THE DEVELOPMENT OF URBAN PUBLIC TRANSPORT IN LATIN AMERICA AND THE WORLD

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Explanatory notes

A point (.) is used to indicate decimals.

A dash (-) between numbers expressing years, for example, 1985-1986, means that the entire period is under consideration, including the two years indicated. A slash (/) between numbers, for example, 1985/1986, is employed to indicate a fiscal or financial year.

The word "tons" indicates metric tons and the word "dollars" refers to dollars of the United States of America, unless otherwise indicated.

References to annual rates of growth or change are for compound rates, unless otherwise indicated.

Partial figures and percentages presented in tables may not coincide with the corresponding totals, due to rounding.

The following signs have been employed in tables:

- three dots (...) to indicate that data are missing or are not available separately;
- a dash (-) indicates that the amount is nil or insignificant.

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SUMMARY AND CONCLUSIONS

According to present-day sources, urban public transport originated in several European cities in the seventeenth century, but there probably were earlier informal services about which historical records are silent. Until the mid-nineteenth century, the only available means was the horse-drawn carriage. Then the animal-powered tram appeared in North American and European cities, arriving in Latin America some 20 years later. However, horse-drawn carriages and trams coexisted until both disappeared as significant means of transport in the second decade of the twentieth century, displaced by the electric tram and the gasoline-powered bus, which together emerged victorious in a very interesting competition with other now nearly forgotten technological options.

At that point, the electric tram began to lose ground, unable to compete with the bus for various technical, economic and institutional reasons. In many Latin American cities, trams returned to their depots for the last time around 1960. In some cities, the trolleybus was considered a substitute for the tram but, with few exceptions, it did not manage to capture an important segment of the transport market. Trolleybus service continues in certain cities and, with each oil crisis, receives the attention of urban transport planners.

Although the railway was not initially considered a means of urban transport, it began to take on that role when railway companies decided to use the urban and suburban sections of their longer-distance lines for the operation of local trains, which in turn had a significant impact on urban land-use patterns. Until early the twentieth century, the only practical way to move trains was with steam locomotives, which eventually came to transport very large numbers of passengers. Electrification preceded the introduction of diesel traction and today is the preferred technological choice, yet many suburban lines in Latin American still use diesel or -in one case- even steam engines. The introduction of self-propelled multiple trains in place of trains hauled by locomotives was a significant innovation.
The "metro" (abbreviation of "metropolitan railway") took some 50 years to reach Latin America and another 50 to establish itself in more than one city of the region. In some situations, especially in corridors with large passenger flows, the only feasible way to satisfy prevailing demand may be with a metro. However, not only are large investments necessary to build such a system, but subsidies are also usually required to cover its operational losses. Metros serve only a small portion of the total demand for urban transport.

After an initial boom era for the metro, during the 1970s there began to appear less-costly alternatives having lower capacities while still being rail-based. To date, however, these have been little used in Latin America.

For various technical and economic reasons, the bus maintains its dominant position in the Latin American urban passenger transport market, even in cities where other important transport systems exist. Buses running on streets shared with other vehicles are not an efficient way to transport people in the most heavily used corridors. However, it is often possible to provide exclusive lanes in which buses, free of interference from other vehicles, can carry up to 20,000 passengers per hour in each direction, at speeds up to 20 kilometres per hour including stops. Giving priority to buses is not a universal solution to traffic problems in congested areas, but this measure has proven to be more acceptable, both socially and politically, than others that directly restrict the use of the private car.

The operation of urban transport infrastructure in Latin America is very inefficient, basically due to excessive automobile traffic in the most congested zones and times of day. However, the cause of the problem is not the car itself but rather its inappropriate use. More firmness by governmental authorities than has been shown to date is needed to curtail such misuse.

The thorough understanding of urban transport in Latin America that made this book possible was gained while carrying out a project to investigate the social and economic impact of subsidies and different forms of control and organization of urban public transport in the region. The project was executed by ECLAC's Transport Unit, with financial support from the Government of the Federal Republic of Germany, whose generosity is deeply appreciated.
THE TECHNOLOGICAL DEVELOPMENT OF URBAN PUBLIC TRANSPORT

A. THE ORIGINS OF URBAN PUBLIC TRANSPORT

Although earlier forms of public transport may have existed, it is generally considered that the first omnibus ran in Paris on 18 March 1662, and was horse-drawn (see box 1). Omnibuses plied regular routes and, for a fixed fare, carried anyone wishing to travel, except for military personnel and peasants. Later, the service was extended to cover the administrative and commercial zones of the French capital. In spite of its success, the service ended after the deaths of its inventor, Blaise Pascal, and his financial backer, the Duke of Roannez (Day, 1973). As in many other areas of human activity in different eras, the development of transport in general and of public transport in particular depended on the efforts of individuals whose dynamism set them apart from their fellows.

By the early seventeenth century, animal-powered “taxis” had been introduced in London, and it is probable that the same type of vehicle could be found in other European cities. In England, horse-drawn interurban stage coaches were pressed into urban service, initially to carry passengers from residential zones to the boarding points for interurban journeys. However, the urban services soon became independent. In 1825, there were 400 departures daily of horse-drawn public transport vehicles from London to the suburbs, with passengers paying fares individually. It is interesting to note that public transport was regulated even in those early days, stage coaches not being authorized to pick up or drop off passengers on paved roads, where “taxis” had exclusive rights.
In Paris, more than a century passed before Jacques Lafitte, in 1819, reintroduced a fixed-fare public transport service on short routes from one side of the city to the other. It proved very profitable, and from that time on, omnibus service became a permanent feature of life in Paris as well as London and, later, in other cities.

The omnibus, drawn by one or two horses, came to dominate public transport in medium-sized cities; in larger ones, it was a complementary means to feed train and tram networks. In Buenos Aires, such a feeder service operated “for several years prior to 1870,” carrying people to train stations, just like buses in later years (Scobie, 1977, p.205).

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**Box 1**

**ORIGIN OF THE OMNIBUS**

According to Day (1973), the origin of the word “omnibus” is as follows: around 1826, Mr. Stanislas Baudry operated a public transport service between Nantes and the suburb of Richebourg, where he owned thermal baths. In Nantes, his terminal was near the store of someone named Omnes, which sold a wide variety of goods and so displayed a sign with the legend Omnes omnibus. This, seemingly, was a play on words, because omnis in Latin means “all” and omnibus is the dative plural meaning “for all”. Omnes omnibus was thus meant to suggest “Omnes has something for everyone.” It seems that Baudry used a sign with the word omnibus, probably to indicate that his terminal was close to Omnes’ store.

In January 1828, Baudry and two partners set up a public transport service in Paris, which they named L’Entreprise des Omnibus. Other public transport operators in Paris then adopted the same term. Baudry’s company fell victim to the severe winter of 1829, when the price of horse feed became exorbitant. As a result, the pioneer Baudry committed suicide.

The definition of omnibus in Webster’s Third International Dictionary (1985) is consistent with this history: “French, from Latin ‘for all,’ dative plural of omnis ‘all,’ a public vehicle usually automotive and four-wheeled designed to carry a comparatively large number of passengers.” The same source indicates that the word “bus” is derived from omnibus.
The first horse-drawn tram ran in New York City in November 1832 (Day, 1977). However, the system did not become popular until 1850. The tram only made its debut in Europe after considerable delay, leading to the suspicion that laws in European countries hindered the operation of rail systems on the streets. Trams were introduced in Paris in 1855, in London in 1860, and in Buenos Aires at the end of February 1870. The tram represented progress, although fear of accidents caused some opposition. In Buenos Aires, the provincial legislature maintained jurisdiction over the city until 1880, and insisted that each tram project be presented separately for approval. Each one had to contain details of the proposed mode of operation, together with the tram company’s commitment to build and maintain the pavement between the rails. The municipality did not intervene
in the awarding of concessions, but did regulate services by—for example—establishing a speed limit of 10 kilometres per hour and prohibiting the carriage of standing passengers. It later required that every company maintain a deposit in the provincial bank to cover possible accidents to pedestrians (Scobie, 1977, p.211).

Toward the end of the 1880s, the tram network in Buenos Aires is estimated to have covered 198 kilometres, very little less than that in London. However, the contrast between the two systems in respect of passenger volumes was marked. In 1889, trams in Buenos Aires carried 49 million passengers, compared to approximately 200 million in London, the difference probably due in part to the fare charged in the former city being higher than in the latter. It has been noted that the Buenos Aires tram system “did not become the means of transport of the common man until after 1900” (Scobie, 1977, p.215), perhaps due to the high fares. However, such issues will not be addressed here, so that attention can be focused on technological matters.

The tram possessed various technical advantages over the omnibus of the day. In particular, the lower friction generated by an iron wheel rolling over an iron rail meant that horses could pull greater loads. Trams could also be fitted with more effective brakes. These advantages led to others of an economic nature, since the productivity of a driver, conductor, and team of horses, in terms of the number of passengers carried, was approximately double for trams as compared with omnibuses. This enabled tram companies to offer lower fares, which they sometimes did. In 1875, London trams carried many people who previously had been unable to pay omnibus fares (Day, 1977, p.9). As a result of their greater productivity, trams rapidly displaced the horse-drawn omnibus in main urban corridors not served by railways.

For a time, the horse-drawn omnibus was able to coexist with the horse-drawn tram and even with the electric tram, basically because it could operate in zones of relatively low traffic density where the fixed installations required by a tram system—especially an electrically powered one—were not justified. In London, the number of horse-drawn omnibuses peaked in 1901. In the end, however, slower and less-efficient animal traction could not compete with mechanical traction (in London, in 1875, London Tramways needed 1,200 horses to pull 139 vehicles), with the result that urban public transport was rapidly mechanized, at least in developed countries. The last horse-drawn omnibus ran in London on 4 August 1914, and the last horse-drawn tram lasted only a few months more, until 30 April 1915.
B. MECHANIZED PUBLIC STREETBORNE TRANSPORT

ALTHOUGH STEAM POWER was applied experimentally to road transport before being employed in rail transport, it did not find lasting success. For public transport, it was widely used only by rail and waterborne systems. On the other hand, considerable numbers of cars and trucks were fitted with steam-powered motors. In the first decades of the twentieth century, in various countries, steam traction engines were used to pull heavily laden trailers on roads and streets. In some markets, steam-powered trucks competed with trucks powered by internal combustion engines until around 1930. It is thought that the last steam trucks were purchased by the Government of Argentina from a British company after the end of the Second World War.

Steam-powered street transport.

Neither the steam bus nor the steam tram was widely accepted. However, steam power was frequently used for hauling heavy freight on roads and for rolling asphalt pavements.
The steam-powered bus appeared and then disappeared from the scene more than once between 1833 and 1920. It made its debut in London in 1833 (Day, 1973, p.8). This was only three years after the inauguration of the first public railway operated exclusively by steam. But it lasted only a short while. It is highly likely that it suffered technical problems, given the primitive state of mechanical motor engineering at that time. However, there may have been other reasons to explain its withdrawal—in England, at least—such as: (i) inadequate capitalization of the operating companies; (ii) some apprehension on the part of the public, which would have heard about the occasional explosions of locomotive boilers, nearly always with fatal results; and (iii) certain laws which complicated development and hindered motorized traffic on public roadways at the time when the steam-powered bus was in its trial period.

The steam bus returned to the streets of London in 1836, but before the end of 1840 it disappeared again and did not reappear for many years. It left the field free to the more primitive horse-drawn omnibus, subsequently complemented by the horse-drawn tram. It is not known with certainty if the same process happened in all European capitals, although the technological development of urban transport in Paris was probably similar to that in London, since France and the United Kingdom were the two countries which led the field in the development of urban transport in Europe in the last century. The case of London is better documented, so it is treated in greater detail in the present work.

The steam tram was introduced in 1859 in Cincinnati, Ohio, United States of America. In general, it did not displace the horse-drawn tram before being replaced itself by the electric tram, although it remained on the scene for many more years. It had two main disadvantages, namely: (i) the weight of the power units, which occasionally exceeded the capacity of tracks built to carry only unpowered cars carrying 20 to 30 passengers and drawn by a pair of horses, and (ii) the objectionable nature of the coal-fired locomotives, which were as noisy and dirty as other engines using the same fuel. It does not matter too much that a locomotive emits noise and clouds of black smoke in the countryside, but it is much more disagreeable when it does so on the main street of a city.

The steam tram achieved considerable success in some parts of Europe, for example, in Germany and the Netherlands. It was also found in other countries such as Brazil, where eight tramways adopted it (Corrêa Stiel, 1984). However, during the period between 1905 and 1910, just when it was beginning to capture a significant segment of the market, it was overcome by the technically superior electric traction. Even so, in Italy and the Netherlands, steam traction on tram lines which were not always urban lingered on until the 1950s (Baddeley, 1980).
Electric traction offered several advantages over steam. It was cleaner, had better rates of acceleration and braking, the motor could easily be installed in the tramcar body itself (instead of in a separate tractor), maintenance was easier, and no on-board space was needed for storing coal and water. However, stationary steam engines found employment pulling the cable cars of San Francisco, the funiculars of Valparaíso, Chile, and even metro trains in Glasgow.

Around 1880, it was not clear which form of traction would predominate. In London alone, trams were moved by compressed air, steam locomotives, electric batteries, coal gas, petroleum, stationary steam engines and, of course, animals. However, by the end of that decade, the technical feasibility of electric traction had been proven, and it soon dominated the tram scene.

Latin America was sometimes, but not always, slow in adopting the technological novelties of Europe and the United States. In 1835, steam ferries already plied between Rio de Janeiro and Niterói (Corrêa Stiel, 1984). The *tilbury de aluguel*, a kind of animal-drawn taxi, appeared in Rio de Janeiro around 1830. The horse-drawn omnibus arrived in 1838, at the initiative of a Frenchman. A British citizen established a horse-drawn tram system in 1859, and his company introduced steam traction in 1862, just three years after it was first applied to tramways. The first electric trams in South America ran in Rio de Janeiro in 1892, less than a decade after they appeared in the United States. They were introduced in Buenos Aires in 1896 and quickly replaced the horse-drawn tram. In the course of only 10 years, the transformation was virtually complete (see table 1).

In London, tram companies began to incur losses after 1920 and, by 1923, bus passengers outnumbered tram users. Although new tramcars continued to be acquired as late as 1933 and the absolute number of passengers carried did not peak until 1929, trams were already in retreat. However, as a result of the Second World War, during which severe restrictions were placed both on the delivery of buses for civilian use and on the consumption of liquid fuels, trams did not disappear completely until 1952 (Barker and Robbins, 1974).

In Buenos Aires, the disappearance of the tram happened in a different way. In 1928, tramways carried 575 million passengers, but this had fallen to 380 million by 1939, when the traffic was almost equally divided between: (i) trams, (ii) buses and (iii) *colectivos* (see box 2) together with the Underground (metro). But then trams regained their riders and, in 1948, carried more than they did 20 years earlier, reaching 640 million passengers and maintaining a third of the total market. In the latter year, the Underground carried a fifth of public transport passengers, an all-time high. It seems that this boom period for trams and the metro was related to difficulties that the Transport Corporation of the City of Buenos Aires had in operating its fleet of buses, and to the obstacles placed in the way of the private operators of *colectivos* (Vicente and Brennan, 1990).
Traditional tram.
One of the early electric trams in South America ran between La Paz and El Alto, Bolivia. This car, of U.S. construction, still survived in 1991, stored under lock and key in a warehouse in Purapura, a suburb of La Paz.

Traditional tram.
Three tramcars follow one another through an intersection in Rome.
Table 1

BUENOS AIRES: TRAMWAY TRAFFIC
(Percentages)

<table>
<thead>
<tr>
<th>YEAR</th>
<th>PASSENGERS BY TYPE OF TRACTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Animal</td>
</tr>
<tr>
<td>1899</td>
<td>88</td>
</tr>
<tr>
<td>1900</td>
<td>81</td>
</tr>
<tr>
<td>1901</td>
<td>76</td>
</tr>
<tr>
<td>1902</td>
<td>73</td>
</tr>
<tr>
<td>1903</td>
<td>53</td>
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<td>1904</td>
<td>44</td>
</tr>
<tr>
<td>1905</td>
<td>32</td>
</tr>
<tr>
<td>1906</td>
<td>12</td>
</tr>
<tr>
<td>1907</td>
<td>3</td>
</tr>
</tbody>
</table>


In 1952, the Government nationalized the tramways and handed them over to the State-owned company Buenos Aires Transport. Around 1962, the few lines still in existence were returned to a private company, Transportes Automotores Lanús Este, which received them with little enthusiasm. The last tram disappeared from the streets of the city at the end of 1964.

In other parts of Latin America, trams disappeared at more or less the same time as in Buenos Aires and, in at least some cases, their disappearance was very rapid. In Rio de Janeiro, for example, trams achieved their maximum ridership in 1949, when they captured 57% of the traffic by all transport modes, but they were extinct by 1968, except for one line to the suburb of Santa Teresa, which still operates (Jornal do Brasil, 1990).

As occurred in the United Kingdom, the virtual extinction of trams in Latin America was delayed by the Second World War. Tramcars and their power supply systems were easier to maintain than internal-combustion-powered buses, nearly all of which had been built by American, British or German companies that were unable to supply spare parts due to the war.

*in Latin America and the World*
Box 2

TERMS BY WHICH BUSES ARE KNOWN IN DIFFERENT LATIN AMERICAN COUNTRIES

A variety of terms are used in Latin America to refer to the bus. The formal word in Spanish is *autobús*. In some countries, this is abbreviated colloquially to *bus*. Other terms, essentially local in nature, are described below.

**Argentina.** The terms *colectivo* and *micro* are both used. The former traces its origins back to the first bus-like transport services in Buenos Aires, when taxi owners began to use their cars collectively, i.e., hiring them out seat by seat, rather than by the whole vehicle. The latter refers to minibuses, vehicles smaller than traditional buses. A luxury bus is officially called a *bus diferencial*, popularly abbreviated to *simply diferencial*, because it offers a service differential.

**Bolivia.** The terms *colectivo* and *micro* are also used in Bolivia. A smaller-capacity vehicle is called a *truhöius*, a name whose origin—now largely forgotten—dates to the early 1970s in La Paz, when shared taxis started operating over permanent routes. The term applied to them was *taxi de ruta fija* (fixed-route taxi), which was soon abbreviated to *truhö*. By analogy, a minibus offering the same type of service came to be called a *truhöius*.

**Brazil.** *Ônibus* is the term most frequently employed. In Rio de Janeiro, a luxury air-conditioned bus is called a *frescão* (cool wind). *Lotação* means a shared taxi, supposedly because it leaves its terminal once it is *lotado* (fully loaded). Around 1980, a service of minibuses also called *lotações* was introduced in Porto Alegre.

**Chile.** Standard-sized buses are called *microbuses* and, in colloquial speech, simply *micros*. Over time, these vehicles have grown to be larger than regular buses in other countries. There are also vehicles with around 22 seats that once carried only seated passengers, which meant they made fewer stops than *micros*. This, together with their being easier to manoeuvre in traffic due to their reduced size, gave rise to the name *lebre* (hare). The term *colectivo* used to have the same meaning as in Argentina, but since shared taxis started to proliferate in the late 1970s, it has been applied exclusively to those vehicles.

**Cuba, Puerto Rico and some parts of Central America.** Urban buses are called *guaguas*. In Cuba, it is said that the term has its origins in the sound of the vehicle’s horn.

**Mexico.** A bus is called a *camión de pasajeros* (passenger truck). Vehicles known as *peseros* are popular and are so called because, initially, they charged a fare of one peso. At that time, they were a kind of shared taxi, but by the 1990s, they had grown to a unit capacity of around 25 seated passengers.

**Peru and Uruguay.** A bus is called an *ómnibus*.

**Venezuela.** After the Second World War, an initially informal shared-taxi service sprang up. Since the fare was per seat rather than for the entire vehicle, such taxis were baptized *carros por puesto* or simply *por puesto* (by seat). As occurred in other countries, these have also grown in size, effectively becoming minibuses.
Traditional tram.
At street corners, turning trams usually hold up traffic for a few moments. This example is from Asunción (Paraguay).

Traditional tram.
The tram driver must choose between holding up service or hitting the badly parked car. This is an example of friction between trams and other vehicles when they share the same way.
In general, trams had the following disadvantages compared with buses:

(i) traffic congestion affected trams more than buses;
(ii) buses were often operated by small-scale entrepreneurs, who were more dynamic and flexible than the large tram companies;
(iii) tram companies were generally subject to stronger regulation than bus operators, and their fares were usually lower;
(iv) technological progress benefitted vehicles powered by internal-combustion engines more than those with electric power;
(v) bus networks were able to adapt more rapidly than tramway systems to the growth of cities.

Originally, nearly all tram companies in Latin America were privately owned, often by foreign interests. They were essentially concessionaires, and were subject to supervision or control by the authority granting the concessions, which was usually more interested in the supply of services of a quality acceptable to users than in profitability. However, profits were the reason the tram companies were in business. Such conflicts of interests led to differences of opinion which, in many cases, resulted in reductions in the quality and quantity of services, provoking State intervention. The latter was occasionally linked to popular protests, apparently sparked by the fact that the companies were foreign-owned.

Once the public authorities took over the tramways, they found they had acquired bankrupt, devalued and obsolete companies, and were unable to find a solution to the same problems that the private companies before them had failed to solve. Some public entities, such as the Companhia Municipal de Transportes Coletivos de São Paulo, tried to revive the service, but social, economic and technological evolution was against them, and the tramways gradually came to a halt. In Buenos Aires, the last tram ran in 1964, in Curitiba (Brazil) in 1952, in Salvador, Bahia (Brazil) in 1961, in Santiago around 1967, in Lima in 1964, and in São Paulo in 1968. Yet they have not disappeared completely in Latin America. Traditional trams still run in Rio de Janeiro and Asunción, although in the latter city they are, at least partially, a tourist curiosity. In Rio, they may eventually disappear because of their obsolescence and poor maintenance. A modernized version operates in Mexico.

In many cities of continental Europe and other parts of the world, trams still offer regular service and, in most cases, will probably continue to do so in the foreseeable future. Interest in trams has undoubtedly revived. The public considers them superior to the bus, but their investment costs are substantially higher than for buses, and so they have not been reintroduced in more than a few Latin
American cities. The tram has returned to Buenos Aires, as a prolongation of the “E” line of the Underground, and a modern system has been built in Campinas (Brazil). In Curitiba, a light rail transit (LRT) system was proposed as a means for obtaining greater capacity than that provided by the bus system, without incurring the prohibitive costs of a heavy metro, but the costs involved were still too high. A system based on an articulated bus with a capacity for 300 passengers was finally chosen.

Modern tram.
This tram in Rome runs on a way physically separated from that used by cars and other vehicles.
Trolleybus.

Trolleybuses offer no capacity advantage over diesel-powered buses, but do have a greater service life. Some trolleybuses in São Paulo such as this one, built in the 1940s, are still running in the 1990s.

The trolleybus was developed in France and the United States. The first line operated in Lyon, France, in 1901. It was publicized as a quieter and more pleasant version of the tram, and became an attractive option for tramway companies because it allowed them to expand their networks without laying new tracks. At the same time, they were able to take advantage of investments already made in substations and other infrastructure.

In the United Kingdom, trolleybuses operated between 1930 and 1965. In other countries, the trolleybus continued to be developed and modernized, especially in continental Europe. During the oil crises of 1973-1974 and 1982-1983, several countries, including Brazil, implemented programmes to increase the use of trolleybuses in the urban public transport market. Between 1971 and 1976, throughout the world, 52 trolleybus systems were shut down and six started up. Then, between 1977 and 1982, interest in them revived again and, although 13 networks were abandoned, 23 were inaugurated (ECLAC, 1989).
Trolleybus.
Some problems affect trolleybuses but not regular buses, such as, for example, power-supply booms that become disengaged from the overhead catenaries. In Latin America, trolleybus systems are usually built only when environmental conditions make them desirable.

The trolleybus appeared and then disappeared in several Latin American cities, among them Buenos Aires, Rio de Janeiro, Bogotá, and Santiago. Trolleybuses still operate in others, such as Recife and São Paulo (Brazil), Valparaíso (Chile) and Mexico City. In Argentina, Cordoba inaugurated a system in 1989; and Mendoza recently expanded its fleet by acquiring used vehicles from Germany, although not all of these were put into operation. Some routes which were originally planned for trolleybuses are now being served by conventional buses with diesel motors.
The introduction or reintroduction of the trolleybus in a city usually responds to a specific need. For example, in 1991, the Chilean Ministry of Transport and Telecommunications promoted its reintroduction in Santiago as part of a plan to help combat the city’s severe air pollution. Two years later, the Municipality of Quito invited tenders for the acquisition of a fleet of trolleybuses to run through the colonial district, since they were deemed to be less harmful to the environment than buses with internal combustion motors.

In Brazil, a programme for the installation or expansion of trolleybus networks has faced setbacks due to the relatively high costs of installation and to the sharp increase in electric energy rates which occurred in mid 1990, at least in the State of São Paulo. Periodic oil-supply problems that cause prices to rise stimulate Brazilian interest in the electrification of urban public transport but, when the crisis passes, interest wanes.

In early years, the technological development of the motorized omnibus was limited by restrictive legislation (Bruce and Curtis, 1973). In the United Kingdom, for example, maximum weight laws did not take into account the weight of fuel, which, in the case of electric buses, was deemed to include batteries. That principle favoured vehicles which consumed much “fuel,” such as those powered by steam or electricity. The first license for public transport, granted by the London police in 1899, seems to have been for an electrically powered omnibus. It carried 1,500 kg of batteries that gave it a maximum speed of 13 kph, at a time when the speed limit for motorized vehicles was only 3 kph. In the same city, for several years after 1905, buses with gasoline motors and electric generators found limited success, because they were easier to drive and maintain than contemporary vehicles with mechanical transmissions.

In London, in 1906, the most important bus company, the London General Omnibus Company, reintroduced the steam bus, made by Clarkson. It was well received by the public because it was quiet and did not emit smoke, characteristics not normally associated with steam vehicles. In this case, kerosene was used as fuel, which seems to have made the buses much more acceptable for urban use than most steam engines. Other manufacturers also existed at that time, such as Darracq-Serpollet of France, which shows that the steam bus was not confined to Britain. But they could not halt the advance of the internal-combustion-powered bus for long, due in part to the latter’s lower fuel costs.

Conventional bus technology developed gradually during the twentieth century. There were no great leaps forward, but important advances were made, such as the introduction of pneumatic tires in place of solid rubber as from the end of the 1920s. A few years earlier, rolling-contact bearings replaced plain bearings.
Beginning in the 1930s, it became possible to locate the motor beneath the floor of the passenger cabin or in the rear of the vehicle, thus permitting greater design flexibility or an increase in passenger capacity. Later, that flexibility permitted reorganizing the interior layout so the driver could collect fares, thereby eliminating the need for a two-person crew. In developing countries, especially in Latin America, the interior design of buses did not evolve as rapidly as in Europe or the United States and, in some countries, buses are still being built which are, effectively, a front-engined truck chassis on which a passenger body is placed.

As from 1930, diesel motors began to replace gasoline ones, first in Europe and then in North America. This process has not yet been completed, and many buses used for public transport in high-altitude cities such as Quito and La Paz are still equipped with gasoline motors, partly because low atmospheric pressure and the lack of oxygen in the air reduce the efficiency of diesel motors. In some cities, such as Buenos Aires, Santiago and São Paulo, there is interest in the use of natural gas for public transport, mainly to reduce the air pollution caused by particle emissions from diesel motors. Gas power is not new: buses powered by coal gas ran in London during the Second World War, when liquid fuels were scarce.

During the first decades of this century, buses with internal-combustion generators and electric motors, similar in principle to the diesel-electric locomotive, appeared as important competitors to the conventional bus in the United Kingdom and the United States.

Various technological options exist for improving the productivity of bus systems, including the following:

(i) articulated or double-decked buses, which are popular in many countries;
(ii) exclusive bus lanes, found in many countries;
(iii) busways, which have been constructed in several cities, such as Curitiba (Brazil);
(iv) automatic guidance systems, typified by the German O-bahn, which has been commercially applied in Adelaide (Australia) and tested in Essen (Germany) and Birmingham (United Kingdom).
High unit-capacity bus.
In Latin America, double-deck urban buses are found only in Quito and São Paulo, while articulated buses run in Lima, Quito and several cities in Brazil. Normally, these high-capacity vehicles are acquired by publicly-owned companies.

Exclusive bus lanes.
In Curitiba (Brazil), the productivity of exclusive bus lanes is maximized by the use of articulated units carrying up to 300 passengers, who enter through an elevated glass tube within which a fare collector sits.
C. SUBURBAN RAIL TRANSPORT

The railway was not designed for urban or suburban transport and, at first, such services usually ran on lines intended for longer-distance traffic. The first Argentine railroad, the Ferrocarril del Oeste, can be classified in this way. However, there are cases of railways built especially for suburban passenger transport, such as: (i) the first suburban railway in the world, inaugurated in 1836, from London Bridge to the suburb of Greenwich, and (ii) the second South American railway, between Lima and Callao, inaugurated in 1851. Unlike buses and trams, suburban railways were operated by steam from the beginning, for lack of feasible alternatives.

Toward the end of the nineteenth century, suburban services—including those operated by regional and national railways, whether State- or privately-owned—were already carrying large numbers of passengers between the central zones of cities such as London, New York and Buenos Aires, and residential suburbs. In those days, all were steam-powered. The first technological advance came around the turn of the century, when several companies with the economic capacity to finance the necessary investments adopted electric traction for their most heavily used lines. The first electrified service in South America operated between La Paz and El Alto (Bolivia), as from the first decade of the new century (Thomson, 1990). Some of the original equipment of that railway was still in existence in the early 1990s.

Some steam-powered lines had impressive passenger carrying capacities. For example, in September 1920, the American manager of the British Great Eastern Railway implemented an operating system for carrying more than 20 thousand seated passengers per hour per track between the Liverpool Street Station in London and the northeastern suburbs (The Railway Correspondence and Travel Society, 1970, and White, 1963). So far as can be determined, that capacity is a world record which still stands. Although modern metros in several cities can carry more passengers, most must travel standing.

Electrification made it much more feasible to replace locomotive and coach combinations with self-propelled railcars. Steam-powered railcars ran in several countries during the first 40 years of this century but they never became popular, mainly because the power units were unable to pull additional coaches during peak demand periods.
Chile, Paraguay and Peru are some of the Latin American countries in which steam-powered railcars were used for local service. One of the units built for Peru was still in use between Tacna (Peru) and Arica (Chile) in the late 1980s, although its steam engine had been replaced with a diesel.

Unlike steam engines, self-propelled electric railcars are easily able to pull additional cars during peak periods, both because their motors can be made sufficiently powerful and because it is more feasible for the attached unit to also be motorized. The use of multiple units makes it possible to minimize turn-around times in terminal stations, thus increasing the productivity of both platforms and rolling stock.

Through the use of the "push-and-pull" system, it is possible to operate intensive suburban services using steam power, without changing the position of the locomotive — that is, leaving it at the same end of the train, with a control cabin at the opposite end. This system was widely used on rural branch lines in Germany and the United Kingdom and, up to the end of the 1960s, in the suburbs of Paris, but it did not achieve universal acceptance. From the technical point of view, it is much more feasible with electric or diesel locomotives. Compared with multiple units, the main disadvantage of the system is the passenger platform space taken up by the locomotive.

Some urban rail networks have been almost completely electrified, especially in the principal cities of Europe, such as London and Paris. In Latin America, only Buenos Aires, Rio de Janeiro and São Paulo have urban surface rail networks longer than 100 kilometres. In the latter two cities, electric multiple unit trains are used nearly exclusively, but 75% of the Buenos Aires network is still operated with diesel locomotives pulling coaches. The push-and-pull system is not used and, on arrival at the terminal station, the locomotive has to be uncoupled and positioned at the other end of the train. That manoeuvre is not only time-consuming but requires that a track next to the arriving train be clear for the locomotive to pass. It is very expensive to leave a track vacant in a city-centre train station during peak hours.
The suburban train.
In the Western world, the only surviving steam-powered suburban service runs through the streets of Asunción to Ypacaraí, Paraguay.
Suburban train.
In September 1920, the Great Eastern Railway of the United Kingdom perfected a system in which small locomotives such as this one pulled trains able to carry more than 20,000 seated passengers per track per hour.

Suburban train.
When new, this railcar was steam powered. In 1986, now with a diesel motor, it provided local passenger service between Arica (Chile) and Tacna (Peru).
Suburban train.
Some Latin American countries, such as Argentina, Chile and Cuba, acquired used electric railcars or multiple unit trains from the United States.

Suburban train.
A locomotive pulls a train into the Saint Lazare station in Paris, in 1964. The train will subsequently depart in reverse, with the driver located in a cabin at the other end, from which he will control acceleration and braking through the push-and-pull system.
Suburban train.
This diesel locomotive has just arrived at the station in La Plata, Argentina. It has left the train in the middle of the platform and must now reposition itself at the opposite end of the train in order to return to Buenos Aires. This manoeuvre would not be necessary with push-and-pull operation.

Suburban train.
Electric multiple units are used on some branches of the Buenos Aires network. Some of them are modern, such as these on the Roca line.
D. METROPOLITAN RAIL TRANSPORT

The first underground metropolitan railway in the world was the initial section of the London Metropolitan Railway. It was placed in service in 1863, with steam power, which was used on some lines until 1905. In New York, the metro used steam power on elevated lines during its early decades. Metro trains in Glasgow were initially pulled by cables propelled by stationary steam engines. All other metros, except that of Vienna, have used electric power from the beginning, normally in multiple-unit trains, which today are employed universally. They generally work at 750 volts direct current, supplied by a third rail. In some lines, for example, in Buenos Aires, current is transmitted through catenaries and pantographs, but such cases are exceptions to the norm, since they tend to require higher tunnels that cost more to build.

Historical metro.
Between 1863 and 1905, some trains of the London Underground were pulled by steam engines. Note the piping to carry steam from the cylinders to the water tank where it was condensed. (Photograph taken in the London Transport Museum.)
Historical metro.
After the steam engine, electric locomotives were used for a short period to pull subway trains.

(Photograph taken in the London Museum of Science.)

The metro arrived in Latin America in 1913, when what is now the “A” line of the Buenos Aires Underground was inaugurated. The region then had to wait more than 50 years until a second metro entered service, in Mexico City in 1969. Then, a boom period began, with metros opening in São Paulo (1974), Santiago (1975), Rio de Janeiro (1979) and Caracas (1982). A section of an elevated electrified railway in Lima was opened for a day or two in 1990, to show it off to the press and authorities, but it has never operated regularly. In other cities, notably in Brazil (Belo Horizonte, Porto Alegre, etc.), there are electrified urban railways dedicated exclusively to passenger transport. They are known as “surface metros.”
First Latin American metro.
The "A" line in Buenos Aires was inaugurated in 1913. Eighty years later, it not only fulfills an important role in moving passengers between the centre and the Plaza Once area, but is also virtually a working museum which merits recognition as one of the city's tourist attractions.

First Latin American metro.
In the Plaza de Miserère station in Buenos Aires, one can have a snack and admire trains from the second decade of this century as they stop at the platform.
Two metros, those of Mexico City and Santiago, use versions of technology developed in France, with pneumatic tires running on steel (Mexico) or concrete (Santiago) beams. The bogies are exceedingly complex, since they are equipped with a total of 12 wheels instead of the conventional four: four pneumatic tires run on the beams in normal operating mode, four tires are located horizontally to guide the train along the track, and four steel wheels support the train on steel rails if a tire on the first set of wheels should burst.

A continuity exists between the technological alternatives used in trams, on the one hand, and metros, on the other. In traditional tramways, the car runs along the street and is not physically separated from the rest of the traffic. The tram concept evolves into a metro as: (i) more cars are coupled together, (ii) the track is progressively separated from the lanes used by other traffic, (iii) specific signalling systems are installed, (iv) stop or station capacity is increased, and (v) stops are made progressively further apart and develop the characteristics of stations. The range of options between trams and metros is covered by the term “light rail transit” (LRT), as mentioned above (see page 21).
Modern Latin American metro.
The Santiago metro was built efficiently and at low cost. Its operation is also highly efficient.

Modern Latin American metro.
The large numbers of passengers using some lines of the Mexico City metro upset train schedules and increase the probability of tire blowouts due to overloading.
Modern tram.
This tram-trailer combination runs on an exclusive track near the centre of the German city of Munich.

Light rail transit.
In Mexico City, tramlike articulated vehicles run on an exclusive way.
Light rail transit.
The new LRT of Manchester uses the streets in the centre of the city, but in the suburbs it runs much faster on an old railway right-of-way.
In some European cities, especially in Germany and Belgium, tram networks are gradually being transformed into LRTs, and perhaps will eventually become metros. This involves tunnelling so the trains can run underground, stopping in genuine stations. The first transformation of this type seems to have been the Kingsway tunnel, completed in London in 1904 for single-deck trams and later enlarged for double-decked ones. However, this development did not lead to its logical conclusion, since its evolution into an LRT never took place. The tunnel was abandoned in 1952, together with the last of London’s trams. Brussels and Frankfurt are two European cities which have begun to transform their tram lines into LRTs.

The city of Buenos Aires may be considered the birthplace of the LRT because, for more than a decade after its opening in 1913, some trains of the “A” line of the Underground extended their runs from the Primera Junta terminal to the suburb of Floresta via city streets. (Trains of this line still run on city streets, but only to and from their depot.)

A tram line can also be promoted to a higher category in other ways. For example, barriers can be constructed to separate tram tracks from lanes for general traffic, and intersections can gradually be eliminated, as has occurred in Rome, Munich and other European cities. No city in South American has transformed its tram network this way, preferring rather to abandon it and, sometimes, build an entirely new metro. However, in Mexico City, the LRT concept has been adopted on the last stretches of the old tram system, where articulated cars run on the surface, on exclusive tracks, providing feeder service to the metro.

It is possible to construct new LRTs or light metro systems without using existing tram networks as a starting point. In different cities, mainly in developed countries, light metros have been built recently, often with lightweight two- or four-car units running on elevated tracks to separate them from street traffic. This type of system operates in Lille (France) and London, for example.

There are also examples in developing countries, such as in Manila and Jakarta. The latter city adopted a technology known as Aeromóvel, in which propulsion is provided by differences in air pressure within the supporting beam, produced by stationary equipment. It was developed in Brazil during the 1980s, based essentially on the ideas of Isambard Kingdom Brunel, who had applied the same principle in the south of England 140 years before. The Jakarta Aeromóvel carries visitors to an amusement park, rather than being used for mass transit.

In the Brazilian city of Campinas, the first sections of an LRT network have been constructed using rolling stock built for line 2 of the Rio de Janeiro metro.

Table 2 summarizes the chronology of urban public transport.
Table 2

LIFE SPAN OF PRINCIPAL TECHNOLOGIES USED FOR URBAN AND SUBURBAN TRANSPORT

<table>
<thead>
<tr>
<th>TYPE OF TECHNOLOGY</th>
<th>1800</th>
<th>1850</th>
<th>1900</th>
<th>1950</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>BUSES</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• animal-drawn</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• steam-powered</td>
<td></td>
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<td></td>
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<tr>
<td>• gasoline-powered</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>• diesel-powered</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>• electric (trolleybus)</td>
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<tr>
<td>• oil-electric</td>
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<tr>
<td>• in exclusive lane</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>• with automatic guidance</td>
<td></td>
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<tr>
<td><strong>TRAM</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>• animal-drawn</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>• steam-powered</td>
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<tr>
<td>• electric</td>
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<tr>
<td><strong>METRO</strong></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>• with steam locomotive</td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• with electric locomotive</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>• multiple-unit electric</td>
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<tr>
<td><strong>SUBURBAN TRAIN</strong></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>• with steam locomotive</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• with electric locomotive</td>
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<td></td>
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<tr>
<td>• with diesel locomotive</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>• steam-powered railcar</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>• electric multiple-unit train</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• diesel multiple-unit train</td>
<td></td>
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<td></td>
</tr>
<tr>
<td><strong>FUNICULAR</strong></td>
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<td></td>
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<tr>
<td><strong>MONORAIL</strong></td>
<td></td>
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</tr>
</tbody>
</table>

Source: Author.

Note: In this table, a solid line denotes regular use during the period indicated; a broken line indicates sporadic or declining use.
Aeromóvel.

Aeromóvel train in Porto Alegre, Brazil.

Primitive bus.

In some Latin American cities, public transport vehicles are both uncomfortable and unsafe. This photograph was taken in Managua.
II

ADVANTAGES AND DISADVANTAGES
OF THE PRINCIPAL URBAN PUBLIC
TRANSPORT SYSTEMS

A. THE SCANT COVERAGE OF URBAN
RAIL NETWORKS

In Latin America, as in the rest of the world, the bus in one or another of its
forms is the normal means of urban public transport. Even in cities with ex-
tensive metro or other urban rail networks, these usually carry fewer passengers.
Of the cities included in table 3, only in Mexico City, where the length of the net-
work exceeds 150 kilometres, does the metro come close to carrying as many pas-
sengers. In Caracas, the metro accounts for 16% of total trips, and regular buses
for only 6%; however, around 30% are made by minibuses (por puesto), each of
which has a capacity of approximately 25 passengers. In all other Latin American
cities with rail networks, be they metros or suburban railways, the percentage of
trips by rail is very much smaller than that by bus.

The World Bank has published data on modal split in some cities of the de-
veloped world (Armstrong-Wright, 1986). Although the report does not specify the
definitions employed in the study (for example, if a metro trip with an inter-
mediate transfer is counted once or twice), the statistics are revealing. In London,
where the metro route length is 423 kilometres and that of the suburban train
network is even greater, just 12% of total trips are made by rail. In Paris, with
a metro network totalling 199 kilometres and an extensive suburban train system,
the percentage is 21%. Only in Tokyo and New York, among the cities covered,
are more passengers carried by train than by bus.
### Table 3

MODAL SPLIT FOR MOTORIZED TRIPS IN FOUR LATIN AMERICAN CITIES  
(Percentages)

<table>
<thead>
<tr>
<th>CITY</th>
<th>TRIPS BY</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Car</td>
</tr>
<tr>
<td>Mexico City Metropolitan Areaa</td>
<td>17</td>
</tr>
<tr>
<td>Buenos Aires Metropolitan Areab</td>
<td>28</td>
</tr>
<tr>
<td>São Paulo Metropolitan Areac</td>
<td>40</td>
</tr>
<tr>
<td>Santiago Metropolitan Regiond</td>
<td>18</td>
</tr>
</tbody>
</table>

*Source: Studies commissioned by ECLAC.*

a 1983 data. The estimated number of passengers by train (metro) includes transfers.
b 1986 data. Public transport trips are counted by segment.
c 1987 data. As long as one segment of a trip was made by metro, it was counted as a metro trip.
d 1986 data. Generated by the ESTRAUS simulation model, which apparently tabulated each trip according to the principal mode used.

* Taxi trips are included in the Minibus category.

### Table 4

METROPOLITAN AREA OF BUENOS AIRES: MODAL SPLIT OF TRIPS  
(Percentages)

<table>
<thead>
<tr>
<th>MODE OF TRANSPORT</th>
<th>TRIPS, 1980</th>
<th>PERSON-KM, 1982</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bus (colectivo)</td>
<td>62.6</td>
<td>38.8</td>
</tr>
<tr>
<td>Private car</td>
<td>17.7</td>
<td>32.9</td>
</tr>
<tr>
<td>Suburban train</td>
<td>7.9</td>
<td>18.8</td>
</tr>
<tr>
<td>Taxi</td>
<td>7.0</td>
<td>7.4</td>
</tr>
<tr>
<td>Underground (metro)</td>
<td>4.8</td>
<td>2.1</td>
</tr>
<tr>
<td>Total</td>
<td>100.0</td>
<td>100.0</td>
</tr>
</tbody>
</table>

In the estimates for Buenos Aires presented in table 4, it is interesting to compare the modal split by passenger-kilometres with that by trips. For suburban trains, the former exceeds the latter, while for the metro the opposite is the case. This shows that the average suburban rail trip is longer than the average for all trips, while the average metro trip is shorter.

In city centres with intensive commercial activity and streets of limited traffic-carrying capacity, such as Buenos Aires, London or Paris, the metro is often used for short trips within the central area. In the centre of Paris, the distance between stations is approximately 500 metres, which makes the metro convenient for short trips (Garbutt, n/d).

Rail modes, although particularly effective in corridors having the greatest passenger flows, particularly during peak periods, will never again dominate urban public transport as they did in the bygone era of the tram and the steam engine. Metros and other urban rail systems require large investments and subsidies, but serve only a small percentage of total trips. This does not necessarily mean that such investments and subsidies benefit only a limited percentage of the urban population, but the implication is clear.

Among metro users, those who benefit most live or work near stations. Those who must change from other modes obviously obtain fewer benefits. The owners of property near stations also gain because the greater accessibility provided by the metro translates, at least partially, into higher commercial values for their property.
B. URBAN DEVELOPMENT AND THE PROGRESSIVE INADEQUACY OF TRANSPORT SYSTEMS BASED SOLELY ON THE BUS

URBAN BUSES have traditionally shared street space with cars and trucks. However, this method of operation becomes progressively less efficient with increases in: (i) the urban population, (ii) the size of the city or (iii) the income of the city’s inhabitants. The spatial and demographic growth of a city alone, without change in personal incomes, increases traffic on radial routes and causes congestion in central zones. Buses trapped in this congestion provide less efficient service to their customers, whose trips take ever longer to make. Lower speeds mean more capital tied up in vehicles and lower labour productivity.

A process like this took place in Buenos Aires in the early 1900s. What is now the “A” line of the Underground was built by the Anglo Argentina tramway company, which operated a large part of the city’s tram system. The demographic and economic growth of the city caused even more congestion. At that time, however, higher personal incomes did not lead to significant absolute increases in the ownership of private cars, which were not yet mass consumption items. Nor was there competition from buses, although a considerable fleet of taxis did exist. In order to avoid the traffic congestion, which was reducing tram productivity, and to increase transport capacity, Anglo Argentina built the first Latin American metro line.

Longer routes and lower speeds help explain the very significant real fare increases that affect Latin American urban public transport. It is not correct to place all the blame for these increases on oil price rises or on inefficiencies in the organization of the transport system itself (Thomson, 1982, pp.92-93).

In practice, higher rates of private car ownership have a negative impact on the costs and quality of public transport services. This tends to reduce the number of people who use those services, causing further negative impacts on the frequency and number of routes operated and, simultaneously, aggravating traffic congestion. The deterioration in the quality of public transport in turn encourages users to buy cars in an attempt to avoid depending on the bus.

Increases in personal incomes are an important factor in determining rates of car ownership, but they are not the only ones. Income distribution must also be considered. In a society in which the average level of personal income is low but skewed, a more equitable redistribution could lower the rate of car ownership by reducing the capacity of the wealthier classes to buy cars, without transferring sufficient resources to poorer families to allow them to enter the car market. On
the other hand, if average income levels are higher, redistribution could result in an increase in the number of cars. Logically, income increases without redistribution tend to produce the same effect.

Neoliberal economic policies, such as those applied in Chile since the 1970s, in Bolivia from the mid 1980s, and in Argentina, Colombia, Peru and other countries after 1990, have given rise to economic expansion which has increased personal incomes and hence rates of car ownership. These policies have often included liberalization of imports, which makes cars cheaper and thereby further stimulates their ownership. In some cases, such as Ecuador and Peru, the importation of used vehicles was also permitted, thus increasing once again the propensity to buy cars. It should be noted that, in Latin American countries, prevailing levels and distribution of personal income cause cars to have relatively long lives, passing down (or "cascading") to someone poorer when the previous owner buys a newer model. Only after many years are cars scrapped. In developed countries, the sale of 100 new cars increases the net supply by only a few units because the new ones replace old ones; in Latin America, the supply may increase by nearly 100, because the old ones keep running.

Congestion and public transport.
Scenes such as this in La Paz are common in many Latin American cities. Buses are trapped in congestion caused mainly by cars.

in Latin America and the World

47
Congestion and public transport.
The situation in Quito is similar to that in La Paz.
Higher car ownership need not lead to greater car usage on congested streets. In practice, though, that is what happens, especially in developing countries. The problem is due in part to inadequate measures imposed by the authorities to control parking in central zones. Further contributing to congestion is the continued operation of old cars, which are slow and often in poor mechanical condition. This helps to explain why the mathematical traffic models calibrated in industrialized countries must be adjusted for use in Latin America. For example, vehicle acceleration when traffic lights change from red to green is simulated through a routine known as “platoon dispersal.” In developed countries, almost all vehicles have good and relatively similar acceleration rates. In Latin America, small cars with sporty pretensions jump the lights at high speed, leaving the j alopies from another era far behind.

Bus speeds on city centre streets are often very low, even in cities where car ownership rates are also relatively low. In Bogotá, for example, buses creep along at approximately seven kph (Armstrong-Wright, 1986, p.5), and in La Paz, they move at an even slower rate of three or four kph (Instituto de Transporte y Vías de Comunicación, 1990). In greater Bogotá, in 1990, although car ownership did not reach even the modest figure of 0.1 per person, the average speed of cars in the entire urban area was not more that 16 kph. Obviously, that of buses was lower. In 1993, the urban area had a population of more than five million people, together with a fleet of more than 23 000 buses (including butenas and micro-buses) plus more than 55 000 taxis and colectivos. The large size of the bus fleet reflects the low productivity of the average bus, which in turn is related to the acute congestion that characterizes the city.

Bogotá is the largest city in the world that has neither suburban trains nor a metro and has not even begun the construction of such a system. With no rail service, it clearly needs a relatively large number of buses. However, the ratio of its bus-fleet size to its population contrasts sharply with the ratios for Buenos Aires (14 000 buses to 12 million inhabitants, in 1988), São Paulo (12 500 buses to 17 million inhabitants, also in 1988), and a city in a developing country far from Latin America such as Seoul, South Korea (13 000 buses to 8.5 million inhabitants) (ECLAC, 1992, and World Bank, 1986).
C. SYSTEMS OF PRIORITY FOR BUSES

Buses sometimes create their own congestion, but they are also subject to that generated by other vehicles, including cars, which are universally recognized as being very costly in terms of road space per person carried. Typically, a person in a car generates the same congestion as 15 bus passengers, supposing occupancy rates of 70 people per bus and 1.6 per car.

Only in extreme cases can the same level of congestion be attributed to a bus passenger as to a car occupant. Such cases probably occurred during peak hours in Santiago around 1990, when the deregulation of public transport stimulated a sharp increase in the number of buses, which were driven in relatively undisciplined fashion by drivers who competed with one another for passengers. The large number of buses meant low occupancy rates, and the lack of driver discipline meant that each bus disrupted traffic flow much more than necessary. However, such cases are unusual, and car-created congestion is normally the dominant factor.

Where congestion is of little importance, measures to reduce it might well cost more than the potential benefits. In contrast, in highly congested corridors, benefits can far outweigh the costs incurred, which mainly take the form of inconvenience for persons who abandon car travel as a result of the control measures adopted. However, it is politically and socially very difficult to implement effective measures to reduce car traffic on congested streets. What has proven to be more acceptable is to designate exclusive bus lanes or implement other measures which give preference to public transport.

The maximum capacity of large, articulated or double-decked buses in mixed traffic cannot surpass approximately 15 000 passengers per hour/direction/lane, even in the most favourable conditions. The bus speeds would not be more than 12 kilometres per hour, taking stops into account. The implementation of exclusive lanes can improve this performance (see table 5).

There are several options available that have been adopted with varying degrees of success, especially in developing countries. One that has proven capable of producing lasting benefits in terms of bus speeds and productivity is for buses to travel in an exclusive lane counter to the direction of other traffic moving on a one-way street. This option tends to work more efficiently than others because cars usually do not invade the counter-flow lane for fear of running into an on-coming bus. Similarly, if they decide to ignore traffic regulations and travel with the flow of the lane as if they were buses, they cannot pass a stopped bus because they may collide with approaching cars.
Table 5

INFRASTRUCTURE COSTS, CAPACITIES AND OPERATIONAL SPEEDS OF DIFFERENT URBAN PUBLIC TRANSPORT MODES

<table>
<thead>
<tr>
<th>MODE</th>
<th>COST OF WAY (millions of dollars/km)</th>
<th>CAPACITY (passengers/lane/hr)</th>
<th>OPERATING SPEED (km/hr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BUS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• in mixed traffic</td>
<td>0</td>
<td>10 000–15 000</td>
<td>12</td>
</tr>
<tr>
<td>• in exclusive lane</td>
<td>less than 1</td>
<td>10 000–20 000</td>
<td>15–20</td>
</tr>
<tr>
<td>• on busway</td>
<td>2</td>
<td>15 000–20 000</td>
<td>15–20</td>
</tr>
<tr>
<td>• on new busway*</td>
<td>7–12</td>
<td>15 000–25 000</td>
<td>17–22</td>
</tr>
<tr>
<td>• on new busway with automatic guidance</td>
<td>8–14</td>
<td>16 500–27 500</td>
<td>20–30</td>
</tr>
<tr>
<td>LRT at grade</td>
<td>8–27</td>
<td>20 000–30 000</td>
<td>17–25</td>
</tr>
<tr>
<td>METRO</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• elevated</td>
<td>22–60</td>
<td>50 000–75 000</td>
<td>28–37</td>
</tr>
<tr>
<td>• underground</td>
<td>50–165</td>
<td>50 000–75 000</td>
<td>28–37</td>
</tr>
</tbody>
</table>


*Figures for newly-built busways, especially those with automatic guidance, are approximate, because there has been very little experience of them to date.

With-flow exclusive bus lanes are also potentially beneficial and not always just for bus passengers. Occasionally, the reduced friction between bus and car traffic made possible by the creation of the bus lanes makes it possible for cars themselves to move faster, even though the street space available to them is reduced. In a recent study, it was noted that, as a result of creating exclusive bus lanes, "In Bangkok, bus and car travel times were almost always reduced, by up to 30%, and in no case were they made worse. In Manila, bus and jeepney travel times halved (speeds increased from 9 to 18 kph) and other traffic speeds were unaffected" (Allport and Thompson, 1990, p.4.19). However the authors add that the benefits seldom endure because of inadequate enforcement.
Busways.
In the Caracas Avenue corridor in Bogotá, two lanes in each direction have been turned into a busway. Although effective, the so-called Tropical Caracas loses efficiency because enforcement is weak and co-ordination among bus drivers is virtually nonexistent.

Busways.
In Porto Alegre, Brazil, buses carry up to 20,000 passengers per hour per lane in each direction. Some of the buses used during peak hours, such as the one in the foreground, pull trailers. These units are known locally as “Romeo and Juliet” combinations. During off-peak hours, the Juliet is left in the garage.
Busways.
A busway in the model city of Curitiba (Brazil), seen between two boarding points consisting of glass tubes through which passengers enter and leave buses, completely protected from the rain.

Exclusive bus lanes.
This photograph, taken in 1989, illustrates a problem existing at that time with exclusive lanes on Libertador Bernardo O’Higgins Avenue, Santiago (Chile). Taxis, both regular and shared, were not allowed to use these lanes, and so were obliged to leave their passengers on the median strip. These unfortunate people then had to risk their lives by crossing four lanes of general traffic and the twin bus lanes before reaching the relative safety of the sidewalk.
In Santiago, the problem is the opposite. On Avenue Libertador Bernardo O’Higgins, buses can only be kept in their two assigned lanes by plastic cones that separate them from the lanes for other traffic, and by the persuasive influence of police officers stationed at frequent intervals along the avenue. Even so, bus drivers take advantage of every chance they get to invade the other lanes.

The potential benefits of exclusive lanes are considerable, especially in view of the low cost of implementing them, usually less than one million dollars per kilomtre. The cost of the exclusive busways found in various cities in Brazil, as well as in Bogotá and in Lima, does not exceed around two million dollars per kilometre.

In some cases, net real investment may even be negative, given that, if bus speeds rise, the same number of passengers can be carried in fewer vehicles. Much depends on the characteristics of each case; however, if the flow of buses is more than approximately 200 vehicles per hour, the capitalized value of the reduction in the bus fleet may exceed the value of the investment required to install the lane.

In several cities, exclusive bus lanes are separated from general traffic lanes by more or less permanent barriers and are sometimes referred to as busways, although at other times the same term is used for new purpose-built infrastructure. Busways are usually located along the central axis of an avenue, separated by a barrier to prevent the entry of other vehicles to ensure that the initial benefits will last in the long term. In Porto Alegre, the busways, on which buses run in ordered convoys, carry 20 000 passengers/ per hour/direction/lane at a commercial speed of approximately 20 kilometres per hour, including stops (Secretaria Municipal dos Transportes, 1982).

Exclusive lanes or busways have a great advantage over metro systems, in that the vehicles which use them can operate many different routes, converging on a busway (or lane) from a wide variety of origins and then spreading out towards a variety of destinations after leaving the busway. Many passengers can travel directly from where they start their trips to their destinations without changing vehicles. With metros, the chances are obviously much greater that a passenger will have to transfer, which is both inconvenient and time-consuming.

Table 6 illustrates a hypothetical trip between a suburban home and a city centre office, first, directly by bus in an exclusive lane for part of the journey, and then by metro. The commercial speed of the metro is higher than that of the bus, even while the latter is running in its exclusive lane. Even though a passenger who chooses the metro needs time to move from the street to the platform and to wait for the train, this option is quicker, because total travel time is 50 minutes compared with 59 minutes for the bus ride, as shown in column A.
Table 6

TRAVEL TIMES BETWEEN A SUBURB AND THE CENTRE
OF A HYPOTHETICAL CITY

<table>
<thead>
<tr>
<th>TRIP SEGMENT</th>
<th>TIME (minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
</tr>
<tr>
<td>ALTERNATIVE 1: BUS IN EXCLUSIVE LANE</td>
<td></td>
</tr>
<tr>
<td>Walk to bus stop</td>
<td>3</td>
</tr>
<tr>
<td>Wait for bus</td>
<td>2</td>
</tr>
<tr>
<td>Pay bus fare (US$0.35)</td>
<td>--</td>
</tr>
<tr>
<td>Travel 3 km over streets at 12 km/hr</td>
<td>15</td>
</tr>
<tr>
<td>Travel 8 km in exclusive lane at 20 km/hr</td>
<td>24</td>
</tr>
<tr>
<td>Travel 2 km over streets at 10 km/hr</td>
<td>12</td>
</tr>
<tr>
<td>Walk to final destination</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>59</td>
</tr>
<tr>
<td>ALTERNATIVE 2: BUS AND METRO</td>
<td></td>
</tr>
<tr>
<td>Walk to bus stop</td>
<td>3</td>
</tr>
<tr>
<td>Wait for bus</td>
<td>2</td>
</tr>
<tr>
<td>Pay bus fare (US$0.20)</td>
<td>--</td>
</tr>
<tr>
<td>Travel 3 km by bus over streets at 12 km/hr</td>
<td>15</td>
</tr>
<tr>
<td>Descend to metro platform</td>
<td>2</td>
</tr>
<tr>
<td>Pay metro fare (US$0.35)</td>
<td>--</td>
</tr>
<tr>
<td>Wait for metro train</td>
<td>2</td>
</tr>
<tr>
<td>Travel 10 km by metro at 28 km/hr</td>
<td>21</td>
</tr>
<tr>
<td>Return to street level</td>
<td>2</td>
</tr>
<tr>
<td>Walk to final destination</td>
<td>3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>50</td>
</tr>
</tbody>
</table>

*Source: Author.*

*Note: Columns are defined as follows:*

A = real travel time.
B = weighted travel time (waiting and walking increased by 100%).
C = travel time weighted as in column B, plus fares converted to times at a rate of US$0.0167 per minute.

*in Latin America and the World*
Busways.

The Paseo de la República in Lima suffered from a shortage of vehicles while it was administered exclusively by the State-owned bus company. It is now open to all bus companies, but competition among them sometimes reduces its operating efficiency.
The cost of travel time to the passenger depends on how the time is spent. For example, certain econometric studies have demonstrated that the cost of time spent walking or waiting is two or three times that spent seated in a bus or train. If the time spent walking and waiting for each mode is increased by 100%, the metro’s advantage is reduced, as can be seen in column B of table 6.

Finally, if fares are converted into minutes, the advantage of the metro disappears completely and the bus emerges as the preferred option.

Depending on the circumstances, the bus will be the better choice in some cases, while in others, the metro will be preferable. However, it is clear that the metro’s intrinsic limitation of efficiently covering only corridors with the highest passenger flow, rather than being able to spread out to cover the whole city, constitutes a comparative advantage for the bus.

A city’s public transport system can be improved in terms of efficiency and productivity, without large investments in infrastructure, by creating exclusive bus lanes or busways. These low-cost options can also limit the rate of deterioration of the transport system of a city whose size and per capita income are both increasing. However, there eventually comes a point at which the installation of a physically independent network, such as a metro, becomes socially and economically worthwhile.

On the other hand, exclusive bus lanes or busways for bus traffic are not a panacea for all congestion problems, because, in practice, it is not always feasible to install them. Among the factors which limit their usefulness are the following:

(i) **High cross traffic flows.** If the flow of buses in the exclusive lane is interrupted by the movement of crossing vehicles, the efficiency of that lane will obviously be reduced. Cross traffic can sometimes be channeled through a reduced number of intersections to minimize the points of friction. Its diversion over bridges or through underpasses is costly.

(ii) **Multiplicity of bus companies.** An exclusive lane only functions efficiently with discipline. When buses from various companies use it, competition among them may have an adverse impact on its efficient operation. If buses travel in convoys, rigorous discipline must be imposed to avoid their passing each other and to maintain order at the entry points.

(iii) **Excessive competition among bus drivers.** It is particularly difficult to maintain discipline if the drivers’ wages depend on the fares each one collects. This can lead to excessive competition among drivers on the same route, even those employed by the same company.
(iv) **Large volumes of general traffic.** Although reduced friction between buses and general traffic following implementation of exclusive lanes may be beneficial for both, it is evident that, if several thousand cars or trucks per hour move along a street, any reduction in the amount of road space available to them will cause problems.

(v) **Large volumes of bus traffic.** Although an exclusive lane does increase the number of buses which can move along a street, it cannot adequately accommodate more than 300 buses per hour. Sometimes, part of the flow can be redirected to parallel streets but, if it is necessary to accommodate many more than 300 buses, another solution must be sought.

(vi) **Inadequate bus maintenance.** When exclusive lanes are separated from general traffic by physical barriers, great confusion ensues when a bus breaks down or an accident holds up bus traffic.

The implementation of exclusive lanes or busways is not the only way of assigning priority to buses. Another is to set traffic signal lights in their favour. Normally, signal phases are calculated to minimize traffic delays, without discriminating among types of vehicles (although some supplementary restrictions, such as setting a ceiling on the red phase for lightly travelled streets, are common). In the simplest case, optimization may involve just one intersection, yet it can cover an entire area of the city if signals are computer controlled.

The principle of optimization grants implicit preference to users of private transport, because a car carrying one or two people receives the same treatment as a bus with 50. It is possible to defend the assignment of values to travellers' time according to their respective hourly incomes, as is sometimes done in the socioeconomic evaluation of transport projects, but there is no way to justify valuing car passengers' time at 25 or 50 times that of bus passengers. It would be much more just and efficient to give preference to buses when synchronizing signal phases.

In some cities, buses have been fitted with mechanisms which modify traffic signal phases. When a bus so equipped approaches a signal, the light stays green, or changes to green, subject to certain restrictions to ensure traffic safety. If the signal is computer controlled along with others in the same area by a system of the TRANSYT type of predefined cycle programmes, depending on the time of day and day of the week, it is possible to increase the green-light phase on a street with a comparatively heavy flow of buses. If another, more modern system—often referred to generically as the SCOOT type—is used, traffic signal phases are adjusted continuously according to traffic distribution. With SCOOT-type systems, it is more difficult to assign adequate priority to buses.

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*The Development of Urban Public Transport*
In some cities, such as Curitiba, Brazil, new busways have been built, but these cases are exceptional. A potentially more interesting option is to install, either in roads being built or those already in use, mechanisms to guide buses automatically. This technology has been tested in Belgium, Germany, and the United Kingdom, although it has only been applied in practice in Adelaide, Australia. Such systems allow headways in exclusive lanes to be reduced, thereby increasing capacity. Since the vehicles are essentially standard buses equipped with a guidance mechanism, they can run normally on local streets at each end of the busway, thereby offering a more nearly door-to-door service than is possible with metro-type systems.

The true potential of busways for automatically guided vehicles has not yet been fully realized. A mechanism should be developed not only to guide the vehicles but also control their speed. Also as yet underdeveloped are mechanisms which would allow for automatic control across intersections.

Guided busways.
Two buses run on an experimental busway installed in Essen, Germany, to test the O-bahn automatic guidance system.
D. RAILBORNE SYSTEMS

EVER MORE ONEROUS RESTRICTIONS on car use in congested zones, together with measures to assign priority to bus traffic, can increase the capacity of a given road system in terms of the number of people who can use it. If private car, taxi and truck use of roads were prohibited completely during peak hours, public transport could function in even the largest cities without recourse to non-streetborne modes.

However, as more severe restrictions are imposed on car traffic, ever higher real costs are incurred. The cost of denying one more person the right to car travel is generally higher than the corresponding cost to the previous person. Some people would be prepared to pay a very high price to be able to travel by car or taxi during peak traffic hours and, if they were forbidden to do so, the welfare loss could be correspondingly very high. Similarly, prohibiting truck circulation at those same times might mean very significant cost increases for some businesses and the commercial life of city centres might decline.

The increasing costs of ever greater restrictions on nonbus traffic means that, eventually, it may make better economic sense to solve the problem by investing in new transport capacity. In the most congested corridors of large cities, this usually means building underground railways. Nonetheless, only in truly extreme cases can the construction of metros or similar systems be justified economically. A recent study identified the conditions that must prevail in order to do so – (Allport and Thompson, 1990):

(i) except in lineal cities, the volume of passengers in the corridor of the proposed metro must be greater than 700 000 per day –i.e., approximately 15 000 per hour per direction in buses running on the main avenue of the corridor – which means that the total population of the city is likely to be more than five million people;

(ii) annual per capita income in the city should be more than 1 800 dollars, which would correspond to around 1 500 dollars for the country as a whole;

(iii) prospects for population and personal income growth should be positive;

(iv) the most appropriate corridors for the installation of a metro are usually radial ones feeding into the city centre, where the economic prospects in terms of the generation of jobs, etc., should be favourable;

(v) the company which would administer the metro should be efficient and, when possible, different from the entities that run existing railways and bus lines;
(vi) fares both for the metro and for surface public transport should be related to the distance travelled, or an integrated fare scale should exist;

(vii) the metro’s fares must be competitive, in order to attract a sufficient number of passengers to justify the service, so they usually will not be sufficient to pay capital and all depreciation costs, some of which must be recovered through subsidies.

Such conditions mean that practically the only Latin American city in which the building of a new metro might be feasible would be Bogotá.

Table 7 presents the ratio between income and costs for some metros in Latin America and other regions. The World Bank estimates total costs of urban bus transport at between two and five U.S. cents per passenger-kilometre, at mid-1980s prices (Armstrong-Wright, 1986, p.7). Operating costs, including depreciation, for metros in developing countries tend to lie in the range between 1.6 and 6.4 cents per passenger-kilometre, being relatively lower in efficient systems or those used intensively, such as in Mexico City or Santiago, and very high in other cases, such as in Porto Alegre or Rio de Janeiro (Allport and Thompson, 1990).

The study cited above does not specifically address the case of a city with an extensive rail network which has fallen into partial obsolescence or decadence. Re-equipment or modernizing an existing suburban rail line costs much less than constructing a new line. The modernization of the TRENSURB system in Porto Alegre, including electrification and the construction of stations, cost around 11 million dollars per kilometre at 1986 prices. The TRENSURB line is partially elevated but mainly runs on the surface, as does the system in Medellín. Construction of the latter was budgeted at 26 million dollars per kilometre at 1984 prices, but will cost around 50 million dollars per kilometre (excluding financial charges) when eventually finished (Acevedo and others, 1993, figures 4.1 and 4.2).

A new metro line, 15 kilometres long, mostly underground, with 10 stations and 25 trains, would cost at least 1 000 to 1 500 million dollars. The reconstruction of an existing line of similar characteristics, including total renovation of the track, signalling system and the trains themselves, with partial reconstruction of depots, substations and workshops, would cost around 300 million dollars.

Although a total flow of 700 000 persons daily in a corridor may be needed to justify the construction of a metro, the continued operation or modernization of an existing line can be justified at much lower demand levels. Given the appreciable growth of cities in developing countries, together with the steadily increasing income and car ownership rates in many of them, serious consideration should be given to maintaining or improving existing rail systems.
Table 7

FINANCIAL INDICES FOR SELECTED METRO SYSTEMS, 1983

<table>
<thead>
<tr>
<th>CITY</th>
<th>CAPACITY (passengers/direction/hr)</th>
<th>FARE (US$/5-km trip)</th>
<th>TOTAL COST (US$/passenger-km)</th>
<th>INCOME/COST RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caracas</td>
<td>28 700</td>
<td>0.47</td>
<td>0.33</td>
<td>0.35</td>
</tr>
<tr>
<td>Santiago</td>
<td>14 295</td>
<td>0.18</td>
<td>0.14</td>
<td>0.26</td>
</tr>
<tr>
<td>São Paulo</td>
<td>58 000</td>
<td>0.07</td>
<td>0.08</td>
<td>0.19</td>
</tr>
<tr>
<td>London</td>
<td>23 000</td>
<td>0.51</td>
<td>0.26</td>
<td>0.40</td>
</tr>
<tr>
<td>New York</td>
<td>68 000</td>
<td>0.90</td>
<td>0.48</td>
<td>0.20</td>
</tr>
</tbody>
</table>


Modern Latin American metro.
The Caracas metro, an architectural marvel constructed at the high cost of around 150 million dollars per kilometre, plays a nearly indispensable role in the city's transport.
Modern Latin American metro.
One of the most expensive metro sections in the world is the Paulista line in São Paulo.

Suburban train.
In 1990, suburban trains began to run once again towards dormitory towns south of Santiago, Chile, after an absence of 12 years.
In cities where suburban rail tracks have been taken up or suburban trains on long distance lines discontinued, politicians, technicians and the man in the street often comment that they should be restored. In Santiago, for instance, the route of the third metro line (known locally as line 5) is nearly identical to that of an electric suburban railway taken up around 30 years ago. Moreover, suburban trains to dormitory towns such as Rancagua and Melipilla, which were discontinued between 15 and 35 years ago, are being put back into operation.

The case for restoring discontinued suburban trains varies from one place to another. On the one hand, in cities such as Quito or Bogotá, rail lines no longer used by suburban passenger trains are not located in highly populated corridors, so the feasibility of restoring them would be questionable in economic terms. On the other hand, in those Latin American cities currently operating suburban train systems, arguments based on costs, capacity or urban development often suggest the desirability of maintaining them. When they were originally built, usually prior to the age of bus transport and long before the use of the private car became widespread, their construction might have been easier to justify. However, their very existence stimulates changes in land use, such as residential and commercial concentrations around stations, which generate demand patterns that could not be easily met if services were suspended. Cities such as Buenos Aires, London, New York and Paris would have had very different growth patterns had they not had suburban train systems; today, having grown as they did, they depend on their trains to function efficiently.
E. NONTRADITIONAL SYSTEMS FOR SPECIFIC NEEDS

During the history of urban public transport, particular needs have arisen which, for a variety of reasons, conventional technological solutions have not been able to adequately meet. For example, in a few cities, including Salvador (Brazil) and Valparaíso (Chile), the complex topography led to the construction of funiculars for public passenger transport because the buses and trams of the day could not climb steep gradients. Some 10 of them, popularly called “elevators,” still exist in Valparaíso, a few with more than 100 years of operation to their credit. They were originally worked by stationary steam engines; later, some were converted to gasoline or diesel power. Currently, all use stationary electric motors. Although their capacity is very limited, it is adequate to meet the prevailing demands. While they carry only a few hundred passengers per hour in each direction at the best of times, they still have a minor role to play in daily passenger transport, and many of them also attract tourists.

In some cases, suspended cableways have been proposed to solve local transport problems. They can climb steep grades, but their capacity is modest and their physical endurance questionable. They are mainly used for tourism. The cableway constructed to the peak of Mount Aguila, between Caracas and the Caribbean Sea, was built partially for passenger transport between the Venezuelan capital and the port of La Guaira, but tourism has been its only market. An important problem, as in similar systems throughout the world, is its mechanical fragility, which puts it out of service for repairs or maintenance for considerable periods of time. It is thus very difficult to imagine such systems providing the reliability required for regular public passenger transport.

In spite of these and other reservations, a cableway system has been seriously proposed as a means of mass transit from La Paz to El Alto and other nearby towns on the Bolivian altiplano, some 500 metres above. Its promoters believe that a version with cars for 24 passengers could carry some 6 000 persons per hour in each direction, with eight- or ten-second intervals between departures. No other cableway in the world has that capacity. A system with cars for 20 passengers and departures every minute would carry 1 200 passengers per hour per direction.

Another possible alternative is the monorail. In Dortmund, Germany, a suspended monorail system connects one university campus with another, across a relatively deep valley. It has a greater capacity than cableway systems, but cannot climb grades. It is not used for tourism, but rather provides a social service to university students. It is heavily subsidized.
In cities built around bays, such as Sydney or Rio de Janeiro, water transport may be very important. In some cases, rivers can also help solve problems of traffic congestion. In London, for example, a high-speed boat service was introduced toward the end of the 1980s to offer an additional option for commuters between suburbs on the banks of the River Thames and the commercial districts in the centre of the city. However, whether they be river boats, funiculars, cableways or monorails, unconventional modes have never had a very important impact on the passenger market, which continues to be dominated by traditional means of transport, especially the bus.

Special solution to a specific problem.
The funiculars of Valparaiso (Chile), known locally as "elevators," illustrate a public transport system built in response to a particular local condition.
Technology of the future?
Magnetic levitation has been tested for urban transport on, for example, a short line in Birmingham (United Kingdom), although it has not been applied commercially. The picture shows a test track of an interurban version in Germany.
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