V Encuentro UPR/MIT sobre el Tren Urbano 7-15 de enero de 1999	5th UPR/MIT Conference on Tren Urbano January 7 - 15, 1999

Lunes, 11 de enero de 1999 Coordinador	**Dr. Iván Baigés**	**Monday, January 11, 1999** Coordinator
Sistemas de Transporte en Europa Dr. John Pucher, Profesor de Planificación Urbana, Rutgers University	9:00 - 10:30	**Transit Systems in Europe** Dr. Johh Pucher, Professor of Urban Planning, Rutgers University
Receso	10:30-11:00	Break
Experiencias en España - Valencia Ing. Julio Gil Roda, Gerente de Proyectos Metro de Valencia	11:00-12:30	**Experiences in Spain - Valencia** Eng. Julio Gil Roda, Project Manager, Valencia Metro
Almuerzo	12:30-1:30	Lunch
2da sesión de posters *(ver itinerario aparte para los posters del día)*	1:30-2:30	**2nd Poster Session** *(see separate schedule for featured posters)*
Análisis de la Ciudad de San Juan Prof. Esteban Sennyey, Escuela de Arquitectura de la UPR	2:30-3:30	**Analysis of the City of San Juan** Prof. Esteban Sennyey, UPR School of Architecture
Receso	3:30-4:00	Break
Desarrollo urbano del área metropolitana de San Juan Dr. Aníbal Sepúlveda, Escuela Graduada de Planificación, UPR	4:00-5:00	**Urban Development of the San Juan Metropolitan Area** Dr. Aníbal Sepúlveda UPR Graduate School of Planning

Please remember to wear boots and long pants for the construction site tour tomorrow.

Making Transit Irresistible: Lessons from Europe

The decline of public transport is not inevitable. As discussed in this article public policies can produce large ridership growth even in countries where auto ownership levels are already high and growing, and where suburbanization is occurring at a rapid pace. The focus is on public transport in Western Germany, generally considered by Europeans to be the ideal model of transit coordination. Multimodal coordination successes in Germany encouraged similar efforts in Switzerland, Austria and the Netherlands. Could similar policy and organizational reforms eventually be adopted in the United States?

by John Pucher and Stefan Kurth

In most countries of Western Europe and North America, public transport ridership has been falling in recent years. Between 1980 and 1993, for example, ridership fell by 26% in Italy, 20% in Great Britain, and 18% in Norway (see Table 1). In the United States, ridership increased by 2% from 1980 to 1990 but then fell by 4% from 1990 to 1993. Similar to the American pattern but more pronounced, Canadian transit ridership grew by 16% from 1980 to 1990 but since then has declined by 11%. In most of the formerly socialist countries of Central Europe, the ridership declines since 1988 have been dramatic. After decades of growth, public transport use plummeted with the overthrow of Communism. In the five years between 1988 and 1993, ridership fell 56% in Eastern Germany, 33% in Poland, and 27% in Hungary.

In general, falling transit use has been due to factors largely outside the control of transit systems themselves. Auto ownership has skyrocketed throughout Europe and North America, confronting transit with increasingly stiff competition. Moreover, rapid suburbanization of both residence and employment has generated longer trips and much more dispersed travel patterns which make public transport less attractive for consumers to use and more expensive for systems to provide.

Increased auto ownership and suburbanization have made things more difficult for public transport everywhere. In some countries, however, transit's predicament has been made even worse through adverse public policies. In Great Britain, for example, the Conservative Government has sharply reduced subsidies to public transport since 1980, resulting in large fare increases and service cutbacks. Deregulation and

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TABLE 1: URBAN PUBLIC TRANSPORT RIDERSHIP IN EUROPE AND NORTH AMERICA

1980 to 1993 (indexed to base year 1980=100)

Country	*Year* 1980	1985	1990	1993
Austria	100	122	128	130
France	100	111	121	118
Germany (West)	100	88	90	99
Italy	100	99	77	74
Netherlands	100	93	105	120
Norway	100	89	85	85
Switzerland	100	107	120	122
Great Britain	100	95	87	80
Czechoslovakia	100	110	115	122
Germany (East)	100	103	82	46
Hungary	100	113	101	86
Poland	100	118	99	82
United States	100	100	102	97
Canada	100	109	116	105

Source: Ministries of transport and public transport associations in the various countries.

privatization of the transit industry in Great Britain have compounded the harmful effect of subsidy losses by breaking up metropolitan transit systems, dissolving regional planning bodies, and making regional coördination of fares, routes, and schedules virtually impossible. Similary, subsidy reductions and privatization in Norway have led to substantial ridership losses.

In contrast to the deliberate, largely ideological policy shifts in England and Norway, most of the formerly socialist countries of Central Europe have been forced to reduce transit subsidies due to extreme fiscal austerity at all government levels. That has resulted in large fare increases, service cutbacks, and serious infrastructure and vehicle deterioration. At the same time, auto availability and affordability have greatly increased. The combination has been devastating to public transport. Only in the Czech Republic (formerly Czechoslovakia) has public transport continued to flourish. Although fully democratic, the new government there resisted the uncontrolled increases in auto use permitted in other formerly socialist countries. Large transit subsidies have been maintained in spite of fiscal austerity, thus enabling service improvements and low fares. In Prague, the capital and largest city, a monthly transit pass costs only CKr 200 ($7), and an annual pass costs only CKr 1,700 ($57). Thus, transit is still a bargain in the Czech Republic. By comparison, the Czech government has imposed very high taxes on gasoline and has sharply restricted auto use and parking in central cities.

Also countering the general trend toward anti-transit policies, a few Western European countries have redoubled their efforts to improve public transport. Western Germany, Switzerland, Austria, and the Netherlands have expanded services and greatly increased their quality, and by doing so, have reversed public transport's decline. Fare structures, routes, and timetables have been coordinated for entire regions by integrating services on different lines and for different types of public transport. Moreover, extremely attractive monthly passes now offer regular transit users deep discounts off the usual fares. The impact of all these policies has been been impressive. Subsequent to their implementation, ridership grew by 22% in Switzerland, 30% in Austria, 25% in the Netherlands, and 15% in Western Germany, an astounding accomplishment during a period of transit ridership declines in most other countries.

The decline of public transport is not :vitable. As shown in this article, supportive public policies can produce large ridership growth even in countries here auto ownership levels are already high and growing, and where suburbanization is occuring at a rapid pace. Western Germany, Switzerland, Austria, and the Netherlands have per-capita incomes among the highest in the world; yet the quality of public transport there has improved to such an extent that even the affluent choose public transport over the auto in many circumstances. In light of the deterioration of transit services in so many other countries, it is important to examine the key to success in those countries where public transport has flourished.

This article focusses on public transport in Western Germany because European transport experts generally consider it the ideal model of transit coordination.[1] Indeed, the successes of regional, multi-modal coordination in Germany encouraged similar efforts in itzerland, Austria, and the Netherlands. Although the pioneering German reforms in transit organizational structure have been the subject of extensive academic analysis in Europe, they have been largely ignored in North America. The United States, in particular, could benefit greatly from the many lessons European transit successes have to offer, as the lack of coordination is one of biggest problems of American transit.

Urban Transport Trends in Western Germany

As in other European countries, long-term socioeconomic and travel trends since World War II, and especially since 1960, have been quite unfavorable for urban public transport in Germany. Most significantly, steady growth in per capita income led to large increases in auto ownership, from only 80 autos per 1,000 population in 1960 to 503 autos per 1,000 population in 1993, one of the highest auto ownership rates in the world (see Table 2). Correspondingly, auto use skyrocketed: from 73 billion veh.km. in 1960 to 425 billion in 1993. Throughout the post-war period, large increases in auto use far outpaced any growth in transit use. Consequently, transit's share of total travel has fallen throughout the past four decades, from 65% of motorized travel in 1950 to only 16% in 1993.

Transit ridership grew by 6% from 1960 to 1970, and by 9% from 1970 to 1980. After 1980, however, ridership began to decline, falling by 15% between 1980 and 1988. Only since 1988 has German transit rebounded, achieving a 13% increase in ridership by 1993, in spite of record high levels of unemployment during the recent recession, which reduced the number of worktrips, the main source of transit demand.

Clearly, the most important source of transit's problems has been growing

TABLE 2: WESTERN GERMAN AUTO OWNERSHIP & USE AND PUBLIC TRANSPORT RIDERSHIP

	1950	*1960*	*1970*	*1980*	*1990*	*1993*
Autos per 1,000 population	12	80	230	377	482	503
Auto km traveled (a)	N.A.	73.2	201.1	297.4	401.6	425.3
Passenger km by auto (a)	31.1	155.2	352.3	472.5	596.3	612.6
(% of total motorized travel)	35.5	64.9	78.5	80.4	84.4	84.1
Passenger km by public transport (a)	56.5	83.8	96.5	115.1	109.8	116.2
(% of total motorized travel)	64.5	35.1	21.5	19.6	15.6	15.9
Urban public transport trips (b)	5,144	6,603	7,015	7,652	6,873	7,312
Urban public transport trips per capita	108	118	116	124	108	112

Notes: (a) billions of kilometers; (b) millions of trips.

Source: German Ministry of Transport, *Verkehr in Zahlen*, annual, 1982 to 1993.

auto ownership, spurred on by increased incomes and suburbanization. Demographic trends, however, have also worked against transit. The dramatic aging of the German population (due to extremely low birth rates) has steadily reduced the relative importance of school and work trips over the past two decades, as an ever higher percentage of the population is retired. Because transit use in Germany has traditionally been highest for such trips, their reduced importance has exerted a long-term drag on transit ridership overall.

Some public policies have also hurt transit. For example, Germany undertook Europe's most extensive program of highway construction, focussed on the highly-touted autobahns as its centerpiece. With a total length of 11,080 km., the German autobahn network is second in size only the the U.S. Interstate Highway System. Moreover, Germany's autobahns are the only superhighways in the world without a speed limit. Especially during the 1960s and 1970s, many German cities were increasingly adapted to the automobile through a range of policies catering to auto use. Thus, public policies exacerbated whatever problems transit systems would have experienced at any rate.

Public transport systems had virtually no control over such external factors which made auto use more and more attractive. To some extent, however, they were the source of their own demise. Until the 1970s, most West German urban areas suffered from highly fragmented, uncoordinated transit services, supplied by a panoply of competing private firms, municipal transit systems, and the German Federal Railways. There was almost no integration of fares, routes, or timetables within the same metropolitan region, making it confusing, inconvenient, and uneconomical to use transit.

The Movement Toward Transit Coordination

It took almost two decades to fully coordinate Germany's transit services through the establishment of various forms of cooperation. Transit coordination spread gradually to more and more cities, and the intensity and scope of coordination increased over time. The largest urban areas were the first to integrate their fares and services. Then came the smaller cities. And by now, even rural transit services are coordinated both within and between regions. The focus here, however, is on the largest cities, since most transit ridership is, in fact, concentrated there.

The coordination movement in Germany began in Hamburg in the mid-1960s. Prior to then, services were provided by a hodgepodge of diverse public and private firms. Routes, station stops, timetables, and fares were woefully uncoordinated; transfers among lines and modes were cumbersome, time-consuming, and expensive. Getting from one end of Hamburg to the other could take up to seven different tickets . Together with increased auto ownership, suburbanization, and unfavorable demographic trends, the low quality of transit service was partly responsible for the 16% decline in total transit ridership in Hamburg from 1956 to 1965.

Recognizing the predicament of transit, government officials from three states, 140 cities and towns, and seven transit firms in the Hamburg region banded together to form the Hamburg Verkehrsverbund (HVV). It is a special public authority that fully coordinates transit services in the region while preserving the individual identities of the component firms, which are still responsible for actually supplying transit services. This cooperative arrangement was the first of its kind in the world. Although various firms provide transit services to the 2.5 million residents of the Hamburg region, the Verkehrsverbund ensures that the transit rider needs only one ticket and one integrated timetable for the entire trip from origin to destination. Bus and streetcar stops, metro (subway) and suburban railroad stations, and ferry docks are carefully coordinated to ensure easy transfers between modes and between lines. Transfers are free, and timetables are designed to minimize transfer times.

The HVV Verkehrsverbund is directed by representatives of the state and local governments in the Hamburg region and the component transit firms. Above all, HVV is responsible for planning and marketing transit services throughout the Hamburg area. It collects and analyzes operational and financial data; designs the route network; determines the frequency of service and exact timetable for each line; sets the fare structure; distributes passenger revenues and subsidies among the member transit firms; and performs all advertising and public relations functions.

The member firms are responsible for providing the services assigned to them. They control the specific details of how the services are provided: the types of vehicles, personnel, work schedules, and maintenance. Moreover, they have an incentive to operate efficiently, since the subsidies they receive from the Verkehrsverbund are based on route km and vehicle km of service provided, not according to the operating deficit.

It has been nearly three decades since the founding of the Hamburg Verkehrsverbund (HVV), and in that time, its improved services and fare structure have generated a 14% increase in ridership. That may not seem very impressive, but it represents an important turn-around in Hamburg's transit ridership and came during a period of enormous growth in auto ownership and use and rapid suburbanization. Moreover, population stagnated in the Hamburg region and actually declined in the central city. Just preventing further ridership losses would have been a considerable accomplishment; ridership growth was all the more impressive.

The success in Hamburg led to the spread of the Verkehrsverbund transit coordination model to Hannover (1970), Munich (1972), Frankfurt (1974), Stuttgart (1978), the Rhein-Ruhr region (1980), Wuerzburg (1982), Berlin (1984), Regensburg (1984), Rhein-Sieg (1987), and Nuremberg (1987). In each case, the Verbund greatly simplified transit use for the rider, offering one integrated route network, one consolidated timetable, and one unified fare structure and ticketing system for the entire metropolitan region. As shown in Table 3, all Verkehrsverbund systems experienced substantial ridership growth over the long-run, although some systems temporarily lost riders during the early 1980s.

Even those German cities without the full coordination of Hamburg's Verkehrsverbund system have similar arrangements to plan, market, and coordinate services. The Verkehrsgemeinschaft, for example, is less a union than a loose confederation of transit firms within the same region. As with the

TABLE 3: RIDERSHIP TRENDS FOR THE LARGEST METROPOLITAN TRANSIT AUTHORITIES (VERKEHRSVERBUND) IN WESTERN GERMANY, 1975 TO 1993

Metropolitan Area (date of transit regionalization)	*Ridership by Year (in millions)*				
	1975	*1980*	*1985*	*1990*	*1993*
Hamburg (1967)	445	436	417	436	470
Hannover (1970)	141	158	158	163	174
Munich (1972)	395	451	485	507	538
Frankfurt (1974)		212	207	223	244
Stuttgart (1978)	--	182	190	208	230
Rhein-Ruhr (1980)	--	901	817	788	1064
Berlin (1984)(a)	--	572	519	705	737
Rhein-Sieg (1987)	--	--	--	328	356
Total for regional transit systems (b)	981	2912	2793	3358	3813

Note: (a) Excludes East Berlin, although by 1990, the transit services in East Berlin had, in fact, been integrated into the Greater Berlin transit system. The adjustment is for comparability with other figures in the table. (b) Excludes Verbund systems in Nuremberg, Trier, Ulm, Kassel, Wuerzberg, and Regensburg, and thus understates total for Verbund systems.

Source: German Ministry of Transport (1994), *Verkehr in Zahlen*, Bonn: Bundesverkehrsministerium.

Verkehrsverbund, fares, routes, and timetables are coordinated, but the member firms retain greater independence than in the Verkehrsverbund, and there is considerably less financial integration in terms of revenue and subsidy distribution. Virtually every German city has either a Verkehrsverbund or a Verkehrsgemeinschaft (German Ministry of Transport 1988; Pucher and Wiechers 1985).

One of the most interesting Verkehrsverbund systems in Germany is also the largest, the Verkehrsverbund Rhein-Ruhr (VRR), serving the multi-centered conurbation that encompasses Essen, Dortmund, Duisburg, Bochum, Dusseldorf, and a host of other cities and towns clustered together near the confluence of the Rhein and Ruhr rivers (Zemlin and Wichmann 1993; Zoepel 1990; Verkehrsverbund Rhein-Ruhr 33 and 1994). With a total population of 7.5 million and an area of 5,026 q.km., the region is three times larger than Hamburg and twice as large as Berlin. Moreover, it poses extraordinarily difficult problems of coordination due to its geographic extent and its inclusion of 24 completely independent cities, 22 transit firms, 11 different types of transit, and 717 transit routes. The large area of the Rhein-Ruhr region leads to longer trips than in other German cities. Its polycentric structure generates more dispersed travel patterns, requiring more transfers than in other German cities, especially between longer-distance rail modes and shorter-distance bus and streetcar modes. Finally, auto ownership levels are higher in the Rhein-Ruhr area than in most other German cities, further increasing the competition for public transport. All of these factors combined presented the Rhein-Ruhr Verkehrsverbund with a formidable challenge, far more difficult than else-re in Germany.

The spatial and temporal coordination of transit services in the Rhein-Ruhr region followed the Hamburg model. For the reasons cited above, the coordination was more difficult, but the result was virtually the same. Passengers need to deal with only one integrated timetable, one fare structure, and one route network. Transfers among different routes and modes are facilitated by the co-location of bus and streetcar stops, metro (subway) and suburban rail stations, and park-and-ride lots. Timetables are synchronized to minimize transfer time, and key connections are often guaranteed through a policy of transit vehicles waiting at transfer points up to a specified time to meet delayed runs. Further enhancing ease of use, the frequency of transit services is at least once an hour, and runs are usually scheduled so that they depart a specific bus stop or rail station at the same minute(s) every hour during the day, thus making the schedule easier to remember. The exact schedule is posted at every stop throughout the system at any rate.

Other Improvements in Transit Service Supply

Although the total supply (veh.km.) of transit service increased by only 8% from 1980 to 1993, vehicle modernization, station improvements, and other infrastructure investments combined with service coordination to vastly improve the overall quality of transit services in the Rhein-Ruhr region. The system of light rail lines, in particular, has been fully modernized and expanded to a network of 182 km., mostly with exclusive rights of way. The underground metro system in Dusseldorf has also been extended. The many commuter rail lines that criss-cross the region have been upgraded and better integrated with the other types of transit.

A number of special transit services have been added to fill market niches previously ignored. For example, 66 special night routes have been established to serve the late-night crowd. And the Rhein-Ruhr Verkehrsverbund now offers dial-a-ride taxi services for customers in low-density parts of its service area. The fare charged is higher than for regularly-scheduled services--ranging from DM 3.20 ($2.00) to DM 5.10 ($3.20) according to distance--but far lower than normal taxi fares. Such paratransit services for low-density areas at the fringes of the region help feed the regular route network.

Traffic management measures have also done much to improve the quality of transit services. Separate bus lanes have been installed on 66 key arterials throughout the Rhein-Ruhr region, and priority is given to bus and streetcars at intersections shared with auto traffic, so that traffic lights automatically turn green for oncoming transit vehicles. Such measure have significantly increased the overall speed of buses and streetcars and improved their on-time performance. Indeed, 90% of streetcar runs are now exactly on-time throughout their routes (Verkehrsverbund Rhein-Ruhr 1994).

German Innovations in Transit Fare Structure

The quality improvements derived from full regional coordination of transit obviously enhanced the attractiveness of transit use. Fare policies also encouraged ridership growth, especially since the late 1980s. Of course, even from their beginnings, Germany's transit systems offered discount monthly passes for regular users. In the late 1980s, however, monthly passes increasingly took on the new designation of "environmental tickets" (Umweltkarten), thus emphasizing the environmental benefits of transit use. Discounts off the regular ticket price were greatly increased for the new environmental tickets. The combined attraction of lower fares and a clear conscience succeeded at increasing transit ridership in most German cities. Indeed, between 1988 and 1993, total transit ridership in Western Germany 13 rose by ~~4~~% (German Ministry of Transport 1994). The exact fare structure varies from one city to another, but the basic variety of offerings is similar. We examine the specific fare structure in the Rhein-Ruhr Verkehrsverbund to convey how economical transit use has become in Germany.

By far the most widely used forms of fare payment in the Rhein-Ruhr Verkehrsverbund are now the various monthly, semester, and annual transit passes, which together account for 72% of all trips. The basic single-trip ticket is used by only 8% of passengers, while the multi-trip strip tickets are used by 13% of passengers. The remaining 6% of passengers use either daily or weekly passes (Verkehrsverbund Rhein-Ruhr 1994). The very deep discounts offered by the longer-term passes explain their popularity.

The standard monthly ticket, called "Ticket 2000", costs only 65 DM (German Marks), or about $40, for an entire month of unlimited travel within the first zone. For 130 DM (about $81), the monthly pass permits unlimited travel across all three zones, and thus throughout the entire region. The passes are good on all transit modes, including suburban rail. If the monthly passes are purchased for the entire year, an additional 20% discount is offered, leading to even more attractive prices of 54 DM ($34) for the inner zone and 109 DM ($68) for the entire region. In order for the regular monthly pass (Ticket 2000) o save money for the user, it requires only 20 one-way trips per month for the first fare zone or 11 one-way trips per month for the full regional ticket covering all zones. Since most transit users make that many one-way trips in one or two weeks, three-fourths of them, in fact, buy the monthly pass. Another advantage of the Ticket 2000 is that it is transferable to anyone, so the ticket can be shared by several persons taking trips at different times. Moreover, at off-peak times (evenings and all weekend), a single ticket suffices to transport the holder, up to three children, a bicycle, and a dog at no additional cost.

As if the Ticket 2000 were not attractive enough, yet further discounts are available. Students, for example, automatically receive semester tickets as part of their university fees. For 85 DM ($53) per semester, students can enjoy mited transit travel within the entire Rhein-Ruhr region. The transit fee is harged by the universities whether the udent actually uses transit or not. At a monthly rate of about 20 DM ($13) for unlimited transit use, that is a bargain. The result has been a tripling of transit ridership among university students.

Yet another discount monthly fare is available to employees of firms with at least 100 employees. In return for payments negotiated separately between the Verkehrsverbund and each individual firm, employees can purchase the Ticket 2000 for less than half the already low price of the regular monthly pass. Thus, for only 24 DM ($15), the employee enjoys unlimited transit travel within the first fare zone, and for 50 DM ($31), the employee can travel within the entire Rhein-Ruhr region. As with the regular Ticket 2000, the monthly pass can be used during off-peak periods for the holder's children, dog, and bicycle at no extra charge, but unlike the regular t t, it is not transferable to other adult passengers. By facilitating additional fare subsidies from the employer, the "Firmen-Ticket" (company ticket) further reduces the price of transit use for the worktrip.

A final fare innovation is worth mentioning: the so-called "Kombi-Ticket". The Verkehrsverbund has negotiated with organizers of most conferences, conventions, sports events, concerts, and amusement parks to include a transit ticket as part of the regular admission price. Since the marginal or effective transit fare to the user thus becomes zero (no additional charge whether transit is actually used or not), there is a strong incentive for the crowds at such mass events to use transit to get there instead of driving.

In addition to this range of tempting fares, the Verkehrsverbund also offers special weekly passes, daily passes, and strip tickets to fill the gap between the rather unattractive single-trip tickets (costing between 2.70 DM and 10.00 DM, depending on zone) and the extremely attractive monthly and semester passes. The goal is to offer such a wide range of fares that virtually every potential rider will be able to find at least one fare variant that is cheaper than auto travel.

Marketing Transit in Germany

The vast improvements made by the Rhein-Ruhr Verkehrsverbund in its services and fare structure represent, in themselves, an essential aspect of the marketing strategy to attract more transit riders (Kolz and Bermann 1989; Zemelin and Wichmann 1993). Those improvements were accompanied by a massive campaign to advertise the more attractive services and fares, to convince non-users to try out transit, and to deepen the customer loyalty of current users.

Since introducing the Ticket 2000 in

1990, the Verkehrsverbund has organized an annual transit carnival to make a major promotional tour of the entire region, offering not only entertainment but also free information about transit. Descriptive brochures, timetables, ticket information, and colorful posters are distributed in a festive atmosphere. There is even a transit sweepstakes with various free gifts as prizes, including transit passes. Moreover, joint events are held with the country's major environmental groups to highlight the wider benefits of transit use. The transit carnival is followed up by more regular, less spectacular information tours of the region, with mobile vans distributing information, answering questions, and selling tickets. Each year, over three million informational brochures have been distributed through the mail. Finally, the Verkehrsverbund has established a network of permanent information and ticket booths throughout the region and has improved its system for handling telephone inquiries.

The Verkehrsverbund also employs the more traditional advertising techniques. Transit ads have appeared on over 7,000 large billboards in the region, and on an even larger number of posters located in a variety of public buildings, public spaces, and of course, in and on transit vehicles themselves. Moreover, transit ads are regularly placed in all the region's newspapers and radio stations.

In a special effort to attract young riders, the Verkehrsverbund makes special presentations in the region's schools. As an extra inducement, the system offers new monthly pass holders introductory gifts such as t-shirts and rucksacks with the transit system logo, free membership in the German youth hostel association, and travel and entertainment guides showing how transit can be used to reach desirable destinations.

The Costs of Making Transit Irresistible

There has been only one major problem with all the efforts aimed at making transit in the Rhein-Ruhr region irresistible: its cost. Improved services and reduced fares have undeniably benefitted users, but they have also required large increases in government subsidies. From 1980 to 1993, the total operating subsidy rose from 444 million DM to 1,144 million DM, a 158% increase. Even adjusted for inflation, that represents a 67% increase in the real subsidy. Increased ridership did not generate revenues sufficient to offset the reductions in fares and the costs of improving services.

The experience in the Rhein-Ruhr region has been typical of other cities in Western Germany, the Netherlands, Austria, and Switzerland. In virtually every case, large subsidy increases have been necessary to finance service improvements and fare reductions (German Ministry of Transport 1988; Netherlands Ministry of Transport 1994; Andersen 1993; Girnau 1994). The percentage increases in ridership have been substantial, but smaller than the percentage reduction in fares. Thus, total fare revenues have fallen. Moreover, expenditures have increased considerably, not only for service improvements, but also for capacity expansion to handle the higher passenger volumes.

Increased subsidy requirements are virtually the only disadvantage of the intensified pro-transit policies pursued by Germany, the Netherlands, Austria, and Switzerland since about 1980. Not only has transit ridership increased, but the growth in auto use has moderated, and in some cities, the modal-split share of the auto has even fallen. In combination with other policie—such as traffic calming, pedestrian zones, bikeway networks, parking restrictions, and traffic priority for transit—improved transit services have been shown to reduce noise, air pollution, accidents, and roadway congestion in central cities.

The Crucial Policy Choice

From a political perspective, increasing subsidies to transit will be very difficult in any country. In Germany, Switzerland, the Netherlands, and Austria, it has only been possible because of severe environmental problems and widespread support among voters and politicians for undertaking measures to curb auto use, including large increases in gasoline taxes and parking fees. Moreover, the increased taxes on auto ownership and use have provided the revenues necessary to finance growing transit subsidies. By making auto use more expensive, they have a doubly beneficial act on transit ridership.

Most other countries have, in fact, reduced support for transit, as dis-ussed at the outset of this article. The long-run consequences of reducing transit subsidies are clear: falling transit ridership, rising auto use, increased roadway congestion and air pollution, and fewer travel options for everyone. Unfortunately, short-term political considerations are now prevailing in most countries. The strong movement toward tax reductions, subsidy cutbacks, and diminished government involvement in virtually all fields is affecting transit as well. Thus, it seems certain that the new Republican majorities in the U.S. Senate and House of Representatives will legislate sharp reductions in transit subsidies, appropriating only a fraction of the funding authorized by the 1991 federal transit act (ISTEA). Such cutbacks will probably reap substantial political benefits in the short-run, but the social and environmental harm done over the long-run may be irreparable.

The range of experience in various European countries highlights the policy choice to be made. Unquestionably, service improvements and fare discounts can greatly increase the attractiveness of transit, thus producing large ridership increases, but only at the cost of large subsidies. Subsidy cutbacks and reduced government involvement (through privatization and deregulation) offer short-run solutions to fiscal problems of the public sector, but only at the cost of increased congestion, pollution, noise, and traffic accidents. The alternatives are clear, but variations in underlying conditions and political constellations obviously lead to different choices in different countries. Transit can indeed be made irresistible, but only through concerted public policy.

Acknowledgements

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Endnotes

1. Eastern Germany is omitted from this analysis. Transit services were provided with completely different organizational structures in socialist East Germany, with 100% financing and control through the central government. Nevertheless, the West German reforms in transit service delivery and pricing have been spreading to Eastern Germany since reunification in 1990.

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Verkehrsverbund: the success of regional public transport in Germany, Austria and Switzerland

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The Verkehrsverbund system of public transport organization offers a practical solution to the problem of providing integrated regional public transport service for the increasingly suburbanized metropolitan areas of Europe and North America. By carefully coordinating fares and services for all routes, all types of public transport, and all parts of the metropolitan region, Verkehrsverbund systems in Germany, Austria, and Switzerland have greatly improved the quality of the public transport alternative to the automobile. Five Verbund systems were chosen for detailed analysis: Hamburg, Munich, the Rhein-Ruhr region, Vienna and Zurich. This article documents the success of each Verbund in attracting more public transport riders and, in most cases, increasing or at least stabilizing public transport's share of modal split. It also analyzes the reasons for the success of the Verkehrsverbund, including service expansion, improvement in service quality, more attractive fares, and extensive marketing campaigns. The five case study systems offer lessons for other public transport systems facing similar challenges of dealing with increasing auto ownership and suburbanization. The article concludes with an analysis of the most challenging problem of all: public transport finance. As shown dramatically by the five case studies, the service improvements and fare structures needed for truly effective regional public transport require substantial government subsidy. Fiscal austerity at every government level is leading to subsidy cutbacks in most countries of Europe and North America. The five case study systems examined in this article provide lessons on how to deal most effectively with limited subsidy funds in order to minimize service deterioration, fare increases and ridership losses.

Keywords: Verkehrsverbund, multimodal integration, urban public transport, regional coordination, public transport associations, regional transit systems

Introduction

Throughout the world, public transport is experiencing problems due to increasing auto ownership and the suburbanization of both residences and firms. Growth in auto ownership obviously creates greater competition for public transport. The continuing decentralization of metropolitan areas may, however, represent an even more serious long-term problem for public transport. Historically, most public transport has been focused in central areas of cities, where high population and employment densities enable frequent services, many routes and high occupancy rates. As metropolitan development spreads out into the suburbs, public transport faces a crucial challenge to extend its services to outlying areas and to integrate suburban services with city centre services to produce a truly coordinated, regional public transport system.

As argued in this article, the Verkehrsverbund system of public transport organization appears to be an ideal solution to the problem of providing an integrated

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regional public transport service for the increasingly suburbanized metropolitan areas of Europe and North America.

We first briefly review the nature of the Verkehrsverbund organization of public transport, its origin in Hamburg in 1967, and its subsequent adoption by many large cities in Germany, Austria and Switzerland. Then we examine in detail five of the most successful and most important Verbund systems: in Hamburg (Hamburger Verkehrsverbund), Munich (Muenchner Tarif- und Verkehrsverbund), the clustering of cities around Dusseldorf, Essen, Duisburg and Dortmund (Verkehrsverbund Rhein-Ruhr), Vienna (Verkehrsverbund Ostregion), and Zurich (Zuericher Verkehrsverbund). We document the success of each Verbund in attracting more public transport passengers and, in most cases, increasing or at least stabilizing public transport's share of the modal split.

Perhaps even more importantly, we analyze the reasons for the success of the Verkehrsverbund, including service expansion, improvement in service quality (especially better coordination), more attractive fares, and extensive marketing campaigns. We emphasize the lessons our five case study systems have to offer for other public transport systems facing similar challenges. We conclude the article with perhaps the most challenging problem of all: public transport finance. As our case studies show, the service improvements and attractive fare structures needed for truly effective regional public transport require substantial government subsidy. Unfortunately, fiscal austerity at every government level is leading to inadequate funding for public transport almost everywhere, including subsidy cutbacks in many countries. The five case study systems examined here offer lessons on how to deal most effectively with limited subsidy funds in order to minimize service deterioration, fare increases, and passenger losses.

Origins of the Verkehrsverbund

The movement toward regional coordination of public transport services began in Hamburg in the mid-1960s. Prior to that time, public transport services in Hamburg were provided by a hodgepodge of diverse public and private firms. Routes, station stops, timetables and fares were woefully uncoordinated; transfers between lines and modes were cumbersome, time-consuming and expensive. Getting from one end of Hamburg to the other could take up to seven different tickets (Doerel *et al.*, 1993). Together with increased auto ownership, suburbanization, and unfavorable demographic trends, the low quality of public transport service was partly responsible for the 16% decline in total ridership in Hamburg from 1956 to 1965.

Recognizing the predicament of public transport, government officials from three states (Laender), 140 cities and towns, and seven public transport firms in the Hamburg region banded together to form the Hamburger Verkehrsverbund (HVV) in 1967. The HVV is a special public authority that fully coordinates public transport services in the region while preserving the individual identities of the component firms, which are still responsible for actually supplying the services. This cooperative arrangement was the first of its kind in the world (Doerel *et al.*, 1993). Although various firms provide public transport services to the 2.6 million residents of the Hamburg region, the Verkehrsverbund ensures that the customer needs only one ticket and one integrated timetable for the entire trip from origin to destination. Bus stops, U-Bahn (metro) stations, S-Bahn (suburban railroad) stations, and ferry docks are carefully coordinated to ensure easy transfers between modes and between lines. Transfers are free, and timetables are designed to minimize transfer times.

The HVV is directed by representatives of the state (Laender) and local governments in the Hamburg region and the component public transport firms. Above all, HVV is responsible for planning and marketing public transport services throughout the Hamburg area. It collects and analyzes operational and financial data; designs the route network; determines the frequency of service and exact timetable for each line; sets the fare structure; distributes passenger revenues and subsidies among the member firms; and performs all advertising and public relations functions.

The member firms are responsible for providing the services assigned to them. They control the specific details of how the services are provided: the types of vehicles, personnel, work schedules and maintenance. Moreover, they have an incentive to operate efficiently, since the subsidies they receive from the Verkehrsverbund are based on route-km and vehicle-km of service provided, not on the operating deficit.

It has been nearly three decades since the founding of the Hamburger Verkehrsverbund, and in that time, its improved services and fare structure have generated a 14% increase in passenger usage (Doerel *et al.*, 1993). That may not seem very impressive, but it represents an important turnaround in Hamburg's public transport ridership and came during a period of enormous growth in auto ownership and use and of rapid suburbanization. Moreover, population stagnated in the Hamburg region and actually declined in the central city. Just preventing further ridership losses would have been a considerable accomplishment; ridership growth was all the more impressive.

The success in Hamburg led to the spread of the Verkehrsverbund model of public transport coordination to Hannover (1970), Munich (1972), Frankfurt (1974), Stuttgart (1978), the Rhein-Ruhr region (1980), Wuerzburg (1982), Berlin (1984), Regensburg (1984), Rhein-Sieg (1987), Nuremberg (1987) and Kassel (1988). In each case, the Verbund greatly simplified public transport use for the rider, offering one integrated route network, one consolidated timetable, and one unified fare structure and ticketing system for the entire metropolitan region (German Ministry of Transport, 1988; Pucher and Wiechers, 1985).

Table 1 Overall descriptive statistics for five regional public transport systems (Verkehrsverbuende)

Metropolitan region	Year Verbund founded	Verbund service area (sq km)	Verbund area population (000)	Population density (per sq km)	Route km service (1993)	Annual passengers in 1993 (millions)
Hamburg	1967	3000	2570	857	3517	470
Munich	1972	4750	2410	507	4837	538
Rhein-Ruhr	1980	5025	7375	1468	11808	1064
Vienna	1985	6423	2179	339	7813	724
Zurich	1990	1728	1200	694	2700	644

Sources: Individual public transport systems (Verkehrsverbuende) in each metropolitan area; and federal transport ministries in Germany, Austria and Switzerland.

The German success with the Verkehrsverbund led to its spread to Austria and Switzerland as well. Indeed, virtually all Austrian cities are now served by some sort of regional Verkehrsverbund system, often including the entire state (Bundesland). The largest Austrian cities, most notably Vienna, Graz, Linz, Salzburg and Innsbruck, have Verkehrsverbuende focused on their own metropolitan regions, whereas smaller cities and rural areas are generally served by state-wide (i.e. provincial) Verbund systems (Austrian Ministry of Transport, 1995). Most recently, the Verkehrsverbund movement has established a foothold in Switzerland, with the largest and most successful Swiss Verbund in Zurich.

The Austrian and Swiss Verbuende are not exactly the same as those in Germany. They have somewhat different procedures for revenue and cost accounting, and thus for distributing subsidy funds among member firms. Moreover, the relative importance of different levels of government — federal, state, and local — varies somewhat from country to country, especially in subsidy finance. Nevertheless, the basic structure of the Verbund system is the same in all three countries. And most importantly, the result is the same for the customer: completely coordinated and integrated services and fare structures.

Five case study Verbund systems for detailed analysis

Table 1 lists the five Verbund systems we have chosen for detailed, case study analysis: Hamburg, Munich, Rhein-Ruhr, Vienna and Zurich. They are the largest public transport systems in Germany, Austria and Switzerland.[1] All five have been quite successful at increasing ridership during a period of sharply rising auto ownership and use. Moreover, they have been at the forefront of innovations in public transport technology, service coordination and marketing. By examining these five Verbund systems in detail, we seek to determine the reasons for their success, and thus to identify strategies for other public transport systems throughout the world to improve their services and attract more riders.

As shown in Table 1, Hamburg has the oldest but smallest of the five Verbund systems, serving 470 million passenger trips per year. The Verkehrsverbund Rhein-Ruhr is by far the largest Verbund, carrying over a billion passengers per year in the conurbation around Dusseldorf, Duisburg, Essen, Bochum and Dortmund. It also has the most extensive route network, roughly twice as large as the other four systems. The Verkehrsverbund Rhein-Ruhr is particularly interesting because it serves such a multicentered area, without the single regional focus found in Hamburg, Munich, Vienna and Zurich. Thus, travel within the Rhein-Ruhr area is not oriented toward any one dominant core, but toward many different cities of comparable importance. Moreover, there is much travel from one city center to another within the region (for example, from Dusseldorf to Dortmund, or from Essen to Duisburg), not simply within cities or from suburbs to cities.

In spite of its distinctly polycentric structure, the service area of the Verkehrsverbund Rhein-Ruhr has by far the highest population density of the five case study systems: twice as dense as Zurich's service area, three times as dense as Munich's, and four times as dense as Vienna's. The Zurich, Munich and Vienna Verbund regions include extensive forests, farms, nature preserves and many small towns and villages, which are essentially rural in character. The Rhein-Ruhr Verbund covers a large area as well, but it consists mainly of high-density cities clustered around this industrial core of Germany.

The public transport systems in the five case studies will be discussed in detail later, but we note here that each is based upon a rail network as its backbone. In virtually every Verbund, the S-Bahn (suburban rail) and U-Bahn (metro) work together to provide almost all of the long-distance public transport services in each region, and an increasing proportion of intermediate-distance travel in high-volume corridors. The S-Bahn systems are the crucial links between the outlying

[1] Recently, Berlin has also established a Verkehrsverbund, but it is less well-integrated than the five systems we examine here. After five decades of division into East and West Berlin with two completely separate transport networks, it has proved difficult to integrate the two halves into a unified system. Currently, East Berliners still pay different public transport fares than West Berliners, even for the same types of services and the same types of tickets. Finally, the very brief history of the Berlin Verkehrsverbund makes any sort of trend analysis of operating and financial data impossible.

portions of the Verbund regions and their central cores (and for Rhein-Ruhr, between the different city centers as well). The U-Bahn systems are primarily designed to provide high-speed travel within the urban core of each region. Diesel bus, trolley bus, minibus and van services are designed as feeder and distribution routes to bring passengers to and from the rail network.

Tramways play an intermediate role; their function varies according to whether they enjoy exclusive right of way. In Dusseldorf, Dortmund, Essen and Bochum (Rhein-Ruhr), tramways have been upgraded to modern light rail standards, largely underground, and on separate rights of way even on surface routes. In Vienna and Munich, the emphasis has been on replacing tramway systems with fully grade-separated U-Bahn and S-Bahn systems. The tramways in Zurich still carry more than half of all passenger trips, and proposals to replace them with a U-Bahn system were rejected by voters in a referendum. Even in Zurich, however, trams serve primarily short- and intermediate-distance trips. Suburban rail (S-Bahn) has grown much more important in recent years and, as elsewhere, is already the key unifying link between the various parts of the Zurich region.

Success of regional public transport

All five of the Verbund systems chosen for detailed analysis in this article have been extraordinarily successful at increasing ridership since the time they were founded (see Table 2). The total number of passenger trips grew by 16% in Hamburg, 50% in Munich, 18% in Rhein-Ruhr, 63% in Vienna, and 34% in Zurich. That accomplishment is all the more impressive when compared to sharp declines in public transport ridership during the same period in Great Britain, Italy, Norway, Denmark, Poland and Hungary. Moreover, in most of the five case study cities, public transport ridership had been declining or stagnating before the establishment of the Verbund systems. Thus, the success of the turnaround can be directly attributed to the Verbund.

Table 2 Total annual passenger trips for five regional public transport systems (Verkehrsverbund) (millions of trips per year)

Metropolitan region	1965	1970	1975	1980	1985	1990	1993
Hamburg	406	435	430	436	417	436	470
Munich		358	405	451	485	507	538
Rhein-Ruhr				901	817	849	1 064
Vienna				443	626	680	724
Zurich					479	616	644

Sources: Individual public transport systems (Verkehrsverbuende) in each metropolitan area; and federal transport ministries in Germany, Austria and Switzerland.
Note: First-year passenger figures for Vienna (1980) and Zurich (1985) refer to ridership prior to founding of the Verbund and include only the main public transport firm. All other first-year figures are for the Verbund's first full year of operation: Hamburg (1967), Munich (1973) and Rhein-Ruhr (1980).

Table 3 Comparison of per capita public transport use in five case study systems with other European cities, for 1993 or latest available year (trips per capita per year in each metropolitan area)

Metropolitan area	Annual public transport trips per capita
Zurich (CH)	537
Vienna (A)	332
Munich (D)	223
Hamburg (D)	183
Rhein-Ruhr (D)	144
Basel (CH)	380
Paris (F)	330
Amsterdam (NL)	320
London (UK)	290
Stockholm (S)	288
Freiburg (D)	210
Lyon (F)	186
Frankfurt (D)	160
Cologne (D)	150
Grenoble (F)	136
Manchester (UK)	131
Lille (F)	100
Bordeaux (F)	96

Sources: Individual public transport systems; national public transport associations; UITP (Brussels).
Note: For all five case study systems, per capita trip rates were calculated explicitly to include the entire metropolitan region. Some of the rates for other European cities are less comprehensive because their public transport systems serve fewer suburban areas. Thus, the public transport orientation of the comparative cities is somewhat overstated in this table relative to the five case study cities, whose service areas include virtually all the suburban parts of their regions.

The increased ridership achieved by the five Verbund systems has led to per capita levels of public transport use that compare quite favorably to even the largest, most public transport oriented cities in Europe (see Table 3). Zurich, for example, has almost twice as many public transport trips per capita as Paris and London, although it is only a tenth of their size. Similarly, Vienna has roughly the same level of public transport use per capita as Paris and London. The three German Verbuende do not score as well on this index, probably due to the extremely high level of auto ownership in Western Germany, together with an extensive, high-quality highway infrastructure. Nevertheless, even Hamburg, Munich and Rhein-Ruhr compare favorably with similarly sized cities in France, Sweden and England.

As shown in Table 4, developments in modal split distributions have been rather mixed in the five case

Table 4 Modal split trends in five metropolitan regions (public transport trips as percent of total motorized trips)

Metropolitan region	1975	1980	1990	1993
Hamburg	41	37	32	
Munich	30	36	38	41
Rhein-Ruhr	36	30	24	25
Vienna		49	44	
Zurich		52	62	

Sources: Individual public transport systems (Verkehrsverbuende) in each metropolitan area; and federal transport ministries in Germany, Austria and Switzerland.

study systems. Only in Munich and Zurich has the modal-split share of urban public transport increased steadily since the Verbund's establishment. In both Hamburg and Vienna, public transport's share of total travel has fallen, although from high levels. In the Rhein-Ruhr region, modal-split fell until 1990 but since then has increased slightly, probably due to the 25% jump in ridership generated by the extremely attractive environmental ticket introduced there in 1990. The steady increases in Munich's and Zurich's modal splits are obviously attributable to rapid growth in public transport ridership. The decline in Vienna is puzzling, since public transport ridership there increased greatly; evidently, auto use increased even more rapidly, especially in the outlying, very low-density portions of the Vienna metropolitan area. All of the trends in modal split shown in Table 4 must be viewed in the context of sharply falling modal splits for urban public transport in almost all European and North American cities. As documented in a recent survey by the Organization for Economic Cooperation and Development (OECD) and in numerous other surveys conducted by individual transport ministries and departments of transportation in each country, the share of total urban travel served by public transport has declined greatly from 1970 to 1990 (Pucher, 1995). Overall, therefore, the modal split trends in the five Verbund regions compare quite favorably with those in other cities.

The most obvious, most measurable and most comparable index of success in urban public transport is ridership growth. Passenger levels directly reflect the consumer's satisfaction with the service offered. Thus, increasing ridership of the five Verbund systems examined in this article indicates a substantial increase in the direct benefits to public transport riders. Moreover, virtually all analysts agree that the indirect social and environmental benefits of public transport (congestion relief, pollution reduction, traffic safety) are also closely correlated with the level of public transport use. Both in terms of direct and indirect benefits, the five Verbund systems must be considered a resounding success. We now examine the reasons for that success.

Ridership growth through service expansion

All five Verbund systems greatly expanded the amount of public transport services they provided since they were founded: Hamburg by 36%, Munich by 62%, Rhein-Ruhr by 11%, Vienna by 45%, and Zurich by 24% (see Table 5). In Munich and Vienna, which had the largest increases, most of the expansion was through the construction of extensive new U-Bahn systems, which not only provided a more extensive service, but also one which is faster, more dependable and more comfortable. Expansions in S-Bahn networks accounted for some of the service increases in virtually all the cities, with the most substantial growth in Munich, Vienna and Zurich.

The five systems also increased the frequency of service on most of their existing rail and bus services.

Table 5 Total service supply for five regional public transport systems (Verkehrsverbund)

Metropolitan region	1970	1975	1980	1985	1990	1993
	Billions of place kilometers					
Hamburg	15.7	24.0	24.2	25.9	25.7	21.4
Munich		14.7	16.0	17.2	19.3	23.8
Rhein-Ruhr			32.6	33.3	33.9	36.3
Vienna				20.0	25.2	28.9
Zurich[a]					9.8	10.8
	Millions of vehicle kilometers					
Hamburg		199.2	195.0	201.1	197.8	222.4
Rhein-Ruhr			241.2	238.1	233.3	250.6
Zurich[b]			30.0	30.2	37.6	37.3

Sources: Individual public transport systems (Verkehrsverbuende) in each metropolitan area; federal transport ministries in Germany, Austria and Switzerland.

Notes: [a]The only index of service supply available for the Zuericher Verkehrsverbund is seat kilometers, which are reported in this table. Since place kilometers also include standing places, the figures for Zurich greatly understate the total supply of service, at least compared to other Verbund systems shown in the table. Nevertheless, they at least show the upward trend in service supply.

[b]Only for the Verkehrsbetriebe Zurich (part of Verbund), thus understating total service supply for Verbund.

Moreover, they provided service at more regular intervals (so-called Taktverkehr) to make the schedule easier for riders to remember and to facilitate transfers between lines and different public transport modes. In Vienna and Zurich, for example, bus and tram services are generally every ten minutes, and on some lines every five minutes. S-Bahn service in Munich is offered every 20 minutes and U-Bahn service is every five minutes. Of course, during weekday peak hours, frequencies are even higher on most lines.

In addition to providing more and better services, all five of the Verbund systems have made considerable investments in improved information for passengers. Perhaps the most advanced development is computerized, individualized timetable, route and fare information for each customer, available in person, over the phone and through direct access for those customers having personal computers. The customer states the desired point of origin, destination and time-of-day, and the computer program automatically calculates the quickest and cheapest route. Some of the Verbund systems have also computerized their information about the current status of train runs, with information boards on station platforms showing actual arrival and departure times (as opposed to scheduled times), and with digital display boards inside vehicles indicating the next station stop, thus supplementing audio announcements. The five Verbuende have also made less spectacular but equally useful contributions to improving passenger information by distributing free route-by-route timetables, expanding and improving their phone information service, and providing extensive route, schedule and fare information at every rail station and bus stop.

Finally, various new types of more flexible services were introduced to fill in the market gaps not served well by rail or conventional fixed-route bus services. A range of vans, minibuses, midibuses and taxi services were added to the five systems to complement the other services offered, acting mainly as feeders from low-density areas to the main system lines which have frequent services. Some of these low-density services even offer door-to-door pickups and drop offs of passengers for a small surcharge. In addition, express bus services were established to those outlying areas where densities were considered too low to justify the large expenditures necessary to extend the suburban rail network.

Ridership growth through better quality service

The service expansion quantified in Table 5 has obviously made public transport more attractive. Equally important are the accompanying improvements in the quality of public transport service. As shown by virtually every statistical analysis of travel demand, speed and dependability are important determinants of modal choice. Each of the five Verbund systems examined here has invested heavily in expanding its rail services, thus enabling much faster travel and much better on-time performance.

Thanks to their completely separate rights-of-way, U-Bahn and S-Bahn services have an obvious advantage over buses and most trams as well. Nevertheless, all five of the Verbund systems have undertaken measures to accelerate bus and tram services and to improve their on-time performance. They have steadily expanded their networks of reserved bus lanes in order to insulate buses from delays resulting from roadway congestion. Tram lines have increasingly been moved from shared rights-of-way on city streets to reserved rights-of-way in street medians, along the sides of roadways, or underground. Moreover, as in many German, Austrian and Swiss cities, computerized traffic control systems have been installed to give buses and trams priority access to intersections shared with cars and trucks. Traffic lights automatically turn green for buses (in reserved lanes) and trams as they approach such intersections, while they turn red for private vehicles. Every one of the five case study Verbund systems reports dramatic increases in the average speed and on-time performance of buses and trams. In the Rhein-Ruhr Verbund, for example, such measures enabled 90% of trams to adhere perfectly to their timetable, remaining on-time throughout their routes. In Hamburg, the same sorts of measures reduced late runs by as much as 50% on some bus routes.

Inter-modal and inter-route connections have been greatly improved in all five study regions. For example, the new S-Bahn system in Zurich for the first time provided a frequent rail service between all six of Zurich's major train stations as well as 16 smaller stations. Similarly, the U-Bahn extensions in Vienna provided the first high-speed rail connections between the most important train station (Westbahnhof), other long-distance train stations and the rest of Vienna's public transport network. Munich is perhaps the premier example of rail system integration, with long-distance, medium-distance and short-distance rail systems merging underneath the long pedestrian mall extending from Karlsplatz to Marienplatz in the city's center. With U-Bahn, S-Bahn and long-distance trains of the Deutsche Bahn running at different levels in certain key stations, transfers are now easier, faster and more dependable. Intermodal coordination has extended to air travel as well, with frequent and convenient S-Bahn services between airports and city centers in all five of the case study regions.

Park-and-ride and bike-and-ride are two additional aspects of inter-modal coordination to encourage more public transport use. All five Verkehrsverbuende in this study dramatically increased the number and capacity of park-and-ride facilities, primarily at their outlying S-Bahn stations. Moreover, bikeway connections to S-Bahn stations are being improved, and most systems have greatly increased the number and quality of bike storage facilities at train stations, including sheltered bike racks and convenient lockers.

Finally, bus stops and stations have been expanded, modernized and redesigned to improve the comfort and safety of passengers waiting to transfer from one bus line to another, or between rail and bus lines. Above all, passengers are now better protected from the weather, and pedestrian access has been improved, both for the transfer from one public transport mode or line to another, and from the surrounding neighborhood.

Over the past ten years, all five of the Verbund systems have greatly improved the quality of their vehicles. Buses, trams, trolley buses and rail cars for U-Bahn and S-Bahn lines have been thoroughly modernized, offering increased comfort, higher capacity, and easier exit and entry. One of the most important developments in this area is the widespread introduction of low-floor buses (Niederflurbusse) and low-floor trams (Niederflurstrassenbahnen).

Most of the service improvements just noted involve physical expansion, modernization or integration of public transport infrastructure and vehicles. Better coordination of service timetables, however, has also increased the overall quality of services in all five of the case study Verbuende. There are obviously limits on how far the schedules of different public transport modes and lines can be made compatible with each other, but the Verbund system of organizing public transport service delivery certainly facilitates intermodal and inter-route coordination. The Verbund brings together many different public transport firms with different modes to act as one unified transport system. That in itself makes it easier for the customer to use public transport. The five case study Verbuende, however, have been especially successful at carefully designing route schedules so as to minimize transfer times between different modes and lines. Increasingly, the unit of analysis for schedule planning is the entire trip from origin to destination, taking transfers explicitly into account, with the goal of minimizing both total travel time and problematic transfers. The synchronization of route schedules has become especially important due to the increasing differentiation of tasks for different public transport modes. With S-Bahns specializing in long-distance trips from the suburbs, U-Bahns specializing in high-density central city corridors, trams covering intermediate distances in the central city, and buses, minibuses, vans and taxis serving as feeders and distributors to the other public transport modes, both physical and temporal coordination of modes becomes crucial. So far, the five Verbuende examined in this study appear to have made significant progress in coordinating and integrating their wide range of services. The overall quality of services offered has unquestionably increased.

Ridership growth through more attractive fare structures

Certainly one of the most significant improvements made possible by the Verbund form of public transport organization is a uniform, integrated fare structure. Even if passengers transfer from one line to another, from one type of public transport to another, or even from one public transport firm to another, only one ticket is needed for the entire trip from point of origin to destination. That innovation in itself has improved the attractiveness of public transport in every Verbund, including the five examined in this study.

In addition, most Verbund systems have increasingly offered extremely attractive monthly tickets and yearly tickets with very large discounts off the regular, one-trip tickets. It is not possible here to list the exact details of each Verbund's fare structure, but in general, the monthly tickets are priced so that they save money for the customer provided he makes 20–30 one-way trips per month, with the exact number varying from one Verbund to another. Regular riders almost always buy monthly or yearly tickets, since they make many more than 20–30 trips per month. Moreover, monthly and yearly tickets increase the convenience for the customer by eliminating the need to purchase a ticket for each trip.

Table 6 shows average monthly ticket prices in each of the five case study Verbuende over the period 1980 to 1993. Differences in zonal structures and certain conditions of ticket use (such as transferability) make it impossible to draw exact comparisons between the different Verbund systems. Nevertheless, the table enables some rough generalizations to be made and also highlights important fare trends over time. For example, both Zurich and Rhein-Ruhr offered dramatic fare reductions in 1990 through the introduction of new environmental tickets (Regenbogenkarte in Zurich, Ticket 2000 in Rhein-Ruhr). By contrast, the price of monthly tickets in Munich has increased at virtually the same rate as inflation, so that the real, inflation-adjusted price has remained constant, and incidentally, much higher than in Rhein-Ruhr, Vienna and Zurich. Monthly tickets in Hamburg have been almost as expensive as in Munich.

Table 6 Trends in monthly ticket prices (in inflation-adjusted, constant 1993 German marks)

Metropolitan region	1980	1985	1990	1993
Hamburg	52	62	72	67
Munich	80	73	72	72
Rhein-Ruhr	51	64	62	49
Vienna	89	62	65	63
Zurich	118	98	52	52

Sources: Individual public transport systems in each metropolitan region.
Note: In general, the ticket prices shown are for the inner zone. Some systems, however, changed their zone structure over time, thus making it difficult to draw exact comparisons of monthly ticket prices in different years. Moreover, since there is substantial variation among systems in their zone structures, comparisons among systems is also difficult.

Monthly and annual tickets have become so much more attractive than single-trip tickets that they are now used by most passengers. Including the semester tickets for university students, school pupils, and apprentices, monthly and annual tickets (Zeitkarten) account for 92% of Vienna's riders, 78% in Hamburg, 78% in Rhein-Ruhr, 54% in Zurich and 50% in Munich. In some systems (such as Rhein-Ruhr), the monthly tickets are made even more attractive because they are transferable from one person to another, and thus can be shared by persons taking trips at different times. Moreover, in off-peak periods a single monthly ticket suffices to transport the holder, up to three children, a bicycle and a dog at no additional cost. While that additional benefit is available at no extra charge in Rhein-Ruhr, monthly ticket holders in Munich must purchase an additional monthly ticket (Gruene Karte) for such expanded benefits. Since the monthly ticket in Rhein-Ruhr is comparatively cheaper anyway, it is no wonder that is has been more popular than in Munich.

Trends in one-trip fares are shown in Table 7. It is very important to note that the substantial reductions in monthly ticket prices shown in Table 6 are not reflected by corresponding reductions in one-trip fares.

Table 7 Trends in one-trip fares (in inflation-adjusted, constant 1993 German marks)

Metropolitan region	1980	1985	1990	1993
Hamburg	1.88	2.04	2.35	2.30
Munich	2.90	2.76	2.69	3.00
Rhein-Ruhr	2.17	2.40	2.24	2.60
Vienna	1.93	2.13	2.29	2.14
Zurich	1.14	1.55	2.05	2.40

Sources: Individual public transport systems in each metropolitan region.
Note: In general, the ticket prices shown are for a one-way trip, including any necessary transfers, within a one-hour period. In addition, most systems limit the number of zones that can be crossed with such one-trip tickets. This table shows the price of a trip limited to the central zone, or of equivalent length within outer zones. Direct comparisons among systems are difficult because of different zonal structures.

Even when adjusted to control for inflation, one-trip fares increased significantly in almost all of the five Verbund systems; only in Vienna did one-trip fares increase at roughly the same rate as inflation. Combined with the decrease in the price of monthly tickets, the increased price of one-trip tickets was a strong incentive for passengers to buy monthly and annual tickets.

All five of the case study Verbuende offer a range of alternative tickets to bridge the gap between the unattractive one-trip tickets for very infrequent riders and the very attractive monthly and annual tickets for regular riders. There are weekly tickets, four-day tickets, three-day tickets, one-day tickets — which offer unlimited travel for those periods of time — and strip tickets, which can be used for multiple-trips. These alternatives are more expensive than the monthly tickets on a per trip basis, but less expensive than the regular one-trip ticket. Thus, the regional public transport systems offer such a wide range of ticket types that virtually every potential rider can find at least one alternative that suits his/her particular needs.

Table 8 provides a summary measure of an average fare that is more comparable among different Verbund systems. By dividing total passenger fare revenues by total passenger trips, it reflects both the low per trip fare of monthly tickets and the higher per trip fare of single-trip tickets. It also reflects all of the other types of tickets sold by each Verbund. Particularly noteworthy is the very sharp reduction in Rhein-Ruhr's average fare since 1990, thanks to the Ticket 2000. Similarly, the average fare has decreased steadily in Zurich since 1980 and, in fact, is currently the lowest of the five Verbund systems in this study. Hamburg and Munich both have much higher average fares than the other three systems, although fares have fallen in Hamburg since 1990.

It is noteworthy that periods of fare decreases in Hamburg, Rhein-Ruhr, Vienna, and Zurich have corresponded to ridership growth in those four systems (compare with Table 2). Ridership in Munich has increased steadily in spite of fare increases, almost certainly because dramatic increases in the quantity and quality of services in Munich (especially the expanded U-Bahn and S-Bahn networks) have offset the impacts of higher fares.

The experiences of our case study systems highlight two other factors that should be considered when designing fare structures. Zurich and Hamburg have recently permitted the use of credit cards for the purchase of tickets. In Hamburg, even ticket machines dispensing one-trip tickets and various daily and weekly tickets now accept debit and credit cards. In both Hamburg and Zurich, credit and debit cards are accepted at ticket offices for purchasing all ticket types, including monthly and annual passes. Clearly, this facilitates the financial transaction for the customer.

Finally, the complexity of zonal fare structures in some cities can discourage ridership. In 1990, the Verkehrsverbund Rhein-Ruhr greatly simplified its zonal fare structure by reducing the number of zones from 11 to only three. That certainly made it easier for the customer to understand. By comparison, the zonal fare structure in Munich is excruciatingly complicated, with 9 inner fare zones, 20 outer fare zones, and 134 different fare zone combinations, each requiring a different fare. To make things even more complicated, Munich offers 24 different kinds of tickets varying by age group, type of education and training, degree of handicap and time of day. In some instances, the passenger must purchase two or even three tickets to be used in combination with each other. Nowhere else in the world have the authors encountered such a baffling fare structure. Surely a drastic simplification of Munich's zonal structure would bring a sigh of relief to its public transport riders. The superb quality of Munich's public transport system, and its continual expansion and modernization, have more than offset this problematic fare structure. Clearly, however, a simpler and cheaper fare structure (as in Rhein-Ruhr) would attract more riders.

Table 8 Trends in average fare[a] for five regional public transport systems (in inflation-adjusted, 1993 constant German marks)

Metropolitan region	1975	1980	1985	1990	1993
Hamburg	1.45	1.38	1.46	1.40	1.30
Munich	1.26	1.27	1.14	1.19	1.21
Rhein-Ruhr		1.29	1.39	1.33	0.89
Vienna			0.83	0.94	0.88
Zurich[b]		1.00	0.97	0.73	0.68

Sources: Information from individual public transport systems and federal ministries of transport.
Notes: [a]Average fare was calculated as total passenger fare revenues divided by total passenger trips.
[b]The average fares could only be calculated for the central public transport system in Zurich, excluding suburban rail (S-Bahn). Thus, they understate the average fare for the entire Verbund system, since average S-Bahn fares are obviously higher.

Ridership growth through better marketing

Faced with increasing competition from the automobile, public transport systems throughout Europe and North America have been forced to undertake a range of measures to market their services more effectively. The time is long past when public transport can rely on captive riders with no travel alternatives.

The five Verbund systems examined here have been especially innovative in their marketing strategies. Of course, they have employed all the classic advertising techniques as well, but with particular vigour since 1990. Advertisements promoting the use of public transport appear regularly on large billboards as well as in smaller poster-size format in public buildings, public spaces and on buses and trams. As a free public service, large stores in Zurich even place public transport ads on their shopping bags. Moreover, public transport advertising appears regularly in each of the Verbund regions' newspapers, in cinemas, and on radio and television stations. Millions of informational brochures and pamphlets are regularly distributed to all households with postal addresses in the Verbund regions. The ads emphasize the environmental and social benefits of public transport, but they also depict public transport as a safe, convenient, money-saving alternative to the automobile.

Some of the systems regularly publish their own free magazine for customers (for example, *Express* in Hamburg and *VIV* in Rhein-Ruhr), providing up-to-date information about new services and fare programs, special offers and future plans. They even publish letters with customer complaints or suggestions for improvements, thus conveying to customers that the Verbund wants to respond to their needs.

All five Verbund systems employ the fare structure itself as a key to marketing. As described earlier, the most important strategy in this respect is the deeply discounted monthly ticket (or annual ticket) for regular users. Monthly passes had been available for many years, but in the late 1980s, they increasingly took on the designation of environmental tickets, thus emphasizing the environmental benefits of public transport. In Zurich, the environmental ticket is called the Regenbogenkarte ('rainbow ticket') and in Rhein-Ruhr, the Ticket 2000. Monthly ticket discounts were greatly increased for these environmental tickets. To further encourage the purchase of monthly tickets, trial weekly passes are available at deep discounts in Hamburg ('Probefahrkarte') and Zurich ('Schnupperkarte'), whose cost can even be credited toward the purchase price of the regular monthly ticket.

An especially attractive form of the monthly ticket is the Firmenticket, a monthly or annual pass which is subsidized by large firms for their employees. The Verbund negotiates a special price with each individual firm, and that firm in turn offers the monthly ticket to employees for a discount up to half the regular price. The proportion of riders using such Firmentickets has risen steadily in all five Verbund systems over the past five years. Special monthly or semester tickets are also available for school pupils and university students, who can purchase them for less than half the regular price. In the Rhein-Ruhr region, the Verbund negotiated with most universities to offer all students a semester ticket for a very small supplement to regular registration fees. The result was a tripling of public transport use among university students.

In addition, most Verbund systems also offer Kombitickets, which automatically include public transport tickets (usually all-day or multi-day passes) in the entrance fees for concerts, sports events, conventions, amusement parks and festivals. In every case, the Verbund negotiates the bulk-discount price with the event organizer. Some hotels even include public transport tickets in their room prices. Such Kombitickets are especially effective at winning riders because there is no additional charge to the user for the public transport ticket itself. The entrance fee is the same whether or not the public transport ticket is actually used; thus, the marginal cost of public transport to the user is zero. Since most Kombitickets are for events with large crowds, they explicitly target peak demands, situations where automobile use might lead to severe traffic congestion.

The five case study Verbund systems employ a wide range of other marketing strategies. The Rhein-Ruhr Verbund, for example, organizes an annual public transport carnival that makes a promotional tour of the entire region, offering not only entertainment but also free information about public transport. Descriptive brochures, timetables, ticket information, and colorful posters are distributed in a festive atmosphere. There are even public transport sweepstakes with various free gifts as prizes, including public transport tickets. Moreover, joint events are held with environmental groups to highlight the wider benefits of public transport in reducing pollution and saving energy.

Each Verbund has a somewhat different marketing strategy to win new riders, but all five case study systems have dramatically intensified their marketing campaigns over the past five years. In general, all the marketing techniques are aimed at advertising the more attractive services and fares of the Verbund, convincing auto drivers to try out public transport, and deepening the loyalty of current riders.

Financing ridership growth

The five case study Verbuende examined in this article have been extremely successful at improving the quality of public transport services they offer. By expanding, modernizing, and integrating their U-Bahn, S-Bahn, and light rail (tramway) systems, they have greatly increased the speed, convenience, and comfort of public transport travel in their regions. Moreover, they have significantly improved the quality of bus services by integrating them better with their rail systems, and also by introducing more comfortable, more attractive vehicles. Finally, fare structures, ticketing procedures, and information systems have been vastly improved, thus making public transport easier and less expensive to use. In every respect, the Verkehrsverbund form of public transport organization represents a genuine advance in the provision of public transport services to metropolitan regions.

In spite of these considerable advantages of the Verkehrsverbund, it has proved to be extremely costly to provide extensive, high-quality regional public transport. In every case, both operating and capital costs have grown substantially since the founding of the five Verbuende examined in this article. Moreover, the operating deficits have grown steadily, and the percentage of operating costs covered by passenger fare revenues has fallen. As shown in Table 9, for example, the percentage of costs covered by fare revenues fell in Zurich from 78% in 1985 (prior to the Verbund's founding) to only 42% in 1993. From 1980 to 1993, the percentage of costs covered by fare revenues fell from 66% to 40% in Rhein-Ruhr, from 65% to 54% in Hamburg, from 65% to 52% in Munich, and from 47% to 40% in Vienna.

Table 9 Trends in operating ratio for regional public transport systems (passenger fare revenues as percentage of total operating costs)

Metropolitan region	1975	1980	1985	1990	1993
Hamburg	61	65	63	62	54
Munich	49	56	55	58	51
Rhein-Ruhr[a]		66	63	44	40
Vienna[b]		47	51	53	40
Zurich[c]		75	78	57	42

Sources: Individual public transport systems (Verkehrsverbuende) in each metropolitan area; federal transport ministries in Germany, Austria and Switzerland.
Notes: [a]Includes suburban rail services of German Federal Railways in 1990 and 1993, excludes suburban rail in 1980 and 1985. Operating ratio of suburban rail was 21% in 1980 and 24% in 1985. Thus, part of sharp fall of operating ratio in 1990 is due to inclusion of very unprofitable suburban rail services, but even the bus and tram services of the Rhein-Ruhr Verbund became much more unprofitable, their operating ratio falling from 64% in 1990 to 55% in 1993.
[b]Part of the reason for the sharp fall in Vienna's operating ratio between 1990 and 1993 is a change in the accounting for U-Bahn costs, which had formerly been financed through a separate fund.
[c]The operating ratio for Zurich only refers to the inner public transport system (Zuricher Verkehrsbetriebe), excluding suburban rail (S-Bahn) for all years.

Since fare revenues thus covered a lower and lower proportion of growing costs, subsidies to public transport had to be greatly increased. Even controlling for inflation, the necessary financial assistance from all levels of government increased considerably. For purposes of comparison, Table 10 reports subsidy trends for all five Verbuende in terms of inflation-adjusted German marks. Over the period 1980 to 1993, the total government subsidy increased by 63% in Hamburg, by 38% in Munich, and by 78% in Rhein-Ruhr. Those percentages represent real subsidy growth, i.e. in excess of inflation. Since government assistance must also finance cost growth due to inflation, the total subsidy growth has obviously been much greater than that shown in Table 10, which only indicates subsidy increases exceeding inflation. Even more dramatic than the three German Verbund systems, Vienna's total subsidy requirements grew by 86% in only eight years, from 1985 to 1993. By comparison, Zurich's subsidy growth seems rather moderate: 16% since the Verbund's founding in 1990. Even in Zurich, however, increasing costs have been a problem. In the pre-Verbund decade from 1980 to 1989, costs grew by an average of only 4% per year. Since then, cost growth accelerated by 14% in 1990, by 10% in 1991, and by 8% in 1992.

Providing yet another index of comparison, Table 11 shows trends in operating subsidy per passenger trip, thus adjusting for the different sizes of the five Verbund systems and for the expansion of systems over time. On this basis as well, public transport has required increasing government subsidy per passenger trip served, well in excess of inflation. Over the period from 1980 to 1993, the real, inflation-adjusted subsidy per passenger trip increased by 51% in Hamburg, by 15% in Munich, and by 52% in Rhein-Ruhr. In this respect, Munich has been the most successful of the German systems at holding down per-unit costs and subsidy needs. Vienna has required vast increases in subsidy, with a 62% increase in per-trip subsidy from 1985 to 1993, in excess of inflation. Over the short period from 1990 to 1993, Zurich's per-trip subsidy needs rose by 11%.

Table 10 Trends in public transport operating subsidies[a], all government levels combined (expressed in millions of inflation-adjusted, constant 1993 German marks)

Metropolitan region	1980	1985	1990	1993
Hamburg	320	359	374	521
Munich	449	456	520	618
Rhein-Ruhr	643	692	1 045	1 144
Vienna[b]		478	529	890
Zurich			326	378

Sources: Individual public transport systems in each metropolitan region and the Austrian and Swiss federal ministries of transport.
Note: [a]Subsidies reported here generally exclude capital subsidies for large investments.
[b]Changes in financial accounting for the U-Bahn between 1990 and 1993 caused some of the reported increase in total subsidy (and decrease in operating ratio) in Vienna.

Table 11 Public transport operating subsidies[a] per passenger trip (expressed in millions of inflation-adjusted, constant 1993 German marks)

Metropolitan region	1980	1985	1990	1993
Hamburg	0.73	0.86	0.86	1.11
Munich	1.00	0.94	1.03	1.15
Rhein-Ruhr	0.71	0.85	1.23	1.08
Vienna[b]		0.76	0.78	1.23
Zurich			0.53	0.59

Sources: Individual public transport systems in each metropolitan region and the Austrian and Swiss federal ministries of transport.
Note: [a]Subsidies reported here generally exclude capital subsidies for large investments.
[b]Changes in financial accounting for the U-Bahn between 1990 and 1993 caused some of the reported increase in total subsidy (and decrease in operating ratio) in Vienna.

There are three possible explanations for the deteriorating financial situation of most Verbund systems. First, and perhaps most crucial, it is virtually inevitable that the increased expenses from expanding service and the reduced revenues of discounting fares will not be matched by commensurate increases in public transport ridership. Virtually every available study of travel demand elasticity shows that the demand for public transport is quite inelastic, especially in response to fare reductions (Goodwin, 1992; Oum *et al.*, 1992; Cervero 1990). Lower fares will indeed increase ridership, but the percentage growth in passenger trips is far less than the percentage reduction in fares, thus leading to overall revenue losses. Service improvements tend to be more effective than fare reductions at increasing ridership, but still with a demand elasticity less than 1.0. Increasing the supply of public transport services produces more ridership, but the percentage increase in passenger trips is less than the percentage increase in service supply. Thus, vehicle occupancies fall. The combination of both lower fares and more service (as in most of the case study Verbund systems examined here) produces a large increase in passenger trips, but the resulting fall in passenger fare revenue per vehicle kilometer of service greatly increases the operating deficit of public transport, and also requires ever larger subsidies per passenger carried.

Price and service elasticities vary considerably among cities, different public transport modes, different routes and different times of day, and there are isolated instances where elasticities can exceed 1.0. In general, however, public transport demand is quite inelastic, requiring large subsidy increases to generate ridership growth (Cervero, 1990). All five of the Verbund systems examined here confirm that financial dilemma.

The ministries of transport in Germany and Switzerland commissioned detailed studies of the ridership and revenue impacts of all German and Swiss cities that had introduced discounted fares to encourage more public transport use (Institut fuer Angewandte Sozialwissenschaft, 1994; Swiss Ministry of Transport, 1989). Because fare reductions, service expansion, and marketing strategies were implemented simultaneously in most cities, the studies were not able to separate out the independent effect of each measure. Moreover, the limited database prevented any formal econometric analysis. The two ministry reports show that overall demand elasticity can be greatly enhanced by a coordinated strategy of fare reductions, service improvements and creative marketing. Equally important, the fare structure can be made more attractive not simply by lowering fares, but also by offering a wide range of alternative fare options and by combining public transport fares with entrance fees, students fees and employee benefit packages. In general, however, the German and Swiss ministry reviews confirm the demand inelasticity estimated by other studies, and the large subsidy increases needed for ridership growth. Sharply discounting monthly fares while raising regular, one-way fares produced a striking increase in the percentage of riders using monthly passes. Most of the new monthly ticket holders were former public transport riders who had previously paid the higher fare for other ticket types. Such shifting among fare types led to revenue losses that were not offset by the additional riders who had not previously used public transport.

Two other factors have compounded the financial problems of the Verbund systems. Some Verbund arrangements have distributed subsidies among member firms based on vehicle kilometers of service supplied, not on passenger trips. Thus, the focus of individual public transport firms within any given Verbund has been on service expansion, not on maximizing usage of existing services or redistributing service supply away from underutilized services toward markets with greater potential demand. In short, there has been insufficient incentive to maximize the efficiency of service provision and utilization. Finally, the extensive suburban coverage introduced by the Verbund systems has been particularly unprofitable. In the lower-density, outlying areas of each of the Verbund service areas, vehicle occupancy rates are generally much lower than in central cities, and trip lengths are much longer as well. The extension of public transport from the cities to the suburbs has indeed succeeded in creating truly regional public transport systems, but only at enormous subsidy costs. On the one hand, it is necessary to provide the growing suburbs with public transport service to win their political support for public transport; yet that very expansion into low-density areas has made public transport far more unprofitable than it had previously been.

Of course, increasing costs and subsidies have produced immense benefits for riders in the form of vastly improved public transport services for entire metropolitan regions. Nevertheless, those subsidies have burdened federal, state (provincial), and local government with severe financial problems. The financial burden of subsidizing public transport is all the more troublesome because all levels of the public sector throughout Germany, Austria and Switzerland — as in other European countries — have been in a period of fiscal austerity, and thus forced to cut back government expenditures for a wide range of services. After years of expansion, public transport is now having to deal with subsidy reductions or at least a stabilization of subsidy levels.

In Zurich, the Verbund has responded with a vigorous cost-control program called the 'Zuri-Schlankline' (loosely translated: Zuricher Verbund on a diet!). Since 1992, it has reduced its workforce by 10%, sharply reduced investment in new infrastructure, and cut back service frequencies on underutilized routes. By redistributing services away from routes and times of day where vehicle occupancies are low to those routes and times of day where vehicle occupancies are high, the Zuricher Verbund has increased the overall productivity of its system and thus minimized the loss of passengers. Indeed, these measures have resulted in cost increases less than inflation in 1993 and 1994.

Other Verbuende have been forced to undertake similar measures. In all five systems there have been strict limits on the hiring of new employees, and underutilized services have been either eliminated or reduced in frequency. There has also been more emphasis on traffic control measures to increase bus and tram speeds (Busbeschleunigungsmassnahmen) through reserved lanes and priority traffic signals. Faster bus and tram speeds increase both employee and vehicle productivity, thus reducing costs while also improving service for the rider.

Virtually all five Verkehrsverbuende have long-range plans for further extensions of their U-Bahn, S-Bahn, and light rail systems, but almost all of these plans have been put on hold until more funding becomes available. Similarly, new investments in bus stations and transfer facilities are being delayed. Most efforts now are focused on making the current system work as efficiently as possible and minimizing the impacts of inadequate funding.

One obvious response in all five Verbuende has been fare increases, at least in line with the rate of inflation in each country. Until now, fare increases have not been large, so that they have not yet resulted in any significant loss of ridership. Another quite innovative response has been the seeking out of private funding to substitute for reduced government subsidies. In both Zurich and Rhein-Ruhr, several private firms have essentially 'adopted' particular public transport lines or stations, and thus have voluntarily provided financial contributions for maintaining or upgrading vehicles, stations, and rail lines serving their firms. It is laudable that some firms have volunteered to provide such funds, but it seems unlikely that private financing will suffice to offset government reductions unless private contributions are made mandatory, for example, in cases where large firms can clearly be identified as the main beneficiaries of certain public transport services.

Conclusion

In spite of the considerable financial problems now faced by urban public transport, the five Verkehrsverbund systems examined in this article have succeeded in providing truly regional public transport services. The more extensive, higher-quality and better integrated services they offer have significantly increased ridership above pre-Verbund levels, and the modal-split share of public transport has either grown or stabilized in most of the Verbund regions, in sharp contrast to the plummeting modal splits of public transport in some other countries.

Adequate government support of public transport is crucial to its continued success. It is not realistic to expect that voluntary private contributions will suffice. Moreover, public transport fares should not be raised substantially; that would lead to ridership losses that would negate all the potential benefits available from the superb public transport systems provided by the five Verkehrsverbuende examined in this article.

Without question, the most logical source of funding for public transport is increased taxes, fees and user charges for automobile ownership and use. Many economic studies have documented the enormous social and environmental costs of automobile use. Because auto users are not required to pay the full costs of auto use, the modal choice between the auto and public transport is severely biased in favor of the automobile. Without exception, economists propose increased taxation of auto use as the optimal solution to the auto's underpricing. Such increased auto taxes would produce enormous new revenues that would be the ideal source of funding for public transport. Not only would higher taxes on auto use help internalize the many severe social and environmental externalities of auto use, and thus eliminate the bias in modal choice; they would also help provide a high-quality, extensive, affordable public transport alternative to auto use. As the five Verbund systems in this study have shown, the Verkehrsverbund form of regional public transport is capable of offering a truly superb alternative to auto travel. Adequate government funding, however, is absolutely essential for the financing of such Verbund systems.

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Urban transport in Germany: providing feasible alternatives to the car†

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With the second highest level of car ownership in the world, and the third highest population density in Europe, Germany has adopted a range of policies to balance the many private benefits of car use with its serious social and environmental problems. In order to 'tame' the car, most German cities have implemented a twofold strategy of expanding and improving pedestrian, bicycling and public transport alternatives simultaneously with restricting car use and making it more expensive. That has increased political acceptability since the car-restrictive measures are not perceived as mere punishment of car drivers. The results of this coordinated urban transport strategy have been impressive. Germany, as a whole, has managed to increase public transport use and to stabilize the car share of modal split. Some cities, of course, have been more successful than others, and this paper examines three of the most successful cities: Münster, Freiburg and Munich. In each of the cities, the percentage of travel by bicycling, walking and public transport has been raised over the past 20 years, while the car's share of modal split has fallen. This article documents the range of policies used to restrict car use, both in Germany as a whole, and in the three case-study cities in particular. The key to success is found to be mutually reinforcing transport and land-use policies. It is the combination of a whole set of coordinated policies that explains the dramatic success in changing travel behavior.

1. Introduction

Germany is one of the most highly motorized countries in the world. With 494 cars per 1000 inhabitants, Germany's level of car ownership is second only to the United States. It is surprising, perhaps, that Germany's car ownership rate exceeds that in much larger and less densely settled countries, such as Canada and Australia, which have more sprawled, polycentric urban development, less focused travel patterns and longer trip distances. Corresponding to its high level of car ownership, Germany also has one of the highest rates of car use (6228 car kilometers per capita per year). Although that is much lower than American car use, it is higher than in

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any other European countries, except Sweden, Norway and Finland, where long trip distances in extensive rural areas raise nationwide averages.

In Germany, as in the rest of the world, the private car is an extraordinarily popular mode of transport, providing levels of comfort, convenience, speed and flexibility that usually exceed those offered by public transport. Thus, as incomes in Germany have risen over the past decades, car ownership and use have also risen. Moreover, the private car has crucial symbolic value in Germany, representing individual freedom and socio-economic status. That psychological attraction has further enhanced the car's lure. A striking indication of the car's popularity in Germany is that car ownership doubled in the formerly socialist East Germany within only five years after reunification with West Germany in 1990.

Unfortunately, the immense private benefits derived from the private car are accompanied by social and environmental costs such as pollution, noise, accidents and traffic congestion. Those external costs of car use are especially significant in urban areas, where the density of car use is the highest, the concentration of negative impacts is the greatest and the most people are harmed. In general, therefore, the higher the density, the more problematic car use becomes.

With 229 people per square kilometer, Germany is one of the most densely populated countries in Europe, exceeded only by Belgium and The Netherlands. Not only is Germany as a whole densely populated, but German cities are quite compact, with four times the average population density of the largest American cities (Newman and Kenworthy 1989). The high level of car traffic in such a small, densely populated area has forced German cities to undertake a range of measures to mitigate the adverse social and environmental impacts of car use. Given the popularity of the private car, public policies have not even attempted to restrict car ownership. Instead, their aim has been to restrict car use in those areas where it does the most damage, namely in cities.

In their efforts to balance off the private benefits of car use with its social and environmental costs, German cities have shown that it is possible to maintain overall mobility levels while limiting car use in central areas and residential neighborhoods. The key to German transport policy has been expanding and improving pedestrian, bicycling and public transport alternatives simultaneously with restricting car use. That has increased political acceptability since the restrictive measures are not viewed as mere punishment of car drivers.

For many years, metropolitan-wide public transport systems have provided high-quality, well-integrated services, and large subsidies have enabled them to offer regular riders inexpensive monthly tickets. Virtually every German city has extensive car-free pedestrian zones, traffic-calmed residential areas and a network of bikeways that encourage walking and bicycling, generally complementing public transport use. Having improved these transport alternatives, German policies have also greatly restricted car use in cities and increased its cost. Lower speed limits, shared rights of way, lane restrictions, limited parking supply, car-free districts and preferential traffic signals for public transport have all made car use more difficult in inner city areas. High motor vehicle fees, license fees, petrol taxes and parking fees make car ownership and use quite expensive in Germany. Only such a twofold strategy can really change travel behavior: restricting car use and increasing its cost, while facilitating walking, bicycling and public transport use.

These urban transport policies have been complemented by stringent land-use policies and building codes, which — together with high land costs — make low-density, sprawled suburbanization almost impossible. The more compact and less extensive suburban development around German cities has produced an overall land-use pattern much friendlier to public transport than in the USA.

The purpose of this paper is to examine specifically how German cities have implemented their coordinated transport and land-use policies, and to what extent they have actually been successful in limiting car use. First, aggregate data are analyzed to portray the overall situation in Germany. That aggregate analysis is then followed by detailed information on three case-study cities that have been particularly successful at 'taming' the private car and improving public transport, walking and bicycling, and thus lowering the car's share of modal split. By examining in depth the situations in Münster (north-west Germany), Freiburg (south-west Germany) and Munich (south-east Germany), the study provides a detailed texture to the analysis not possible by looking only at nationwide aggregates. The focus is on the integrated and carefully coordinated package of car-restrictive, public-transport-supportive and anti-sprawl policies that have not only increased public transport use over the past 20 years, but even reduced the private car's percentage of urban travel in the three cities. As a contrast, the most car-oriented metropolitan conurbation in Germany (Rhine–Ruhr) is examined briefly to isolate the impacts of generous roadway supply on public transport use.

2. Aggregate trends in travel behavior and land use

We begin our analysis with some basic information on trends in travel behavior and land use for Germany as a whole. This establishes the overall context for the individual case-study cities. Moreover, the aggregate trends demonstrate that the three case-study cities, while models of balanced transportation and sustainable development, are not extreme exceptions to policies in other German cities. In almost all German cities, car ownership and use have increased dramatically since 1945, but this has not come at the cost of reduced public transport use, in sharp contrast to both the United States and Britain. Likewise, suburbanization of residences and employment can be found in virtually every German city, but the extent of suburbanization is much less, and its density is much higher than in the USA.

2.1. *Aggregate travel trends*

Car ownership and use have increased dramatically in Germany over the past four decades (see table 1). In 1950, West Germany had one of the Western World's lowest rates of car ownership: only 12 cars per 1000 population. Between 1950 and 1992, however, car ownership skyrocketed to 492 cars per 1000 population, a 41-fold increase, giving West Germany the second highest rate of car ownership in the world (Heidemann *et al.* 1993; German Ministry of Transport 1993a). As shown in table 1, the motorization rate of the unified Germany in 1992 was somewhat lower than the rate for West Germany alone (470 versus 492 cars per 1000 population). Although car ownership in East Germany had doubled in the three years after the fall of Communism, it was still about 10% lower than the West German rate in 1992, thus bringing down the average for Germany as a whole. Between 1992 and 1995, car ownership in both Eastern and Western Germany continued to grow and, by 1995, the unified Germany again had the second highest rate of car ownership in the world (at 494 cars per 1000 population).

As car ownership has increased, so have vehicle kilometers of car use. The data series for car kilometers in West Germany starts in 1952. In the 40 years from then until 1992, car use rose from 18·2 billion km to 409·8 billion km, a 23-fold increase. Of course, the extremely rapid growth in car ownership and use far exceeded population growth, which was only 36% for the entire 42-year period from 1950 to 1992 (excluding the increase due to the reunification with East Germany). The first consolidated statistics for the unified Germany were collected in 1992, and in table 1 it is shown that vehicle kilometers of car use have continued to increase (by 44 billion vehicle km or about 3% per year).

Corresponding to the trends toward ever greater car ownership and use, the number of passenger kilometers traveled by car also increased greatly between 1950 and 1995, and the percentage of motorized travel by car has continually risen. As shown in table 2, passenger km by car in West Germany rose from only 31 billion in 1950 to 613 billion in 1992, roughly a 20-fold increase in total car travel, and a 14-

Table 1. Trends in German population, car ownership and use, 1950 to 1995.

	1950 (a)	1960 (a)	1970 (a)	1980 (a)	1990 (a)	1992 (a)	1992 (b)	1995 (b)
Population (c)	47696	55958	60651	61556	63726	65100	80800	81817
Cars (c)	570	4490	13941	23192	30685	32007	37947	40404
Cars per 1000 population	12	80	230	377	482	492	470	494
Car km traveled (d)	18·2 (e)	73·2	201·1	297·4	401·6	409·8	470·9	514·4

Notes: (*a*) Includes only West Germany; (*b*) both West and East Germany; (*c*) thousands of units; (*d*) billions of units; (*e*) for 1952.

Source: German Ministry of Transport, *Verkehr in Zahlen* (annual, 1982 to 1996).

Table 2. Trends in German car travel and public transport use, 1950 to 1995.

	1950 (a)	1960 (a)	1970 (a)	1980 (a)	1990 (a)	1992 (a)	1992 (b)	1995 (b)
Passenger km by car (c)	31·1	155·2	352·3	472·5	596·3	612·6	717·2	741·5
(% of total motorized travel)	35·5	64·9	78·5	80·4	84.4	84·1	83·6	84·0
Passenger km by public transport (c)	56·5	83·8	96·5	115·1	109·8	116·2	140·5	140·9
(% of total motorized travel)	64·5	35·1	21·5	19·6	15·6	15·9	16·4	16·0
Urban public transport trips (d)	5144	6603	7015	7652	6873	7296	9148	9314
Urban public transport trips per capita	108	118	116	124	108	112	113	114

Notes: (*a*) Includes only West Germany; (*b*) both West and East Germany; (*c*) billions of units; (*d*) millions of trips.

Source: German Ministry of Transport, *Verkehr in Zahlen* (annual, 1982 to 1996).

fold increase in car kilometers of travel per capita. From 1992 to 1995, car travel continued to grow in the unified Germany, to 742 billion passenger km.

During the same period, public transport use in West Germany was also growing, but much slower than car use (see table 2). Total passenger km by public transport doubled (104% increase), and passenger km per capita increased by 49%, compared to the 1348% increase in car travel per capita. As a consequence, public transport's proportion of total motorized ground transport in West Germany fell from 65% to 16%, while the car's share rose from 36% to 84%. Even after reunification, the car's share of total passenger kilometers traveled remained roughly the same, since by 1995 car ownership and use had increased so dramatically in East Germany compared to socialist, pre-unification levels there. Indeed, there is almost no difference in overall modal split between the Western part of Germany in 1992 and the entire reunified Germany in 1995 (see table 2).

Although the focus of this paper is on urban transport, it is interesting to note that long-distance rail passenger transport in Germany has hardly declined over the past 45 years. Within West Germany, the number of long-distance rail passengers fell only very slightly, from 120 million in 1950 to 117 million in 1992. Thanks to the addition of East Germany, the number of passengers increased to 139 million by 1995. What a contrast to the USA, where the number of intercity rail passengers fell by a staggering 93% between 1945 and 1993! (Pucher *et al.* 1993; US Department of Commerce 1975, p. 729, and 1996, p. 616.)

The preceding aggregate statistics do not separate out travel trends exclusively for urban areas, and in Germany, as elsewhere, further disagregation of data by urban, interurban and rural travel is more difficult. Nevertheless, various urban travel statistics are available, even if less comprehensive than the overall national averages.

For example, the total number of *urban* public transport trips in West Germany increased between 1950 and 1980 (+49%), then decreased from 1980 to 1990 (−10%) and rebounded from 1990 to 1992 (+6%). Much of the change in public transport ridership was evidently due to overall population trends, since on a per capita basis, public transport usage in 1992 was only slightly different than in 1950 (112 versus 108 trips per year). The total passenger level increased substantially with the addition of East Germany, but on a per capita basis there was only a slight increase between West Germany in 1992 and the unified Germany in 1995 (from 112 to 114 trips per capita per year).

As in the case of long-distance rail passenger trends, the very stability of urban public transport passenger levels in Germany over the past 45 years forms an impressive contrast to the plummeting of public transport use in the USA over the same period. From 1945 to 1995, American urban public transport systems lost almost 70% of their passengers (American Public Transit Association 1970 and 1996).

Two aspects of urban travel have remained virtually unchanged since 1972 in both West and East Germany: frequency of travel, and time spent traveling. As shown in table 3, both West and East Germans made about three trips per day over the entire period, and spent about an hour each day making those trips, with only a very slight increase in both indices. By contrast, average trip distance roughly doubled. Thus, the almost universally constant travel time budget appears to hold for Germany: increased travel speeds over the years almost exactly offset increased trip distances, thus yielding only slight changes in overall amount of time per day spent traveling.

Similar to most countries, the modal-split share of urban public transport in Germany has fallen in recent decades, just as the modal-split share of car travel has risen. The changes, however, have been smaller than in most other countries. In particular, there has been only a small decline in public transport's share of urban travel.

Table 4 shows modal-split trends for all urban travel in West Germany. The figures were derived from a representative sample survey conducted for the German Ministry of Transport, which still conducts separate surveys for the Eastern and Western parts of the country. As a percentage of travel by all modes (including non-motorized travel), the car's share rose from 31% in 1972 to 49% in 1995. Public transport's share fell slightly from 17% to 16%. As in most European countries – and in sharp contrast to North America – bicycling and walking are important urban travel modes. Nevertheless, their relative significance has also fallen as urban areas in West Germany have begun to spread out and trip distances have increased. The combined modal-split share of bicycling and walking declined from 49% in 1972 to 34% in 1995.

The direction of trends in East Germany has been similar but with different timing. The car became relatively more important in urban transport over the entire period from 1972 to 1995 for which detailed surveys are available (see table 5). The rise in car modal split was gradual, however, until reunification. It increased from 11% to 25% in the 15-year period from 1972 to 1987 and then from 25% to 44% in

Table 3. Mobility trends in Germany: travel time, trip frequency and travel distance, 1972–1995: contrasting East and West Germany.

Index/region	1972	1977	1982	1987	1992	1995
Trips per day per capita						
East Germany	2·8	2·9	3·1	3·1	3·0	3·0
West Germany	2·9	2·9	2·9	3·0	3·0	3·0
Average trip distance (km)						
East Germany	10	11	12	13	17	19
West Germany	11	13	15	17	19	19
Total travel time (min/day)						
East Germany	56	57	59	58	65	63
West Germany	57	58	57	56	59	60

Source: Brög (1996), p. 4.

Table 4. Modal-split trends for urban travel in West Germany, 1972–1995 (percentage of total urban trips by each mode).

Year	Car		Motorcycle or moped	Public transport	Bicycle	Walking
	Driver	Passenger				
1972	20	11	3	17	8	41
1977	27	13	2	17	7	34
1982	31	11	1	17	10	30
1987	36	10	1	15	12	26
1992	38	10	1	16	12	23
1995	39	10	1	16	12	22

Source: Brög (1996), p. 3.

Table 5. Modal-split trends for urban travel in East Germany, 1972–1991 (percentage of total urban trips by each mode).

Year	Car: Driver	Car: Passenger	Motorcycle or moped	Public transport	Bicycle	Walking
1972	6	5	5	23	10	51
1977	9	6	4	25	8	48
1982	12	7	3	24	9	45
1987	16	9	2	24	9	40
1992	33	11	1	15	8	32
1995	37	11	1	14	8	29

Source: Brög (1996), p. 3.

the five years from 1987 to 1992. Public transport, by comparison, fell from 24% to 15% of total urban travel, and bicycling and walking combined fell from 49% to 40%. In the next period, from 1992 to 1995, these trends continued, with the car's share up to 48%, public transport down to 14% and walking and bicycling down to 37%. Thus, in only a few years, the eastern portion of the new re-unified Germany has become as car-oriented as the western portion (48% versus 49% of travel by auto). Corresponding to that increase in car modal split in the eastern part of Germany, car ownership doubled between 1988 and 1992, and public transport ridership fell by 56%. Since 1992, however, public transport ridership has stabilized somewhat, declining by a relatively modest 6%. Thus, the level of public transport use there is currently less than half what it was before reunification. It is truly amazing how quickly the much more public-transport-oriented system in socialist East Germany was replaced by the more car-oriented system of West Germany. In less than a decade, travel behavior has been completely transformed.

2.2. *Aggregate land-use trends*

With 229 persons per square kilometer, Germany is one of the most densely populated countries of Europe, surpassed only by Belgium and The Netherlands. The contrast is even greater with the USA, whose population density is less than one-eighth the German level (28 versus 229 persons per sq. km). In addition, Germany is a highly urbanized country, and its cities and urban agglomerations are quite compact and densely populated. The largest German cities are not more densely populated than other large European cities, but they are much denser than the largest American cities. In their comparative study of 32 world cities, Newman and Kenworthy (1989) found that population and employment densities for central business districts, inner residential areas and suburbs were about the same for German and non-German cities in Europe, but roughly four times as high as for American cities. For example, the overall population density of German cities was 54 persons per hectare, compared to only 14 persons per hectare in the 10 largest American cities. Overall employment density in German cities was 32 jobs per hectare in 1980, compared to only 7 jobs per hectare in American cities.

Not only are urban areas in Germany denser than in the USA, but the extent of suburbanization is much less. Newman and Kenworthy found an average of 31% of all metropolitan population living in German central cities (compared to 26% in the US) and 51% of all metropolitan employment in German central cities (compared to only 36% in the US). Moreover, the German suburbs are much denser than American suburbs – about four times as dense – with 47 persons residing per hectare (versus 11 in US suburbs) and 20 jobs per hectare (versus only 5 in the US).

In a partial update to that earlier study, Kenworthy *et al.* (1997) essentially confirm the 1980 results, but find that the differences between Germany and the USA have narrowed somewhat. For example, inner city population density in German cities in 1990 is found to be only about two-and-a-half times that in American cities (85 versus 36 persons per hectare), and suburban population densities are slightly less than four times higher in Germany than in the USA (40 versus 12 persons per hectare). Although German cities and suburbs remain much denser and more compact than their American counterparts, they appear to be decentralizing and becoming less dense over time.

Thus, the trend toward decentralization throughout Europe and North America can also be found in Germany (Heidemann *et al.* 1993, Jansen 1993). Increasingly, one finds shopping centers and office complexes near the edges of cities, rather than in the center, and German suburbs are generally growing faster than their central city counterparts. The 1993 OECD study of urban travel and land-use trends from 1970 to 1990 included seven German cities: Düsseldorf, Freiburg, Heidelberg, Berlin, Lübeck, Weimar and Schwerin. All the German cities reported an increasing proportion of their metropolitan area population living in the suburbs and a declining proportion of metropolitan area jobs located in the central business district (Sharman and Dasgupta 1993).

The increased decentralization of German cities makes the provision of public transport more difficult. As German cities begin to spread out into the surrounding areas, trip lengths increase and radial traffic focused on the city center becomes relatively less important. Cross-commuting is increasing, especially within some of the large urban agglomerations such as the Rhine–Ruhr region, Frankfurt, Munich and Hamburg (Heidemann *et al.* 1993, Jansen 1993). The relative advantage of car travel is greatest precisely for those sorts of trip from one non-central location to another. That is probably one explanation for the rapid growth in car use.

East German cities have a rather different structure. Suburbanization under socialism was driven not by the market, but by the decisions of ministry bureaucrats and planners who located almost all new residential construction at the outermost periphery of the city, where land was most available. Thus, in the former East Germany, as in Poland, Hungary, the former Czechoslovakia and the former Soviet Union, massive, high-density apartment complexes ring virtually every city. Because there was almost no coordination between housing and industrial location, the journey to work was quite long and time-consuming. Moreover, the peripheral apartment complexes were never adequately supplied with recreational, educational, medical and shopping facilities, so that long trips into the city center were necessary for those purposes as well. The current trend in East Germany is toward ever more commercial facilities on the fringe to service the population that lives there. That will probably reduce trips to the central city and greatly increase the amount of cross-commuting between the suburbs. Both developments are likely to encourage more car use and less reliance on public transport.

3. Case studies of developments in selected cities

In order to get a better feel for what is actually going on at the local level, we examine a few individual cities in more detail. Three of the cities have been chosen precisely because they are generally considered to be among the most progressive cities in their transport and land-use planning: Münster (Westfalen) in north-west Germany; Freiburg (Breisgau) in south-west Germany; and Munich (Bavaria) in south-east Germany. Although these three cities have been particularly successful at increasing public transport use, bicycling and walking, they are not so unusual as to be atypical. On the contrary, virtually every German city has implemented similar transport and land-use policy measures, and some have been equally successful. Most cities, however, have not gone quite as far in promoting public transport and bicycling or restricting car use.

As a contrast to the three model case studies, we also examine briefly a more car-oriented metropolitan area in Germany, the Rhine–Ruhr region, which is really a metropolitan conurbation rather than a single urban area. Because it is also the region best served by autobahns, it may provide some lessons about the impacts of limited access highways in those rare instances in Germany where they do provide important commutation routes within metropolitan areas.

3.1. *General information on the cities*

The three model cities chosen cover quite a population range. Freiburg has about 180 000 inhabitants and serves as the economic, cultural and political center of the Black Forest region of south-west Germany, which has a population of about half a million. Its economy is based on tourism, university teaching and research, government and church administration, and a broad range of services provided to the surrounding region. The development of Freiburg has been favored by its ideal climate – sunnier and warmer than any other major city in Germany – and by its key location at the gateway to the Black Forest and less than an hour's travel from Switzerland and France.

Münster has about 270 000 inhabitants and has long been the administrative capital of Westfalen, just north of the Ruhr region, in the north-eastern part of the state of Nordrhein-Westfalen. It has the third largest university in Germany, with over 45 000 students. Similar to Freiburg, its economy is based on services, government administration, education and finance. It is much less focused on tourism than Freiburg. Although considered one of Germany's most beautiful cities, its climate is so unpleasant that it is often referred to as the 'rain hole' (*Regenloch*) of Germany, and the surrounding countryside is almost completely flat, in contrast to the mountains surrounding Freiburg on all sides.

Munich is the world-renowned capital of Bavaria, with about 1 245 000 residents in the city itself and a total metropolitan area population of 2 418 000, making it Germany's third largest city after Berlin and Hamburg. Munich is probably most famous for its beer and BMW cars, but its economy is very diverse, including government administration, education, research, light industry and a wide range of services. Munich is even more important than Freiburg as a center of tourism, and is included on virtually every foreign tourist's itinerary through Germany.

All three cities have long histories, having been founded over a thousand years ago. Their central cities thus reflect centuries of existence as compact, walled cities during the Middle Ages. Even with technological advances, population growth and the demolition of city walls, the cities remained dense settlements through the early twentieth century, partly due to the overall scarcity of land in Germany.

The three cities share one other sad historical event. Their central areas were almost completely destroyed in Allied bombing raids during the Second World War and had to be rebuilt. Although it was impossible to rebuild the three cities exactly as they had been prior to the war, they managed to resurrect much of the old urban form instead of adopting a modern, car-oriented structure. Freiburg and Münster, in particular, deliberately chose to preserve their historic layouts of narrow, winding streets, pedestrian passageways and monumental squares in their old towns, thus ensuring the continued feasibility of walking and bicycling in their central districts. Partly because of its sheer size, there was more modernization in Munich. But there, as well as in Freiburg and Münster, impressive efforts were made in the 1970s and 1980s to establish extensive car-free pedestrian zones that greatly enhanced the attractiveness and safety of walking, thus improving pedestrian facilities over their prewar condition.

The decision in all three of these cities to rebuild many destroyed structures and retain historic street patterns was probably the most important land-use policy they undertook and is certainly one reason for the success of public transport, bicycling and walking in the succeeding decades. As mentioned later, many other land-use and development policies have reinforced this basic land-use decision.

The Rhine–Ruhr region is about 150 km south-west of Münster; the grouping of cities in the region is best known for mining and heavy industry, severe air and water pollution, rather unattractive cities and large working-class populations. Indeed, the Ruhr has always been the most important industrial center in Germany, since the beginnings of the Industrial Revolution in the early nineteenth century. The south-western part of the Rhine–Ruhr region is the area around Düsseldorf, the capital of Nordrhein-Westfalen and an important European fashion center. Although it also contains much industry, its economy is far more diverse than the Ruhr cities to the north and east. Including that portion of the Rhineland around Düsseldorf, the Rhine–Ruhr is the most populous urban agglomeration in Germany, with 7·5 million residents. The region includes 24 separate cities, the most important being Essen, Dortmund, Duisburg, Bochum, Wuppertal and Düsseldorf. The exact boundaries of the region are highly debatable, but for the purposes of this paper, we set them equal to the service area of the Verkehrsverbund Rhine–Ruhr, the metropolitan-wide public transport system that serves the entire region, encompassing 5026 sq. km.

In contrast to Freiburg, Münster and Munich, the Rhine–Ruhr region is distinctly polycentric, generating dispersed travel patterns that are not focused on any single city center. Moreover, the region is criss-crossed with numerous autobahns and other major national highways, some of which pass directly through or near the various city centers. Most cities of the Rhine–Ruhr region, which were also destroyed during the Second World War, were more extensively modernized and adapted to the car during their reconstruction, partly because they were less historically interesting and less scenic even before the war. Nevertheless, even cities in the Rhine–Ruhr region have undertaken massive efforts to expand and improve public transport services, and their fully integrated public transport system (Verkehrsverbund Rhine–Ruhr) offers the most attractive fare structure in Germany.

3.2. *Travel trends in the selected cities*

Corresponding to the strong trends toward increased car ownership and use in all of Germany, car ownership and use have also risen dramatically in each of the case-study cities. Precise figures are not available for all the cities, especially for vehicle

Table 6. Public transport passenger trends in Munich, Münster, Freiburg and Rhine–Ruhr (millions of passenger trips per year).

Year	Munich (*a*)	Münster (*b*)	Freiburg (*c*)	Rhine–Ruhr (*d*)
1975	405			
1980	451	20	28	643
1985	485	19	34 (57)	692
1990	507	19	45 (64)	1045
1995	529	32	66 (92)	1077

Notes: (*a*) All figures for Munich are for the Münchner Verkehrsverbund, the regional public transport system created in 1972 to serve the entire region. (*b*) Münster does not have a Verkehrsverbund, but a slightly less integrated regional form of cooperation, a Verkehrsgemeinschaft. These passenger figures include only the central Münster bus system and none of the suburban firms. (*c*) The figures in parentheses are passenger totals that include all regional services — i.e. suburban rail and bus, as well as city rail and bus services. (*d*) The Verkehrsverbund Rhein–Ruhr, a regional public transport organization, provides integrated services throughout the area, including bus, tram, metro and suburban rail.

Sources: Public transport systems in each individual city.

Table 7. Modal-split trends for Freiburg, 1976–1994 (percentage of total trips by each mode).

Year	Car	Public transport	Bicycle	Walking
1976	39	14	12	35
1989	37	20	21	22
1994	36	21	22	21

Source: Stadtwerke Freiburg (1996).

and passenger kilometers of car travel in individual cities. All interviews, however, confirmed the impression of rapid increases in the amount of car travel, and a few cities provide specific figures on increases in car ownership. In Freiburg, for example, car ownership grew from 248 cars per 1000 residents in 1970 to 422 cars per 1000 residents in 1990 (Pucher and Clorer 1992). In Munich the rate of car ownership rose from 286 cars per 1000 residents in 1972 to 529 per 1000 residents in 1995 (Münchner Verkehrs-und Tarifverbund 1996). In Münster the rate increased from 290 cars per 1000 residents in 1975 to 521 cars per 1000 residents in 1991 (Stadt Münster 1994). Thus, the rate of car ownership has roughly doubled in each of the case-study cities over the past 20 years.

In light of the rapid increases in car ownership, it is all the more impressive that public transport use has been increasing in all three of the case-study cities, and also in the Rhine–Ruhr region with its dense network of autobahns. As shown in table 6, the number of passenger trips on public transport (including suburban rail) rose from 1980 to 1995 by 17% in Munich, by 55% in Münster, by 136% in Freiburg and by 67% in the Rhine–Ruhr region.

Tables 7–10 provide detailed modal-split breakdowns for each of the four case-study regions over the past 20 years, indicating how the percentage of total travel by each transport mode has changed over time. Perhaps the most striking trend is the increase in public transport's share of modal split in all three of the model case studies. Even in the autobahn-intensive Rhine–Ruhr conurbation, the percentage of travel by public transport has remained quite high, falling from 15% in 1976 to 11% in 1990 but rebounding back to 15% in 1994 and 1996 (see table 10). Perhaps most impressive is the trend in Munich, where public transport's share of all travel rose steadily from 19% in 1976 to 25% in 1995 (see table 9). Equally impressive, the percentage of travel by bicycling more than doubled (from 6% to 14%), reflecting the enormous investment in bike lanes and bikeways throughout Munich. By contrast, the car's share of travel fell from 42% to 40%.

The modal split distributions for Freiburg and Münster reflect their smaller size, shorter trip distances and, thus, greater relative importance of bicycling and walking (see tables 7 and 8). That is most striking in the case of Münster, where over half of all trips are by walking (22%) or bicycling (32%). Münster, in fact, is the most bicycle-oriented city in all Germany, with 40% of all non-pedestrian trips by bicycle. The modal-split share of public transport rose considerably in Münster between 1990 and 1994 (from 7% to 10%), mainly due to the introduction of sharply discounted semester tickets for university students. The shift of some students from bicycle to public transport caused bicycle modal split to fall from 34% to 32% of all trips. The net result, however, was favorable, as the car's share of modal split fell between 1982 and 1994 from 39% to 37%. The car's share of total travel fell in Freiburg as well, from 39% of all trips in 1976 to 36% in 1994. Increases in bicycling and public transport use were more striking in Freiburg than in Münster. Indeed, bicycling almost doubled, rising from 12% to 22% of all trips. Public transport modal split rose by 50%, from 14% to 21%.

Table 8. Modal-split trends for Münster, 1976–1994 (percentage of total trips by each mode).

Year	Car	Public transport	Bicycle	Walking
1976	39	7	29	25
1989	38	7	34	21
1994	37	10	32	22

Source: Stadtplanungsamt Münster (1995).

Table 9. Modal-split trends for Munich, 1976–1995 (percentage of total trips by each mode).

	Car					
Year	Driver	Passenger	Motorcycle and mopeds	Public transport	Bicycle	Walking
1976	29	13	2	19	6	31
1982	30	8	1	22	10	29
1989	31	9	0	24	12	24
1992	29	7	0	25	15	24
1995	30	8	0	25	14	23

Source: Socialdata (1996).

Table 10. Modal-split trends for Rhine–Ruhr metro area, 1976–1996 (percentage of total trips by each mode).

Year	Car: Driver	Car: Passenger	Motorcycle and mopeds	Public transport	Bicycle	Walking
1976	28	12	1	15	5	38
1982	33	11	1	13	8	34
1990	41	11	1	11	7	29
1992	40	12	1	13	6	28
1994	39	12	1	15	8	25
1996	39	13	1	15	7	25

Source: Socialdata (1996).

The modal shifts in Münster, Freiburg and Munich have gone against the general trend toward increased car use. As described below in section 4 on policy, the move toward lesser reliance on the car has been brought about by a range of public policies deliberately aimed at greater use of public transport, bicycling and walking. Without those policies, car modal split almost certainly would have risen, as elsewhere.

3.3. *Land-use trends in the selected cities*

There is very little statistical information available on the extent of suburbanization and the compactness of urban and suburban development in the individual case-study cities. Nevertheless, interviews with city officials and planners clearly indicated substantial increases in suburban development in recent years. That development often takes the form of rapid growth in independent towns and villages at the urban fringe which are captured in the outward spreading commutation radius of the main urban center.

As suggested by the suburban density statistics reported earlier for Germany in aggregate, suburban development is a much higher density than in American cities. Thus, although metropolitan areas are indeed spreading out into the countryside, development remains relatively compact, and the monocentric orientation towards the main city center continues to dominate (with Rhine–Ruhr being an obvious exception).

Suburban developments are more difficult to serve with public transport than central cities. Public transport managers and urban planners in all the case-study cities lamented the problems caused by increasing suburbanization. Whereas they rejoiced in the success of their central city transport networks, they acknowledged the sharp limitations they face in the growing fringe settlements. The extensive surburban rail systems in Germany provide ever better radial linkages between the suburbs and the central city, but there is almost no cross-suburban service. Thus, almost all motorized travel within and between suburbs is by car, just as in the USA. Since most growth in travel demand is precisely for such suburban-oriented trips, the future promises to be challenging for public transport.

4. Urban transport policies

Whereas car use and car modal split have been rising in most of the world's cities, our three case-study cities have at least succeeded in reducing car modal split.

Moreover, Germany as a whole has managed to keep public transport use quite stable and has avoided the sharp increase in car modal split observed in many other countries. The trends in travel behavior and land use in Germany in aggregate, and the case-study cities in particular, have resulted largely from deliberate public policies that have limited car use, and made it more expensive, while promoting public transport, bicycling and walking. We examine in this section the range of transport policies, which together have been so successful at controlling car use. It is the coordination of these transport policies with one another and with land-use and housing policies that has been key to overall success. In the sections that follow, we present an overview of German policies in general, as well as policies in the case-study cities in particular.

4.1. *Improvement of public transport*

One of the crucial aspects of German transport policy over the past two decades has been the steady improvement in public transport. Both the quantity and quality of services has increased. Moreover, the various types of public transport services have been better integrated than ever before, with improved coordination of routes, station stops, timetables and ticketing.

The largest German cities rely on rail lines as the backbone of their route network, and that has been the focus of their efforts to improve the public transport system overall. Smaller cities generally have bus-only systems, but even they benefit substantially from short-distance regional rail services of the German Railroad.

4.1.1. *Metro, advanced light rail and tramway systems*

German cities have a range of rail modes available to them, in addition to the very extensive suburban rail services throughout the country. Only the largest cities have their own full-scale heavy rail metro systems: Berlin, Hamburg, Munich and Nuremberg. Due to their high construction costs, no new heavy rail metro systems are currently planned, but the existing systems have been extended considerably over the past 20 years, and plans foresee further expansions in the future. The most significant expansions are in Berlin and Munich. In Berlin the focus is on providing the key additional links to integrate the two formerly separate U-Bahn systems in West Berlin and East Berlin, but some suburban extensions are also planned. Munich has completed its inner U-Bahn network (at 71 km) and is now extending its radial lines farther out into the suburbs.

Almost all large German cities, and many medium-sized cities, have been building new light rail lines or upgrading old tram (streetcar) lines to grade-separated light rail standards. The advanced LRT systems are usually designated as Stadtbahns or Schnellbahns; they usually have their own rights of way and sometimes are hardly distinguishable from full-scale U-Bahns, especially since many run underground in the city center. In the Rhine–Ruhr region, for example, the Stadtbahn network already covers 227 km of routes, and it is still being expanded (Pucher and Kurth 1995). Freiburg expanded its LRT Stadtbahn from 16 km in 1985 to 23 km in 1995, and further extensions are being built (Stadtwerke Freiburg 1996). In addition, about 50 cities have retained their old tram (streetcar) lines, with shared rights of way, frequent stops and, thus, much slower average speeds than the advanced light rail systems. But even on traditional tram lines, services have improved due to modernization of tracks and other infrastructure, new vehicles and a variety of traffic-priority measures that speed up tram travel in mixed traffic.

Munich has 85 km of tram routes, and Rhine–Ruhr has over 600 km of tram routes.

4.1.2. *Suburban train (commuter rail)*

Regional railroad services are far more important in Germany than in the USA. Indeed, virtually every German city benefits from such services, which were originally operated and financed by the German Federal Railways, but are now being devolved to the states and metropolitan areas. The extent of devolution, regionalization and integration into the rest of the urban transport network varies from city to city. In the largest cities, however, regional rail routes have been integrated more and more into the central city U-Bahn and S-Bahn networks. Munich has the best integrated suburban rail services. Designated as the S-Bahn, they are almost identical in concept and design to the R.E.R. (Réseau Express Régional) suburban rail services in Paris, with many stops shared with underground metro lines (U-Bahn) in the central city, thus making transfers quite convenient. Munich has 510 km of S-Bahn routes fanning out into its suburbs. With over 1600 km of routes, the Rhine–Ruhr public transport system has far more regional rail service than Munich, which is not surprising given the large size of the region and the many cities, towns and villages in the district that need such connections. Freiburg and Münster also are at the center of extensive suburban rail networks serving their entire hinterlands, but in both cases, access to the system is mainly at the central train station, with very few additional stops. At least in Freiburg, as in Munich and the Rhine–Ruhr, the ticketing and scheduling between suburban rail and other public transport modes are fully integrated. In Münster the systems have remained separate because the German Railroad and local public transport system have not yet been able to reach agreement on joint financing.

Overall, however, suburban rail services in Germany have improved considerably over the past 10 years, primarily due to new vehicles, more regularly scheduled services (i.e. every 10 or 20 minutes at the same time after every hour), better service integration and uniform ticketing, which allows travelers to use the same ticket for all public transport modes.

4.1.3. *Park-and-ride and bike-and-ride*

Virtually every rail system in Germany has been expanding its park-and-ride facilities to attract those riders living in low-density areas outside of walking distance or convenient bus service from suburban rail, metro or LRT stations. As suburban areas expand, the construction of additional park-and-ride facilities is viewed as crucial to retain those customers moving to the suburbs. For example, Munich has increased the number of parking spaces at its outlying U-Bahn and S-Bahn stations from only 3000 in 1972 to 26 400 in 1995. Many systems are also catering to the other end of the market by providing bike-and-ride facilities and improving pedestrian access to bus-stops and rail stations. In Munich, for example, the number of bicycle-racks at stations now exceeds 28 000 and is steadily increasing. In Freiburg over 1500 bike-racks are available at LRT stops, and bicycle parking at the main train station can handle 850 bikes. In Münster, the problem of bicycle parking at the main railroad station is so severe that an underground parking garage is now being built to handle 3000 bikes (Stadt Münster 1996). In short, much has been done to facilitate access to rail services.

4.1.4. *Bus services*

Although hardly as dramatic as new rail systems, bus services have also been improved in most German cities. The bus fleet has been completely modernized, featuring mostly low-floor vehicles (for easy boarding) with large windows and comfortable seating. Moreover, virtually all cities have introduced a variety of measures to give buses priority in traffic. Separate bus lanes, bus turnouts and loading bays, access ramps and bus-activated traffic signals (giving buses the green light) have both speeded up bus travel and reduced operating costs. These *Beschleunigungsmassnahmen* ('speed enhancement measures') have been quite successful, which accounts for their rapid spread. Finally, transfers among as well as between bus lines and rail services have been greatly facilitated by special transfer stations, which make transferring simpler than previously. Better coordination of schedules has also reduced the time for transferring. Every city relies heavily on buses, so that these improvements in bus travel are crucial. Most small cities have only bus services, and even the largest cities depend on buses to serve low-density areas and to bring passengers to rail routes.

Of course, the same holds for Freiburg, Münster, Munich and the cities in Rhine–Ruhr. The improvements were especially important for Münster, which has a bus-only system (except for suburban rail). From 1985 to 1995, the route network in Münster was only slightly expanded, but the network configuration, bus scheduling and bus speeds were so much improved that the overall impact was considerable, attracting 58% more passengers with almost no increase in subsidy.

4.1.5. *Overall service supply*

Different cities provide different indices of total public transport service supply thus making intercity comparisons and aggregate summations difficult. Nevertheless, the available supply indices clearly indicate considerable overall service expansion in all the case-study cities. Munich, Rhine–Ruhr and Freiburg, for example, report total place kilometers of service, a measure which takes into account the larger capacity of rail vehicles and different sizes of buses, and reflects both seating and standing room. From 1980 to 1995, place kilometers of service increased from 16·0 billion to 23·8 billion in Munich (+49%), from 32·6 billion to 36·3 billion in Rhine–Ruhr (+11%) and from 565 million to 858 million in Freiburg (+52%). Large service expansion in Munich appears to have offset the fare increases there. In Münster service supply is measured by bus kilometers, which increased from 5·9 million in 1980 to 7·1 million in 1995 (+20%).

4.1.6. *Public transport fare structure*

One important reason for ridership increases over the past 10–15 years is the introduction of innovative, highly attractive fare structures on most German public transport systems. Whereas regular one-trip fares can be quite high (3·30 DM in Munich), weekly, monthly, semester and annual tickets for regular riders are generally inexpensive, thus permitting very low per trip fares for most public transport riders in Germany. Indeed, precisely because the monthly, semester and annual tickets are a bargain, users of such tickets account for the great majority of riders on public transport systems.

We provide just a few examples of fare levels in the case-study cities. The standard monthly ticket in Rhine–Ruhr, the so-called 'Ticket 2000', costs only 65 DM (German Marks), or about $40, for an entire month of unlimited travel within the first fare zone. For 130 DM (about $81), the monthly ticket permits unlimited travel across all three fare zones and, thus, throughout the entire 5026 sq. km region. The tickets are good on all modes, including suburban rail. If the monthly tickets are purchased for the entire year, an additional 20% discount if offered, leading to an even more attractive price of 54 DM ($34) for the inner zone and 109 DM ($68) for the entire region. The Ticket 2000 is transferable to anyone, so the ticket can be shared by several persons taking trips at different times. Moreover, at off-peak times (evenings and weekend), a single ticket suffices to transport the holder, up to three children, a bicycle and a dog at no additional cost.

As if the Ticket 2000 were not attractive enough, other discounts are also available. Students pay only 85 DM ($53) per semester for unlimited travel within the region, which represents a monthly cost of only 20 DM ($13), a great bargain. Many firms subsidize the monthly tickets of their employees, enabling them to purchase the Ticket 2000 for less than half its already low price: 24 DM ($15) for the first zone pass and 50 DM ($31) for unlimited travel in the entire region.

Rhine–Ruhr is exceptional in the extremely low prices of monthly, semester and annual tickets, but all of the other case-study systems also offer attractive fare structures, at least for regular riders. In Münster the regular monthly ticket costs 66 DM ($39) for the extensive inner zone, which includes both the city and innermost suburbs. If purchased for the entire year, the monthly ticket costs 58 DM ($34). University students pay only 63 DM ($37) per semester for unlimited travel in the same large inner zone. As in most German university towns, the cost of the monthly ticket is included as a regular part of compulsory student fees and is thus paid whether the students use public transport or not. In effect, the marginal price of public transport is zero, offering a very strong incentive for students to use public transport.

In Freiburg, the monthly ticket costs 64 DM ($38) and allows unlimited travel in the large region surrounding Freiburg, extending far into the Black Forest to the east and toward France in the west. Students and apprentices pay only 47 DM ($28) for the same ticket.

The fare structure in Munich is so complicated that it is almost impossible to summarize with any sample figures. It has 9 inner fare zones, 20 outer fare zones and 134 different fare zone combinations, each requiring a different fare. Moreover, Munich offers 24 different kinds of ticket, varying by age-group, type of education and training, degree of handicap and time of day. Although it certainly offers a wide variety of choice, Munich's fare structure seems overly complicated and its average fare per passenger trip (taking into account various discounts) is 36% higher than for Rhine–Ruhr: 1·21 DM versus 0·89 DM (Pucher and Kurth 1995).

In many German cities, the deeply discounted monthly tickets are designated as environmental tickets, emphasizing the pollution, noise and congestion reduction derived from public transport use. Freiburg, in fact, was the first city to introduce the environmental ticket (*Umweltkarte*) in 1984. It was so successful at attracting more riders that many other cities adopted the same approach of marketing public transport as an environmentally friendly mode. For the customer, the monthly environmental ticket combines the advantages of a low fare with the satisfying feeling that one is helping to improve the environment.

4.1.7. *Regional transport organizations*

Germany has been at the forefront of regional coordination of public transport services in urban areas (Pucher and Kurth 1995). Starting with Hamburg in 1967, an increasing number of German cities have established various organizational forms of regional cooperation and integration (German Ministry of Transport 1988d). By 1990, virtually all West German cities had integrated their public transport systems. The two most important organizational forms are the Verkehrsverbund and the Verkehrsgemeinschaft. Both types of public transport agency enable fully integrated route networks, timetables and fare structures. From the perspective of the passenger, it is as if only one firm were providing all public transport services within each German metropolitan area. The same ticket or monthly pass can be used for any mode of public transport in any part of the region. Route maps, timetables and service standards are uniform. Transfers among modes and routes are easier, both due to physical coordination of services (spatially and temporally) and to the zone-based unification of the regionwide fare structure, which allows passengers free choice of modes and routes (including suburban rail services).

In Freiburg, Munich and Rhine–Ruhr, all public transport services are organized, coordinated and financed by large Verkehrsverbund systems covering extensive service areas that encompass even distant suburbs and related towns. Both services and fares are fully integrated over expansive regions, including some rural areas. Münster's system is a Verkehrsgemeinschaft, with a lesser degree of integration but still substantial coordination, except for suburban rail services, which remain completely separate in Münster, in contrast to the other three cities.

Regional coordination of public transport services has greatly enhanced the quality of public transport in Germany. In most cities, coordination has achieved ridership growth or at least a slowdown in ridership loss. Nevertheless, it has not succeeded in reducing costs or subsidy needs (German Ministry of Transport 1988d). Indeed, the total operating subsidy for urban public transport in Germany grew especially fast during the late 1960s and the 1970s, when most regional transport agencies were formed. Some of that subsidy increase was due to service expansion and fare discounts; it is unlikely that regional coordination in itself caused deficit growth.

4.1.8. *Financing public transport*

Throughout Europe, it has required substantial subsidy growth to finance the range of service improvements and fare reductions necessary to increase public transport ridership. That has become a considerable problem in recent years, with increasing strains on government finances at every level and in every country, including Germany.

In general, operating subsidies in Germany are financed by local government and city-owned public utilities; special fare reductions are financed by state (provincial) government; and capital subsidies are financed mainly by the federal government, with state and local contributions. Until 1995, all subsidies for suburban rail services were paid by the federal government; since devolution, however, states and metropolitan regions are now responsible for covering these costs. As part of the devolution deal, the federal government agreed to provide the states with additional funds each year to cover the suburban rail subsidy (e.g. 12 billion DM, or $7·5 billion, in 1997). Overall, 54% of the subsidy burden is borne by the federal government, 22% by the states and 24% by local governments (German Parliament 1997).

The exact details of public transport finance in Germany are rather complicated, but the total burden of subsidy finance is substantial, amounting to 32·4 billion DM ($20·3 billion) in 1993, the latest year for which the German government has calculated complete subsidy statistics (German Parliament 1997). Indeed, the German subsidy level exceeds the subsidy to public transport in the USA ($17·5 billion), a country many times larger. Thus, the public transport subsidy per capita is four times larger in Germany than in the USA ($248 versus $67 per year). Moreover, the combined operating and capital subsidy per passenger trip averages 3·48 DM ($2·17), with passenger fares covering only 40·3% of operating costs. Not only are public transport subsidies in Germany large, they have been growing at an average annual rate of 5·9%, roughly twice the rate of inflation.

In short, Germany has indeed succeeded in improving public transport services and offering attractive fares, but at considerable taxpayer cost. Currently, the federal and state governments in Germany are struggling with serious budget crises. The federal government, in particular, must reduce its budget deficits in order for Germany to qualify for European monetary union in 1999. It seems questionable, therefore, whether the German public sector will be able to afford to be so generous to public transport in the future.

4.2. *Improvement of pedestrian and bicyclist facilities*

With 30–40% of urban travel in Europe by walking or bicycling, facilitating these two important non-motorized modes of transport has been crucial. Together with The Netherlands and Denmark, Germany has been at the forefront of efforts to improve the convenience, speed and safety of walking and bicycling.

4.2.1. *Car-free pedestrian zones*

In virtually all German cities, as well as many smaller towns and villages, there is an interlocking system of streets in the old town center and main shopping district that is almost completely off-limits to private cars (Hajdu 1989, Hass-Klau 1992, 1993). Most of those zones enhance pedestrian and bicycle access to the heart of the city while keeping cars at a distance, forcing them to park in fringe lots and garages. By contrast, public transport is allowed direct access to this central zone, although buses and trams are usually required to travel at reduced speeds to ensure the safety of pedestrians and bicyclists. Freiburg, for example, has 8·5 km of streets off-limits to private cars in its central district. Münster has 5·5 km of pedestrian streets in the city center and another 11 km of streets with partially restricted car use. Likewise, many important shopping streets, squares and plazas in Munich restrict access by private cars.

4.2.2. *Traffic calming*

Especially since 1980, most West German cities have reduced speed limits in urban residential areas to 30 km per hour (19 m.p.h.) and have further discouraged car traffic by narrowing streets, increasing the number of curves and installing speed bumps, posts (bollards), concrete planters, wider pavements (sidewalks) and bicycle lanes. Such traffic-calming measures are aimed at reducing car use or, at least, making it less dangerous for pedestrians and bicyclists. Speed limits and other traffic regulations within cities are strictly enforced not only directly by police officers, but also by remote cameras that monitor traffic and automatically photograph cars speeding, failing to stop or to yield right-of-way, or violating various other regulations.

In Freiburg, all residential neighborhoods have been traffic-calmed, with pedestrians, bicyclists and cars having equal rights to use roads in their full breadth, with cars required to limit their speeds to no more than 30 k.p.h. (19 m.p.h.) and to avoid endangering pedestrians and bicyclists using the roadway. Münster and Munich have been increasing the number and extent of traffic-calmed neighborhoods, but they remain somewhat behind the pathbreaking policies in Freiburg.

4.2.3. *Bikeways, bike lanes and bicycle parking*

Münster has been the unchallenged leader in policies promoting bicycle use in Germany. It has not been satisfied with resting on its past record of having the highest level of bicycle use in Germany. On the contrary, Münster has vigorously built on its past successes by expanding its system of bikeways and steadily introducing new innovations to promote more bicycle use. For example, its network of integrated bicycle paths was expanded from 145 km in 1975 to 252 km in 1995, with most paths separated from car and pedestrian traffic. Münster even has a major bicycle expressway that encircles the city center along the route of the old city wall. In addition, bicyclists benefit from over 300 km of bike paths over lightly traveled roads restricted to local traffic, mostly used by farm vehicles. (Agricultural fields not only surround Münster, but also occupy a substantial part of the city area itself). Moreover, most local residential streets in Münster can be safely used by bicyclists, thanks to traffic-calming measures that give bicyclists and pedestrians right-of-way priority and restrict car speeds to 30 km per hour (19 m.p.h.). Other innovations in Münster include *Fahrradstrassen*, or special bicycle streets, which permit car traffic but give bikes right of way; *falsche Einbahnstrassen*, streets that are one-way for cars but two-way for bicyclists; street networks with artificial dead ends and circuitous routing for cars but direct, fast routing for bicyclists; bus lanes that can be used by bicyclists but not by cars; freedom for bicyclists to make left and right turns where prohibited for cars; and a variety of measures giving bicyclists preferential treatment at intersections, generally intended to speed up bike travel and make it safer.

The success of bicycle policies in Münster has promoted their spread to many other German cities. There is a regular exchange program among cities to share knowledge and experiences with bicycle policies, and Münster is generally seen as the model to follow. Freiburg, for example, has adopted many of the innovations pioneered in Münster: *falsche Einbahnstrassen*, *Fahrradstrassen* and special traffic-priority measures for bicyclists at intersections. Moreover, Freiburg has also invested considerably in its bikeway network, which currently includes 145 km of completely separate bikeways and bike lanes, supplemented by 120 km of bike paths through woods and agricultural areas and 130 km of bike routes on local streets with minimal traffic. As mentioned previously, all residential neighborhoods in Freiburg have been traffic-calmed, which also enhances bicycle use. Similar to Münster and Freiburg, Munich has doubled the extent of its bikeway network since 1980 and currently offers 456 km of grade-separated bikeways along streets, 51 km of bike lanes on streets and 137 km of bikeways through parks, woods and nature reserves.

Virtually all German cities have been expanding bike-parking facilities. In Freiburg, for example, the number of bike-racks in the city center increased from 2200 in 1987 to 4000 in 1996. Since there are more bicycles than residents in Münster, it would not be practical to provide bike-racks in the city center for all bicyclists, and most bikes are simply parked any way possible. Nevertheless, the city already has 6226 bike-racks in the city center and is currently building an underground bicycle-parking facility at the main train station that will handle 3000 additional bikes.

Münster has also been introducing innovations in bike parking, including special rack designs, rack roofing and bicycle lockers at key transport nodes. Bike repair and rental services are provided at some large parking facilities.

4.3. *Policies toward car use*

At the same time as German cities have greatly improved public transport, bicycling and walking, they have restricted car use and made it increasingly expensive. That has provided a double incentive to use the so-called 'environmental modes'. We have already mentioned a variety of measures that have directly restricted car use by favoring bicyclists, pedestrians and public transport users: bus lanes, bike lanes, car-free pedestrian zones, traffic-calming, right-of-way priority and signal priority for non-car modes. Each of those measures either removes roadway space from cars or restricts their speed and right of way. German cities have also been implementing various other policies that yet further discourage car use, especially in the inner city.

4.3.1. *Car-parking policies*

Parking in German cities has become more difficult and much more expensive since 1980 (Topp 1993). In most cities, the price of on-street metered parking increases considerably with proximity to the city center. The largest cities now charge 5 DM per hour for car parking in the center, roughly equal to the price of a round trip by bus, tram or metro. In Freiburg, a medium-sized city, metered parking costs 4 DM per hour in the historic core, 3 DM per hour in the zone just outside the core and 1 DM per hour in the outlying districts. Most free, non-metered on-street parking has been eliminated, except for residential areas, where such parking is generally restricted to residents who purchase car decals entitling them to park in their own neighborhood. Moreover, special parking meters have been installed to prevent long-term parking by commuters in residential neighborhoods. In Münster, all free on-street parking in the city core has been eliminated, and the total number of car-parking places has been reduced. Additional parking facilities have been built outside the city center, thus encouraging drivers to park their cars outside the center and walk or take public transport for the trip to the center. Similar parking policies have been adopted in most German cities. The overall impact has been to make parking a car more expensive and more difficult, at least in the city center.

4.3.2. *Taxes on car ownership and use*

Local policies making car use more expensive have been complemented by national policies that make owning and driving a car increasingly expensive. Germany imposes considerable taxes on car ownership and use. Even in 1989, before various tax increases, total roadway user taxes by all government levels in Germany were more than double the total public expenditures on roadway construction, maintenance and administration (International Road Federation 1991). Since 1990, taxes on car use have been raised considerably. Most recently, the petrol tax was raised by 0·16 DM (about \$0·10) per liter on 1 January 1994, bringing the total tax to 0·98 DM per liter (about \$3 per gallon). That tax rate is roughly average for Western Europe but six times as high as in the USA.

The result of high petrol taxes is obviously high petrol prices. As shown in table 11, petrol prices were 3·4 times higher in Germany than in the USA in 1995, and almost all the difference is due to the high taxes in Germany, which account for 78% of the final retail price of petrol.

There is also an annual motor vehicle excise tax, ranging from 13·20 DM to 45·50 DM per cc engine size. The total tax depends on the size of the motor, whether it is petrol- or diesel-powered, and whether its emissions are high or low.

4.3.3. *Slowdown in roadway expansion*

As shown in table 12, urban roadway capacity has grown considerably over the past four decades. The fastest growth was from 1960 to 1970 (+19%), with successive slowdowns from 1970 to 1980 (+14%) and 1980 to 1990 (+6%). The slowdown in roadway construction reflects the new philosophy of limiting and channeling car use rather than accommodating it. Moreover, fiscal constraints and opposition from environmental and community groups have also limited roadway expansion.

In all of our case-study cities, considerable improvements have been made to the urban roadway network over the past two decades. The rapid growth of Munich has

Table 11. Comparison of petrol prices and taxes in Germany and the USA.

	Germany			USA	
Year	US dollars per liter	Tax as % of price	Ratio of petrol prices, Germany/USA	US dollars per liter	Tax as % of price
1978	0·462	58	2·6	0·177	19
1981	0·628	46	1·7	0·380	11
1983	0·538	50	1·5	0·362	21
1985	0·490	49	1·5	0·318	23
1989	0·583	64	2·2	0·270	29
1991	0·767	68	2·5	0·301	33
1993	0·812	74	2·8	0·293	31
1995	1·047	78	3·4	0·304	33

Source: Energy Prices and Taxes, International Energy Agency, OECD, Paris, quarterly from 1988 to 1996 (IEA 1988–1996).

Table 12. Supply of roadways in Germany, 1951–1996 (thousands of kilometers).

	Interurban roadways		
	Autobahns	Total	Urban roads
1951 (a)	2·1	127·6	217
1960 (a)	2·5	135·3	227
1970 (a)	4·1	162·3	270
1980 (a)	7·3	171·5	308
1990 (a)	8·8	173·9	325
1993 (a)	9·1	174·1	331
1993 (b)	11·0	215·8	413
1996 (b)	11·2	217·7	N/A

Notes: (a) Only West Germany; (b) both East and West Germany.
Source: German Ministry of Transport, *Verkehr in Zahlen* (annual, 1982 to 1996).

made this an absolute necessity; all its successes in raising the modal-split shares of bicycling and public transport have not reduced auto use overall. Freiburg and its surrounding area have also been experiencing considerable population growth and increases in travel volumes. Even slow-growing Münster has had to deal with traffic growth.

The three cities have adopted essentially the same approach to the problem: increasing capacity on key arteries outside the city center and residential neighborhoods, while reducing capacity within the city center and residential neighborhoods. Thus, all cities have widened many of the most important thoroughfares, bypasses and intersections, and improved them in various other ways as well, to increase their vehicle-carrying capacity. By contrast, they have introduced traffic-calming measures in almost all residential neighborhoods, often narrowing streets, creating dead ends, reducing speeds, installing traffic bumps and forcing circuitous routing. Extensive car-free pedestrian zones in the heart of each city exclude private car traffic altogether. The intent, of course, is to divert car traffic away from the city center and residential neighborhoods, while avoiding undesirable congestion on key arterial routes.

Another important factor is the limited supply of high-speed motorways in German cities. Although the German autobahn system is the oldest and second most extensive limited access highway system in the world, it is not primarily used for urban travel. By contrast, in the USA, 61% of total vehicle mileage on Interstate Highways is in urban areas (US Department of Commerce 1996, p. 616). Autobahns often provide bypasses or beltways around German cities; they very rarely pass through the city center. Instead, they primarily serve long-distance intercity travel needs.

In conclusion, one can hardly say that Germany in general, or German cities in particular, are poorly supplied with roadways. On the contrary, the German roadway system is not only extensive, but its quality is at least as high as that in the USA, where many roads are pockmarked by dangerous potholes. The difference is that German cities and their transport systems have been less adversely affected by the disruption of high-capacity limited access highways than in the USA. Autobahns primarily offer interurban and interstate connections and are far less used for daily urban commuting than in the USA. City cores in Germany have far less high-speed roadway capacity (including key arterials) than American cities, and this appears to be a deliberate policy, namely to restrict car use in the center and instead to encourage walking, bicycling and public transport use.

5. Land-use policies

One important factor influencing land-use policies in Germany is that much of the total land area is taken up by urban uses, leaving less land for agriculture, forests and wilderness areas than in larger, less densely settled countries. That scarcity of land has led to a strict overall land-use policy in Germany, which also carries over to urban land-use planning. For example, state and local governments sharply restrict new residential development at the urban fringe. Much privately owned land around cities is zoned exclusively for agriculture, forests, nature reserves or simply open space. Those restrictions greatly limit the supply of land available for urban development, driving up the price of land, and thus encouraging quite dense development. The compactness of urban development, even in the suburbs, obviously facilitates public transport, which relies on high-volume, focused travel corridors.

Thanks to strict zoning over many years, for example, both Freiburg and Münster contain extensive woods, agricultural fields, forest preserves, wildlife sanctuaries and undeveloped open space directly within their city limits, as well as surrounding their built-up area. Within minutes from central Freiburg, pedestrians and bicyclists can reach vineyards, fruit orchards and dense forests. Bicyclists in Münster use paths through the extensive wheat, rye, corn and oat fields in and around Münster. Hundreds of dairy farms surround Münster. The direct proximity of these rural land uses within or near the city obviously makes their potential for commercial development high. Yet government authorities, presumably in agreement with the majority of the population, have chosen to pursue long-term environmental and social goals instead of short-term economic objectives. They have resisted the encroachment of private industrial and residential development into the protected areas. By raising the overall density of development, such land-use policies have also promoted public transport, bicycling and walking.

6. Conclusions

Urban transport policies in Germany show that it is possible to 'tame' the private car by limiting its use in central cities and providing travelers with an attractive choice of alternative transport modes. By offering cheaper and better public transport services, extensive bikeway systems, large car-free zones, and priority rights of way and traffic signalization for bicyeles, buses and trams, Freiburg, Münster and Munich have reduced the percentage of travel by car. That is quite an accomplishment at a time when the car's modal-split share has been increasing almost everywhere else in the world. Although car ownership rates in Germany continue to rise, the social and environmental problems caused by car use are being brought under control.

The key to success in Freiburg, Münster and Munich has been their coordinated, multifaceted approach. In each city, advocates of 'taming' the car carefully garnered the necessary political support for restricting car use and expanding alternative transport modes. Indeed, urban transport has been an important issue in local elections. Thanks to strong support from students, environmentalists, community activists, bicyclists and other opponents of excessive car use, the Social Democrats and Greens have controlled local government in all three cities in recent years. With political support in hand, it was possible to implement a truly coordinated, mutually reinforcing set of policies and programs. Rather than simply punishing car users, the three cities provided a rich, attractive set of alternatives simultaneously with the imposition of restrictions on car use. Another crucial element in the policy shift in each city was an extensive public relations campaign undertaken to explain the reasons for the shift in policy and to provide easily understandable, readily available information on the use of alternative modes. That public information campaign continues unabated, thus consolidating and expanding public support.

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Table 1.6. Trends in auto ownership and use in various OECD countries, 1980 to 1994

Country	Auto ownership per 1,000 population			Kilometers of auto use per capita per year		
	1980	1994	percent increase	1980	1994	percent increase
Austria	299	435	45	3,220	4,175	30
Belgium	321	417	30	4,173	5,376	29
Denmark	271	310	14	4,216	6,250	48
Finland	256	367	43	4,625	6,941	50
France	357	430	20	4,647	6,079	31
Germany	375	489	30	4,310	6,216	44
Great Britain	278	374	35	3,916	6,086	55
Greece	89	199	124	n.a.	n.a	n.a.
Italy	310	528	70	3,338	5,402	62
Netherlands	322	382	19	4,090	5,461	34
Norway	303	385	27	3,980	5,488	38
Portugal	114	357	213	1,745	3,697	119
Spain	202	350	73	1,419	2,878	103
Sweden	356	404	13	5,123	6,124	20
Switzerland	356	452	27	4,580	6,300	38
Japan	204	344	69	2,082	3,304	59
Canada	424	495	17	n.a.	n.a.	n.a.
USA	573	635	11	8,485	9,789	15

Source: Calculated on the basis of data in British Department of Transport (1997), Transport Statistics Great Britain, "International Comparisons," pp. 143-146.

Pucher exhibits (1-12)

PUCHER EXHIBITS

1

(2)

Table 1. Trends in Urban Public Transport Ridership in Europe and North America, 1980 to 1995 (indexed to base year 1980=100)

Country	Year			
	1980	1985	1990	1995
Austria	100	122	128	132
France	100	111	121	120
Germany (West)	100	88	90	104
Italy	100	99	77	72
Netherlands	100	93	105	125
Norway	100	89	85	85
Switzerland	100	107	120	122
Great Britain	100	95	87	75
Czechoslovakia	100	110	115	105
Germany (East)	100	103	82	40
Hungary	100	113	101	78
Poland	100	118	99	76
United States	100	100	102	93
Canada	100	109	116	104

Source: Ministries of transport and public transport associations in the various countries.

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Table 1.8. Modal split for urban passenger travel in Europe and North America, 1995 (as percent of trips, all trip purposes)

Country	Percent of trips by travel mode				
	Auto	Public Transport	Bicycle	Walking	Other
USA	89	2	1	6	3
Canada	76	10	2	10	2
England and Wales	65	14	4	12	5
France	54	12	4	24	6
Italy	52	16	4	24	4
Germany	49	16	12	22	1
Switzerland	46	20	10	24	3
Sweden	46	11	10	29	4
Netherlands	45	7	28	18	2
Austria	45	13	9	28	5
Denmark	42	14	20	21	3

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Source: Ministries of transport and departments of transportation in various countries.
Note: Modal split distributions for different countries are not fully comparable due to differences ir definitions, survey methodologies, and urban area boundaries. The distributions here are intended the approximate differences among countries and should not be used for exact comparisons.

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Table 2. Trends in German Auto Travel and Public Transport Use, 1950 to 1995

	1950(a)	1960(a)	1970(a)	1980(a)	1990(a)	1992(a)	1992(b)	1995(b)
Passenger km by auto (c)	31.1	155.2	352.3	472.5	596.3	612.6	717.2	741.5
(% of total motorized travel)	35.5	64.9	78.5	80.4	84.4	84.1	83.6	84.0
Passenger km by public transport (c)	56.5	83.8	96.5	115.1	109.8	116.2	140.5	140.9
(% of total motorized travel)	64.5	35.1	21.5	19.6	15.6	15.9	16.4	16.0
Urban public transport trips (d)	5,144	6,603	7,015	7,652	6,873	7,296	9,148	9,314
Urban public transport trips per capita	108	118	116	124	108	112	113	114

Notes: (a) includes only Western Germany; (b) both Western and Eastern Germany; (c) billions of units; (d) millions of trips.
Source: German Ministry of Transport, Verkehr in Zahlen, annual, 1982 to 1996.

From: PUCHER, "Sustainable Transport in German Cities"

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Table 2. Total annual passenger trips for five regional public transport systems (Verkehrsverbund) (millions of trips per year)

Metropolitan region	1965	1970	1975	1980	1985	1990	1993
Hamburg	406	435	430	436	417	436	470
Munich		358	405	451	485	507	538
Rhein-Ruhr				901	817	849	1,064
Vienna				443	626	680	724
Zurich					479	616	644

Sources: Individual public transport systems (Verkehrsverbuende) in each metropolitan area; and federal transport ministries in Germany, Austria, and Switzerland.
Note: First-year passenger figures for Vienna (1980) and Zurich (1985) refer to ridership prior to founding of the Verbund and include only the main public transport firm. All other first-year figures are for the Verbund's first full year of operation: Hamburg (1967), Munich (1973), and Rhein-Ruhr (1980).

This table is from the article by Pucher and Kurth, "Verkehrsverbund: The Success of Regional Public Transport in Germany, Austria, and Switzerland."

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Exhibit A. Policies Encouraging Transit Use, Walking, and Bicycling in German Cities

1. Vast improvements to public transport systems
   - physical expansion of systems, esp. metro and LRT systems
   - modernization of bus, tram, metro and suburban rail vehicles and stations
   - superb physical and temporal coordination of all transit services within each metropolitan region through Verkehrsverbund
   - total coordination of transit fares, incl. suburban rail
   - extremely attractive monthly and annual transit passes
   - massive, multi-faceted marketing program to emphasize the environmental advantages of transit

   expanded park-and-ride and bike-and-ride facilities

2. Continual improvement of pedestrian and bicyclist facilities
   - extensive auto-free pedestrian zones
   - traffic calming in residential neighborhoods
   - huge increase in bikeways, bike lanes, and bicycle parking facilities

3. Sharp restrictions on auto use in central cities
   - high price for auto parking and limited supply in central districts, also limited parking time
   - high taxes on auto ownership and use
   - slowdown in roadway expansion
   - auto-free zones, traffic calming, etc. noted above

4. Land-use policies that discourage suburban sprawl
   - much stricter zoning to preserve open space, agricultural areas, forests, etc., near cities
   - much higher price of land, due to limited supply of legally developable land, thus higher density of uses

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EXHIBIT 1. FARE POLICY ACTIONS TO INCREASE TRANSIT RIDERSHIP

1. **Deeply discounted monthly/semester/annual tickets for regular users**
    a. Environmental tickets
    b. Regular monthly tickets, with extra discount if for full year
    c. Student semester tickets purchased at deep discount through regular university fees
    d. Extra discount on monthly tickets via company subsidy negotiated with transit system to finance lower price for employees (usually tax deductible for firm)

2. **Combination tickets that include transit fare as part of entrance fees for mass events** (sports events, conventions, concerts, amusement parks, etc.), with no extra cost for attendees using transit (negotiated payment by event sponsors to transit system)

3. **Wide range of other ticket types** to meet every conceivable type of transit user need
    a. Daily, multi-day, weekly transit passes
    b. Strip tickets
    c. Short-trip tickets
    d. 30/60/90 minute trip tickets

4. **Special discounts for off-peak use**

5. **Transferability and multiple-use allowances** of certain tickets to increase their attractiveness

6. **Facilitating purchase of tickets** by allowing credit card use, widespread ticket automats, ticket offices or authorized agents (such as tobacco shops, newspaper stands)

7. **Keeping price increases for regular users as low as possible**, focussing fare hikes on occasional users, single-trip fares

8. Obviously, **keeping overall transit fare as low as possible**, given available financing through subsidies

9. **Coordinating fare structure to permit a single ticket to be used for multiple legs of trip, regardless of number of transfers or transit modes or transit systems used**: i.e. fully integrated fare structure for entire metro region to increase convenience and flexibility for transit rider.

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EXHIBIT 2. SERVICE POLICIES TO INCREASE TRANSIT RIDERSHIP

1. **Spatial and temporal coordination of transit services**
   a. Co-location of suburban rail and metro stations, bus and streetcar stops, ferry docks, park-and-ride facilities in order to ease transfer from one mode to another
   b. Integration of schedules of different transit modes and different transit firms in order to facilitate transfers, and to allow mutual complementarity among different types of transit
   c. Guaranteed transfers at key connection stations/stops

2. **Modernization of rail vehicles and buses**
   a. Low-floor vehicles with ease of entrance and exit
   b. More comfortable seating, air conditioning

3. **Modernization of rail stations, bus stops, and rights of way**
   a. Better shelter for waiting passengers
   b. Up-to-date information on arrivals and departures of transit runs
   c. Better lighting, security at stops
   d. Making at least new stations and stops fully accessible

4. **Reserved bus lanes and priority traffic signalization for buses** to speed up bus travel, make scheduling more dependable, reduce bunching of vehicles

5. **Extension of rail transit system** (and/or exclusive busways) to provide high-speed, long-distance transit travel, as backbone to regional transit network. Most European systems have relied on rail system expansion to increase speeds.

6. Conversion of shared-right-of-way streetcar lines to **exclusive right-of-way light-rail lines,** thus improving speed and dependability.

7. Introduction of **wider range of transit modes** to serve diverse needs of users and varying circumstances (**minibuses, midibuses, dial-a-ride taxis**), **especially to complement main-line** transit services in low-density areas that cannot support heavy-volume transit services

8. **Improved information systems** for transit users
   a. Real-time schedule and route information for passengers, at stations, bus stops, and even on certain vehicles (showing actual arrival and departure times)
   b. Exact timetables posted at every transit stop
   c. Computerized timetable and route information tailored to specific needs of each individual passenger

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EXHIBIT 3. MARKETING STRATEGIES TO INCREASE TRANSIT RIDERSHIP

1. **Full-scale campaign to advertise the more attractive fare and service policies listed in Exhibits 1 and 2**

2. **Transit carnivals, transit sweepstakes** (with free transit passes as prizes)

3. **Joint transit-environmental fairs** to emphasize environmental advantages of transit

4. **Informational brochures sent via mail** to virtually all households in region

5. Regular **transit informational tours by mobile vans** distributing leaflets and selling tickets

6. **Transit ads** regularly placed in region's newspapers, magazines, on billboards, on transit vehicles, in transit stations and at bus and streetcar stops; also transit advertising on radio and television.

7. **Special monthly or quarterly magazine** produced by transit system and distributed free of charge to riders, with highlights of new services, improvements, environmental advantages, etc.

8. **Informational presentations in schools** to teach children about children and to encourage them to use it, together with special gifts to children using transit, including t-shirts, rucksacks with transit logo; entertainment guides showing how to use transit to reach desirable destinations

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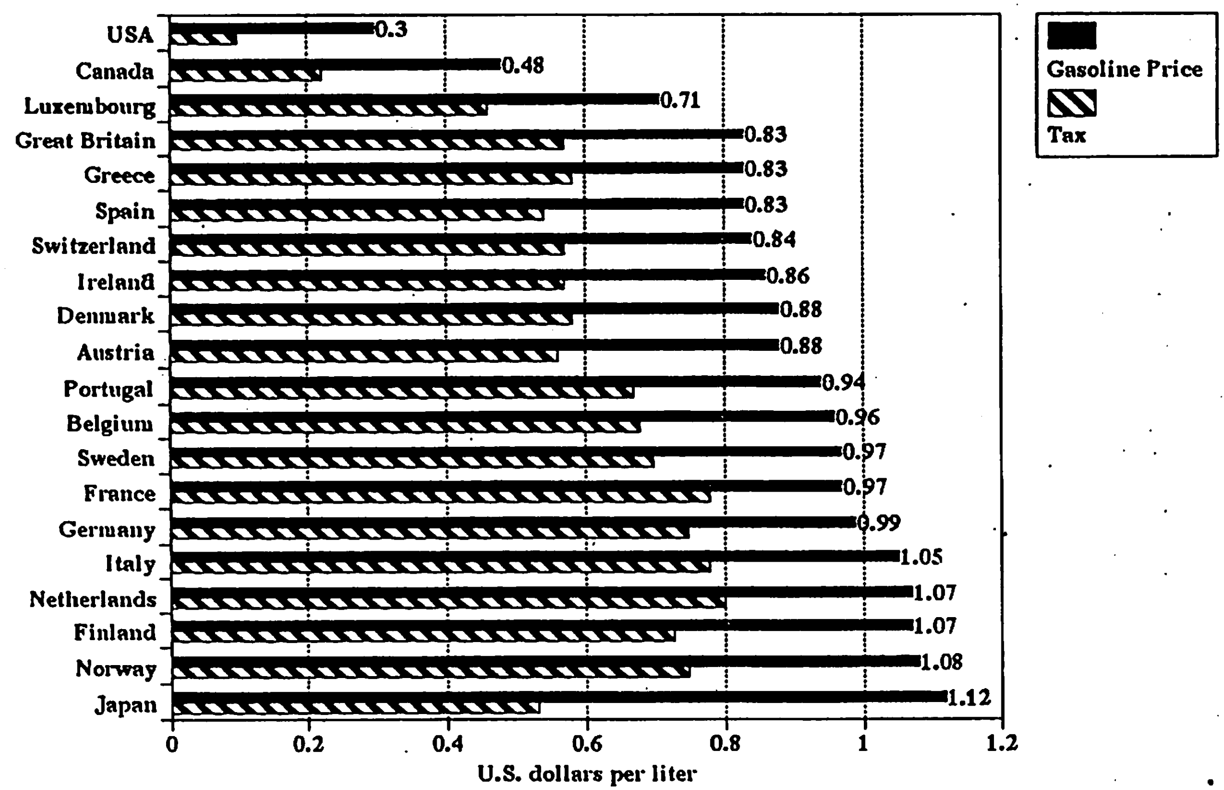
FIGURE 2. Gasoline Prices and Taxes in OECD Countries, 1994
(U.S. dollars per liter)



Source: Organization for Economic Cooperation and Development, International Energy Agency.
Note: Dollar values of gasoline prices and taxes subject to substantial variation due to fluctuation in dollar exchange rates in each country.

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Table 12. Comparison of Gasoline Prices and Taxes in Germany and the U.S.A.

Year	Germany		Ratio of gasoline prices Germany/USA	United States	
	US dollars per liter	tax as % of price		US dollars per liter	tax as % of price
1978	.462	58	2.6	.177	19
1981	.628	46	1.7	.380	11
1983	.538	50	1.5	.362	21
1985	.490	49	1.5	.318	23
1989	.583	64	2.2	.270	29
1991	.767	68	2.5	.301	33
1993	.812	74	2.8	.293	31
1995	1.047	78	3.4	.304	33

Source: Energy Prices and Taxes, Paris: International Energy Agency, OECD, quarterly from 1988 to 1996.

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TABLE 4: Government Roadway Expenditure and Taxes, 1989-1990

	Roadway taxes per motor vehicle	New car sales tax (a)	Ratio of roadway user taxes to government roadway expenditures
Austria	1,586	52%	1.7
Denmark	1,518	105%-180%	3.0
Finland	2,323	148%	2.8
France	1,151	25%	--
Germany (West)	786	14%	2.1
Greece	--	20%-100%	--
Ireland	--	10%-50%	--
Netherlands	1,108	18%-27%	5.1
Norway	1,145	48%-90%	--
Portugal	--	20%-144%	--
Spain	950	33%	4.3
Sweden	1,136	19%	3.0
Switzerland	1,174	7%	1.3
United Kingdom	1,386	25%	4.2
USA	234	5%-8%	0.6

Sources: *World Road Statistics* (Geneva: International Roadway Federation, 1990); *Verkehr in Zahlen* (Bonn: German Ministry of Transport, 1992); *Highways Statistics* (Washington, DC: U.S. Department of Transportation, Federal Highway Administration).
(a) Sales tax reported here includes sales tax, value added tax, first registration fee, and in certain countries import tax; range of rates due to car size differences.

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V Encuentro UPR-MIT Tren Urbano

San Juan de Puerto Rico 11 enero 1998

AMPLIACIÓN DE LA RED METRO - TRANVÍA DE VALENCIA

PRESENTACION

Buenos dias. En primer lugar deseo manifestar mi agradecimiento a la organización de este V Encuentro UPR-MIT Tren Urbano por su amable invitación.

Mi nombre es Julio Gil, soy Ingeniero de Caminos, Canales y Puertos de la Administración de la Generalitat Valenciana y, desde 1990, Director del Programa de Ampliación de la Red Metropolitana de los Ferrocarriles de la Generalitat Valenciana.

El objeto de mi intervención va a ser la explicación del proceso de planificación, diseño, construcción y suministro de las infraestructuras, instalaciones y equipos que, desde 1990 se están implantando en la ciudad de Valencia y su Área de influencia a fin de conformar el sistema de transporte metropolitano que, con las peculiaridades que a lo largo de la exposición trataré de poner de manifiesto, constituye el Metro de Valencia, y cuya culminación definitiva se prevé alcanzar en el año 2005.

SITUACION

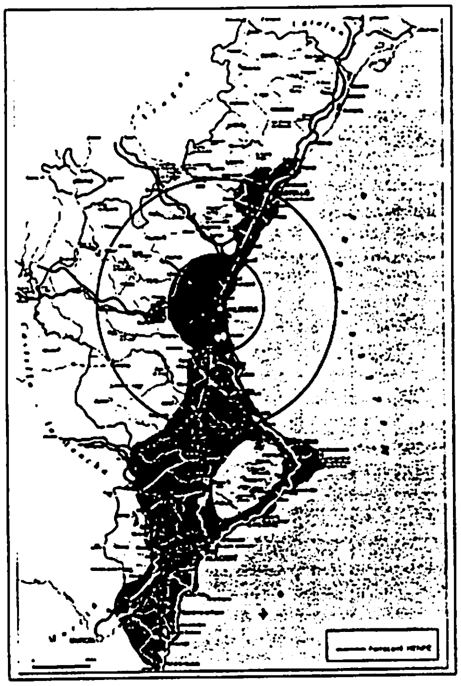
Conviene, antes de entrar a analizar el proceso de planificación inicial, situarnos territorial y demográficamente.

La Comunidad Valenciana, una de las 17 Comunidades Autónomas que integran el Estado Español al amparo de la Constitución de 1978, ocupa un territorio de 23.000 km^2, lo que supone un 4,6% del total nacional y cuenta con una población de 4 millones de habitantes, un 10% de la población española. Las comunidades vecinas son Cataluña al Norte, Murcia y Castilla-La Mancha al Sur y Oeste respectivamente estando abierta en todo su frente Este al Mar Mediterráneo.

En el centro de la Comunidad se encuentra la Ciudad de Valencia, que ostenta la capitalidad administrativa y la separan 350 kms de la capital del Estado, Madrid.

LAS COMUNICACIONES

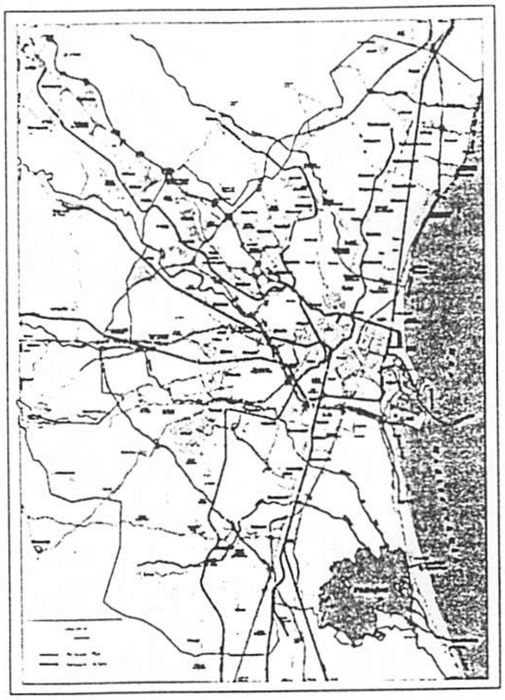
EN LAS COMUNICACIONES CON VALENCIA HAY QUE DISTINGUIR TRES ÁMBITOS ESPACIALES DIFERENCIADOS POR LO QUE A NECESIDADES DE TRANSPORTE SE REFIERE:



EL CONJUNTO DE LA COMUNIDAD Y LAS RELACIONES CON EL RESTO DEL TERRITORIO ESPAÑOL.

LA REGIÓN METROPOLITANA QUE ENGLOBA AQUELLOS MUNICIPIOS SITUADOS HASTA UNA DISTANCIA MÁXIMA APROXIMADA DE 60 KMS Y CUYAS RELACIONES CON LA CIUDAD DE VALENCIA TIENEN UN CIERTO GRADO DE COTIDIANEIDAD. INCLUYE CIUDADES DE LA IMPORTANCIA DE CASTELLÓN POR EL NORTE, BUÑOL AL OESTE Y XÀTIVA O GANDIa por el Sur.

El Area Metropolitana de Valencia que está formada, en un radio aproximado de 30 kms por el conjunto de núcleos urbanos situados en torno a la ciudad de Valencia como núcleo central y que mantienen con el centro una intensa relación de viajes tanto por motivo de trabajo como de estudios, ocio,



administrativos o sanitarios.

Para atender las necesidades de movilidad en los tres ámbitos geográficos descritos y por lo que al transporte terrestre se refiere se cuenta con los sistemas viarios de carácter nacional, regional, metropolitano y local, que atienden fundamentalmente el transporte privado o individual, la mayor parte del transporte de mercancías generado por vía terrestre y una parte significativa del transporte colectivo de viajeros en relaciones de media y baja capacidad a través de las líneas regulares de autobuses y del autobús urbano en las ciudades dotadas de este modo de transporte colectivo, en particular en la ciudad de Valencia.

Sin embargo son las redes ferroviarias existentes las que van a ser objeto de análisis a continuación y más concretamente la red metropolitana de ferrocarril en el Area de Valencia.

EXISTEN DOS OPERADORES FERROVIARIOS IMPLANTADOS EN EL TERRITORIO DE LA COMUNIDAD.

RENFE ES EL OPERADOR QUE EXPLOTA LA RED DE ÁMBITO NACIONAL Y EN CONSECUENCIA ATIENDE LAS RELACIONES DE LARGO RECORRIDO EN EL INTERIOR DE LA COMUNIDAD Y CON EL RESTO DEL PAÍS.

EL CORREDOR MEDITERRÁNEO GARANTIZA LAS RELACIONES NORTE-SUR CON OFERTA QUE ALCANZA, EN LOS SERVICIOS EUROMED, EL MAYOR NIVEL DE CALIDAD CON VELOCIDADES MÁXIMAS DE 220 KM/H, MIENTRAS QUE LAS RELACIONES CON MADRID Y EL RESTO DE LA PENÍNSULA QUEDAN GARANTIZADAS CON LOS CORREDORES MADRID-ALBACETE-VALENCIA Y ALICANTE, MADRID-VALENCIA POR CUENCA Y ZARAGOZA-TERUEL-VALENCIA. ACTUALMENTE LA RELACIÓN MADRID-VALENCIA SE SIRVE CON TRENES INTERCITY QUE DESARROLLAN VELOCIDADES MÁXIMAS DE 180 KM/H, HABIÉNDOSE INICIADO YA POR PARTE DE LA ADMINISTRACIÓN CENTRAL DEL ESTADO LOS ESTUDIOS NECESARIOS PARA LA IMPLANTACIÓN DEL TREN DE ALTA VELOCIDAD PARA EL EJE MADRID-VALENCIA.

LOS OTROS SERVICIOS PRESTADOS POR RENFE EN LA COMUNIDAD VALENCIANA SON LOS DE CERCANÍAS, CUYO ÁMBITO DE ACTUACIÓN, POR LO QUE A LA CIUDAD DE VALENCIA SE REFIERE, ABARCA EL TERRITORIO QUE HE DENOMINADO REGIÓN METROPOLITANA, QUE ENGLOBA UNA POBLACIÓN DE DOS MILLONES DE HABITANTES Y QUE QUEDA RELACIONADA CON VALENCIA A TRAVÉS DE LAS SEIS LÍNEAS DE CERCANÍAS EXISTENTES: VALENCIA-CASTELLÓN, VALENCIA-CAUDIEL, VALENCIA-RIBARROJA, VALENCIA-UTIEL, VALENCIA-XÀTIVA Y VALENCIA-GANDIA, TODAS ELLAS CONVERGENTES EN LA ESTACIÓN DEL NORTE DE VALENCIA UBICADA EN EL CENTRO DE LA CIUDAD, LA CUAL ES, A SU VEZ, ESTACIÓN ORIGEN O TÉRMINO PARA LAS RELACIONES DE LARGA DISTANCIA A QUE ANTES HE HECHO REFERENCIA.

EL SEGUNDO OPERADOR ES FERROCARRILES DE LA GENERALITAT VALENCIANA Y OPERA SOBRE LA RED DE COMPETENCIA AUTONÓMICA IMPLANTADA EN EL AREA METROPOLITANA DE VALENCIA. ESTE ÁMBITO TERRITORIAL, COMPRENDIDO EN UN CÍRCULO APROXIMADO DE 30 KMS EN TORNO A LA CIUDAD DE VALENCIA, CONTIENE UNA POBLACIÓN DE UN MILLÓN Y MEDIO DE HABITANTES, LO QUE SUPONE UN 37,5% DE LA POBLACIÓN TOTAL DE LA COMUNIDAD, Y DE LA CUAL UN 50% RESIDE EN EL NÚCLEO CENTRAL.

CON ESTE ESQUEMA TERRITORIAL Y POBLACIONAL, EL MODELO DE TRANSPORTE PARA VALENCIA Y SU AREA METROPOLITANA GRAVITA EN TORNO A LA RED DE FERROCARRILES DE LA GENERALITAT VALENCIANA EN BASE A LAS DOS CONSIDERACIONES SIGUIENTES:

En primer lugar, en su fase final de desarrollo, se estructura como un sistema interconectado de modos de transporte de media y alta capacidad capaz de atender la movilidad en medios públicos entre los dintintos núcleos del Area Metropolitana y en aquellos corredores urbanos del núcleo central de mayor nivel de demanda.

En segundo lugar establece el nexo de unión en condiciones de intermodalidad con el resto de operadores de transporte de ámbitos territoriales diferentes, en particular con Renfe y con los autobuses de la Empresa Municipal de Transportes en la ciudad de Valencia consiguiendo la integración de los distintos modos y, en consecuencia, posibilitando el establecimiento de itinerarios combinados entre los niveles urbano y metropolitano, tanto Area como Región, así como entre estos y las relaciones exteriores de larga distancia.

EL PROCESO DE PLANIFICACION

Una vez hecha esta introducción, situada Valencia y su Area Metropolitana en el contexto regional y nacional y conocida la estructura general del sistema de transporte existente, pasaré a describir el proceso de planificación que la Administración Autonómica ha llevado a cabo para implantar a partir del año 1990 la Red Metropolitana de Ferrocarriles de la Generalitat Valenciana en el Area de Valencia que, genéricamente, denominamos Metro de Valencia aunque en su conjunto engloba elementos diferenciados desde el punto de vista de la explotación haciendo convivir en una red unitaria tramos tranviarios, tramos de circulación exclusivamente subterránea y tramos en superficie con condiciones de explotación típicamente ferroviarias.

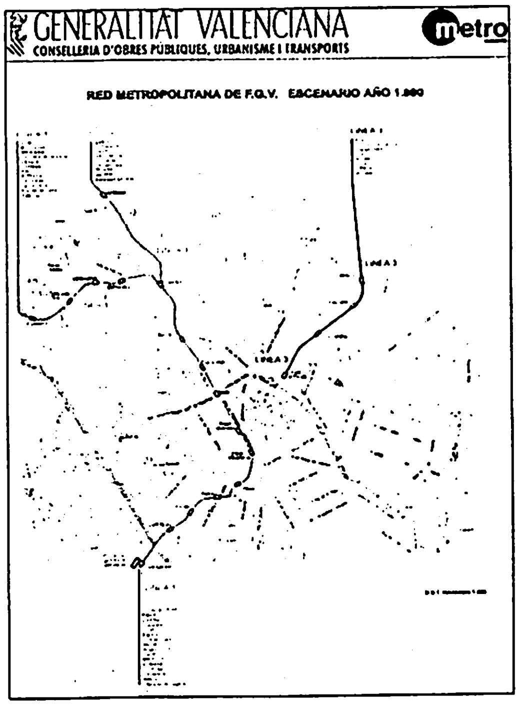
Los objetivos de partida para el desarrollo del proceso fueron básicamente los tres siguientes:

En primer lugar, tomando como referencia las líneas existentes, conseguir su interconexión para dotar al sistema del efecto red.

En segundo lugar, identificar en el núcleo central del Area, en la ciudad de Valencia, aquellos corredores de mayor nivel de demanda que se manifestaran como los más adecuados para el trazado de las nuevas líneas de mallado e interconexión de la red.

Y en tercer lugar definir los nuevos trazados de tal manera que se estableciera una efectiva integración del sistema global de transporte permitiendo la intermodalidad, y, en particular, facilitando el transbordo con la red de cercanías y largo recorrido de Renfe y potenciando el papel del autobús urbano como medio fundamental de dispersión y concentración de los viajes generados en el núcleo central.

El escenario inicial correspondiente al año 1990 está formado por las dos



líneas preexistentes sin conexión entre sí.

La línea 1, con 96,5 kms de los cuales solamente 7,1 son subterráneos en la ciudad de Valencia, atendía las relaciones Norte-Sur del Area Metropolitana con dos ramas hacia el Norte de 15 y 25 kms separadas a partir de la estación común de Empalme, y una rama Sur de 50 kms.

La línea 3, con 13,3 kms de longitud, todas ellas en superficie se iniciaba en la denominada Estación de Puente de Madera, en una situación que el desarrollo

URBANO DE LA CIUDAD HABÍA DEJADO FUERA DE LOS PRINCIPALES CIRCUITOS DE EQUIPAMIENTO COMERCIAL, DOCENTE, ADMINISTRATIVO O DE OCIO.

EL PRIMER PASO PARA LA DEFINICIÓN DE LAS NUEVAS LÍNEAS O MODIFICACIÓN DE LAS EXISTENTES CONSISTIÓ EVIDENTEMENTE EN EL ANÁLISIS Y CARACTERIZACIÓN DE LA DEMANDA DE TRANSPORTE EN MEDIOS MECANIZADOS EN EL AREA METROPOLITANA, SU DISTRIBUCIÓN EN MODOS PÚBLICOS Y PRIVADOS Y DENTRO DE LA DEMANDA ATENDIDA POR EL TRANSPORTE PÚBLICO LA CAPTADA POR LOS DISTINTOS AGENTES QUE OPERAN EN EL AREA. PARA ELLO SE PROGRAMÓ Y LLEVÓ A EFECTO UNA IMPORTANTE CAMPAÑA DE ENCUESTAS.

UNA VEZ CARACTERIZADA LA DEMANDA, EN LA QUE TAMBIÉN SE INTRODUCE EL FACTOR MOTIVOS DE VIAJE, SE ESTABLECIERON DETERMINADAS HIPÓTESIS DE PROYECCIÓN APOYÁNDOSE EN LAS TENDENCIAS CONTRASTADAS DE EVOLUCIÓN DE LA POBLACIÓN Y EL EMPLEO Y EN LA PLANIFICACIÓN VIGENTE DE LA EDIFICACIÓN Y LOS EQUIPAMIENTOS PRODUCTIVOS EN LOS PLANES GENERALES DE ORDENACIÓN URBANA DE LOS DISTINTOS MUNICIPIOS, TODO ELLO PARA OBTENER LA ESTIMACIÓN DE DEMANDA ESPERADA EN LOS HORIZONTES DE PLANIFICACIÓN QUE FUERON FIJADOS EN DOS ETAPAS, AÑO 2000 Y AÑO 2011.SUPERADO ESTE PUNTO FUE NECESARIO DEFINIR UN MODELO QUE, ADECUADAMENTE CALIBRADO CON LA INFORMACIÓN DEL ESCENARIO DE PARTIDA, FUERA CAPAZ DE SIMULAR EL COMPORTAMIENTO DEL SISTEMA DE TRANSPORTE EN LOS DOS HORIZONTES DE PLANEAMIENTO BAJO DISTINTAS ALTERNATIVAS POSIBLES DE AMPLIACIÓN DE LA RED.

ESTE EJERCICIO DE SIMULACIÓN APORTABA INFORMACIÓN SOBRE LA CARGA EN LOS NUEVOS TRAMOS PROPUESTOS Y EN EL CONJUNTO, LO QUE PERMITÍA VALORAR LAS DISTINTAS ALTERNATIVAS DESDE EL PUNTO DE VISTA DE LA CAPTACIÓN DE DEMANDA Y EN CONSECUENCIA DEL AHORRO DE TIEMPO GENERALIZADO.

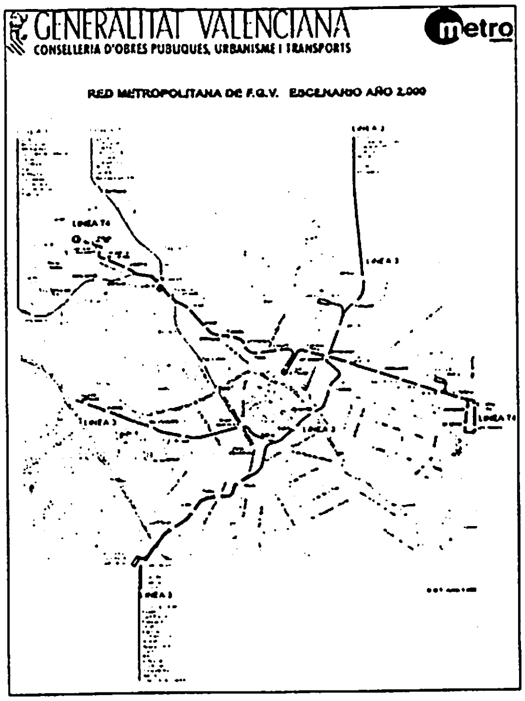
EVIDENTEMENTE LAS ALTERNATIVAS ENSAYADAS DEBÍAN CONTEMPLAR LOS OBJETIVOS DE PARTIDA DE INTERCONEXIÓN DE LA RED E INTEGRACIÓN DEL SISTEMA, A LO QUE SE AÑADIERON LAS CONSIDERACIONES DE CARÁCTER CONSTRUCTIVO Y DE AFECCIÓN CIUDADANA DURANTE EL PERÍODO DE EJECUCIÓN DE LAS OBRAS.

RESULTADO DE ESTE PROCESO FUE LA ELECCIÓN DE LA ALTERNATIVA CONSIDERADA ÓPTIMA PARA EL ESCENARIO DEL AÑO 2000 QUE SE CONCRETÓ EN LO SIGUIENTE:

PENETRACIÓN EN SUBTERRÁNEO DE LA LÍNEA 3 HACIA EL CENTRO DE LA CIUDAD, CON CARACTERÍSTICAS DE EXPLOTACIÓN TIPO METRO, HASTA ENLAZAR CON LA LÍNEA 1 UTILIZANDO

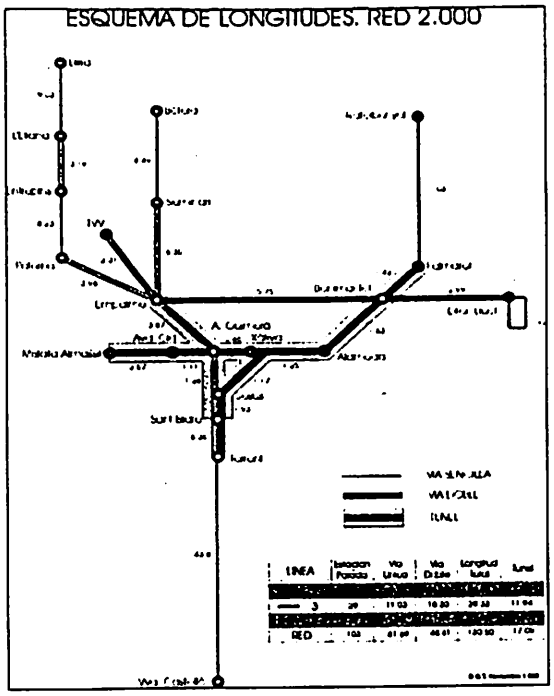
EL TRAMO FINAL DEL TÚNEL EXISTENTE PARA CONTINUAR EN SUPERFICIE HASTA LA ESTACIÓN DE TORRENTE Y PROLONGANDO EL NUEVO TÚNEL POR EL CORREDOR URBANO DE MAYOR DEMANDA EN DIRECCIÓN OESTE HASTA EL LÍMITE DEL NÚCLEO CENTRAL.

IMPLANTACIÓN DE UNA NUEVA LÍNEA DE CARÁCTER TRANVIARIO, LA LÍNEA T4, CON UN ITINERARIO ALGO PERIFÉRICO EN RELACIÓN AL CENTRO DE LA CIUDAD PERO CON LA

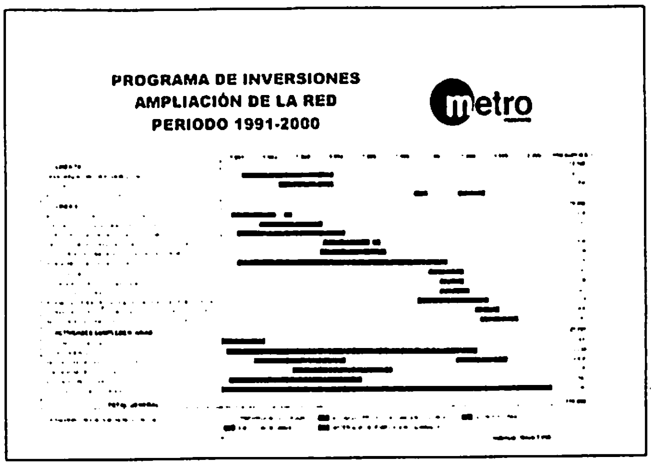


VIRTUALIDAD DE ENLAZAR LOS DISTINTOS CAMPUS UNIVERSITARIOS Y EL DISTRITO MARÍTIMO CONECTANDO MEDIANTE TRANSBORDOS DIRECTOS CON LAS LÍNEAS 1 Y 3.

EL ESQUEMA DE LA RED METROPOLITANA DE FERROCARRILES DE LA GENERALITAT VALENCIANA PASA EN ESTE ESCENARIO A CONTAR CON UNA LONGITUD TOTAL DE 130 KMS, 49 EN VÍA DOBLE, 81 EN VÍA SENCILLA EN LOS EXTREMOS DE LA LÍNEA, CON UN NÚCLEO CENTRAL DE 17 KMS EN TÚNEL Y ORGANIZADA EN TRES LÍNEAS INTERCONECTADAS, UNA DE LAS CUALES SE OPERA EN CONDICIONES DE EXPLOTACIÓN TRANVIARIA Y LAS OTROS DOS CON CARACTERÍSTICAS DE METRO EN LA ZONA CENTRAL EN CONSIDERACIÓN A SUS FRECUENCIAS Y CON CONDICIONES TÍPICAMENTE FERROVIARIAS EN LOS TRAMOS DE SUPERFICIE.

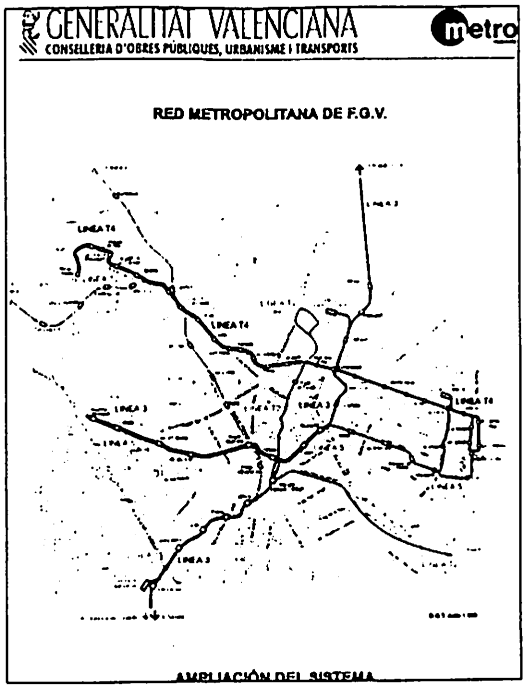


Este escenario 2000 está llegando a su culminación, de hecho a mediados del año próximo se pondrán en servicio los últimos tramos. La línea T4 entró en servicio en Abril de 1994, el primer tramo de la línea 3 en Mayo de 1995 y el segundo tramo en Septiembre de 1998. Para ello se estableció una estricta programación de inversiones que está movilizando un volumen de recursos de 116.000 millones de pesetas, aproximadamente 770 millones de dólares americanos, en el período 91/99, a un ritmo medio de 13.000 millones de pesetas año para lo que se han utilizado fórmulas de financiación novedosas en relación con los procedimientos ordinarios de la Administración Española.



Finalmente el proceso de planificación se reabrió a finales de 1997 y se ha culminado recientemente para concretar la segunda y definitiva ampliación de la red relativa al escenario 2011, utilizando el mismo modelo de transporte que en la fase anterior con la proyección de demanda correspondiente al nuevo escenario y la calibración del modelo en base a los datos de partida y a los nuevos datos registrado en la explotación de la red con los nuevos tramos puestos en servicio.

Esta segunda ampliación, cuya maduración a efectos operativos se proyecta al año 2011, se programa para su ejecución en el período 2000/2005 y se concreta en dos nuevas líneas.



La línea T2, una nueva línea de caracter tranviario y de recorrido exclusivamente urbano con un tramo central subterráneo para atravesar el casco antiguo de la ciudad de Valencia, conectada con las líneas 3 y T4, y la línea 5, también urbana, y tecnológicamente diferente al haberse optado por un sistema mixto de explotación tranvía/metro que utiliza la infraestructura e instalaciones de la línea 3 de metro y la circulación tranviaria en el distrito marítimo de la ciudad atendiendo, en parte con la línea 3, el corredor urbano Este-Oeste de la ciudad de Valencia con mayor nivel de demanda. Para el diseño de este línea 5 ha sido necesario considerar especialmente algunos elementos de las instalaciones y el material rodante para compatibilizar aspectos como circulación sobre carriles de diferente sección o con tensiones de tracción distintas.

El resumen de las cifras más significativas que identifican el Metro de Valencia una vez culminado el proceso de planificación iniciado en 1990 es el siguiente:

DATOS BASICOS DE LA RED DE FGV DEL AÑO 1991, DE LA RED BASE DEL AÑO 2000 Y DE LA RED AMPLIADA (2011)

AÑO 1991

	LINEAS 1	T2	3	T4	5	RED
Longitud(Km)	96.5		13.3			109.8
L. vía única	72.7		13.3			86.0
L. vía doble	23.6					23.6
L. túnel	7.1					7.1
Estaciones	56		12			68
Plazas ofrec.	13 030		2 504			16 434
Viajes/año	15 500 000		3 100 000			18 600 000

AÑO 2000

	LINEAS 1	T2	3	T4	5	RED
Longitud(Km)	96.5		20.3	13.0		130.0
L. vía única	69.5		11.0	1.9		83.4
L. vía doble	27.0		10.3	11.1		46.0
L. túnel	7.1		11.0			17.1
Estaciones	56		29	27		103
Plazas ofrec.	13 030		7 812	5 025		26 767
Viajes/año	10 700 000		18 400 000	5 200 000		34 300 000
Inversión(Mpt)	6 997		86 456	22 000		116 869

AÑO 2011

	LINEAS 1	T2	3	T4	5	RED
Longitud(Km)	96.5	15.6	20.3	12.4	11.3	146.8
L. vía única	69.5	1.6	11.0	1.9		84.3
L. vía doble	27.0	14.0	10.3	10.5	11.3	66.0
L. túnel	7.1	1.6	11.0		0.7	21.0
Estaciones	56	30	29	27	15	130
Plazas ofrec.	13 030	6 030	7 812	5 035	4 020	36 817
Viajes/año	14 600 000	15 100 000	19 100 000	8 400 000	21 300 000	78 900 000
Inversión(Mpt)		30 047			27 405	57.452

DEL AÑO BASE 1991, CON 110 KMS DE RED DE LOS CUALES HAY 7 SUBTERRÁNEOS Y EL RESTO SE EXPLOTA EN CONDICIONES TÍPICAMENTE FERROVIARIAS CAPTANDO UNA DEMANDA DE 18.600.000 VIAJES/AÑO, SE PASA AL ESCENARIO 2000, MEDIANTE UN PROGRAMA DE INVERSIONES DE 116.000 MILLONES DE PESETAS, CON UNA RED DE 130 KMS, DE LOS CUALES 17 SON EN TÚNEL CON EXPLOTACIÓN TIPO METRO Y 13 TRANVIARIAS PASANDO A UNA DEMANDA CAPTADA DE 34.300.000 VIAJES/AÑO, ES DECIR, PRÁCTICAMENTE SE DUPLICA LA DEMANDA.

EN EL ESCENARIO FINAL, CON UNA INVERSIÓN DE 57.000 MILLONES DE PESETAS, APROXIMADAMENTE 380 MILLONES DE DÓLARES AMERICANOS, LO QUE SUPONE LA MITAD DE LA INVERSIÓN DEL ESCENARIO ANTERIOR, SE VUELVE A DUPLICAR LA DEMANDA PASANDO A 78.900.000 VIAJES/AÑO, LO QUE TIENE SU EXPLICACIÓN EN EL EFECTO MULTIPLICADOR QUE SOBRE LA DEMANDA EJERCE EL EFECTO RED QUE EN ESTA ÚLTIMA FASE SE CONSOLIDA DEFINITIVAMENTE, PASANDO EL SISTEMA A TENER 146 KMS DE RED CON 22 KMS DE TÚNEL, DOS LÍNEAS DE CARÁCTER EXCLUSIVAMENTE TRANVIARIO DE 16 Y 12 KMS, LA LÍNEA 5 DE CARÁCTER MIXTO METRO/TRANVÍA CON 11 KMS DE LONGITUD QUE UTILIZA EN PARTE LA INFRAESTRUCTURA E INSTALACIONES DE LA LÍNEA 3 Y LAS LÍNEAS 1 Y 3 CON EXPLOTACIÓN TIPO METRO EN LA PARTE SUBTERRÁNEA DEL NÚCLEO URBANO Y DE CARÁCTER TÍPICAMENTE FERROVIARIO EN LOS TRAMOS DE SUPERFICIE.

EL DISEÑO Y LA CONSTRUCCION DE LAS NUEVAS LINEAS

UNA VEZ PLANIFICADAS LAS NUEVAS LÍNEAS QUE HABÍAN DE CONFORMAR DEFINITIVAMENTE LA RED METROPOLITANA DE FERROCARRILES DE LA GENERALITAT VALENCIANA SE INICIA TODO EL PROCESO DE DISEÑO Y CONSTRUCCIÓN AL QUE AHORA ME VOY A REFERIR.

LA PRIMERA FASE DEL PROGRAMA, QUE COMO HE DICHO, SE DESARROLLA EN EL PERÍODO 1991/2000 INCLUYE LAS LÍNEAS 3 Y T4, QUEDANDO PENDIENTE PARA UNA SEGUNDA FASE ENTRE EL 2000 Y EL 2005 LA EJECUCIÓN DE LA LÍNEA T2 Y LA LINEA 5.

HA SIDO NECESARIO DEFINIR EN PRIMER LUGAR LOS CRITERIOS BÁSICOS DE LOS NUEVOS TRAMOS, TANTO PARA LA PRIMERA COMO PARA LA SEGUNDA FASE, SI BIEN EN EL SEGUNDO CASO, Y POR LO QUE A LA LÍNEA 5 SE REFIERE HUBO QUE INTRODUCIR CONDICIONES ADICIONALES DESPUÉS DE OPTAR POR EL SISTEMA MIXTO DE EXPLOTACIÓN METRO/TRANVÍA, QUE EN VALENCIA EMPEZAMOS A DENOMINAR TRANVÍA RÁPIDO, Y QUE BÁSICAMENTE RESPONDEN A REQUERIMIENTOS DE COMPATIBILIDAD ENTRE AMBOS MODOS EN ASPECTOS TALES COMO TENSIÓN DE TRACCIÓN, CONTACTO RUEDA CARRIL QUE AFECTA EN GRAN MEDIDA AL DISEÑO DE SECCIÓN DE RUEDA EN EL MATERIAL RODANTE, O INTERFACE ENTRE EL SISTEMA DE SEGURIDAD EN LA CONDUCCIÓN EN MODO METRO Y EL SISTEMA DE AYUDA A LA EXPLOTACIÓN EN MODO TRANVÍA.

JUNTO A ESTOS CRITERIOS BÁSICOS DE DISEÑO SE DEFINIÓ EL EQUIPAMIENTO MÍNIMO DE TÚNEL Y DE ESTACIONES ASÍ COMO UN CONJUNTO DE ELEMENTOS IMPRESCINDIBLES PARA LA SEGURIEDAD EN LA EXPLOTACIÓN DEL SISTEMA COMO SON LA SEÑALIZACIÓN, LAS COMUNICACIONES Y EL CONTROL DE INSTALACIONES.

PROGRAMA DE AMPLIACIÓN DE LA RED METROPOLITANA DE FERROCARRILS DE LA GENERALITAT VALENCIANA

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CRITERIOS BÁSICOS DE DISEÑO DE LOS NUEVOS TRAMOS

- Radio mínimo en tramos de metro 100 m
- Radio mínimo en tramos de tranvía 25 m
- Pendiente máxima en tramos de metro 25 ‰
- Pendiente máxima en tramos de tranvía 40 ‰
- Longitud mínima de andenes en metro 90 m
- Longitud mínima de paradas en tranvía 50 m
- Accesibilidad de personas de movilidad reducida
  - En estaciones de metro Ascensores a vestíbulos y andenes
  - En paradas de tranvía Rampas en zonas de acceso
- Movimientos verticales mecanizados para desniveles superiores a los 4.5 m

EQUIPAMIENTO DE TÚNEL Y ESTACIONES DE METRO

- Salidas de emergencia en túnel para distancia inter-estaciones mayor de 760 m
- Pasillo de evacuación en emergencia independiente de la vía
- Sistemas de protección contra incendios (detección y extinción)
- Red de distribución de energía mediante circuito cerrado de M.T. y transformadores
- Sistemas de ventilación para situaciones normal de explotación y en emergencia
- Telefonía, megafonía y circuito cerrado de televisión en estaciones
- Cronometría, señalética y teleindicadores
- Sistema de seguridad en la conducción mediante bloqueos automáticos y A.T.P.

SEÑALIZACIÓN, COMUNICACIONES Y CONTROL

- Puesto de control local en estaciones de metro
- Enclavamientos electrónicos de todos los sistemas y servicios
- Comunicación tren-tierra en metro y tranvía y red de fibra óptica
- Puesto de mando central con control de circulación, energía y seguridad en líneas de metro
- Sistema de ayuda a la explotación (S.A.E.) en líneas de tranvía

A NIVEL DE INFRAESTRUCTURA SE FIJARON COMO PARÁMETROS DE DISEÑO LOS SIGUIENTES:

RADIOS MÍNIMOS DE CURVAS EN TRAMOS DE METRO Y DE TRANVÍA DE 100 Y 25 M. RESPECTIVAMENTE.

PENDIENTES MÁXIMAS DE 25‰ EN METRO Y DE 40‰ EN TRANVÍA.

LONGITUDES MÍNIMAS 90 M Y 50 M PARA LOS ANDENES DE METRO Y LAS PARADAS DE TRANVÍA.

TODOS ESTOS PARÁMETROS, QUE A PRIMERA VISTA PUEDEN PARECER IRRELEVANTES, TIENEN EN REALIDAD UNA GRAN TRASCENDENCIA PUESTO QUE CONDICIONAN EN UNOS CASOS LAS SOLUCIONES CONSTRUCTIVAS DE LA INFRAESTRUCTURA Y EN OTROS EL DISEÑO DEL MATERIAL RODANTE, TANTO EN DIMENSIONES COMO EN POTENCIA.

OTRO ELEMENTO QUE FUE CONSIDERADO CON RANGO DE CRITERIO PREVIO PARA EL DISEÑO FUE LA NECESIDAD DE ATENDER ADECUADAMENTE LA ACCESIBILIDAD AL SISTEMA DE PERSONAS CON MOVILIDAD REDUCIDA POR MINUSVÁLIAS, EDAD AVANZADA U OTRAS CAUSAS. EN BASE A ELLO SE HAN DOTADO LAS ESTACIONES DE METRO DE ASCENSORES DE CALLE A VESTÍBULO Y DE VESTÍBULO A ANDENES Y EL VEHÍCULO TRANVIARIO HA SIDO DISEÑADO DE

PLANTAFORMA BAJA CON 35 CM. ENTRE PLATAFORMA Y COTA DE CARRIL, PERMITIENDO EL ACCESO DIRECTO A LAS PARADAS MEDIANTE SUAVES RAMPAS DIRECTAS DE ACCESO.

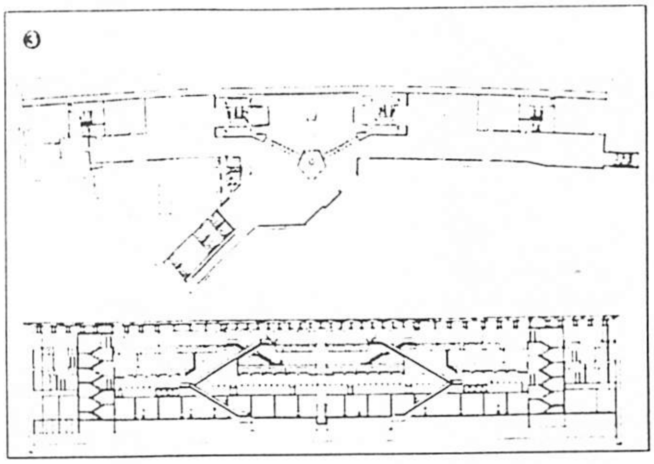
COMPLEMENTARIAMENTE TODAS LAS ESTACIONES SUBTERRÁNEAS SE DOTAN DE MEDIOS MECANIZADOS EN LOS MOVIMIENTOS VERTICALES PARA DESNIVELES SUPERIORES A LOS 4,5 M.

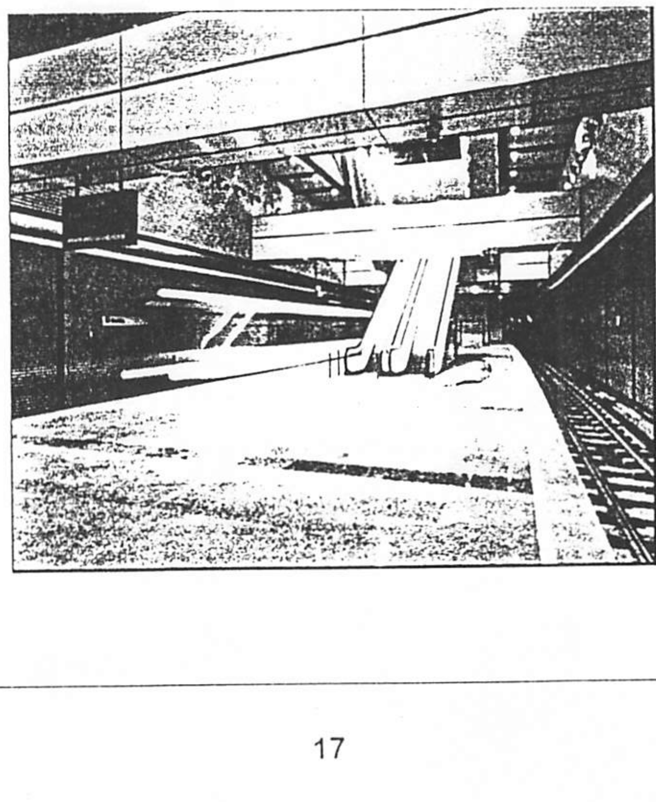
FINALMENTE HAY QUE DECIR QUE OTRA PREOCUPACIÓN IMPORTANTE EN EL DISEÑO DE LAS ESTACIONES SUBTERRÁNEAS HA SIDO CONSEGUIR LA MÁXIMA DIAFANEIDAD POSIBLE A FIN DE CONSEGUIR UNA PERCEPCIÓN INMEDIATA DEL ESPACIO QUE PERMITA LA FACIL IDENTIFICACIÓN DE LOS ITINERARIOS DENTRO DE LA ESTACIÓN INDEPENDIENTEMENTE DE LA INFORMACIÓN FACILITADA POR LA PROPIA SEÑALÉCTICA. POR ELLO SE HA PRIMADO EL ASPECTO FUNCIONAL FRENTE A OTROS ASPECTOS DEL DISEÑO ARQUITECTÓNICO DE LAS ESTACIONES.

EN CUANTO AL EQUIPAMIENTO DE TÚNEL Y ESTACIONES SE DEFINIERON TODOS AQUELLOS QUE DEBÍAN SER INCLUIDOS EN LOS PROYECTOS DE CONSTRUCCIÓN, UNOS RELACIONADOS FUNDAMENTALMENTE CON LA SEGURIDAD TALES COMO LA DISPOSICIÓN DE SALIDAS DE EMERGENCIA EN TÚNEL PARA DISTANCIA INTER-ESTACIONES MAYOR DE 760 M. Y PASILLO DE EVACUACIÓN INDEPENDIENTE DE LA VÍA, SISTEMAS DE DETECCIÓN Y EXTINCIÓN PARA PROTECCIÓN CONTRA INCENDIOS Y VENTILACIÓN PARA SITUACIONES DE EMERGENCIA EN TÚNEL Y ESTACIONES, Y OTROS RELACIONADOS MÁS CON LA ATENCIÓN AL VIAJERO, TALES COMO TELEFONÍA, MEGAFONÍA Y CIRCUITO CERRADO DE TELEVISIÓN EN ESTACIONES, CRONOMETRÍA, SEÑALÉCTICA Y TELEINDICADORES O VENTILACIÓN SOBRE ANDEN.

Y POR LO QUE SE REFIERE A LOS SISTEMAS DE SEÑALIZACIÓN, COMUNICACIONES Y CONTROL, LA CIRCULACIÓN DE TRENES EN LAS LÍNEAS DE METRO ESTÁ GOBERNADA POR UN SISTEMA DE SEGURIDAD EN LA CONDUCCIÓN MEDIANTE BLOQUEOS AUTOMÁTICOS Y SISTEMA AUTOMÁTICO DE PROTECCIÓN DE TRENES (A.T.P.) MIENTRAS QUE EL TRANVÍA SE OPERA CON CIRCULACIÓN A LA VISTA AUXILIADO POR UN SISTEMA DE AYUDA A LA EXPLOTACIÓN (S.A.E.) QUE RELACIONA EL VEHÍCULO CON EL PUESTO DE MANDO CENTRAL DE LA RED, TODAS LAS ESTACIONES DISPONEN DE UN PUNTO DE CONTROL LOCAL BAJO LA JERARQUÍA DE UN PUESTO DE MANDO CENTRAL QUE CONTROLA LA CIRCULACIÓN DE TRENES, ENERGÍA DE TRACCIÓN E INSTALACIONES FIJAS DE ESTACIONES, Y EXISTE COMUNICACIÓN TREN-TIERRA TANTO EN TRAMOS DE METRO COMO DE TRANVÍA.

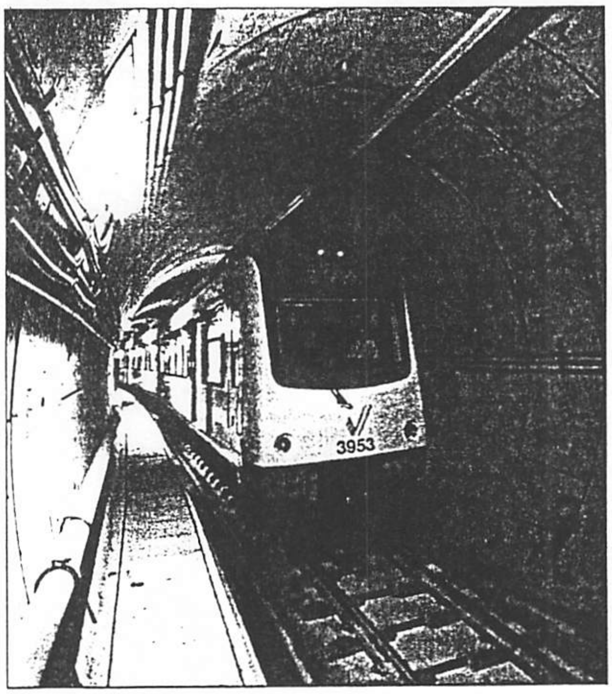
LAS DIAPOSITIVAS QUE INCLUYO A CONTINUACIÓN PRETENDEN ILUSTRAR SOBRE EL RESULTADO DE LA APLICACIÓN DE ESTOS CRITERIOS DE DISEÑO EN EL PROYECTO Y LA EJECUCIÓN DE LAS OBRAS.





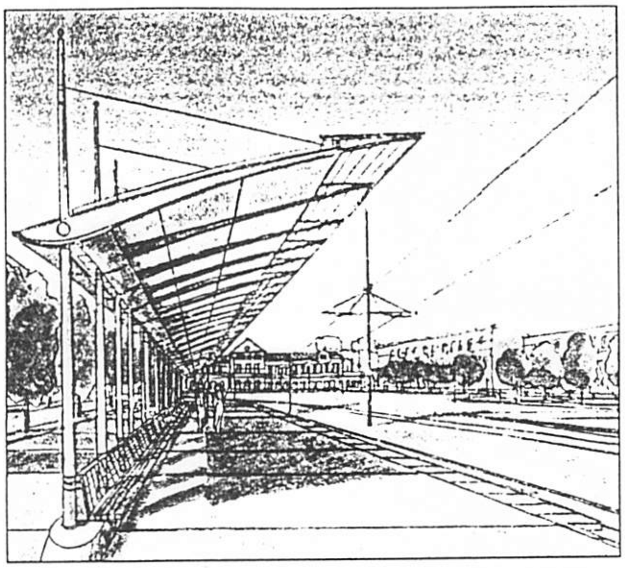
EN LAS DOS PRIMERAS SE MUESTRA EL ESQUEMA EN PLANTA Y SECCIÓN LONGITUDINAL Y LA OBRA TERMINADA A NIVEL DE ANDENES DE LA ESTACIÓN DE COLÓN DE LA LÍNEA 3, UNA DE LAS MÁS IMPORTANTES DE LA RED POR LO QUE A AFLUENCIA DE VIAJEROS SE REFIERE.

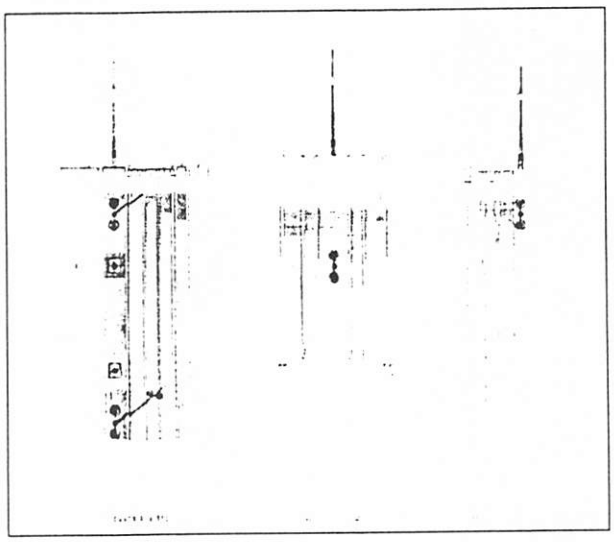
DE ELLAS CABE DESTACAR QUE, A PESAR DE LA PROFUNDIDAD DE LA ESTACIÓN POR CAUSA DE LAS CONDICIONES DE TRAZADO DE LA LÍNEA, LA PERCEPCIÓN DEL ESPACIO Y LA IDENTIFICACIÓN DE ITINERARIOS PARA EL USUARIO ES INMEDIATA LO QUE FACILITA EN GRAN MEDIDA LOS MOVIMIENTOS DENTRO DE LA ESTACIÓN, CONDICIÓN FUNDAMENTAL EN LOS MOMENTOS PUNTA DE GRAN AFLUENCIA DE VIAJEROS. SE OBSERVA TAMBIÉN LA PRESENCIA DE UNO DE LOS TELEINDICADORES QUE INFORMA AL USUARIO EN TIEMPO REAL DEL MOMENTO DE PASO DE LOS DOS PRÓXIMOS TRENES Y DE SU DESTINO EN CASO DE BIFURCACIÓN POSTERIOR DE LA LÍNEA.

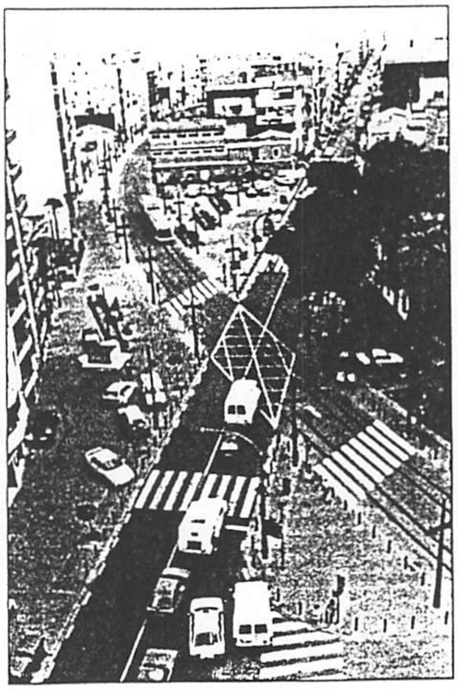


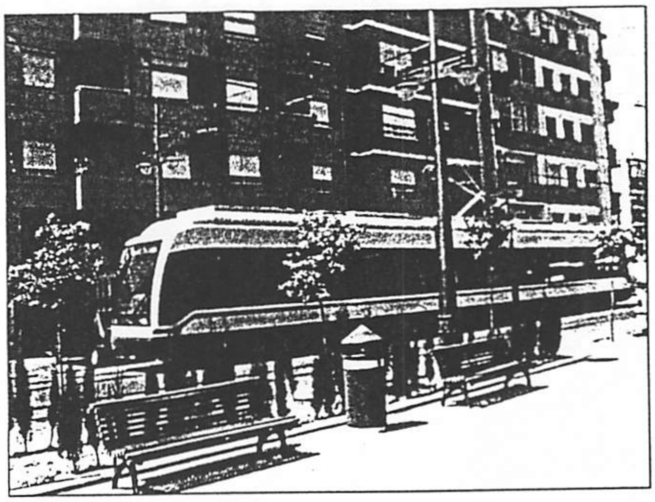
EN LA SIGUIENTE TENEMOS UNA DE LAS SECCIONES TIPO DE TÚNEL, QUE LUEGO COMENTARÉ AL HABLAR DE LOS PROCEDIMIENTOS CONSTRUCTIVOS, DONDE SE VE EL PASILLO DE EVACUACIÓN QUE EXISTE A LO LARGO DE TODO EL TÚNEL Y LA COLUMNA SECA QUE FORMA PARTE DEL SISTEMA DE EXTINCIÓN DE INCENDIOS.

LAS CUATRO SIGUIENTES DIAPOSITIVAS CORRESPONDEN A LA LÍNEA DE TRANVÍA.









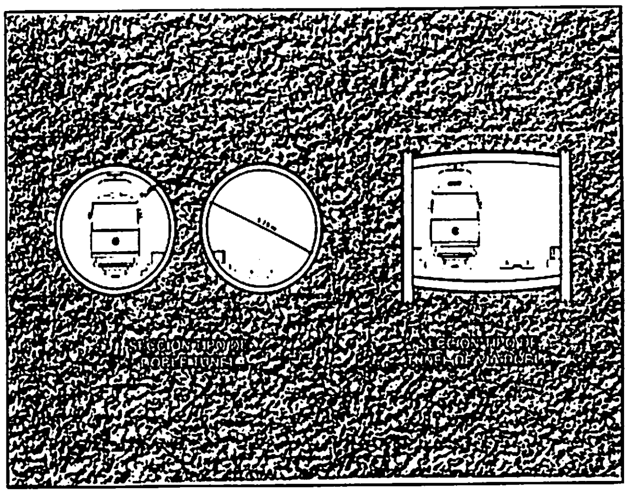
EN EL PROYECTO DE ESTA LÍNEA SE HA CUIDADO ESPECIALMENTE SU INTEGRACIÓN URBANÍSTICA A FIN DE ELIMINAR POR COMPLETO LA POSIBILIDAD DEL EFECTO BARRERA QUE UNA INFRAESTRUCTURA DE ESTE TIPO PUDIERA HABER PLANTEADO.

El camino de rodadura en la plataforma tranviaria está formado por carril tipo Phoenix embebido en el pavmiento y el hilo de contacto es autoportante consiguiéndose una absoluta transparencia en el trazado.

En la circulación del tranvía, el vehículo se comporta como uno más en el tránsito rodado regulando su marcha mediante el sistema semafórico de la ciudad, si bien se establece un protocolo de preferencias en los cruces en función de su importancia desde el punto de vista del tráfico urbano dando como resultado una jerarquización de los mismos que se catalogan como de preferencia absoluta al tranvía, preferencia ponderada o igualdad de trato, todo ello gobernado por el puesto central de control de tráfico municipal en coordinación con el Sistema de Ayuda en la Explotación del tranvía

Pasemos a la construcción, y me referiré a la parte más significativa del programa de ejecución de las obras, que ha consistido en la construcción de la infraestructura de los túneles y las estaciones de la línea 3.

Se definieron dos secciones tipo para el túnel de línea y una tipología estructural uniforme para las estaciones.



En los tramos extremos se opta por la sección tradicional de túnel para doble vía construída por el procedimiento de cut&cover excavando bajo bóveda o losa al abrigo de pantallas y cerrando la sección con contrabóveda o losa de fondo, mientras que, en el tramo central de la línea la sección está formada por dos túneles gemelos de vía sencilla con diámetro interior de 5,75 m. construídos

CON ESCUDO DE PRESIÓN DE TIERRAS Y REVESTIDOS POR ANILLOS DE 1,20 M DE ANCHO FORMADOS POR SIETE DOVELAS DE HORMIGÓN ARMADO QUE COLOCA EL PROPIO ESCUDO SIMULTÁNEAMENTE CON EL PROCESO DE EXCAVACIÓN.

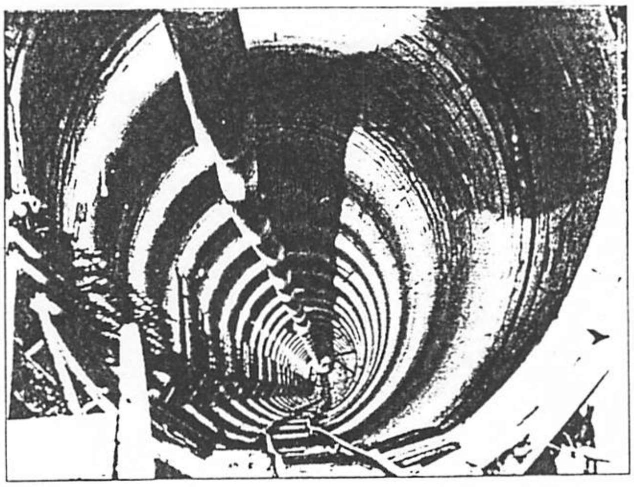
LA ELECCIÓN DE UNA U OTRA SECCIÓN SE JUSTIFICABA FUNDAMENTALMENTE EN LA NECESIDAD DE MINIMIZAR LOS EFECTOS NEGATIVOS DE LA CONSTRUCCIÓN EN EL CENTRO DE LA CIUDAD, LO QUE SE CONSEGUÍA CON LA UTILIZACIÓN DEL ESCUDO TUNELADOR AL NO AFECTAR A LA SUPERFICIE SALVO EN LOS POZOS DE ACCESO DE LA MÁQUINA A AMBOS EXTREMOS DEL TRAMO.

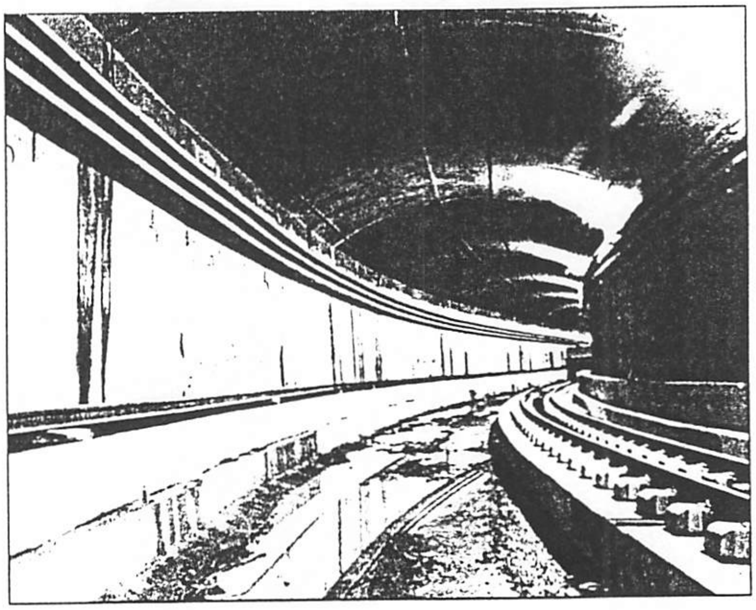
EN CUANTO A LAS ESTACIONES EL PROCESO CONSTRUCTIVO ES IDÉNTICO AL DE LA PRIMERA SECCIÓN DE TÚNEL.

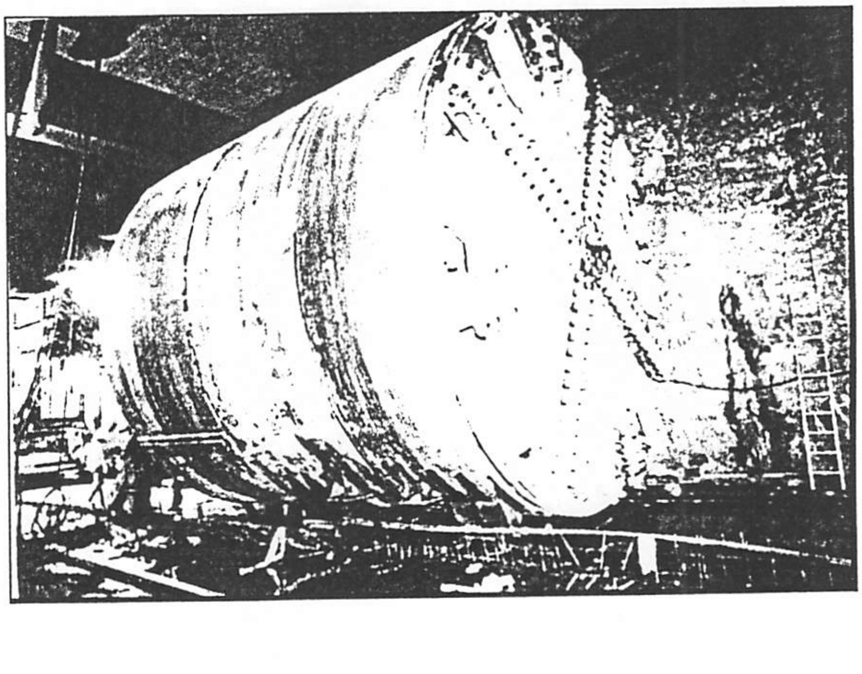
POR ÚLTIMO HAY QUE HACER ALGUNA REFERENCIA A LAS IMPLICACIONES QUE EN EL PROCESO CONSTRUCTIVO DE LA INFRAESTRUCTURA TUVO LA GEOLOGÍA Y LAS CARACTERÍSTICAS GEOTÉCNICAS DEL SUELO DE VALENCIA EN LA TRAZA DE ESTA LÍNEA DE METRO.

EL SUELO DE VALENCIA ESTÁ CONFORMADO POR UNA LLANURA ALUVIAL PROCEDENTE DE LOS APORTES DEL RÍO TURIA QUE LA CARACTERIZAN POR LA ALTERNANCIA DE CAPAS DE DIFERENTE POTENCIA DE MATERIAL GRANULAR Y COHESIVO Y POR LA PRESENCIA DE UN NIVEL FREÁTICO MUY SUPERFICIAL. ELLO IMPLICABA QUE LA EXCAVACIÓN, EN EL CASO DE LA TIPOLOGÍA CUT&COVER, REQUERÍA DE LA PROTECCIÓN DE PANTALLAS DE GRAN PROFUNDIDAD QUE FUERAN CAPACES DE ALCANZAR CAPAS COHESIVAS SUFICIENTEMENTE POTENTES PARA PERMITIR UN EMPOTRAMIENTO ADECUADO SIN RIESGO DE ROTURAS DE FONDO. ESTE CRITERIO HUBIERA SUPUESTO, AL MARGEN DE LAS DIFICULTADES INHERENTES A LA CONSTRUCCIÓN DE PANTALLAS DE 30 A 40 M DE LONGITUD CON CARÁCTER PRÁCTICAMENTE GENERALIZADO EN TODA LA TRAZA DEL TÚNEL Y EN LAS ESTACIONES, UN ELEVADO COSTE DE CONSTRUCCIÓN. LA SOLUCIÓN ADOPTADA FINALMENTE FUÉ LA UTILIZACIÓN DE LA TÉCNICA DE JET GROUTING QUE PERMITIÓ EL DISEÑO DE PANTALLAS CORTAS CONSTRUYENDO CON DICHA TÉCNICA, DESDE LA SUPERFICIE Y ANTES DE EXCAVAR, UN TAPÓN DE FONDO DE SUFICIENTE ESPESOR INMEDIATAMENTE DEBAJO DE LA COTA DE EXCAVACIÓN QUE FUNCIONABA COMO CAPA IMPERMEABLE CAPAZ DE RESISTIR LAS SUBPRESIONES DEBIDA A LA CARGA DE AGUA, QUE EN OCASIONES ALCANZÓ ENTRE 16 Y 20 M, Y SIMULTÁNEAMENTE EJERCER LA FUNCIÓN DE ACODALAMIENTO DE LAS PANTALLAS A LOS EFECTOS DE SU EMPOTRAMIENTO.

EN LAS DIAPOSTIVIAS QUE SE MUESTRAN PODEMOS VER AMBAS SECCIONES DE TÚNEL EN FASE DE EJECUCIÓN Y LA UTILIZACIÓN DE TALADROS PARA INYECCIÓN DE JET GROUTING EN EL SUBSUELO ASÍ COMO UNA IMAGEN DE LA CABEZA DE CORTE DEL ESCUDO DE PRESIÓN DE TIERRAS.







EL MATERIAL RODANTE

POR ÚLTIMO UNA BREVE REFERENCIA AL MATERIAL RODANTE.

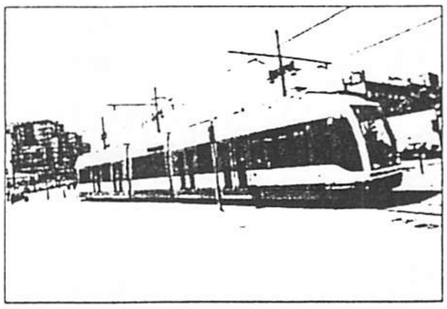
Tanto para línea T4 como para línea 3 el número de vehículos suministrado responde a una estimación de la necesdiad de plazas ofertadas en función de la proyección de demanda establecida para el horizonte de planificación.

En línea T4 se han incorporado 21 unidades de tranvía de piso bajo con un ancho de caja de 2,40 m. y una longitud total de 23,78 m. formado por tres elementos yuxtapuestos mediante rótula que permiten una inscripción del vehículo en curvas de 25 m. de radio.

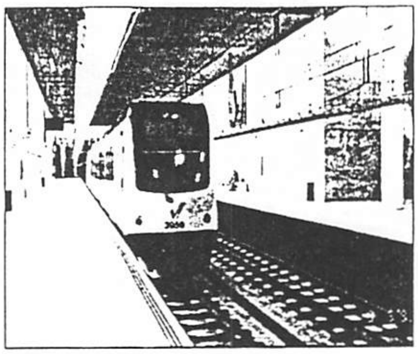
La capacidad del vehículo es de 201 plazas, 65 sentados y 136 de pie.

La tensión de alimentación es de 750 v desarrollando una potencia de 103 kW por cada uno de sus cuatro motores (dos por bogie).

En cuanto a las prestaciones dinámicas más significativas su velocidad máxima es de 65 km/h lo que permite una velocidad comercial en el ámbito urbano de 22 km/h, con una aceleración media de 1m/seg^2 y unas aceleraciones de frenado de 1,2m/seg^2 en servicio y de 2,6 m/seg^2 en emergencia.



MATERIAL MÓVIL LINEA 4



MATERIAL MÓVIL LINEA 3

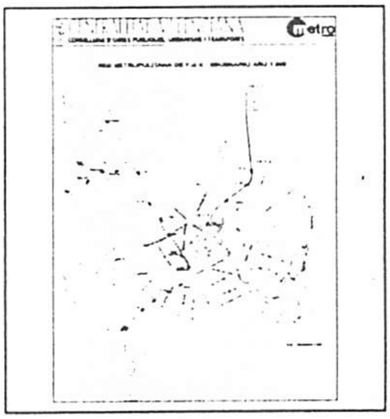
Por lo que se refiere al parque de la línea 3 tiene 18 unidades de una longitud total de 45 m. y anchura máxima de 2,55 m. formadas por dos coches

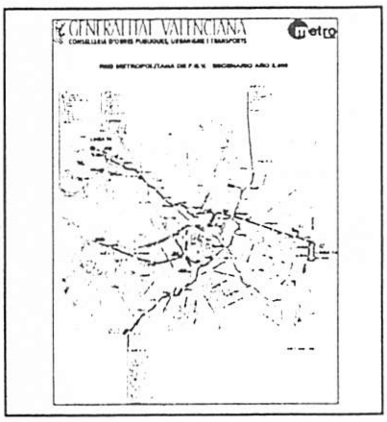
TRACTORES Y UNO CENTRAL PORTANTE ARTICULADOS DE TAL MANERA QUE PERMITEN LA INSCRIPCIÓN DEL VEHÍCULO EN CURVAS DE 100 M. DE RADIO A VELOCIDAD DE RÉGIMEN. LA CAPACIDAD DEL VEHÍCULO ES DE 436 PLAZAS, 94 SENTADOS Y 342 DE PIE.

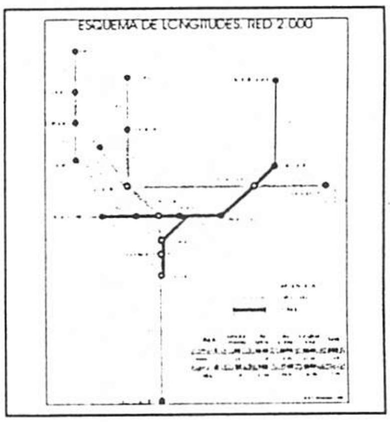
EN ESTE CASO LA TENSIÓN DE ALIMENTACIÓN ES DE 1.500 V DE CORRIENTE CONTINUA Y DESARROLLA UNA POTENCIA DE 164 KW POR CADA UNO DE LOS CUATRO MOTORES CORRESPONDIENTES A CADA UNO DE LOS DOS COCHES MOTORES.

LA VELOCIDAD MÁXIMA ES DE 80 KM/H CON UNA ACELERACIÓN MEDIA DE 0,95 M/SEG^2 Y UNA DECELERACIÓN MEDIA DE FRENADO DE 1,2 M/SEG^2.

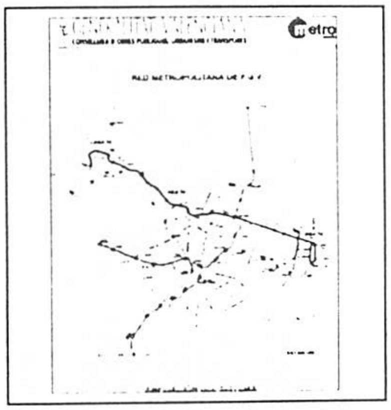

metro
AMPLIACIÓN DE LA RED
METRO - TRANVIA DE VALENCIA

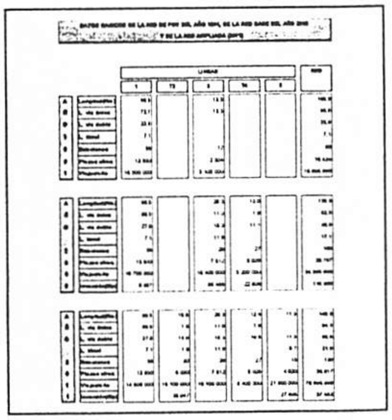


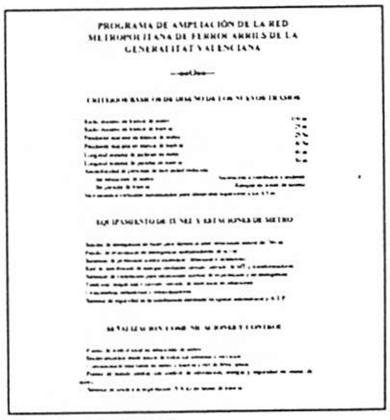

GENERALITAT VALENCIANA
CONSELLERIA D'OBRES PUBLIQUES, URBANISME I TRANSPORTS
metro

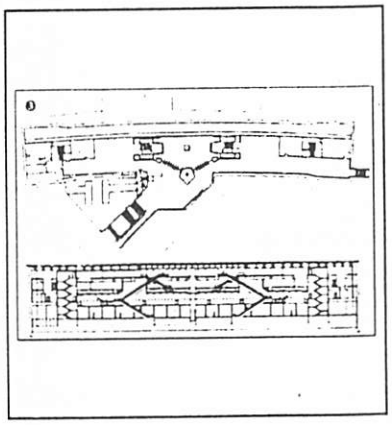

ESQUEMA DE LONGITUDES. RED 2.000

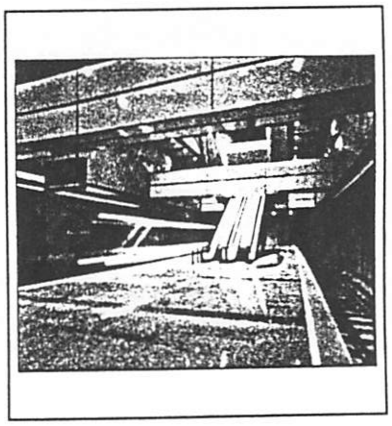

PROGRAMA DE INVERSIONES
AMPLIACIÓN DE LA RED
PERIODO 1991-2000
metro

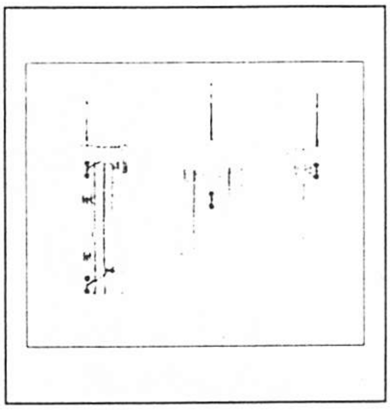

metro
RED METROPOLITANA DE F.G.V.

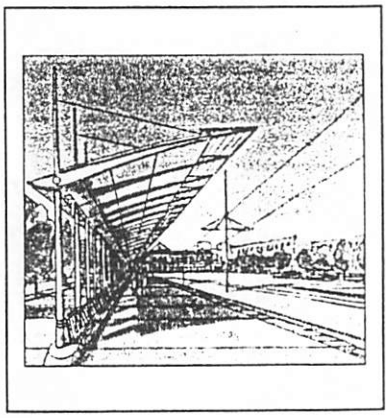


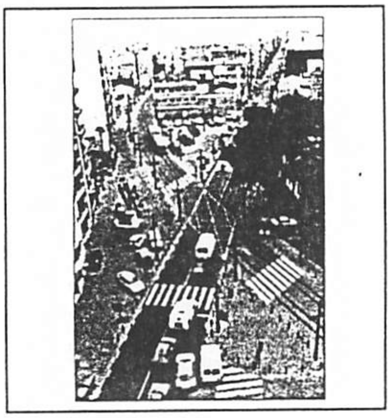

PROGRAMA DE AMPLIACIÓN DE LA RED METROPOLITANA DE FERROCARRILES DE LA GENERALITAT VALENCIANA
CRITERIOS BASICOS DE DISEÑO DE LOS NUEVOS TRAZADOS
EQUIPAMIENTO DE TUNEL Y ESTACIONES DE METRO
SEÑALIZACION COMUNICACIONES Y CONTROL

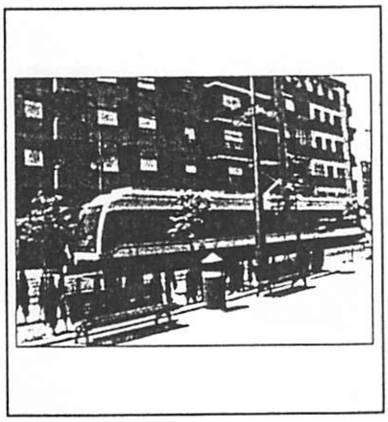


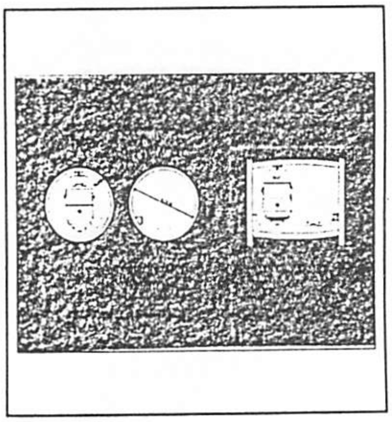


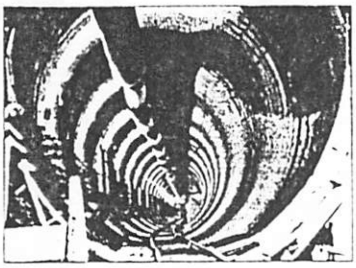


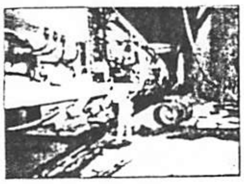


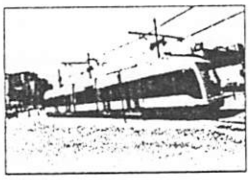




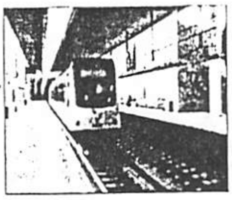




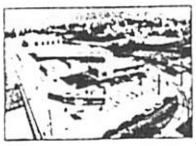




MATERIAL
MÓVIL
LINEA 4



MATERIAL
MÓVIL
LINEA 3



COCHERAS
TALLERES
NARANJOS

COCHERAS
TALLERES
MACHADO