North American Light-Rail Transit Ridership and Operating Costs: A Basis for Comparison

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Comparisons of light-rail transit (LRT) performance on the basis of per mile or per kilometer cost or ridership ratios may be misleading, particularly if the systems are of different length or are located in urban areas with different populations and forms. A method for adjusting for these factors is presented, and the 1992 performance of North American LRT in terms of new indexes reflecting the additional factors is evaluated. Observations are made regarding relative performance of North America's LRT systems, and conclusions are reached as to additional factors that influence their relative positions. Also compared is the ranking of LRT systems according to the new indexes with a ranking derived from per-kilometer measures.

Planners and designers of new light-rail transit (LRT) systems or extensions to existing systems benefit from information on, and comparison among, systems already in service. Regularly published statistics by the Federal Transit Administration (FTA) can provide considerable insight into many aspects of comparison, as demonstrated at the Sixth National Conference on Light Rail Transit in 1992 (*1,2*).

Comparisons of ridership and operating costs among North America's LRT systems are complicated, however, by significant differences among both the characteristics of the systems and the metropolitan areas in which they operate. Principal among these differences are size of the metropolitan area, urban form, physical extent of the system, operating speed, level of service provided, and crewing arrangements for multiple-unit trains, where applicable. Significant ridership differences also appear to exist between Canadian and U.S. transit systems in cities of comparable size. Although numerous other factors also contribute, these begin to require knowledge of local geographic features, the extent of highway congestion, and other information not readily available from published sources.

This paper is intended to compare the performance of existing LRT systems by adjusting for the above-mentioned differences. It attempts to level the field to some extent by comparing each system's reported operating results for 1992 against an objective estimate that incorporates the principal system characteristics just listed. Each system's performance relative to these estimates may be considered as an index of performance distinct from traditional "per kilometer" ratio measures. Per kilometer ratios do not account satisfactorily for either differences in operating speed or trip end density related to urban size. On the indexed basis, a small system may be indicated as a good performer while still exhibiting higher costs per passenger-kilometer (PK) or lower ridership per route-kilometer (RK) than a larger system. Similarly, a system in a larger, denser, East Coast city may have higher ridership than a system in a less dense area, but a lower ridership index. This way of viewing relative performance may point to some existing systems that should receive more attention from planners looking for examples of good practice.

Approach and Limitations

For most of the U.S. systems covered by FTA in 1992, and to the extent possible for Calgary and Edmonton, both ridership and operating costs were estimated from system characteristics with a mathematical model; these models are described in the following sections. Two major LRT systems are notable by their absence: those in Toronto and Philadelphia. These systems are predominantly streetcar operations with a complex network of radial and crosstown routes; proper application of the ridership model would have required much more information than is readily available in published sources. Other, simpler, predominantly radial streetcar systems (e.g., those in San Francisco and New Orleans) were evaluated.

The ridership and operating cost relationships used here were derived by both linear and nonlinear regression techniques from both time-series and cross-sectional data. Although much of the underlying data came from two published sources (*3,4*), much information on individual LRT lines and stations was collected by the principal author from transit operators over a period of approximately 20 years.

The ridership index used here was formed by dividing the reported ridership by the model estimate; values greater than 1.0 indicate higher-than-estimated ridership. The operating cost index was formed by dividing the estimated cost by the reported value, so values greater than 1.0 indicate lower-than-estimated costs. Higher values of both indexes therefore represent better performance relative to the model estimates.

Because the information used in computing these indexes was derived from secondary sources, index values may not in some instances fairly represent the actual situation, for example, in cases of under-, over-, or misreporting of costs or ridership. Observations on some special situations that may have contributed to outlying values of the indexes are made in the Observations section of this paper.

Although the techniques discussed here could be used to estimate ridership or costs for a system in the planning stages, their accuracy is relatively low; estimates prepared using knowledge of local conditions, especially the distribution of land use and the nature of the transit labor contracts in a specific urban area, will almost always be more accurate.

Ridership Model

Formulation

The basic ridership forecasting technique applied was developed by the principal author in 1989 to identify a likely ridership range for a transit line given various urban and line characteristics and is documented elsewhere (*5*). The original technique yielded a ridership range expressed in terms of a central (most likely) weekday inbound ridership value and a cumulative frequency distribution of the ratio of ridership to the central value. The technique has since been upgraded by the principal author to adjust for two of its major shortcomings: the inability to reflect major differences in urban age and form and the absence of an adjustment for operating speed. Given R_{peer}, the central value peer group baseline daily inbound ridership predicted by the original method as documented, the original adjustment factor of 1.5 for Canadian cities is replaced by a form factor, F_{form}. This factor is in turn expressed in terms of a variable called the urban form criterion (UFC) and is computed according to

$$F_{\text{form}}^{\text{USA}} = 0.35 + 0.98e^{-.31\text{UFC}}$$

for U.S. metropolitan areas and

$$F_{\text{form}}^{\text{Canada}} = 0.06 + 1.95e^{-.17\text{UFC}}$$

for Canadian metropolitan areas. The separate Canadian formula accounts for both a higher tendency for downtown concentration and a higher acceptance of transit for daily commuting by automobile owners.

The UFC used in this technique represents the ratio of the 1970 (1971 in Canada) census population of the central city of the metropolitan area to the 1920 (1921 in Canada) population. These years were selected to represent the transition between a primarily streetcar-centered development pattern and one predominantly centered on the automobile.

Typical values of UFC for states and provinces appear in Table 1 and may be used as working values if population data are not available. A range of likely values is also shown in Table 1; values derived from actual population data that lie outside these ranges should be checked carefully.

In the upgraded technique, the central ridership value is also multiplied by a speed factor, F_{speed}, determined by

$$F_{\text{speed}} = 0.45\ (V - 5.0)^{0.366}$$

where V is the average LRT operating speed in revenue service in miles per hour. For most cases this speed was obtained from the FTA operating statistics.

The upgraded technique yields the basis for the ridership index in this paper:

$$R_{\text{basis}} = 2DF_{\text{form}}F_{\text{speed}}R_{\text{peer}}\ (1 - F_{\text{linked}})$$

TABLE 1 Typical Values of UFC

State or *Province* (Postal Abbreviation)	Urban Form Criterion (UFC) Typical Value	Check Range
New England (CT,MA,ME,NH,RI,VT)	0.9	0.7 - 1.5
Northwest (northern CA,OR,WA,*BC*)	1.6	1.2 - 2.5
South (AL,AR,GA,KY,MS, NC,SC,TN,VA)	2.5	1.5 - 5.0
Plains (CO,ID,IA,KS,MO,MT,ND,NE, SD,UT,WY,*AB,MB,SK*)	2.0	1.2 - 4.0
Sun Belt (southern CA,FL,LA,NM,NV,OK,TX)	6.5	3.5 - 15.0
All others	1.4	1.0 - 4.5

where D is the effective weekdays per year (i.e., the total annual ridership divided by average weekday ridership), and F_{linked} is the assumed fraction of linked trips (e.g., transfers between branches). The factor 2 expands the ridership to include both directions.

Example of Ridership Estimation

The LRT system in St. Louis, Missouri, began operation in 1993, and therefore had no results published in the 1992 FTA reports. The base ridership for the index used in this paper would be prepared as follows:

1. Application of the 1989 basic peer forecasting technique to the St. Louis system would yield a central ridership value (R_{peer}) of 14,340 [for 2 million metropolitan population, 27 km (17 mi) of route with the center of the central business district (CBD) 4 km (2.5 mi) from one end, and 19 stations]; space limitations prevent showing these calculations here.
2. The ratio of the city of St. Louis' population in 1970 to the 1920 population is 0.806; however, this value is below the Table 1 check range for Missouri. Examination of historical population data for greater St. Louis indicates that municipal boundaries are continuing to change with the incorporation of new suburbs in the metropolitan area, so the value 1.2 (minimum check value from Table 1) should probably be used instead; the true value could be even higher. Application of the U.S. equation for F_{form} would return a value of $0.35 + 0.98e^{(-.31 \times 1.2)}$, or about 1.026.
3. The average operating speed of the St. Louis LRT is about 35 km/hr. Assuming a corresponding value of 22 mph, the equation for F_{speed} yields approximately 1.269.
4. St. Louis' motor bus system exhibits annual ridership equivalent to 278 weekdays, and because the LRT system has only one line with no branches, all trips should be unlinked trips. The basis for the ridership index would therefore be as follows: 2 directions $\times$ 14,340 $\times$ 1.026 $\times$ 1.269 $\times$ 278, or about 10.4 million unlinked passenger trips per year. This value corresponds to approximately 37,300 riders per weekday.

According to a recent account (*6*), ridership on this line has reached 35,000 per weekday. This value suggests that the ridership index ratio for St. Louis has reached 0.94 in less than 2 years of operation. If the UFC is actually closer to a typical "plains state" value of 2.0, the actual ridership index ratio could be as high as 1.10.

Ridership Estimates

Table 2 shows the values used for population, UFC, form factor, speed factor, and the central value ridership for the LRT systems examined. The results of the R_{basis} computations are shown in the column titled "Estimated Unlinked Passenger Trips." The reported values for unlinked passenger trips were taken from the 1992 FTA Section 15 annual report (*4*), except where noted in Table 2. The estimating technique explains 67.76 percent of the variation among the properties reported in Table 2; that is, the R^2 value is 0.6776.

Operating and Maintenance Cost Model

The operating and maintenance cost model was the result of a simple linear regression against the 1992 FTA reported operating cost results:

TABLE 2 Comparative System Statistics and Ridership, 1992: FTA Section 15 Reports Versus Ridership Model Estimates

Urban Area	System	Estimated Metro. Population (Millions)	UFC	Central Ridership Value (Rpeer)	Form Factor (Fform)	Speed Factor (Fspeed)	Assumed Fraction Linked Trips (Flinked)	Effective Weekdays per Year (D)	Estimated Unlinked Passenger Trips (000s)	Reported Unlinked Passenger Trips (000s)	Ratio of Reported to Estimated
Baltimore[a]	MD DOT	1.89	1.23	644	1.019	1.04	0.00	289	393	208	0.53
Boston[b]	MBTA	2.68	0.86	52,951	1.101	1.05	0.02	323	38,887	58,500	1.51
Buffalo	NFTA	0.95	0.91	5,308	1.089	0.94	0.00	288	3,123	8,570	2.74
Calgary[c]	C-Train	0.78	6.30	15,235	0.728	1.21	0.05	300	7,665	24,300	3.17
Cleveland	GCRTA	1.75	0.94	17,746	1.082	1.13	0.02	285	12,119	5,044	0.42
Edmonton[d]	ETS	0.85	7.10	7,216	0.643	1.18	0.00	300	3,291	10,300	3.13
Los Angeles	SCRTD	8.00	7.80	70,162	0.437	1.16	0.00	356	25,241	11,307	0.45
New Orleans	RTA	1.08	1.53	14,355	0.960	0.70	0.00	312	6,036	6,912	1.15
Newark (New York)	NJT	15.59	1.40	6,706	0.985	1.01	0.00	288	3,854	3,057	0.79
Pittsburgh[e]	PAT	1.81	0.88	24,257	1.096	1.05	0.02	290	15,807	9,968	0.63
Portland	Tri-Met	1.17	2.20	10,187	0.845	1.05	0.00	330	5,962	7,703	1.29
Sacramento	RT	1.10	3.60	16,712	0.671	1.21	0.05	285	7,356	6,781	0.92
San Diego	SD Trolley	2.35	9.40	39,636	0.403	1.23	0.02	342	13,130	17,163	1.31
San Francisco	Muni	3.63	1.41	87,861	0.983	0.85	0.02	298	51,319	39,034	0.76
San Jose	SCCTD	1.44	6.60	23,919	0.477	1.08	0.05	311	7,291	6,135	0.84
Seattle	Metro	1.39	1.69	376	0.930	0.45	0.00	292	92	186	2.02

[a]System opened in 1992; only a few weeks of system operation were reported. Central ridership value was adjusted to compensate.
[b]Ridership from 1991 ridership study by Calgary Transit.
[c]Ridership from Planning Unit, Edmonton Transit
[d]Reported trips adjusted to remove subway portion reported as rapid transit
[e]Prior Year (1991) datum used because of work stoppage in 1992.

$$OC_{LRT} = 0.68 * AM_{LRT} + 112.70 * TH_{LRT}$$

where

OC = operating cost per year (including labor cost), in 1992 dollars;
TH = train-hours of operations per year; and
AM = axle-miles of light-rail vehicle (LRV) operations per year.

Axle-miles, the product of vehicle-miles and axles per vehicle, was used to adjust for the difference between four-axle and six-axle LRVs on various systems. Train-hours represents the number of hours operated by LRV consists, regardless of length. For agencies operating multiple-unit trains, train-hours were estimated from published revenue operator hours, vehicle-miles, and known operating practices.

The costs reported for 1992 in the FTA Section 15 reports are compared with the results of the estimate in Table 3. The index ratio of estimated to reported values is used to preserve the "higher is better" convention. The estimating technique explains 77.21 percent of the variation among the agencies reported in Table 2; that is, the R^2 value is 0.7721.

INDEXED RESULTS

Tables 2 and 3 contain the index ratios for ridership and operating costs, respectively. Figure 1 presents the index results with the ridership index on the horizontal axis and the cost index on the vertical axis. The points corresponding to each system are labeled. In keeping with the "higher is better" convention for both indexes, the farther from the origin (lower left corner) a point is, the better its overall performance relative to the estimates. Three quadrants in Figure 1 have been labeled to indicate both the relative ridership and cost performance in the portions of the "index space" formed by the graph.

Factors not included in the estimating equations, and largely associated with local or site-specific conditions, should provide some clues as to the systems' positions within the index space of Figure 1. Chief among these factors are likely to be

- Location of the LRT route and stations in the urban context, that is, with respect to specific population and employment concentrations and major activity centers;
- Relative cost and complexity of LRT infrastructure, such as the extent of subway operation;
- Ability of the system to operate multiple-unit trains with a single crewperson; and
- Presence or absence of major trip generators on the routes.

TABLE 3 Comparative System Operating Costs

Urban Area	System	Estimated Operating Cost (Millions)	1992 Reported Operating Cost	Ratio of Estimated to Reported
Baltimore	MD DOT	$2.81	$1.24	0.441
Boston	MBTA	$25.30	$15.64	0.658
Buffalo	NFTA	$12.20	$6.59	0.540
Calgary[a]	C-Train	$17.10	$29.34	1.716
Cleveland	GCRTA	$10.91	$10.48	0.961
Edmonton[a]	ETS	$9.10	$9.26	1.018
Los Angeles	SCRTD	$41.19	$23.26	0.565
New Orleans	RTA	$5.30	$11.63	2.193
Newark	NJT	$4.30	$6.89	1.604
Philadelphia	SEPTA	$56.96	$65.63	1.152
Pittsburgh	PAT	$23.49	$22.59	0.962
Portland	Tri-Met	$11.44	$10.78	0.942
Sacramento	RT	$11.35	$12.76	1.124
San Diego	SD Trolley	$18.93	$31.06	1.642
San Francisco	Muni	$62.26	$44.24	0.711
San Jose	SCCTD	$19.23	$19.81	1.030
Seattle	Metro	$1.27	$1.45	1.141

[a]Canadian dollars discounted 15 percent

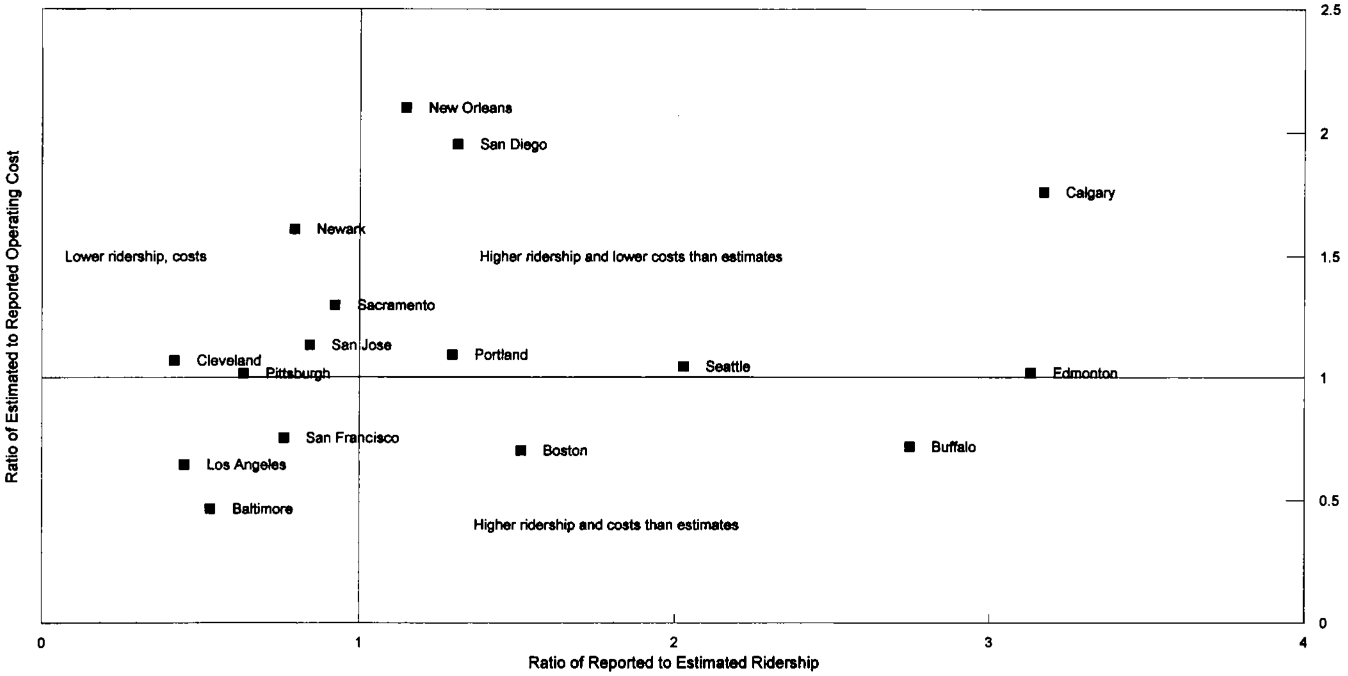

FIGURE 1 Comparison of ridership and cost ratios.

Some of these factors are discussed in the following section. Once again, relatively minor differences in index values should not be considered significant.

Observations

The following observations may be readily drawn from Figure 1:

1. Calgary appears to have the best all-around performance, with significantly higher ridership and lower costs than the estimating equations would suggest (i.e., in terms of indexed values).
2. Buffalo and Edmonton, and to a lesser extent Seattle, have very high ridership in indexed terms.
3. San Diego and New Orleans exhibit relatively low operating costs, that is, high index values.
4. Boston, Portland, and San Diego have relatively strong ridership indexes.
5. Cleveland, Pittsburgh, Los Angeles, and Baltimore have relatively weak ridership indexes.
6. Los Angeles, Baltimore, San Francisco, Boston, and Buffalo exhibit relatively high costs, that is, low index values.

Likely contributing factors can be advanced for many of these observations; other differences may prompt the study of individual systems. Factors relating to cost and ridership are considered separately in the following sections.

Operating and Maintenance Cost

First and foremost, it is not surprising that San Diego and Calgary have a very similar, positive cost experience. These systems both went into operation in the same year (1981); are almost entirely at-grade, operating on street in downtown areas; use the same rolling stock; have extensive stretches of high-speed (80 km/hr) running; and carefully tailor their single-operator consists to demand. Edmonton also shares the age, equipment, and operating practice similarity, but has an extensive underground infrastructure, including several subway stations, to operate and maintain.

From a cost perspective, the systems with an index near 1.0 (Cleveland, Pittsburgh, San Jose, and Portland) can be considered the mainstream of modern North American LRT.

The cost experiences of San Francisco, Boston, and Buffalo are probably similar because all these systems have extensive underground operation, with correspondingly higher maintenance costs for infrastructure, and predominantly single-unit operation or an operator in each car of the train.

New Orleans' high cost index (i.e., relatively low costs) may in part be due to lower wages than the national average, an entirely at-grade system without extensive signaling, lower track maintenance associated with lower operating speeds, and the recent extensive refurbishment of the fleet. It should be remembered that the index takes into consideration and adjusts for the effect of additional operator hours for low-speed operation.

Los Angeles' high cost may be attributable to its security efforts, which have been suggested to be as much as 40 percent of the total operating cost. An adjustment for this expense would place the system close to the mainstream systems of modern LRT. Edmonton also spends close to 30 percent of its costs on fare collection and security.

Baltimore's high cost result probably reflects the start-up nature of the operation, which operated only during a small fraction of the year.

None of the foregoing factors offers a convenient explanation for Newark's apparently low relative costs. The system is largely underground, has a complex infrastructure, and operates single-unit vehicles. The agency's reporting practices for costs may be a contributing factor, but they could not be explored as part of this paper.

Ridership

Alberta's two large cities, Edmonton and Calgary, have very high ridership indexes. In effect, they violate the built-in premises of the ridership model in two important respects. First, both cities grew very rapidly during the 1970s, with planning controls such that tremendous concentrations of downtown employment were established; in other words, their UFCs are effectively much lower than their population data for 1921 and 1971 would suggest. Second, for moderately large cities (on the order of 800,000 population), they are unusual in not having radial freeway systems converging on, and connecting into, the downtown; in both cases, LRT was implemented as an alternative to freeways before the fact rather than as a remedy for existing central area freeway congestion. Both systems also connect large urban university campuses to the downtown. The construction of major sports facilities directly on the LRT routes in both cities has also been advanced as a significant contribution to their ridership (7). In considering all these factors, it should be remembered that the index takes into account and adjusts for generally higher ridership in Canada.

Seattle's high ridership is probably related to its atypical market; it draws roughly twice as many riders as a commuter route would a similar distance from the CBD, including substantial tourist trips.

Boston's solid ridership performance is probably linked to the branching surface routes serving several universities, hospitals, and other major generators as well as major employment centers in the Back Bay.

A university anchoring the outer end of the line probably contributes to Buffalo's high relative ridership, but other factors are almost certainly active. One possibility is its direct location under a major urban arterial, which is more characteristic of heavy-rail rapid transit than LRT.

Adverse economic developments of the past several decades may have contributed to the relatively low ridership indexes of Cleveland and Pittsburgh. The major universities on Cleveland's east side are either not well served by LRT or are better served by "heavy" rapid transit in the corridor, whereas none of Pittsburgh's major urban universities outside the CBD are in the South Hills LRT corridor.

The economic conditions prevailing in many of the neighborhoods surrounding the Los Angeles Blue Line may account in part for its lower ridership index. Recent accounts suggest, however, that the Blue Line's ridership index has increased to at least 0.50, indicating that its relatively recent start-up may have also been a factor in 1992.

Baltimore's lower ridership is likely to relate to its start-up status, though later experience suggests that its index remains less than 1. 0. A contributing factor may be the poor position of the line relative to outlying population concentrations, including several that have good competing bus service. There are no universities on the line outside the CBD. Adverse general economic conditions may also have contributed.

Index Performance Versus Per Kilometer Comparisons

When the systems are ranked according to the indexes used in this paper rather than the more traditional bases of per RK (for ridership) or per PK (for costs), some interesting differences emerge. The comparative results for ridership are shown in Table 4. The two leading systems on a per RK basis (Boston and San Francisco) fall several places in ranking when compared on the index basis. In effect, because these are larger and denser cities than many others, their ridership per RK should be higher. In the indexed-ridership sense, some of the newer systems in California rate higher than San Francisco because they are relatively more successful in attracting ridership in their respective contexts. Age of the systems also clearly appears to be a factor; the indexed value rankings for

TABLE 4 Ridership Ranking Comparison: Per RK Versus Index

Urban Area	System	Rank by Riders per Route-km	Rank by Ridership Index	"Survivor" System?	Difference in Ranking
Baltimore	MD DOT	14	14	No	0
Boston	MBTA	1	5	Yes	(4)
Buffalo	NFTA	4	2	No	2
Calgary	C-Train	3	1	No	2
Cleveland	GCRTA	13	16	Yes	(3)
Edmonton	ETS	5	3	No	2
Los Angeles	SCRTD	9	15	No	6
New Orleans	RTA	6	8	Yes	(2)
Newark	NJT	7	11	Yes	(4)
Pittsburgh	PAT	11	13	Yes	(2)
Portland	Tri-Met	10	7	No	3
Sacramento	RT	12	9	No	3
San Diego	SD Trolley	8	6	No	2
San Francisco	Muni	2	12	Yes	(10)
San Jose	SCCTD	15	10	No	5
Seattle	Metro	16	4	No	12

Boston and San Francisco, and in fact for all "survivor" LRT systems that have been operating for decades, are all lower than their per RK rankings. This is not unexpected for systems that were planned around more recent developments than the survivor systems.

The comparative results for operating cost are shown in Table 5. There is generally little difference between the systems, with the exception of Los Angeles and Edmonton, which are ranked seven places lower on the indexed basis, and three systems that rated significantly higher: San Jose, New Orleans, and Newark. There is no immediately apparent reason for these exceptions. Los Angeles and Edmonton have significant security and infrastructure maintenance costs in common, but without further research they cannot be presumed to be unique in this respect. The three systems that are higher-ranked are very disparate, suggesting that further research would also be appropriate.

Conclusions

A number of conclusions may be drawn:

1. At least two-thirds of the variance in ridership and operating costs among North American LRT systems can be attributed to large-scale aggregate characteristics of the systems and the metropolitan areas they serve.
2. Single-person operation of multiple-unit trains is a key source of operating cost efficiencies on the continent's newer LRT systems.
3. Underground operation, particularly of subway stations, drives LRT operating costs up significantly.
4. The strongest relative ridership performances in North America are achieved by systems that either (*a*) concentrated an employment growth boom downtown without building freeways into the CBD (Calgary and Edmonton) or (*b*) invested heavily in an underground alignment along a major arterial (Buffalo).
5. Systems that are building on readily available right-of-way not located through population concentrations may be trading off relatively low ridership for construction cost savings.
6. All LRT systems with ridership indexes near 1.0 or higher, including the new St. Louis system, connect the CBD to at least one major university campus outside the CBD.

ACKNOWLEDGMENTS

The authors wish to express their appreciation to the individuals who supplied information on the two Cana-

TABLE 5 Operating Cost Ranking Comparison: Per PK Versus Index

Urban Area	System	Rank by Cost per Passenger-km	Rank by Operating Cost Index	Difference in Ranking
Baltimore	MD DOT	16	16	0
Boston	MBTA	15	14	1
Buffalo	NFTA	14	13	1
Calgary	C-Train	2	3	(1)
Cleveland	GCRTA	6	8	(2)
Edmonton	ETS	3	10	(7)
Los Angeles	SCRTD	8	15	(7)
New Orleans	RTA	7	1	6
Newark	NJT	10	4	6
Pittsburgh	PAT	12	11	1
Portland	Tri-Met	4	7	(3)
Sacramento	RT	5	5	0
San Diego	SD Trolley	1	2	(1)
San Francisco	Muni	13	12	1
San Jose	SCCTD	11	6	5
Seattle	Metro	9	9	0

dian LRT systems included in the analysis: David Padgett of the Planning Unit of the Edmonton Transit System and Oliver Bowen, Director of Transportation for the City of Calgary.

REFERENCES

1. Parkinson, T. Rail Transit Performance. In *Transportation Research Record 1361,* TRB, National Research Council, Washington, D.C., 1992, p. 47.
2. Miller, D. R., and J. D. Wilkins. Recent Developments in LRT Staffing and Productivity. In *Transportation Research Record 1361,* TRB, National Research Council, Washington, D.C., 1992, p. 151.
3. Ingram, G. K. *Reductions in Auto Use from Carpools and Improved Transit.* Discussion Paper D76–10. Harvard University Department of City and Regional Planning, Oct. 1976.
4. *Data Tables for the 1992 Section 15 Report Year.* FTA, U.S. Department of Transportation, 1993.
5. Allen, D. W. "Peer Group" Comparisons for Transit Ridership Forecasts. In *1990 Compendium of Technical Papers,* Institute of Transportation Engineers, Washington, D.C., 1990, pp. 318–321.
6. Apelt, B. Riders' Joy. *American Consulting Engineer,* Vol. 6, No. 3, July/August 1995, pp. 12–15.
7. Bakker, J. J. LRT Lessons That Can Be Learned from Edmonton and Calgary. In *Transportation Research Record 1361,* TRB, National Research Council, Washington, D.C., 1992, p. 46.