COMPARISON OF BUSWAY AND LIGHT RAIL MODES

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Much has been offered to convince decision makers that busways are the least costly of fixed-guideway services in medium-density urban corridors. Until recently, these claims could be questioned but not refuted because a thorough analysis of comparable busway and light rail transit (LRT) systems did not exist. However, such a work was completed in late 1974. The Rochester, New York, Charlotte-Henrietta corridor studies are a detailed busway-versus-LRT mode comparison for a specific corridor. The studies show that, although LRT and busway investment costs are similar for equal facilities, LRT exhibits substantial operating cost, operation, and service advantages.

Proposed new applications of busway and light rail transit (LRT) technology in U.S. cities have focused mainly on radially oriented, city-suburb corridors. In medium-sized cities, busway and LRT proposals are similar in their patronage handling, line-haul characteristics, private right-of-way (ROW), high speed, multiple stations and central business district (CBD) distribution.

In 1970, Rochester, New York, began an analysis of busway engineering and economic feasibility for the 19.4-mile (31.2-km) Charlotte to Henrietta (C-H) urban transit corridor. For a number of reasons, the busway analysis soon became a series of detailed busway-versus-LRT mode comparisons. The study output is a landmark in that the several volumes of final report represent the most comprehensive comparison of LRT and busway costs yet performed in the United States for a specific corridor. The findings of the Rochester studies may provide useful guidance to others choosing between a busway and light rail transit.

CHARLOTTE-HENRIETTA CORRIDOR

The 1969 Metropolitan Transportation Plan, which was adopted by the local Rochester government, recommended construction of a high-speed busway running north and south from city center. The corridor location was carefully established by the plan to be on or parallel to existing, active freight railroad rights-of-way (ROWs). The old Rochester City Subway ROW was to be used under the CBD.

From the beginning, Rochester area policymakers determined that the C-H busway must exhibit high degrees of comfort, safety, and speed. The urban transit facility was to be totally grade separated from highways and streets at intersections and designed to enable travel speeds as high as 60 mph (96.6 km/h) and automobile-competitive average scheduled speeds exceeding 30 mph (48.3 km/h). Use of comfortable air-conditioned buses and pleasant, high-quality stations also were provided for. To minimize acquisition of private property and the relocation of persons and businesses, every reasonable effort was to be made to construct the new busway entirely within the confines of existing railroad ROWs.

COMPARISON OF BUSWAY AND LIGHT RAIL CONCEPTS

Recently, exclusive busways have been promoted as the best option for low capital investment in the intermediate patronage range between the extremes of rail rapid transit and buses in mixed traffic. Light rail transit, however, also is well suited for intermediate patronage corridors.

Busways

A busway is a roadway limited to exclusive use by buses. The nation's largest bus manufacturer has promoted bus rapid transit, bus platooning, and Metro-Mode use of busways. Bus rapid transit involves use of a high-speed, grade-separated roadway along which stations are spaced at various distances; buses operate in local, limited, skip-stop, and express service.

Metro Mode is a variation on bus rapid transit. Theoretically, the bus provides its own feeder service; that is, it exits the busway and picks up and discharges passengers on local streets. The ability to operate on streets as well as on the high-speed busway eliminates some requirements for passenger transfers. Two types of Metro Mode service were examined for the C-H corridor. One, which involved the use of small buses in local feeder, express busway, distributor service, was not considered because of its large rolling stock and high operating costs. The other, which involved substituting main-line vehicles (using busway on and off ramps) for feeder buses on local streets, was eliminated because it increased total fleet requirements, capital costs, and operating costs.

Bus platooning involves groups of buses operated together in closely spaced, minimum-headway, trainlike fashion. In other words, trains of buses provide rapid transit service. (Bus platooning at speed has never been tested and proved in actual passenger service, nor is it likely that it will be because flow stability and safety standards are seriously affected when the stopping time of independently operated vehicles approaches the headway between those vehicles.)

Light Rail Transit

Although many light rail vehicles (LRVs) are manufactured throughout the world, only the basic U.S. standard Boeing Vertol LRV was considered for Rochester.

Because LRVs are guided by rails, cars may be coupled together and operated as a train. If the vehicles contain proper equipment, only 1 operator is required to handle a train of several cars.

The ROWs, tracks, and structures of freight railroads may be used by LRVs with modified wheels. Scheduling provisions can enable this facility-sharing if either service can be given exclusive track occupancy during individual periods of the day or night. Safety rules forbid mixing freight-train and LRT services on a common track at the same time of day.

Given the availability of tracks and catenary, LRT systems can perform all busway operations: rapid transit, Metro Mode, and platooning. The ability of LRT to be operated in these ways has been tested and proved.

VEHICLE CHARACTERISTICS

Both the physical and performance characteristics of LRVs and buses influence the mode-selection process. A review of existing and planned foreign and domestic equipment clearly indicates that no high-capacity, double-deck, or articulated bus of adequate horsepower (wattage) would be available to render high-speed, start-stop corridor service. Conversely, high-seating-capacity LRVs, offering a wide range of desirable physical and performance characteristics, are being produced.

Physical Characteristics

The transit vehicles selected for LRT and busway comparison in Rochester's C-H corridor were the standard 49 to 53 passenger diesel transit bus and a modified LRV manufactured by the Boeing Company. The basic physical dimensions of both vehicles are well known. The 75-ft-long (22.9-m-long), 6-door, articulated LRV seats a nominal 80 passengers and has 4 in. (10 cm) more aisle space than the bus has. The bus, with its rear door widened to 54 in. (137 cm), seats only 49 passengers. Both vehicles use 36-in. (91-cm), transverse, semisuburban seats. Passenger boarding on the LRV is by high platform; passenger boarding on the bus is by steps.

Performance

Speed

A check with Boeing Company representatives indicated that minor variations in their production-line vehicle (changes in gear ratio and wheel diameter) would permit safe LRV speeds of 60 mph (96.6 km/h).

The acceleration and speed characteristics of LRT are clearly superior to those of the bus. The bus attains 60 mph (96.6 km/h) in 33 s while traveling 1,560 ft (476 m); its initial rate of acceleration is 2 mph/s (0.9 m/s^2. [Improvements in bus acceleration (gearing modifications or wheel diameter reductions) are obtained at the sacrifice of top speed.] Accelerating initially at 3 mph/s (1.35 m/s^2), the LRV requires only 22 s and a distance of 1,020 ft (311 m) to reach 60 mph (96.6 km/h). Taking other factors into account, C-H corridor, peak-hour average speeds were estimated to be 34.3 mph (55.2 km/h) for LRT and only 30.8 mph (49.6 km/h) for buses.

Braking

The normal braking characteristics of LRVs and buses are satisfactory for corridor rapid transit service. However, on a wet or frozen surface, the bus operator could easily lose control of the vehicle while braking. LRVs, because they are physically guided, are not subject to this hazard.

Dwell Times

Because of the basic physical characteristics of the vehicles, bus and LRV dwell times differ significantly. The limited number and narrowness of door openings [30 in. (76 cm) at the front and 54 in. (1.37 m) at the rear] and necessity of stairs in buses cause high dwell times compared with those of the modified LRV, which has wide doors and high-platform loading at all entrances.

Calculations of C-H corridor dwell times assumed prepaid fares at all stations. The formula used a constant of 10-s minimum reaction time for both vehicles and 0.4-s/passenger boarding time for LRT and 1.3-s/passenger boarding time for bus. Use of this formula for calculating peak-hour dwell times at all 20 C-H corridor stations resulted in averages of only 322 s for LRT and 452 s for buses. A requirement for on-board fare collection would increase station dwell times for both modes. The disparity between bus and LRV dwell times would remain great, however, because LRVs have more and wider doors and no steps.

CORRIDOR CHARACTERISTICS

The physical characteristics (types of stations, ROW widths, and the like) of the C-H corridor were shown to have little effect on mode selection. Far more important in influencing decisions were factors related to passenger volumes and perceived quality of service.

Passenger Volume

Busway and LRT systems are capable of handling wide ranges of corridor patronage. In Table 1, the Boeing LRV modified to Rochester specifications and seating a nominal 80 passengers is compared with a standard 50-passenger bus over a range of peak-period patronage estimates. The comparison assumes only that a given number of passengers must be moved to, from, or past a certain point on the transit line during a 15-min time period. (On the C-H corridor, the peak 15-min patronage in 1 direction equals approximately ⅓ of peak-hour boardings.) Note that, as patronage increases, headways for the busway become extremely short. The ability of LRT to maintain 2- or 4-min standard headways by using trains of various lengths (1 to 4 cars) enables operation of a safe, near-constant headway at rush hour; this permits reliable service without delays.

Qualitative Factors

Several of the physical and operational characteristics of bus and rail vehicles influence the design, operating cost, and use of the corridor, and most affect the quality of service that can be offered. A comparison of selected corridor characteristics, many of which are qualitative in nature, is given in Table 2.

Two qualitative characteristics purportedly favoring the busway are: (a) the ability of buses to overtake each other at stations and (b) the ability of buses to provide through services to and from neighborhoods. But both are possible, at substantial additional cost, for either the LRT or busway modes. These options were examined for the C-H corridor and discounted for their cost or service implications or both. The ability of the transit operator to use vehicles for charters and school trips was proposed as a busway advantage. However, Rochester's existing fleet of buses is available for such uses during base periods.

RIGHTS-OF-WAY AND COSTS

Both modes can be accommodated on any reasonable horizontal or vertical alignment. Either mode also can be constructed entirely or partially on private ROW and be grade separated at some or all street intersections. Decisions on the type of ROW to be used and whether grade crossings are to be permitted have a substantial effect on the construction cost and safety of both systems.

Grade Separations

Grade crossings are safety hazards and easy transitway access points. If fare controls are station located rather than vehicle borne, at-grade crossings close to stations cannot be easily tolerated. Under such circumstances, limiting platform access to fare-paid passengers is nearly impossible.

Safety

Above a minimum patronage level, the frequency of service on a busway must be greater than on an LRT system. The greater the frequency of transit vehicles intersecting cross streets at grade is, the greater the risk of accidents involving automobiles and transit vehicles is.

A nomogram developed for railroad operations showed the high probability for grade-crossing accidents to occur even on corridor outer ends. After further analysis, it was concluded that the 1990 rush-hour headways of LRV trains (averaging 3.25 min for both directions of travel) would permit the installation and safe observance of railroad-type grade-crossing control devices or LRV-actuated traffic signals.

For the busway, conclusions were different. Average rush-hour headways for buses on the C-H corridor outer ends in 1990 were as low as 42 s. To prevent a total disruption of street traffic at busway intersections, regular pretimed traffic signals would have to be used. These would reduce the average scheduled speeds of the busway, and extra buses would have to be added to the fleet to cover headway and capacity gaps.

If we do not consider other factors, the required high frequency of buses during rush hours compared with the much lower frequency of LRV trains makes exposure to any C-H corridor grade-crossing accident a minimum of 2.5 times greater for the busway than for LRT.

Investment

Three main factors affect the construction costs of busway and LRT grade-crossing-elimination projects: gradients, clearances, and the relocation or sharing of freight tracks. Typical unit costs in 1974 dollars for transit-highway grade-separation structures on the C-H corridor are as follows:

	Cost		
Facility	Busway	Simple LRT	LRT and Freight
Transitway underpass	2,550,000	2,830,000	4,135,000
Transitway overpass	1,040,000	860,000	1,380,000

Each LRT and freight separation is designed to accommodate rail freight traffic. Busway and simple LRT structures do not reflect any rail-freight-related costs. One may quickly conclude that the cost of a transitway underpass (retained cut) ranges from about 2.5 to more than 3 times the cost of a comparable overpass. Such costs do not include cost of land or charges for any related highway work. Among all the alternatives except a subway, the simple LRT overpass is the least costly of all grade-crossing-elimination structures.

The requirement for a greater vertical clearance makes a simple LRT underpass more costly than its busway equivalent. A busway requires a vertical clearance of only 14.5 ft (4.4 m); LRT requires 17 ft (5.2 m).

Freight grades should not exceed 2 percent; LRT or busways can easily tolerate 4 percent grades. Thus the LRT line accommodating freight requires grade-separation facilities that are greater in total length and more costly than comparable busway or exclusive LRT structures. The interrelationships of freight service continuance, maximum gradients, and construction costs are given in Table 3.

Economy can be maximized if a simple LRT or busway structure can be constructed and, if necessary, separate freight tracks can be relocated horizontally to an existing vertical alignment. However, before a final decision on freight-track sharing versus relocation can be made for LRT, other factors should be considered, including (a) public policy, traffic improvements, and social and environmental benefits derived if the at-grade freight crossing were eliminated; (b) land costs; and (c) related highway construction costs.

Use of 7 fully protected grade crossings (instead of grade separations) on the C-H corridor outer ends would save an estimated 10.3 million 1974 dollars in construction

Table 1. Travel volumes, vehicle requirements, and headways.

	Light Rail Transit				Busway	
Passenger Demand[a]	Cars Required	Cars per Train	Trains	Headway (min)	Headway (min)	Buses
500	7	1	7	2.14	90	10
500	7	2	4	3.75	90	10
1,000	13	2	7	2.14	45	20
1,500	19	3	7	2.14	30	30
2,000	25	3	9	1.67	23	40
2,500	32	4	8	1.88	18	50

[a]All passengers seated and a 15-min peak period.

Table 2. Corridor characteristics.

Facility	Vertical Clearance (ft)	Maximum Gradient (percent)	Facility Length (ft)	Total Cost[a] (1974 dollars)	Add for Freight Track Relocation[b] (ft)
Highway overpass					
LRT and freight	14.5	2	2,100	1,380,000	Not applicable
Simple LRT	14.5	4	1,325	860,000	0.095
Busway	14.5	4	1,125	1,040,000	0.081
Railroad overpass					
LRT and freight	22.0	2	2,800	2,540,000	Not applicable
Simple LRT	22.0	4	1,700	1,385,000	0.122
Busway	22.0	4	1,600	1,800,000	0.115
Underpass					
LRT and freight	17.0	2	2,300	4,135,000	Not applicable
Simple LRT	17.0	4	1,450	2,830,000	0.105
Busway	14.5	4	1,150	2,550,000	0.083

Note: 1 ft = 0.305 m.

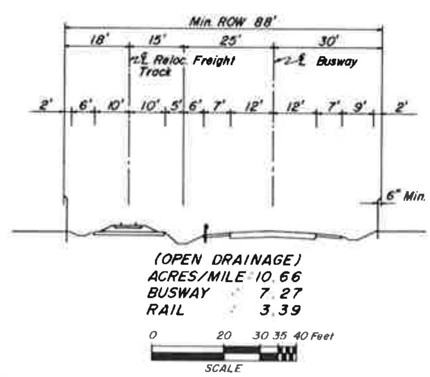
[a]Costs shown are exclusive of any highway-related work. [b]Horizontal relocation to existing vertical alignment (at grade).

Table 3. Adaptability of LRT and busways to typically desired corridor characteristics.

	Mode	
Corridor Characteristic	LRT	Bus
Passenger accessibility		
High platform loading potential	Yes	No
Curb height loading only (steps)[a]	Yes	Yes
Combination high platform and curb height loading potential	Yes	No
Passenger safety		
Simple deadman control	Yes	No
Fail-safe signalization	Yes	No
Aesthetics and environment		
No overhead wires	Yes[b]	Yes
Low vehicle emissions	Yes	No
Low vehicle noise emission	Yes	No
Low noise incidence[c]	Yes	No
Engineering and economics		
Share common freight track	Yes	No
Low labor intensity	Yes	No
Upgrade to rapid transit	Yes	No
Potential for total automation	Yes[d]	No

[a]Significant disadvantage for the physically handicapped.
[b]Where LRT is located on private right-of-way, power can be transmitted by a third rail (though at higher cost than for catenary operation). Conduit-encased, underground third-rail power transmission systems have been used successfully in Washington and New York.
[c]The frequency of occurrence is lower for an LRT system compared with that of a busway at a given patronage level (Table 1).
[d]If fully grade separated.

Figure 1. Relocated freight track for simple, at-grade busway.



Note: 1 ft = 0.305 m. 1 in. = 2.54 cm. 1 acre/mile = 0.25 hm²/km.

costs for LRT and 12.7 million 1974 dollars for a busway. LRT 1990 operating cost would be unaffected; busway operating costs, however, would increase by 90,000 1974 dollars as a result of adding vehicles to compensate for increased running times.

Private Right-of-Way

The private ROW, high-speed aspect of busway and LRT operation makes both attractive alternatives to private automobile usage. Free of interfering traffic, busway and LRT top speeds of 60 mph (96.6 km/h) and average scheduled speeds exceeding 30 mph (48.3 km/h) can be obtained easily. The use of private ROW implies safety, high speed, schedule adherence, and transit dependability and reliability.

Busways and LRT lines can be built and safely operated on relatively narrow private ROWs. LRT, at a desirable and safe dimension, generally requires less ROW width [45 ft (13.7 m)] than does a busway [60 ft (18.3 m)]. Because rail vehicles are physically guided, their lateral motion is restricted; this is not so for bus. In addition, a rail vehicle that breaks down can be pushed; a stalled bus must be bypassed.

Ideally, a private ROW should be entirely fenced. At minimum, fencing should be included along all high-speed segments, at stations, and wherever else pedestrians or pets might trespass. Other safety features, such as guardrails on busways, standing-room clearance between busway lanes or rail tracks, and adequate grade-crossing protection, are desirable. Comparisons of LRT and busway ROW requirements and costs are without merit when reasonable safety features have been omitted or unjustifiably reduced.

Light rail transit and busway ROW requirements and construction costs for the C-H corridor are given in Table 4. These costs include engineering and contingency costs but not land costs. The busway with closed drainage categories are for urban situations in which ROW width is restricted or land value is high or both.

At-Grade Private Right-of-Way

A review of Table 4 indicates that only in the typical at-grade open drainage situation does the busway exhibit a construction cost advantage. If land values were high, the marginal cost advantage for the busway would not exist because its ROW requirement is $1/3$ greater than that of LRT.

It is proposed frequently that busways be constructed on railroad ROWs parallel to active freight tracks. However, Rochester-area railroad ROWs are typically only 66 ft (20.1 m) wide with 8 acres/mile (2 hm^2/km). Even with the freight track relocated to 1 side of the rail ROW (Figure 1), the busway cannot be accommodated without the purchase of additional land. This is not the case with LRT because LRT can share freight railroad tracks.

Other Construction

Embankment, viaduct, and retained cut are construction forms widely encountered in highway and rail transportation. Generally, on a cost-per-mile (kilometer) basis, these construction forms are less costly for LRT than they are for busway because LRT has a narrower ROW requirement. Caution is exercised against oversimplification, however. Construction standards, land values, and environmental or site-specific factors can alter such general situations.

Subway

Dedicated ROWs, modern traffic control devices, and good traffic engineering practice can enable busways or LRT to achieve satisfactory speed characteristics on the street surface in many urban core areas. This is a major attribute of busways and LRT; such low-cost solutions to speed and capacity problems may minimize or obviate the need for tunneling in CBDs.

Rochester's C-H corridor will require only 3,750 ft (1144 m) of new cut-and-cover subway if street operation is to be avoided entirely. No station structure is planned in the subway, and busway speeds would be high. Therefore, the ventilation of diesel bus exhausts is a minor item of busway cost. No ventilation is required for the LRT system. LRT vertical clearances [a minimum of 17 ft (5.2 m) for catenary] will permit freight operations to be conducted if necessary. The comparative costs for this new subway segment are as follows in 1974 dollars:

	Cost		
Mode	Construction	Ventilation	Total
Busway	11,344,000	2,025,000	13,369,000
LRT and freight	12,263,000	Not required	12,263,000

A comparison of the C-H corridor busway and LRT and freight profiles is shown in Figure 2. The comparison indicates that almost twice as much at-grade construction may be used for LRT compared with that for busways. Also significant is the fact that additional private property abutting the freight ROW must be purchased along 6.2 route miles (9.9 route km) of the busway. However, on the LRT system, only slightly more than 1 mile (1.6 km) of ROW must be widened beyond existing railroad ROW boundaries.

STATIONS

Light rail transit and busway stations may range from controlled-access, grade-separated, rapid-transit-type structures to unsheltered curbsides. The ability to select from or adapt to such a wide range of station possibilities is one of the most significant attributes of LRT and, to a lesser degree, busways.

To encourage high transit ridership on the C-H corridor, Rochester planned for complex busway or LRT stations. Each is to have heating, ventilating, and air conditioning; controlled and TV-monitored passenger access (for security); fare collection facilities; and, where appropriate, elevators and escalators. High platforms at LRT stations will speed passenger travel, minimize boarding and alighting mishaps, and enable the physically handicapped to have access to transportation. Because the use of high platforms is not possible on the busway, the same benefits could not be enjoyed by patrons of that mode.

The efficiency, design, and cost of a busway station can be radically affected by high patronage. Determinants affecting busway station design are bus headways, average dwell times per vehicle, and peak boarding and alighting volumes. When the station dwell time of a bus exceeds vehicle headways, buses will back up waiting for others to clear the station platform. Under such conditions, vehicle flows, service schedules, and station efficiency will suffer. One proposed but unproved solution to this problem is to platoon the buses. However, more practical methods of speeding the movement of large peak-hour bus movements through stations would be to provide additional passenger platforms, lengthen existing platform areas, and construct bus bays.

The cost, in 1974 dollars, of 20 complex stations in the C-H corridor was estimated to be 16,165,000 dollars for a busway and only 13,278,000 dollars for LRT. A minimum of slightly more than 2 million dollars extra would be required to add elevators to the LRT single-platform stations. A much greater expense would be incurred to equip double-platform busway stations with elevators.

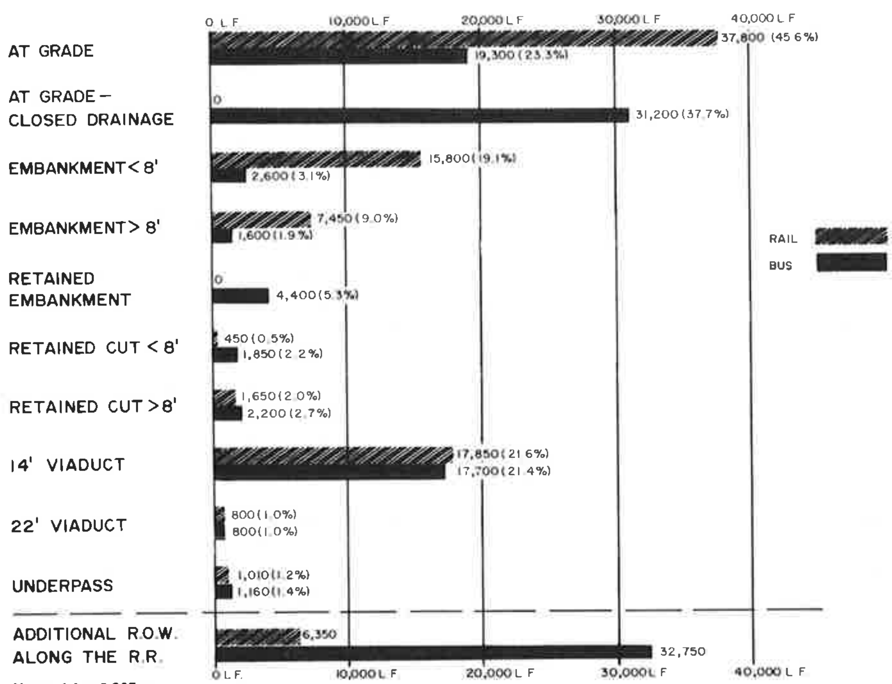
Table 4. Right-of-way requirements and construction costs.

		Right-of-Way Width (ft)			Acres/Mile			Construction Cost (1974 dollars)		
Location	Mode	Minimum	Add for Freight Track Relocation[a]	Total	Minimum	Add for Freight Track Relocation[a]	Total	Cost per Mile	Add for Freight Track Relocation[a]	Total
At grade	LRT and freight									
	Open drainage	45	—[b]	45	5.45	—[b]	5.45	665,000	—[b]	665,000
	Closed drainage	—[b]	—[b]	—[b]	—[b]	—[b]	—[b]	—[b]	—[b]	—[b]
	Busway									
	Open drainage	60	28	88	7.27	3.39	10.66	605,000	380,000	985,000
	Closed drainage	50	21	71	6.06	2.54	8.60	921,000	380,000	1,301,000
Embankment[c]	LRT and freight									
	Open drainage	87	—[b]	87	10.54	—[b]	10.54	855,000	—[b]	855,000
	Closed drainage	—[b]	—[b]	—[b]	—[b]	—[b]	—[b]	—[b]	—[b]	—[b]
	Busway									
	Open drainage	98	28	126	11.88	3.39	15.27	890,000	380,000	1,270,000
	Closed drainage	90	20	110	10.91	2.42	13.33	1,365,000	380,000	1,745,000
Retained cut[d]	LRT and freight	50	—[b]	50	6.06	—[b]	6.06	13,622,000	—[b]	13,622,000
	Busway	53	24	77	6.42	2.91	9.33	15,056,000	380,000	15,436,000
Viaduct[e]	LRT and freight	27	—[b]	27	3.27	—[b]	3.27	6,716,000	—[b]	6,716,000
	Busway	35	27	62	4.24	3.27	7.51	6,909,000	380,000	7,289,000
Subway[f]	LRT and freight	49	—[b]	49	5.94	—[b]	5.94	17,266,000	—[b]	17,266,000
	Busway	52	—[b]	52	6.30	—[b]	6.30	18,818,000	—[b]	18,818,000

Note: 1 ft = 0.305 m; 1 acre/mile = 0.25 hm^2/km.

[a]Horizontal relocation to existing vertical alignment (at grade).
[b]Not applicable.
[c]Maximum height: 19 ft (5.8 m).
[d]Vertical clearance for LRT: 17 ft (5.2 m); vertical clearance for busway: 14.5 ft (4.4 m).
[e]Vertical clearance: 14.5 ft (4.4 m).
[f]Simple, unimpeded cut-and-cover construction including ventilation cost. Vertical clearance for LRT: 17 ft (5.2 m); vertical clearance for busway: 14.5 ft (4.4 m).

Figure 2. Rail and bus profiles.



Note: 1 ft = 0.305 m.

CAPITAL INVESTMENT

Basic, all-inclusive construction costs of the 1990 LRT and freight and busway systems in the 19.4-route-mile (31-route-km) C-H corridor [20 complete stations, 3,750 ft (1144 m) of new cut-and-cover subway, land acquisition, and total grade separation] are estimated (in 1974 dollars) to be 130,032,000 dollars for LRT and 137,540,000 dollars for a busway. The lower LRT construction cost is partially explained by its lesser ROW acquisition requirements because of its ability to share freight track and lower station costs.

The construction cost advantage of LRT for equal facilities in the C-H corridor is relatively insignificant. Rather than indicating a clear advantage for either mode, the analysis should indicate to the observer that for comparable facilities neither mode exhibits a significant construction cost advantage over the other. System capital costs over 60 years are slightly higher for LRT than they are for busway primarily because of the disparity in vehicle investment. For the C-H corridor, LRT and busway total system capital costs, in 1974 dollars, are as follows:

	Cost	
Item	Busway	LRT
Construction	137,540,000	130,032,000
Rolling stock		
Main line	27,378,000	36,400,000
Feeder	5,520,000	5,520,000
Total capital costs	170,438,000	171,952,000

Rolling stock includes initial orders and replacement vehicles over an assumed system life of 60 years (1977 to 2027).

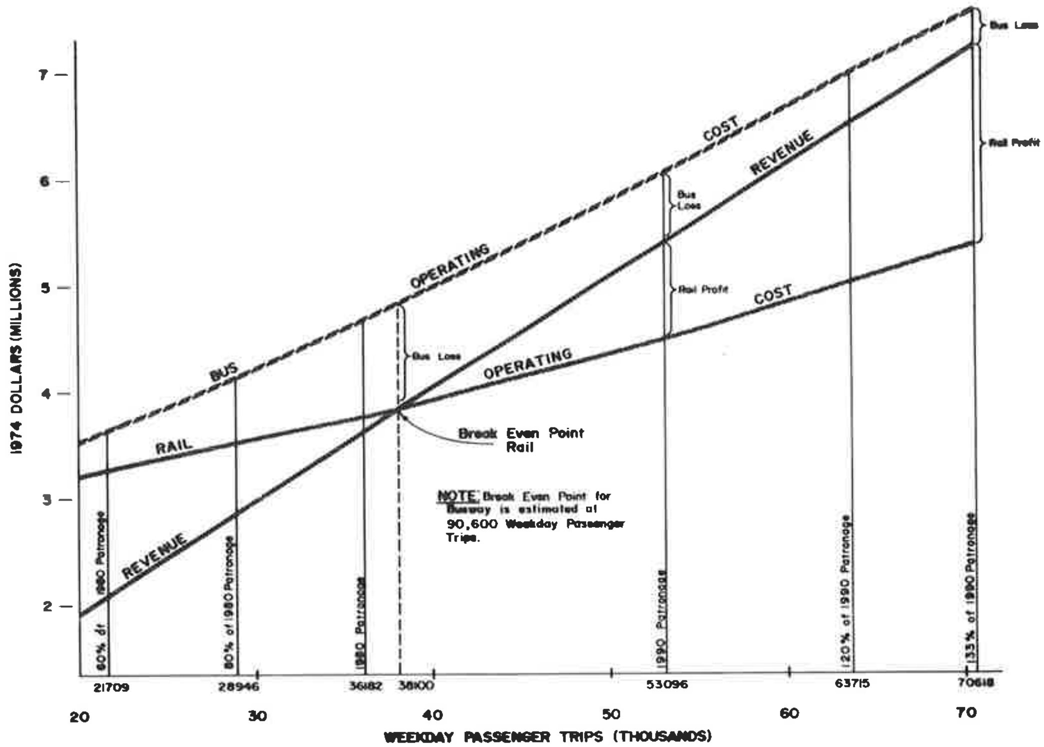
OPERATING COSTS

It is in the specific area of operating cost that LRT demonstrates a clear superiority over busways. The comparative 1990 total system operating costs, in 1974 dollars, for the C-H corridor systems are 4,986,000 dollars for the busway and only 3,351,000 dollars for LRT. LRT evidences a direct operating cost advantage of more than 1.6 million dollars at the projected 1990 level of service. Feeder bus operating expenses are estimated to be an additional 1,053,000 dollars for either the busway or LRT systems.

Figure 3 shows a comparison of busway and LRT operating costs throughout a range of patronage levels. Even at the maximum patronage level shown, revenue has failed to cover busway operating expenses. As patronage increases above the 38,000 weekday trips, the potential for the earning of a revenue surplus by LRT appears to be excellent.

Differences in personnel requirements resulting mainly from the ability of LRT to be operated in trains of LRVs controlled by only 1 operator and the higher per-unit passenger capacity of LRVs compared with that of buses are responsible for superior cost performance of LRT. Total personnel requirements for the year 1990 are 134 busway vehicle operators versus 38 LRT vehicle operators. One hundred twenty-one other personnel would be needed for each system.

Figure 3. Operating cost and revenue versus weekday passenger trips.



CONCLUSIONS

As a proposed solution to transportation problems in Rochester's C-H corridor, LRT exhibits a number of qualitative and quantitative advantages over the busway. Because of its characteristics of labor intensity and passenger capacity, the grade-separated, line-haul busway mode exceeds LRT operating costs. This operating cost advantage of LRT, which is evident at patronage estimates as low as 20,000 per average weekday, increases markedly with C-H corridor ridership growth.

Busway implementation costs in the corridor are slightly lower than those for LRT primarily because of the disparity in vehicle investment. Neither mode exhibits a significant construction cost advantage over the other. In terms of qualitative factors (passenger accessibility, safety, and environment), LRT was judged to be clearly superior to a busway in the Charlotte-Henrietta corridor.

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