Exclusive Busways Versus Light Rail Transit

A Comparison of New Fixed-Guideway Systems

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Busways can offer clear advantages over light rail in many transit corridors. By comparing Pittsburgh's exclusive busways with light rail there and in four other cities—Buffalo, Portland, Sacramento, and San Diego—these advantages can be demonstrated. Light rail transit (LRT) theoretically offers greater capacity. But experience has shown that not only can busways carry just as many passengers, they actually can carry more riders per mile of guideway because busways can be shorter in length and still provide a good level of service. Busways cost less than half as much per passenger to operate than LRT and, in terms of capital cost, busways can be built for about one-fourth of an LRT of equal capacity. Busways can handle the passenger volumes expected in the great majority of urban corridors and, given their expected level of ridership, should prove to be as attractive to development interests as LRT. Simpler to operate and maintain than LRT, busways also provide greater operational flexibility.

IN THE LAST 10 YEARS, transit agencies in a number of U.S. cities have been busy building new fixed-guideway facilities. For Portland, San Diego, Buffalo, and Sacramento, the mode chosen was light rail. Most of these cities have opened their new light rail transit (LRT) systems within the last $2^1/_2$ years and are still fine tuning their operations.

A different mode was chosen in Pittsburgh—busways. Two new exclusive busways were built and opened in the last 10 years—the South Busway and

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the Martin Luther King, Jr. East Busway. A light rail line was also opened in Pittsburgh recently, but not a new one. Port Authority of Allegheny County (PAT) recently rebuilt about half of its old streetcar system to light rail standards.

PAT's favorable experience with operating its two busways is the impetus for this paper, which compares four new light rail systems and one rebuilt light rail system with PAT's exclusive busways. Operating experience on the light rail systems is still somewhat limited, but the author believes that sufficient evidence exists to conclude that busways offer an advantage over light rail for many applications due to their attractiveness to riders, cost-effectiveness, and flexibility.

There are many types of busways, including high-occupancy-vehicle (HOV) and busway lanes, contraflow lanes, and concurrent flow lanes. However, PAT's exclusive busways were chosen to provide a conservative standard for comparison with light rail facilities.

DESCRIPTION OF SYSTEMS

The five cities discussed in this paper are all medium-sized, medium-density cities. Two are older northeastern cities with long-established transit systems and declining populations. The other three are western cities with increasing populations and newer transit systems. Light rail and busway facilities were opened in each city within the last 10 years.

Buffalo has a 6.4-mi light rail line that has both at-grade and subway sections. Buffalo's downtown distribution system operates at-grade on city streets. The initial system was opened in 1985, the last section in 1986. There are 14 stops and stations along the line.

Portland's Banfield light rail line is 15.1 mi long with 27 stops and stations. This at-grade facility was opened in late 1986 and operates on city streets in the downtown area.

Sacramento completed its two light rail lines, which total 18.1 mi in length, in 1987. This at-grade system with its 28 stations and stops is operated in through-routed fashion. An unusual feature of the Sacramento system is the preponderance of single-track line sections. To minimize capital costs, the system was built with seven single-track sections totaling 11 mi. Vehicle headways are limited to a minimum of about 15 min as a result. Downtown distribution is handled on city streets.

San Diego has operated its light rail system longer than the other four cities discussed here. Two lines totaling 20.4 mi, built entirely at-grade, have 22 stops and stations. The South line was opened in 1981, the East Urban line in 1986. Downtown distribution is handled by light rail vehicles (LRVs) operating on city streets.

Pittsburgh has two busways and a rail system. Both busways are two-lane roadways built exclusively for mass transit and are located on separate rights-of-way owned by PAT. The 4-mi South Busway was opened in 1977. It is primarily at-grade with one section in tunnel. Two sections of the South Busway operate in combination with Pittsburgh's light rail/streetcar system. There are five locations where buses can enter and exit the South Busway.

The 6.8-mi Martin Luther King, Jr. East Busway is entirely at-grade except for a 0.25-mi elevated section. The East Busway has six bus access points and was opened in 1983. Both of Pittsburgh's busways utilize downtown streets for distribution.

Pittsburgh's 22.5-mi rail system is composed of two interwoven lines in one corridor, 10.5 mi of which have been rebuilt to LRT standards. The light rail line is primarily at-grade. It has a downtown subway section and two additional tunnel sections necessitated by Pittsburgh's hilly terrain. Old streetcars, which operate on the remaining 12 mi of streetcar line, also operate in the downtown subway and short outer sections of the rebuilt LRT line. The light rail line was opened in sections between 1984 and mid-1987. Two unique features of Pittsburgh's light rail system are its unusually large number of stops and stations—35 within 10.5 mi—and its incorporation of both high and low platforms at major stations to accommodate both LRVs and streetcars. Only the 10.5-mi light rail portion of Pittsburgh's rail system is used in making comparisons in this paper.

Operation of these new light rail systems should still be considered as being in a "break in" period. All five cities are making adjustments to maximize system performance. For example, some cities are fine tuning headway spacing and the number of LRVs that are being entrained. Others, like Sacramento, San Diego, and Pittsburgh, will be phasing in more feeder bus service, which will change the character of their systems.

Operation of Pittsburgh's two exclusive busways has generally stabilized. Nevertheless, over the next few years it is expected that efficiency will be increased through the use of additional articulated buses.

CAPITAL COSTS

Examining capital costs, ridership, and guideway length helps illustrate the differences between the five light rail and two busway systems. As shown in Table 1, the light rail line segments range in length from 6.4 to 15.9 mi, whereas the two busways are 4 and 6.8 mi long. Weekday ridership for the seven systems ranges from 14,000 to 30,000. The range in daily riders per mile is 800 to 4,700.

TABLE 1 CAPITAL COSTS OF RECENT LIGHT RAIL AND BUSWAY SYSTEMS

	System Length (mi)	Weekday Ridership	Ridership per Mile	Capital Cost ($ millions)	Capital Cost per Mile ($ millions)
Light rail					
Buffalo	6.4	30,000	4,700	540	84
Pittsburgh	10.5	18,000[a]	1,700	500[a]	48
Portland	15.1	19,000	1,300	223	15
Sacramento	18.1[b]	14,000	800	176	10
San Diego	20.4[c]	27,000	1,300	175	9
Average	14.1[d]	21,600	1,500	313	23
Busway					
Pittsburgh East	6.8	29,000	4,300	132	19
Pittsburgh South	4.0	18,000	4,500	36	9
Average	5.4	23,500	4,400	84	16

NOTE: Costs updated to 1987 dollars.
[a]Ridership and cost are shown for the rehabilitated portion of the system only. Excludes ridership on the older portion of the line and capital costs that could be attributed to the older system.
[b]Includes two lines 8.6 and 9.5 miles in length.
[c]Includes two lines 15.9 and 4.5 miles in length.
[d]The average length of each line *segment* equals 10.1 mi.

Capital cost ranges from $36 million for the shortest busway to $540 million for one of the light rail lines. Capital cost per mile varies between $9 million and $19 million for the two busways and three of the light rail systems. The other two rail lines range from $48 million/mi to over $80 million/mi. The higher cost of these two systems results from the use of expensive subway construction.

Hence, the busways are shorter in length than the light rail lines, carry about the same number of passengers per day (although at higher rates of ridership per mile because of their shorter length), and cost about the same per mile to construct as lower-cost light rail lines.

The average length of the two busways is 5.4 mi versus an average of 10.1 mi for the light rail line segments. One advantage of busways emerges: they can be shorter than light rail lines, and therefore cost less to construct, yet still carry as many riders. Busways can be shorter because the routes that use them can fan out into residential areas for passenger collection and distribution. Of course, light rail lines typically have feeder bus routes that serve the same purpose. But the time delay and associated rider frustration involved in transferring from feeder bus to an LRV mean that the light rail line probably has to extend further to provide a travel time benefit, hence the length of the LRT systems in Table 1.

Another reason that light rail lines need to extend further is to gain locations for vehicle maintenance shops and park-and-ride lots. Land close to downtown areas is generally not available for these purposes. In contrast, bus maintenance facilities can be located at any suitable site in the service corridor because they do not have to be located adjacent to the busway.

OPERATING COSTS

Past attempts to standardize transit industry operating cost data have been difficult at best. UMTA's Section 15 data are probably the closest thing there is to an industrywide standard. Unfortunately, Section 15 data were not available at the time of this writing due to the newness of the systems being discussed.

Operating cost data gathered for this paper were obtained directly from transit agencies in the topic cities. Care was taken to request the same data from each agency. The operating cost data presented here include the full cost of transportation, vehicle and facility maintenance, fuel and utilities, and administrative overhead in the transportation and maintenance areas. Purposely excluded were agencywide support costs for other functional areas such as administrative overhead, scheduling, accounting, service planning, and so forth.

Feeder bus data were not included in the costs of either mode. This resulted in excluding the cost of operating feeder bus to rail and the cost of that portion of busway routes that lay beyond the busway limits. The operating cost of the downtown distribution portion of the busway routes, however, was included.

The operating cost data collected are shown in Table 2. Annual operating cost for the light rail systems ranged from $5.4 million to $10.5 million versus $3 million to $3.7 million for the busways. Operating cost per passenger ranged from 89 cents to $1.55 for light rail, and from 43 cents to 56 cents for busway. Average cost per passenger for the five light rail systems was $1.21 compared with 50 cents for the busways.

It can be seen from Table 2 that the most cost-effective light rail system was still 60 to 80 percent more costly than the average busway. And on the average, light rail operating costs were 200 percent greater than busway operating costs.

The operating cost and ridership figures shown in Table 2 will change, because the systems are still undergoing operational changes. Probably the best way to standardize an analysis of operating costs would be a systemwide approach similar to that employed in many corridor alternative analyses.

TABLE 2 OPERATING COSTS OF RECENT LIGHT RAIL AND BUSWAY SYSTEMS

	Annual Operating Cost ($ millions)	Operating Cost per Passenger[a] ($)
Light rail		
Buffalo	10.5	1.17
Pittsburgh	8.1	1.50
Portland	5.4	0.95
Sacramento	6.5	1.55
San Diego	7.2[b]	0.89
Average	7.5	1.21
Busway		
Pittsburgh East	3.7	0.43
Pittsburgh South	3.0	0.56
Average	3.4	0.50

NOTE: Operating costs are for calendar year or fiscal year 1988.
[a]A ridership annualization factor of 300 was used in the calculation of operating cost per passenger.
[b]Includes operating cost data obtained from the property minus a portion attributed to nonoperational overhead that was estimated from the American Public Transit Association 1986 Operating Report.

Nevertheless, it is the author's opinion that the basic differences in operating cost per passenger favoring busways will remain.

OTHER FACTORS

To make a clear distinction between the two transit modes, busways and light rail can be compared in several ways: planning, design and construction, operation and maintenance, capacity, passenger satisfaction and image, capital and operating requirements, and development potential.

No significant difference exists in the manner in which planning for these transit systems is conducted. Indeed, both types of fixed-guideway systems fall under the same federal Alternatives Analysis/Environmental Impact Statement process. The following factors are considered in this process regardless of mode: cost, level of service, ridership, and environmental impacts. However, estimation of capital and operating cost for busways should be simpler and more accurate than for light rail because of the greater prevalence of the bus mode, and because of the similarity of busways to highways in terms of construction and design characteristics.

In terms of design and construction, light rail systems present more difficulties for three reasons:

- Light rail has some complicated design characteristics, including electrification, train control, computerization, rail alignment requirements, weight, and specifications of LRVs.
- Light rail lines are more likely to have sections in subway, leading to special design and construction requirements.
- Busways are essentially simple highways and can be designed and constructed as such. Significantly more design and construction firms are experienced in highway design than light rail design.

Busways are also simpler to operate and maintain than light rail systems. The need for operations control centers is unique to rail. Even the vehicle maintenance facilities are more complicated to operate and maintain. The requirement for separate but interrelated communication, signal, power, and propulsion systems for LRT also contributes to complexity for training, operating, and maintenance.

Busways permit far more flexible operation than light rail. With busways, the same vehicle that performs the feeder system function also performs the line-haul function. Further, buses going in the same direction can pass each other more easily than light rail cars, particularly when off-line busway stations are used. Broken-down light rail cars are much more likely to tie up the system.

Light rail operates at a greater theoretical capacity than busways, but this advantage does not necessarily hold up under closer examination. The capacity of light rail is about 200 passengers per vehicle times 40 vehicles/hr (90-sec headway) or 8,000 passengers/hr. Articulated buses operating at 60-sec headway yield 6,000 passengers/hr, assuming 100 passengers per bus.

Of course, light rail vehicles can be entrained, thus providing two, three, or more multiples of this 8,000/hr capacity. However, three factors can greatly increase busway capacity as well. First, it is relatively easy for two buses to use a single off-line station at the same time, thereby doubling capacity. Second, through buses that pass buses stopped at a station increase capacity even more. Third, busways can serve as a "shunt facility" on which buses that have performed passenger pick-up on local residential streets can bypass traffic congestion and travel nonstop to downtown areas at a high rate of speed. These nonstop buses can then provide passenger distribution on any number of downtown streets.

For these reasons, busway capacity can be 10,000 riders/hr or greater. Expanding the capacity of 10,000/hr to a daily ridership average yields 67,000 riders/day, assuming that 15 percent of daily riders are riding in the peak hour in the peak direction. This is more than twice as high as the ridership of any of the new light rail systems. Therefore, although light rail has a greater theoretical capacity, busways can easily carry the expected ridership in the great majority of urban corridors.

In terms of passenger satisfaction and image, neither transit mode can claim a clear advantage. Although busways and light rail provide equivalent levels of service in terms of travel time and vehicle comfort, busways have an edge in that transfers to and from feeder bus are less likely to be required. However, due to the prevalence of light rail systems as opposed to busways, light rail is considered to have an image advantage that belies the comparability of customer service for the two modes.

Capital costs per mile are similar for some of the light rail and busway systems shown in Table 1. However, light rail's longer length and more frequent use of subway clearly leads to higher total capital cost.

Given the significantly lower busway operating costs shown in Table 2, why is it commonly stated that rail is less labor-intensive than bus? It is true that light rail requires fewer operators for a given level of ridership based upon the ability of each LRV to carry about twice as many passengers. This ratio of 2 to 1 holds only during peak periods, however. During other time periods the number of operators for the two modes is closer to being equal because policy headways, rather than capacity, play a greater role in scheduling service. However, light rail requires personnel in other job categories such as track crew, structures crew, switch maintainers, overhead lines crew, signals and communications crew, and substation maintainers. This increases the personnel requirements for light rail, thereby contributing to higher operating costs.

In terms of development potential, rail advocates claim that their mode spurs development. It seems clear that the ability of fixed-facility transit systems to move large numbers of people would be attractive to those developments that are located at or near stations. However, there is no reason to think that attractiveness to development is inherent in a specific mode. As long as the number of riders is equal, there should be equivalent development potential; as shown in Table 2, the newer busways and light rail systems typically carry the same range of riders.

SUMMARY AND CONCLUSIONS

The recent investments and operating experience of San Diego, Pittsburgh, Portland, Buffalo, and Sacramento provide the transit industry with new information about fixed-guideway systems. In nearly all areas of comparison, busways appear to offer advantages over light rail systems.

Experience of the past few years has shown that busways carry as many riders as light rail systems do. Because busways can be shorter in length and still provide a good level of service, they carry more riders per mile of guideway.

The operating cost advantage is such that busways cost less than half as much per passenger to operate than light rail. On the capital side, the averages presented in this paper show that an $80-million busway carries as many riders as a $310-million light rail system.

The capacity of busways is sufficiently large to carry the expected ridership in the great majority of urban corridors. And, on the basis of their expected level of ridership, busways are as attractive to potential development as light rail.

In addition, busways and bus systems are simpler to operate and maintain, and training requirements are less in comparison to light rail. Finally, busways provide greater operational flexibility than light rail, particularly in the ability to skip stops or to not stop at any stations along the busway if passenger demand warrants. Express and local services can be better tailored to suit patron requirements.

Those planning new fixed-guideway facilities are encouraged to consider busways. The advantages are simply too great to ignore.