Ridership Forecasting Considerations in Comparisons of Light Rail and Motor Bus Modes

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From the standpoint of ridership forecasting, light rail transit (LRT) and motor bus modes vary in their attributes. Specific modal attributes (stations, passenger space and seating, ride quality, air pollution, noise, schedule reliability and safety, system identity and public orientation, familiarity) can be rated for LRT, busway, and street bus systems and analyzed. While LRT is rated highest in this comparison, the implications for mode choice behavior require more intensive research. Another factor in mode choice is the hypothesis that LRT and other rail transit modes have stronger potential to induce adjacent real estate development in contrast to busway operations. The results of a survey of perceptions of real estate decision-makers in eight U.S. cities operating either LRT lines or busways indicate that decision-makers tend to perceive LRT stations as significantly more desirable than busway stations for commercial real estate development. Respondents' perceptions regarding public orientation to LRT versus busway routes and service levels also score LRT higher, but analysis did not determine this difference to be statistically significant. Improvements in the acccuracy of ridership forecasting are essential, particularly in terms of differences between LRT and motor bus as alternative transit modes, and some approaches for further investigation can be defined.

FOR MANY COMMUNITIES CONSIDERING the installation of new fixed-guideway rapid transit systems an analysis of alternative transit modes frequently leads to an evaluation of conceptual light rail transit (LRT) counterposed to motor bus configurations for a given application. One of the

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major focuses for most analyses is the ridership attracted to the proposed alternatives.

Taking a specified pattern of land use and other data as input, conventional ridership forecasting methodology typically calculates time and out-of-pocket cost "disutilities" or "impedances" to project ridership on each modal configuration for a selected design year. The result—commonly expressed as a discrete patronage volume—plays a critical role in the decision-makers' process of evaluating the alternative systems.

However, many professionals point to weaknesses in current ridership forecasting methodology. Some analysts refer to deficiencies in the mode choice component of forecasting, while others cite land-use impacts on potential ridership that may be neglected. Inaccuracies in accounting for different characteristics in ridership generation between transit modes (e.g., LRT versus bus) could lead to unwise investment decisions.

Over 20 years ago, Hille and Martin observed that "modal split models have been only moderately successful." While commenting that "modal choice decisions appear to be more complex than generally thought," they noted that "as few as two variables have been used (travel time and cost) to predict modal choice." They concluded that "the development of valid prediction models for modal choice seems to rest on incorporating several factors into the prediction milieu" and improving model sensitivity to "the complex interrelationships" among such factors (*1*).

Some 10 years later, Spear observed that "a major problem confronting both transportation planners and researchers in travel behavior is how to build travel demand models that are sensitive to transportation system attributes other than time and cost" (*2*). Similar observations were made by Algers et al., who noted (*3*):

> Research on travel choice has for the past 10 years been concerned with the value of time savings and estimates of time and cost elasticities. The role of comfort and convenience was always referred to as important but rarely was incorporated explicitly as a policy-oriented variable in econometric models.

These researchers developed a model incorporating transit seat availability as an indicator of comfort and convenience factors, such as the need for automobile availability during working hours, and applied the model to work travel in metropolitan Stockholm. Their studies determined that, in addition to other influences such as waiting time, "the level of the travel-time value also depends to a large extent on the in-vehicle comfort in terms of seating opportunities. The overall travel-time value decreases substantially when commuters can enjoy a seat as compared to when they cannot." The only

modal difference analyzed was in terms of transfers; here it was found that rail-to-rail and bus-to-rail transfers were significantly less onerous than bus-to-bus. The researchers concluded that this was due to the greater comfort of rail stations, the lower schedule reliability of street buses, and the difficulty of synchronizing interconnecting bus routes (*3*).

In a paper on ridership attraction to LRT, Jessiman and Kocur pointed out that, at least for some riders, schedule reliability might be a more important consideration than conventional time and cost factors. While presenting a modeling approach that based impedance solely on travel time and cost, they suggested that other factors such as a transit mode's level of passenger comfort could play a significant (though currently unquantified) role in ridership attraction (*4*). Despite such concerns, travel cost- and time-related factors continue to be virtually the sole attributes considered in most current forecasting models. Capital Metro's rapid transit sketch planning model in Austin, Tex., did incorporate a "convenience" variable representing number of transfers, but this could also be interpreted as a time-related convenience attribute (*5*).

Differences in passenger attraction to alternative modes independent of the usual time and cost impedance characteristics have been found in some studies. Finding that some travelers surveyed indicated a preference for the slower mode, Spear suggested that "attributes are not perceived in terms of absolute differences but rather in terms of some difference in satisfaction for the alternatives" (*2*). Some conventional forecasting procedures have also been criticized for deficiencies in accounting for mode-specific attributes, a circumstance that could more directly affect LRT versus bus evaluations. Referring to "sketch-planning projections of questionable veracity, "Tennyson has suggested that ridership forecasting should take into account the "inherent passenger appeal" of LRT, citing attributes such as "the wider aisles, smoother movement, absence of odor and engine noise, all-weather reliability . . ., and obvious fixed route to which people can relate." Tennyson concludes by observing that "the estimating process may be reasonably good, but the pressure on the estimators to produce a 'winning' estimate may be unprofessional and irresistible" (*6*).

Similar concerns have been raised elsewhere. For example, in response to the solicitation of views regarding Capital Metro's demand estimation methodology, it was suggested that several passenger-attracting attributes of LRT should be considered for inclusion in the proposed model: (1) route understandability—the public's "enhanced sense of the permanence and presence of the system and where it goes," (2) riding comfort, and (3) attraction of real estate development near LRT stations. However, it was acknowledged that "no reliable studies contrasting rail vs. busway systems up-and-down have been conducted which provide hard, empirical data on

these phenomena" (*7*). Inclusion of such factors in Capital Metro's forecasting process was subsequently rejected on the grounds that "biases in mode choice models which are different between rail and bus modes" are unacceptable to UMTA, and that "we must use technical methods which are generally accepted within the profession and which are acceptable to UMTA" (*8*).

Nevertheless, the presence of qualitative differences between modes—even under conditions of time and cost equivalence—is propounded as a significant modal choice factor by numerous analysts. Suggesting that a variety of behavioral variables may be relevant to the modal choice process, Feldman has pointed out that "different modes, while performing the same essential functions in terms of origins and destinations apparently satisfy the needs of their users in different ways" (*9*).

Certainly, these are issues that could have implications not only for present and future fixed-guideway planning but also for the accuracy and validity of demand forecasting. Contrasting operational differences between LRT and motor bus configurations are readily modeled today in terms of different schedule speeds and running times, headways and waiting times, number of transfers, etc. But possibly different public behavior toward other modal attributes, and trip-generating differences in land-use impacts, is widely disregarded in both research and practice.

Does the public indeed perceive LRT as inherently more comfortable and reliable than motor bus transportation? Is LRT route structure more understandable? Does an LRT line tend to be more attractive to real estate development than a street bus route or a busway? How might researchers go about evaluating such factors? And if differences are validated in regard to certain modal attributes, how might these be quantified and incorporated as modifications of demand forecasting procedures?

PASSENGER MODE CHOICE FACTORS

The significance of passenger comfort and other perceptual characteristics in travelers' choices between mass transit modes is suggested by many analysts. Researchers developing a modal-split model for the Buffalo area, for example, recognized that factors such as comfort and crowding were important indexes of service quality, but "the difficulty with these factors was lack of evidence . . . . There was, therefore, no real choice open to our research workers, and these factors were excluded" (*10*). Feldman's marketing-oriented survey of travelers' attitudes in the Chicago area likewise found that modal dependability and comfort tended to rival speed and convenience in ranking by respondents—well above trip cost, in fact (*9*).

In assessing implications for LRT versus bus systems planning, three issues are involved: (1) whether there are qualitative (other than operational)

differences between these modes, (2) to what extent these differences are perceived by the public and are significant in their modal choice behavior, and (3) how such differences might be quantified and incorporated in predictive models capable of generating numerical passenger forecasts.

Comfort and Convenience

Wide variances of opinion (and, in some cases, data) exist in regard to whether there are differences in comfort levels between rail and bus transit modes. In the development of modal-split models in the 1960s and 1970s, comfort differences between modes were deemed insignificant in many studies. Evaluating rail versus bus alternatives for Washington and suburban Chicago, for example, Pratt and Deen observed that "it seemed not unreasonable to assume that passenger loadings and transportation equipment conditions would in the aggregate not seriously affect sub-modal choice" (*11*). The consulting firm of Coverdale & Colpitts, Inc., has observed that "from the standpoint of riding comfort, there does not appear to be any great difference between buses and the types of vehicles employed in fixed guideway systems. Seat configuration, air conditioning, lighting and other features are quite comparable" (*12*).

The existence of distinct differences in comfort levels between LRT and bus, however, has been cited by others. In an article written when abandonment of streetcar lines was still widely favored, Ferreri noted that "transit riders who remember the spacious and comfortable PCC [President's Conference Committee] trolley cars may not agree that there has been any progress at all." Pointing out that "PCC trolley cars are rapidly disappearing from the urban scene, to be replaced by the diesel-powered transit bus," Ferreri observed that operational advantages, such as "increased flexibility in modifying routes," were being obtained "with passenger comfort as a secondary consideration; bus operations are accompanied by what some feel are offensive exhalations of smoke, noise and odor" (*13*). Calling for improvements in bus design, an industry magazine article noted that "present buses emit noise, noxious gases, and odors which are objectionable to individuals and contribute to the degradation of the urban environment" (*14*). Even an International Road Federation news article promoting bus-based rapid transit acknowledged that "the aesthetic and passenger comfort features of buses commonly used in U.S. local and commuter services certainly need improvement" (*15*).

Engineers reporting the results of an LRT versus busway feasibility study for Rochester concluded that "while individual preferences may vary, there is no doubt that the rail vehicle with wider seats, wider aisles, wider doorways and high level boarding provides a more pleasing environment for the

traveler" (*16*). Citing evidence that LRT operations have tended to retain ridership substantially better than surface transit as a whole, Tennyson attributes this success, in part, to amenities such as absence of "on-board engine noise or smell," absence of "unexpected swerving or sudden stops," ability of passengers to read while commuting, smoothness of ride, and availability of double doors "to speed loading and unloading," among other factors (*17*).

A leading textbook on urban public transportation, while acknowledging that the riding comfort of buses "in straight running on well-maintained streets is excellent," observes that in conditions of heavy traffic and frequent maneuvering "vehicle sway and high jerk rates often make standing uncomfortable." In addition, buses' "noise and air pollution are often objectionable, particularly at terminals and stops due to engine idling and frequent accelerations." On the other hand, "rail transit provides better riding quality than any other mode." Furthermore, "the spaciousness of rail vehicles allows the use of a larger space per seat and design of wider aisles than in buses. Sitting is therefore generally more comfortable, and standing is more acceptable for short to medium travel than in buses" (*18*).

System Identity and Public Orientation

By its nature, LRT's trackage, electrical supply, and stations accord it a high profile. This highly visible route structure, some analysts contend, may enable the public to recognize and understand a line's location, connectivity, and service—giving potential riders an enhanced sense of the permanence and presence of the system—and may be simpler and easier to comprehend and retain than is the case with bus systems.

The simplicity, identity, and clearer image that may characterize what Tennyson has called LRT's "self-proclaiming route" (*17*) could foster an important "user-friendly" sense of orientation to the system among the public that could influence patterns of modal choice behavior distinct from those of bus alternatives. (Likewise a busway may exhibit similar influences to some extent in contrast to local street bus service.)

The implications for ridership forecasting could be quite significant. Not only might such popular awareness of and orientation to the system produce greater short-term public acceptance of a new installation, but, sustained over time, potentially greater cumulative ridership for the mature system.

Assessment of Specific Factors

To evaluate the issue of mode-specific attributes such as passenger comfort and schedule reliability in regard to LRT and bus facilities and vehicles, it is

worthwhile to consider specific components of these attributes, especially as they have been examined in various research studies.

Stations

Transit stations or stops can vary drastically in amenities, from fully climate-controlled enclosures to a simple pole marker. While the quality of such facilities undoubtedly influences public perceptions, this has not been adequately measured in terms of mode choice behavior. Assessment of existing and proposed new systems indicates that, per length of route, LRT tends to have substantially more well-defined stations with amenities such as sun and rain shelters and route information. Busway systems tend to have some well-defined stations together with simple pole-marker stops off the guideway in suburban and downtown areas. Street bus systems rarely have shelters or stations, perhaps only at a major interchange or park-and-ride location. Based on research such as the previously cited Stockholm study (*3*), it is reasonable to assume that station facilities as a passenger-attracting feature are greater for LRT than bus modes, and greater for busway than street bus, but additional research is needed to quantify this attribute.

Passenger Space and Seating

Because dimensions of LRT and bus vehicles vary substantially, firm conclusions on this factor are elusive. Light rail vehicles (LRVs) tend to have one or two more doors per vehicle than buses, and doors tend to be 1.2 ft wider (*18, 19*); thus LRVs tend to provide greater boarding convenience than buses. Finn's comparative study of transit modes, however, based on observed peak operations, concluded that space on LRVs averaged 0.26 to 0.29 m^2 per passenger while on buses it averaged 0.32 to 0.59 m^2 (*20*). For non-crush-load and off-peak conditions, however, LRT may be more spacious. A vehicle comparison in Minneapolis indicates 265 ft^2 of aisle space for a typical LRV versus 73 to 100 ft^2 for a standard or articulated bus (*21*).

While LRVs tend to have greater passenger capacity, buses tend to offer approximately as many seats (*18*), with a higher proportion of seated passengers in service conditions (*19*). The importance of seat availability has been observed in the Stockholm study previously noted (*3*). Experience in some new West Coast LRT operations likewise indicates significant passenger resistance to standing; similar experience could be anticipated in new fixed-guideway services in the Southwest and South.

Implications for passenger-attractiveness would need further study. This should also consider trip distance as a factor—e.g., seat availability is

possibly more important for longer trips, but these tend to originate closer to line end-points where more seats may be available. Because of all the trade-offs indicated, in this analysis LRT and bus must be considered approximately equal and moderately comfortable modes in regard to this factor.

Ride Quality

Jerk rate (rapid change in acceleration) is a common measure of ride comfort. While LRVs provide much higher acceleration than buses, the Finn study concludes that buses are highest in jerk "because their acceleration is incontinuous" (*20*). Ride quality at running speed is probably also superior for LRT due to the predominantly greater smoothness of steel rails versus asphalt or concrete and the suspension and weight qualities of modern LRVs. It is also likely that busway operations would yield superior ride quality, on average, than stop-and-go street bus service. The effect of these advantages on public perceptions, however, needs further research.

Air Pollution

While some air pollution is associated with both electric and internal-combustion transit modes, only with motor buses is the pollution produced directly by the vehicle. Except for conditions of poor maintenance, exhaust odor inside buses is no longer a problem. However, objectional levels of exhaust fumes could exist in roofed or enclosed waiting areas, during heavy accumulations of vehicles (e.g., bus "platoons"), during long idling, or under conditions of poor maintenance. While public perception may be worse than the actual problem, it could have a direct bearing on mode choice and should be researched.

Noise

Both exterior and interior noise levels are substantially higher for buses than LRVs by some 5 to 15 dbA (*19, 20*). Exterior noise could be a problem for passengers waiting in bus stations. Since, as Finn notes, vehicular frequency tends to be much higher for bus operations, noise exposure would be more frequent.

Schedule Reliability/Safety

Taken together, reliability and safety may contribute to passengers' sense of confidence in a given system. In regard to safety, an LRT promotional booklet

produced by Rhein-Consult cites an LRT accident rate about half that of bus measured in hours of traffic participation (*22*). The DeLeuw, Cather state-of-the-art review, using subjective indicators, rates LRT and bus as roughly equal in accident potential (*19*). An LRT/bus versus all-bus comparison for Harrisburg calculated substantially lower annual accidents for the LRT/bus system (*23*). On the other hand, an analysis of U.S. data from the early 1970s indicated an accident rate, measured in passenger-miles, some 30 percent higher for LRT than bus (*24*).

In terms of schedule reliability, the DeLeuw, Cather review, based on Pittsburgh projections, indicated a 99.5 percent schedule reliability for LRT versus 99.6 percent for bus (*19*). Finn's more comprehensive study, however, reports LRT schedule reliability to be twice that of bus (*20*). Vuchic's study of the Washington, D.C., Shirley Busway in the early 1970s indicated that only 46 percent of buses using the facility arrived on time or no more than 6 min late (*25*).

Although there are some conflicts in the data analyzed, it is reasonable to rate LRT highest in this factor; likewise busway service could be expected to provide somewhat greater service reliability than local street bus operations.

System Identity/Public Orientation

Vuchic observes that "a strong image and identity of rail transit, caused by the simplicity of its services and permanence of its lines, represents a major element of passenger convenience. This strong recognition contributes greatly to the large passenger-attracting ability of rail transit" (*18*). Tennyson refers to LRT's "obvious fixed route to which people can relate" (*6*).

Although a busway's fixed facilities undoubtedly have similar effects, these may be diluted by the meandering, confusing patterns often followed by routes leaving the guideway in suburban and downtown areas. Vuchic's analysis of the Shirley Busway presents an example; he notes the "extreme complexity of the service" as a factor in the failure of the system to tap substantial latent demand. Vuchic cites one major route with 48 subroutings and another with 21 subroutings. In central Washington, the study found, each bus followed one of three routings to one of three different terminals. Even the management of the major transit system using the busway had "no clear idea of where all its stops are" at the time of Vuchic's study (*25*).

Regarding local bus routes, Vuchic has indicated elsewhere that "the identity of bus services is very poor because of lack of fixed facilities," although he notes that this drawback can be partially overcome by good public information services (*18*). Based on such observations, it is reasonable to conclude that LRT rates highest in this factor, while busways, with their

guideways and occasional stations, tend to have greater system identity than street buses.

Familiarity

It must be acknowledged that for totally new systems, LRT may initially be a less familiar and more intimidating transit alternative than the bus, especially for current bus riders; likewise a busway would be rather less familiar than a local bus running on streets. (On the other hand, LRT may represent a more appealing mode for some individuals precisely because it is different.) While this unfamiliarity should disappear over time, it may affect mode choice.

Summation

Conclusions from this analysis of specific modal attributes are summarized in Table 1 for LRT, busway, and street bus. Each mode is rated on a scale of 1 (low) to 3 (high) for each attribute. While LRT clearly is rated highest in this comparison, the implications for mode choice behavior are a separate issue. (It should be noted that with electric trolley buses vehicular air pollution and noise are not problems. However, for reasons of cost, performance, and other considerations LRT versus trolley bus comparisons are extremely rare. In any case, the subject of public perception of trolley bus comfort versus that of LRT lies outside the scope of the present discussion.)

TABLE 1 RATING OF MODES BY SPECIFIC ATTRIBUTES AFFECTING RIDERSHIP

	LRT	Busway	Street Bus
Stations	3	2	1
Passenger space and seating	2	2	2
Ride quality	3	2	1
Air pollution	3	1	1
Noise	3	1	1
Schedule reliability/safety	3	2	1
System identity/public orientation	3	2	1
Familiarity	1	2	3
Total	21	14	11

Exploring Modal Choice Behavior

If there is a greater passenger-attractiveness of LRT, it is unlikely that it is individually measurable for each of the separate factors discussed; rather, it would more probably take the form of an aggregate enhanced "image" perception by the public. The need for research to examine public perceptions and to evaluate modal choice implications of these mode differences is definitely indicated—particularly so in the case of federal involvement. While UMTA allows the incorporation of a bias constant in mode choice models that reflect differences in comfort, convenience, and "other unincluded variables" between transit, single-driver automobiles, and carpools, the agency notes that "these biases are computed in the development of the model based on the observed behavior of a sample of travelers." However, UMTA emphasizes that incorporating similar biases between mass transit modes (e.g., LRT versus motor bus) must be based on acceptable research data (*26*).

Use of a sensitivity scale, perhaps as a means towards developing a generalized attribute variable such as Spear has described (*2*), might represent a productive approach. Cities currently operating both LRT and bus-based systems would undoubtedly be the most fruitful areas to conduct research, since public familiarity with both modes would be useful. If significant differences in public mode-choice behavior toward LRT and bus are ultimately quantified, alterations to modal choice models could take the form of incorporation or alteration of bias constants (per UMTA's example), modifications to coefficients of current impedance variables, or perhaps the development of new variables and coefficients using standard regression and curve-fitting techniques.

REAL ESTATE DEVELOPMENT AND RIDERSHIP

Another characteristic that may lead to significant differences in ridership between LRT and motbr bus modes is land use impact. Substantial evidence exists that LRT stations can function as strong attractors of adjacent clusters of real estate development. Such effects, if they could be quantified and predicted with some accuracy, undoubtedly would have major implications for rider forecasting.

As Vuchic points out (*18*),

> The most significant single impact of rail transit is its strong influence on land use and the form of cities. The permanence of rail transit lines and stations generates the developments of land use which interact with and

> depend on the high-quality transit service. Therefore, in time, stations generate their own patronage and "anchor" themselves at their locations. With good planning and urban design, this interaction can be used for the creation of attractive urban environments.

This latent potential to function as a tool to attract development and to stimulate and guide urban growth has been emphasized by Priest of the Urban Land Institute (*27*):

> Urban rail transit can promote development and redevelopment in the major cities of the United States. It can do so not only in the older cities of the northeastern and north central regions, but also in the auto-oriented cities of the South and West.

Knight reports the results of a federally funded study of the effects of rapid transit on land use, conducted in 1977, which found that "recent major rapid transit improvements have been important inducements to intensified development near stations both in CBDs [central business districts] and in outlying areas . . . ." While other factors such as land availability, appropriate economic conditions, and supportive public land use policies were essential, Knight observes, "major transit improvements often act as catalysts in the process of land use change . . . ." [Regarding LRT, it should be noted that the study found that "evidence of early impact is inconclusive" since the systems were either uncompleted or only recently inaugurated (*28*).]

A later study by Cervero focused on LRT's land use impact and concluded that "the urban development possibilities of LRT appear substantial, though only if other pro-development forces exist." Land use incentives and supportive local policies were deemed essential adjuncts to foster desired development, Cervero emphasized (*29*).

Considerable circumstantial evidence exists that indicates that newly installed LRT lines do attract or reinforce significant adjacent real estate development. The following summary provides examples:

- San Diego Trolley: Important influence on suburban development near stations is reported; several transit center and joint development projects are noted; a $120 million, 800,000-$ft^2$ mixed-use development is planned for downtown with an integral LRT station (*30–32*).
- Buffalo Metro Rail: LRT has been directly associated with downtown revitalization; over $200 million in private downtown construction was committed during the first year of construction; adjacent downtown office space is expected to increase by one-third; over $100 million in private development has occurred near one station alone; an extensive Theater District reconstruction boom is associated with the new LRT line (*29, 33*).

- Portland's Metropolitan Area Express (MAX): $214 million in adjacent private development was completed upon opening of the line; an additional $300 million is planned or under construction (*34*).
- Pittsburgh's LRT: The system has helped generate $1.5 billion in downtown construction; local developers are exploring the feasibility of commercial and office complexes at suburban stations (*35, 36*).
- Sacramento's LRT: RT Transit cites a list of developers who have invested in facilities to improve connection of their developments with LRT stations. Illustrative major impacts include a 465,000-ft^2 state office development with 3,000 employees and nearly 1 million ft^2 in adjacent office and retail development (*37*).

While the development-inducing effects of rail transit are generally perceived, professionally accepted ridership forecasting processes typically do not take them into account. The following are suggested as some of the most important reasons for this:

- Precise levels of development that could be attracted are extremely difficult to quantify.
- Real estate development tends to be unpredictable, with a staggering array of influential variables such as size and density of service area, economic conditions, length of line, character of immediate station sites, public attitude towards transit, local government policies, etc. Furthermore, land use regulation in U.S. cities is quite weak, leaving development significantly dependent on free-market forces.
- Researchers encounter great difficulty in distinguishing between transit-induced development and development that would occur otherwise.
- In alternatives analyses, typical procedures currently assume no differences in land use influences between different modes. In addition, inclusion of transit-induced traffic generation changes would likely increase the complexity and cost of modeling procedures.

These problems notwithstanding, it seems unrealistic for ridership forecasting efforts to assume, in effect, that a relatively massive investment in fixed-guideway transit stations, and its dramatic alteration of an urban landscape, will have no more effect on land use patterns, and experience no greater adjacent concentration of activity centers and other ridership generators, than ordinary local bus service.

Comparative Influences: LRT Versus Bus

It is generally recognized that all major public transport passenger facilities, from fixed-guideway stations to bus terminals and park-and-ride locations, can attract real estate development to some degree. However, fixed-guideway systems—particularly rail—are widely perceived to have especially strong influence both in the quantity of development attracted and in areawide impact. As a working paper prepared by the Austin (Texas) Planning and Growth Management Department observes (*38*):

> The influence of transit in stimulating development increases as the permanence and volume of the transit system increases. Bus systems which can be easily rerouted thus have less effect on development patterns than fixed guideway systems that represent a significant public commitment and generally carry a larger volume of passengers.

Directly discussing the relationship of LRT and development, Paaswell and Berechman have stressed a major difference between bus and rapid transit modes (*39*):

> Buses take people to where activities are and can follow the movement of activities over a wide geographic pattern. On a rapid transit line, there is a more active land use/transportation relationship. Large numbers of people are concentrated at specific spots, and activities become linked to the stops. Transit induces changes in station areas that often would not occur if no transit were there.

While the impact of most LRT facilities in terms of attracting or stimulating adjacent development seems evident, if not precisely quantifiable, the land use impact of busways is more debatable. Knight's 1977 study led him to conclude that "busway improvements have had no discernible impacts on land use to date" (*28*). In comparing exclusive busways versus LRT, Calgary's Transportation Department observed that "one of the advantages of a bus system is its flexibility. However, this characteristic reduces commitment to the facility. Therefore, busways do not influence land use to the extent that rail systems do" (*40*).

On the other hand, substantial real estate impacts are cited in connection with Ottawa's new busway system (*41*):

> The system operates just like any other rapid transit facility with vehicles, which in this case are buses, stopping at every station. In addition, ramp access is provided for express- and limited-stop routes so that a direct no-transfer service is provided between the residential street system and downtown and other major trip generators. . . .

> Much has been written about the development impacts of rapid rail transit. Preliminary indications in Ottawa-Carleton show that a similar relationship exists for busway systems. High-rise construction is already occurring at some stations and an integrated shopping centre/transitway station is nearing completion. In total, $600 million in new construction is already under way or in the final planning stages around Transitway stations.

It must be noted, however, that Ottawa planners possess some of the strongest land use regulatory powers existing in North America. Bonsall reports that a legislatively mandated land use and transportation plan was enforced to guide development in desirable patterns. Based on giving "precedence to public transit over all forms of road construction or road widenings" and implementing the bus-based rapid transit system, Ottawa's planning regulations require developers to concentrate developments near transit, orient buildings and private accesses to transit stops, provide walkways and transit-only roadways through developments, and enter into agreements with the municipality on matters such as staging construction to accommodate transit (*41*). While such formidable land use controls may be envied by many U.S. planners, it is most unlikely that the massive legal, political, and other obstacles to their implementation in U.S. cities could be overcome.

Despite the Ottawa busway's obvious success, many U.S. professionals and decision-makers continue to perceive a stronger potential for LRT in achieving land use objectives, all things being equal. Discussing LRT versus busway alternatives, San Jose-area planners concluded that "the light rail alternatives . . . generate the most opportunity for new development around major stations with a significant amount of developable land. The alternatives with a busway would provide slightly less opportunity. . . ." However, the planners noted that "light rail or a busway could be a catalyst to create the situation for this station area development to occur . . ." (*42*). Discussing the potential for transit-induced development in Seattle, Kask concluded that "high-capacity transit located in nonfreeway corridors would be more likely to generate significant transit-induced development; rail impacts would be the most significant" (*43*).

A likely factor in such conclusions is the smaller number of passenger stations associated with busway systems, due to reliance on collection and distribution activities off the busway. In addition, smaller congregations of passengers in each station could be expected for the same reason. Finally, mode-specific attributes such as air pollution and noise generated by motor buses may additionally act to suppress private developer interest in bus transit facilities in contrast to LRT, and thus may diminish the attraction of nearby real estate development and, ultimately, the ridership such development can generate.

Summation

Widespread circumstantial evidence of transit-induced development leads many planners to conclude that fixed transit facilities have the potential, in consort with other forces such as economic conditions, market demand, private developer cooperation, and public policies, to attract real estate development and thus create and expand their own traffic generators. Stations, serving as collectors of people, undoubtedly are the major influence in this phenomenon. LRT and other rail transit modes appear to have especially strong potential to attract such development; busway and other bus stations would seem to have significantly more land use effect than street bus operations.

Despite difficulties in predicting and quantifying these effects, research to enable their incorporation in ridership forecasting appears merited. For LRT, such adjacent development not only can produce short-term traffic generation to feed the LRT service, but may promise even more significant rewards in terms of securing steady, long-range ridership. To an undetermined extent, similar effects may occur in regard to busway stations. A major reexamination of rider-forecasting methodology would therefore warrant consideration. In the next section, research results touching upon this issue are discussed.

PERCEPTIONS OF DEVELOPMENT DECISION-MAKERS

The results of a recent study sponsored by Texas Association for Public Transportation (TAPT) provide some initial, tentative data related to certain ridership forecasting issues previously discussed.

Survey Description

In the fall/winter of 1987–1988 TAPT conducted a survey intended to elicit perceptions of individuals in a position to make decisions about real estate development at fixed-guideway stations in eight U.S. and three Canadian cities with relatively new LRT or busway facilities. It was expected that this research would begin to give some indication of the relative perceived attractiveness of each mode for real estate development. The target survey population was intended to consist primarily of organizations involved in real-estate development with emphasis on the private sector. A questionnaire addressing issues of real estate development and public orientation associated

with LRT and busway systems was sent by mail to more than 200 organizations in the selected cities (copies of the questionnaire are contained in the project final report, which is available from the author).

It was hoped that such an assessment of relative perceived attractiveness would serve as a stimulus toward a more closely focused assessment of actual transit-induced development. However, the particular approach was undertaken because measurement of perceptions of real estate decision makers was comparatively less difficult to carry out. While a separate questionnaire was prepared for each individual system, customized to refer to that system by name to avoid misunderstanding, all survey questions were otherwise worded identically.

Survey Results

Because of the substantial differences between Canadian and U.S. cities in regard to land use regulation, transit policy, public acceptance of transit, and other characteristics, aggregation of Canadian data with that of U.S. systems has been deemed inappropriate; furthermore, the number of responses received to date from Canadian organizations pertaining to each of the two modes was regarded as insufficient to permit reliable statistical comparisons of new LRT and busway systems in Canada. For the remainder of this discussion, only data pertaining to new U.S. LRT and busway systems, for which sufficient responses for each mode were received, will be considered.

A listing of the nine systems surveyed in eight U.S. metropolitan areas, together with 1980 population and density data (taken from UMTA's Section 15 annual report), is provided in Table 2. As this exhibit indicates, 78 completed questionnaires have been returned from U.S. cities, yielding an aggregate response rate of 31 percent. About 64 percent of respondents represent organizations involved with real estate development (e.g., developers, construction firms, brokers, appraisers); the remainder are split about evenly between general businesses and public-sector planning and transit agencies that would also play a key role in real estate decision-making.

Statistical analysis of the questions dealing with the desirability of development near transit stations (questions A-1/B-1) and those concerning public understanding of system route structure and service (questions C-1/C-2) consisted of a one-tailed z-test. In this discussion of the survey, "LRT respondents" refers to those organization representatives responding to LRT system questionnaires; "busway respondents" refers to those answering busway system questionnaires. A tabulation of averaged responses for each of the U.S. systems surveyed is presented in Table 3.

TABLE 2 LRT/BUSWAY SURVEY INFORMATION: U.S. CITIES

Urban Area	1980 Population (Persons)	1980 Density (Pop./sq mi)	System ID	System Type	No. Orgs. Contacted	No. Orgs. Responding	Response Rate (%)
Buffalo	1,002,285	3,768	Metro Rail	LRT	23	9	39.1
Houston	2,412,664	2,300	Transitways	Busway	37	11	29.7
Los Angeles	9,479,436	5,189	El Monte Busway	Busway	22	4	18.2
Pittsburgh	1,810,038	2,539	The "T"	LRT	43	15	34.9
Pittsburgh	1,810,038	2,539	South/East Busways	Busway	43	14	32.6
Portland	1,026,144	2,940	MAX	LRT	17	10	58.8
Sacramento	796,266	2,864	RT Metro	LRT	16	4	25.0
San Diego	1,704,352	2,789	San Diego Trolley	LRT	27	6	22.2
Washington	2,763,105	3,424	Shirley Busway	Busway	24	5	20.8
TOTAL				LRT	126	44	34.9
TOTAL				Busway	126	34	27.0
TOTAL				ALL	252	78	31.0

TABLE 3 LRT/BUSWAY SURVEY INFORMATION: RATINGS

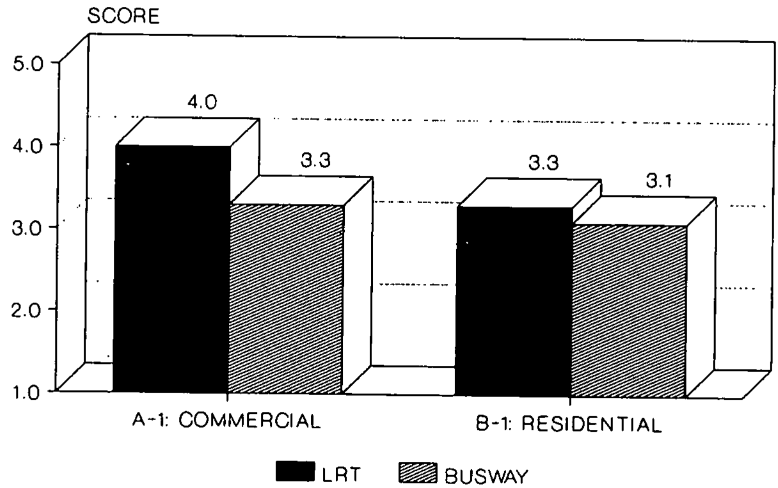
Urban Area	System ID	System Type	----Ratings---- A-1	B-1	C-1	C-2
Buffalo	Metro Rail	LRT	3.9	3.0	2.9	2.9
Houston	Transitways	Busway	3.4	3.3	2.2	2.4
Los Angeles	El Monte Busway	Busway	3.8	2.3	3.0	2.8
Pittsburgh	The "T"	LRT	3.8	3.7	3.9	3.8
Pittsburgh	South/East Busways	Busway	3.2	3.0	3.4	3.4
Portland	MAX	LRT	4.5	3.5	4.2	3.9
Sacramento	RT Metro	LRT	4.6	3.3	3.1	3.3
San Diego	San Diego Trolley	LRT	3.4	2.6	3.5	3.3
Washington	Shirley Busway	Busway	3.3	3.4	3.4	3.4
ALL		LRT	4.0	3.3	3.6	3.5
ALL		Busway	3.4	3.1	3.0	3.0

Real Estate Development

Results of the real estate decision-makers' survey are illustrated in Figures 1 through 5. Analysis of these survey results suggests that real estate decision-makers in the cities surveyed tend to perceive LRT stations as significantly more desirable than busway stations for commercial real estate development. Figure 1 illustrates the results of the question "Please rate the areas adjacent to the [system] stations as locations for commercial development" (question A-1), which yield a significantly higher mean "desirability" rating for LRT versus busway; statistical analysis indicates that this higher score is significant at the 99 percent confidence level.

Factors that these real estate decision-makers seem to perceive as particularly encouraging commercial development near LRT stations are the understandability of LRT's routes and service, its pleasant environment, and favorable land use regulations. Factors perceived as particularly discouraging development near busway stations would seem to include insufficient speed and service, poorly understood routes and service, and noise, pollution, or other environmental problems.

In regard to residential development, although the difference indicated was not determined to be significant at the 0.01 level used, a higher mean rating was registered for LRT. Factors perceived as particularly encouraging residential development near LRT stations would include, again, the understandability of LRT's routes and service and its pleasant environment. On the



KEY: A-1: Rating of areas adjacent to [system] stations as location for commercial development.
B-1: Rating of areas adjacent to [system] stations as location for residential development.

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Scale:      |---------|---------|---------|---------|
            1         2         3         4         5
        Undesirable          Neutral           Desirable
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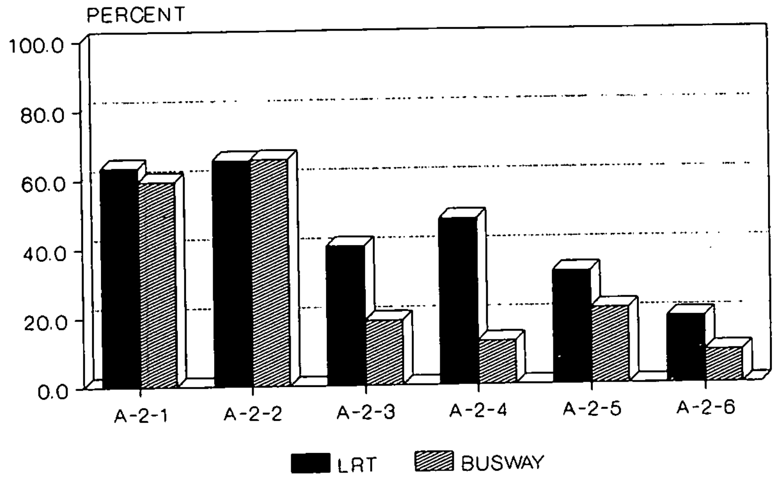
FIGURE 1 Development desirability scores: LRT and busway.

other hand, the availability of rapid transit appears to be perceived as an especially strong factor for busways in encouraging residential development adjacent to the system. Factors perceived as particularly discouraging development near busway stations would seem to be poorly understood routes and service, as well as noise, pollution, or other environmental problems.

Implications for Ridership Modeling

Results of the survey tend to suggest that there is some validity to the supposition that LRT is a stronger force than busway in commercial real estate development. If relevant decision-makers tend to regard LRT stations as significantly more desirable for development, it is reasonable to speculate that actual development might have a greater likelihood of materializing. Likewise, there are indications that fixed-guideway modes generally have more potential to attract development than street bus systems without stations and other fixed facilities. However, the quantification of such effects and differences is a subject for further research.



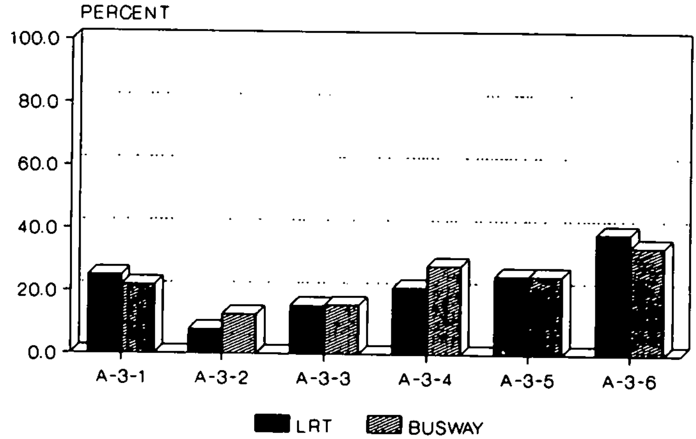
KEY: A-2: Factors strongly encouraging commercial development adjacent to [system] stations.
A-2-1 Lots of people gather there
A-2-2 Rapid mass transit is available
A-2-3 Route/service are well understood
A-2-4 [System] environment is pleasant
A-2-5 Favorable land-use regulations
A-2-6 Other

FIGURE 2 Commercial encouragement: percent respondents citing question A-2.

Nevertheless, while predictions of real estate development near transit stations are currently uncertain and unreliable, the potential for such effects could be approximated through the modeling of alternative land use/travel demand scenarios, with clustering of development near proposed stations being one scenario. An example of such a procedure is the Alternative Futures process initiated by the Austin Transportation Study in the 1970s, in which a redevelopment scenario assuming nodes of development at transit stations forecast ridership 7 to 8 percent higher than a base scenario without such land use effects (*44*). Such a process could be refined as more precise data regarding transit-induced impacts and modal differences are generated.

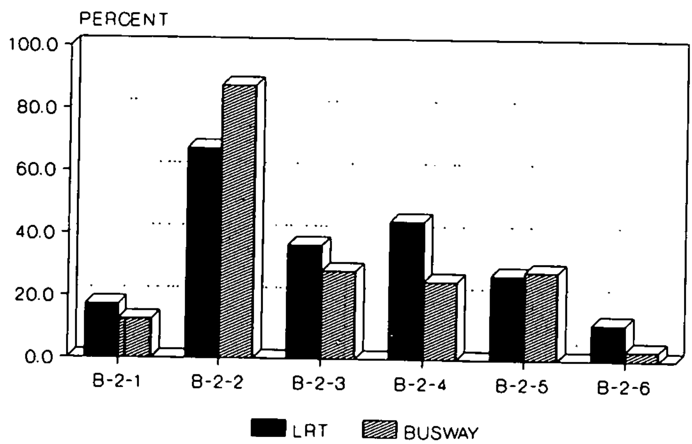
Public Orientation

While the survey results in regard to public orientation to a given system (see Figure 6) indicate higher average ratings for LRT, analysis at the .01 level did not find this difference to be significant. However, *z*-scores were sufficiently



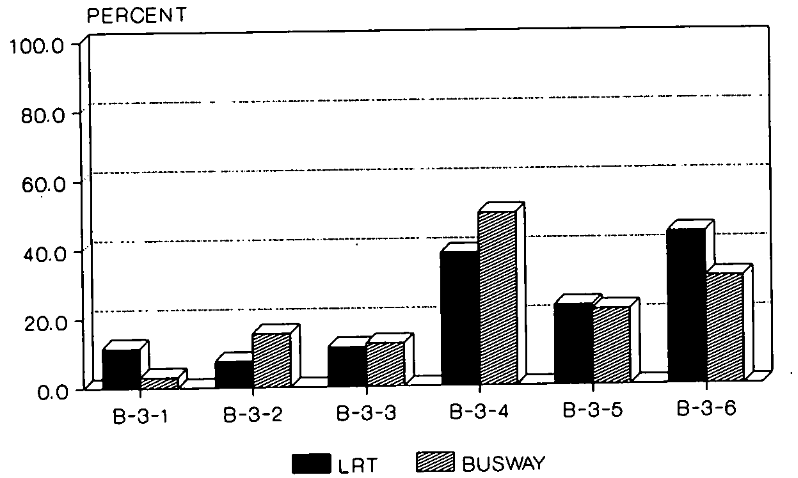
KEY: A-3: Factors strongly discouraging commercial development adjacent to [system] stations.
A-3-1 Not used by enough people
A-3-2 Speed/service not good enough
A-3-3 Route/service are poorly understood
A-3-4 Noise, pollution, or other environmental problems
A-3-5 Unfavorable land-use regulations
A-3-6 Other

FIGURE 3 Commercial discouragement: percent respondents citing question A-3.



KEY: B-2: Factors strongly encouraging residential development adjacent to [system] stations.
B-2-1 Lots of people gather there
B-2-2 Rapid mass transit is available
B-2-3 Route/service are well understood
B-2-4 [System] environment is pleasant
B-2-5 Favorable land-use regulations
B-2-6 Other

FIGURE 4 Residential discouragement: percent respondents citing question B-2.



KEY: B-3: Factors strongly discouraging residential development adjacent to [system] stations.
B-3-1 Not used by enough people
B-3-2 Speed/service not good enough
B-3-3 Route/service are poorly understood
B-3-4 Noise, pollution, or other environmental problems
B-3-5 Unfavorable land-use regulations
B-3-6 Other

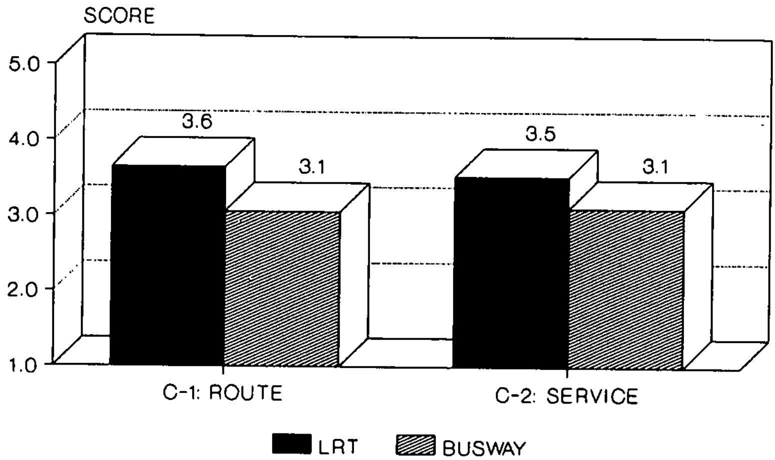
FIGURE 5 Residential discouragement: percent respondents citing question B-3.

high for both questions to provide strong justification for further research, e.g., to assess public attitudes directly.

CONCLUSIONS AND RECOMMENDATIONS

Improvements in the accuracy of transit ridership forecasting are essential. Significant underpredictions and overpredictions both can lead to costly errors in fixed-guideway implementation. However, gross ridership forecasting has not been the primary focus of this discussion, but instead the differences between LRT and motor bus as alternative transit modes. In this comparison, ridership projections represent one of the primary criteria on which most decisions are currently based, and for this reason must be made as realistic and accurate as possible; otherwise, poor investment decisions could be a consequence. Several considerations may be helpful toward this goal:

1. Problems of Current Methodology. While differences in LRT and busway operation (passenger access, headways, schedule speeds, etc.) are



KEY: C-1: Rating of how well, in respondent's opinion, [system] route structure is understood by the public.
C-2: Rating of how well, in respondent's opinion, [system] service characteristics (schedule, travel time, etc.) are understood by the public.

Scale: |---------|---------|---------|---------|
1 2 3 4 5

Poorly Understood **Neutral** **Well Understood**

FIGURE 6 Public orientation scores: LRT and busway.

generally accounted for in current ridership forecasting methodology, important characteristics affecting ridership are omitted. These include differences in (a) passenger comfort and confidence and the level of public awareness and understanding of a given system, and (b) effects of possible real estate development in clustering traffic generators adjacent to transit stations. Preliminary evidence suggests that these factors are stronger for LRT than for busways; and while quantification is difficult, their exclusion from current modeling procedures may produce inaccurate results that underpredict potential LRT ridership vis-à-vis motor bus alternatives.

2. Need for Further Research. To further verify and resolve such possible deficiencies, investigative research appears essential, perhaps along the lines suggested earlier in the paper. Initially this could involve public surveys, particularly in urban areas where both LRT and bus modes are operated. Inclusion of other modes such as heavy rail rapid transit, commuter rail, and automated-guideway transit might also be considered.

3. Possible Alternatives to Procedures and Models. Current ridership forecasting procedures typically predict a single calculated passenger volume for each alternative mode for a targeted design year. This can tend to give an inappropriate illusion of certainty when such figures are considered in evaluation and decision-making. In view of the forecasting weaknesses discussed in

this paper, changes to prevailing forecasting procedures might be considered: (a) predictions could be presented in the form of ranges of potential ridership volumes reflecting various assumptions as to public attraction to alternative systems; and (b) alternative land use/travel demand scenarios, with clustering of real estate development near stations modeled, could be generated to reflect the potential impact of different modes and provide a richer information base for decision-making.

If research eventually validates and quantifies significant mode-specific differences in passenger attractiveness and real estate development, efforts should be made to translate such results into improvements in the accuracy of forecasting models and techniques.

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