

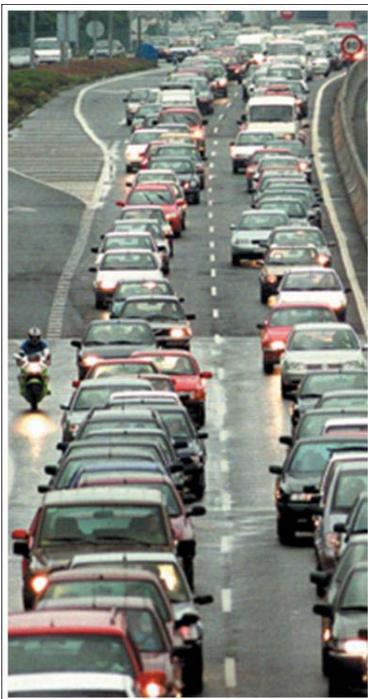
2. Urban Public Transportation

2.1 URBAN TRANSPORTATION

Human activities in dynamic economies require the need of moving from one place to another, and in due to moderns' cities characteristics, and the importance of time in these displacements, they often use motorized vehicles.

However transport is the main source of urban environmental pollution and the responsible of streets congestion¹. In addition of these problems mentioned before, transport presents problems of available space, accidents, noise, vibration, and some other ones.

2.1.1 Congestion Environmental Pollution and Accidental Issues



The continued growth in the population of our cities, along with the increasing specialization in the uses of the ground, has originated a greater number of urban mobility in number displacements and in length. At the moment, this demand of mobility is being solved often by the use of the private car² instead of a rational application of optimal model share.

In spite of the evident and immediate advantages that private vehicle offers to its users, the profusion of the car is the origin of good part of the urban problems.

Cities of the world have many differences ones from the others, but most of them have something in common: Congestion and Environmental Pollution, *which in the European Union represent between them approximately 150.000 Million of Euros per Year (4% of the Gross Internal Product)*.

Congestion is paralyzing the cities; Pollution is damaging people's health; road insecurity is each time bigger; and the use of the automobile is one of the main causes that are pushing humanity to contribute in the climatic change³ and acid rain, putting in danger the future of the world.

The city of the present is paralyzed by traffic, poisoned by high levels of ozone, carbon monoxide, hydrocarbons, heavy metals particles, and other air contaminants. Transit has become into an atmospheric contaminating source in big cities.

¹ The white paper affirms that the 84% of the transport's CO₂ emissions are generated by road transport.

² According to the white paper of the European Commission cars numbers have trebled in the last 30 years and are rising by 3 million a year in the EU.

³ According to the European Environment Agency, climatic change will exacerbate the loss of biodiversity and in 30 years approximately 2/3 of world's population will face water scarcity.

Nitrogen dioxide (NO₂) has an adverse effect on our health and the one of the plants too, it reduces the growth and induces injuries in the sensible harvests, and inside human body it can irritate the respiratory system; reduce the operation of the lungs; and perhaps increase the susceptibility to the infections by virus. The nitrogen oxides play a greater role in the acid rain; also they are important contributors to the formation of ozone at level of the ground. *More of 70% of the emissions of nitrogen dioxide come from vehicles.*

Non – burned and partially burned fuels that emanate the mufflers of cars are known as Hydrocarbons (HC) or Organic Volatile Compounds, which cause serious damage to environment and are the catalysts of the formation of troposphere ozone and others photochemical agents, responsible of general damage of woods in Europe and United State. *Traffic around the World is responsible of almost 39% of hydrocarbons emissions.*

The suspended particles are fine dust units. Generally, they are very small coal particles that absorb chemistries potentially toxic. The particles are so small that when breathing, they penetrate deep in the respiratory apparatus. The particles suspended in the air can aggravate respiratory diseases such as the bronchitis and the asthma. *70% of the air breathed in developed cities of the European Union, exceeds the tolerable limits of Suspended Particles.*



In addition to these damages, *the automobiles dismiss to the atmosphere more than 4.000 Millions of Tons of carbon dioxide (CO₂).* According to studies made by the European Environment Agency, from 1990 to 2001 the emission of CO₂ increased 20% due to high growth in passenger (40%) and freight transport (18%) by road.

In the last decades, innovations in automotive engineering have reduced some of the above-mentioned emissions; nevertheless the numbers of cars in cities have increase in a considerable way, such that the total amount of the polluting emissions has been increasing enormously.

The Earth already has been warmed up between 0,5 and 0,7 Celsius degrees during the last century⁴. Nobody can foretell which will be the true outcomes of the global heating, but signals of potential catastrophes for the future already exist.

⁴ “Global mean surface has increased by 0.6°C since the late nineteen century, a change that is unlikely to be entirely natural in origin. The balance of evidence suggests a discernible human influence on global climate”. Abstract taken from the EIB climate change seminar. Jol 2004.

Another issue caused directly by traffic is accidents. The social costs of accidents are extremely high in the European Union. In fact according to the white paper of the European Commission the cost of accidents this year will represent the 2% of GNP, and the trend is to the increasing of the number of accidents in the years to come due to a bigger utilization of the private vehicles. *One of each 100 driver will die this year in the European Union because of accidents in the routes.*

2.1.2 Other Issues

As commented above traffic transforms cities, and the congestion and air pollution are not the only problems caused by the transport.

The issue of the occupation of space is a concerning problem generated from the continuous using of the private vehicles mainly. Not only the cars that are circulating occupy the streets, the ones parked represent also a relevant problem, in fact studies demonstrate that *a private automobile spends about 90% of the time parked.*

As an example, Los Angeles represents a clear transformed city by the traffic; where *streets, highways and parking places, cover the 55% of its surface.* Complementary studies demonstrate that *an urban displacement needs between 30 and 40 times more space if it is realized in private vehicles than in public transport.*

The noise and vibration pollution is another issue caused by traffic. Engines and tires friction with the pavement make strong noise while transiting. The noise starts to bother from levels of 55 decibels. *70% percent of population of developed countries lives in zones with more than 55 db, and 25% percent of them live in zones with the unacceptable levels of more than 65 db.*

Trucks, motorcycles and buses are the vehicles that produce the biggest noise in the cities. *For example a normal truck produce a noise equivalent to the one produced by 10 to 15 cars.*

The result of all these issues is a city occupied by vehicle and not by people, leaving us with only one clear solution: *Enhanced Utilization of Urban Public Transportation.*

2.2 PUBLIC TRANSPORT IN MODERN CITIES

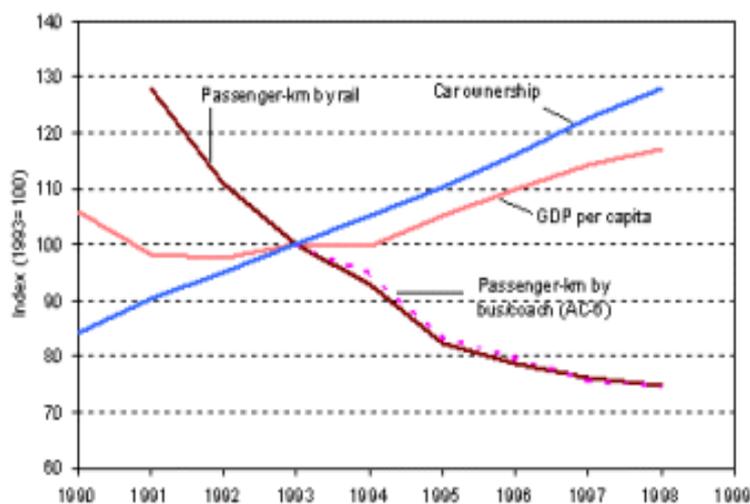
The rapid population growth occurring across much of the Globe (*see Table 1 of European Countries Population in Annex I*) means not only that more people than ever before will be living and working in cities but also that more people and more goods will be making more trips in urban areas, often over longer distances.

Cities have traditionally responded to travel demand by expanding the transportation supply. In much of the developed world, that has meant building more roads to

accommodate an ever-growing number of private vehicles, thereby creating a new urban form: the sprawling metropolis.

The actual transport system based on the automobile is unsuitable. In the last thirty years the number of vehicles has grown, in percentage terms, in greater measurement than the worldwide population. Beyond technical solutions, it is the time to foment the use of others alternatives transport modes, more respectful with environment, such as the soft modes (walking, bicycling, and public transportation).

The graphic below shows the trend that followed the transportation modes (Urban Guided Transport, Bus and Private Car ownership per inhabitant), as well as the GDP per capita (in US Dollars) in the European Union in the 1990's.



Source Eurostat/ECMT/DG TREN data.

All around the world, central governments and cities transport authorities, have started up different plans to try to stop this global problem.

2.2.1 Public Transport Modes Classification

The literature is full of attempts to categorize public transport modes, and there is no single 'right' answer. They may be categorized in terms of their technology, right-of-way exclusivity, grade-separation, guidance and operational regimes, etc. There is a large range of possibilities in practice.

According to the guidance and operational regimes, the public transport can be classified as follows:

1. Non – guided Collective Transport System

This non – guided transport system makes its route by surface, being the bus the characteristic mode of this system.

2. Guided Collective Transport System

Both, in surface or in underground, can make the route. In the surface route, Tramways, Trolleybuses and Light Rail take part in this system. As in the underground form, the Metro is the main actor of the system.

For aims of studies in this research, it will just be deal with the guided collective transport system in its two forms, as much in surface as in underground. In the same way the Trolleybus, in spite of belonging to the group of the guided collective transport of surface, will not comprise part of the present analysis.

Due to the heavy investment required by Tramways, Light Rail Transit and Metros Projects, the rest of this paper will concentrate in those modes of transport.

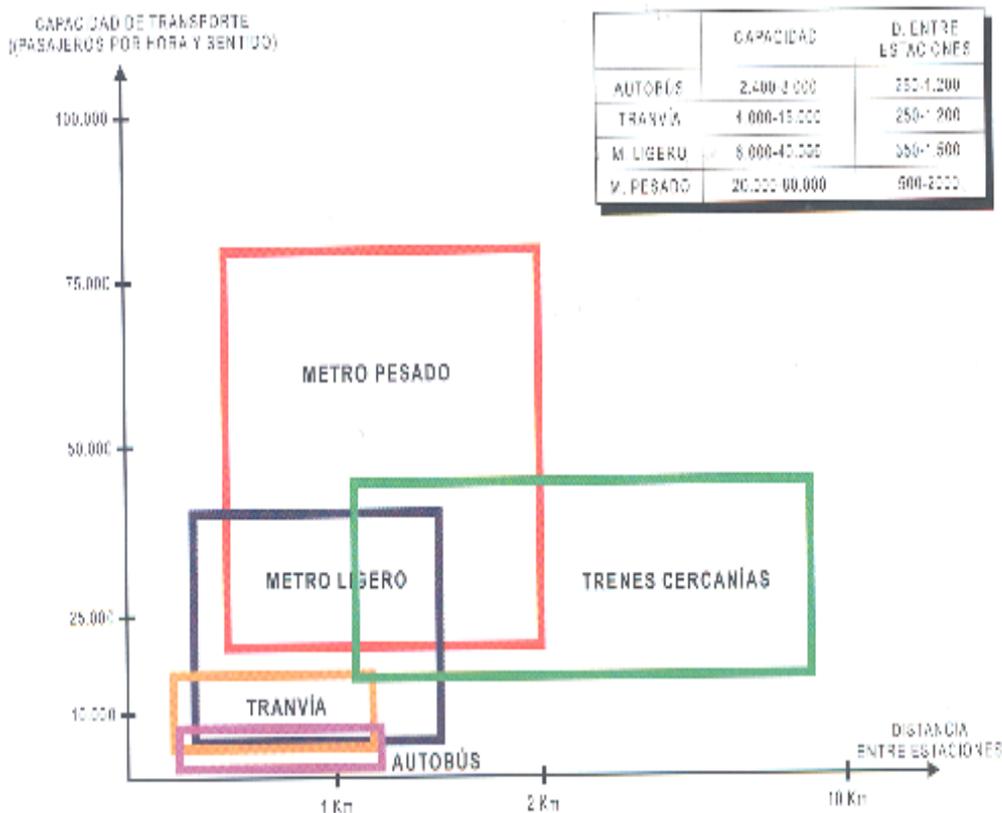


Fig. 2.2.1.

Source: Gestión y financiación de las infraestructuras de transporte terrestre

2.3 TRAMWAYS AND LIGHT RAIL TRANSIT

2.3.1 Tramways

Everything seems to indicate that, to maintain a certain quality of life in cities, the use of public transport must be harnessed. Technical solutions to be applied are clear:

- To small cities, with low volumes of transport, public transportation leads to the use of bus or trolleybuses, which generally share their platform with the rest of vehicles.
- To big cities, with high volumes of transport, public transport is based in railway systems, as metro, which has an own platform, and complemented by buses.

But, what can we do with cities with intermediate transport demands?

Some German cities made the same question at the end of the decade of the 60's, when municipal authorities realized that their tramways system had arrived at the limit of their possibilities. To consider high capacity urban transport system (like a metro), was out of their financial reach. The idea that arose in this context was the one to improve the operation of the tramway system by increasing its passenger capacity by means of a raise of its commercial speed. This was obtained segregating circulating of tramways of the rest of the vehicles in certain zones.



Choosing the Tramway as the main public transportation mode has become an option of success in many European cities in recent years. This is a comeback (of the Tramway), in which much of its concept has changed, as well as its design and characteristics compared to their last years of operation. Now, the vehicles are quiet, agile and quick although they conserve its essence: running on tracks and being powered with by electricity.

Some of the advantages that the tramway has while operating in the streets of modern cities are:

- Induces the *rearranges* of traffic, *extending* the sidewalks while *reducing* the anarchical parking.
- *Reduction* of the gas discharge and the power consumption.
- *Creation* of “Green Roads”.
- *Improvement* of the environmental conditions of the city.
- *Reduction* of 30% in average of the time in trips compare to cars and buses.

- *Generation* of the conditions necessary to foment the sustainable development.
- Helps to *release* the congestion of the cities center.
- *Occupies* less dynamic space.

The putting in service of the Tramway has made that the cities have changed their appearance, presenting a new landscape that offers a renewed and modern image of the 1950's, and have been able to gain space in damage of the agglomerations caused by the private car. Overall it is accepted that the implantation of the modern Tramway generates benefits to all the society.

2.3.2 Light Rail Transit (LRT)

Once again based in the fact of having an always increasing demand and a greater saturation of the urban nucleus, another way of effective and economic mobility appears. The Light Rail has been granted as a solution in many places in the last years. It appears in a big number of new projects to improve the networks of public transport.

Light Rail (LR) has to be understood as: *“a tracked, electrically driven local means of transport, which can be developed step by step from a modern tramway to a means of transport running in tunnels or above ground level. Every development stage can be a final stage in itself. It should however permit further development to the next higher stage”*⁵.

This broad definition encompasses a wide array of situation, from conventional tramway, to tram – train⁶ solutions. Tramway and Light Rail are two stages of a same evolution. The fundamental difference between a modern Tramway and a LR is the passenger capacity of the system, cradle in the greater or smaller reserve of platform whereupon it counts the second. Another difference between the Light Rail Transit and the conventional Tramways is the rolling stock; the trains that operate in LRT systems are capable of transport more people than the ones operating in the Tramway systems; usually is compose by two or three car per train.

Light Rail Systems are thus flexible and expandable. It is not absolutely necessary to have an independent bed track over the whole route: however, the highest degree of segregation from private traffic should be aimed for. LR systems can be developed from traditional tramway systems or planned and built as entirely new systems.

The most important advantages that that the LRT offer are the following:

- This new system of transport offers great possibilities to those zones of less demand where setting up the conventional Metro it's highly non - viable and technically complicated. The advantages of the LR are:

⁵ Definition from the UITP (Union Internationale des Transport Publiques).

⁶The Tram-train is a guided transport system that operates not only in the urban area, but also in interurban routes in railways with international wide.

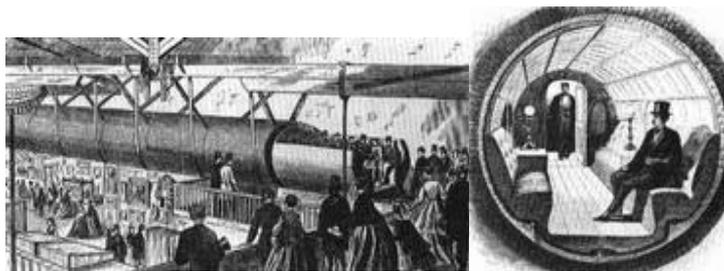
- Their reasonable cost of implementation and maintenance
- Their facility of connection with other types of transport and his reduced consumption
- In addition, and responding to other types of social demands, is considered an ecological system that would release some zones of the cities of more serious the circulatory problems
- The LR are on of the most quiet system of collective transport, with a level of almost anecdotal noise
- Its accessibility is even superior to the one of the buses of low floor

The Light Rail market has a high growth potential ahead. In terms of numbers of European cities that are equipped with Light Rail Train Systems, the growth has reached 55% of them.

2.4 METRO SYSTEMS

In 1844 the Long Island Rail Road opened the Atlantic Avenue Tunnel, carrying its line under the streets of Brooklyn (now part of New York City). Although sometimes called the "world's oldest subway tunnel", this had no stations and was used for long-distance as well as suburban trains.

As mentioned before, the first deep-level urban underground line was the City and South London Railway, which opened in 1890. Steam operation being considered ridiculous, cable traction was chosen; but during construction the management decided to try electric locomotives instead, and so the C&SLR became the first underground electric railway and the first important electric railway of any kind.



The first line of the Paris Metro opened in 1900. Its full name was the *Chemin de Fer Métropolitain*, a direct translation of London's Metropolitan Railway, and the use of the word "metro" in various languages is derived from this.

The UITP defines a Metro System as “a tracked, electrical driven local means of transport, which has an integral, continuous track bed of its own (large underground or elevated sections)”. This results in a high degree of freedom for the choice of vehicle

width and length, and thus a large carrying capacity. Intervals between stations would be typically more than one kilometer, and because the alignment does not have to follow existing streets, curve radii and section gradient can be more generously dimensioned and permits for an overall higher commercial speed.

Metro systems require, therefore, heavier investment than light rail, and can be implemented only in large cities where demand justifies the investment cost.

Those who prefer the American term "subway" or the British "underground" would additionally specify that at least the most important, central parts of the system must be located below street level; those who prefer "metro"⁷ tend to view this as a less important characteristic and are pleased to include systems that are entirely elevated or at grade. In some cities "subway" refers to the entire system, in others only to the portions that actually are underground.

Some Metro Systems are built to the full size of main-line railways; others use smaller tunnels, restricting the size and sometimes the shape of the trains (in London the informal term *tube train* is commonly used). Metro Systems are often viewed as the backbone of a large city's public transportation system.

Traditionally, metro trains are operated by human drivers, but automated trains also exist, in, for example, London, Singapore, and Paris. This is not a recent invention; operation of trains on the Victoria Line (London) has been automatic since its opening in 1968. However, in common with most systems, an operator is still carried in a cab at the front of the train. The VAL (*véhicule automatique léger*) of Lille (Paris), inaugurated in 1983, provided the first driverless underground system. Singapore's North - East Line (2003) claims to be the world's first fully automated heavy rail line.

Underground systems use a variety of technologies. Most systems run on steel wheels and rails, although a number of modern systems use rubber tires and concrete rollways. (The Montreal metro was the first completely rubber-tired metro system.) Power is usually supplied either by means of a single third rail (New York), but some systems use two live rails (London) or overhead lines (Madrid).

2.5 URBAN RAILS VS. OTHER RAILS: DIFFERENCES

It is not easy to define sharply where is often located the barrier between a metropolitan railroad and other railroads of short and average distances; especially now when the interurban railway, which until relatively few years were conceived as railroads for medium and regional ranges, are forced (by the demand of travellers of the suburbs of the cities) to adopt formulas of operation equals to those of the Light Rail, Tramways and Metros.

⁷ The word "Metro" comes from the metro-politan term; therefore "metro" is a short term that has being used to call the train that operates urban area of a city.

Most of urban railroads (Light Rail, Tramways, Metros, etc.) base their exploitation systems on lines or routes with great density of population. It, among other peculiarities, forces to design stations with “small” distances one respect the other, avoiding great displacements of the citizens in surface. This first conceptual premise forces transport systems that, to offer high commercial speeds - and therefore lower times of routes - need a movable material able of important accelerations and decelerations (of the order of 1 or 1.2 m/s²), unlike other types of railway operations, in which the distance between stations is of many kilometers.

The headways in urban guided transport system are usually really short, causing that the system operates by intervals between trains, on the other hand interurban rails operate most of the time by predetermined schedules and the headway between trains is bigger than the ones of urban railways.



Another important differentiating characteristic is the fact that a great part of the Light Rail, Tramways and Metros circulate, either within the urban areas in surface, or underground through tunnels. In both cases, the sizes of the boxes of their cars usually are smaller than those of the conventional railroads, but the need of high accelerations requires very powerful motorizations in comparison of the conventional railway sector. Therefore, it is that the classical composition of a train with a tractor head and towed cars is not applicable to the metropolitan operations, and must go to compositions formed by units Engine - Engine, Engine - Tow - Engine, Engine - Engine - Tow - Engine - Engine, or similar.

It must also be indicated that the electrical feedings in the urban railway transports usually are made in DC and with tensions between the 600 and 1,500 Volts, unlike the electrical interurban railroads, which use alternate feedings, with industrial or special frequencies, but always with much more elevated tensions (of 15,000 to 25,000 Volts).