Comparative Evaluation of Performance of International Light Rail Systems

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Findings are presented from an analysis of the performance of international light rail transit (LRT) systems, conducted by the Urban Transport Group of the European Conference of Ministers of Transport (ECMT). The analysis is based on case studies and national overviews provided by the six participating countries (France, Germany, the Netherlands, Switzerland, the United Kingdom, and the United States), which are included in the detailed ECMT report. The project traced LRT development; reviewed policy, managerial, and technological trends; and analyzed comparative cost-effectiveness. Policy conclusions reflect the consensus of the six national delegations. Standardized financial and operational data, as developed for the study and applied in a balanced set of performance measures, are difficult to define for international systems. Nevertheless, efforts such as this encourage an objective exchange on international experiences with different public policies and operational approaches. The standardized framework developed for the project allowed consistent comparisons of the international systems. The seven systems evaluated were publicly operated, but several included private involvement, ranging from private equity shares in Nantes and Grenoble, France, to the turnkey approach in Manchester, England. The governments sponsoring LRT in the case study cities set broad goals, ranging from attracting automobile drivers and improving air quality to reducing congestion while recovering costs. Even though success was often not quantified, the governments were generally satisfied with results. All countries conducted some analysis of alternatives before selecting LRT, but analysis was less comprehensive and rigorous than might, for example, be expected of major investments under the requirements of the Intermodal Surface Transportation Efficiency Act.

In recent years there has been an upsurge of interest in member countries of the European Conference of Ministers of Transport (ECMT) in building new urban light rail transit (LRT) systems and extensions to existing ones. Many urban areas that did not have the size and density for conventional heavy urban rail systems have considered LRT as an attractive alternative. LRT systems are less expensive than heavy metro systems but nevertheless entail substantial transportation investments for urban areas and the organizations that finance them.

National and local governments are, therefore, concerned about the appropriate role of LRT systems in providing transportation in urban areas (as well as other concerns related to the environment and livability of these areas). They are interested in the economic performance of these systems and the factors and conditions that affect that performance. In light of this current interest in LRT, the Urban Transport Coordinating Group of the ECMT carried out a detailed study with the following objectives:

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1. Tracing the development of LRT in ECMT participating countries;
2. Reviewing current LRT trends in policy, managerial, and technological innovations;
3. Identifying current economic, financial, and broader social policy issues and concerns related to LRT, including environmental, safety, congestion relief, and urban structure;
4. Analyzing the cost-effectiveness of light rail systems in the context of broader social policy issues and concerns; and
5. Identifying conditions that affect the economic performance of LRT.

Information for this study was obtained from the six participating countries: France, Germany, the Netherlands, Switzerland, the United Kingdom, and the United States. Each country prepared an overview of its existing and proposed light rail systems. These were supplemented from other data sources, including the International Union of Public Transport, which also participated in the project (*1*). Each country also analyzed one or two of its own new LRT systems using a consistent framework that standardized methodologies and data to be evaluated. The framework allowed the comparison of results and a synthesis of findings and conclusions based on international experiences. In addition, the work group discussed policy issues and their implications and reached related conclusions by consensus based on national experiences.

The results of these analyses have been synthesized into a detailed report to be presented to the transportation ministers of the ECMT countries (*2*). This paper summarizes some of the most important analyses and findings of the research and focuses on the third and fourth objectives listed earlier: comparative analysis of cost-effectiveness and discussion of policy issues.

DEFINITION OF LRT AND RECENT DEVELOPMENTS

Defining LRT can be a matter of controversy in the international public transportation industry. For the purposes of the ECMT report, a flexible definition was applied. The definitions used were provided by TRB's Light Rail Transit Committee, which defines light rail as

> a metropolitan electric railway system characterized by its ability to operate single cars or short trains along exclusive rights of way at ground level, on aerial structures, in subways, or occasionally, in streets, and to board and discharge passengers at track or car floor level.

This definition allows older tram systems, even those operating primarily in mixed traffic with no grade separation, to be included in this study.

In the six countries participating in this study, LRT systems have enjoyed strong support the past 15 years. Most large cities in the former West Germany never abandoned their tram systems and in the 1960s began to upgrade them to full LRT by resurfacing surface street lanes for trams, building tunnels, buying large capacity vehicles, and integrating them with other modes. Trams have remained popular in the former East Germany but generally have not been upgraded and will require substantial new investment.

Trams had passed into virtual extinction in France and the United Kingdom by the early 1970s, but by the end of the decade LRT was receiving new attention. Since then new French systems have been built in Grenoble, Nantes, and Paris, and a new British system opened in Manchester. Additional urban LRT is planned or proposed in both countries. The British seek to route LRT on underused railroad rights of way, whereas the French design their systems to be the focus of urban development.

After declining to seven systems in the 1970s, LRT in the United States enjoyed a resurgence beginning in the 1980s. Old systems were reconstructed or extended, and new lines were opened beginning with the San Diego Trolley in 1981. Between 1980 and 1993 LRT systems in the United States more than doubled, from 7 to 15, and additional service is being considered in many other cities.

Trams have continued to operate in several large cities in the Netherlands. Since the late 1970s the Dutch government has regarded LRT as one solution to the transportation needs of smaller "satellite" cities. In Switzerland trams remain in five large cities and many electrically powered regional light rail lines operate throughout the country. Many of the regional lines have been modernized with light rail vehicles, and a completely new LRT system recently opened in Lausanne.

EVALUATION AND COMPARISON OF PERFORMANCE

This section evaluates the performance of the LRT systems included in the case studies: Grenoble and Nantes, France; Stuttgart and Hannover, Germany; Nieuwegein (Utrecht), the Netherlands; Bern, Switzerland; and San Diego. Information is also included from Manchester, although actual operational data were not available from this new system. Each system studied is expected to achieve broad goals ranging from improving mobility, to decreasing congestion, to recovering costs from fares. To compare the overall performance of the LRT, this section evaluates standardized data on benefits, costs, and service. The reporting framework established a rigorously defined standard set of comparable performance data for the participating countries.

Given differences in the completeness and underlying assumptions of data provided by public transit authorities, performance measures should be used with caution to compare LRT. To prevent distorted assessments, the measures should be reviewed together rather than as separate components. For example, an emphasis on operating costs that excludes consideration of capital costs will bias comparisons in favor of systems that have low operating costs, such as some that rely heavily on automation. The following analysis clarifies assumptions and data differences where possible and draws a number of conclusions about relative performance. Other analysts may apply their own assumptions to the data provided (for example, choosing different asset lives and discount rates) to make system comparisons.

Because currencies and the time periods during which LRT investments were made differ, cost figures obtained were adjusted. To derive comparable capital costs for new systems or extensions, figures reported by the different LRT operators were converted into dollars based on International Monetary Fund exchange rates. These nominal dollars were then converted into constant 1990 dollars based on an index of U.S. gross national product growth from 1950 to 1990. The resulting figures provide a reasonable estimate of total capital expenditures. Using a standard capital recovery factor that assumes asset lives of 20 years for vehicles, 40 years for construction, and infinity for rights of way, the 1990 capital investments were annualized. The capital recovery factor was derived using the formula $i/[(1 + i)^n - 1] + i$, where i equals the discount rate, which is 8 percent, and n equals years of asset life. An 8 percent discount rate was used because it falls roughly between the 10 percent rate used by the U.S. Office of Management and Budget and the lower rates used by European nations. The quality of the cost estimates is dependent on the data—more disaggregate data would improve comparisons.

The intent of the performance analysis is not to rank transit systems by performance measures but to evaluate relative performance using a balanced set of measures. It is probable that relative performance will change over time, and is sensitive to the assumptions used. It was not possible to test the degree of sensitivity of the different assumptions, for example, use of an 8 percent discount rate or different currency exchange rates.

Total capital cost figures allow a rough comparison of the magnitude of investment in the different LRT systems. Although data provided was of varying degrees of completeness, the figures illuminate some interesting differences. Costs from Grenoble, Nantes, and San Diego were separated for right of way, construction, and vehicles; total reported costs for their projects (all figures are in 1990 dollars) were $400 million, $129 million, and $346 million, respectively. Bern reported expenditures between 1956 and 1990 for construction and vehicles totaling $237 million. Nieuwegein listed expenditures in 1983 for construction and vehicles totaling $100 million. Hannover and Stuttgart reported uncategorized total annual depreciation costs for their light rail transit systems of $15 million and $16 million, respectively, which were assumed to reflect their annualized capital costs but not total capital investments.

The older systems, reporting no right-of-way costs (Hannover, Stuttgart, and Bern), could be assumed to have been given their rights of way; the value of the existing right of way might conceivably be estimated, but this was not done for this project. These systems are upgrades, in contrast to the others, which are new starts (Grenoble, Nantes, Nieuwegein, and San Diego). Also note that the French systems are urban and run over street-based track, which does not involve purchases of right of way, as do the more suburban systems. Because the approach to right-of-way costs is so different among the systems, right of way was separated from other capital costs (Figure 1).

Estimated annual capital costs were used to compare the effectiveness and efficiency of use of capital per: passenger kilometer, vehicle revenue kilometer, and unlinked trip. Low annualized capital unit costs indicate either intense use of capital in the form of heavy ridership or well-planned, efficient investments.

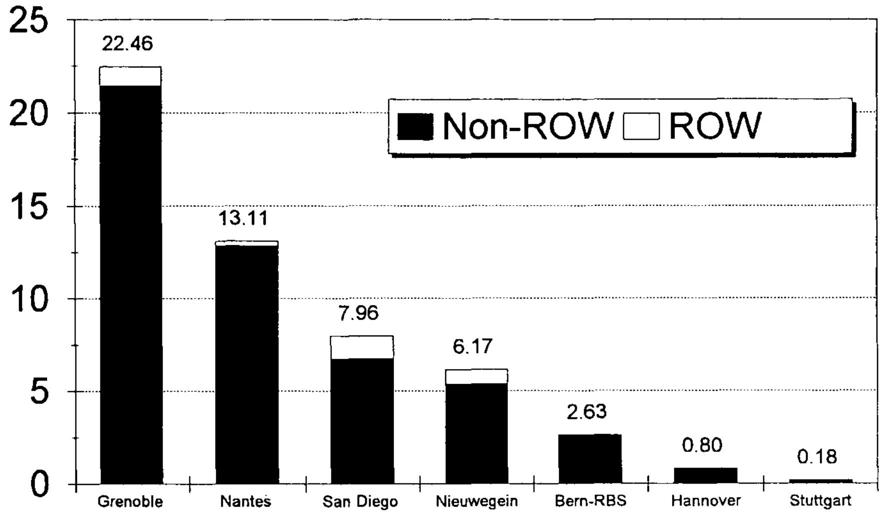

FIGURE 1 Annual capital costs ($/vehicle-revenue-km).

Conversely, high capital unit costs may suggest low ridership or relatively expensive investments. In the definition of vehicle kilometers, two or more sections that are connected by an articulated area are considered as one vehicle. Two or more separate units coupled without connecting articulation are considered separate vehicles, even if the coupling is semipermanent.

A number of efficiency and cost-effectiveness performance measures are calculated for each system, and the policies of each are analyzed. Tables 1 and 2 present the data from which the 11 quantitative performance measures in the figures are derived.

Capital costs per trip suggest that Nantes ($0.79) and Nieuwegein ($1.24) have low capital costs relative to those in San Diego ($2.70). Per trip costs, however, tend to be low on systems with short average trip lengths, such as Nieuwegein. More neutral costs per vehicle revenue kilometer (Figure 1) indicate that Nantes ($13.11) and Grenoble ($22.46) have relatively high capital costs. San Diego ($7.96) uses capital effectively according to this measure. Stuttgart ($0.18), Hannover ($0.80), and Bern ($2.63) indicate relatively modest costs per vehicle kilometer, but their costs appear comparatively low because of the absence of reported right-of-way expenditures.

Passenger kilometer data were incomplete, but the figures provided indicate that ridership is relatively heavy in Bern and Nieuwegein (Table 1). When 1989 capital and operating costs are combined (Figure 2), Grenoble's costs per kilometer are high ($27.99) and San Diego's are lower ($10.37), whereas those of the cities not reporting right-of-way costs appear comparatively low.

Operating costs alone offer a consistent means of comparing cost-effectiveness, measured in cost per unit of service, and cost-efficiency, measured in cost per unit of service consumed (ridership). The expenditures per trip suggest that the French and Dutch systems are relatively inexpensive, whereas those in Germany, Switzerland, and the United States are more costly. However, costs per trip are affected by differences in average trip length (Figure 3), which vary widely depending on system characteristics—for example, whether they provide shorter urban trips (Grenoble and Nantes) or longer more suburban trips (Bern, San Diego, and Nieuwegein).

Operating costs per vehicle kilometer and passenger kilometer (Figure 4) suggest that San Diego, where average trips are long, and Nieuwegein provide relatively cost-efficient and effective LRT service.

Financial performance measures indicate whether some of the systems have achieved fare recovery targets. The San Diego Trolley recovered 92 percent of operating costs through fares, substantially more than other American LRT systems. In France, re-

TABLE 1 Background Data

	Opened	Population (000)	Operating Costs ($000)	Revenues Fares ($000)	Subsidies Total ($000)	Other Income ($000)	Train Intervals Peak	Peak Vehicle
Bern-RBS	1899	190	29059	15735	5139	8185	15	60
Grenoble (1988)	1987	362	5277	19240	17957		4/2	21
Hannover	1883	1050	72804	60666			8/12	
Manchester	1992	2600						
Nantes (1988)	1985	464	4116	22721	24371		5	28
Nieuwegein	1977	230	4255				8	24
San Diego	1980	1704	9159	8732	1787	53	7-15	45
Stuttgart	1868	1600	98270	73549			6/10	

TABLE 2 Operating Data

	Speed (KM/HR)	Veh. Rev KM (000)	Veh. Rev. Hours (000)	Pass. Trips Unlinked (000)	Passenger Km (000)	Route KM Total	Staff
Bern-RBS	37	8366	227	17500	168100	63	353
Grenoble (1988)	18	955	53	16500	35049	9	59
Hannover	24	18336	752	96501	476736	192	2414
Manchester							
Nantes (1988)	22	873	40	14500	24008	13	81
Nieuwegein	29	1768	45	8685	59053	18	
San Diego	30	3808	126	11217	122182	53	148
Stuttgart	22	36726	1454	94383	495801	110	3156

covery rates for all transit modes increased after LRT service began. More impressively, 1988 operating revenues in Grenoble for LRT service exceeded costs by 29 percent. In contrast, Stuttgart and Hannover had recovery rates of 66 and 70 percent, and Hannover's rate had fallen from 78 percent in 1985. However, in both German cities LRT costs per passenger and vehicle kilometer are lower than for buses, suggesting the relative success of investment in LRT. The Bern system reported a 72 percent recovery rate. Note that all of these figures exclude capital costs. This comparative analysis would improve with information on how and at what level fares are set in different cities to achieve targeted cost recovery rates.

Combined capital and operating cost figures allow a more complete comparison of service effectiveness and efficiency. Because data on passenger kilometers are not collected in all the countries studied, only a limited comparison of cost-effectiveness is possible. Combined costs per vehicle kilometer and passenger trip, however, suggest a range of efficiency (Figures 2 and 5). Grenoble's combined costs are high per vehicle kilometer and trip, whereas these costs are consistently low in the German cities. As expected, all costs are lower on improved or extended LRT routes (Stuttgart and Hannover) than on entirely new systems (Grenoble and San Diego). Long trips (San Diego and Bern) also result in higher combined costs than short trips (Stuttgart, Nantes, and Hannover), making it difficult to rely on this indicator for comparison.

The systems studied reported different LRT impacts on ridership. On the San Diego Trolley, boardings per vehicle kilometer increased by 23 percent between the first year of operation and 1988–1989, and a 1985 survey indicated that 48 percent of riders had previously traveled by car. In Nantes 18 percent of LRT riders were new to public transit and 17 percent formerly traveled by car. Trips also grew by 31 percent between 1984 and 1987, while cost per passenger kilometer was lower than for buses; by 1989 public transit accounted for a lower proportion of total trips than in 1980. Twelve percent of riders were new to public transit in Grenoble in 1988, where LRT accounted for 30 percent of all transit trips.

Total rail trips grew in Hannover and Stuttgart after LRT was improved, although ridership in Hannover actually dropped between 1985 and 1989. Nieuwegein identifies 23 percent of its 1984 riders as new to LRT and 8 percent as former automobile drivers. Bern decreased one-way and commuter subscription fares in 1987, resulting in increased ridership and costs, decreased receipts per passenger, and a larger operating deficit. However, tran-

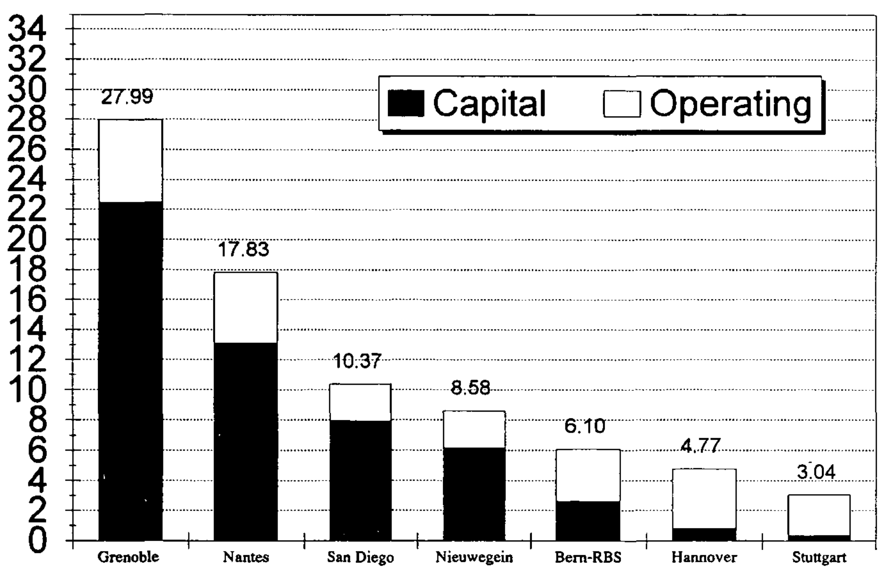

FIGURE 2 Operating and capital costs ($/vehicle-revenue-km).

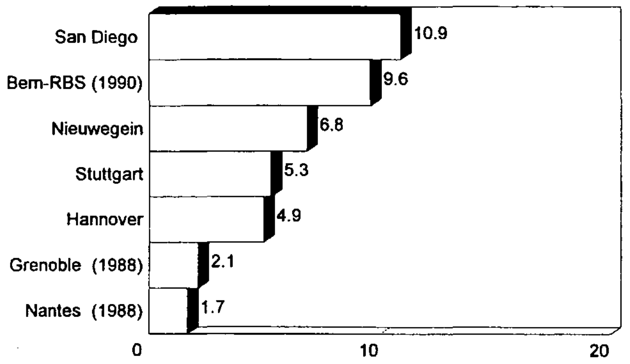

FIGURE 3 Average trip length (passenger-km/unlinked trip).

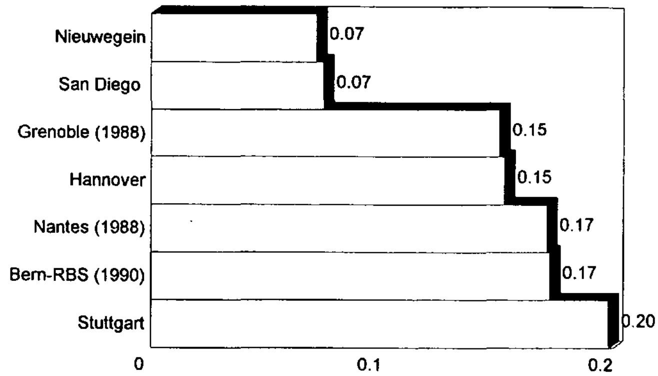

FIGURE 4 Operating expense per passenger kilometer ($/passenger-km).

sit ridership in Bern-RBS grew from 15 million to 18.3 million between 1987 and 1991, and automobile traffic on the Bernstrasse has actually declined since 1985. Bern-RBS has integrated its LRT lines with a system of feeder buses and timed transfers. Better data on total automobile use, trip times, and emissions would indicate how well LRT has discouraged automobile travel and reduced congestion and air pollution in all of these cities.

Load factors (average car loads) also provide some measure of how service outputs and ridership are linked. Although the data for this indicator are imperfect because some systems provide loads for their entire rail systems, the information still is informative. Nieuwegein and San Diego reported more than 30 passengers per vehicle kilometer. This is notable in San Diego, where average trips are quite long and capacity appears to be heavily utilized. Stuttgart and Hannover also report respectable load factors—27 and 26, respectively—but this is for LRT combined with other modes.

Average speed is an important factor in system efficiency. The fastest systems, San Diego and Nieuwegein, also have the lowest costs per hour. These two systems, along with Bern-RBS, are generally suburban and operate on reserved rights of way, which increases speed relative to the more urban systems, Nantes and Grenoble.

POLICY ANALYSIS

In this section the planning and management policies that have guided the development of the LRT systems are analyzed. The analysis is based on the case studies, national overviews, and discussions among the national delegations on policy issues and implications. Conclusions reflect the consensus of the delegations.

Expectations and Results

Reasons for building LRT systems are similar but vary somewhat by location. Many U.S. cities are experiencing rapid growth in automobile trips and declining use of transit service, causing congestion and air pollution. European cities such as Grenoble and Hannover face growing automobile travel and intense use of public transit facilities that are wearing out or, in the case of bus systems, increasingly in conflict with automobiles. All cities studied have strained financial resources. LRT systems are intended to offer large numbers of passengers convenient transit that supplements and is more rapid than buses but that is less expensive to build and operate than metro. In most cases LRT and buses were planned as parts of an integrated system.

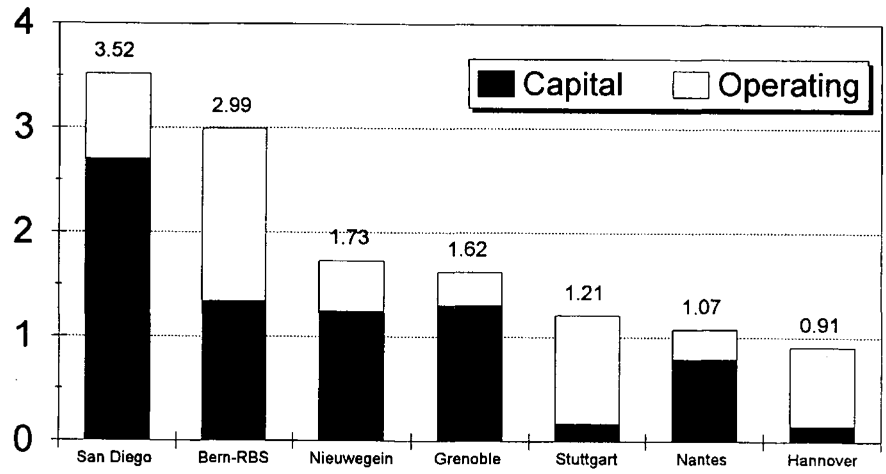

FIGURE 5 Operating and capital costs ($/unlinked passenger trip).

New LRT systems are expected to carry passengers who might otherwise travel by automobile or bus, or not at all. As stated by the Grenoble operator, these systems may positively alter "the quality and fabric of city life." Goals range from increased public transit use, reduced automobile and bus use, and reduced congestion and air pollution to improved mobility for those with disabilities. Passengers are often drawn from peripheral bus routes and automobiles and channeled onto LRT, easing traffic in central cities. The service is considered socially and environmentally attractive because it runs on largely segregated rights of way that reduce the conflict and delay caused by buses, entails a less disruptive construction process than metros or highways, and, if well-integrated with other modes, is attractive and accommodating to riders. Reduced congestion, combined with reliance on vehicles that use electricity rather than directly burning fossil fuel, should also improve air quality. Not least important, LRT offers the possibility of low capital costs relative to metro projects and low operating costs relative to bus and some other transit options.

Each system seeks to maximize fare recovery and ridership. These goals are difficult to achieve simultaneously: low fares might attract new riders but can reduce revenue, and high fares can deter riders. More frequent service, convenient access, and careful routing are alternatives to pricing that may induce ridership and allow reasonable fares. Given the external benefits expected from LRT use, some costs may be covered through subsidies, depending on federal, state, or local policy.

All of the cities studied stated that LRT has met most expectations and achieved high levels of service and ridership. Though the data are sparse, cost and ridership information suggests how well LRT systems have performed. For example, after LRT was added to an exclusive bus system in Grenoble, vehicle kilometers and ridership grew while expenditures declined and cost recovery improved, suggesting that the new investment met major objectives. Bern-RBS reports that automobile traffic on the local Bernstrasse actually declined after LRT service was modernized. San Diego, Nantes, and Nieuwegein identify many of their LRT users as former drivers. Manchester is evaluating travel patterns and road congestion to assess whether expected LRT benefits have been achieved.

Project Selection Methodologies

Project selection methodologies, such as alternatives analysis, whether superficial or comprehensive, are fundamental to decisions about whether to build LRT systems. Planners and policy makers seek to build cost-effective transportation systems and therefore should evaluate a range of alternatives. In each country studied, some alternative analysis was required and performed, but approaches differed. Incomplete responses from participants in the study and data limitations preclude a detailed review of the various analyses. For example, it is not possible to determine which criteria were used to assess the relative values of project benefits and costs. And project economic lives and discount rates applied in analyses were not identified.

The data do suggest limited conclusions about the extent of alternatives analysis in the different countries. Analyses range from assessments of strict financial benefits and costs to assessments of broader benefits and costs related to urban design, air pollution, travel times, and other more complex factors. Population and transit use projections do not appear to be conducted routinely, and it is not clear that environmental impacts and the value of time are consistently calculated. Estimates of LRT's potential to divert travel from private to public transit are crucial, but sometimes they appeared to be done after instead of before the new systems were installed.

Analysis of benefits and costs is often overwhelmed by other issues. LRT systems are sometimes selected as the mode providing more capacity than buses at lower cost than heavy rail or metro systems rather than on the basis of more thorough analysis.

Britain requires extensive alternatives analysis before government funding, which provides an incentive for the development of cost-effective systems. Public projects must demonstrate that their future benefits will exceed costs. Fares must be designed to recover costs from beneficiaries, usually defined as riders. A demonstration of benefits to nonusers, however, may serve as the basis for grants from the British government to meet revenue shortfalls. This method encourages cost control and imposes discipline on selection. Consideration of many alternatives can lead to the discovery of options for meeting transportation needs not previously considered. Such a process rationalizes expectations, reduces waste, and promotes accountability.

Before LRT was explored in Manchester, three alternatives for linking commuter rail lines that terminate in the central city were rejected by the national government because costs exceeded benefits. Once LRT was proposed as a means of using and expanding the aging urban and suburban rail network, a 5-year alternatives analysis was conducted during which three options were compared: (a) closure of rail network and shift of emphasis to buses, (b) retention of network as commuter rail, and (c) conversion of network to LRT.

This process began with the assumption that no project was feasible that did not use the existing less expensive right of way. Ninety percent of the right of way ultimately used already existed. Although this was a strong effort, it should be noted that even here no route corridors or land use schemes appropriate for completely different applications were considered. Other cities in Britain, however, have conducted wider strategic studies before developing specific transportation schemes for implementation.

In the United States, new LRT and other urban rail systems are almost always built with financial assistance from the federal government. Applicants for federal capital contributions had to compare new LRT project proposals to alternatives that include transportation system management, defined as low-capital investments and strategies to improve use of existing facilities, and a no-build option, which continues the present investment level. Since 1980 transit agencies have been required to produce environmental impact statements for new projects. The federal government does not require comparisons to be based on a benefit-cost analysis. The initial phase of the San Diego Trolley was built with state and local funds, eliminating the federal alternatives analysis requirement. Metro and bus system improvements were discussed as alternatives to LRT, but analysis of alternatives appears to have been limited. The Intermodal Surface Transportation Act of 1991 requires analysis of the social and environmental costs and benefits of all major metropolitan transportation investments, including transit, highway, and other alternatives (*3*).

France undertook alternatives analyses before construction of LRT systems, but decision rules and the depth of evaluation are not clear. Expanded and improved bus systems appear to have been rejected because they were not able to meet needs cost-effectively using existing technology. Nantes and Grenoble sought to increase capacity, lower operating costs, reduce congestion and air pollution, and use existing rights of way. In Nantes, the assessed alternatives included shared use of existing rails, a trolleybus system, and a metro. In Grenoble the options besides LRT were a cable car system and a metro. Noncapacity changes to improve the management or pricing of existing facilities were not discussed. However, the LRT system in Grenoble costs less to operate and carries more riders than did the exclusive bus system. French grant incentives favoring dedicated right of way and infrastructure work may have encouraged the decision to build LRT.

When considering its Nieuwegein LRT, the Netherlands rejected metro as too expensive. A high-speed bus system was also considered, but was rejected despite a lower cost. According to a Dutch transportation official, it "was doubtful whether a fast bus system will generate the same ridership" because marketing studies indicated that passengers might not regard buses as favorably as LRT. It should be noted, however, that the Dutch decision-making process uses other factors in addition to cost and the effects of willingness to pay, with a stated policy "to provide fast and reliable services which are sufficiently attractive to divert trips by car to public transit, particularly in congested corridors."

The Hannover tram system was gradually upgraded to LRT standards, and new extensions were built without detailed analysis of alternatives. A metro was rejected because of high costs; busways and transportation system management were not seriously considered.

In general, alternatives analysis could be more thorough, with consideration of a broader range of options and market studies. Route designations could focus more on travel demands than on specific technologies. When planners are urged to define benefits narrowly (users only), they can underestimate the value of projects. The existing costs of subsidies to automobile users, through underpriced road use, are rarely added to the comparisons. These opposing pressures might balance one another, but they can distort assessments. To encourage informed, rational decisions, benefits and costs should be properly assessed and publicly provided goods should be correctly priced. Alternatives analysis alone may not guarantee selection of an "optimal" investment, because transit planners often work with limited information and in politicized environments, but careful project evaluation adds rigor to all transportation investment decisions.

Pricing and Fare Recovery Policy

LRT systems encourage efficiency by striving to recover expenses through fares rather than public subsidies. Although ridership is expected to respond to reasonable fares and appropriate service levels, expectations vary. The British government has required that Manchester's LRT system recover 100 percent of its operating costs through fares, though it is not clear what will happen if this mandate is not achieved. The purpose of the requirement is to allocate costs fairly and encourage the local executive, which holds an interest in the 75 percent private operating consortium, to set efficient service levels that are based on user willingness to pay. Manchester also hopes to recover capital expenses not covered by the initial government grant through operating profits. San Diego also seeks 100 percent recovery, which is unusually high for the United States. In Switzerland most local transit systems are expected to achieve a recovery rate of 65 percent. No fare recovery goals are indicated for France, but the involvement of private equity could provide additional incentives for efficient performance. Germany and the Netherlands note no fare recovery goals; the Netherlands uses national fare collection and does not report cost recovery for each system.

Light Rail System Ownership and Operating Funding Policy

LRT lines are generally publicly controlled. Only the San Diego has facilities jointly owned by public and private entities. On the extension to the central city's Bayside neighborhood, the operator and private investors built and jointly own LRT stations in two new mixed-use real estate developments, sharing costs and risks.

To encourage efficient service, three of the systems studied involve private interests in LRT operation. Rolling stock and infrastructure in Nantes and Grenoble are owned by the local transportation organizing authorities; operation is entrusted to mixed-economy companies with 35 percent of equity held privately. In Manchester the right to operate and maintain the system and set fares was given to the same private consortium that designed and built the system, all through a single design-build-operate contract. This arrangement was intended to induce efficient construction and reasonable service levels. The San Diego Trolley is publicly operated, but a private security force is used and a freight railroad company rents the right of way during hours when LRT is not in service. The Dutch, Swiss, and German LRT systems are entirely public. In all the countries except Britain, operating deficits are covered by subsidies from federal, regional or state, and local governments. In Britain, shortfalls are made up by the operating government or through service changes.

Capital Funding Policy

Capital funding requirements affect how LRT systems are designed and determine whether or not they are built. LRT investment funds come from combinations of national, state, and local sources in France (30 percent national), Germany (60 percent national), the Netherlands (100 percent national), and Switzerland (50 percent national). National and local governments demonstrate need for a system together, costs are estimated, and grants and tax levies are legislated. France allows transit organizing authorities building public transit on dedicated right of way with national subsidies to raise local capital through a dedicated tax on wages of up to 1.75 percent. Both Nantes and Grenoble used this device. Manchester sought public savings by funding capital with national (50 percent) and local grants but contracting design and construction to a 75 percent private company, further encouraging efficiency and shifting some costs to the private sector. The British government required such private involvement as a condition of providing the public capital grant, precluding an entirely public project. Manchester also expects to recover a portion of capital costs through its future stream of operating revenues.

San Diego's capital funding process was unusual. Most U.S. transit systems have obtained 75 percent of their capital funds from the federal government. In contrast, construction of the first San Diego Trolley line was financed entirely by a combination of state gas and state and county sales taxes, which allowed LRT planners to avoid complex federal grant conditions relating to material sources, cost projections, contracting, and other design features. San Diego County adopted a $^1/_6$-cent transportation sales tax to fund LRT extensions. The transportation sales tax was approved by referendum and ensures that costs are borne, in part, by residents of its service area. San Diego County also contributes to an annual LRT depreciation fund, depending on fare box revenues, that reflects equipment costs and provides resources for future capital purchases.

Trade-Offs Between Financial and Nonfinancial Objectives

Although cost recovery through fares is an objective of all case study operators, the relative importance of this objective varies by country. None of the system descriptions suggests that profitability is the major goal of LRT service, although British LRT operators are expected to recover operating costs and minimize losses. Transit providers have a range of nonfinancial objectives, and governments have varying willingness to pay for them. Like ridership goals, these broad objectives can conflict with financial objectives such as fare box cost recovery.

Improved accessibility and mobility are also goals of all systems studied. In the United States, the Americans with Disabilities Act requires transit operators to make their systems accessible to those with disabilities. LRT systems in Britain, France, Germany, and the Netherlands are being made accessible through the use of equipment such as high station platforms and low-floor vehicles. The Manchester LRT uses profiled platforms and vehicles with doors at different levels, which together provide level access at a number of points. The Bern-RBS LRT has recently purchased 11 accessible two-car twin units and plans to buy more. All of these broader objectives must be balanced carefully with financial goals.

All operators seek to draw travelers out of their automobiles into public transit to promote environmental policies, including conserving energy and reducing toxic emissions from automobile use. In the United States, national ambient air quality standards require metropolitan areas that are not in compliance to make efforts to reduce air pollution emissions; transit development is one means of doing so. Under the Clean Air Act Amendments of 1990, U.S. cities with excessive ground-level ozone and carbon monoxide levels must reduce these pollutants by specified target dates or risk losing federal transportation grants (*4*). An explicit goal of the San Diego Trolley is to decrease emissions by encouraging drivers to switch to transit, reducing both automobile trips and congestion. For the European countries, the primary environmental goal related to transit is to reduce energy consumption and the resultant carbon dioxide production.

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