

CLOSING GENERAL SESSION

Continuing Developments in Light Rail Transit in Western Europe *United Kingdom, France, Spain, Portugal, and Italy*

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The primary focus of this paper was to provide a brief but informative survey of new light rail transit applications in Western Europe, concentrating on developments and trends in the United Kingdom, France, Spain, Portugal, and Italy. Since the author's last update in November 2000 for the 8th National Light Rail Conference, a spirited amount of activity has been observed in the countries cited above. The trend toward constructing new light rail systems, which had its genesis in France, and which has continued at a high level in that country, has generally spread throughout Western Europe and the British Isles. Light rail also continues to be implemented in progressively smaller cities than previously noted with cities having populations as low as 150,000 choosing to make significant long-term capital investments in fixed rail facilities (and willing to tax themselves to do so).

The goals of all new cities implementing light rail projects in the countries examined in this paper have proven to be astonishingly similar to those of cities previously implementing light rail projects. The influence of the largely successful trailblazer systems in France cannot be underestimated [Nantes (1985) and Grenoble (1987)]. All cities expressed the urgent need to provide a viable, affordable alternative to the automobile, improve the quality of life, enhance mobility, address environmental concerns, and promote land use trends that produce energy efficient, traffic reducing development, and enhance the overall competitiveness of the city as a desirable place to live and work. Cities continually cited the flexibility of light rail in being able to meet such a diverse set of goals.

INTRODUCTION

The trend toward the adoption of light rail transit in cities of all sizes (large, medium and small, even as low 150,000 population) in Western Europe has continued unabated since the last National Light Rail Conference was held in Dallas, Texas, in November 2000. Indeed, since the first recognized new light rail system in Western Europe opened in Nantes, France, in 1985, an additional 15 systems have opened in France, the United Kingdom, Germany, and Italy¹.

Germany, it must be pointed out, possesses the most light rail systems of any country in Western Europe (exceeded in the world only by Russia and other parts of the former Soviet Union), having generally avoided the massive abandonments that prevailed in France, the United Kingdom, the United States, and Canada in the 1950s and 1960s. The Germans, in both the West and the East, chose to retain and, especially in the West, modernize street-based urban rail systems after World War II. In the West, the Germans systematically converted and expanded basic streetcar networks into model light rail systems (*stadtbahnen*). With the exception of Hamburg, all large and most medium-sized German cities maintain robust light rail networks. As a consequence, Germany has added only two new systems since World War II, in Saarbrücken

and Oberhausen. Saarbrücken was conceived and implemented as a Tram-Train application and successfully developed and applied over a wide area surrounding Karlsruhe. The Tram-Train concept is making additional headway with the concept being implemented in suburban Paris (Aulnay-sous-Bois to Bondy) and Mulhouse, France, the RijnGouweLijn-Oost project in the Netherlands (in the testing phase) and Kassel, Germany. Other developing applications will be mentioned in the paper.

In France, where the current trend emerged, light rail continues as the mode of choice in a surprisingly large number of small and medium-sized cities. In the mid-1970s, the French Minister of Transport announced a new policy to encourage medium-sized cities in France to consider light rail transit as a viable alternative and promised to provide national funding to underline his commitment. This policy initiative has born fruit beyond anyone's wildest dreams, spawning the implementation of eight new light rail systems, and the building continues unabated. Three new systems are now under construction in Bordeaux, Valenciennes, and Mulhouse, and funding for new systems has been approved for systems in Le Mans and Nice. In Toulon, a new city administration has also reactivated plans for a light rail system and expects to receive final approval for a modified plan in early 2004. The city of Brest has advanced plans for a modest light rail system and is seeking approval for national funding. In Paris, where two routes were opened in the 1990s (T1-1992 and T2-1997), light rail has assumed an increasingly prominent role in expanding mobility options in the City of Light. Currently one extension is under construction, another has been approved, and two are in the public hearing process. Finally, of the three systems predating the light rail renaissance, Saint Etienne has accomplished some modernization with a further expansion in the works, Marseilles has launched ambitious plans to use the existing line as the nucleus of a three route, 16.4 km network, while Lille has already completed a thorough modernization of its two-route system (known locally as Le Mongy).

The United Kingdom has built on the successes achieved in Manchester (opened in 1992); Sheffield (1994); Birmingham (1999); and Croydon (London Borough-2000). One new system is under construction and is nearing completion (Nottingham) and the British Government has recently approved funding for new systems in Portsmouth (South Hampshire), Bristol, Leeds and Liverpool. The Scottish Government has also pledged funds toward a three-route system in Edinburgh. The Mayor of London, Ken Livingston, most famous at this juncture for his bold (and successful) pricing plan for reducing congestion in central London, has announced firm plans to construct light rail in two central London corridors (Cross River and West London). This will dramatically expand transit capacity in central London. A pioneering hybrid system opened in 1980 in Tyneside, serving the Newcastle-on-Tyne metropolitan area, featuring high platform operation with overhead power collection and light rail-type vehicles on a fully grade separated system. This system has recently expanded and whether or not future extensions might feature some reserved street running is being debated.

In Spain, one new system has opened in Bilbao to complement a brand new Metro and a two-route system (with spurs) is currently under construction in Barcelona. Barcelona abandoned its previous street railway system in 1971, a decision it reportedly came to regret. A Coruña, in the upper northwest part of the country on the Atlantic, and Alicante, on the Mediterranean Sea, are edging toward true light rail networks with incremental development. Additional proposals are being refined in Vitoria, Vigo and San Terife in the Canary Islands. The State of Andalusia has recently adopted plans to build light metros in Seville, Malaga and Granada and has budgeted one billion Euros for the projects, representing 75% of the total cost.

In Portugal, Porto has opened an initial segment of what will become a region-wide light rail system involving short subway segments, reserved rights-of-way, and the conversion of a previously existing meter gauge suburban railway service to light rail operation. A short segment was opened in November 2002. At the same time, Porto is proceeding to revitalize a small portion of the previous conventional tram network to provide a complementary, historic service to the light rail network. Already partially in operation, this small network is being worked by rebuilt vintage trams. Coimbra has also announced plans for a new light rail system and recently called for bids for the construction, financing, operation, and management of a future 40 km system. The first line would use an existing railway spur. A new system is also being built under a turnkey contract on the Setúbal peninsula on the south side of the Tagus River, opposite the capital city of Lisbon.

Italy, which has witnessed in the late 1990s the resurgence of existing tram networks in Roma, Milano, Napoli, and Genova, will see new light rail systems built in cities where traditional tram networks disappeared in the 1950s and 1960s. One system in Messina, on the island of Sicily, opened for service in April 2003. Other new systems are under construction in Firenze (Florence), Verona, Bergamo, and Sassari on the island of Sardinia. Additional systems are planned for Palermo and Cagliari.

Dublin, Ireland, will also initiate service next year on 24 km of an eventual combination of light rail and light metro services. The system is the city's answer to burgeoning traffic congestion and mobility issues. Although slowed recently, Dublin's local economy has experienced rapid growth and generated attendant pressure on the transport network.

FRANCE

The light rail renaissance maintains steady progress in this country, even in light of the emergence of competing concepts. Although recent guided bus installations in Nancy and Caen have opened with mixed results, additional systems in Clermont-Ferrand and those proposed for the Paris *banlieu* (inner suburbs) will have ample opportunities to show their value. Since Nantes opened in 1985, new light rail systems have been built in Grenoble (1987), Paris (1992 and 1997), Strasbourg (1994), Rouen (1994), and Montpellier, Lyon and Orléans (all in 2000). All of these systems (except Rouen and possibly Orléans) have either engaged in significant extensions or are planning to do so. Both Montpellier and Lyon, both in operation for less than three years, have experienced patronage growth that has far exceeded projections. Montpellier will add center sections to its existing tram fleet to expand capacity in the short term.

Bordeaux

Bordeaux has followed a tortuous path to securing the necessary public consensus to pursue a major fixed guideway solution. After initially selecting the automated VAL (Vehicule Automatique Leger) system (also selected and built in Lille, Toulouse and Rennes), the decision was reversed after extensive public discussion over the merits of a system requiring complete separation and extensive tunneling in central Bordeaux, versus a street-based system requiring less extensive disruption and infrastructure modifications and attendant traffic measures. Light rail was finally selected due to a number of factors, including cost, unstable soil conditions (making subway construction expensive and difficult), proven ability to carry increasing volumes of

patronage, ease of insertion into the city's historic core, and high visibility of the service. The system's Stage 1 consists of three routes totaling 24.5 km (14.7 mi) and 53 stations that coil through the downtown and close in suburbs of Bordeaux. The Stage 1 system will be served by 44 Alstom-built low floor trams. An additional 26 trams will be delivered for Stage 2. Stage 1 will cost 680 million Euros (US\$598.5 million or \$40.7 million/mi). The system will essentially be street-based but completely segregated from adjoining traffic except at intersections. All intersections will have priority signalization for trams. As with other new light rail systems in France, Bordeaux will see the extensive revitalization activities along the route of the trams. Tram rights-of-way will either be in grass-covered medians or appointed with distinctive surfaces clearly identifying the exclusive tram reservation. Trees are added where feasible, especially along the grassy medians. Bordeaux will also feature discrete sections powered by a unique ground-based power system (Alimentation par Sol-APS, literally surface current collection). This new system will obviate overhead wire installation in the sections that are located in the city's historic district and in other selected areas. About 10.5 km of Stage 1 track (44%) will be equipped with APS. Trams will draw power from a surface third rail located in the center of the trackway that is controlled electronically to activate (energize) only when a collector extending from beneath the tram passes overhead. The system was developed by INNORAIL and extensively tested on Marseilles' single tram route and on French tram-builder Alstom's test track in La Rochelle. The system is undergoing final testing for safety certification and has already logged 3,000 km (1,800 mi). Bordeaux also has applied one of three methods of track construction to mitigate noise depending upon the distance between the track structure and nearby buildings. Standard track on concrete sleepers chosen where buildings were more than 12 m from the track. Resilient supports were added to the track structure for distances from 7 to 12 m. For 7 m or less, tracks were laid on a floating roadbed with resilient supports. Full service on Stage 1 is now expected toward the end of 2003 or early 2004. The additional 18 km of Stage 2 will be fully operational by the end of 2006. As has been the practice for new French systems, 4 min headways will be maintained during peak periods, and an 8 min frequency in the off peak. Connex has been awarded a contract to maintain and operate the system.

Valenciennes

After a period of uncertainty, Valenciennes has affirmed its original decision to construct a light rail system. The first phase will total 9.5 km (5.7 mi) with 19 stations and represents the precursor of a three route 30 km network. Dubbed Transville (literally "through the city"), Valenciennes is seeking to duplicate the success achieved by other light rail applications in France. In common with the latest systems, Valenciennes has ordered 17 Alstom-built Citadis 100% low floor trams. This first phase will cost €242.75 million (US\$212.4 million or US\$37.3 million/mi). Construction is slated to begin in 2004 with the initial segment scheduled for a June 2006 opening. Valenciennes will apply the same track construction engineering specifications adopted by Bordeaux to mitigate noise.

Nice

France's fifth largest city, Nice (350,000), has reacted to a worsening traffic problem by adopting a public transport on reservation (Transport en Commune en Site Propre-TCSP) solution. For Nice, this translates into a modern light rail system as well as an east-west reserved

bus line. The light rail system will initially consist of an 8.7-km (5.22-mi) U-shaped line serving the northeast and northern reaches of the city via central Nice. The reserved bus lanes will be built along a west–east axis and is designed for easy conversion to light rail when patronage levels so warrant. The reserved bus lanes will go into service in 2004 with the light rail line to follow by the end of 2006. Central Nice will be made over with the arrival of the tram. This project shows the same attention to detail so visible with other light rail projects in France. In fact, Nice even developed a *Plan Lumière* to ensure proper illumination of the street, the tram, and the urban surroundings all along the route. There will be eight types of lighting, designed and deployed to accentuate particular urban settings such as historic, cultural or work destinations. In conjunction with the coming of the tram, numerous streets will become tram-only or auto-free pedestrian zones. The bus system will be extensively revised to feed into the tram line. The initial light rail line will cost €350 million (US\$306.3 million or US\$58.7 million/mi). The initial line will require 20 low floor articulated trams. A tender is expected shortly for this order. Nice has received a Declaration of Public Utility, the last hurdle before construction can begin.

Mulhouse

Track laying has begun in Mulhouse, a medium-sized city located near the convergence of the Swiss and German borders. Mulhouse has adopted an innovative two-pronged approach. The urban portion of the plan consists of two lines of which the first 12 km (7.2 mi) will be placed into service in the autumn of 2005. A further 7.7 km (4.62 mi) will be gradually placed into service between 2005 and 2010. Mulhouse has ordered 20 Alstom-built Citadis trams for the urban segment of the project, with an option for an additional four units. This first increment of the urban portion of the work will cost €340.2 million (US\$297.7 million or US\$41.3 million/mi). The second half of the project will see the employment of the Tram-Train concept (*Périurbain*), with the urban segment connecting to and utilizing French National Railway (SNCF) tracks to access the Thur valley northwest of Mulhouse. Seventeen Siemens dual voltage trams will be acquired for service on this segment, which is planned for opening in 2007. Four km of new track will be constructed from central Mulhouse to Lutterbach, where the line will connect with the SNCF main line tracks. The line will jointly use 36 km of main line trackage with SNCF trains to Kruth in the Thur valley. Although other systems have discussed this option, this is the first actual application of this concept in France². The capital costs of the Mulhouse Tram-Train portion of the project is estimated at €89.6 million (US\$78.4 million), highlighting the low cost nature of this approach.

Paris

Having achieved the status of new system in 1992 with the opening of an in-street but largely on reserved rights-of-way light rail line (T1) between Sainte Denis and Bobigny, two working class suburbs in the northeast portion of the city, Paris proceeded to add in 1997 the enormously successful second line (Val du Seine or T2) between the La Defense edge city and Issy-Plaine, a commuter rail transfer point west of central Paris. The latter line largely follows the contour of the Seine river. The Sainte Denis–Bobigny line, or T1, is currently being extended east to south from the Bobigny–Picasso terminus to Noisy Le Sec, a distance of 2.9 km (1.74 mi) with plans for further extensions to eventually linkup with T2 as part of a grand circle (*Roncade*) around the

periphery of Paris. The Noisy Le Sec extension will open later this year. The Val du Seine line (T2) will also be extended northwest from the La Defence edge city to Pont de Bezons, a distance of 4.1 km (2.46 mi). The line will be placed in the median of a regional highway. The extension is expected to cost €215 million (US\$ 188.1 million or US\$76.4 million/mi) and attract 70,000 daily passengers. The line is projected to open in 2008. T2 will also be extended at its southern end to Porte de Versailles (2.3 km/1.4 mi). In anticipation of significant patronage increases generated by these extensions, Regie Autonome Transports Parisiens (RATP), the Paris regional transit operator and planner, has already taken delivery of 13 Citadis low floor trams capable of multiple unit operation for operation on T2. RATP has also ordered an additional 13 trams of this design for delivery in 2004. All of the new trams will be assigned to T2 with existing trams of the old Grenoble design shifted to T1. T1 is currently carrying 80,000 daily passengers and T2 has reached 58,000 a day. Both lines registered an aggregate 8% increase in patronage in 2002. Significantly, Paris has also embarked on a plan to establish a new 7.9-km, 17-station, street-based route from Porte du Garigliano along Boulevard de Maréchaux (and other names celebrating military leaders from the Napoleonic era) to Porte d'Ivry. Called the Tramway des Maréchaux Sud (TMS), the line will consolidate a number of bus lines and is expected to quickly become one of the city's strongest routes, carrying 95,000 passengers when opened in early 2006. The line will provide connections with five metro lines and two RER suburban lines. The line will run largely in grassy medians (*voies engazonnées*) and will be shaded by 400 additional trees to be planted as part of the project. The line, slated to cost €185.2 million (US\$ 162.1 million or US\$32.2 million/mi), is part of the aggressive transit first policy being pursued by the Socialist Mayor of Paris, Bertrand Delanoë, who has already inaugurated a comprehensive network of bus only lanes throughout the city. The Mayor is also planning an ambitious inner orbital light rail line connecting the main train stations of Paris. Not to be left out, the French National Railways (SNCF) is employing the Tram-Train (*Périurbain*) concept and has ordered 15 Avanto dual voltage low floor trams from Siemens to run on an 8 km section of electrified (25 kV) main line track between Aulnay-sous-Bois and Bondy in the inner suburbs (*banlieu*) east of Paris. The line will interface with three RER (Paris area commuter rail) services. SNCF plans to eventually extend the line at both ends of the line by utilizing space on existing roads for reserved light rail operation. The *Périurbain* service will replace an existing suburban line operated by SNCF push-pull trains in June 2005. The resounding success of T1 and T2 has demonstrated that light rail clearly deserves the prominent role assigned to it in recently adopted plans for expanding transit options throughout the Ile de France.

Toulon

After some introspection occasioned by a change in the city administration in 2001, the new Toulon municipal authorities have affirmed the original decision to construct a light rail line. While the project had secured a Declaration of Public Utility in 2000, some revisions to the original plan will now require that a modified procedure be followed to secure final approval for construction. It is assumed that the go-ahead will be received in mid-2004. The east-west line will be 18.3 km (10.98 mi) in length and require a fleet of 24 articulated low floor trams. The vehicle selection process, which had actually been completed under the original project (the AnsaldoBreda Sirio model has tentatively been selected), will now be re-started. The system will connect La Gard and Gare de la Seyne and include 37 stops, 5 of which will include park-and-

ride facilities. The system is projected to open in 2009, assuming all approvals are secured as planned.

SPAIN

Spain has been a late arrival to the light rail party. Spanish light rail had shrunk to tourist operations in Barcelona and one modern system in Valencia. Now, A Coruña opened a tourist line in 1997 with the idea of conversion to a legitimate light rail operation in the future. Alicante has constructed a short section of tramway in the harbor area to demonstrate the light rail concept and is upgrading a long meter gauge commuter line to light rail. Bilbao has just opened the first line of a three route light rail network (December 2002) and Barcelona is constructing not one but two light rail lines (Trambaix and Trambesós), both scheduled to open initial lines in 2004. The Spanish Region of Andalusia has also announced plans to fund light metros in three cities.

Barcelona

Renewal and expansion are the key words to describe the work in Barcelona, the capital of the Catalunya region of Spain. While the extensive metro and commuter rail systems are being modernized and extended (including the construction of a 46 km driverless metro running the length of the conurbation), the region is also moving to create an efficient intermediate capacity mode serving major districts in the city. Although the city abandoned a conventional tram system in 1971, there has been a growing realization that additional capacity represented by an intermediate capacity mode such as light rail is vital for the surface network. After the success of a short 640-m LRT demonstration line (*Prueba Piloto*) built on Barcelona's famed Diagonal in 1997 (a progression of different tram designs were operated over the line), the resulting surge of support overcame the skepticism of light rail in some quarters and the region moved to plan its introduction into Barcelona. *Autoritat del Transport Metropolitana* (ATM), the region's transit operator, is now overseeing a plan to introduce light rail serving the Baix Llobregat section of Barcelona. Known locally as Trambaix, the 15.5 km (9.3 mi) system features two branches and major stops at Sant Feliu, Cornellà, and Sant Joan Despí. The line is being constructed and will be operated by a consortium, TramMet, led by French carbuilder Alstom. The line will cost €240 million (US\$210.0 million or US\$22.9 million/mi). Alstom is providing 19 Citadis low floor trams for this project. The project will be opened in stages, with the full network operational by April 2004. Even as Trambaix construction got underway, ATM approved another 17.4 km (10.4 mi) network of four routes to serve the Besós area of Barcelona. The cost of this second tram project is valued at €213 million (US\$186.4 million or US\$17.9 million/mi). TramMet also won the contract to design, build, operate, and maintain this project, known as Trambesós. Alstom will deliver an additional 18 Citadis low-floor trams for Trambesós. The Trambesós lines will be opened progressively between April 2004 and January 2005. Both lines will be operated by the private consortium Alstom and Connex. The trams for both Trambaix and Trambesós will be maintained by Alstom under a 25-year contract. After an absence of only 33 years, the tram will again return to Barcelona in the modern form, as light rail.

Bilbao

Bilbao, the capital of the Basque region of Spain, recently opened (December 18, 2002), a 2.1-km segment of an eventual 5-km meter gauge light rail line. The line is a mix of double track (3.1 km/1.86 mi) and single track (1.9 km/1.14 mi) with passing loops. The single track segment was dictated by the narrow street alignment in the city center. The line (Eusko Tram) is being served by eight CAF-built articulated 75% low floor trams (€18 million or US\$ 15.75 million or US\$1.97 million/tram). Ridership has reached 8,000 but is expected to increase substantially when the full system is placed into operation in April 2004. When completely opened, the line will provide access to many of the city's main attractions, including the world acclaimed Guggenheim Museum, the city's new Metro, theaters, a meeting hall, and a major hospital.

Alicante

Alicante, located on Spain's eastern Mediterranean coast 330 mi south of Barcelona, is in the process of upgrading to light rail standards a meter gauge line that follows a northeasterly direction from the outskirts of the city along the coast. The upgrade will include a short 3.6-km tunnel to access Alicante's main train station (Término). This tunnel will also provide access to Término for a second line to be built to the city's university. The local railroad operator has ordered nine dual voltage tram trains from Alstom for delivery in 2005 to work the intercity portion of the line. The new vehicles will cost €46 million and will operate on sections energized at 750 V dc and 1500V dc. An additional 10 low floor trams will be ordered in the future for the urban portion of the line. Initial operation on the 750 V ac portion of the line may be furnished by trams borrowed from Valencia. As part of the overall program to modernize the line, Alicante also built in 1999 a 700-m section of electrified tram line from the existing coastal line terminal at La Marina to Puerta del Mar, along the rim of the city's harbor. This section of track has been used to demonstrate different types of light rail equipment and build public support for Alicante's ambitious plans (a la Barcelona). Nearby Valencia, which has upgraded its light rail network and built the highly successful tram line (Route 4), is providing technical advice to Alicante during this process.

IRELAND

Dublin

After a decade of planning, significant revision and finally construction, Dublin is in the final leg toward the opening of two initial segments [Lines B-9 km (5.4 mi) and A/C-15 km (9 mi)] in June and August 2004 respectively. Known as *Luas*, or speed in Irish (Gaelic), the light rail network is one measure in Dublin's comprehensive vision to enhance the quality of city life, expand mobility options, and confront pollution concerns. The plan also calls for the modernization of the existing commuter rail network (DART) and expansion of bikeways throughout the city and suburbs. The initial segments cost €691 million (US\$604.6 million or US\$42.0 million/km). A total of 40 trams built by the French railcar builder Alstom are currently being delivered and will come in two versions. While both versions are 70% low floor, 26 trams will be 29 m in length and feature three section articulation while the balance of the order, 14

trams, will have five sections and measure 40 m in length. These latter vehicles will be employed on the upgraded Line B. From an initial plan to create a five route classic light rail system, the decision was made in mid-stream to construct Line B to light metro standards (complete grade separation). This conversion was facilitated by the route configuration which largely follows a railway alignment abandoned some years ago. Line A/C from suburban Tallaght to Connolly Station (terminus of Dublin's electrified commuter rail network) in central Dublin remains a conventional light rail application, utilizing a variety of surface rights-of-way, including a former section of canal (shades of the Newark Subway). Line B will have no physical connection with Line A/C and plans call for extending the line into the downtown core via a tunnel, eventually reaching the airport. Each line will have its own maintenance and storage facility. Operation of both lines has been contracted out to Connex, a subsidiary of the French Conglomerate, Vivendi. Connex will also be responsible for maintenance of rolling stock and two depots. The contract will run for 5 years with an option for an additional 5 years. Connex, Europe's largest private transport operator, also operates rail systems in Sydney and Stockholm and will run light rail systems in Bordeaux and Barcelona, both currently under construction (and described in this paper).

UNITED KINGDOM

The trend to light rail in the United Kingdom began slowly but was firmly established by the success of Manchester Metrolink system, opened in 1992. While there was a brief hiatus in the mid-1990s when the former Conservative government became disenchanted after operational problems were encountered in another brand new system in Sheffield, the Sheffield system, christened the South Yorkshire Supertram and opened in 1994, eventually solved those teething problems (including unregulated bus competition) and has since achieved solid ridership gains. Another light rail project was successfully implemented in Birmingham in 1999. Birmingham's Midland Metro consists of a single route linking a commuter rail station located on the periphery of the downtown with suburban Wolverhampton via an old railroad right of way abandoned some 30 years earlier. This project also experienced initial problems associated with vehicle reliability and catenary system design shortcomings but, like Sheffield, solved these problems and has emerged with steadily rising patronage and firm plans to extend the system. Although the new Labor government initially displayed some ambivalence toward light rail, that initial coolness turned to a warm embrace with adoption of an aggressive goal of doubling light rail use by 2010 and the promise of funding for up to 25 new LRT lines ("trams not jams"). This policy change was no doubt influenced by the success of a new Tramlink three route system opened in 2000 to rave reviews in the London borough of Croydon. The momentum has been building ever since. An artistic success (the system now carries over 65,000 daily weekday patrons), the financing for the Croydon system has proven problematic with the Public-Private Partnership (PPP) contract apportioning too much risk to the private sector. The terms of the agreement are currently being renegotiated to ensure a financially healthy collaboration over the long term.

Nottingham

At present, only one new system is under construction in the United Kingdom, in Nottingham. This industrial city (population 275,000) located north of London, broke ground for a light rail

system in mid-2000. Dubbed Nottingham Express Transit (NET), the line is slated to open on November 11, 2003. As with other schemes throughout Europe, NET is a long-planned reaction to mushrooming congestion and spectacularly rising automobile travel in the region as a whole. Nottingham is determined to provide a viable and affordable alternative to the auto. The line under construction will serve as the initial component in an ultimate region-wide network. The 14 km (8.4 mi) line will furnish 3,040 parking spaces at key stations outside the urban core and is expected to carry 30,000 daily passengers in the initial months of operation. The private consortium selected to build, operate, and maintain the system, Arrow, Inc., is not expected to experience financial difficulties similar to Birmingham or Croydon. This is due to the contract being structured to distribute identified financial risk factors in an equitable fashion between the private and public partners. The trams being built by Bombardier are based on a design recently supplied to Nantes, France (the Incentro). The system is a blend of street-running and private rights-of-way, including a physically separate operation in the same corridor with existing main line rail operations. The line costs £220 million (US\$362.4 million or US\$43.1/mi). The Nottingham City Council and the Nottinghamshire County Council have already given the green light to begin serious planning for two additional routes.

Portsmouth

As part of the big bang announcement by the Labor Government supporting light rail initiatives in three cities, the city of Portsmouth and the Hampshire County Council are proceeding to implement phase one of a regional network. The system has been christened South Hampshire Rapid Transit (SHRT) and the initial line, 14 km (8.4 mi) in length, will connect Portsmouth with neighboring Gosport and Fareham. The line will also feature a short 1-km tunnel beneath Portsmouth harbor (Portsmouth is located in Southern England and the harbor opens into the English Channel and is situated opposite the Isle of Wight). As with other proposals in the United Kingdom, the system will be built with significant private financial participation (Public Private Partnership). Two consortia (including Siemens and Mitsubishi, respectively) have submitted bids to design, build, and operate and partly finance the system. Award is expected in the fall. The initial line is estimated to cost £190 million (US\$311.1 million and US\$37.03 million/mi). The line will have 16 stops of which 5 will be interchanges with railway stations and three with major bus stations. Approximately 70% of the mileage will be located on abandoned railroad alignments with the balance on reserved street space in Fareham town centre and Portsmouth. Travel time end to end is estimated at about 30 min with a frequency of 7½ min during the day and 15 min evenings. Weekday patronage is estimated to reach 32,000 in the first year of operation. With worsening congestion and the projection of ever increasing automobile use, the light rail line is part of the area's answer to ensuring mobility without major road construction. The line is also expected to be a catalyst for revitalization in several disadvantaged areas served by the new service. Portions of the Gosport area are especially targeted for economic renewal. Construction is expected to take 3 years and the first trams are expected to be in operation in 2007.

Bristol

With government approval, Bristol is embarking on a program to construct an initial 16.7-km (10-mi) light rail route with 16 stops from central Bristol to the city's northern suburbs.

Estimated to cost £194 million (US\$319.6 million or US\$31.96 million/mi), plans call for construction to begin in 2004, but some uncertainty over a portion of the alignment and the ultimate northern terminus could push this date back considerably.

Leeds

Leeds, one of three systems approved by the government, will construct a 28-km three-route network to be served by 40 articulated trams, bringing to fruition some 10 years of planning. The genesis of this effort traces back to 1993 when Leeds received parliamentary powers to proceed with a single route project. These powers briefly lapsed in 1998 but were renewed in 2000 with an additional two routes. The main impetus for the system came from the realization that a reliance on road building alone would not solve Leeds' transport needs. The plan developed and put forward contained a mixture of road improvements, commuter rail upgrades, bus priority measures, and a surface running light rail system (which was the number one priority). The adopted system, Leeds Supertram, is estimated to cost £500 million (US\$823.7 or US\$49.0 million/mi). After considering the bids submitted from two consortia (from an original four aspirants), the contract to design, build, maintain, operate, and partially fund the proposed system has been awarded to the EUROTRANS consortium (includes trambuilder Bombardier). In an effort to intercept automobile trips, 4 of the 49 stops will feature large park-and-ride facilities. Although taking advantage of existing road space to carve out most of the system mileage, fully 75% of the right-of-way will be separated from adjoining traffic. Approximately 50 intersections with vehicular traffic will require integration into the traffic control network. The main construction phase is expected to get underway in early 2004, although advance work involving road works and utility relocation has already begun, with completion projected in 2007.

Liverpool

Liverpool will construct a 19-km network, Merseytram, that includes a downtown loop serving key business, tourist and shopping destinations, and a terminal in suburban Kirkby Town Centre. Seven of the nine downtown stops would connect to other transport modes. The system is estimated to cost £225 million (US\$370.6 million or US\$32.5 million/mi). The full plan calls for an additional two routes to be built to complete the system. Total cost of the completed network is estimated at £400 (US\$658.9 million). The initial route has received government approval and the promise of 75% of the cost.

London

After the success of the Croydon Tramlink system (19% of patrons abandoned their cars for the service), London's Lord Mayor, Ken Livingston, has authorized advanced planning for two light rail lines to be built on in-street reserved rights-of-way in central London. These are the West London line running from Shepherd's Bush to Uxbridge, a distance of 20 km (12 mi), and the Cross River line navigating a 15-km (9-mi) route through central London with two branches at each end. The West London line will intersect with four tube (subway) stations and four town centers. The West London line is estimated to cost £200 million (US\$329.5 million or US\$27.5 million/mi) while the Cross River line will total £300 million (US\$494.2 million or US\$54.9 million/mi). These initiatives seek to provide additional capacity to alleviate overcrowding in

London's subway lines and allocate scarce road space from automobiles to more efficient public transport vehicles. A final decision on West London is expected in January 2004 upon conclusion of the public consultation process. Assuming final approvals and taking into account planning, design, and construction time, the West London line is expected to open in 2009 and Cross River in 2011. Mayor Livingston has vowed to find ways to accelerate this process and bring these initiatives on line at an earlier date.

Edinburgh

After considering a diverse number of alternatives including a 5.9-km curbed-guided bus route, Edinburgh has settled on a three-route, 31-km (18.6-mi) light rail system to be the cornerstone of the region's ambitious 10-year £1.0 billion transport improvement plan. As part of this plan, the city of Edinburgh has also developed a congestion-pricing component, similar in scope to the London's successful scheme, to manage congestion in Edinburgh central core. This scheme appears to have strong public support if the resulting revenues are used to improve transit. The Scottish Government has given its approval to Edinburgh's tram proposal and has pledged £375 million towards the estimated £487 million (US\$802.2 million or US\$43.1 million/mi) cost of implementation. The first line, the 15-km North Edinburgh loop, is on schedule for a 2009 opening as is the 8-km second line to the west toward the Edinburgh airport. The Edinburgh City Council created a company, Transport Initiatives Edinburgh, Ltd., to develop the three route concept and bring the plan to reality.

ITALY

The renaissance in transit across Italy continues as transit investments are being targeted not only to revitalize existing systems in Roma, Milano, and Napoli, but also to establish new systems in Sassari, Verona, Messina, and Firenze (Florence). Additional systems are also on the drawing boards in Palermo and Cagliari.

Firenze (Florence)

The jewel on the Arno has endured a number of false starts in its efforts to install a modern light rail system. The most recent travail involved the choice of a consortium to design, build, and operate the system. The original selection, a group led by the French rail-builder Alstom, was challenged by an Italian-led consortium, including the Italian railcar builder, AnsaldoBreda, which ultimately prevailed in court. The legal wrangling delayed the initiation of construction. With legal difficulties finally resolved, construction is underway and Firenze will soon enjoy the first 7.5-km segment of an eventual three-route network. The initial line will run from suburban Scandicci to a terminal opposite the main train station (Santa Maria Novella) and will not penetrate the medieval district of the city (Il Duomo, etc.). Except for intersections, the entire route will be on reserved rights-of-way. Trams will have priority at all signalized intersections. Underpasses for automobiles at two major squares (piazzas) are being built to leave the surface free for the light rail line and pedestrians. A new tram and pedestrian-only bridge will be built across the Arno river. With plans to operate on 3-min headways during peak periods, a total of 17 low-floor trams will be required. An order has been placed with AnsaldoBreda for the 100%

low-floor Sirio model (also being furnished to Milano, Sassari, and Athens, Greece). Travel time from end to end is estimated at 15 min. Two additional lines are already in the advanced planning stages and have received guarantees for funding from the Italian government and the municipality of Firenze. Significantly, Line 2 will penetrate the historic center of Firenze where local officials have called for a system similar to Bordeaux to eliminate overhead wires in this visually sensitive area. The exact technology has not been chosen although two competing approaches developed by French and Italian companies are being considered. The French technology (Alimentation par Sol-APS) has the advantage of being tested and operationally deployed in Bordeaux and will soon have a track record on which to evaluate its suitability. Firenze is also moving ahead on Lines 2 and 3, asking for expressions of interest for a contract to build and operate the two lines. Only one bid was forthcoming, which is being evaluated by the city. The city estimates that both lines could be built for €231.6 million (US\$202.7 million). Firenze is creating this system to provide a viable alternative to the chaotic traffic congestion plaguing the city and other metropolitan areas across Italy.

Messina

The Sicilian city of Messina has joined the ranks of operating light rail systems with the opening of its initial 7.7-km line on April 3, 2003. The line connects the city's downtown center and harbor area with the main train station. The service is provided by 15 100% low-floor "Cityway" articulated trams built by Alstom Ferroviaria. Similar vehicles have been delivered to Roma.

Sassari

Construction of a small 6-km (3.6-mi) line from the main train station to Emicicio Garibaldi in this Sardinian city is now complete but initiation of service has been postponed until 2004. Once service commences, the 950-mm gauge line will be served by five AnsaldoBreda Sirio low-floor trams which have already been delivered. Sassari has investigated the feasibility of converting two lightly used railroad lines to light rail service.

Verona

The town of Verona has selected a consortium led by Siemens to construct the first two routes of a planned three-route light rail system for an estimated €126 million (US\$110.3 million or US\$12.3 million/mi). Both routes total 15 km (9 mi) and will be served by 22 Siemens-built Combino low-floor trams. The first route will run on an east-west axis from Stadio Bentegodi to a park-and-ride facility at suburban San Michele Extra. The second route will run south from the city center to Ospedale Borgo Roma. A planned second phase calls for a 4-km (2.4-mi) extension from the terminus at Ospedale Borgo Roma to a new park-and-ride facility and a new Route 3 connecting the center of the city with a suburban rail station at Parona. The first phase is projected to be ready for service in mid-2004.

Bergamo

A total of 14 low light rail vehicles of the Sirio design have been ordered from AnsaldoBreda for the 12.6 km (7.56 mi) Bergamo-Alzano line, scheduled for completion in July 2004.

Cagliari

The city is moving ahead on a 6.5-km (3.9-mi) line from Piazza Repubblica to Museo Monserrato including the electrification of an existing rail line.

PORTUGAL

Oporto

Porto, faced with a severe decline in public transit usage, decided to make substantial investments to stabilize and dramatically increase transit over the long term. Spanning an 8-year period from 1988 to 1996, transit's share of all trips declined from 65% to 37% while auto trips increased from 35% to 62%, a mirror reversal. Porto's city fathers saw a real threat to Porto's competitiveness and attractiveness as a business location in Europe. Porto's answer was the Metro do Porto embodying the light rail concept. A full metro was rejected on cost grounds and other modes were considered and rejected as ill-suited for Porto's topography and developmental patterns. Porto was also heavily influenced by the success of the Strasbourg system, and the smooth integration of Strasbourg's initial tram line into the public transit network. It is therefore probably no coincidence that Porto's Metro reflects many similarities with the Strasbourg system. Metro do Porto opened an initial segment of 9.3 km between Senora de Matosinhos and Trindade in December 2002 of what will be an ultimate four-route, 70-km system connecting all quadrants of the city and surrounding suburban areas. The full system, expected to cost €900 million (US\$787.5 million, or US\$18.8 million/mi) is expected to carry 250,000 weekday passengers. The financing plan for the system contains an array of funding from the national government as well as regional and municipal authorities. The European Union has also provided additional funding. The initial segment is already carrying 18,000 weekday passengers. Bombardier is supplying 72 full low-floor seven-section trams (€265 million or US\$231.9 million or US\$3.0 million/vehicle) patterned after the successful Strasbourg Eurotram design (as mentioned above). The bi-directional Porto vehicles will be wider than the Strasbourg version (2.65 m versus 2.4 m) and are equipped for multiple unit operation.. This may be the last order for this type of vehicle as Bombardier has decided to concentrate on its own in-house models. The Eurotram was an Adtranz product, a firm recently acquired by Bombardier. Besides Strasbourg and Porto, Milano has also received a small order of Eurotrams. Metro do Porto will incrementally extend service with the next segment, a 2.7-km (1.62-mi) tunnel section between Trindade and Campanhã, to open in early 2004. Also under construction is an 8-km north-south line which will connect Hospital Sao Joao in the north through central Porto via tunnel (with an underground interchange at Trindade) before crossing the famed double-decked High Level bridge (built in 1886) to cross the Douro river and reach Santo Ovideo. The upper level of the bridge will be reserved exclusively for the Metro trams. The remainder of the system, two former long meter gauge suburban lines being converted to standard gauge Metro operation (Povoa-32 km/19.2 mi) and Trofa-23 km/13.8 mi), are expected to open for service before 2005. Porto has clearly tapped the flexibility of light rail, deploying the system on grassy medians, high viaducts, short tunnel segments, converted railroad rights-of-way and reserved space along existing streets.

South Tagus LRT

The Portuguese government is funding the construction of a light rail system to serve the communities located on the south bank (Setúbal peninsula) of the Tagus river (opposite the capital city of Lisbon). Dubbed the Metro Transportes do Sul, the system will ultimately grow to an ambitious 27.5-km (16.5-mi) network linking Almada, Seixal, and Barreiro but the initial phase consists of a 12-km (7.2-mi) segment. This initial phase will also include connections with the cross-Tagus rail link to Lisbon as well as to commuter ferries. A consortium of Siemens and local Portuguese partners has won the contract that will ultimately total €397.5 million (US\$347.8 million or US\$21.1 million/mi) at full buildout. A total of 24 Siemens Combino low-floor light rail vehicles have been ordered for the first phase. The first phase is projected to open in late 2005.

CONCLUSION

The trend of constructing new light rail systems in medium-sized and small cities in Western Europe has become progressively stronger since the first trailblazer system was opened in Nantes, France, in 1985. Significantly, the trend has not been confined to cities under 500,000 as London, Paris, and Barcelona are pursuing ambitious light rail programs in their respective cities. It should also be noted that firms in Western Europe have acquired a large body of knowledge and experience in successfully implementing light rail. This has been applied to subsequent projects but has not precluded innovations as the tram-train concept forges ahead and Bordeaux's new system will employ a unique system that obviates overhead wires. It, of course, remains to be seen if light rail will continue at the same pace through the rest of this decade. The trend may slow, if for no other reason than many of the most promising locations have now implemented or chosen light rail or a competing intermediate mode (various forms of guided bus, etc.). Unlike the United States, financing does not represent as formidable a barrier to implementation of major projects. The United Kingdom has employed a PPP financing mechanism grounded in legislation to transfer some portion of the risk of projects to the private sector. While this has resulted in some problems on the financial side for projects such as Croydon in the United Kingdom, other projects (Nottingham, for example) have learned from this experience and structured contracts to better reflect project financial realities and achieve a more realistic distribution of risk. Financing in France is reflective of that country's inclusive multimodal approach to finding long-term solutions to current mobility, congestion, air pollution, and land use disfunctionalities. Substantial national government financing is available and localities have a number of financing alternatives from which to choose. National, provincial, and localities are expected to contribute to the project, consistent with the benefits received. Similar circumstances exist in Italy (still benefiting from the special legislation passed in 1992 to better balance the funding mix for transit-based solutions) and Spain. In Spain, the devolution of political power to the regions (Basque, Andalusia, Catalunya) has resulted in a shift favoring transit as the decision-making level has been moved closer to the Spanish people and is more reflective of their opinions. It is clear that all of the countries surveyed recognize the long-term benefits of enhancing the transit infrastructure and uniformly exhibit the political will to deploy the necessary resources to capture those benefits.

NOTES

1. This is not to ignore the expanding role of light rail elsewhere in Europe but the limitations on the size of this paper preclude reporting on such developments as the reintroduction of light rail in Stockholm, Sweden, (in operation) and Athens, Greece (under construction), important developments in The Netherlands, Belgium, and Switzerland, the proliferation of light rail systems in Rumania, the introduction and expansion of light rail in Istanbul, Turkey, and other Turkish cities, and the extensive developments in Germany, the recognized world leader in light rail. Even tiny Luxembourg has gotten into the act, officially approving construction of a tram-train scheme.
2. SNCF has also ordered 15 LRVs for testing the concept between Aulnay-sois-Bois and Bondy in suburban Paris beginning in 2005.

REFERENCES

Books

1. Future of Urban Transport: Learning from Success and Weakness: Light Rail.
2. Hass-Klau, C., and G. Crampton. Environmental and Transport Planning, Brighton, United Kingdom, 2002.
3. Jane's Urban Transport Systems. 18th Edition, 1999-2000, (T. Pattison, ed.), 1999.
4. The Four World Cities Transport Study. London Research Centre, London. Her Majesty's Stationary Office, 1998.
5. Walinsky, D. A., and K. E. Perrett. The Effects of Rapid Transit on Public Transport and Urban Development. Transport Research Laboratory, 1992.
6. Pulcher, J., and C. LeFèvre. The Urban Transport Crisis in Europe and North America. MacMillan Press, Ltd., 1996.

Periodicals

1. *Tramways and Urban Transit*
2. *Rail et Transports* (formerly *La Vie du Rail*)
3. *Today's Railways*
4. *Railway Gazette International*
5. *International Railway Journal*
6. *Strassenbahn Magazin*
7. *Stadtverkehr*
8. *Blickpunkt Strassenbahn*