

Exploring the Land Use Potential of Light Rail Transit

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ABSTRACT

The potential role of light rail transit in influencing urban growth and revitalizing central city areas is explored. Land use characteristics of cities that have recently built or are planning light rail systems are examined. Specific development strategies designed in response to new or anticipated light rail investments are also reviewed. In order to probe some of the key factors related to the urban development potential of light rail transit, 12 study sites are examined in more detail.

Some 20 or so North American cities have recently built, are building, or are planning to build light rail transit (LRT) systems. The potential impacts of these investments on city form, downtown redevelopment, and urban densities are important to transportation planners. In particular, exploiting opportunities for joint public and private development around station sites will be crucial if there is to be significant land use impact.

By improving access along a corridor, LRT, like any other fixed-guideway system, has the potential to attract and cluster new development around station sites and to rejuvenate declining areas. Because LRT generally has poorer performance characteristics (e.g., in terms of speed and regional coverage) than heavy rail systems, its overall city-shaping abilities could be expected to be less. One might ask, then, what lessons San Francisco's Bay Area Rapid Transit (BART), Washington's Metrorail, and other recent heavy rail investments provide on how LRT systems can be planned and designed to effectively promote regional development objectives? Studies during the past decade have consistently shown that rail transit can have a significant effect on shaping urban form and land uses only if integrated with local prodevelopment policies (1,2). Zoning, taxation, and joint-development incentives are particularly important. Other necessary conditions are a strong regional economy, the availability of land that is easily assembled and developed, citizen support, a hospitable physical setting (in terms of aesthetics, ease of pedestrian access, etc.), and the existence of some automobile discouragements (e.g., limits on new highway construction and downtown parking restrictions).

Besides these factors, it is also necessary that an urban setting meet minimum land use requirements to ensure that there is sufficient demand to warrant light rail investments. Pushkarev and Zupan (3,4) have estimated these minimum warrants employing national data on LRT's capital and operating costs, average fare levels, and land use trip generation rates. To justify an LRT line that operates with 5-min headways during rush hour, Pushkarev and Zupan suggest the following minimum thresholds:

1. A cluster of nonresidential activity downtown or elsewhere (e.g., office, retail, hotel) of 25 to 50 million ft² of floor space and

2. Residential densities averaging at least 9 dwelling units per residential acre in a corridor of 25 to 100 miles².

They conclude that as many as 30 urban areas in the United States are valid candidates for LRT based on these criteria. Some of the recently constructed or planned North American LRT projects are examined in relation to Pushkarev and Zupan's warrants later in this paper.

TWELVE RECENT LRT PROJECTS

Streetcar and trolley lines have existed in Pittsburgh, Philadelphia, Boston, and five other North American cities since the mid-1930s or earlier (5). LRT, essentially a modern-day version of turn-of-the-century streetcar technology, is today being heralded by many as a moderate-cost alternative to heavy rail investments. Indeed, interest in LRT has gained tremendous momentum in recent years. Edmonton's 1978 opening of its northeast line ushered in the first of the recent wave of light rail projects. Calgary and San Diego began their service just 3 years later. New systems are now under construction in Buffalo, Portland, and Vancouver. Some dozen or more other systems and extensions are also at various stages of planning and preliminary engineering. They range in size from Boston's proposed 7-mile Lechmere Extension and Roxbury Line replacement to Denver's 77-mile, 85-station regional system. A number of the new projects and extensions are being proposed in rapidly growing areas, notably San Jose, Sacramento, Orange County, Columbus, Calgary, and Salt Lake City, where the land use and development potential of LRT could be significant.

To explore the urban development potential of LRT, information was compiled on areas that have constructed, are constructing, or are planning LRT projects or extensions from 1978 to the present. (Areas still conducting alternatives analyses or at the pre-route-level planning stage were not studied.) Questionnaires elicited background information from local officials responsible for planning and managing their area's LRT projects and related land use programs. Twelve fairly complete questionnaires were returned from among the 17 sent out. This response rate was considered quite high given the somewhat preliminary nature of some projects. Responses were obtained from Buffalo, Boston, Calgary, Columbus, Denver, Orange County, Pittsburgh, Portland, Sacramento, San Diego, San Jose, and Toronto. In the remainder of this paper various planning efforts being carried out in these 12 areas to assess the urban development potential of LRT are examined.

LRT AND LAND USE PLANNING

Operating and Financial Characteristics

The 12 study sites offer a range of LRT environments in terms of right-of-way, operating, and financial characteristics. From Table 1, it is seen that both exclusive and semiexclusive or mixed-traffic rights-of-way are or will be used to varying degrees.

TABLE 1 Operating and Financial Characteristics of 12 Recently Constructed or Planned LRT Systems

System	Right-of-Way (miles)		Operating Features		Funding Characteristics	
	Exclusive ^a	Mixed or Semiexclusive ^b	Avg Speed ^c (mph)	Peak Headways ^d (min)	Percentage of Capital Costs of Locally State Financed	Percentage of Farebox Recovery ^e
Built						
Calgary ^f	7.0	20.3	8-24	5	100	41
San Diego ^g	0.0	15.9	15-30	15	100	82
Under construction						
Buffalo	5.2	1.2	12-22	6	20	48
Pittsburgh	12.0	12.9	20-35	1-3	20	50
Portland ^g	0.0	15.1	20-45	5-10	15	NA
Toronto	0.5	3.8	12-20	17	100	68
Planned						
Sacramento	5.4	12.9	10-30	15	27	75
San Jose	4.0	15.7	7-30	5-10	49	50
Columbus	1.8	8.7	10-35	7-10	NA	40
Orange County	29.0	12.5	20-30	5-10	NA	70
Denver	54.0	23.0	20-30	5	NA	80
Boston	NA	NA	11-23	3-4	20	NA

^a Exclusive rights-of-way are those that are or will be totally grade separated, such as subway or aerial structures.

^b Semiexclusive rights-of-way are those that have some modest entry controls (e.g., curbed or raised median, mall, traffic preemption); mixed rights-of-way involve surface street operation in mixed traffic.

^c Speed ranges are for downtown sections on the low end to outlying segments on the high end.

^d Peak headways signify the average minutes between LRT trains during the morning and evening peak periods.

^e Farebox recovery equals passenger revenues divided by operating expenses. Figures are either actual current rates or anticipated rates.

^f Includes current system and future extensions.

^g Data only for existing system. Information on planned extensions is not available.

Buffalo's LRT, for instance, will run underground for more than 80 percent of the 6.4-mile system, whereas Portland's Banfield Line will operate almost totally as a separate surface track, although in mixed-traffic surroundings. Exclusive rights-of-way (e.g., subway and aerial) are currently or will make up roughly 35 percent of the total alignments of the 11 sites for which data were available. Likewise, existing and projected operating speeds and headways differ markedly, from 7 to 35 mph and from 1- to 15-min intervals between trains.

With regard to funding, most projects anticipate receiving substantial federal support to finance construction and capital acquisitions. Only the Canadian systems and San Diego in the United States have used nonfederal sources exclusively for financing capital costs. San Diego, however, is seeking federal aid to help finance future extensions to El Cajon and Point Loma. Finally, existing and projected farebox recovery rates (passenger revenues divided by operating costs) range from 40 to 82 percent; the average for 10 of the systems is just over 60 percent. It is apparent that some LRT operations expect to be heavily dependent on government subsidies to help offset future operating expenses.

Land Use Characteristics

A variety of land uses--residences, stores, offices, and industries--lie within the corridors of all 12 LRT study areas. Urban densities vary somewhat, and some have far greater shares of mixed land uses than others. Data from Table 2 (4, Exhibit 3.13) reveal that residential densities vary from 6 dwelling units per developable acre along Sacramento's north-east corridor to more than 50 in the case of Boston's Lechmere Extension. Most projects meet Pushkarev and Zupan's minimum threshold of nine dwelling units per acre, though several fall below it. Because Calgary averages 40,000 passengers per average weekday with a comparatively low residential density, however, these criteria are only general rules of thumb.

TABLE 2 Land Use Characteristics of Cities with Recently Constructed or Planned LRT Systems (4)

System	Avg Dwell- ing Units/ Residential Acre Along Corridor of Residential Segment	Downtown Segment		
		Nonresidential Floor Space in CBD ^a (ft ² 000,000s)	CBD Land Area ^b (acres)	CBD LRT Alignment
Built				
Calgary	8	26	500	Mall and sub- way
San Diego	9	25	1,200	Surface
Under construction				
Buffalo	8	26	900	Mall
Pittsburgh ^c	12	40	400	Subway
Portland	9	25	640	Mall
Toronto ^c	12	3 ^d	500	Aerial
Planned				
Sacramento	6	12	640	Mall
San Jose	13	5	640	Mall
Columbus	9	21	550	Surface
Orange County	12	40 ^e	4,200 ^e	Aerial
Denver	9	36	1,200	Subway
Boston ^c	55	66	640	Subway

Note: Some data from survey responses and local inventories.

^a Nonresidential includes office, retail, hotel, government, and industrial land uses.

^b 1983 estimates.

^c Extension or modernization.

^d CBD floor space is for the Scarborough Town Centre. Downtown Toronto's nonresidential floor space exceeds 100 million ft².

^e CBD floor space and land area for Orange County are for 10 urban centers of varying sizes, the largest being Santa Ana and Anaheim.

Far fewer areas meet the minimum requirement of 25 million ft² of nonresidential floor space in the downtown area. It is significant that Pushkarev and Zupan identified this factor as being the most important simply because there needs to be a substantial and vital central core to attract paying customers. Not counting Orange County, five of the areas fall at or below this mark. Though Orange County has more than 40 million ft² of centralized nonresidential floor space, it is spread over 10 subcenters scattered throughout the region. Given

the relatively low intensity of downtown activities in some of these areas, it becomes particularly important that concerted land use and joint development planning be carried out if LRT operations are to be successful. The integration of LRT with downtown malls by a significant share of areas is encouraging in this regard.

Possibilities for Urban and Joint Development

LRT officials were questioned regarding the possibilities for urban and joint public and private development around stations. Two-thirds of the officials indicated that LRT was or is being planned as part of a larger downtown redevelopment effort. Light rail is also being coordinated with development and redevelopment activities elsewhere along the corridor in 10 of the 12 cases, according to respondents. It is noteworthy, however, that all indicated that a concerted effort either was or might possibly be initiated to encourage private investment and joint development around LRT stations. Clearly this reflects a strong commitment to private-sector involvement and perhaps an appreciation of the current political mood in the United States and Canada.

Eight of the 12 study areas have used or are strongly considering a variety of specific land use strategies to stimulate private development around LRT stations (Table 3). The most frequently cited strategy involves parking controls--either physically reducing the number of downtown spaces or relaxing minimum requirements in local zoning ordinances. Major capital improvements (e.g., new sewer facilities) and public lease or sale of land were being used or considered for attracting private investment by one-quarter of the areas. Less frequently cited strategies were air rights development, tax increment financing, zoning revisions, provisions for pedestrian amenities, the creation of special transit development districts or authorities, and the granting of density bonuses. It is noteworthy that automobile disincentives, such as parking controls, are being used or considered so extensively, at least in contrast to more positive land use incentives. This undoubtedly reflects the belief that transit ridership can be maximized and a transit-oriented downtown can be more effectively established by limiting automobile entry (via parking restrictions) than by almost any other strategy.

LAND USE ISSUES

The 12 study sites offer unique settings for examining issues regarding LRT and urban development. In this section land use issues surrounding these 12 LRT projects are summarized, focusing on those factors that could prove most important in shaping the urban development outcomes of future LRT investments.

Sites with Existing LRT Systems

Calgary

Calgary's current 7.7-mile LRT system, along with 18 miles of extension, holds considerable land use promise. Calgary itself is a fast-growing city of 620,000 that has enjoyed the spin-off from the oil industry boom throughout western Canada. It functions as a major regional center and, unlike many similar-sized cities, has a well-defined, intensely developed central business district (CBD). One-third of all regional employment (82,000 workers) is in downtown Calgary. Office construction continues around the clock to meet the growing demand for central city location.

Perhaps more than any area, Calgary has embarked on a concerted effort to make the downtown area a truly transit- and pedestrian-oriented environment. The 1981 initiation of LRT services in a downtown mall setting represented just one element of an overall plan to increase by 1990 the share of CBD trips made by transit to 55 percent (5). Other key strategies have involved regulatory parking reforms, the use of density bonuses, and major downtown public investments. Calgary has reduced minimum parking requirements by as much as 80 percent for buildings that connect to light rail stations and also allows cash payments in lieu of parking to help finance public parking structures and pedestrian improvements. During the past decade, downtown parking has declined by 1,000 spaces (even though employment and office floor space have doubled) and the city's downtown transit mode split has increased from 34 to 45 percent (6).

Around outlying stations, Calgary has taken an altogether different approach to parking. To date, 2,000 park-and-ride spaces have been provided. Calgary planners have accepted the low-density, single-family character of residential stations (see Table 2) and realize that automobile access is necessary to make the LRT system work. Although park-and-ride lots could discourage possible apartment and mixed-use development around non-CBD stations (currently 82 percent of all households are single family), relocating parking out of the CBD was considered a higher priority. Private interests helped in the financing of park-and-ride lots under a shared-use plan that gives customers of nearby hotels and shopping centers access during weekends and off-peak hours (7).

Calgary has also revised its zoning ordinance to allow mixed residential, commercial, and office uses within 0.25 mile (400 m) of LRT stations. Moreover, floor-space ratios have been increased by 80 percent within these radii. A creative system of density bonuses has also been designed that permits more floor space for new buildings that provide pedestrian arcades, public open spaces, and direct access to LRT stations. Higher bonuses are granted for

TABLE 3 Land Use and Financing Strategies Employed or Being Considered for Promoting Private Development Around LRT Stations

Land Use or Financing Strategy	City Using or Considering Strategy
Reductions in downtown parking or in minimum parking requirements	Calgary, San Diego, Pittsburgh, Portland, Toronto, Sacramento
Major public investment and capital improvements in station area	Pittsburgh, Portland, Buffalo, Sacramento, San Diego
Public lease or sale of land around stations to private developers	Pittsburgh, Portland, Buffalo, Sacramento
Pedestrian walkways and mezzanines to LRT stations	Calgary, Pittsburgh, Toronto
Air rights development above LRT stations	Calgary, Boston
Tax increment financing	Portland, Sacramento
Revised zoning densities	Portland, Sacramento
Special transit development districts or authorities	Portland, Sacramento

interconnected elevated skywalks, and even higher ones when such facilities are temperature controlled.

Calgary appears to have the essential ingredients for a successful partnership between LRT and downtown: a strong economy, parking controls, and a plethora of development incentives. Having the city's transportation and planning departments under one city jurisdiction has also helped. Though there has been only a modest amount of concerted joint-development activities to date, interest by private investors has remained high. The two planned LRT extensions can be expected to further strengthen the downtown area and the regional transit network.

San Diego

Like Calgary, San Diego is a relatively low density, sprawling city. The 16-mile San Diego Trolley, although not intended to change this predominant land use pattern, has nonetheless been a much-heralded success. The line runs from downtown San Diego (on both exclusive and mixed-traffic rights-of-way with simple loading islands instead of stations) southward along a railroad alignment to the Mexican border. Much of the corridor traverses an industrial belt and unusable scrubland, although several South Bay residential areas are also crossed. The availability of a suitable railroad right-of-way along this corridor has been responsible for much of the system's construction cost savings; however, one condition of acquisition has been that mixed freight traffic be allowed during evenings. Average weekday ridership has leveled off over the past 2 years at about 11,500 (although it is up to 17,000 on Saturdays), yet the farebox recovery rate has remained relatively high at 82 percent (see Table 1). Several major employers are located at the downtown end of the line (e.g., National Steel and Shipbuilding and Rohr Corporation) and at the south end Tijuana provides a steady stream of tourists, laborers, and shoppers. Thus, there has tended to be a near-constant distribution of LRT traffic throughout most hours of the day.

There is little evidence of any positive land use impacts from the trolley to date. Although San Diego's Mass Transit Development Board (MTDB) guidelines officially "encourage, to the extent feasible, the concentration of appropriate development adjacent to stations" (8), because much of the line is in an active freight railroad right-of-way the trolley's development potential is limited. Joint development has been invited by formal requests for proposals and newspaper advertisement inquiries, although no significant progress has been made with prospective investors. Neighborhoods near the stations are already built up, and no significant redevelopment has yet occurred. Although the five southernmost stations all have considerable amounts of vacant land within walking distance, no great increases in residential density are being sought nor are any anticipated. As with Calgary, the availability of 2,000 park-and-ride spaces will probably preserve the automobile orientation of these outlying regions.

As in other cities, San Diego's LRT is seen as playing a supporting, although not a major, role in downtown redevelopment plans. Downtown office floor space increased from 4 million to 6 million ft² from 1981 and 1982; an additional 1.5 million ft² is currently either under construction or planned. These and other CBD developments are described by MTDB as being coordinated with but not dependent on the trolley.

More ambitious efforts are being made to encourage intensive development around stations on the

proposed 17-mile East Line extension, largely because future state aid has been tied to the establishment of such a policy. MTDB's plan for promoting growth along this corridor includes relaxed parking requirements for new developments around stations and influencing private investment via major public improvements, such as the construction of a multimodal transportation center at the terminus of the East Line financed jointly by MTDB and the city of El Cajon.

In sum, LRT is working in San Diego despite relatively low population densities and only modest public interest in stimulating joint development. The availability of an inexpensive right-of-way together with San Diego's fortuitous position as a military, tourist, and international retail center have been the key factors behind the trolley's success to date.

Sites Currently Constructing LRT Systems

Buffalo

Buffalo began constructing its 6.4-mile LRT system in 1979 and hopes to complete the downtown mall segment by late 1984 and the remainder by 1986. Unlike Calgary and San Diego, however, Buffalo is a nongrowth area. Population has declined by 25 percent over the past decade and both downtown retail sales and employment have dropped off as well. Perhaps more than anywhere else, in Buffalo LRT is being looked on as a key and necessary component of a massive downtown revitalization effort. Buffalo's Department of Community Development is the lead agency in an ambitious effort to reverse the exodus of retail stores from the central city and reestablish a vital downtown core (9). The city has already invested more than \$70 million in a new downtown civic center, a network of enclosed overhead walkways, landscaping, and the acquisition of properties for open space. Buffalo opted for building a 1.2-mile surface street transit mall, which will be one of the longest anywhere, to make LRT within easy walking distance and a highly visible part of the downtown redevelopment effort.

Responses by private investors to the LRT system and related projects to date have exceeded expectations. During the first year of construction, more than \$200 million in private downtown construction was undertaken or announced. One joint development, Main-Genesee, includes two bank office towers and a new 400-room hotel complex located adjacent to a downtown station. Downtown office space is expected to increase by one-third by the time the entire 6.4-mile system is in full operation. Although some have noted that the opening of a new major arterial highway on the eastern edge of downtown might suppress redevelopment efforts by diverting potential LRT users, most community leaders believe that downtown Buffalo has a bright future (9).

Pittsburgh

Pittsburgh has embarked on a major reconstruction and modernization of its 25-mile system, replacing 35-year-old streetcars with new LRT vehicles, upgrading tracks, and building a downtown subway link through an existing tunnel. An underground loop will serve the Gateway Center, a six-building office complex, as well as the Golden Triangle. Two downtown stations, slated to open in late 1984, will have mezzanine connections to downtown streets. Downtown landscaping, public leases of land near the station, and parking reforms are also being used to

encourage redevelopment. City officials have also raised long-term downtown parking rates to encourage office workers to commute by transit, whereas the short-term rates have been lowered to stimulate downtown shopping (10). As in Buffalo and Calgary, LRT is being looked on as an integral part of Pittsburgh's downtown redevelopment effort.

Toronto

Toronto is in the process of extending its already heavily patronized LRT system from the terminus of the Bloor-Danforth line to Scarborough Town Centre, one of five suburban municipalities within metropolitan Toronto. The LRT extension is part of a developing civic center in Scarborough where 1.75 million ft² of retail and office floor space already exists and another 1 million ft² is under construction along with several major hotel complexes.

Unlike Toronto's celebrated heavy rail system, no special land use strategies are being employed to encourage growth along the LRT extension, primarily because a strong market already exists. Still, a pedestrian walkway system is being built incrementally throughout the Town Centre and integrated with the new elevated station. Moreover, parking is being reduced near the station. Overall, the LRT line is expected to reinforce an already vital cluster of office and retail uses in central Scarborough and perhaps stimulate some new residential development as well.

Portland

Portland's 15-mile LRT line will run at grade from the downtown mall eastward to the bedroom community of Gresham. Two historic districts will be crossed and the Memorial Coliseum will be served. Scheduled to open in mid-1986, the alignment, named the Banfield Line, will parallel two freeways much of the way, which will perhaps limit some of its urban development potential.

More than most cities, Portland's economy has been hard hit by the recession, a factor that could affect the LRT's city-shaping role. Still, along with the city's new fleet of articulated buses, LRT is being viewed as an integral part of Portland's long-range comprehensive Downtown Plan. LRT's importance lies more in its possible contribution to improving downtown circulation and enhancing the pedestrian-mall environment than in stimulating redevelopment. Because downtown stations will be simply shelters, any clustering effects of LRT would likely be, in comparison with the situation in other cities, modest.

Because of the abundance of vacant land, much of the joint development potential of the Banfield LRT is in Gresham. The city has prepared a joint development plan calling for tax increment financing, though the plan suffered a major setback in 1982 when Gresham voters rejected the creation of an urban renewal agency. Multnomah County's attempt to form a redevelopment agency to help plan LRT-related growth was similarly rejected by voters. The county has, however, invested \$3 million in sewer improvements in several unincorporated areas to stimulate growth. Moreover, it has systematically increased zoned residential densities along the Banfield corridor, whereas multifamily zoning has been restricted outside of it. Minimum parking restrictions have also been eased. Some mixed-use growth is expected, in particular around the Lloyd Center where a large corporate interest has assembled sizable tracts of developable land.

Portland's transit authority, Tri-Met, made an early decision against pursuing joint-development possibilities on its own; instead a separate authority was created for this function. In August 1982, the Transit Investment Corporation (TIC) was formed to manage mixed-use joint development around stations and to influence private capital through various public improvements such as skybridges and open-space enhancement. The five-member, nonprofit corporate board is empowered to incur indebtedness and to negotiate virtually unrestricted joint-development contracts with private investors. So far, the board has been instrumental in stimulating more than 2.5 million ft² in new office and retail construction throughout the region. It has also negotiated lease and sale options on land surrounding several stations. TIC is expected to play an increasingly important role in development along the Banfield Line as well as the proposed 12-mile westside extension to Beaverton. Overall, the development potential of LRT in Portland could eventually prove to be significant, despite a stagnant local economy, given the region's strong commitment to comprehensive planning and redevelopment.

Sites Planning LRT Systems

Sacramento

Sacramento is in the final stages of designing an LRT system; construction began in late 1983 and actual operations are scheduled for mid-1985. Unlike most new North American light rail starter lines, Sacramento's LRT will operate on a single track along two close-by 9-mile corridors in the city's northeast. The project is being constructed in lieu of a freeway halted by community protest groups; federal Interstate transfer funds as well as state assistance will be used.

Because of the high concentration of state offices, Sacramento already has a fairly vital downtown for its size, with approximately 80,000 jobs located within 1 mile². Though local officials believe LRT will promote positive downtown growth, it is not a formal part of the Master Redevelopment Plan for the CBD. The downtown transit mall is expected to attract private investments; however, developer initiative is being solely relied on.

A special authority, the Sacramento Transit Development Agency, was created in 1981 to manage the system's construction program as well as to prepare a compatible land use and development study. Six of the system's 27 stations have been identified as having high development potential--large vacant and unifiable land parcels, ownership by a few, and strong market. Seven others have been identified as having strong redevelopment potential--transitional neighborhoods with mixed and changing uses and older buildings (11). These 13 areas have been designated special planning areas where residential densities will be raised and minimum parking requirements relaxed. A 10 percent reduction in parking is allowed for nonresidential developments, and an additional 10 percent reduction is granted for projects within 660 ft of an LRT station. Growth around the six targeted development areas will be encouraged by using some combination of density bonuses, tax increment financing, and industrial development bonds. Given Sacramento's strong economy and growth posture, in addition to a local commitment toward station planning, the land use impacts of its LRT system could prove consequential over time.

San Jose

San Jose plans to begin building its 20-mile LRT

line in early 1984 with final completion scheduled in 1989. The line will run from the northern industrial zone of Santa Clara through downtown to a southern residential area with a nearby shopping mall and industrial park. A number of major activity centers lie along the corridor, including a major recreational theme park, a commuter railroad station, and several large high-technology industrial plants.

Though LRT connections to these activities suggest a high urban development potential, there are other countervailing influences. One is that San Jose has an unusually small downtown for a city of its size (see Table 2). Of 500,000 total jobs in Santa Clara County, fewer than 15,000 are located in San Jose's CBD. Not unrelated to this is the character of San Jose as a sprawling, automobile-reliant metropolis with an extensive freeway system and abundant free parking. Currently transit accounts for only 1 percent of all trips made in the area (12). Moreover, the LRT line is to be flanked by two new expressways along much of the corridor, which could serve to reinforce the highway orientation and suppress the rail line's development potential. In addition, though the high-technology industry flourishes in the San Jose region, many plants are converting from assembly line production to less labor-intensive research and development activities.

Clearly, the greatest prospects for LRT-generated development are in downtown San Jose. LRT is the centerpiece of the city's intensive downtown redevelopment program. The transit mall, along with density bonuses and various landscaping and amenity improvements, is expected to stimulate retail and office growth. Beyond these strategies, no other joint-development programs are being formally considered, however. Outside the CBD, no density bonuses are being offered nor has any up-zoning occurred. To date, there has been only one major non-CBD development—a mixed office and commercial development near the Oakridge Mall—whose location city officials even partially attribute to the planned LRT line. Planners are hoping, however, that LRT will help curb some of the leapfrogging growth the city has experienced in recent years. Overall, local officials are optimistic about LRT's role in rejuvenating San Jose's downtown, although a radical transformation of the city's predominantly low-density structure is not expected.

Columbus

Columbus is planning a 10.6-mile light rail system running along a railroad right-of-way from downtown to the north. Like Sacramento, Columbus, also a state capital, has a fairly recession-resistant economy. The downtown is growing; more than 6 million ft² of office, retail, and hotel floor space have been added in the past 6 years. No specific development strategies have come forth to date as part of the LRT project. Current LRT plans call for extensive park-and-ride facilities around most stations because the proposed railroad right-of-way does not penetrate any major residential or commercial areas. The choice of this alignment on cost-saving grounds might limit the development potential of the project, however.

Orange County

Orange County is planning a regional LRT network to interconnect 10 communities with populations ranging from 40,000 to nearly 200,000. The project is being planned principally to relieve congestion on the

county's extensive freeway system. Orange County's LRT setting is unique because of the absence of any major central core, a criterion that Pushkarev and Zupan contend is the most important. Orange County's polynucleated structure closely resembles San Jose's; both are products of the automobile age. Development is booming, however, in downtown Anaheim, Santa Ana, Fullerton, and Garden Grove at a rate of nearly 4 million additional square feet of nonresidential floor space per year. Planners estimate that more than 130,000 jobs are located within walking distance of the LRT corridor. The generally scattered layout of activity centers in Orange County may dissipate any clustering effects of LRT, although the new rail line could function as an important regionwide connector.

Denver

Denver's proposed 77-mile system represents by far the most extensive of the new LRT projects. Though the network focuses on downtown Denver, it will still serve all major employment and activity concentrations in the region. Transit is already an integral component of Denver's downtown: Free shuttle services currently operate along a pedestrian mall and a major multimodal transportation center has just been opened. Though no formal plans exist, special benefit assessment districts and tax increment financing are being explored as ways to help finance the system and stimulate joint development. According to local planners, private investors have shown little interest to date in shared-development concepts, largely because of the absence of a formal implementation plan. The city has begun purchasing abandoned railroad right-of-way in anticipation of building the southeast corridor first; however, the more than \$2 billion in capital funding remains the biggest hurdle. If built, the system would be on a par with San Francisco's BART and Washington's Metrorail systems in terms of regional coverage and land use potential.

Boston

Boston is planning an extension of light rail services beyond its Lechmere Station to the cities of Somerville and Medford. However, the extension is expected to play a fairly modest role in shaping future development because of the built-up nature of the corridor. Three redevelopment projects have already been announced for the Lechmere Extension, though, according to local officials, they are not dependent on the LRT line's being built. Overall, the extension could be expected to reinforce an already comprehensive network of light and heavy rail transit in the Boston area.

CONCLUSIONS

Key factors that can be expected to influence the land use impact of LRT are presented in Table 4, along with a summary evaluation of how the 12 study sites rate on these factors. For LRT to have a large-scale impact on urban form, a strong and growing regional economy is an important prerequisite. Over the long run, places such as Calgary, Sacramento, San Jose, and Columbus, therefore, could experience large-scale land use benefits from LRT investments. For some, however, the current automobile-highway system seems so firmly rooted that any major structural changes in urban form would appear unlikely. The development potential of land and a

TABLE 4 Factors Serving as Stimulants and Deterrents for Urban Development

	STIMULANTS										DETERRENTS									
	Strong and growing regional economy	Local development commitment	Public improvements integrated with LRT	Strong private development interests	Available and assembleable land	Provision of pedestrian amenities	Adoption of various land use incentives	Enactment of parking controls	Creation of special development authority	Major activity centers along corridor	Weak or stagnant local economy	Sprawling, low-density character of the area	LRT aligned along highway or railroad	Park-and-ride could reinforce auto usage	Insufficient residential densities	Small size of downtown area	Much of corridor already built-up	Modest LRT design or terminal features	Small change in regional accessibility	
LRT PROJECTS:																				
Already Built:																				
Calgary	+	+		+		+	+	+							-	-				
San Diego	+				+					+		-	-	-				-		
Under Construction:																				
Buffalo		+	+	+		+					-				-					
Pittsburgh		+	+			+		+			-						-		-	
Portland		+	+		+		+		+	+	-		-					-		
Toronto		+	+	+		+		+									-			
Planned:																				
Sacramento	+	+				+	+	+	+			-		-		-		-		
San Jose	+		+			+						-	-	-		-				
Columbus	+												-	-		-				
Orange County	+			+								-				-				
Denver	+					+							-				-			
Boston																	-		-	

NOTES: + means the factor could be expected to have a positive influence on urban development

- means the factor could be expected to impede LRT's urban development and land use impacts

suitable physical setting around LRT stations are likewise important conditions for positive land use changes. In some areas LRT alignments were chosen principally on the basis of minimizing construction costs rather than maximizing development potential (e.g., San Diego and Columbus). In these cases, lines often traverse industrial belts and undevelopable land. Some cities, notably San Jose and Portland, plan to run LRT lines next to or between urban freeways. Though an underlying rationale for building LRT in the first place is to minimize costs, public officials need to recognize the trade-off involved in terms of possibly suppressing longer-range urban development.

Perhaps the strongest development potential of LRT is in downtown areas, particularly where lines are integrated into open pedestrian malls. Buffalo, San Jose, Calgary, and Portland all hope to spark downtown redevelopment with their transit malls. Density bonuses and up-zoning are being used as well in most of these settings to attract private investments. Some joint development and cost sharing with private interests is also occurring (e.g., Calgary), though not on a major scale. A few areas (e.g., Buffalo) are also targeting public improvements around downtown LRT stations as part of the overall redevelopment package. Though these strategies could be a tremendous boon to downtown office construction and retail sales, it should be pointed out that

unless an entire region is experiencing growth, such impacts could turn out to be largely redistributive (e.g., taking retail sales from another area).

Parking reforms, such as supply restrictions and easing of minimum requirements, are being used in a number of LRT communities to transform downtown areas into predominantly transit and pedestrian environments (e.g., Calgary, Pittsburgh, and Portland). Park-and-ride lots, however, are being provided at the same time in some of these places to facilitate access to suburban stations. Although these facilities might effectively reinforce the highway orientation of an area, LRT planners seem mindful of the need to provide park-and-ride facilities on a selective basis so as to enhance light rail ridership along suburban corridors. Park-and-ride access also functions as an interim use that can easily be converted to accommodate major land developments if and when a station's market becomes firm.

In closing, the urban development possibilities of LRT appear substantial, though only if other pro development forces exist. Compared with heavy rail systems, LRT projects must be accompanied by various land use incentives and supportive local policies if meaningful land use impacts are to be expected. Unfortunately, much of the emphasis in siting and designing new LRT projects has been placed on minimizing costs, perhaps at the expense of suppressing

LRT's urban development potential by aligning segments along abandoned railroad rights-of-way and freeways. Although the record on LRT in the United States and Canada is still rather short, experiences with rapid rail transit are sobering reminders that a strong regional economy, supportive local policies, and a hospitable station environment are essential if positive and substantial land use outcomes are to occur.

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The Impact of Light Rail Transit on Travel Behavior in Calgary

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ABSTRACT

In May 1981 light rail transit (LRT) was introduced in Calgary between the downtown and the southern part of the city. An extensive 2-year monitoring program of the impact of LRT on the transportation system has been conducted by the city, the results of which are reported. The methodology consisted of a series of before-and-after surveys, which included conventional traffic counts, speed and delay studies, and an on-board survey. An important component of the study was a home interview survey. LRT has had a significant impact on travel downtown. Transit modal split across the south downtown screen line has increased from 35 to 40 percent to 50 to 55 percent in the a.m. peak period. The study also examined the public's atti-

tudes and perceptions of the transportation system as well as the reasons for mode choice. The majority of residents believed that both transit service and overall traffic congestion had improved with the introduction of LRT. Most travelers indicated that convenience is the critical factor in choosing between the automobile and transit. A significant portion of the population, however, identified travel time as the most important factor.

The purpose of this paper is to outline the effects that the implementation of a 12.5-km light rail transit (LRT) line and associated feeder-bus system has had on travel behavior in the rapidly growing city of Calgary, Alberta, Canada.