of the problem can be traced to the original purchase of the equipment, where common regular-duty escalators were specified instead of the heavy-duty type suited for public transit use.

Water leakage is another major problem with underground stations. The membrane covering the original two underground stations, Central and Churchill, has failed. When it rains or when the snow melts, water flows into the stations, resulting in considerable damage. A program is in place to carry out the required repairs over the next several years to prevent any long-term structural damage. The water leakage problem can be avoided in underground stations by using the proper sealing techniques during construction. Since the Central and Churchill stations were constructed, sealing techniques have improved considerably. Fortunately, these new methods have been employed on the newer stations with good success, and water seepage has been kept to a minimum.

Water seepage, especially in the winter, can be a problem in the tunnels. In extremely cold conditions the groundwater entering the tunnels freezes as the cold air makes its way through the tunnels. As the water freezes it can build up around and over the rails with serious consequence. Edmonton Transit experienced freezing problems in the LRT tunnels once opened at both ends with the university extension. Because the tunnel has an elevation difference between each end of approximately 26 m, a "stack" effect is created. The stack effect causes the tunnel to behave like a chimney: it draws air from the lower portion of the tunnel and exhausts it at the higher end. As the cold air rises through the tunnel, the surrounding structures begin to lose their heat, eventually causing the groundwater to freeze. The effect also creates low ambient temperatures in the stations, which results in discomfort for customers.

The freezing problem has been corrected by the installation of natural gas heaters at the lower end of the tunnel on either end of the bridge. When outside air temperatures reach a critical temperature, the heaters will start, heating the air as it enters the tunnels. This solution has resolved the groundwater freezing problem as well as improved the ambient air temperature in the stations. The operating cost of the heaters is approximately $25,000 a year for each.

Signal System

The signal system used on the LRT system is a European design using fix block signals and discreet speed checks. A mimic board at the central control room monitors the movement of the trains throughout the system. The controller is able to see where the trains are located and effect route changes as required. System reliability has generally been good; there have been a few problems with the speed checks.

On the university extension, a North American–type signal system was installed and integrated with the existing system. The decision to change was primarily economic, but there was also a desire to convert from the

European technology because of availability and shorter delivery times of the North American equipment.

Traction System

The traction power used on the LRT system is nominal 600 V-direct current (DC). The power is supplied to the vehicles by an autotensioned simple catenary system. The autotension system is used to compensate for the significant expansion and contraction that takes place between summer and winter. Generally, reliability of the system has been good. However, the vehicle pantograph will get caught in the catenary occasionally, causing considerable damage. Most often, the cause of these incidents is extremely difficult to pinpoint because of the dynamics involved between the vehicle and the catenary wire.

Communications

Radio communication is provided throughout the system. Central control keeps in constant touch with the trains, work crews, and security. The communication system is the lifeblood of the system, enabling controllers to provide advisory information and respond to emergencies.

Track

Good track design and maintenance is an important element of the LRT system. Poor track systems can result in serious safety concerns and passenger discomfort due to poor ride quality. Edmonton Transit has worked on improving ride quality over the past few years. Because of a number of factors—such as climate, vehicles, installation, and the fundamental differences between heavy rail and light rail track requirements—the ride quality on the system has not been as good as it should be.

In 1990 Edmonton Transit asked the consulting firm Advanced Rail Management (ARM) to review its track with the object of improving ride quality. Following an extensive evaluation of the system, ARM recommended a new rail profile that it believed would greatly improve ride quality and reduce wheel wear. The recommendation was accepted, and a test section of rail was selected for grinding in October 1991. The results were impressive—ride quality improved substantially—so an additional section was ground in 1992. It was also discovered that rail icing problems were almost eliminated in the areas of profile grinding because of the narrow contact band. Reprofiling of the remaining surface rail was completed in 1994.

Experience with road grade crossings has demonstrated the importance of design. The road sand, salt, and water, combined with poor drainage, have contaminated and deteriorated most of the crossings, necessitating major repairs after only 10 years of service. Most of the crossings have been replaced at a cost of approximately $200,000 each. The new design includes proper drainage, concrete ties, and panels with Epflex flange ways; design life is estimated at 25 years.

Safety and Security

The safety and security of the passengers is of paramount importance. To ensure safety and security, closed-circuit surveillance cameras have been installed in all stations and pedestrian areas. The cameras are monitored on a 24-hr basis and the stations patrolled during operating hours by 25 fare agents. The fare agents provide both fare payment enforcement and security functions. Public washroom and elevator access is controlled remotely and monitored to ensure the safety of those persons using the facilities.

Edmonton Transit recently installed a passenger assistance communication system on board the vehicles that allows passengers to contact the train operator from anywhere on the train. Passengers can respond to an on-board emergency by either pulling a red handle at alternate passenger doors or pressing a touch strip above the seating area. Once the system is activated, the passenger and operator can talk to each other. The system also allows central control to make public address announcements directly to the trains.

The Edmonton LRT system has benefited from its exclusive right of way and tunnel sections by reducing the number of accidents associated with surface-operated LRT systems. Since 1978 the LRT system has had 20 major accidents. Of those, 15 occurred at level crossings, 3 were along the right of way, and 2 were derailments. Pedestrian accidents accounted for eight of the level crossing accidents. In all there have been five fatalities.

Pedestrian safety was of major concern at the Belvedere LRT Station. Belvedere, a center-platform station, is situated immediately east of the CN mainline. It is a high-volume station with numerous parking lots surrounding it; a bus transfer terminal sits next to it. To access the station from the bus terminal and some of the parking lots, passengers are required to cross both the CN track and the southbound LRT track. The pedestrian sidewalk across the tracks is protected by crossing arms and an audible alarm.

There were two problems with the Belvedere crossing. First, when a train arrived at Belvedere Station, passengers generally were unwilling to obey the warning and control devices out of fear of missing their transfer. (This applied to passengers transferring either to bus or rail.) The second problem was that when a CN train passes through the area it is generally extremely long and can delay passengers for up to 5 min. When passengers see the CN train coming, there is usually a rush to beat the train to the crossing, even if the crossing protection is active. Occasionally, the CN train will stop, blocking the crossing, and some people will climb between the cars. Fortunately, there have been only two accidents at the crossing in the past 17 years, but there have been many near misses. To control this problem, the station entrance and crossing arrangement were redesigned. Originally it was the intent to provide an elevated walkway over the tracks; however, the costs of such a solution proved prohibitive. A much less expensive design changed the station entrance design to improve the sight lines. Additional pedestrian gate arms were installed for each track, enabling gate activation times to be adjusted to reflect the available crossing times more accurately. Edmonton Transit has since experienced a significant drop in gate violators.

Fare Payment

The fare collection used on the LRT system is the proof-of-payment system. Passengers are required to obtain their proof of payment prior to entering the "fare paid area." Their proof of payment may be a single ticket bought at one of the many machines situated in the stations, a monthly pass, a multiride ticket, or a bus transfer. To enforce fare payment, fare agents roam the system and randomly check passengers. Occasionally, the fare agents will conduct a check of all passengers as they exit the station platform. This type of fare system has worked well. The operational cost savings are considerable by not requiring ticket agents at each station. Fare evasion averages 1.5 to 2.5 percent, which is consistent with many other LRT operations.

Accessibility

The accessibility to Edmonton's light rail system has been an important design consideration throughout the development and expansion of the service. The object has been to provide barrier-free facilities that provide access to all those who choose to use the LRT system. Elevators and escalators are provided at all stations except for Belvedere and Clareview, where ramps provide wheelchair access to the platform. Work is ongoing at making further improvements such as automatic opening doors and improved signage. LRV access is currently the major accessibility issue being addressed. Groups representing the physically challenged have advised that the vertical gap of approximately 80 to 100 mm between the vehicle floor and the station platform presents an obstacle to them. To address this problem, Edmonton Transit has initiated a pilot project for the design and installation of a test ramp that would reduce the vertical gap. The ramp will be integrated into the car and deploy automatically upon request. Operator assistance will not be required.

Accessibility issues are a continuing concern that is addressed through regular meetings with the disabled community. The Disabled Adult Transportation System is under increasing demand for its services. However, service delivery on the system is very expensive, and as demand increases it will have a sizable impact on Edmonton Transit's budget. The more that the LRT system can be made accessible to all members of the community, the more that individuals with special needs can be mainstreamed, helping to reduce operating costs.

Operating Costs

Edmonton Transit's annual operating budget is approximately $12 million (Canadian), to which must be added between $1 million and $2 million for capital expenditure on major rehabilitation of equipment and infrastructure (Figures 8 and 9).

The underground operation bears heavily on the operating costs of the light rail system. Typically, underground stations cost three to four times as much as the surface stations for utility and maintenance expenses. The opening of the university extension saw a fall in unit operating costs despite the addition of another underground station, a large bridge, and 1.6 km of track (Figure 10). The corresponding increase in ridership has more than offset the higher operating costs, showing the efficiency of carrying large numbers of people. Unit operating costs have fallen by 24 percent, to $1.04 (Canadian) per passenger journey. Add to this the annual savings of $500,000 in reduced bus operating costs directly attributable to the extension, and it has provided a valuable boost to the efficiency of the LRT. Any further extension beyond the university will be on the surface, which will further improve the per-unit operating efficiency and negate the higher costs associated with the underground section.

Quality Initiatives

Over the past few years, many initiatives have been undertaken to enhance comfort, safety, security, and accessibility.

MEASUREMENT FACTORS				
	PLATFORM HOURS	MONTH	YEAR TO DATE	BUDGET
	REGULAR	2,737	32,845	32,845
	SPECIAL EVENTS	148	1,780	1,780
	TOTAL	2,885	34,625	34,625
	KILOMETERS	MONTH	YEAR TO DATE	BUDGET
	REGULAR	204,182	2,350,337	2,300,000
	SPECIAL EVENTS	14,405	191,975	200,000
	TOTAL	218,587	2,542,312	2,500,000

PERFORMANCE INDICATORS		ACTUAL YTD		BUDGET		% BUDGET	
		COST/HR.	COST/KM.	COST/HR.	COST/KM.	COST/HR.	COST/KM.
ADMIN & TECHNICAL	650	$20.03	$0.27	$20.15	$0.28	99.38%	97.73%
FLEET INS. & LIC.	652	$13.35	$0.18	$13.35	$0.18	100.00%	98.34%
	SUB-TOTAL	**$33.38**	**$0.45**	**$33.50**	**$0.46**	**99.63%**	**97.97%**
EQUIPMENT MTCE. & SERVICE	651	$48.75	$0.66	$56.84	$0.79	85.76%	84.33%
CLEARING & REVENUE	653	$0.00	$0.00	$0.00	$0.00		
FARE COLLECTION SYSTEM MTCE.	654	$9.85	$0.13	$12.95	$0.18	76.05%	74.78%
POWER	692	$16.84	$0.23	$19.11	$0.26	88.12%	86.66%
	SUB-TOTAL	**$75.44**	**$1.03**	**$88.90**	**$1.23**	**84.86%**	**83.44%**
OPERATIONS	502	$31.03	$0.42	$29.72	$0.41	104.41%	102.68%
INSPECTORS	507	$24.24	$0.33	$22.72	$0.31	106.72%	104.95%
BYLAW ADMINISTRATION	508	$31.21	$0.43	$32.51	$0.45	96.00%	94.41%
DISPATCH & TRAINING	509	$3.30	$0.04	$3.23	$0.04	102.05%	100.35%
SPECIAL EVENT SERVICE	557	$4.16	$0.06	$2.46	$0.03	168.89%	166.08%
	SUB-TOTAL	**$93.95**	**$1.28**	**$90.64**	**$1.26**	**103.64%**	**101.92%**
LRT RIGHT OF WAY MTCE	531	$19.12	$0.26	$18.62	$0.26	102.66%	100.95%
LRT CATENARY & SUB-STATION	532	$8.06	$0.11	$9.14	$0.13	88.20%	86.73%
LRT SIGNALS MTCE	533	$12.31	$0.17	$11.76	$0.16	104.70%	102.95%
COMMUNICATIONS & SURV.	534	$13.62	$0.19	$12.84	$0.18	106.07%	104.30%
	SUB-TOTAL	**$53.11**	**$0.72**	**$52.36**	**$0.73**	**101.43%**	**98.74%**
D.L. MACDONALD GARAGE	661	$9.49	$0.13	$10.14	$0.14	93.61%	92.05%
LRT STATION MAINTENANCE	620	$77.78	$1.06	$79.88	$1.11	97.38%	95.76%
	SUB-TOTAL	**$87.28**	**$1.19**	**$90.02**	**$1.25**	**96.96%**	**95.34%**
	TOTAL	**$343.14**	**$4.87**	**$355.42**	**$4.92**	**96.54%**	**94.94%**
INTERPROGRAM BILLING	OBJ. 95	($11.12)	($0.15)	($8.36)	($0.12)	133.07%	130.85%
INTER-DEPARTMENT BILLING	OBJ. 99	($2.16)	($0.03)	$0.00	$0.00		
OUTSIDE REVENUE	OBJ. 98	($0.82)	($0.01)	($1.17)	($0.02)	70.30%	69.13%
	SUB-TOTAL	**($14.10)**	**($0.19)**	**($9.53)**	**($0.13)**	**148.04%**	**146.57%**
	TAX LEVY	**$329.04**	**$4.48**	**$345.90**	**$4.79**	**95.13%**	**93.54%**

COSTS		YTD COST	BUDGET	Comments
ADMIN & TECHNICAL	650	$693,528	$697,835	
FLEET INS. & LIC.	652	$462,126	$462,126	
	SUB-TOTAL	**$1,155,654**	**$1,159,961**	
EQUIPMENT MTCE. & SERVICE	651	$1,687,818	$1,968,034	- Parts and materials purchases deferred as a budget
CLEARING & REVENUE	653	$0	$0	control initiative.
FARE COLLECTION SYSTEM MTCE.	654	$341,100	$448,540	
LRT POWER	692	$583,100	$661,692	- Mild winter resulting in lower energy usage.
	SUB-TOTAL	**$2,612,018**	**$3,078,266**	
OPERATIONS	502	$1,074,518	$1,029,089	- Voluntary retirement program payouts.
INSPECTORS	507	$839,407	$786,535	- Voluntary retirement program payouts.
BYLAW ADMINISTRATION	508	$1,080,778	$1,125,757	
DISPATCH AND TRAINING	509	$114,261	$111,971	
SPECIAL EVENT SERVICE	557	$143,924	$85,216	- Offset by obj. 99 Re: switch tender costs.
	SUB-TOTAL	**$3,252,888**	**$3,138,568**	
LRT RIGHT OF WAY MTCE	531	$661,860	$644,718	
LRT CATENARY & SUB-STATION	532	$279,116	$316,457	
LRT SIGNALS MTCE	533	$426,344	$407,219	
COMMUNICATIONS & SURV.	534	$471,447	$444,473	
	SUB-TOTAL	**$1,838,767**	**$1,812,867**	
D.L. MACDONALD GARAGE	661	$328,716	$351,146	- Utility costs lower due to mild winter.
LRT STATION MAINTENANCE	620	$2,693,238	$2,765,780	- Utility costs lower due to mild winter.
	SUB-TOTAL	**$3,021,954**	**$3,116,926**	
	TOTAL	**$11,881,281**	**$12,306,588**	
INTERPROGRAM BILLING	OBJ. 95	($384,981)	($289,313)	
INTER-DEPARTMENT BILLING	OBJ. 99	($74,861)	$0	- Switch tender billing Re: SLRT.
OUTSIDE REVENUE	OBJ. 98	($28,529)	($40,582)	
	SUB-TOTAL	**($488,371)**	**($329,895)**	
	TAX LEVY	**$11,392,910**	**$11,976,693**	

FIGURE 8 LRT performance measurement indicators, 1994 budget.

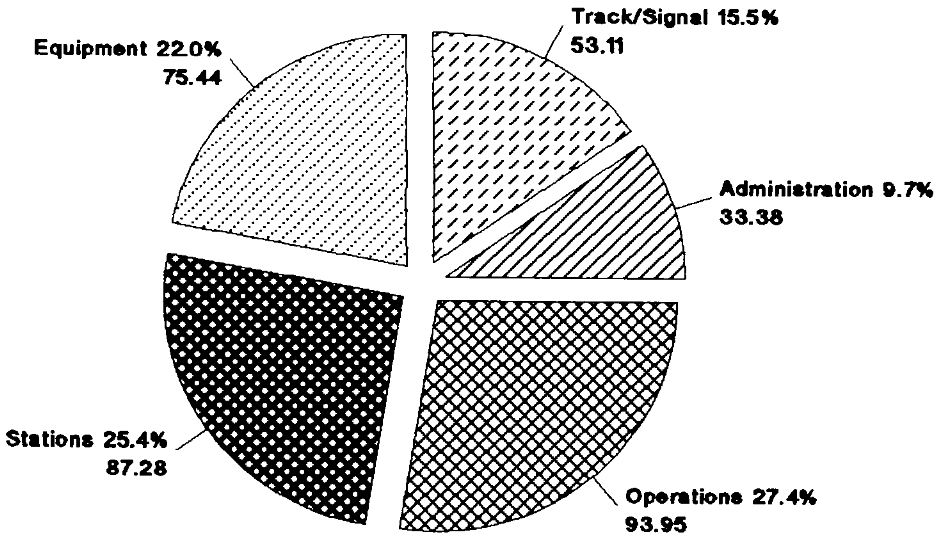

FIGURE 9 LRT cost per platform hour, 1994.

All LRV's have been equipped with the passenger assistance communication system, enabling riders to communicate directly with the operator from anywhere on the train; yellow touch strips along the windows connect that area directly to the motorman via a two-way intercom. Similarly, blue emergency phones have been installed at several locations on the platforms and at mezzanine level in each station, providing a direct customer link to the LRT control center for emergency assistance. Additional customer information panels have been provided, with communication lines to the customer service office.

Accessibility has always been an important design consideration. Although all stations were equipped with

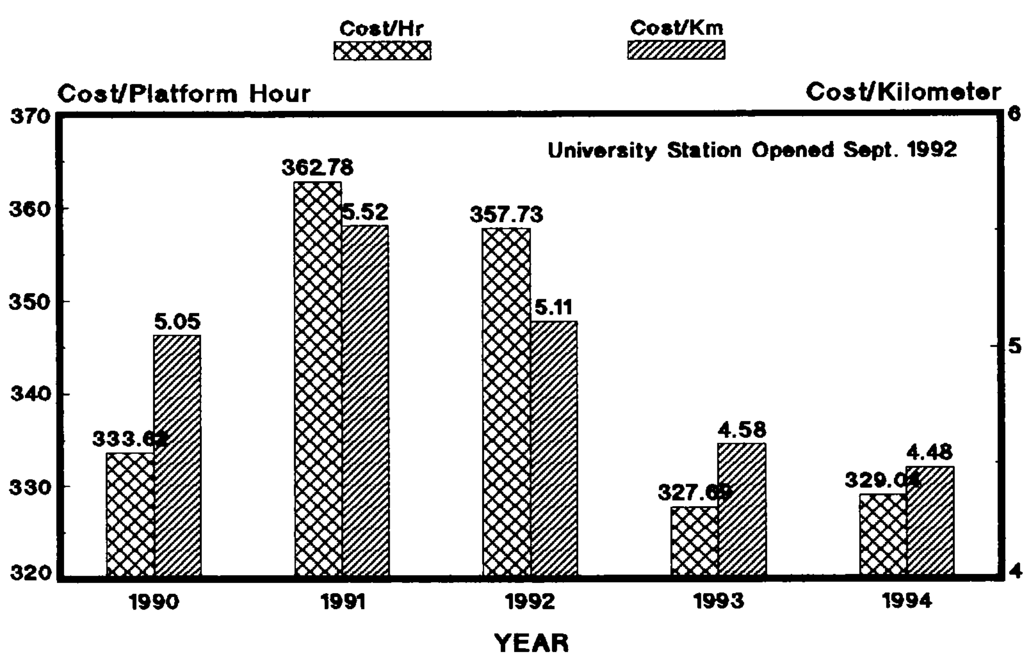

FIGURE 10 LRT costs per platform hour and per kilometer, 1990–1994 (1994 $).

elevators and escalators, work is under way on further improvements, such as automatic doors, improved signage, a reduced horizontal and vertical gap between platforms and car floors, and pay phones at each station equipped for hearing-impaired customers.

An electronic message and station announcement system has been fitted to all LRVs, and all door controls have been modified to incorporate enhanced safety features. Station washrooms and elevators have been fitted with remote access control and are opened only by central security staff upon customer request. This has improved personal safety in these areas and has greatly reduced the former levels of vandalism. Improved ride quality has resulted from the rail profile grinding program mentioned earlier.

The Future

Ever since the first stage of the light rail system opened, Edmonton Transit has had plans to expand. Further extensions are highly desirable, but unfortunately construction funding is not available in the current 5-year capital plan. Nevertheless, planning for future alignments continues on a limited basis, as it is hoped that all quadrants of the city eventually will be served by light rail. Two of the most favored extensions would continue beyond the university: a surface link south to the existing Southgate Transit Center, and a part-underground route running westward to West Jasper Place and the giant West Edmonton Mall shopping complex.