

Light-Rail Transit Developments in Western Europe

Glen D. Bottoms, *Federal Transit Administration, U.S. Department of Transportation*

Events in Europe during the past 5 years have shown a number of important trends that favorably position the light-rail concept, in both existing and proposed systems, for continued positive development and intensified implementation. The building of new systems in western Europe has been a key element in enhancing the visibility of the concept. The widespread upgrading of existing systems has further accentuated the concept. Finally, the almost total market penetration and acceptable performance of low-floor light-rail vehicles have allowed light rail to serve diverse populations while retaining its inherent flexibility. In light of the above developments, the most significant events in light rail in western Europe will be described, first by touching on significant advances on a country-by-country basis but then largely concentrating on the phenomenal growth of new systems in France and the implementation of the regional or "Karlsruhe" concept of joint light-rail-railroad operations in Germany. This approach will point out the trends that have emerged in Europe and document the strong desire to employ affordable fixed-guideway solutions that support the overall objectives of heightened mobility, compatible urban growth, and improved quality of life.

The 1990s have witnessed the significant interest in cities across western European in revitalizing public transportation in general and fixed-guideway systems in particular. In every city that has retained light-rail and tram operations, serious efforts have

been undertaken to renew or expand the existing systems. In a number of cities that had previously discontinued old tram services, new systems have been implemented or are currently in final planning (principally in France and Great Britain).

The following is a quick survey of these activities. Although the primary focus of this paper is the emergence of new systems in France, another key objective is to briefly chronicle, in some depth, activities in other countries as well. Therefore, the following narrative highlights events in eight key western European countries and supports the premise that the renewed interest in light rail is not confined to a single country or region.

OVERVIEW OF LIGHT RAIL IN WESTERN EUROPE

France

France has clearly emerged as the European, if not the world, leader (followed closely by the United Kingdom) in the design and implementation of new light-rail systems. The success of new light-rail systems in Nantes (1984), Grenoble (1987), Paris-Saint Denis-Bobigny (1992), and Rouen and Strasbourg (1994) has provided momentum for other medium-sized conurbations with populations over 300,000 to seriously examine the advantages of the light-rail concept. A detailed look at light rail in France is provided later in this paper.

United Kingdom

The United Kingdom has recently seen the successful start-up of new systems in Manchester (April 1992) and Sheffield (South Yorkshire Supertram, May 1994), the approval of the Midlands Metro (Birmingham to Wolverhampton), and well-advanced planning in Leeds, Croydon (Greater London), and Nottingham. A completely grade-separated hybrid light-rail system was opened in Newcastle (Tyne and Wear Metro) in 1980 and in London (Docklands) in 1987. The Newcastle system is now 60 km long, and the Docklands Railway undertaking, an automated operation, has reached a length of 20 km. The Manchester system has achieved a length of 15 km and is carrying more than 50,000 passengers daily. Two proposed extensions have already been approved. The Sheffield undertaking is being expanded in phases. Of note is the fact that the Croydon proposal (Croydon Tramlink) may involve a significant investment from the private sector. Final approval of this project by the Department of Transport will hinge on confirmation of the private-sector participation (Parliament assented to the project in July 1994). The Leeds Supertram line received Parliamentary authority in 1993, and a funding application is expected to be approved in 1996. The Nottingham proposal would apply the Karlsruhe, Germany, regional approach utilizing British Rail rights-of-way to access diverse regional destinations.

Germany

In Germany, the acknowledged western European leader in light rail with 55 individual light-rail systems currently in operation, an innovative variation has been embraced called the Karlsruhe approach, in which light rail assumes a truly regional character through the shared use of existing main-line railroad alignments. The city in which this innovation was developed and proven feasible, Karlsruhe, is described in more detail in the third section of this paper. One city, Saarbrücken, has secured approval for a light-rail system (the first new system in Germany in over 60 years) that will create a regional network based on the Karlsruhe experience.

Although many other countries in the West (including France) moved to discontinue existing tram operations before and soon after World War II, German cities, once they recovered from the devastation of the war, began to upgrade street tramways incrementally to what would be characterized today as true light-rail standards. Among the major German cities, only Hamburg and West Berlin discontinued tram operations, in 1978 and 1967, respectively. In the case of Berlin, reunification has meant the resurgence of trams (tram service was retained in the eastern half of the city), which will now be selectively

reextended into the western sectors of the city. In Hamburg, plans have been developed for reintroducing trams in the form of a four-route light-rail network. Foremost among German cities implementing the full range of light-rail options (subway, aerial, partially and fully reserved street alignment, fully segregated right-of-way, and high and low platform operation) are Bonn, Frankfurt, Hannover, Cologne, and Stuttgart (the last also effected a change from meter gauge to standard railroad gauge). All remaining German cities, including those in the former eastern part of the country, are in the midst of some type of modernization activity, including acquisition of low-floor light-rail vehicles (LRVs), increasing the percentage of segregated traffic, extending routes, and renewing infrastructure.

Italy

Italy has experienced a resurgence of emphasis on surface rail urban transit; Milan, Turin, Rome, and Naples, each in its own way, have increased reliance on an expanded light-rail infrastructure as an alternative to mounting traffic congestion, air pollution, and the high cost of full metro construction. A change in the city administration in Milan has led to increased emphasis on the tram network, including planning for new extensions. Turin, after flirting with plans for an automated metro, has returned to previous plans for incrementally upgrading the existing tram system to light-rail standards over the long term. Rome has developed firm plans for extensions to the existing system and has recently taken delivery of low-floor LRVs (which was interrupted, however, when the original builder went bankrupt). After abandoning a traditional tram network in 1966, Genoa recently opened a hybrid light-rail-metro system, connecting a new subway section to the old Certosa tram tunnel. Light-rail systems have also been proposed for Bologna and Florence.

Belgium

Belgium, with strong systems in Brussels, Antwerp, and Ghent and a unique coastal operation (Coastal Vicinal) serving Belgium's North Sea beaches, pioneered the "pre-metro" concept in Brussels. The pre-metro approach as practiced in Brussels consists of the phased upgrading of tram lines to full metro status (high platforms, grade-separated operation) over a period of years as increased ridership justifies such service. Antwerp is slowly constructing a series of tram subways in the downtown area as funding permits while fully segregating many on-street segments to enhance system speed and overall attractiveness for current and potential riders (the auto-

mobile is a serious competitor in Belgium, too). Ghent, a small town by most standards (200,000), has skillfully employed its meter-gauge tram system to avoid ridership losses to the ever-present automobile. The last remnant of the vast regional system that once blanketed Belgium remains in operation in and around the southern Belgian industrial city of Charleroi, Belgium's parallel to America's Rust Belt, which has sunk scarce capital into upgrading interurban lines linking the city with surrounding jurisdictions. Although these improvements have failed to arrest a downward trend in ridership, additional measures to enhance system attractiveness (reserved rights-of-way, traffic preemption, etc.) have been instituted.

The Netherlands

The Netherlands, ever progressive and deliberate, has aggressively pursued preservation and expansion of light rail in Amsterdam, The Hague, Rotterdam, and Utrecht (which has a relatively new system opened in 1983). A final decision on expansion of the Utrecht system remains under consideration. A long extension was recently opened in The Hague, with plans to implement short subways in areas of concentrated congestion. Rotterdam will reextend light rail across the Scheldt River to connect with previously isolated Route 3 in South Rotterdam. Additional extensions will also be implemented in a recently adopted program entitled "Tram Plus." Amsterdam, where the effectiveness of light-rail operations has earned them the label "street metro," adroitly employs every facet of light-rail technology, including a hybrid "sneltram" concept, first introduced in 1992. Sneltram utilizes third-rail and overhead power as well as high-platform operation and thus possesses the ability to operate over light-rail or metro tracks. Rotterdam also chose to employ this approach as a lower-cost extension of its metro system. Construction is well advanced on a circular sneltram line in Amsterdam utilizing space carved from existing railroad rights-of-way.

Spain

Valencia, which has recently upgraded largely grade-separated light-rail routes including the provision of a crosstown subway and new rolling stock patterned after the Utrecht LRV, in May 1994 opened a new 9.7-km light-rail line (Route 4). The line utilizes on-street alignments segregated from traffic except at intersections. The new service employs 21 German-designed (Siemens/Duewag), Spanish-assembled low-floor double-articulated LRVs. Zaragoza is currently in the planning stages for a light-rail system.

Switzerland

In Switzerland, where textbook light-rail systems operate in Zurich, Basel, Bern, and Neuchâtel, there has also been a revival of light rail in Geneva and the establishment of a new line in Lausanne. In Geneva, where by 1969 the system had been pared to a single route, new LRVs have been acquired, including Europe's first modern low-floor car, and a new route was opened in 1995. Plans are also firm to extend the system further in 1996. In Lausanne a new light-rail line (TSOL, or Metro Ouest) was opened in 1991 to connect the suburb of Renens with the center city at Flon. An immediate success, the mostly single-track line is equipped with 12 LRVs.

LRV Trends

Another trend, not linked to a specific area but to a change in technology, is the tidal wave of orders for low-floor LRVs, irrevocably changing the European transit vehicle market. In fact, all new systems now being implemented feature low-floor equipment, either the 60 to 70 percent or 100 percent variety. Since the successful advent of a low-floor vehicle in regular service in the modern era—the Vevey/Duewag low-floor car for Geneva, Switzerland, in 1984—the market has steadily gained momentum. In fact, the market is currently flooded with competing low-floor designs offered by some 12 builders.

LIGHT-RAIL DEVELOPMENTS IN FRANCE

When Paris consigned its last tram to posterity in 1937, the event was heralded as a profound change for public transport, not only in Ile de France, but also across France and Europe in general. Ultimately the impact proved to be minimal in Europe (only London and Madrid among major European cities followed suit, not counting Hamburg, which terminated tram operations in 1978), but it obviously set the trend for France. By the mid-1960s, almost all major French cities had discontinued tramway operations, even though some systems remained in use, possessing, for example, substantial reserved or private rights-of-way.

By 1970 only three small systems survived: (a) in Lille, an industrial conurbation in northern France near the Belgian border; (b) in Saint Etienne, an industrial town in southeast France; and (c) in Marseilles, a Mediterranean port city. As was the case in the United States, each system possessed some unique aspect that contributed to its longevity. In the case of Lille, two long lines (locally known collectively as Le Mongy after the city official who masterminded its planning and original construc-

tion) to the industrial suburbs of Tourcoing and Roubaix retained a healthy ridership with well-maintained but antique equipment, copious amounts of reserved trackage, and an efficient operation. But even in this case, the authority was simply fully depreciating the plant before supplanting these residual lines with Véhicule Automatique Léger (VAL), a successfully employed but rather expensive automated system. By 1965 the Marseilles system had been pared to one single line accessing the downtown area via a short subway, the line's one endearing quality. Saint Etienne chose to modernize, taking delivery of 30 Belgian-built (La Brugeoise) PCC trams in 1958, with an additional 5 articulated PCCs ordered from the same builder in 1964. However, it was not until the pioneering Nantes system was successfully launched in 1984, with official government encouragement, demonstrating the workability of the concept of light rail (*métro léger* in French) that other French cities began to seriously consider the concept as legitimate. Light rail then began to make headway against other competing types of transit.

In the following sections, additional detail is provided on the development of light rail in individual urban settings in France. System features for nine new and existing operations are given in Table 1. It should be noted that the decision to proceed with the light-rail option was not a foregone conclusion in any of these cities. Although a consensus was obviously achieved in each instance, the road to that consensus was neither smooth

nor uneventful. There was pressure from industry and some local politicians to adopt the rival VAL system. The success of the Lille installation had proved that the system was workable and could function reliably in the unforgiving urban environment on a daily basis. This emboldened VAL advocates to push for adoption of the automated system in other French cities. The VAL system was subsequently chosen over the light-rail option in Toulouse, Bordeaux, Rennes, and, initially, Strasbourg. The Toulouse system is now operating smoothly. In Bordeaux the initial decision for VAL is being reviewed. In Strasbourg the decision to install a VAL system was overturned. Other French cities, it should be noted, have opted for less capital-intensive options such as improved bus service or trolleybus operation. Just recently, Caen opted for a third form of fixed-guideway operations, a bus guided by a single rail embedded in the roadbed with power collection by overhead wire.

Nantes

Officials in the greater Nantes area sensed that upgraded public transport was the key to ensuring the growth and prosperity of this French city of over 450,000. After receiving encouragement from the French government in 1975 to investigate the possibility of introducing upgraded tram systems, Nantes decided to aggressively pursue the implementation of a fixed-guideway solution.

TABLE 1 Light-Rail Systems in France

| Locality | Year System Opened | System Length | High/Low Platform | Type & No. of Vehicles | Vehicle Builder | Total Cost (\$ millions) | Patronage/Day | Future Plans |
|--------------------------------------|--------------------|---------------|-------------------|---|-----------------|--------------------------|-----------------------|---|
| Paris (Ste. Denis-Bobigny) | 1992 | 9.0 km | Low | Low Floor (20) | GEC Alsthom | 121 | 63,000 | Extensions proposed |
| Paris ¹ (Val de Seine) | 1997 | 14.1 km | Low | Low Floor (20) | GEC Alsthom | 280 | 41,000 (Projected) | Extend along Petite Ceinture; other routes planned |
| Nantes | 1984 | 27.0 km | Low | Modified Low Floor (20) Low Floor (26) | GEC Alsthom | 100 ⁴ | 68,000 | Additional extensions planned |
| Grenoble ² | 1987 | 18.4 km | Low | Low Floor (53) | GEC Alsthom | 120 | 85,000 | Additional extensions planned |
| Rouen | 1994 | 11.2 km | Low | Low Floor (28) | GEC Alsthom | 480 | 45,000 | Additional extensions planned |
| Strasbourg ³ | 1994 | 9.8 km | Low | Low Floor (26) | ABB | 388 | 57,500 | Additional extensions planned |
| Lille | 1909 | 19 km | Low | Low Floor (24) | Breda | 240 | 28,500 | Modernization completed |
| Ste. Etienne | 1901 | 9.3 km | Low | Low Floor (27) | Vevy/Duewag | NA | 95,000 | Modernization continues |
| Marseille | 1911 | 3 km | Low | Conventional | La Brugeoise | NA | 35,000 | Single line may form basis for expanded system |

¹Initial segment to run to Issy-Plaine

²Includes extensions to line A & B scheduled to open in 1995 & 1997 respectively

³Full service inaugurated in February 1995

⁴Cost for initial line segment only

Note: Total cost converted to USD @5FF=\$1

Armed with the promise of 50 percent funding from the central government, Nantes was able to complete a financing package for the line through use of the famous *versement transport*. This national provision, adopted originally for the Paris region in 1971 and later extended to apply to all other localities with populations over 300,000, allowed the imposition of a payroll tax on companies with 10 or more employees (Nantes adopted a 1.5 percent rate). The terms of this provision required that proceeds from the tax be dedicated to transit improvements.

This initial new light-rail system in Nantes was an effective demonstration of the flexibility afforded by the light-rail concept. The alignment selected for Route 1 sought to link residential and employment centers and reemphasize the centrality of the downtown area. Stations (all with low platforms) embodied the simple, low-cost nature of the system. Alignments were blended into the surrounding environment using modern urban design concepts to ensure lasting compatibility. The initial line, running from Haluchère to Commerce, opened in January 1985. This was followed by extensions from Commerce to Bellevue in February 1985 and from Haluchère to Beaujoire in April 1989. The line was an immediate success, reaching a patronage level of over 45,000/day by mid-1986. Today that number has climbed to 68,000/day. This initial line cost approximately \$100 million (U.S.) (5 francs = \$1.00), or about \$16 million per mile. With extensions, Line 1 now extends 12.6 km (7.9 mi) and has 24 stations.

The success of the initial line encouraged the city to begin planning for construction of another line to serve areas north and south of the city. Construction was initiated on Line 2 in 1990, and it opened in increments completed in 1994. Like Line 1, this new route has achieved considerable success and a strong ridership base. Line 2 exhibits the same design concepts employed on Line 1. In fact, many improvements to the surrounding areas were undertaken during construction of the new line. The Cours des 50 Otages, a former four-lane highway, was converted into a tree-lined boulevard sporting a two-track light-rail path, normal lanes, and a pleasant environment for pedestrian movement. Vehicles for the initial line were designed to serve as France's standard LRV. The first 20 LRVs came equipped with center articulation but contained no provision for handicapped access. These cars have since been modified and equipped with center low-floor sections, significantly improving their accessibility. Follow-on orders have incorporated this feature as a standard item. All LRVs have been constructed by GEC Alsthom at its La Rochelle plant. The system will now continue to expand, with plans well advanced for a third line running northwest to southeast. Construction will be initiated on Line 3 in 1996. Plans also call for extending the original two lines

in the long term. Total length of the system has now reached 27 km with service by 46 LRVs.

Grenoble

Following the example set in Nantes, Grenoble, located in southeast France, opened a new light-rail line in September 1987. The city had discontinued its antiquated, mostly single-track meter-gauge tram system in 1952. The renaissance of public transport in Grenoble can be traced to the creation in 1973 of the Syndicat Mixte des Transports en Commun de l'Agglomération Grenobloise (SMTC). This organization, the counterpart of the U.S. metropolitan planning organization (MPO), made up of representatives from Grenoble and the surrounding area, was to guide transport investment in the Grenoble region and distribute financial support for capital improvements. These organizations are a common feature among French cities. They were key to the resurgence of mass transit, certainly in the French cities described here. In addition, the Société d'Economie Mixte des Transports Publics de l'Agglomération Grenobloise (SEM-TAG), a hybrid entity owned jointly by local authorities and private enterprise, was established in 1975 with mission of operating the public transport system.

Armed with a study prepared by SOFRETU—a consulting subsidiary of the Paris transport authority, Régie Autonome des Transports Parisiens (RAPT), recommending the construction of four surface tram routes—SMTC began searching for the necessary political and financial consensus to bring the proposal to reality. In the same year, the French government proposed that French cities consider modern tramways as a means for meeting future urban transport demand. This action had the effect of legitimizing the concept and encouraging localities to give the concept serious consideration. The possibility of central government financial support was also envisioned.

By January 1983 a plan had been approved by SMTC to pursue construction of the first line. At the behest of an incoming mayor, the plan was subject to a popular referendum held in June 1983. The project passed with a 53 percent majority, not overwhelming approval but enough to get the project moving. Again, use of the *versement transport* (payroll tax) was crucial to generating the necessary financing for the line. The central government pledged \$78 million toward the project, with the *versement transport* furnishing the balance. Although the Nantes LRV was initially envisioned as the rolling stock for the line, its lack of handicapped access forced a reconsideration. A committee was formed to consider a more accessible vehicle. The result was an order for vehicles with a low-floor design. The initial 20 LRVs for Grenoble incorporated this design and also es-

essentially became the standard French LRV for future systems (excepting that in Strasbourg). Construction of the line began in late 1984, and it was opened with great fanfare in September 1987. The line carried more than 65,000 passengers daily in the first year of operation, representing a 26 percent increase in ridership over bus routes displaced by light rail, and now handles about 85,000 daily.

As with the Nantes undertaking, significant improvements were made in conjunction with the construction of the light-rail line. These included creating pedestrian precincts, altering the street environment to heighten the livability of the immediate area, and instituting new traffic patterns favoring the exclusivity and priority of the new light-rail line and other public transport (Grenoble also has a fine trolleybus network). The highest quality of urban design prevailed in all aspects of the light-rail undertaking.

As a testament to the success realized with Line A, construction was quickly begun on a second route, Line B, branching from Line A to serve a large university. Extending 4.6 km, this new line was opened in November 1990.

Currently, a 3.4-km southward extension of Line A is under construction, with service scheduled to commence in 1996. Line B is to be extended 1.6 km in a northwesterly direction; service is projected to begin in the spring of 1997. Cost of these two extensions is estimated at \$200 million, including rolling stock (an additional 12 LRVs will be required for the extensions).

It should be noted that a key component in reintroducing surface rail into Grenoble was the expected patronage increase and stabilization of the local transit operating subsidy. Recent figures indicate that the regional operating ratio (or fare recovery ratio) is now 63 percent contrasted with 45 percent before light rail. This increase in the operating ratio stems in part from the fact that general transit usage in Grenoble has increased 50 percent since 1987.

Paris

When the French Transport Minister suggested in 1975 that eight French towns should seriously consider the light-rail concept, he did not have Paris in mind. Nevertheless, Paris has pursued the light-rail concept with a vengeance. Beginning in 1992 with the inauguration of service on the 9-km Saint Denis–Bobigny light-rail line and the initiation of construction of the ambitious Val de Seine line, the Paris conurbation has developed extensive plans to install light-rail services around the periphery of the City of Light.

Connecting the working-class suburbs of Saint Denis and Bobigny in the northeast quadrant of the metropoli-

tan region, the first light-rail line reflects the same exacting design standards found in Nantes, Grenoble, Rouen, and Strasbourg. Describing an arc, the line intersects with the suburban terminals of three Paris Métro lines radiating from central Paris at Saint Denis, La Courneuve, and Bobigny as well as with the Réseau Express Régional (RER), the suburban commuter rail system, providing the interconnectivity envisioned when the line was conceived. The line also interfaces with a large number of bus routes. The line is fully segregated from surrounding traffic except at intersections through the use of various low-cost but effective traffic channelization techniques. Stations are spartan but attractive and provide the necessary elements (ticket machines, benches, weather protection, etc.) for passenger comfort. The overhead is unobtrusive, incorporating the latest in design advancements, which minimize the number of poles, pull-offs, and feeder cable connections on the system (the feeder cable itself is buried along the route). The line utilizes the same low-floor design for LRVs as the Grenoble system and is therefore completely handicapped-accessible. Ten-minute headways are maintained throughout operating hours. The line has achieved a daily patronage of 63,000, almost tripling the volume carried by the former bus line.

Now under construction and expected to open an initial segment for service in 1997 is the Val de Seine light-rail line. The line was originally conceived to replace an old third-rail commuter route originating northwest of Paris and essentially paralleling and then crossing the Seine to access central Paris. The line has since received approval for progressive extensions to penetrate deeper into central Paris south of the Seine. Originating at La Défense, an edge-city development northwest of downtown Paris, the line was slated to terminate at Issy-Plaine along the Seine. Plans now call for extending the line to Porte de Versailles, an additional 2.7 km, for a total length of 14.1 km. With the extension to Porte de Versailles, the line is projected to carry 41,000 passengers/day. A total of 22 LRVs, currently being delivered by GEC Alsthalm, will be required. A further extension of 7 km from Porte de Versailles to Porte d'Ivry is now also under consideration. The line would utilize an existing trackbed (La Petite Ceinture) and interface with the experimental Meteor automated metro now under construction. Cost of the line without the proposed extension to Porte de Versailles is an estimated \$210 million (including rolling stock).

Rouen

Another medium-sized town encouraged by the French government in 1975 to consider modernized tram systems, Rouen followed the same design criteria so suc-

cessfully applied in Nantes, Grenoble, and Paris and inaugurated 14.2 km of Metrobus in December 1994. The two-branch system represents the culmination of planning begun in 1986 when an assessment of the area's public transport revealed serious shortcomings. After an exhaustive study and evaluation, authorities (as in Grenoble), guided by the French equivalent of the MPO, opted for light rail, and ground was broken in November 1991. Although there was much debate over the amount of tunneling envisioned, the final system alignment features roughly a mile of subway in the downtown area and two grade separations at major intersections (including the line branches). This civil works project resulted in a higher price tag than that for the other new systems in France: \$480 million, or approximately \$56 million per mile.

A total of 28 LRVs were built in France to the GEC Alstom standard for the Metrobus system. Although the Strasbourg design was considered, the proven performance of the GEC Alstom LRV in Grenoble and Paris (its French-built aspect was also an attraction) tipped the scales. A variety of surface right-of-way configurations are employed throughout the system, although the majority entail side-of-the-road reservations. Many sections feature grass surfaces, lending an ambiance that is distinctly environmentally compatible.

Strasbourg

Construction of one of France's most handsome light-rail systems was not accomplished without difficulty. In fact, the decision to implement the rival VAL automated metro had actually been made but was overturned when the election for mayor of Strasbourg in 1990 resulted in defeat for the incumbent and victory for a "pro-tram" slate. Thus the capital city of Alsace, home to over 430,000 people, proceeded to design and build a next-book light-rail system (Figure 1).

First-hand experience with this magnificent example of light rail confirms that a fixed-rail facility, when designed in a meticulous and sensitive manner, can achieve multiple urban design objectives, including the significant enhancement of the basic livability of an area. The result is an urban transport facility that effortlessly blends into a full range of urban settings, enhancing their beauty and efficacy while furnishing the city with effective, efficient, and pleasant transit service. The eclectic, even eccentric, nature of French urban design is well known. One need only look at the recent addition to the Louvre, the many-colored edifice dedicated to former French President Georges Pompidou at Les Halles, the new National Opera, and the burgeoning city development at La Défense (all in Paris) to gain an appreciation for the French flair for unusual, surprising, even bi-

zarre, but never dull, architecture. This flair is present throughout the Strasbourg system. Even the LRV for the line is reflective of this approach, being not the standard, French-built 60 percent low-floor vehicle but an Italian-designed (Socimi), British-built (ABB), 100 percent low-floor conveyance, representing an almost flamboyant dimensional design change.

The rights-of-way are finely crafted into the Strasbourg urban environment. The 9.8-km line employs a variety of right-of-way treatments, including grass, colored gravel, and cobblestone, achieving a smooth, unobtrusive integration with the surrounding area. To further beautify the route, over 1,000 trees were planted along the rights-of-way. These included cherry, lime, and chestnut varieties. Artwork was also commissioned and sited at key stations. Right-of-way placements for the outer portions of the line have been largely on the side of the road, whereas entire streets have been dedicated exclusively to the line and pedestrians in the central city. A 1.2-km tunnel takes the line under a railroad yard, a highway, the old city fortifications, and finally the city's railway station (Gare), where the only subway station is situated. The city took the opportunity to restrict the plaza fronting the Gare (Place de la Gare) to pedestrians in reconstructing the area after subway excavation. In fact, the inner-city route of the line was also completely restricted to pedestrians, with traffic channelization measures instituted to deflect automobile traffic along four loops outside the inner historic district. Convenient parking provisions were also made at critical locations. These measures were specifically designed to discourage automobile access and promote use of light rail (transit) to gain access to and traverse the city's historic section.

Service was implemented in three phases over three months to minimize start-up problems and promote familiarity with the system. Although service began on a limited basis in November 1994, full integration with the existing bus system (including discontinuance of parallel bus services) did not occur until February 1995. Authorities expected the system to attract over 55,000 passengers per day, and they were not disappointed (current patronage is over 57,000). Cost of the system totaled \$388 million, or approximately \$66 million/mile. As with the financing scheme for other new French systems, the *versement transport* played a large part in generating the funds necessary to construct the system. This tax provided 27 percent of the cost of the system, with the French government granting 17 percent and the remainder from the Strasbourg city council and other levels of government.

The southern portion of the line, which was to have been opened with the rest of the line, will be further extended in 1996 or 1997 past Baggersee. The city already has advanced planning for a second line on an east-west orientation. The success of the original line will likely



FIGURE 1 Strasbourg light-rail system (line will be extended past Baggersee in 1997) (courtesy of city of Strasbourg).

dictate the level of enthusiasm for undertaking this extension.

Saint Etienne

One of the original "gang of three" that survived the lean 1950s and 1960s, this working-class city continues to operate one modern 9.3-km meter-gauge light-rail line. Not electing to stand pat, and in the tradition of other recent undertakings in France, the local transport entity has aggressively sought to enhance the efficiency and effectiveness of its backbone light-rail service. The city modernized early, purchasing cars of the PCC design in 1958 followed by an order for five articulated PCC cars in 1964. Both orders were filled by La Brugeoise of Bruges, Belgium. Intensified efforts were made in the 1970s to physically segregate the line from other traffic. The line was also extended by some 1.5 km in 1983 and further extended in 1993. The line now carries a total of 95,000 passengers/day and covers over 70 percent of operating costs from the farebox. Finally, new low-floor vehicles built by a combination of Vevey, Duewag, and GEC Alsthom were introduced in 1991–1992 and have gradually replaced refurbished PCCs, which had previously provided the bulk of service.

Marseilles

Route 68, the sole remaining tram line in Marseilles, managed to survive because of a strategically placed 900-m tunnel that gave the line excellent access to the downtown. Since the service could not be replicated with buses (the tunnel was too narrow to be converted to bus operations), it was decided to modernize the 3-km line over the near term. This modernization included acquiring 16 new trams, 2-m-wide PCCs, built as in St. Etienne by Belgium's La Brugeoise in 1969. In 1984 the line's tunnel access was diverted to provide a direct transfer to the Marseilles rubber-tired metro Line 2 at the Noailles station. The PCC fleet has recently been refurbished, and the line boasts a healthy 35,000-passenger volume/day. Plans recently unveiled project an expansion of the light-rail network in Marseilles. Route 68 would serve as a centerpiece of this proposed system.

Lille

Lille, the fourth largest conurbation in France (after Paris, Lyon, and Marseilles), boasts a two-route, meter-gauge light-rail system serving the twin suburbs of Rou-

baix and Tourcoing. Known locally as Le Mongy after the town's public works director, the lines follow two wide boulevards to reach their destinations. Lille also inaugurated France's first automated system, VAL (Véhicule Automatique Léger), in 1983. In fact, plans called for a VAL expansion to supplant the light-rail lines before the year 2000. To implement this plan, 33 second-hand trams were acquired in 1983 from Germany and Switzerland to replace 1950-vintage equipment and enable the service to continue until the VAL extension had been built. After intense pressure from users of the system, this plan was shelved in 1989 and the decision made to modernize the system. This modernization included procurement of 24 new full low-floor vehicles (eventually built by Breda Costruzione of Pistoia, Italy), a new maintenance facility (replacing the original 1909 complex), two grade separations, and complete rehabilitation of track and right-of-way as well as electrical subsystems (upgraded to 750 V d.c.). Basic station designs are identical to those on the Saint Denis–Bobigny line. With a short subway in downtown Lille to gain entry to the main train station (La Gare), Le Mongy will provide cross-platform access to VAL and to train services, including the Très Grand Vitesse (TGV) high-speed rail line. The subway was originally provided in 1983 but subsequently relocated to provide better access to long-distance trains and the VAL terminal. An expansion of VAL (currently under construction) will put stations at both Tourcoing and Roubaix and will parallel the Roubaix service on its outer section. What effect this will have on the Roubaix patronage levels is subject to conjecture at this point. However, authorities believe that the high-level transit service in the corridor provided by VAL plus Le Mongy will encourage greater development and eventually foster high ridership for both services. The area was once the center of a strong textile industry, which has downsized in recent years.

Other Cities

At this juncture, a number of other French cities are thought to be close to decisions regarding the light-rail option. Montpellier has now chosen light rail and hopes to have an initial line in operation by the year 2000. Nice, Toulon, and Valenciennes all have advancing plans in which light rail could play a significant role. Moreover, Orléans is seriously considering a regional-type system based on the Karlsruhe approach, using shared rights-of-way with existing mainline railroad operations [those of the French National Railways (SNCF)] to reach distant suburbs. With intensive implementation over the past 10 years and a growing pipeline of potential projects, France can truly stake its claim as being the van-

guard of new system development for the European continent.

LIGHT-RAIL TRENDS IN GERMANY

With the few exceptions already mentioned (Hamburg and Berlin), major German cities elected to retain traditional tram systems and incrementally upgrade operations by increasing stretches of unencumbered rights-of-way, short tunnel segments to avoid areas of congestion, and well-conceived traffic measures to ensure priority for public transport in general and light rail specifically. Moreover, Germany took the lead in developing high-performance, high-capacity vehicles to fully capitalize on the concept. Now emerging is an operational variation that further exploits the flexibility of light rail. The following narrative examines the developments in Karlsruhe where innovative local government and transit officials cooperated to turn their local light-rail network into a genuine regional transit service.

Karlsruhe

A progressive town with a regional population exceeding 400,000 located on the northern edge of Black Forest region (Schwarzwald), Karlsruhe is bucking the trend in some German cities of stagnating transit patronage because of record automobile ownership. The reasons for transit's success in Karlsruhe are simple: the provision of high-quality, competitively priced transit that goes where people want to go.

Karlsruhe authorities, with the cooperation of surrounding jurisdictions and the German Federal Railways [Deutsche Bundesbahn (DB)], have forged an innovative and low-cost approach to creating a truly regional light-rail network. By pioneering the shared use of existing regional DB lines by LRVs, Karlsruhe has been able to institute high levels of service to multiple regional destinations in relatively short periods of time. The higher costs, long implementation times, and disruptions normally accompanying the construction of conventional light-rail extensions have been avoided as well.

The regional light-rail system that has emerged over the last 8 years was based on the original experience gained in operating a mixed passenger and freight operation since 1958 (known locally as the Albtalbahn line). Having acquired this dilapidated meter-gauge electric railway in 1958, Karlsruhe proceeded to modernize the line, changing to standard gauge (in order to institute through running with the existing city tram system and thus eliminate a time-consuming transfer) and retaining the capability to accommodate goods traffic. This latter

provision required that the LRVs be equipped to accommodate mainline railroad design and safety standards (wheel profiles, ability to negotiate railroad switch pointwork, and provision of safety equipment). An additional extension in 1979 in the Neureut area again utilized portions of existing DB lines and provided further experience in joint operations as well as institutionalizing the necessary arrangements between the Karlsruhe transport undertaking and DB to ensure smooth operations.

Bolstered by this experience and a study that projected significant time savings for passengers destined for and departing from the center city (on the order of 12 to 13 min for a majority of passengers), the possibility of utilizing one or more of the seven electrified passenger routes operated by DB became a tempting option. A major obstacle to this possibility was the requirement for a vehicle capable of operating under the 750-V d. c. power of the city system and at 1500 kV a. c. on the National Railway lines. This impediment was resolved when trials undertaken in 1987 to test LRVs equipped for dual voltage confirmed that the operation was technically feasible. Moreover, it was also found that the necessary a.c./d.c. equipment could be accommodated within the existing LRV envelope.

The first line to receive this versatile service was the DB line to Bretten, of which 23.8 km of the 28.2-km length would actually be under DB 1500-kV power. Provision of the service was not without some capital expense (about \$30 million) and some lengthy negotiations with DB. The need for capital expense sprang from the need to provide additional stops on the line, improve station access, and build the necessary connections between the two systems. Moreover, 10 dual-voltage LRVs were required and ordered for the line at a cost of \$23.3 million. Although the construction work attracted 85 percent financing shared by the federal government and the Land (equivalent to a U.S. state), the cost of the new LRVs was a local responsibility, with the city of Karlsruhe paying the majority, or 60 percent, and the remainder being picked up by other benefiting towns along the line.

The second application slated to receive this treatment will be the Woerth line. Again, estimated construction costs are projected to be reasonable (\$24 million). Environmental problems have forced a delay in the implementation of service on this line, although four dual-voltage LRVs have been unofficially assisting in providing service on the line.

The option to utilize existing infrastructure to access regional markets has provided Karlsruhe with a powerful tool to provide high-quality service at low cost. The success of this program has encouraged other areas in Europe to follow the "Karlsruhe approach." Orléans, in France, has made plans for a regional light-rail system

based on the Karlsruhe approach. Nottingham, England, is pursuing a similar plan. And in Germany itself, Saarbruecken has received official approval to build a regional system based on shared use of DB lines. A description of this nascent system is provided in the next section.

It is worth noting that the Karlsruhe system features a pedestrian mall 2.5 km long that serves as the spine of the regional system. As suburban services over DB lines are added, the traffic channeled into this line will inevitably climb, posing the possibility of resulting congestion. Thus, in the long term, Karlsruhe planners are hoping to construct a tunnel for regional lines feeding into the downtown. City tram lines would continue to use the surface alignment.

Saarbruecken

This city of 200,000, located in the Saargebiet and hard on the French border, has recently received approval to construct a new light-rail system, the first in Germany in at least 50 years. Local authorities had compared the cost and applicability of an enhanced bus system, a VAL minimetro (similar to the VAL in Lille, France), and light rail (*Stadtbahn*). Authorities decided after extensive study that light rail was the most efficient mode for achieving a system serving both Saarbruecken and surrounding areas. This decision was influenced in part by the ability of light rail to utilize DB lines to provide the desired comprehensive regional service. During the planning phase, local authorities engaged planning teams from Karlsruhe and Cologne, thus tapping the experience gained by Karlsruhe in pioneering the shared-running concept and accessing Cologne's extensive light-rail design and operating knowledge.

As now planned, phase one of Stadtbahn Saar will consist of a 42-km route stretching from Jabach in the north through downtown Saarbruecken to Sarreguemines (actually located in France) in the south. The route alignment will partially utilize electrified mainline DB rights-of-way on both the north and south segments. The line will also be built in reserved space on downtown streets in Saarbruecken proper and in Reigelsberg on the northern segment. Partial service is slated to begin in May 1997. Phase one is projected to cost \$360 million, with the German federal government contributing \$142.7 million.

A total of 28 partial low-floor LRVs are initially envisioned for the system with the capability of operating both under 750 V d. c. on city sections and under 1500 kV a. c. on the DB mainline segments. The LRVs are being built by Bombardier Eurorail.

Additional extensions to the initial system are being actively planned, including service that would also em-

ploy DB rights-of-way and actually supplant existing DB local passenger rail service.

CONCLUSION: ACCELERATING TRENDS

The almost frenzied action in light rail in Europe since 1984, especially in the building of new light-rail systems and the application of low-floor car designs, reveals a heightened appreciation for the attributes of the system in a region of the world where the concept has already gained wide acceptance. The potential to insert a high-capacity mode in a mature urban setting has led the French to implement five new systems over the past 10 years and has given impetus for at least three additional systems likely to be approved in the near term. The British have built two new systems and have three systems on the drawing boards.

Also key in France has been the favorable institutional setting in which the existence of firm financing mechanisms and multimodal-oriented organizations with the power to nurture and guide urban transport investment has proved as effective as the attractiveness of the concept itself. The ability of transport officials to truly forge a balanced multimodal approach and largely avoid the modal biases that plague other areas deserves much credit for the success in implementing the new systems in France. This success is being duplicated in other European countries within the context of their own institutions and decision-making environments.

The attractiveness of the modern light-rail concept in France has also been enhanced by the high standards of design found in the new systems and the high degree of passenger acceptance and acclaim. Strasbourg, Rouen, and Nantes have demonstrated that public transit systems can be enhanced in such a manner as to not only markedly improve transit access and institute higher levels of service, but also dramatically alter urban settings to create pleasant, attractive places to live, work, and play.

The success of the Karlsruhe approach, with joint light-rail and railroad operations, has already spawned one new system in Germany (Saarbruecken) and fostered considerable interest for this approach in French light-rail decisions, especially in Orléans. The ability to expand light-rail services cheaply and relatively quickly has been key to the popularity of this approach.

The popularity of low-floor LRVs throughout Europe will likely lead to this design's becoming an inextricable component in decisions to build new light-rail systems as well as to upgrade existing ones. The ability to accommodate the disabled without expensive station facilities as well as the anticipated decreases in dwell times (leading to reduced car requirements) are compelling elements. The veritable explosion of contending low-floor

designs offered by 12 builders is resulting in some consolidation of car builders in Europe, which could lead to needed efficiencies. Price economies achieved through standardization and consolidated orders will probably become an absolute necessity if the boom in light rail is to be sustained.

With proposals appearing for new systems throughout Europe, the next 10 years are likely to be as active as

the last 10, if not more so. The next National Conference on Light-Rail Transit may indeed chronicle these advances but will most likely also include an abundance of positive developments in many other locations throughout the world. In fact, on the basis of what has already been achieved in Tunis, Guadalahara, Monterrey, Manila, and Tuen Muen, to name just a few, it seems more than likely.