In the non-OPEC countries, more and more thought is given to electric vehicles, which offer undeniable advantage in areas such as air pollution, noise, capacity, and economy.

Most of the networks in European cities with 1 to 3 million inhabitants that ventured upon a standard metropolitan railway operation can only conclude that the operating costs are very high (vehicles as well as stations); that some platforms at different levels are accessible only with great difficulty (elderly people sometimes panic at the mere sight of an escalator, and, moreover, the maintenance is extremely burdensome); and that insecurity grows with the volume of the stations, and this climate has a restraining influence on the use of public transport.

Once again, light rail traffic can offer a valid alternative, as it is possible to build the required facilities at ground level on very long sections. A tendency exists to construct high platforms at stops to permit easy access to the vehicles. This reduces the stopping times and increases the commercial speed, which contributes to the attractiveness of the system.

The wide range of rail vehicles, each with its own width, length, number of articulations, and couplings, offers the possibility to choose the type of vehicle that seems most appropriate for a particular operation.

I should like to conclude by emphasizing that public transport services can contribute strongly to a city's functioning. Each vehicle is constantly connected with the company's traffic control center, and the vehicles run through a vast network of roads at regular intervals. The drivers can therefore inform the control center about any anomaly met on the way.

On the S.T.I.B. Brussels Passenger Transport System network, for example, the drivers intervened, by transmitting information, on the following occasions: 166 accidents between third parties, 651 calls for an ambulance, 320 cases of traffic lights being out of order, 24 calls for the fire department, 23 cases of lost children, 40 acts of aggression, 44 brawls, 3 cases of leaking petrol and risk of fire, 22 cases of inundation, and 5 uprooted trees fallen on the road.

To strongly motivate the authorities responsible for the organization of all urban transport, it is absolutely necessary to draw their attention to the numerous complementary services public transport in general, and LRT in particular, can offer. With their support, an urban renovation can be brought about that gives the city back to the inhabitants and prepares the shape of the urban region for the coming decades.

LRT Fixed Facilities and Vehicles

THOMAS F. LARWIN, San Diego Metropolitan Transit Development Board

The existing and planned light rail installations in North America serve as testimony to the progress being made to move people more efficiently during this era of tight financial resources. An outstanding feature of LRT is its versatility and its corresponding ability to develop incrementally.

The San Diego project is but an initial increment of a larger LRT plan. We are already in the midst of a construction program to double-track a system that began as a single-track line in San Diego. Ten more vehicles are now on order, and we intend to expand the service to the eastern suburban areas within the next couple of years. Even then we will not be done—there are northward extensions being planned, grade separation projects being designed, and operating enhancements continually being made.

This flexibility and versatility can be translated into low-risk development and low cost. Light rail offers the flexibility and versatility to satisfy transportation needs at low capital and operating costs. Although we hear a lot about the capital cost features of light rail transit, low operating costs are equally important. There needs to be constant vigilance during the planning and the design process to achieve a low-cost operation. A proper balance will continue to pay financial dividends in the future.

VEHICLES

A wide variety of vehicle technology is currently operating. PCC cars are still operating in Cleveland, Pittsburgh, Toronto, San Francisco, Boston, and Newark. These cars average 40 years of age. Table 1 shows recent activities in procurement of newer vehicle technology. In Calgary and San Diego, 3-car train units are in peak-period service. In San Diego, 4-car train units will eventually be operated. While most of the areas are opting for double-ended vehicles, single-ended vehicles are also available if the operations permit their use. These new vehicles have 3 or 4 doors on each side. Seating capacity ranges from 49 for the Tokyu car in Buffalo to 84 for the Breda car being used in Cleveland.

Platform boarding conditions vary. Subway sections of the San Francisco Muni use high-level boarding (platform aligned with the floor level of the car), but the San Francisco Boeing cars can use both high- and low-level off boarding. Low-level boarding is used outside of the subway sections. In San Diego, low-level boarding is used, although Edmonton and Calgary use high-level boarding on the same car.

Special needs of the elderly and handicapped are also a consideration in choice of boarding type. However, it is not necessary to provide handicapped assistance on the vehicle. The intended station design for the at-grade stations in downtown Buffalo has a platform that enables a person in a wheelchair to be lifted to the floor level of the train even though the car will have low-level boarding. Portland is also designing this type of off-vehicle lift. Special car lifts are provided on one end of each San Diego car.

RIGHT-OF-WAY VARIATIONS

LRT operating environments range from on-street, mixed traffic to grade-separated conditions. Mixed-traffic operations are still prevalent in most of the pre-1978 systems. Mixed traffic is the least desirable situation because of automobile traffic interference that causes delay, impaired reliability, and increased safety hazards. However, exclusive and separated rights-of-way are not always possible, especially in today's era of scarce resources.

On-street operations can be improved through various traffic engineering treatments. Such treatments include exclusive transit lanes as in Philadelphia and San Diego, paint striping to keep automobile traffic out, and special

Table 1. North American light rail vehicle procurement, 1977-1982.

City	No. Ordered	Manufacturer	Configuration	Type[a]	Loading Level	Seats/ Unit
Toronto	190[b]	Hawker-Siddeley w/UTDC	Single-unit four-axle	SE	Low	46
Edmonton	37	Siemens-DueWag	Articulated six-axle	DE	High	64
Calgary	37	Siemens-DueWag	Articulated six-axle	DE	High	64
Cleveland	48	Breda Construzione	Articulated six-axle	DE	Low	84
Philadelphia	112	Kawasaki	Single-unit four-axle	SE	Low	51
Philadelphia	29	Kawasaki	Single-unit four-axle	DE	Low	50
San Diego	24	Siemens-DueWag	Articulated six-axle	DE	Low	64
Buffalo	33	Tokyu Car Company	Single-unit four-axle	DE	High, Low	49
Portland	26	Bombardier	Articulated six-axle	DE	High, Low	76
Pittsburgh	55-60	Siemens-DueWag[c]	Articulated six-axle	DE	3 Doors High, 1 Door Low	58

[a]DE = Double Ended; SE = Single Ended

[b]Six prototypes (not included in above total) were built by SIG, a Swiss rail car manufacturer

[c]Apparent low bidder as of May 14, 1982

pavement texture and a small curb on each side of the transitway as in San Francisco. Hybrid methods can also be used. In Philadelphia, striping and overhead signing are used to allow left-turning auto traffic to enter the restricted transit area.

Various types of horizontal separation can further upgrade the LRT operating environment. In Toronto and San Francisco, LRT operates in arterial medians on a normal gravel-ballasted trackbed; a curb separates traffic from the trolley operation. Planned operation in Portland's downtown area contemplates a one-way operation along with one-way traffic, with the LRT in an exclusive transit lane. Calgary has a new twist in the downtown situation: a transitway that buses are allowed to use, which creates a joint light rail-bus path. In an area outside of downtown Pittsburgh, a joint trolley-bus transit facility can also be found. An at-grade transit-pedestrian mall will be developed in the downtown section of the Buffalo system now under construction.

San Diego's downtown operating environment is different from most; almost every block presents a different situation. Transit has an exclusive path, but it operates two-way, with one-way traffic on one side of the street. In another situation, the LRT operates in the center of the street on a path reserved for two-way trolley operation, with parallel automobile flow on each side of the light rail path. A combination of pavement markings and signing, plus a different pavement texture, is used to preserve the path for transit.

There are many examples of exclusive rights-of-way that range from simple grade separations to tunnel sections. San Francisco, Edmonton, San Diego, Pittsburgh, Philadelphia, Cleveland, and Calgary all have grade separations. Further, San Francisco, Edmonton, and Toronto have subway operations. The new line in Buffalo will also have a subway section, but it will be outside the downtown; the light rail rapid line will operate at-grade in the downtown area.

Various instances of shared rights-of-way with freight and heavy rail or commuter rail systems further illustrate the versatility of light rail transit. Edmonton and Calgary have rights-of-way that are also used by freights. In San Diego, track facilities are used by freights that operate at times when the light rail transit line is not open.

STATION FACILITIES

Light rail station facilities range from the very simple shelter to major subway platforms. The simple stations—as in Cleveland, San Francisco, Pittsburgh, and Toronto—are basically a small raised platform, probably with some weather protection. These shelters are easy and inexpensive to maintain; in most cases, security is heightened because of the visibility. However, these facilities would not be suitable for high passenger-load locations. The platforms in San Diego have been designed for 4-car trains and are generally about 340-360-ft long, even though the shelter itself is only about 60 ft long. This station facility, while somewhat larger than the simple streetside shelter, represents less than a $100 000 investment.

Light rail stations are more complex for systems having barriers with fare-collection facilities that require conductors aboard the cars, paying the train operator, or ticket agents and turnstiles at the stations, as with the San Francisco Muni.

Major facilities can also be developed to enhance transferring between bus and light rail. Toronto is particularly recognized for its devotion to mode transfer. The new lines at Edmonton, Calgary, and San Diego emphasize coordinated, timed transfers at the light rail stations. Facilities for transferring between light rail and regional rail (BART) are provided at the Muni Embarcadero station in the heart of downtown San Francisco.

TRACKWORK

There are numerous variations to trackwork construction; its design depends on the specifics of the area and the alignment. Climate, availability, cost of T-rail as opposed to girder rail, and traffic conditions are factors that will determine the best design. Type of tie (wood or concrete) and weight of rail are other variables on the nonstreet portions of the line. San Diego used normal ballasted track with wood ties covered with asphaltic concrete for street construction; portland cement concrete was used at intersections. Calgary placed the tracks on a portland cement concrete base spaced with tie rods and then brought them up to grade with portland cement concrete. No street traffic is allowed on San Diego's light rail path, while Calgary's path accommodates bus traffic throughout the day. In San Diego, 14 miles were on existing railroad property, where about 50 percent of the existing ties were judged to be usable and left in place.

ELECTRIFICATION FACILITIES

Electrification facilities, overhead wires, and substations can have a significant impact on the visual environment; however, this impact does not have to be negative. Design of the facilities will benefit from urban design assistance.

For example, organizing power poles in the center or even on the side of the roadway can lessen the visual impact. In sensitive environments, such as downtown areas, all wires other than the contact wire can be placed in underground conduits. This method worked well in San Diego, and the vision of overhead wires cluttering the sky has not resulted.