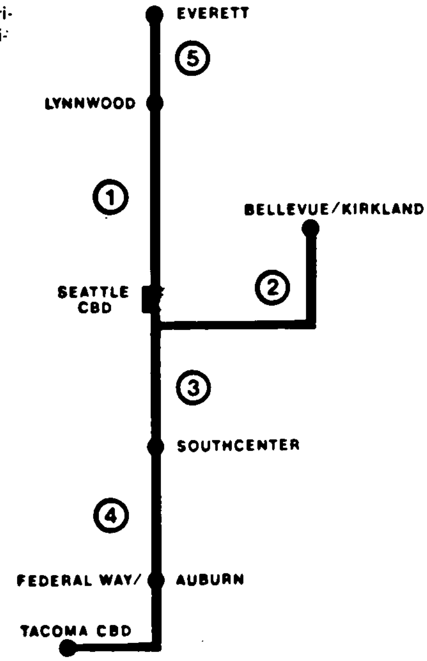
Figure 3. Ranking of corridors, light rail transit feasibility.



major cost savings and reduced transfer volume in terminals when compared to various bus-related options for solving the Seattle CBD issues.

- Light rail costs may be comparable to those of an all-bus system, considering the level of investment expected in the high-volume segments of the corridors with the all-bus option. Life cycle costs may also be comparable and potentially more favorable because of differences in operating costs and vehicle life. A more detailed analysis is necessary to determine these relationships accurately.
- LRT system operating costs may be lower at the demand levels projected by recent PSCOG studies.
- An LRT system has a significant potential for reduced energy consumption, particularly petroleum fuels.

These findings indicate that a feasible LRT project exists and warrants inclusion in a detailed alternatives evaluation. However, the findings also indicate that the project must be on a lesser scale than the full 80+-mile system described in this assessment. In that context, the probability of a feasible and cost-effective project within a corridor or combination of corridors may be ranked as follows (Figure 3):

1. The north corridor, including the Seattle CBD, between the CBD and the general Lynnwood area;
2. The east corridor from the Seattle CBD to some point north or northeast of Bellevue;
3. The south corridor to some point south of South Center (preferably in a nonfreeway corridor);
4. The south corridor to Tacoma; and
5. The north corridor to Everett.

FUTURE STEPS

The first step after completion of the feasibility study was to put light rail transit in the regional transportation plan update as a long-term recommendation.

The next step will be detailing the system and evaluating light rail compared to buses in individual corridors. This will involve looking at alignment, station location, system operation, and connections with a feeder bus system. The consultant has done a fairly detailed scope of work for this phase, and the PSCOG plans to request an UMTA Section 8 alternatives analysis grant when the FY 1982 appropriations bill becomes effective.

In the meantime, PSCOG is working with the City of Seattle and Metro on the environmental impact statement for the midrange transit alternatives for the Seattle CBD to ensure that light rail transit could be accommodated if it later became the chosen mode. The CBD project also has tasks, not yet begun, that deal with such long-term solutions as dual-mode vehicles operating in a tunnel, LRT in a tunnel, and LRT on the surface with terminals and a mall. The objective is to preserve the option for a future regional light rail transit serving the Seattle CBD.

Suburban and Interurban Applications of Light Rail Transit

RICHARD F. TOLMACH, California Department of Transportation

While most analysis of light rail transit has been focused on urban premetro and semimetro development, many of the more successful European light rail developments have been on routes that operate primarily on off-street surface trackage through low-density suburban and rural areas. This paper examines design and operations of light rail systems that serve areas of low population density. Six European and three North American examples are described, with attention to geographic, sociological, and financial aspects of their operating environments. Scheduling strategies, fare structures, and methods of traffic generation used by these systems are given special emphasis. The prospects for future North American interurban light rail developments are examined, with a view to San Diego's new system being a model for selected conversion of North American intercity railroad facilities to provide electric interurban services.

The words "light rail transit" often do not convey the technology or development philosophy symbolized by them. They are misunderstood by the public and even by some transportation professionals. Many Californians fixate on the word "light," and imagine light rail transit to be a form of automated people mover technology; this causes someone to explain that light rail is "modern streetcars." This simplified definition has been tolerated by transportation professionals, but it causes more misunderstandings. To describe the light rail systems being built in North America today in terms of streetcars is obviously inadequate. One can invoke such European terms as "pre-metro" or "Stadtbahn," but this does not help explain the attributes of light rail.

The model for light rail's development is not streetcars down Main Street but the interurbans' innovative use of a variety of rights-of-way. Light rail's future is not in narrow, 45-foot cars based on street railway practice but in cars that are longer, wider, heavier, and owing more to interurban practice. The functional role proposed for most new systems is not to serve compact cities' local trips but to provide regional trunk services for the decentralized urban areas of North America, with bus services providing the local feeders.

The purpose and meaning of light rail transit are not simply modern streetcars—it is the creation of affordable metropolitan railways to serve regional travel needs. In view of this, suburban and interurban applications of light rail have the most to offer American cities in terms of relevant examples. (See Figures 1 and 2.)

THE EUROPEAN EXPERIENCE

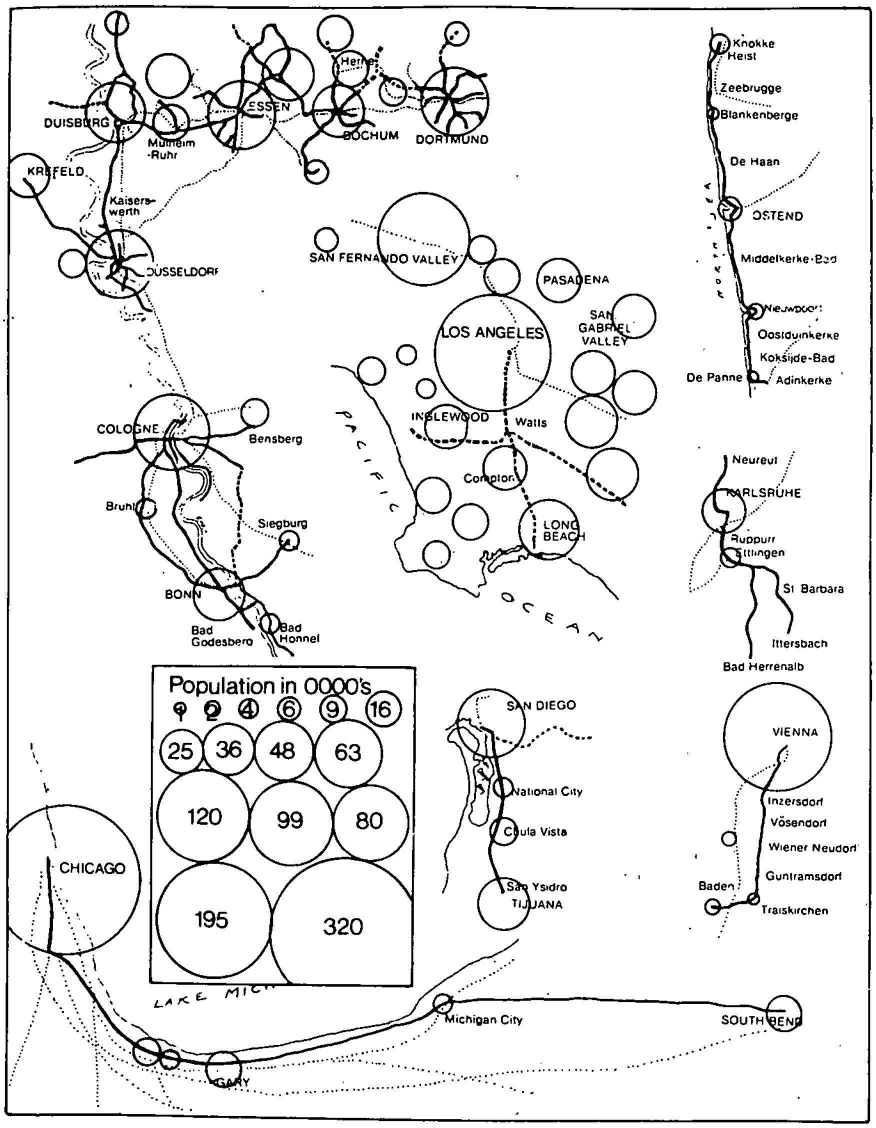
The technology used in Edmonton, San Diego, and Calgary came from West German Stadtbahn development, which also was heavily influenced by interurbans. Stadtbahn systems incorporated many elements of standard rapid transit practice; however, much of the Stadtbahn concept, including design of Stadtbahn cars, originated from the need to optimize existing interurban electric railways for modern transit needs. Cologne, Frankfurt, and Hannover, the first cities in West Germany to develop Stadtbahn systems, all began with interurban lines that influenced their system and vehicle designs.

Each of these cities created its Stadtbahn by linking high-standard suburban and interurban lines by constructing new sections of central city trackage to bypass restrictive curves and clearances. This allowed higher speeds and the use of wider, longer cars with rapid-transit-type capabilities. The station spacing, speed characteristics, and off-street rights-of-way of German interurbans were elements critical to the success of the Stadtbahn concept. These elements are now being attributed to light rail; however, where interurbans still survive, these elements, as well as a wealth of lessons about economics and expedients of the transit business, may still be observed.

The sources of interurbans' financial viability—freight haulage, charter traffic, resorts and other innovative sidelines, labor productivity, efficient equipment use, and unconventional traffic such as tourist and intercity trips—are important examples for transportation planners in an era when urban bus networks typically have a farebox ratio of less than 30 cents on the dollar. European interurbans today operate cost-effectively, even in environments that would be considered impossible territory for rail transit by North American transportation planners.

An examination of today's interurban networks and their operating environments may help define the limits of light rail—how sparse a population can support light rail or how large and dispersed an urban area can be and still have an effective light rail network.

Figure 1. Comparative population of areas with interurbans.



The Rhein-Ruhr agglomeration in West Germany is the site of the largest network of electrified urban transit services in the world. The German Federal Railway and local transit enterprises provide hundreds of miles of railway and tramway services spanning a 90-mile expanse from Bad Honnef and Bad Godesberg in the south; north through Bonn, Köln, Düsseldorf, and Duisburg; east through Mülheim, Essen, and Bochum to Dortmund. The Rhein-Ruhr urban area is even more decentralized than Los Angeles; it does not contain a single predominant center of business activity, but 3 primary ones and 6 secondary ones. Most jobs are outside these centers, in factories and strip commercial developments reminiscent of American regional cities. The northern tier of cities, from Düsseldorf to Dortmund with the cooperation of the German Federal Railway, recently organized all local rail and bus services into a consolidated tariff organization, the Verkehrsverbund Rhein-Ruhr. Four separate "schnellverkehr" (express transit) services are incorporated into the VRR: Düsseldorf's Rheinischebahn interurban lines to Krefeld and Duisburg, sections of the projected Rhein-Ruhr Stadtbahn, the German Federal Railway's S-Bahn services throughout the region, and Wuppertal's unique monorail.

The southern tier of cities on the Rhein, from Koln's northern suburbs to Bonn's southern suburbs, now also have through tramway service and tariffs and have organized their lines into the Rhein-Sieg Stadtbahn.

The least densely populated areas served by interurbans in the Rhein-Ruhr are on the Krefeld (22 km) and Duisburg (25 km) lines of the Rheinischebahn, which roughly parallel the Rhein on opposite banks. The Krefeld-Düsseldorf line has no intercity railway competition; it has a heavy through ridership to Krefeld on its direct route. There are 20-minute headways, often using two 8-axle Düwag cars. The Duisburg-Düsseldorf line, which must compete directly with a faster, 20-minute headway S-Bahn service, has had less end-point-to-end-point travel. Its main ridership comes from intermediate towns unserved by the S-Bahn, but it also attracts some through passengers on its half-hourly service by providing a buffet car in the center section of its Rheinbahn cars.

These 2 interurban lines both went underground in Düsseldorf with the October 1981 start of U-Bahn service, and Düwag "Stadtbahn B" cars, similar to those of Essen, Cologne, and Bonn, are now assigned to these runs. The subway sections eliminated the last sections of line on the 2 interurbans that necessitated the sharper turning radius of the Rheinbahn cars. Duisburg is also constructing a section of subway trackage to be used by the Rheinischebahn line, as well as by the projected Rhein-Ruhr Stadtbahn, and Duisburg will also use the Stadtbahn B car.

The street railways of the Ruhr basin have become increasingly constricted by traffic congestion. Although their span is 25 miles and total trackage is in the hundreds,

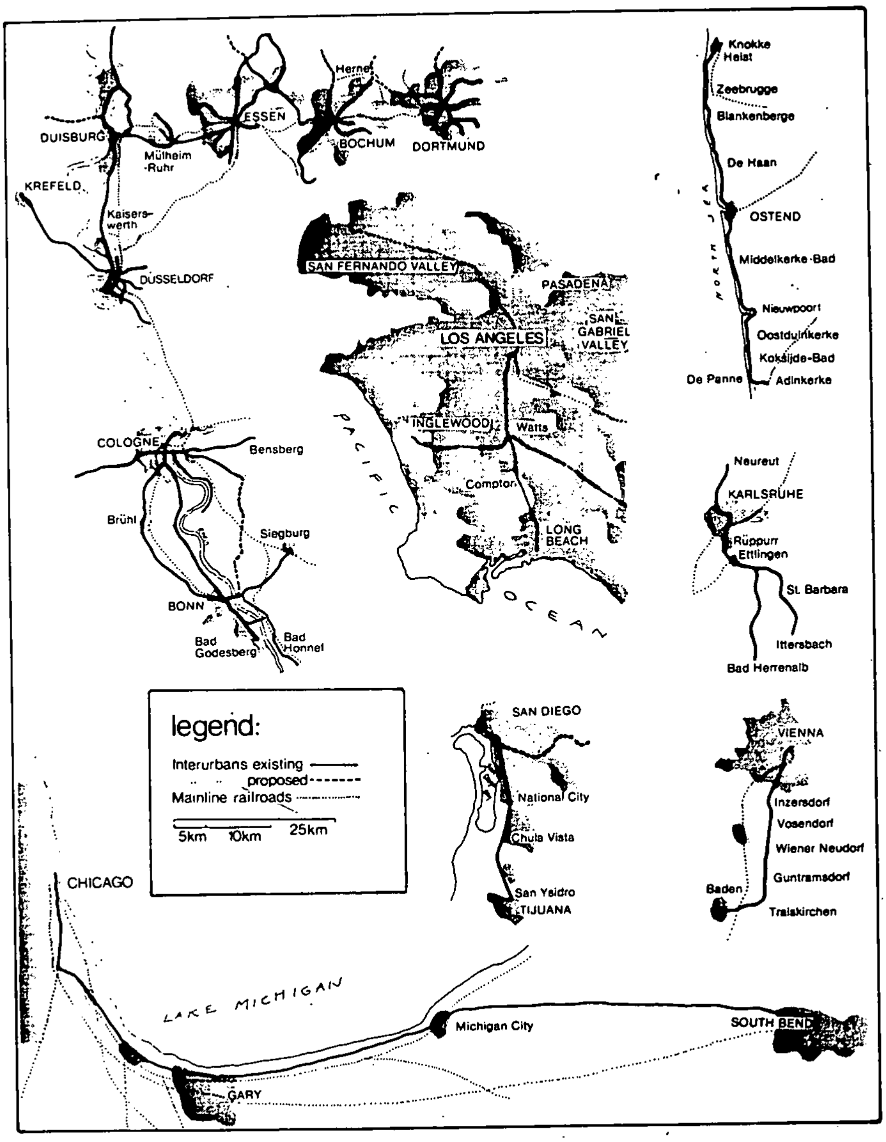


Figure 2. Comparative scale of interurban electric railways.

these predominantly meter-gauge lines had few real interurban or light rail characteristics until recently, when the sections of subway and other grade-separated routes constructed for the Rhen-Ruhn Stadtbahn came into use.

The Stadtbahn was originally planned to be a wholly standard-gauge, grade-separated network that incorporated the strongest routes in the region. About 15 percent of its routes are still to be constructed to full metro standards, with grade separations and high platforms. Stadtbahn B cars have been ordered, indicating that some on-street or at-grade operations are anticipated. The main east-west route of the Stadtbahn is taking shape through separate construction projects in Duisburg, Mülheim, Essen, Bochum, and Dortmund; the Mülheim-Essen segment and a Bochum segment are already in operation. North-south links of the Stadtbahn, some of which may remain meter gauge, are to be constructed (or upgraded) to feed the east-west spine and its S-Bahn competition. The integration of the Federal Railway's S-Bahn and the Stadtbahn is particularly good, with common facilities at the main railway stations in Duisburg, Essen, Bochum, and Dortmund.

Köln (Cologne) may be said to have begun the Stadtbahn movement. Its Kölner Verkehrs-Betriebe accommodated interurban operators on its tracks; accordingly, many of its lines are constructed to impressive standards. Since completion of central city U-Bahn trackage, the KVB has operated large Stadtbahn cars virtually to the exclusion of 4-axle cars. The Köln-Bonner Eisenbahn, an interurban similar to Chicago's North Shore line in speed and facilities, has now had one of its 2 routes integrated into the U-Bahns of Köln and Bonn, as Route 16. This 45-km line links Köln, Bonn, and Bad Godesberg with half-hourly service, which lacks the 80-mph top speeds of the old KBE equipment, but makes up for that with improved connections and better coverage of the commercial centers of Köln and Bonn. Bonn's cross-Rhein suburban routes serve an area with the most Americanized landscape in Europe, including a Disneyland-like amusement park in Rheinau.

The Rhein-Ruhr provides the most pertinent model for transit development in large decentralized cities of the western United States, as it has combined the following techniques:

- Utilization of existing main-line railroads for trunk high-speed transit,
- Combination of existing interurban tramway trackage between cities with new grade-separated construction to tap commercial centers, and
- Full integration of these two "schnellverkehr" modes with each other and with local feeder buses and streetcars.

These techniques have effectively linked all major employment centers, commercial centers, and residential areas in the decentralized Rhein-Ruhr area with high quality transit at a reasonable cost.

Other interurbans show how less populated areas can support rail transit and how recreation areas can be developed without heavy investment in highway access. A recurrent issue in California is how to preserve popular coastal or mountain areas from overdevelopment and yet accommodate greater public use of these areas.

In the United States, development of recreational resources has almost always assumed that there is no alternative to highway-based access. Unfortunately, highway-based development for recreational use of scenic areas often results in marring the natural beauty that originally attracted the tourist traffic. Although parking lot proliferation and air pollution in western parks has been the subject of numerous newspaper articles and government studies, no alternative development model has emerged.

In Europe, interurban tramways have been widely used in place of, or along with, highways to provide access to wilderness and scenic areas. The Tatra National Park in Czechoslovakia, for example, uses a narrow-gauge electric tramway to provide access to the park from the intercity main-line railhead in Poprad, 13 km away. There is also 20 km of additional tramway routes inside the park that provide access to certain areas where automobiles are banned. Switzerland has many such places where automobiles are denied access to areas served by tram, including mountain villages such as Zermatt and Wengen, whose lively tourist trade is because of their unspoiled tranquility. Switzerland's auto-free villages are pleasing to the eye, the nose, and especially the ear. It is an uncanny experience to be outdoors in a village where sounds of human activity predominate rather than those of internal combustion engines.

If the concept of auto-free recreation area development is too advanced for Americans, there are examples of European tramways that compete with automobile access in such areas. The coastal Vicinal tramway of Belgium and the Albtalbahn of West Germany illustrate the use of such recreation-oriented tramways.

Operated by the Societe Nationale des Chemins de Fer Vicinaux, Belgium's coastal tramway may be the longest continuous tramway corridor under exclusive passenger operation. Its 40-mile (65-km), narrow-gauge route follows the coastal dunes from the French border to Holland and links all Belgium's coastal towns. In the absence of any north-south railroad service along the coast, the line serves as a de facto part of the national railway system. Its Ostend terminal is located optimally, adjacent to the railway and channel ferry terminals. The line incorporates a wide variety of trackage, including mixed-traffic running in Ostend.

Until recently, its capital facilities had been allowed to deteriorate. The new 6-axle trams, built by BN Industrie in Brugge in 1981 to replace the 1940's 4-axle trams, have been accompanied by substantial reconstruction of portions of the route, new power supply equipment and overhead wire support, and a certain amount of relocation of tracks into reservations.

Inefficient labor practices and undercapitalization in the past limited the financial success of the line. Instituting a one-man operation system and providing new, attractive equipment and automated ticketing are likely to improve its performance. The nature of the line's traffic is more typical of a main-line intercity railroad than a transit line. It offers no peak-hour service except one short run morning and evening, because no major employment centers are on the line.

The Vicinal has a heavy summer peak; British and Continental tourists besiege the Belgian Coast in July and August. During these 2 summer months, the coastal tramway runs on 30-minute headways, compared to 60-minute headways in the colder months.

The decision by Belgian transportation authorities to invest substantial sums in the line to rebuild its capital facilities and provide new cars was made in the context of land use planning decisions that called for preservation of undeveloped areas of the coast. A tramway is more appropriate than further highway development for this area; it is less visually intrusive and requires less land. The tramway can provide access to beaches by simply stopping; auto access requires parking lots and other facilities that would despoil the beauty of the coast.

The Albtalbahn, operated by the Albtal Verkehrs Gesellschaft (AVG), is a standard-gauge interurban tramway that links Karlsruhe, West Germany, with its northern and southern suburbs and provides a regional service through the woods to several small towns and resorts on the northern edge of the Black Forest. Both the Ittersbach and Bad Herrenalb branches are sparsely populated, and a number of the Albtalbahn's relatively infrequent stops are made at locations where no urbanization is visible. South of Ettlingen, the last true suburb of Karlsruhe, the primary traffic on the Bad Herrenalb line is vacationers traveling to spas and Black Forest resorts. The traffic to Ittersbach is more typical. Both branches use Düwag and Waggon-Union 8-axle, articulated cars to provide staggered half-hour headways during off-peak periods. A local service fills in from Rüppurr to Karlsruhe, so the closer suburbs have 10-minute headways all day.

The German Federal Railway interchanges freight traffic with the AVG near Ettlingen, and the AVG does a moderate freight business on its southern lines, using diesel switching locomotives for traction. Despite the presence of freight, there are gradient changes on the Ittersbach line that would preclude long trains, and the line's engineering appears to be optimized for tram use.

The Albtalbahn's financial performance is good. According to the 1979-1980 Jane's World Railways, the line has an operating ratio of 0.83. This profit may be partly due to such side businesses of the AVG as charter tours, rail freight, and motor transport, but the rail passenger business is a near break-even operation.

Some factors making the Albtalbahn so cost-effective merit examination. The Bad Herrenalb line has no peak-hour operations; the stations exclusive to it are beyond the commuter zone. Its equipment is shifted to the Ittersbach line during peaks; it actually has two 60-minute gaps in the schedule during the morning peak. This substantially reduces the need for equipment that would be used only in the peak hours.

Much of the Albtalbahn's traffic is linked to arrival and departure of midday intercity trains, so it realizes revenue during periods when most transit systems have light patronage. The tourist traffic is not as seasonal as that of the Belgian coastal tramway but has several peak periods, e.g., spa traffic in the spring, hikers in the summer and fall, and substantial winter sports traffic. Tourist traffic fares are appropriately priced to maximize revenues. Karlsruhe Hauptbahnhof to Bad Herrenalb had a 4-Deutschmark tariff ($2.05 U.S.) in 1980, substantially higher than for equivalent distances on other transit systems or the German Federal Railway. At the same time, local commuter travel was reasonably priced.

Freight haulage is also an important supplemental revenue source for the Wiener Lokalbahn, a 30-km, standard-gauge interurban linking Vienna, Austria, with the resort of Baden. The Lokalbahn's right-of-way includes mixed-traffic street operations, sections of railroad-type right-of-way, highway-side, tramway-type reservations, and shared trackage with Vienna's light rail system in subways and on the surface.

The nonarticulated 1920s and 1930s interurban cars of the Lokalbahn are slowly being replaced by 8-axle cars similar to Düwag's Rheinbahn cars. Other investment in the line seems to have been postponed, and the Lokalbahn retains its quaint stations and arching catenary supports. Other such traditions persist as a conductor on-board, manned stations in place of automatic ticket machines, and charter parlor car service. The Wiener Lokalbahn also provides scheduled bus services that parallel and connect to the Vienna-Baden corridor and has a fleet of 3 switching locomotives to work the freight carried to its connection with the Austrian Federal Railway.

The Lokalbahn's operating environment is increasingly competitive, but its market share has not suffered greatly. Its terminal in Vienna is on the surface at the Opernring, a more central location than that of the S-Bahn trains. It also has an advantageous central location in Baden, while the S-Bahn must use a station on the edge of town. Additionally, significant traffic is generated by suburban stops 10 to 16 km from Vienna.

THE AMERICAN APPLICATION

The Chicago, South Shore, and South Bend Railroad, the last surviving interurban of Chicago's Insull empire, is a good example of integration with main-line railroads. It is owned by the Chessie system, and its trains enter Chicago on the tracks of the Illinois Central Gulf Railroad and share the ICG's Central Station on the lakefront.

The South Shore's adoption of railroad standards and practices and integration into the freight-hauling railroad system are the primary reasons for its survival. Its volume of freight haulage is substantial, with unit coal trains contributing a large proportion of ton-miles. The South Shore penetrates the primary industrial area of northern Indiana, a center for steelmaking, manufacturing, and other industries that require mass quantities of resources and must have ample freight traffic both inbound and outbound.

On the other hand, the South Shore's passenger services were a major financial liability for over a decade. The Illinois Regional Transportation Authority and the State of Indiana have stepped in to support these services. In the face of declining passenger traffic during the 1970s, the South Shore adopted a tactic from intercity main-line railroading—it cut back passenger services and raised fares. The public response was predictable and led to a subsequent round of service cuts and truncation of most of the trains at Michigan City.

The South Shore has gradually lost many attributes required to attract passenger travel. Its fleet of Pullman-Standard cars, dating from the 1920s, is literally falling to pieces. Service has been cut to an almost unsalable level, with only 2 daily round trips beyond Michigan City and 2-hour headways during midday between Michigan City and Chicago.

The appearance and condition of many of its stations deter ridership. The level of maintenance of vehicles and electric power facilities has reduced reliability and comfort of service.

The South Shore has also lost most of its interurban character by terminating on-street operations penetrating the commercial center of South Bend. This cutback lost most of the remaining South Bend traffic and is now recognized as having been a mistake.

New terminal facilities in South Bend and possible direct service to the South Bend Airport area are expected to recover the ridership losses there. New 85-foot main-line railroad-type cars are on order and will provide the foundation for reinstituting more frequent operations, the best hope for improvement of the South Shore's market share.

Although other surviving electric tramways in the United States are not now operated in conjunction with freight service, many of the more successful surviving lines have sections of off-street rights-of-way and station spacing typical of interurban operations. These lines include Boston's Riverside line; Philadelphia's Media, Sharon Hill, and Norristown lines; Cleveland's Shaker Heights line; and Pittsburgh's South Hills line.

America's new interurban, the San Diego Trolley, was fashioned out of the remains of a marginal freight-hauling railroad—the San Diego and Arizona Eastern. It has been a remarkable experience for Californians to observe how rapidly and inexpensively it was converted. Only 20 years ago, Los Angeles' Pacific Electric, a major passenger-hauling interurban, became a set of marginally viable freight branches with limited social utility.

The SD and AE's conversion into the San Diego Trolley was accomplished by adding electrification, new rail, and a new line tapping the commercial center of San Diego. The only station facilities are several parking lots and tile-roofed shelters located at major cross streets along the line. Total cost, including cars, was about $5 million per mile.

The specifics of the facility have been discussed but what is important is the applicability of the development to other Californian cities. It would be just as easy to revive the Los Angeles-Long Beach line of the Pacific Electric as it was to convert the San Diego-Tijuana line. Despite protest of Los Angeles freeway apologists, it is difficult to imagine how something that works so well in San Diego would not work 100 miles up the coast.

Previous claims held that California was different from other places because its population density was so low that it could never afford rapid transit systems extensive enough to serve its metropolitan regions. San Francisco's BART and San Diego's light rail system have put the lie to these suppositions.

San Diego's accomplishment is particularly embarrassing for Los Angeles because the San Diego-Tijuana capital works have been accomplished for about the same sum as Los Angeles public agencies have spent over the past 25 years on alternative analyses and engineering for never-built rail lines.

Whatever the eventual outcome of the Los Angeles debates over transportation policy, it should be obvious that population density is a not an issue in coastal California. The Los Angeles-Long Beach line has roughly twice the density of San Diego-Tijuana and roughly 20 times the density of the Belgian coast or the Karlsruhe area in West Germany, where the Albtalbahn operates.

Beyond about 100 passengers per trip, the economics of electric rail transit are superior to that of the bus, regardless of population density, length of the travel corridor, or category of traffic. There is little hope of fares ever covering 80 percent of bus system operating costs. San Diego's light rail system is already achieving this coverage rate, largely because of "recreational" traffic, such as tourists and intercity travelers.

Highway and air transportation systems derive a large percentage of their traffic from recreational travel, a trade that currently gives the airline industry its only profitable seasons. The transit industry's failure to attract a substantial noncommute traffic with buses shows the public's lack of acceptance of the all-bus mode. The recreational and intercity connection markets are particularly lucrative ones for the transit industry, because the trips are most often made during nonpeak hours when there is ample excess capacity. When transit systems were privately run, there was more promotion of recreational travel, and amusement parks and other traffic-generating facilities often were purpose-built by the companies. If public transit enterprises are to be operated in a more businesslike manner in the future, the industry must recognize that off-peak discretionary traffic is good for business no matter what its purpose.

Finally, the potential revenues from freight haulage should not be overlooked. Even lines with marginal carloading levels and lines that railroads consider abandoning may, with more efficient labor practices, offer a net gain by continuing freight service. The successful mixing of freight and transit on the Köln-Bonner Elsenbahn, the Albtalbahn, the Wiener Lokalbahn, the South Shore, and the San Diego Trolley shows that this practice is not hazardous and is by no means innovative.

CONCLUSIONS

The electric railway is a flexible, versatile, and inexpensive means of providing transportation of people and materials. Only when inadequate conceptions of its parameters and capabilities are applied do its form and abilities become limited. When conceived and constructed as a street-railway, it becomes limited in speed and passenger attraction because of traffic congestion. When conceived as a subway with full grade separation, it becomes unduly expensive to construct and limited in range. Under either conception, it loses the ability to provide freight haulage or attract significant recreational traffic and also becomes limited in its applicability to modern cities.

The term "light rail transit" has been moderately successful in breaking through the inadequate conceptions of what rail transit can be. To continue the breakthrough, a definition of light rail that incorporates all the capabilities and potential uses of the electric railway must be applied.

Maintaining Transit Service During Light Rail Rehabilitation in Newark: A Case Study

GREGORY P. BENZ and JEROME M. LUTIN, Parsons Brinckerhoff Quade & Douglas, Inc.

The Newark City Subway is a 4.3-mile (6.9-km) light rail system with 11 stations and an average weekday ridership of 12 600 passengers. As part of the $15 million rehabilitation of this New Jersey Transit Corporation line, alternative transit service will be required during off-peak periods when rail service must be suspended. Suspension of service at night and on weekends is necessary to accommodate rehabilitation of the track, stations, and right-of-way. In developing alternative service options, the advantages of light rail service along the corridor became apparent, both from the perspective of the passenger (travel time) and the operator (operating cost). This paper documents the planning methodology used to develop ridership data and operating plans for alternative bus service. As a result of the alternative service planning, it was determined that the light rail system required significantly fewer vehicle and crew hours than did buses to provide equivalent service and capacity.

The Newark City Subway is one of the few streetcar subways remaining in operation in the United States. Completed in 1935 and operated continuously to the present time, the line has gradually deteriorated as the financial problems of its owners and operators limited the resources available for maintenance and rehabilitation.

During the 1970s, state agencies' increased concern with mass transit led to renewed interest in preserving the mass transit infrastructure of urban areas. This concern caused state and local officials to take a fresh look at the Newark subway and to include it in an overall program of transit rehabilitation in New Jersey called "Transpac." Under the terms of Transpac, funds from a bond issue and from the Port Authority of New York and New Jersey would be used as a local matching share for an UMTA capital grant. Approximately $14 million was earmarked for improvements to the Newark City Subway.

The subway rehabilitation program was to stress renewal of the fixed facilities of the system. Procurement of new vehicles was to be included in the program's later phases. During the planning of the rehabilitation design and engineering work, it became obvious that normal service would need to be suspended for extended periods to expedite the trackwork and right-of-way rehabilitation. As part of the engineering design, an operations planning task was undertaken.

This paper reports on the methods used to plan for