

Status of North American Light Rail Transit Systems: 1995 Update

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Progress in light rail transit (LRT) in North America since the last National Light Rail Conference in 1992 is summarized. Existing system rehabilitation and new project planning, design, construction, and start-up activities are discussed. To depict the effects of recent changes in the North American LRT situation, the text and tables update information presented at earlier LRT conferences. Highlights of progress since 1992 include three more new-start LRT systems opened in Baltimore, St. Louis, and Denver; completion of the Los Angeles Green Line in mid-1995; and final design or construction of new starts in Dallas and downtown Chicago as well as on extensions in Portland, Baltimore, San Jose, Los Angeles, San Diego, Sacramento, and Cleveland. Other LRT systems continue to make improvements and renewals. Planning and preliminary design continue in several more places. With older systems largely renewed and a continuing string of new starts and extensions, LRT continues to be the affordable rail mode for an increasing number of cities. Current LRT projects encompass areas in which LRT is a natural step up from an all-bus system, as well as places that have discarded proposals for more technically novel or costlier guideways.

Twenty years and 90 mi separate the current meeting from the Transportation Research Board's (TRB's) first national light rail conference, in Philadelphia in 1975. Light rail and streetcar systems survived then in only eight U.S. cities, Toronto,

and Mexico City. Aided by federal funds, Boston and San Francisco ordered replacements for aging car fleets, and several cities were comparing light rail transit (LRT) new starts with other technologies in alternatives analyses.

Much progress has been made in two decades. Older systems have been renovated, and new LRT systems are operating in 13 North American urban areas: nine in the United States and two each in Canada and Mexico.

As the latest in a series of TRB papers on this topic dating to 1977, this version updates the 1992 edition. Tables 1–6 provide information on the alignment characteristics, revenue vehicles, and operations of 22 physically distinct LRT systems in 20 U.S. and Canadian cities. Information is current as of the end of 1994.

DIFFERENCES AMONG LIGHT RAIL, STREETCARS, AND MINIMETROS

A recurring topic among transit professionals and enthusiasts is the debate over just what LRT is or is not. Because light rail can be located so flexibly and encompasses a spectrum of applications, this debate probably will continue. TRB's Committee on Light Rail Transit uses this definition:

Light rail transit is a metropolitan electric railway system characterized by its ability to operate single cars or

TABLE 1 Line Lengths, Car Fleets, and Productivity Indicators

City/System	Parameters			Statistics		
	One-Way Line km(mi)	No. of Cars	Rides/ Weekday	Cars/ km(mi)	Rides/ km(mi)	Rides/ Car
LRT-Group I:						
Baltimore, Central Corridor(d)	35.4(22.0)	35	20000	1.0(1.6)	565(909)	571
Calgary, C-Train(a)	29.3(18.2)	85	114500	2.9(4.7)	3908(6291)	1347
Cleveland, Shaker Rapid(b)	21.1(13.1)	48	9900	2.3(3.7)	469(756)	206
Denver, MAC(d)	8.5(5.3)	11	15000	1.3(2.1)	1765(2830)	1364
Edmonton, LRT(a)	12.3(7.6)	37	36000	3.0(4.9)	2927(4737)	973
Los Angeles, Long Beach (a)	35.4(22.0)	54	42000	1.5(2.5)	1186(1909)	778
Newark, City Subway(b)	6.9(4.3)	24	16800	3.5(5.6)	2435(3907)	700
Phila, Media-Sharon Hill(b)	19.2(11.9)	29	8200	1.5(2.4)	427(689)	283
Portland, MAX(a)	24.3(15.1)	26	24500	1.1(1.7)	1008(1541)	942
Sacramento, RT Metro(a)	29.5(18.3)	36	24300	1.2(2.0)	824(1328)	675
St. Louis, MetroLink(d)	29.0(18.0)	31	40000	1.1(1.7)	1379(2222)	1290
San Diego Trolley(a)(e)	55.4(34.4)	71	45000	1.3(2.1)	812(1308)	634
San Jose, Guadalupe(a)	32.2(20.0)	50	20000	1.6(2.5)	621(1000)	400
Subtotals/Averages	338.5(210.2)	537	416200	1.6(2.6)	1230(1980)	775
LRT-Group II:						
Boston, Green Line(b)	40.1(24.9)	220	213000	5.5(8.8)	5312(8554)	968
Boston, Mattapan-Ashmont(b)	4.3(2.7)	12	7000	2.8(4.4)	1628(2593)	583
Buffalo, MetroRail(a)	10.3(6.4)	27	28000	2.6(4.2)	2718(4375)	1037
Ft. Worth, Tandy	1.6(1.0)	8	5900	5.0(8.0)	3688(5900)	738
New Orleans, St Chas/Riverfront(b)	14.0(8.7)	41	26000	3.1(5.0)	1857(2989)	634
Philadelphia, Subway-Surface(b)	35.9(22.3)	112	77500	3.1(5.0)	2159(3475)	692
Pittsburgh, South Hills(b)	31.2(19.4)	71	29000	2.3(3.7)	929(1495)	408
San Francisco, Muni Metro(c)	39.1(24.4)	128	134300	3.3(5.2)	3435(5504)	1049
Toronto, Streetcars	75.5(46.9)	267	307100	3.5(5.7)	4068(6548)	1150
Subtotals/Averages	252.0(156.7)	886	827800	3.5(5.7)	3285(5283)	934
Totals/Averages	590.5(366.9)	1423	1244000	2.4(3.9)	2107(3391)	874

(a) New start opened since 1977; (b) Major reconstruction/rehabilitation since 1977; (c) Upgraded from streetcar to LRT standards since 1977; (d) New start opened since 1992; (e) LRV fleet shown (71 cars) excludes 34 new SD100 cars on site but not in service, as well as 18 more SD100s due in 1995.

short trains along exclusive rights of way at ground level, on aerial structures, in subways or, occasionally, in streets, and to board and discharge passengers at track or car-floor level.

This wording is intended to describe the technology that has emerged on new systems completed during the past quarter century while not categorically excluding streetcar systems that may be upgraded in whole or in part to LRT standards (i.e., reservation of some or all trackways from other traffic). At the same time, the definition specifically separates LRT from systems that are not propelled by electricity and those guideways—whether automated or manually operated—for which full grade separation is mandatory, namely,

- Automated systems that cannot interact with street traffic (at least, not yet); and
- Systems taking electric power from a third rail, which is not compatible with at-grade street operation whether in mixed traffic or reserved lanes.

Although their opinion is not universally shared, the authors believe the TRB definition, strictly interpreted,

excludes certain systems that otherwise have some LRT characteristics:

- Philadelphia's grade-separated, third-rail Norristown High Speed Line, which nonetheless runs mostly single cars and collects fares on board;
- Vancouver's Skytrain, a "mini-metro" whose automated controls and linear induction motors preclude at-grade operation over crossings or in streets; and
- Chicago's Skokie Swift, with its modified subway-elevated cars, and South Shore Line, which has changed over time from country interurban to heavy-duty commuter railroad.

Even without these lines, there are now enough LRT systems on this continent to illustrate a broad range of facility, vehicle, and service applications.

Like the cities that they serve, LRT systems are never really finished. Facilities and vehicles must be renewed and replaced periodically as they reach the ends of their useful lives. For newer systems, and some older ones too, extensions and new lines are being built or planned to tap additional markets. Progress since 1992 is summarized here by city, starting with new starts opened

TABLE 2 Key Descriptive Statistics

City/System	Portion of R/W Reserved	Average Stop Spacing	Double Track	Through Service Routes	Number of Cars:		System Average Speed
					4-Axle(a)	6-Axle(b)	
	(%)	km(mi)	(%)	(No.)	(No.)	(No.)	km(mi)/hr
LRT-Group I:							
Baltimore, Central Corridor	100%	0.7(1.1)	61%	1	0	35	35(22)
Calgary, C-Train	100%	0.9(0.6)	100%	3	0	85	29(18)
Cleveland, Shaker Rapid	100%	0.8(0.5)	100%	2	0	48	30(18)
Denver, MAC	100%	0.8(0.5)	94%	1	0	11	23(14)
Edmonton, LRT	100%	1.3(0.8)	100%	1	0	37	30(19)
Los Angeles, Long Beach	100%	1.6(1.0)	100%	1	0	54	34(21)
Newark, City Subway	100%	0.6(0.4)	100%	1	24	0	28(18)
Phila, Media-Sharon Hill	87%	0.4(0.2)	71%	2	29	0	28(16)
Portland, MAX	99%	0.9(0.6)	89%	1	4(c)	26	30(19)
Sacramento, RT Metro	84%	1.0(0.7)	68%	1	0	36	34(21)
St. Louis, MetroLink	100%	1.5(1.0)	97%	1	0	31	43(27)
San Diego Trolley (d)	100%	1.6(1.0)	99%	2	0	71	30(20)
San Jose, Guadalupe	100%	1.1(0.7)	95%	2	6(c)	50	32(20)
Subtotals/Averages	98%	1.0(0.6)	90%	19	63	484	---
LRT-Group II:							
Boston, Green Line	89%	0.5(0.3)	100%	4	0	220	22(13)
Boston, Mattapan-Ashmont	100%	0.5(0.3)	100%	1	12	0	20(12)
Buffalo, MetroRail	100%	0.7(0.5)	100%	1	27	0	20(12)
Fort Worth, Tandy	100%	0.3(0.2)	100%	1	8	0	17(11)
New Orleans, St Chas/Riverfront	90%	0.2(0.1)	100%	2	41	0	15(9)
Philadelphia, Subway-Surface	17%	0.2(0.1)	100%	5	112	0	18(11)
Pittsburgh, South Hills	82%	0.5(0.3)	88%	4	16	55	26(16)
San Francisco, Muni Metro	45%	0.2(0.1)	100%	5	0	128	18(11)
Toronto, Streetcars	10%	0.1(0.1)	100%	10	215	52	15(9)
Subtotals/Averages	48%	0.2(0.1)	97%	33	431	455	---
Totals	77%	0.4(0.2)	93%	52	494	939	---

(a) Non-articulated, rigid body; (b) Articulated; (c) Vintage trolley cars for downtown loop, not included in totals; (d) See footnote (e) on Table 1.

since then and notes on existing systems in the United States, Canada, and Mexico.

NEW STARTS SINCE PREVIOUS UPDATE (1992-1994)

Three more new starts have opened just since 1992: in Baltimore, St. Louis, and Denver. In each city, the first LRT line is designated as the *central corridor*.

Baltimore

Maryland's Mass Transit Administration added LRT to its multimodal system in the Baltimore region when the northern half of its central corridor line was opened in May 1992. Just over a year later, the southern half entered revenue service, completing a 35-km (22-mi) starter line between Timonium and Glen Burnie. Former railroad lines, including a section of the abandoned Baltimore-Annapolis interurban, are connected through downtown Baltimore using tracks in reserved lanes on Howard Street.

Baltimore's cars are 29 m (95 ft) long and 2.9 m (9.5 ft) wide and are the first in North America with alter-

nating current (AC) propulsion. Since opening, weekday patronage has grown to 20,000.

Three extensions to the basic line were contemplated in the original planning: north to Hunt Valley, at the edge of downtown to an Amtrak connection at Penn Station, and off the south line to Baltimore-Washington International Airport. These will increase the system to nearly 47 km (29 mi). It was decided to have these built under a single design-build contract, which was bid in 1994 and awarded to Whiting-Turner for completion in 1997.

St. Louis

At the end of July 1993, Bi-State Development Agency began service on *MetroLink*, an LRT line linking East St. Louis, Illinois, and downtown St. Louis, Missouri, with a chain of activity centers to the northwest: hospitals, the University of Missouri at St. Louis, Forest Park, Busch Stadium, and other leisure attractions. Completed to its full 29-km (18-mi) length in June 1994, the line now reaches Lambert Airport, the regional hub for commercial flight. Bi-State created an enhanced transit system by connecting many activity centers and carefully coordinating LRT with suburban

TABLE 3 Right-of-Way Locations

City/System	km(mi) of Line						Total
	Subway/ Tunnel	Exclusive R/W	Private R/W	Street or Highway Median	Reserved St. Lanes or Mall	Mixed Traffic	
		(a)	(b)	(c)	(d)	(e)	
LRT-Group I:							
Baltimore, Central Corridor	---	---	32.2(20.0)	---	3.2(2.0)	---	35.4(22.0)
Calgary, C-Train	1.9(1.2)	1.3(0.8)	13.2(8.2)	10.5(6.5)	2.4(1.5)	---	29.3(18.2)
Cleveland, Shaker Rapid	---	11.3(7.0)	---	9.8(6.1)	---	---	21.1(13.1)
Denver, MAC	---	---	5.6(3.5)	---	2.9(1.8)	---	8.5(5.3)
Edmonton, LRT (f)	4.7(2.9)	---	7.6(4.7)	---	---	---	12.3(7.6)
Los Angeles, Long Beach	0.8(0.5)	---	29.8(18.5)	3.2(2.0)	1.6(1.0)	---	35.4(22.0)
Newark, City Subway	2.1(1.3)	4.8(3.0)	---	---	---	---	6.9(4.3)
Phila. Media-Sharon Hill	---	---	16.3(10.1)	---	0.3(0.2)	2.6(1.6)	19.2(11.9)
Portland, MAX	---	8.7(5.4)	3.7(2.3)	8.4(5.2)	3.4(2.1)	0.1(0.1)	24.3(15.1)
Sacramento, RT Metro	---	9.5(5.9)	12.4(7.7)	1.0(0.6)	1.8(1.1)	4.8(3.0)	29.5(18.3)
St. Louis, MetroLink	1.3(0.8)	16.0(9.9)	11.7(7.3)	---	---	---	29.0(18.0)
San Diego Trolley	---	---	51.8(32.2)	1.6(1.0)	2.0(1.2)	---	55.4(34.4)
San Jose, Guadalupe	---	15.8(9.8)	1.8(1.1)	13.5(8.4)	1.1(0.7)	---	32.2(20.0)
Subtotals	10.8(6.7)	67.4(41.8)	186.1(115.6)	48.0(29.8)	18.7(11.6)	7.5(4.7)	338.5(210.2)
LRT-Group II:							
Boston, Green Line	7.2(4.5)	17.1(10.6)	---	11.4(7.1)	---	4.4(2.7)	40.1(24.9)
Boston, Mattapan-Ashmont	---	4.3(2.7)	---	---	---	---	4.3(2.7)
Buffalo, MetroRail	8.4(5.2)	---	---	---	1.9(1.2)	---	10.3(6.4)
Fort Worth, Tandy	0.6(0.4)	---	1.0(0.6)	---	---	---	1.6(1.0)
New Orleans, St. Chas/Riverfront	---	---	3.5(2.2)	9.0(5.6)	0.2(0.1)	1.3(0.8)	14.0(8.7)
Philadelphia, Subway-Surface	4.0(2.5)	---	---	1.9(1.2)	---	30.0(18.6)	35.9(22.3)
Pittsburgh, South Hills	3.4(2.1)	---	22.2(13.8)	---	---	5.6(3.5)	31.2(19.4)
San Francisco, Muni Metro	10.2(6.4)	---	1.2(0.8)	6.3(3.9)	---	21.4(13.3)	39.1(24.4)
Toronto, Streetcars	1.0(0.6)	---	2.6(1.6)	4.0(2.5)	---	67.9(42.2)	75.5(46.9)
Subtotals	34.8(21.7)	21.4(13.3)	30.5(19.0)	32.6(20.3)	2.1(1.3)	130.6(81.1)	252.0(156.7)
Totals: km(mi)	45.6(28.4)	88.8(55.1)	216.6(134.6)	80.6(50.1)	20.8(12.9)	138.1(85.8)	590.5(366.9)
% Total	8%	15%	37%	14%	3%	23%	100%

(a) Aerial or surface with no grade crossings; (b) Surface, LRT private R/W with grade crossings; (c) Surface, reserved medians of highways and streets with grade crossings; (d) Surface, reserved lanes (other than medians) and LRT/pedestrian malls; (e) Street lanes shared by LRT and other traffic; "streetcar" operations; (f) Saskatchewan River bridge included under Subway.

buses. In late 1994, weekday LRT patrons numbered about 40,000.

Like almost every other city with a new-start LRT line, St. Louis has extensive plans for expansion. Encouraged by the success of the starter line, voters in St. Clair County, by a 2:1 margin, have already approved a half-cent sales tax increase to provide the local share for a 40-km (25-mi) easterly extension from East St. Louis to Belleville and Scott Air Force Base. With private right of way, 13 stations, and average stop spacing of 3.1 km (1.9 mi), it should be one of the faster new LRT lines.

Denver

The newest start began revenue service in October 1994, when the Regional Transportation District (RTD) opened the 8.5-km (5.3-mi) *Metro Area Connection* (MAC). Using local funds to break a 20-year pattern of "analysis paralysis," RTD achieved several objectives:

- Provided enhanced transit to downtown Denver and adjacent neighborhoods;

- Set technology and design criteria for budget-conscious extensions;

- Completed two typically expensive elements of system construction: downtown trackage in streets and the maintenance shop for a regional network; and

- Removed several hundred daily bus runs from streets approaching downtown.

At 15,000, initial weekday ridership exceeded the forecast by 1,000, and RTD quickly ordered six more light rail vehicles (LRVs). Engineering is already in progress for a 14-km (8.7-mi) southwest extension to Englewood and Littleton. In addition, the region has embarked on major investment studies (MIS) in three more corridors: southeast along I-25, west to Lakewood, and east to the new airport.

EXISTING SYSTEMS IN THE UNITED STATES

Boston

Serving the heart of the Boston metropolitan area, the Green Line network carries more people per weekday

TABLE 4 Stations, Double Tracking, Electrification, and Signaling

City/System	Passenger Stations & Car Stops	Double Track km(mi)	Traction Power (VDC)	Substations		Type of Overhead (b)	Signals	
				No.	Rating (mW)		Block (c)	Traffic (c)
	No.	(a)			(mW)		(c)	(c)
LRT-Group I:								
Baltimore, Central Corridor	25	21.7(13.5)	750	14	1	Catenary	91%	9%
Calgary, C-Train	31	29.3(18.2)	600	17	≤2	Both	92%	8%
Cleveland, Shaker Rapid	28	21.1(13.1)	600	6	(d)	Catenary	84%	46%
Denver, MAC	11	8.0(5.0)	750	7	1	Both	60%	40%
Edmonton, LRT	10	12.3(7.6)	600	8	2	Catenary	100%	---
Los Angeles, Long Beach	22	35.4(22.0)	750	21	(i)	Both	86%	14%
Newark, City Subway	11	6.9(4.3)	600	4	0.75	Trolley	100%	---
Phila, Media-Sharon Hill	50	13.7(8.5)	635	4	(h)	Trolley	50%	25%
Portland, MAX	26	21.6(13.4)	750	14	0.75	Both	52%	48%
Sacramento, RT Metro	29	20.1(12.5)	750	14	1	Both	77%	23%
St. Louis, MetroLink	18	28.0(17.4)	750	12	1.5	Catenary	100%	---
San Diego Trolley	36	54.7(34.0)	600	21	1	Both	94%	6%
San Jose, Guadalupe	30	30.9(19.2)	750	15	1.5	Both	58%	42%
Subtotals	327	303.7(188.7)	---	---	---	---	---	---
LRT-Group II:								
Boston, Green Line(f)	84	40.1(24.9)	600	11	3-6	Trolley	61%	39%
Boston, Mattapan-Ashmont(g)	8	4.3(2.7)	600	1	6	Trolley	100%	---
Buffalo, MetroRail	14	10.3(6.4)	650	5	2	Catenary	81%	19%
Forth Worth, Tandy	5	1.6(1.0)	600	1	(h)	Trolley	---	---
New Orleans, St. Chas/Riverfront	55	14.0(8.7)	600	(h)	(h)	Trolley	---	100%
Philadelphia, Subway-Surface	167	35.9(22.3)	600	(e)	---	Trolley	11%	89%
Pittsburgh, South Hills	74	27.4(17.0)	640	6	6	Both	90%	10%
San Francisco, Muni Metro	204	35.6(22.1)	600	12	2-8	Trolley	19%	81%
Toronto, Streetcars	616	75.5(46.9)	600	(h)	(h)	Trolley	---	100%
Subtotals	1227	244.7(152.0)	---	---	---	---	---	---
Totals	1554	548.4(340.7)	---	---	---	---	---	---

(a) Includes paired 1-way street single tracks functioning as double track; (b) Type of Construction: Catenary, Trolley, or Both; (c) % of line km(mi) equipped: Blk-Block Signals; Tfc-Traffic Lights; May not add to 100% as some segments have no signals, others both Blk & Tfc; (d) 1.5 and 3.0 mW; (e) 28 major substations serve all electric transit in City of Philadelphia; (f) 4 of 11 substations also serve other lines; (g) Substation also provides power to Red Line rapid transit; (h) Data not available at time of publication; (i) 19 @ 1.5 mW plus 2 @ 3.0 mW

than any other LRT system in this survey. Boston's system of five LRT routes includes North America's oldest transit subway, dating from 1897. There is a strong emphasis on system renovation and renewal.

Breda has been awarded an order for 100 new articulated low-floor LRVs (LFLRVs) to initiate accessible service and replace the remaining Boeing cars. The 22-m (72-ft) cars will have low floors through about two-thirds of their length, with high floors above conventional powered trucks at each end.

Remaining president's conference committee (PCC) cars assigned to the Mattapan-Ashmont feeder to the Red Line rapid transit have been refurbished.

Green Line physical changes contemplated include relocation from elevated structure to subway at North Station and relocation of the Lechmere terminus to a new site that will improve its operation and capacity and set the stage for eventual extension.

Newark

Since its surface streetcar feeders were pruned in the early 1950s, the Newark City Subway has continued as

New Jersey's only LRT line. Facilities were largely renewed in the 1980s, but nearly 50-year-old PCC cars continue in service. NJ Transit is working to dovetail their replacement with car purchases for new lines in the Newark area and elsewhere in the state.

Conceptual specifications for vehicles to replace the City Subway fleet of 24 PCC cars contemplate an articulated LFLRV about 27 m (88 ft) long, with about two-thirds of its length at the low floor level between high floors over conventional power trucks at each end. This design might become a standard New Jersey LRV for use on other planned lines.

Introduction of the new fleet is expected to require facility changes, including a new maintenance shop beyond the outer end of the City Subway line, and conversion of the electrification for more powerful, pantograph-equipped cars.

NJ Transit is planning three new LRT lines. The Hudson Waterfront Connector is being readied for implementation under a turnkey contract, and the Newark-Elizabeth Rail Link (which would be physically connected to the City Subway) and a Moorestown-Camden-Woodbury line in southern New Jersey are farther back in the planning pipeline.

TABLE 5 Revenue Service Vehicles

City/System	Car Types	Characteristics of Car Equipment					
		Builder	Fleet	Accelrtn	Max Spd	Length	Weight
	(a)			(b)	(c)	(d)	(e)
LRT-Group I:							
Baltimore, Central Corridor	LRV-6-A	ABB	35	1.3(3.0)	88(55)	29(95)	50(55)
Calgary, C-Train (f)	LRV-6-A	Siemens	85	1.0(2.2)	80(50)	24(80)	32(35)
Cleveland, Shaker Rapid	LRV-6-A	Breda	48	1.3(3.0)	88(55)	24(80)	40(45)
Denver, MAC	LRV-6-A	Siemens	11	1.3(3.0)	88(55)	24(80)	37(41)
Edmonton, LRT	LRV-6-A	Siemens	37	1.0(2.2)	80(50)	24(80)	40(45)
Los Angeles, Long Beach	LRV-6-A	Nippon-Sharyo	54	1.3(3.0)	88(55)	27(89)	43(47)
Newark, City Subway	PCC-4-R	St. Louis	24	1.8(4.0)	72(45)	14(46)	17(19)
Phila, Media-Sharon Hill	LRV-4-R	Kawasaki	29	1.3(3.0)	100(62)	16(53)	27(30)
Portland, MAX	LRV-6-A	Bombardier	26	1.3(3.0)	88(55)	27(89)	42(46)
Sacramento, RT Metro	LRV-6-A	Siemens	36	1.1(2.5)	80(50)	24(80)	36(40)
St. Louis, MetroLink	LRV-6-A	Siemens	31	1.3(3.0)	88(55)	26(86)	41(45)
San Diego Trolley	LRV-6-A	Siemens	71	1.0(2.2)	80(50)	24(80)	33(36)
San Jose, Guadalupe	LRV-6-A	UTDC	50	1.3(3.0)	88(55)	27(89)	45(49)
Subtotals			537				
LRT-Group II:							
Boston, Green Line	LRV-6-A	Kinki	100	1.3(2.8)	80(50)	22(72)	38(42)
(Also in Service)	LRV-6-A	Boeing	110	1.3(3.0)	84(52)	22(72)	30(33)
Boston, Mattapan-Ashmont	PCC-4-R	Various	12	1.8(4.0)	72(45)	14(46)	17(19)
Buffalo, MetroRail	LRV-4-R	Tokyu	27	1.3(3.0)	80(50)	20(67)	30(33)
Fort Worth, Tandy	PCC-4-R	St. Louis	8	1.8(4.0)	72(45)	14(46)	17(19)
New Orleans, St. Chas/Riverfront	VTL-4-R	Perley-Thomas	41(g)	0.8(1.7)	43(27)	14(48)	19(21)
Philadelphia, Subway-Surface	LRV-4-R	Kawasaki	112	1.3(3.0)	80(50)	15(50)	26(29)
Pittsburgh, South Hills	LRV-6-A	Siemens	55	1.3(3.0)	80(50)	26(84)	36(40)
(Also in Service)	PCC-4-R	St. Louis	16	1.8(4.0)	72(45)	14(46)	17(19)
San Francisco, Muni Metro	LRV-6-A	Boeing	128	1.3(3.0)	84(52)	22(72)	30(33)
Toronto, Streetcars	LRV-4-R	UTDC	196	1.5(3.2)	85(53)	16(53)	23(26)
(Also in Service)	LRV-6-A	UTDC	52	1.3(3.0)	80(50)	23(75)	37(40)
(Also in Service)	PCC-4-R	Various	19	1.8(4.0)	72(45)	14(46)	17(19)
Subtotals			876				
Total			1413				

(a) See Note (a) on next page; (b) Initial acceleration: meters/sec/sec(mi/h/sec); (c) km/h (mi/h); (d) Meters (feet overall, to nearest full unit); (e) Metric tons (short tons); (f) Fleet includes 83 cars with DC propulsion plus 2 with AC drives. (g) Includes 3 ex-Melbourne cars on Riverfront Line.

(continued on next page)

Philadelphia

LRT operations on five West Philadelphia lines and the Media-Sharon Hill suburban routes remain essentially unchanged from 1992, except that limited peak-period service using two-car trains has begun on two subway-surface lines. Three North Philadelphia streetcar lines are closed: 15-Girard, 23-Germantown/South Philadelphia, and 56-Erie. Because they are being operated by buses, these lines have been omitted from the data tables.

On a more upbeat note, a new trolley loop opened in 1995 to link the new convention center near the former Reading Terminal with other tourist-oriented places in the center city.

The Southeastern Pennsylvania Transportation Authority (SEPTA) has created a light rail operations unit directed by a chief officer. In addition to having responsibility for day-to-day LRT service, this group is considering the two major related projects. Procurement of new accessible LRVs for subway-surface lines could re-

lease enough Kawasaki cars to reopen the streetcar lines in North Philadelphia. SEPTA and the city agree that these three lines will be restored to service by the year 2000. Dedicated street median "transitways" and other "Transit First" measures are being discussed to improve operations.

Pittsburgh

The rebuilt Stage 1 line via Mt. Lebanon currently carries South Hills Village, Library, and Castle Shannon short-turn LRV services from the south into Pittsburgh, with Drake service operating as a PCC shuttle to and from South Hills Village trains.

Reconstruction of the Allentown route over Mt. Washington has been completed and track inside the Mt. Washington tunnel, rebuilt. However, the Overbrook Line on the hillside above Saw Mill Run has been embargoed because of its deteriorated condition. A study of options for Stage 2 of the South Hills rail ren-

TABLE 5 (Continued)

City/System	Car Types	Characteristics of Car Equipment					
		Endedness	Train	Seats	Capacity	AC?	ATS/ATO
	(a)		(b)		(c)	(d)	
LRT-Group I:							
Baltimore, Central Corridor	LRV-6-A	Double	3	84	174	Yes	No
Calgary, C-Train	LRV-6-A	Double	3	64	162	No	ATS
Cleveland, Shaker Rapid	LRV-6-A	Double	2	84(h)	144	Yes	ATS(g)
Denver, MAC	LRV-6-A	Double	3	64	144	Yes	No
Edmonton, LRT	LRV-6-A	Double	5	64	162	No	ATS
Los Angeles, Long Beach	LRV-6-A	Double	3	76	160	Yes	ATS(f)
Newark, City Subway	PCC-4-R	Double	1	54	83	No	No
Phila, Media-Sharon Hill	LRV-4-R	Single	2	50	95	Yes	No
Portland, MAX	LRV-6-A	Double	2	76	160	No	ATS
Sacramento, RT Metro	LRV-6-A	Double	4	60	144	Yes	No
St. Louis, MetroLink	LRV-6-A	Double	3	72	155	Yes	ATS(f)
San Diego Trolley	LRV-6-A	Double	4	64	144	Yes	No
San Jose, Guadalupe	LRV-6-A	Double	2	75	160	Yes	No
LRT-Group II:							
Boston, Green Line	LRV-6-A	Double	3	50	130	Yes	No
(Also in Service)	LRV-6-A	Double	3	50	130	Yes	No
Boston, Mattapan-Ashmont	PCC-4-R	Single	1	52	83	No	No
Buffalo, MetroRail	LRV-4-R	Double	3(e)	51	121	Yes	ATS
Fort Worth, Tandy	PCC-4-R	Double	1	60	83	Yes	No
New Orleans, St. Chas/Riverfront	VTL-4-R	Double	1	52	68	No	No
Philadelphia, Subway-Surface	LRV-4-R	Single	1	51	90	Yes	No
Pittsburgh, South Hills	LRV-6-A	Double	2	62	151	Yes	ATS
(Also in Service)	PCC-4-R	Single	1	50	83	No	No
San Francisco, Muni Metro	LRV-6-A	Double	3	62	130	No	ATS(f)
Toronto, Streetcars	LRV-4-R	Single	1	46	95	No	No
(Also in Service)	LRV-6-A	Single	1	61	159	No	No
(Also in Service)	PCC-4-R	Single	1	50	83	No	No

(a) LRV-Light Rail Vehicle, PCC-Presidents' Conference Committee, VTL-Pre-PCC Vintage Trolley; # Axles, 4 or 6; R-Rigid, Non-Articulated, A-Articulated; (b) Maximum Cars/Train in Regular Operation; (c) Comfortable load, seats + standees at ±4/m²; (d) Air Conditioning; (e) 4-car trains for special events; (f) Cab signals; (g) Cab signals, Tower City Center to East 79th Street on segment shared by LRT and heavy rail trains; (h) Seats being reduced from 84 to 80 to make room for chopper ventilation ducts from roof.

TABLE 6 Changes in North American LRT and Streetcar Systems, 1992-1995

City/System	Code(a)	Changes since 1992
LRT-Group I:		
Baltimore, Central Corridor	N	Opened 1992, 35.4 km (22.0 mi)
Calgary, C-Train	-	---
Cleveland, Shaker Rapid	X	Begin Waterfront Extension for 1996 opening, 3.2 km (2.0 mi)
Denver, MAC	N	Opened 1994, 8.5 km (5.3 mi)
Edmonton, LRT	X	Opened 1992, extension to U. of Alberta, 1.6 km (1.0 mi)
Los Angeles, Long Beach	-	Construct Green Line, Norwalk-El Segundo, 32 km (20 mi) to open in summer 1995
Newark, City Subway	-	---
Phila, Media-Sharon Hill	-	---
Portland, MAX	X	Begin Westside and Hillsboro Extensions for 1997 and 1998 openings, 28.5 km (17.5 mi)
Sacramento, RT Metro	R	Double tracking and add two stations: 1 project, 1993-94
St. Louis, MetroLink	N	Opened 1993, 29.0 km (18.0 mi)
San Diego Trolley	VX	Opened 1992, County Center extension, 0.8 km (0.5 mi); delivery of 52 LRVs begun, 1994 (b)
San Jose, Guadalupe	-	---
LRT-Group II:		
Boston, Green Line	R	Begin relocation of North Station area from elevated structure to subway
Boston, Mattapan-Ashmont	-	---
Buffalo, MetroRail	-	---
Fort Worth, Tandy	-	---
New Orleans, St. Chas/Riverfront	-	---
Phila, Subway-Surface	-	---
Pittsburgh, South Hills	R	Complete reconstruction of Allentown line
San Francisco, Muni Metro	V	Delivery of 50 LRVs begun, 1995
Toronto, Streetcars	X	Begin Spadina LRT line for 1997 opening, 3.2 km (2.0 mi)

(a) N-New Start, R-Rebuild/Rehab/Expand Facilities, V-New Vehicles, Xextension
 (b) Major yard and shop expansion completed 1994

ovation has been completed. Local decisions are pending on the affected line segments: South Hills Junction–Drake, Washington Junction–Library, and South Hills Junction–Castle Shannon via Overbrook.

Planning for the Spine Line, a central area connector, and other extensions is in progress.

Buffalo

Metro Rail operations and facilities in Buffalo remain unchanged from 1992, and ridership is stable at 28,000 per weekday. The Niagara Frontier Transportation Authority (NFTA) has plans for at least four extensions: Tonawanda, Amherst, Southtowns, and Airport. Limited revenues and needs elsewhere on the NFTA system, however, pose a funding challenge likely to prevent near-term implementation.

Cleveland

The Greater Cleveland Regional Transit Authority (GCRTA) is working to correct the long-standing restraint on ridership posed by stopping only once at the periphery of downtown.

Using local funds, GCRTA intends to complete its 3.2-km (2-mi) Waterfront Line for the city's bicentennial in 1996. Operating as an extension of the Blue and Green lines from Tower City, this extension will improve central area passenger distribution and reach several existing and planned leisure venues: a major stadium, the Rock and Roll Hall of Fame, aquarium, and Great Lakes Museum.

To further address the downtown passenger distribution problem, GCRTA is considering additional modified options that would attain the principal goals of the full-subway "dual hub" proposal, but at a lower cost.

New Orleans

The St. Charles Line has become a treasured part of historic New Orleans' scene, whereas the much newer Riverfront Streetcar has proven successful in the tourist market. Since 1992, rehabilitation of the historic St. Charles fleet has been completed.

There are plans to extend the Riverfront Line up and downstream from its existing terminals as well as to revive streetcar lines on Canal, St. Louis, Rampart, and Esplanade streets. LRT from downtown to the airport is contemplated as a longer-term project.

Fort Worth

The 1-mi Tandy Subway continues to do what it was built to do in 1962: shuttle passengers efficiently from

a remote parking lot to a subway station in the Fort Worth central business district (CBD). There have been no significant changes since 1992.

San Diego

It is fitting that the first U.S. new-start LRT, opened in 1981, has grown to the largest new system at 55 km (34 mi) and 71 LRVs. Although the planning horizon of the San Diego Trolley has been stretched by the long-running recession in California, the Metropolitan Transit Development Board (MTDB) continues to make progress on several projects that will further expand the system.

The first of 52 SD-100 LRVs has been delivered from Siemens Duewag's Sacramento assembly plant. These cars were ordered primarily for use on several extensions planned to run generally north from downtown San Diego, and none of them had been placed in revenue service as of early 1995.

With a short link open from the Santa Fe Station to the County Center/Little Italy Station, construction continues on two extensions: 5.6 km (3.5 mi) farther north to Old Town and scheduled for completion in summer 1996, and 5.6 km (3.5 mi) east from El Cajon to Santee. The latter, to open in 1995, includes the first significant section of single track since the original South Line was completed in 1981.

In spring 1995, the MTDB awarded construction contracts on facilities that will form the Mission Valley West extension. From Old Town, this line will operate through the Hotel Circle area and past several regional shopping centers to the Jack Murphy Stadium sports complex.

Los Angeles

The Los Angeles basin's multimodal rail transit system continues to take shape, even as the region's transit organizational structure has undergone major changes, and the pace of rail development has had to slow in deference to the effects of California's extended recession on local funding. In addition to quick-start Metro-link commuter rail lines and massive Red Line construction, LRT progress continues on several fronts:

- Los Angeles–Long Beach Blue Line weekday ridership has reached 42,000.
- Construction and the initial LRV procurement are well advanced on the 20-mi east-west Green Line, which is expected to open in summer 1995.
- Initial construction work has begun on the 21.9-km (13.6-mi) Blue Line to Pasadena, and studies are in

progress on a subway link under the Los Angeles CBD to link this extension with the line to Long Beach.

Although the Green Line will open with 15 new cars identical to the existing Blue Line vehicles, it will eventually be served by some of the 72 "L.A. standard" LRVs being developed by Siemens Duewag. Although initially they will be set up for manual control, these cars could become North America's first LRVs fitted for automatic operation on fully grade-separated line segments while retaining operator controls for at-grade branches.

Santa Clara County

Since 1992, average weekday ridership in Santa Clara County has leveled at about 20,000 as area residents have discovered the reliability and convenience of LRT. Although a court challenge has slowed the flow of local funding, preparatory work on extensions continues.

Final design has been completed for the 24-km (15-mi) Tasman Corridor Line that will extend the existing Tasman Drive link west past several employment centers to the Mountain View CalTrain commuter rail station and southeast through the community of Milpitas to northeastern San Jose.

Preliminary design is under way for the Vasona Line (San Jose to Los Gatos) and the Capitol Corridor Line.

San Francisco

Deliveries of Muni Metro's new Breda LRVs have begun, and installation of moving block signals in San Francisco's Market Street tunnel is well advanced. In addition, several extensions that will broaden the reach of this heavily used system are in various stages of development.

The San Jose Avenue extension from 30th Street to Ocean Avenue has opened, extending J Line service by 3.7 km (2.3 mi) and reducing deadhead time and mileage for both the J and N lines.

Construction continues on the Embarcadero turn-back loop and subway-surface extension through South Beach and Mission Bay to the CalTrain depot at Fourth and King streets. The start of service is anticipated by 1996.

PCC cars will return to Market Street in 1995, operating between Castro Street and the Transbay Terminal. This service will be extended to the foot of Market Street, then turn Northwest on the Embarcadero to Fishermen's Wharf.

Two major extensions are the subject of planning studies. A concept has been completed for a Bayshore

Line as an extension south from the CalTrain depot through a hoped for "new town in town" on the site of SP's former Mission Bay freight yards, then on Third Street to CalTrain's Bayshore station. Currently under way is a study for LRT from Market Street west to Park Presidio Boulevard along Geary Street, Muni's most heavily patronized diesel bus corridor.

Sacramento

LRT and total transit system ridership have grown in Sacramento since LRT was introduced, and especially since the spring 1989 schedule changes that implemented the coordinated timed-transfer network envisioned in the original preliminary engineering operating plan. As a result, regional transit enjoyed its highest system ridership ever during 1993-1994, with more than 24,300 weekday LRT boardings on average.

Construction, starting in 1995, on a 4-km (2.5-mi) extension of the Folsom Line east from Butterfield Way to Mather Field Drive will bring LRT service into the large and growing suburb of Rancho Cordova. Further extensions to both ends of the starter line have been designed and construction funds identified, but implementation must await the designation of a guaranteed source of operating funds for Sacramento-area transit.

Construction of a new 18-km (11-mi) line through South Sacramento is planned. An alternatives analysis/draft environmental impact statement (AA/DEIS) has been finished, leading to a preferred alignment along the Union Pacific railroad line and then east along Consumer River Boulevard to SR-99. An innovative funding package is being negotiated and must be completed for the project to proceed.

Portland

Local public and business leaders intend that the single Eastside MAX light rail line will grow into a regional system of trunk lines forming the core of a multimodal, multidestination system. That this is likely to occur is in part due to a 20-year history of state-mandated land use planning that contains development within an *urban growth boundary*, as well as the willingness of local voters to fund transit operations and the local shares of capital projects.

North America's first low-floor LRVs will enter service as through-routed trains on the East-West Line when the first 18.5-km (11.5-mi) section of the Westside extension opens in 1997. A year later, the Westside extension will be completed with the addition of another 10 km (6 mi) to Hillsboro.

It is anticipated both AA/DEIS and PE/FEIS requirements will be completed by 1998 for a South-North Line to extend 33 km (20 mi) or more from Clackamas Town Center through downtown Portland and across the Columbia River to the northern part of Vancouver, Washington. Regional authorities hope to move this ambitious project into final design and construction upon completion of the Westside extension and start service about 2005. In a 1994 referendum, Oregon voters approved \$475 million in bonds backed by property taxes for their portion of the local share. Rejection of a similar measure by the electorate in Clark County, Washington, during February 1995 has required a re-evaluation of project end points and implementation timing.

EXISTING SYSTEMS IN CANADA

Calgary

The Calgary LRT system continues essentially unchanged from 1992 and continues to enjoy the highest ridership of any of the post-1975 new starts: more than 100,000 weekday boardings on the C-Train. The system also leads new starts in productivity, measured in rides per route kilometer and per vehicle (Table 1). Although the city plans an eventual line west from the CBD, constrained finances are expected to prevent its construction until after 2000.

Edmonton

The extension to the University of Alberta opened in August 1992. This was a significant event, because it taps the university's large transit market and because Edmonton's LRT now serves the CBD from two directions. Buses feed south-area riders to LRT at the University Station, mirroring the long-established pattern on the Northeast Line. As a result, patronage has jumped by nearly 60 percent, to 36,000 per weekday.

Plans are in place for further LRT extensions to the south and west from the university, as well as north from downtown Edmonton. Implementation timing is uncertain because adequate funds have not yet been identified.

Toronto

Measured by line length, number of cars, and weekday ridership (Table 1), Toronto's is the largest LRT system in the United States and Canada. Its 10 routes, totaling 75.5 km (46.9 mi), primarily serve local transit needs

within and between densely populated city neighborhoods. Most tracks are in street lanes shared with automobile traffic, but reserved medians are being provided on new extensions: the Harbourfront Line opened in 1990, and the Spadina Line under construction and scheduled for completion in 1997.

A Waterfront west extension from the Harbourfront route awaits funding and probably will be built in stages. It is planned to reach out to Etobicoke. The Toronto Transit Commission anticipates its next purchase of LRVs will be for 100 percent low-floor cars.

EXISTING SYSTEMS IN MEXICO

Guadalajara

After using a turnkey contract to complete its successful initial 15.3-km (9.5-mi) Line 1 in 1989, Guadalajara—Mexico's second largest city—quickly started building a second route. The first phase of Line 2, which extends 8.5 km (5.3 mi) east from a station with Line 1, opened for revenue service in July 1994. Further plans call for extending Line 2 to the west and adding a third line to the northwest. Like Line 1, these two links will reach out to the circumferential highway, *Anillo Periferico*.

Monterrey

Mirroring the pace of LRT construction in Alberta a decade earlier, the 1991 opening of Monterrey's initial 18.5-km (11.5-mi) line followed closely behind Guadalajara's project. Monterrey also used a turnkey contract covering all facilities and equipment. *Metrorrey* also is being expanded at a rapid pace. The first 5.0-km (3.1-mi) section of Line 2 opened in late 1994. Further extensions to and branches from both lines are anticipated to build gradually a regional network of 74 km (26 mi).

Mexico City

The rebuilt and reequipped 14.5-km (9.2-mi) LRT line from the Taxqueña Metro terminus to Xochimilco continues as reported in the 1992 update. Service on the short branch to Tlalpan remains suspended. Running southeast from a common terminus with rubber-tired Metro Lines 1, 5, and 9, steel wheel/steel rail trains collecting power from overhead wires on Line A introduced a version of heavy rail service with LRT overtones that allowed inclusion of a few grade crossings. A second line using this technical approach is now pro-

posed to extend from the heart of Mexico City to growing communities in the northwestern area.

NEW START UNDER CONSTRUCTION IN DALLAS

Construction is well advanced on the Y-shaped 32-km (20-mi) starter system being developed by Dallas Area Rapid Transit (DART). Like several previous LRT projects, much of the alignment reuses former railroad rights of way. Exclusive lanes in city streets carry the line through the CBD, then twin tunnels provide full grade separation for the first 5.6 km (3.5 mi) of the North Central leg. The 21 stations are spaced at intervals of 1.6 km (1.0 mi) on average. Several stops will serve as transit centers coordinating LRT with DART buses.

Built to a new design, the first of DART's 40 articulated LRVs was delivered in spring 1995. Additional cars have been received since and are active in the system test, training, and start-up program.

Progress is on track to open the downtown and most of the West and South Oak Cliff branches in June 1996. The North Central segment will follow by the end of 1996, with the outer South Oak Cliff link to Ledbetter entering revenue service by May 1997.

DESIGN AND PLANNING FOR FUTURE NEW STARTS

The success of established new systems in cities such as Calgary, San Diego, and Portland, as well as the latest new starts in St. Louis and Denver, provide encouragement for those places still in planning and design.

Chicago

From its historic start within "The Loop," Chicago's central area has expanded over the past century to cover an area of about 15 km² (6 mi²). This size makes many internal trips too long for walking, yet the areas are not well served by local buses or regional commuter rail and rapid transit lines. The Central Area Circulator LRT system will have four routes totaling 15.6 km (9.7 mi) to accommodate local trips of all kinds, shuttle commuters between regional rail train stations and their places of employment, and serve special events at McCormick Place and Navy Pier. Tracks occupying reserved lanes in city streets will be used by a fleet of 38 articulated LFLRVs to reach 32 initial stations. Proof-of-payment fare collection will be used so that boarding and alighting riders may use all doors and open unfenced station platforms can be free areas. With com-

mitments in place for system implementation, construction and procurement activities have begun.

Salt Lake City

Preliminary engineering has been completed for the 24-km (15-mi) line south from downtown Salt Lake City's Temple Square to the suburb of Sandy. Similar to San Diego's South Line, this project involves the use of reserved street lanes through the city center linked to a railroad line, already purchased by the Utah Transit Authority (UTA). Local freight service is being provided by a short-line contractor to UTA. The authority is working to refine the scope of the starter line and complete a capital funding package enabling the project to progress into final design.

Seattle

In late 1994, a new Regional Transit Authority (RTA) won approval from the councils of its three member counties for a 16-year Phase 1 system plan including LRT on three routes totaling 70 mi. In addition, the plan calls for an 81-mi commuter rail line to link Everett, Seattle, Tacoma, and Lakewood (Fort Lewis/McChord Air Force Base) and improved bus services, all to be united into a seamless regional transit system using timed-transfer scheduling and a single fare system. A "transit federation" is proposed to ensure coordination among regional and local operators, similar to the program in San Diego and common in Western Europe. In a March 1995 referendum, voters rejected local funding for this plan. As a result, the RTA is reevaluating the scope of the plan and timing for a second financing referendum.

Others

Plans for rail transit have been or are being made in several other metropolitan regions. Many places are focusing on LRT as a technology that is affordable yet can provide desired levels of service quality and carrying capacity. Planning or preliminary engineering for new-start LRT projects is ongoing or recently completed in the Minneapolis/St. Paul, Memphis, Austin, Columbus, Cincinnati, Kansas City, Spokane, Hartford, Milwaukee, and Charlotte. Other places that have considered LRT and might revive previous proposals or develop new ones include Orange County (California), Norfolk, Phoenix, Orlando, and Rochester. New York City is evaluating turnkey contractor submittals for the proposed crosstown line on 42nd Street.

CONCLUSIONS

As of 1995, rail transit systems of regional significance (i.e., routes serving as the main lines of a regional transit system) are operating or under construction in more than half of the U.S. metropolitan areas of 1 million or more population: 20 of 39 such places in the 1990 Census. LRT lines form all or significant parts of such rail systems in 16 regions (80 percent), up from only 7 when the first TRB conference on LRT was held, in 1975.

The next 20 years could see further additions to the stream of recently completed North American LRT projects. Growing travel demand in candidate corridors and the impossibility of eliminating traffic congestion by building more freeway lanes will require responsible authorities to look at nonroad alternatives. Considering public transit's continuing need to stretch scarce financial resources, the prospects for future new starts would be improved by a renewed emphasis on lower-cost approaches to LRT system design. It appears more and

more likely that those major urban regions still without rail lines will want to add them and that factors of demand and finance will lead to selection of LRT as the preferred rail technology.

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