Street-Running Rail Transit: A Historical Perspective

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The strengths and weaknesses of street-running rail transit are presented, along with examples of where streetcar lines, inter-urban electric railways, and rapid transit lines have relocated sections of route to private rights-of-way (ROWs) to improve safety, travel time, and reliability. It is important to avoid (or minimize) street-running today because of more potential conflicts among autos, buses, pedestrians, and trains, and because of a need to maximize speed and reliability. Street-running in the central business district generally should be viewed as the first stage that leads to incremental transitions to reserved ROWs. The goal is to plan for and provide off-street or reserved operations as soon as possible and as resources permit. A historical overview of the experiences of various transit systems are presented and techniques are identified that may be applicable to current rail transit development.

Light rail transit (LRT) is growing in popularity as a means of improved public transport. The ability of light rail vehicles (LRVs) to operate in a broad range of environments, both on and off-street, and their appeal have made them an attractive transport option for many urban areas.

Several of the newer LRT systems in the United States and Canada involve some street-running, especially in city centers. This street-running (in transit malls, reserved lanes, and within median reservations) reduces construction costs and complexity. At the same time it introduces LRVs into an already complex environment and makes trains more susceptible to delays and interferences.

A historical perspective of street-running rail transit is presented with descriptions of the strengths and weaknesses of street-running. A series of case studies illustrates how streetcar and light rail systems, inter-urban railways and rapid transit lines have reduced or eliminated street-running over the years. Finally, emerging implications for rail transit planning are discussed.

OVERVIEW OF STREET-RUNNING

Street-running includes rail transit lines that operate in mixed traffic, preferential lanes, or transit malls. It also includes low-speed (i.e., less than 25 mph) operations in median reservations. These non-exclusive and semi-exclusive rights-of-way (ROWs) are usually found in the central business district (CBD) and the area around it.

The strengths and weaknesses of street-running versus grade-separated ROWs reflect the tradeoffs between lower initial costs and longer travel times. Key comparisons follow.

Street-running rail transit significantly reduces initial construction costs and the time needed to place a system in service. Costs for surface lines are about one-third of those for aerial lines and one-ninth of those for subways. This is an important consideration, particularly in "medium-sized" urban areas. The lower construction costs may reduce the costs-per-rider and thereby improve the cost-effective index. Thus, they may keep systems financially or economically infeasible.

Another advantage of street-running is that it makes full and perceivable use of available public ROWs. In some cases, the system becomes a catalyst for needed street traffic and pedestrian improvements.

However, street-running introduces another somewhat disparate element into an already complex traffic stream. Trains must interact with vehicle traffic and pedestrians. This results in lower speeds, less reliability, reduced capacity, and more accidents.

The combined effects of dwell times at stations (stops) and red times at traffic signals result in a travel time loss of about 3 to 5 min per mile (2 to 3 min per kilometer). This could reduce passenger attraction and increase operating costs, especially when several kilometers (miles) of street-running are required.

The greater travel times may increase operating and fleet costs depending on the amount of time lost and the service frequency. Thus, 4.8 km (3 mi) of street-running with a time loss of 4 min per mi (2.5 min per km) would require one additional train set for headways of 10 to 12 min. Traffic signal preemption can reduce delays at signals, but its extent is limited in most city centers because of the need to clear pedestrians to accommodate intersecting bus routes and, in some cases, heavy cross traffic. The constraints of signal network coordination requirements further limit the signal preemption opportunities in downtown settings.

During peak loading periods, trains are more likely to bunch unless the intervals between them are long. Heavy passenger loadings might cause a train to "miss a green light," and fall behind its leader, with a cumulative effect.

LRV capacities are limited in that (*a*) the train consist length is normally governed by the street block spacing; (*b*) the number of trains per track per hour is limited not only by dwell time and train clearance requirements, but also by the time required by cross street traffic; and (*c*) train turns from one street to another may require a special signal phase, thereby limiting the amount of green time available for trains. This poses a serious constraint where train turns are located adjacent to a major passenger stop.

System safety is reduced because the greatest number of accidents occur along street-running segments of LRT lines. Street-running accounts for about 17 percent of the route miles and 89 percent of the accidents along Howard Street in Baltimore; 8 percent of the route miles and 75 percent of the accidents along the 7th Avenue Transit Mall in Calgary; 25 percent of the route miles and 79 percent of the accidents along the Los Angeles Blue Line; and 10 percent of the route miles and 57 percent of the accidents along 12th Street in Sacramento (*1*).

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Left turns across oncoming train tracks is a commonly reported problem. Contra-flow LRV operations pose problems related to motorist and pedestrian expectancy. The intermingling of pedestrians and trains at stops, on turns, in pedestrian precincts, and at intersections creates a new set of conflicts.

Street-running often poses additional problems to general traffic and pedestrians. The tracks and stations may be barriers to pedestrians crossing the street; there is less capacity for road traffic; and goods delivery and service vehicle access is more limited. Left turns often must be prohibited or given exclusive phases and right turns are often problematic with side-running.

Street-running through the city center is somewhat analogous to building an express highway on both approaches to the CBD with the central section consisting of city street operations with traffic signal control.

EFFORTS TO REDUCE STREET-RUNNING

The elimination of street-running dates back to the early years of electric traction. A literature review identified 18 examples of street railway, inter-urban, or rapid transit lines that removed all or part of their operations from city streets (Table 1). Most of these examples were found in the larger metropolitan areas. The relocations were designed to reduce or relieve streetcar congestion, remove terminals from streets, increase reliability, provide faster entry into the city by cutting running times (and thereby operating costs), and in one instance to allow conventional freight car operations. Rapid transit lines were removed from streets when the growth of surrounding areas made street-running no longer feasible.

Street Railways

Sections of street railways in Boston, Cleveland, Newark, Philadelphia, Pittsburgh, Rochester, and San Francisco were placed in subway or private ROWs, often to eliminate the congestion caused by the streetcars themselves.

Boston

The congested traffic conditions in downtown Boston in the latter years of the 19th century reached acute dimensions. "On Tremont Street during the afternoon rush hour, the cars were packed so close together that one could almost walk from Scollay Square to Boylston Street on the car roofs" (*2*) (Figure 1). These conditions led to the construction of the Tremont Street Subway, which opened in 1897. This was the first rail transit subway in North America. The initial sections ran from Park Street to the Public Garden on Boylston Street, and to Tremont and Pleasant streets. In 1898, the subway was extended northerly from Park Street to North Station. The Lechmere Viaduct to Cambridge was opened in 1912, and in 1914 the Boylston Street incline in the Public Garden was relocated to the center of Boylston Street (*3*).

The western extension to Kenmore Square and beyond was completed in 1925 and 1932 respectively. In 1941, the Huntington Avenue subway opened, and the Boylston Street trolley incline was discontinued, eliminating all street-running in the center of Boston ("Boston Proper").

Post-World War II improvements by the Massachusetts Bay Transit Authority and its predecessor agency, the Metropolitan Transit Authority, continued to reduce on-street operations. The Riverside extension was built on the old Highland Branch railroad ROW. In 1962, the streetcar routes from Broadway and Tremont streets were discontinued. More recently in the 1980s, revenue service on the street-running line to Watertown has been abandoned, and the tracks are being removed. As of mid-1994, the only remaining nonsegregated street-running is along sections of Huntington Avenue and South Huntington from Brigham Circle to Heath Street. On-street service between Heath Street and the Arborway has been discontinued to improve reliability along other parts of the route. This service is provided by bus.

Newark

Newark also took an incremental approach to eliminating street trackage in its downtown area. Its "Four Corners" intersection of Broad and Market streets was once one of the busiest trolley intersections in the United States. In 1910, as many as 525 streetcars passed through this intersection during a single peak hour, and trolley backups of as many as 20 cars were common (*4*).

To alleviate this congestion, the New Jersey Public Service Company redesigned and rebuilt downtown streetcar routes to divert streetcars from congested areas. This reconstruction included a large off-street terminal, built in 1916, in which a short subway in Cedar Street could load and lay over cars from public streets to the basement and second floor of the new terminal (D. Phraner and S. Kashin, personal communication). The City Subway, built in 1935 to serve cars from the west, now operates a single 6.8-km (4.2-mi.) line, partly in an abandoned canal bed. Average daily ridership exceeds 12,000, and overall speeds are approximately 20 mph.

Philadelphia

Street traffic congestion prompted the Philadelphia Rapid Transit Company to develop the parallel Market Street rapid transit and surface-car subways.

The original rapid transit line was opened between 69th and 15th streets in 1907 and was extended to second-Port Street in 1908. An elevated extension was built to South Street and Delaware Avenue in 1908, but was discontinued in 1939. Between the Schuylkill River and City Hall, a four-track subway was built. Subway-surface cars have used the outer two tracks since 1905 (*5*).

In 1955 both the rapid transit and surface-car subways were extended west to about 45th Street.

Pittsburgh

Streetcar subways were proposed for more than 75 years to relieve streetcar congestion in the Golden Triangle. (By the mid-1920s almost 700 streetcars left the 0.5-sq-mi^2 (1.3-sq-km^2) downtown area over nine routes; 150 used the Smithfield Street Bridge) (*6*). A 1.6-km (mile-long) subway was opened in 1958, modern LRV cars were acquired, and downtown street-running was eliminated. The subway connects the area's remaining trolley lines that serve the South Hills area mainly via the Mount Washington Tunnel. These lines, which run largely on private ROWs, continue to be upgraded.

TABLE 1 U.S. Electric Railways That Eliminated Street-Running

CITY AND/OR SYSTEM	LOCATION	YEAR
STREET RAILWAYS		
BOSTON	PARK ST.- BOYLSTON ST. SUBWAY	1897-1898
	BOYLSTON SUBWAY EXT. TO KENMORE SQ.	Beyond 1925-1932
	HUNTINGTON AVE SUBWAY	1941
NEWARK	CEDAR STREET SUBWAY	1917
PHILADELPHIA	CITY SUBWAY	1935
	MARKET ST. SUBWAY, 15TH TO SCHUYKILL	1905
	SCHUYKILL TO 45TH	1955
PITTSBURGH	DOWNTOWN SUBWAY	1985
ROCHESTER	MAIN ST. SUBWAY	1927
SAN FRANCISCO MUNI	MARKET ST. RELOCATION TO SUBWAY	1972
SHAKER HEIGHTS (CLEVELAND)	SHAKER SQUARE TO UNION TERMINAL	1930
INTERURBAN ELECTRIC RAILWAYS		
CHICAGO, AURORA AND ELGIN		1934
CHICAGO NORTH SHORE AND MILWAUKEE RAILWAY	SKOKIE VALLEY BYPASS	1926
	WINNETKA GRADE SEPARATION	1939-1940
CHICAGO SOUTH SHORE AND SOUTH BEND RAILROAD	EAST CHICAGO BYPASS	1956
COLUMBUS, DELAWARE AND MARION	WORTHINGTON BYPASS	1923
ILLINOIS TERMINAL RAILROADS	FREIGHT BELT LINES IN CHAMPAIGN, URBANA, DECTATUR, SPRINGFIELD, EDWARDSVILLE	1915-1937-
	ST. LOUIS ELEVATED & SUBWAY TERMINAL	1933
INDIANA PUBLIC SERVICE CORPORATION	WABASH BYPASS	1931
THE MILWAUKEE ELECTRIC RAILWAY AND LIGHT CO.	SUBURBAN AND INTERURBAN ENTRIES INTO MILWAUKEE FROM SOUTH, AND WEST, INTO KENOSHA.	1928-1932
PACIFIC ELECTRIC RAILWAYS (LOS ANGELES)	ELEVATED APPROACH TO MAIN ST. TERMINAL	1917
	HILL ST. TUNNEL	1925
	LINE IN HOLLYWOOD FREEWAY MEDIAN THROUGH CAHUERGA PASS	1949
WASHINGTON, BALTIMORE AND ANNAPOLIS	RELOCATE TO B&O CAMDEN STATION	1922
RAPID TRANSIT LINES		
BROOKLYN RAPID TRANSIT	CULVER AND WEST END LINES	1919 AND 1917
	36TH ST.-CONEY ISLAND	RESPECTIVELY
CHICAGO & OAK PARK ELEVATED	RELOCATING RANDOLPH ST. LINE TO SOUTH BOULEVARD	CIRCA 1901

SOURCE: Compiled by Herbert S. Levinson and George Krambles.

Rochester

To reduce downtown congestion, Rochester opened a streetcar and inter-urban subway in the abandoned bed of the Erie Canal in 1927. Inter-urbans of the Buffalo, Lockport, and Rochester Railway; the Eastern Rochester and Rapid Railway; and the Rochester and Syracuse operated in the subway until about 1931. Local trolley operation in the Municipal Subway continued until 1956.

San Francisco

Streetcar and traffic congestion on Market Street in the downtown area has a long history. Four tracks were provided, two for the Market Street Railway and two for the Municipal Railway. Each track carried about 75 cars in the peak evening period of 5:00 p.m. to 5:30 p.m. Daily volumes on the western entrance to the downtown area exceeded 125,000 passengers in 1929 (*7*).

The combinations of heavy passenger boardings and alightings on both the inside and outside tracks; the short spacing between cars (20 to 30 sec); cross street interferences; and automobiles encroaching on tracks resulted in speeds that were less than 4 mph on sections of downtown streets during peak periods (Figure 2). "In some sections . . . it was . . ." possible to walk faster than the cars traveled (*8*). Minor accidents or unusual occurrences resulted in streetcars leaving the downtown area 5 to 10 min behind schedule (*8*). Two of the four tracks were removed after World War II when trolley or motor buses replaced streetcars on several routes.

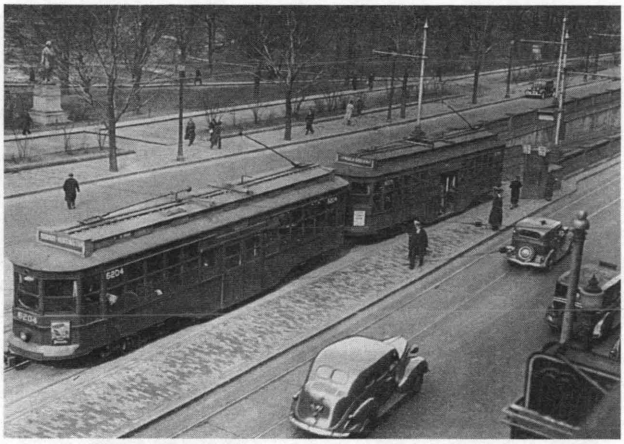

FIGURE 1 Boylston Street Incline (Boston) near the Public Garden, was used by Jamaica-Arborway subway-surface line until 1941. (From collection of Fred F. Freeman, reprinted from *Rapid Transit Boston Bulletin 9*, 1971, with permission).

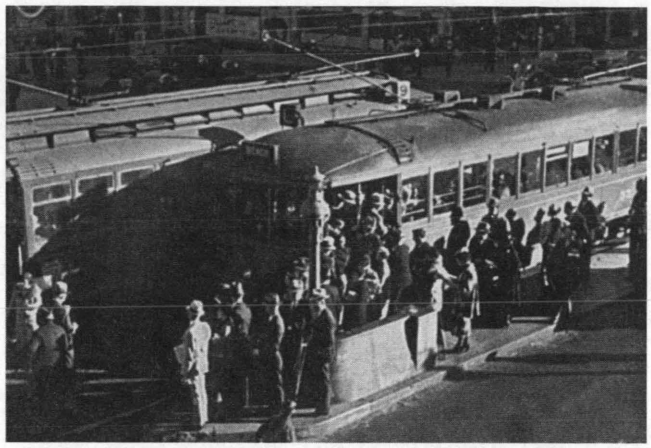

FIGURE 2 Loading zone on Market Street, San Francisco, circa 1935 (*8*).

The Market Street streetcar subway, built in conjunction with Bay Area Rapid Transit and opened in 1972, is a culmination of a half century of proposals. Since then, all streetcar operation has been moved underground, although one set of tracks remains on Market Street. The city of San Francisco is re-establishing a single route on the surface along Market Street and the Embarcadero to reinforce tourism and supplement the subway lines, including the use of vintage trolleys.

The travel time between the Embarcadero and Powell Street stations (a distance of 1.9 km) (1.2 mi) was reduced from about 10 to 12 min to 4 min as a result of the subway operation.

Shaker Heights

The Shaker Heights Rapid Transit System (now part of the Greater Cleveland Regional Transit Authority) was initially built on open land by the Van Sweringen Brothers to encourage real estate development. The Shaker Boulevard Line was opened in 1909 and the Moreland Boulevard (Van Aken) Line was opened in 1920. Both lines were built within wide median reservations (*9,10*).

Access to downtown Cleveland was provided over the existing street railway network between 1909 and 1920. In 1920 a new line on an exclusive ROW was built from Moreland Circle (now Shaker Square) to 34th Street, where a ramp provided access to the downtown area via the existing streetcar lines. Operation into Union Terminal began in July 1930, thereby providing a 8-km (5-mi) high-speed, fully grade-separated entry into the city center; running times over this section have ranged from 10 to 13 min. These faster running times permitted short outer extensions while preserving the 1-hr round trip.

The line shares several kilometers with the Cleveland Rapid, as well as a new terminal in the new Tower City Development of Union Terminal.

Other Examples

Off-street routes and terminals were proposed or developed in other areas as a remedy for street-running. Some avoided complex intersections, such as Capital Transit's Du Pont Circle Subway in Washington, D.C. Some, like Cincinnati's subway, were started but never completed.

Inter-urban Electric Railways

Inter-urban railways frequently ran on city streets and shared slow streetcar tracks to reach their downtown terminals. The time lost in street-running was one of the inter-urban's major disadvantages, and it became severe as automobile traffic and curb-parking conflicts increased.

Accordingly, many of the systems serving large urban centers relocated their lines over the years to eliminate street-running. Street-running was eliminated on sections of the inter-urban railways serving Baltimore, Chicago, Los Angeles, Milwaukee, and St. Louis, as well as several lines in Indiana and Ohio. The reasons cited include (a) to provide a faster entry into the city center, (b) to eliminate slow or congested street running, (c) to remove the terminal from city streets and, (d) in the case of the Illinois Terminal Railroad, to make it possible to operate standard freight cars.

Chicago, Aurora, and Elgin Railroad

The Chicago Aurora and Elgin Railroad (CA&E) was one of the three high-speed lines that linked the Chicago Loop with surrounding areas. The line opened in 1902 and 1903 between Laramie Avenue in Chicago and the Fox River Valley suburbs of Aurora, Batavia, and Elgin—about 65 km (40 mi) west of the loop. Direct entry into the loop was provided via the elevated lines in 1905. An extension to Geneva and St. Charles was opened in 1907.

Operation was mainly on private ROWs with third rail power collection. However, there was street-running in the Fox River Valley towns of Geneva, St. Charles, and Aurora. The West Chicago-Geneva-St. Charles Line was abandoned for lack of traffic in 1937. A private ROW and a new terminal replaced street-running in Aurora, the last on the CA&E, in 1939 (*11*).

Construction of the Congress Street Expressway in Chicago and the median strip rapid transit required surface operation of "L" trains in 1953. At this time, CA&E trains terminated at Des Plaines

Avenue. The loss of one-seat service to downtown Chicago coupled with the increase in auto ownership and deferred maintenance led to the termination of passenger service in 1957. Freight service was stopped 2 years later.

Chicago North Shore and Milwaukee Railway

The initial line between Milwaukee and Evanston was completed between 1891 and 1908. Street-running took place in Milwaukee, Waukegan, Winnetka, and Wilmette. In 1916, the Insull Interests acquired the railroad and began a decade-long modernization process. In 1919, direct entry was provided into the Chicago Loop via the elevated lines. A new terminal was built in Milwaukee from 1920 to 1921 and several blocks (1.1 km or 0.7 mi.) of street-running were removed (*12*).

The 42-km (26-mi.) Skokie Valley route was opened from Howard Street, Chicago to North Chicago Junction in 1926 as a high-speed bypass of the original Shore Line. This resulted in a 10- to 15-min time savings. Travel times for the 145 km (90 mi.) between the loop and downtown Milwaukee were reduced to 2 hr or less, including 12 min for 5 km of street-running in Milwaukee.

The North Shore Line cooperated with the parallel Chicago and Northwestern, and public agencies cooperated in a line relocation project through Glencoe, Winnetka, and Kenilworth in 1939 and 1940. The relocation eliminated more than a dozen grade crossings and several miles of street running.

However, street-running remained in Wilmette and Waukegan until the abandonment of the Shore Line route in 1955. Elimination of street-running in Milwaukee came with the complete abandonment of operations in 1963. The 8-km (5-mi.) Skokie Swift operation was established on the south end of the Skokie Valley Line by the Chicago Transit Authority (CTA) in 1964.

Chicago, South Shore, and South Bend Railroad

The 145-km (90-mi.) South Shore Line provides an excellent example of the incremental elimination of street-running over several decades. The line opened between Chicago and South Bend in 1909 and was substantially improved during the 1920s under Insull control. Trains entered Chicago over Illinois Central tracks that were electrified in 1927. They operated on city streets in South Bend, Michigan City, and East Chicago, Indiana (Figure 3) (*13*).

Street-running was eliminated in East Chicago in September 1956 when a new 8-km (5-mi.) cutoff was built alongside the Indiana Toll Road (Figure 4). The relocated line eliminated 32 rail and street crossings, thereby improving on-time performance and saving 3 to 4 min of running time.

The 3.5 km (2.2 mi.) of street-running in South Bend was eliminated in 1970 when a new terminal was built at Bendix, and the line to the original downtown terminal was discontinued. Within the last few years, the South Shore Line was extended northerly and then westerly to a new terminal at the South Bend Michigan Regional Airport. This extension is along mostly unfenced side-of-the street running with frequent grade crossings.

The street running in Michigan City remains a vestige of the inter-urban era. However, the Northern Indiana Commuter Transit District, the current operator, is planning a bypass around the city.

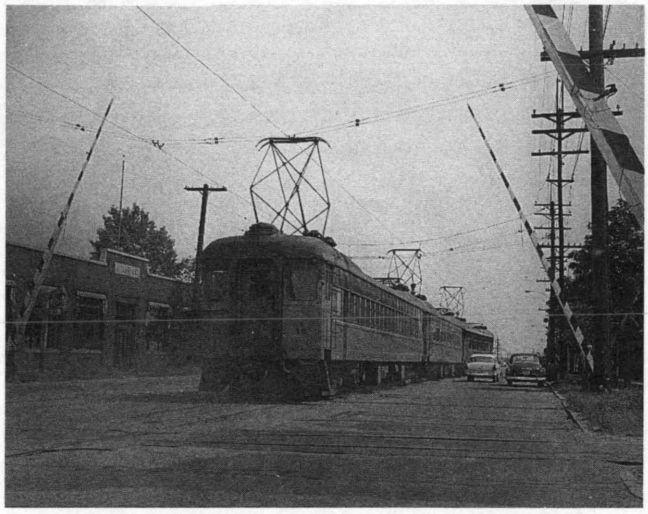

FIGURE 3 South Shore Line: street-running in Michigan City (old route), circa 1930 (from collection of George Krambles; used with permission).

Columbus, Delaware and Marion Railway

This 81-km (50-mi.) inter-urban, opened in 1903, was located mainly on a private ROW separated from the parallel highway by a ditch and pole line (*13*). In 1923, 10.5 km (6.5 mi.) of its entrance into Columbus including a bypass around Worthington were relocated onto private ROWs. Passenger service was discontinued in 1933.

Illinois Terminal Railroad

The 645-km (400-mi.) Illinois Terminal Railroad System (initially, the Illinois Traction System) was the largest inter-urban railroad except for the essentially suburban Pacific Electric System. Its lines served St. Louis, Alton, Springfield, Peoria, Bloomington, Decatur, Champaign-Urbana, and Danville, and covered much of central Illinois. Unlike most inter-urbans, the line carried both passengers and freight with equal intensity and emphasis (*14*).

The original lines between Danville and Urbana were completed in 1901. By 1908, the entire system was in place. A new bridge over the Mississippi River was opened in 1910.

Street-running was common in many towns and cities along the route. Under the management of William B. McKinley, an Illinois congressman, freight belt lines were completed around Decatur, Springfield, Edwardsville, and Granite City between 1911 and 1913. These bypasses enabled freight trains to avoid city streets and to handle car load freight. Many 65-km (40-ft) radius curves limited the length and types of trains that could be accommodated. Some communities restricted freight trains between midnight and 6 a.m. (*14*).

An additional belt line was built in the Champaign-Urbana area in 1927 to eliminate street-running and to permit the interchange of freight cars with steam lines. This belt involved electrifying sections of Illinois Central and Wabash Railroad tracks (*15*).

An elevated approach to downtown St. Louis was completed in 1931, and a new St. Louis subway terminal opened in 1933. These improvements eliminated all street-running in St. Louis.

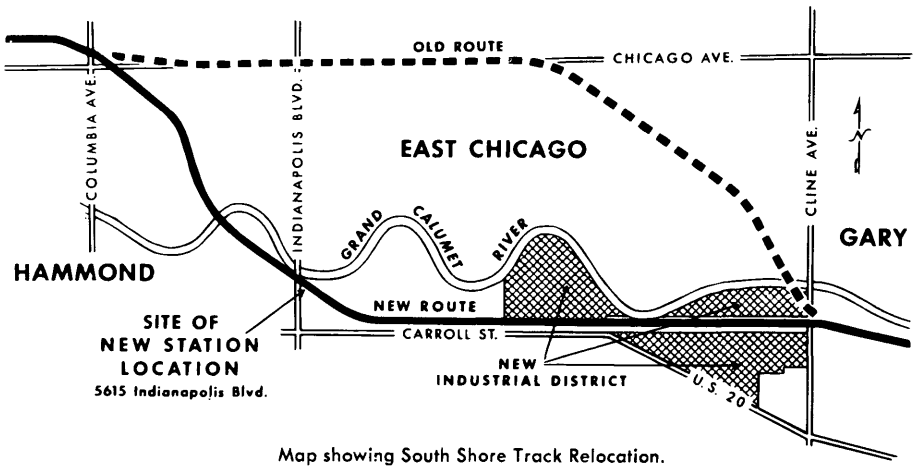

FIGURE 4 South Shore track relocation, Michigan City, 1956 (courtesy Chicago, South Shore, and South Bend Railroad).

Passenger service was eliminated by 1956, except for the Granite City-St. Louis streetcar line that remained until 1958. The various lines were then dieselized for freight service. The Norfolk and Western purchased the remaining freight lines and trackage rights in 1981.

The Milwaukee Electric Railway and Light Company

This 322-km system connected Milwaukee with Kenosha, Racine, Watertown, and Sheboygan. It was developed between 1895 and 1909. Street-running was common in these cities.

During the 1920s, the company initiated a $6 million improvement project to improve access into downtown Milwaukee. An 11-km (7-mi.) private ROW surface entrance for western lines with three and four tracks was completed between Eighth Street and West Junction by 1932. A 17-km (10.5-mi.) belt around south Milwaukee cut 30 min of travel time on the route to Racine and Kenosha. A similar project on the Sheboygan Line and a 0.8-km (half-mile) subway into the downtown terminal from the Western Line were never completed (*16*). Street-running remained on the approach to the downtown (off-street) Milwaukee terminal.

The West Side Line was used both by inter-urban trains and city streetcars. Speeds on the private ROW including stops averaged 48 km/hr (30 mph).

The various lines were abandoned between the 1930s and the 1950s. Service to Waukesha and Hales Corners was discontinued in 1951. [A serious accident in 1950 resulting insurance difficulties, and the loss of traffic contributed to the final abandonment (*13*)]. City streetcar service over the exclusive ROW continued until 1959. An interstate freeway was subsequently built over much of the ROW.

Pacific Electric Railway

The Pacific Electric (PE) Railway traces its origin to the Los Angeles-Long Beach Line built by Henry E. Huntington about 1905 where the Blue Line LRT trains now run. The system was extensively developed by 1915 when its 1 600 km (1,000 mi.) of track covered the entire metropolitan area and made it the largest intercity electric railway system in the United States. The railway came under Southern Pacific control after a merger in 1911.

A large part of the system operated on private ROWs. These included the lines to Long Beach, Santa Ana, Newport Beach, and San Bernardino. However, there was considerable street-running on the Western District Lines leading out of downtown Los Angeles, in Hollywood, Santa Monica, Pasadena, Glendale, and in the downtown area itself.

The PE Lines were built largely ahead of the population at a time of low car ownership. Consequently, street-running posed relatively few problems at first, except in downtown Los Angeles. As traffic congestion increased, several sections of street-running in downtown Los Angeles were relocated.

To improve entry into the downtown area from the south, an elevated approach was built between San Pedro Street and the terminal at Sixth and Main in 1917. This left only a few blocks of street-running on San Pedro Street and Olympic Boulevard before reaching the four-track private ROW along Long Beach Boulevard. (The current Blue Line LRT has more street-running along Washington Boulevard and Flower Street than the PE approach to its former terminal.)

Two short tunnels were opened under Bunker Hill in 1909 to shorten running time for cars traveling to and from the west. One tunnel extended about 168 m (550 ft) from First to Temple, and the other almost 305 m (1,000 ft) from Temple Street to Sunset Boulevard (*17*).

A 1.6-km (1-mi.) subway for trains was built from a point near Glendale Boulevard and First Street to a terminal at Hill and Fourth streets in 1925 at a cost of about $5 million. The subway served trains for Hollywood, Burbank, and Van Nuys, removing these services from downtown streets. Travel times were reduced by about 5 min.

A further attempt to eliminate street-running was achieved in 1949 when a rail line was located in the median of the then six-lane Hollywood Freeway through Cayuenga Pass. This was the first rail transit line built within a freeway median.

A significant portion of PE passenger service was abandoned between 1938 and 1941 in response to a study by the California Public Utilities Commission. However, the high-density lines remained until after World War II (*18*).

After World War II, the inter-urban lines gradually disappeared. The Burbank and Hollywood Lines (and the Hill Street Subway) were abandoned in 1958, and the Hill Street Tunnel remains unused. The last line—to Long Beach—ceased passenger service in 1961. The Southern Pacific continues to operate dieselized freight service on portions of several lines (*7*).

Current plans to develop a regional light rail system incorporate many former PE ROWs. Downtown distribution will be via an extension of the Flower Street subway through the northern part of central Los Angeles.

Washington, Baltimore, and Annapolis

The Washington, Baltimore, and Annapolis (WB&A) was a high-speed, high-density inter-urban that connected Washington, Baltimore, and Annapolis. Its Washington-Baltimore main line was opened in 1908.

Beginning in 1921 and through the next year, a modern passenger and freight terminal was built north of the B&O Camden Station in Baltimore. This eliminated street-running and the use of an on-street terminal in Baltimore.

In March 1921, a new 3-block loop station was opened at 12th Street and New York Avenue in Washington D.C. This eliminated loading and unloading directly from the street. However, trains continued to use local streetcar tracks in Washington and took 30 min to reach the private ROW to Baltimore. Running times of the faster trains for the 65-km (40-mi) trip to Baltimore were reduced to 65 min, but still remained longer than that on parallel main-line railroads (*19*).

The long, slow trip to downtown Washington caused the WB&A to abandon its Washington service during the Depression. The line between Baltimore and Annapolis was reorganized as the B&A and continued to provide passenger and freight service until 1950 when passenger service stopped. Sections of this line form part of Baltimore's Central LRT that was opened in 1992. The LRT, unlike its predecessors, has extensive street-running along Howard Street in downtown Baltimore.

Rapid Transit Lines

Rapid transit systems were developed around the turn of the century in Boston, Chicago, New York, and Philadelphia to overcome the congestion and capacity constraints associated with surface transit. Similarly, the first 6.5 km (4 mi.) of Toronto's Yonge Street subway, which opened in 1954, replaced the slow and overcrowded Yonge streetcar line.

Rapid transit lines in outlying parts of Brooklyn and the Chicago area ran on the surface, often with overhead current collection. Four lines in Chicago (Douglas, Evanston, Ravenswood, and Skokie) still operate partly on the surface.

Two examples were found (in Southern Brooklyn and in Oak Park, Illinois) where rapid transit trains actually ran on the streets.

Brooklyn

Early rapid transit trains operated on several streets in Southern Brooklyn between 36th Street and Coney Island. Trains on the Culver Line ran along McDonald (Gravesend) Avenue from about 1900 to 1919 when the line was elevated. Trains on the West End Line ran along New Utrecht, Bath, and Stillwell avenues until 1916 to 1917, when the line was elevated as part of New York City's Dual Contracts program (Figure 5). Both lines, along with the Sea Beach and Coney Island lines, evolved from steam railroads serving the Coney Island area during the last part of the 19th century (R.A. Olmsted, personal communication).

Chicago

The Chicago and Oak Park (Lake Street) Elevated Line was extended on the surface of Austin Avenue and Randolph Street to about Wisconsin (Harlem) Avenue in Oak Park in 1899 (Figure 6). This street-running lasted about 2 years when the line was located to the immediate north on a separate ROW on the northern half of South Boulevard (*20*).

The CTA relocated the line from South Boulevard to the parallel Chicago and Northwestern Railroad embankment in October 1962 at a cost of $4 million. The relocation eliminated all at-grade crossings and the need to change from third-rail to trolley operations (*21*). The entire Lake Street Line, including the embankment, is currently under reconstruction.

The CTA and its predecessor agencies eliminated a considerable amount of rapid transit operations at surface level. Eleven km (7 mi.) of the north side elevated line were grade-separated (between Wilson Avenue, Chicago, and Central Street in Evanston) in the 1920s. The grade separation was developed by the Chicago, Milwaukee, and St. Paul Railroad at the behest of its tenant, the Northwestern Elevated Railroad (later, the Chicago Rapid Transit Company). The CTA eliminated some 7.3 km (4.5 mi.) of surface operations on the outer ends of the Garfield-Maywood-Westchester and Douglas lines in the 1950s. Completion of the Congress Expressway by 1960 made it possible to eliminate 4.0 km (2.5 mi.) of grade level operation with numerous grade crossings by relocating the rapid transit line into the expressway corridor.

FIGURE 5 Brooklyn Rapid Transit: street-running on New Utrecht Avenue at 63rd Street 1914 (from Edward B. Watson Collection, courtesy Arthur J. Lonto).

FIGURE 6 Chicago and Oak Park Elevated: temporary route on Randolph Street, 1902 (from collection of George Krambles, used with permission).

IMPLICATIONS

Street-running in mixed traffic, reserved lanes, or within median reservations introduces another, somewhat disparate element into an already complex traffic stream. It poses potential problems of reliability, safety, lower speeds, and reduced capacities, especially in downtown areas. For these reasons, many U.S. electric railways have made concerted efforts to get their operations out of the streets.

The preceding case studies indicate that electric railways eliminated street-running where this was possible and where resources were available. Many of these decisions were made when there was little auto use and competition, and when travel demand was growing.

Today, it is even more important to avoid (or minimize) street-running. There are more potential conflicts between autos and trains despite better traffic engineering. Moreover, there is a need to provide rapid and reliable transit service that is competitive with driving. Minimizing conflicts, accident potentials, and travel times is not possible where there is extensive street-running, especially in the city center and the area around it.

Street-running in the CBD and other congested areas, therefore, should be viewed mainly as the first stage of a future off-street, preferably grade-separated, system. The basic goal should be to plan for and provide off-street operations (even at-grade) as soon as possible. Incremental transitions to off-street operations should be achieved where time and cost constraints preclude grade-separated alignments initially. This suggests the "pre-Metro" incremental approach used in European cities such as Brussels and Frankfurt.

LRT systems such as Cleveland (Shaker Heights) and the new St. Louis LRT line provide good examples of how street-running can be minimized in the planning, design, and operation of new systems.

Obviously, there may be exceptions in which CBD street-running in reserved lanes or medians may be appropriate. These include: (*a*) low-frequency train service, (*b*) long block spacings, and (*c*) low auto traffic volumes. These, however, should be the exception rather than the rule. Operations in median reservations may be appropriate where the number of street crossings can be controlled and operating speeds of at least 25 mph can be maintained between passenger stops.

Vintage special-interest operations in pedestrian and transit malls are another exception. Low speeds and frequent stops are desirable to serve tourists, shopping, lunch time, or other short CBD trips.

Investments in rail transit can be substantial. They buy speed, reliability, safety, and capacity. These service improvements are best achieved in cities where the trains will not affect or be affected by, street traffic.

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