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# LRT - A Dynamic Transit Mode With Continuing Innovations

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# LRT - A Dynamic Transit Mode With Continuing Innovations

## **Abstract**

When increasing use of the private automobile intensified street traffic congestion, cities, generally pursued one or two types of policies. The "Car accommodation policy" was aimed 'primarily at accommodating the car and highway traffic, neglecting all other modes. The "Balanced transportation policy" was directed to achievement of a co-ordinated system of different transportation modes.

The former group of cities eliminated streetcars I tramways. The latter upgraded them through numerous innovations, into Light Rail Transit - LRT. The intermediate transit modes, which LRT represents, have been increasingly found effective as a solution for the cities which need better services than buses on streets can offer, but which cannot afford the high investment for metro systems.

Due to its innovative concepts, LRT is increasingly used in a number of different forms and functions. The recent invention of low floor vehicles has further contributed to the image of LRT as a major contributor to livable cities.

The paper compares the conditions and policies toward streetcars which led to their elimination from many cities in the 1950's, with those of the 1990's, which have resulted in a strong promotion of LRT systems in many cities of developed and developing countries. This comparison offers a useful lesson for the cities which find themselves now, belatedly, in the stage when streetcars are considered "obsolete". They can avoid the costly mistake of allowing transit systems to deteriorate only later to be upgraded at a much higher cost.

## **Disciplines**

Civil Engineering | Engineering | Systems Engineering | Transportation Engineering

Tuesday - Mardi - Dienstag  
01/10/1996

FIRST SESSION - PREMIERE SÉANCE - ERSTE SITZUNG

***LRT - A Dynamic Transit Mode with Continuing Innovations***

***Le métro léger - Un mode de transport dynamique à la pointe de l'innovation***

***Die Stadtbahn, ein dynamisches Verkehrssystem mit großer Innovationskraft***

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## **SUMMARY - RESUME - KURZFASSUNG**

### **LRT - A Dynamic Transit Mode with Continuing Innovations**

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### **Le métro léger - Un mode de transport dynamique à la pointe de l'innovation**

Lorsque l'utilisation accrue de la voiture privée a augmenté les embouteillages, les villes ont, en général, adopté l'un des deux types de politiques existantes. La politique en faveur de la voiture, d'une part, avait pour but de favoriser les traffics routiers et autoroutier, négligeant ainsi tous les autres modes de transport. La politique en faveur d'une utilisation équilibrée de tous les modes de transport, d'autre part, avait pour but de parvenir

à créer un système coordonné entre les différents modes de transport

Le premier groupe de villes a supprimé les tramways tandis que le second, grâce à de nombreuses innovations, les a transformé en métros légers. On a de plus en plus opté pour ces types de transports intermédiaires, dont fait partie le métro léger, car ils sont la solution idéale pour les villes qui ont besoin de services meilleurs que ceux offerts par les bus, mais qui ne peuvent se permettre d'investir en masse pour des systèmes de métro.

Grâce à ses concepts innovateurs, le métro léger est de plus en plus utilisé sous différentes formes et pour différentes fonctions. Les véhicules à plancher bas, récemment mis au point, ont de nouveau contribué à améliorer l'image du métro léger, important facteur contribuant à faire des villes des endroits où il fait bon vivre.

Le présent exposé compare les conditions et les politiques qui ont conduit à l'élimination des tramways dans de nombreuses villes dans les années 50, avec les conditions et les politiques des années 90 qui ont permis une grande promotion des systèmes de métro léger dans de nombreuses villes de pays développés ou en voie de développement. Cette comparaison offre une leçon utile aux villes qui se retrouvent aujourd'hui, assez tardivement, avec des tramways considérés comme obsolètes. Elles peuvent ainsi éviter l'erreur coûteuse de laisser les systèmes de transport se détériorer et de les moderniser plus tard à un coût plus élevé. (Vuchic)

### **Die Stadtbahn, ein dynamisches Verkehrssystem mit großer Innovationskraft**

Als die zunehmende Benutzung des Pkws zu wachsenden Staus im Straßenverkehr führte, wandten sich die Städte im allgemeinen einer der beiden folgenden Lösungen zu: entweder wurde eine Politik verfolgt, die den Anforderungen des Pkws und des Straßenverkehrs Rechnung trug und alle anderen Verkehrsarten vernachlässigte, oder es wurde eine ausgewogene Verkehrspolitik eingeführt, mit der ein koordiniertes System aus

unterschiedlichen Verkehrsarten geschaffen werden sollte.

In der ersten Gruppe angehörnden Städten wurde die Straßenbahn abgeschafft. In der zweiten Gruppe wurde sie durch zahlreiche Innovationen zur Stadtbahn modernisiert. Diese Zwischenformen des ÖPNV, wie sie die Stadtbahn repräsentiert, werden zunehmend als wirksame Lösung für Städte betrachtet, die einen besseren ÖPNV benötigen, als er durch Busse auf den Straßen gewährleistet werden kann, die sich aber die hohen Investitionen für eine U-Bahn nicht leisten können.

Wegen ihrer Innovationsfähigkeit wird die Stadtbahn zunehmend in verschiedenen Formen und Funktionen benutzt. Die kürzliche Erfindung der Niederflurfahrzeuge hat das Image der Stadtbahn als wichtigen Beitrag zu bewohnbaren Städten weiter verbessert.

Das Referat vergleicht die Bedingungen und die zugrundeliegende Verkehrspolitik, die das Verschwinden der Straßenbahn aus vielen Städten in den fünfziger Jahren zur Folge hatten, mit denjenigen der neunziger Jahre, die zu einer starken Renaissance von Stadtbahnssystemen in vielen Städten der Industrie- und der Entwicklungsländer geführt haben. Dieser Vergleich liefert nützliche Lehren für diejenigen Städte, die sich jetzt - verspätet - in dem Stadium befinden, in dem Straßenbahnen als "veraltet" angesehen werden. Sie können die erheblichen Kosten sparen, die entstehen, wenn man Verkehrssysteme aufgibt, nur um sie später mit viel höheren Kosten in modernisierter Form wieder aufleben lassen zu müssen. (Vuchic)

Several decades ago streetcars/tramways\* were eliminated from many cities as a mode considered to be an obsolete technology, whose time had past. Today, the intensive development of Light Rail Transit (LRT) systems in many cities around the world clearly shows a bright future for its wider and increasingly diversified applications. This process represents one of the most interesting developments in urban transportation in recent decades. LRT has not only had remarkable technical innovations of its tracks, signals and vehicles, but even more importantly, its entire system concept has undergone fundamental changes.

The past policies should be reviewed to define their failures, successes and lessons for the future. This is particularly important because some cities today are going through transportation development stages which occurred in cities of industrial countries during the 1950's and 1960's, and they are in danger of repeating the mistakes of their predecessors which have proved to be very costly.

## **1. FOUR PHASES OF STREETCAR/LRT DEVELOPMENT**

An historic-analytical review of the developments of streetcars and LRT systems in different cities around the world over the recent decades gives an interesting insight into the entire problem and trends in urban transportation and cities in general. In spite of great differences in the characteristics of cities and countries, it is remarkable that basically two different patterns of urban transportation policies, which resulted in very different transit developments, can be observed.

Since 1881, the time electric streetcar was invented and later made practically operational by Siemens in Germany, Sprague in America and many other inventors and engineers, one can define four major phases in its development up to today's LRT systems. These phases are shown schematically in Figure 1. Most countries and cities which used this mode have passed through these phases, but the crucial difference in their policies and developments took place in Phase III, as will be discussed below. That phase actually did not decide only the role of LRT, but also the character of cities and quality of life in them.

The time when different cities go through the four phases of this sequence of streetcar-LRT evolution vary, because the developments are related to the timing of the economic growth and, particularly, of the increase in private car ownership.

### **1.1 Phase I: Transit Dominance Era**

In the first phase, streetcar systems represented the basic, by far the most important transportation carrier in cities. In developed countries streetcar networks were ubiquitous, serving

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\*Classical street-based rail transit systems are known as "streetcars" or "trolleys" in the U.S. and Canada, "Strassenbahn" in German-speaking countries, "trams" or "tramways" in most other English and French-speaking countries. LRT systems are characterized by partially or fully separated rights-of-way, which allow operation of longer trains and have higher performance: speed, reliability, comfort, etc. than streetcars operating on streets have.

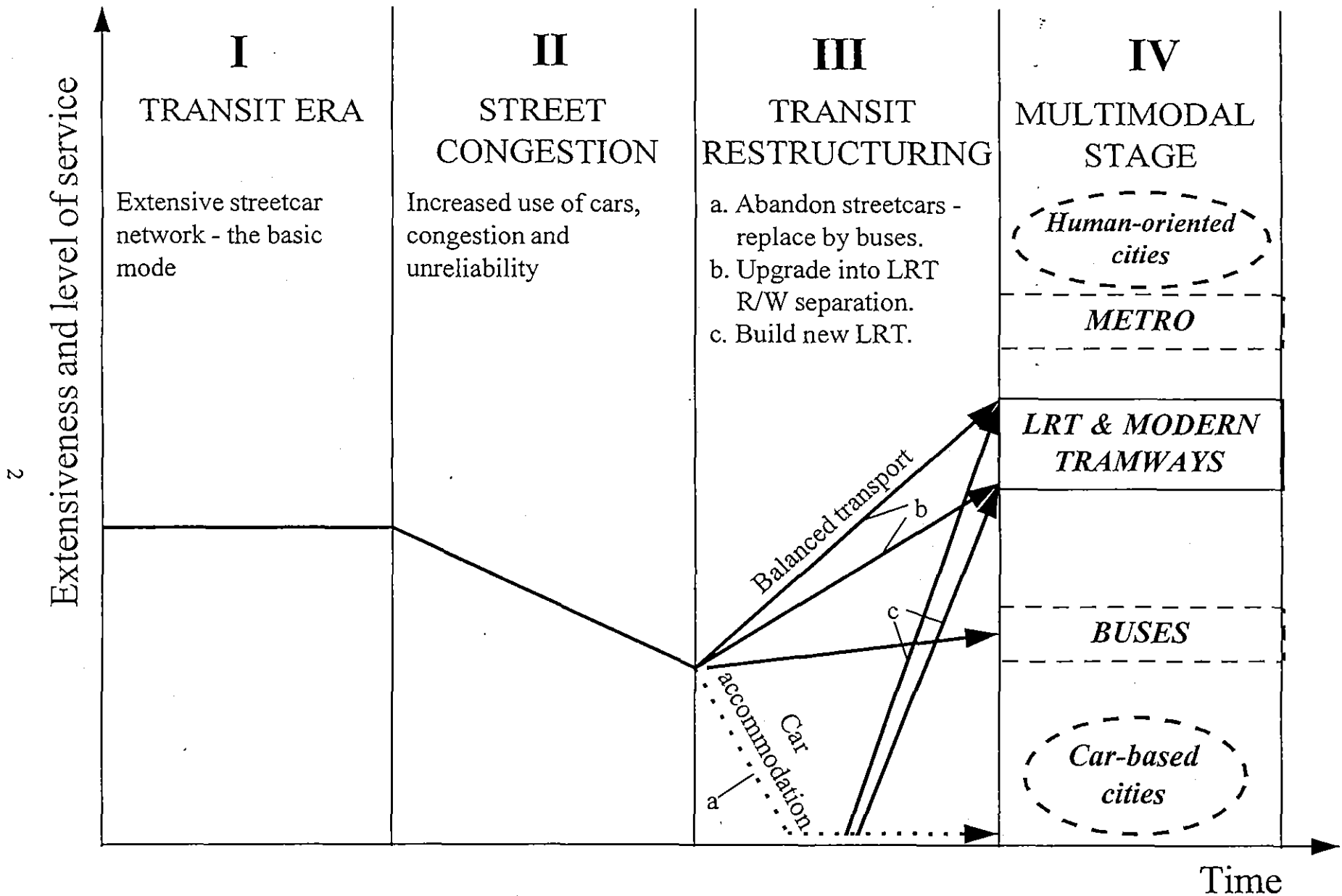


Figure. 1 Four phases of streetcar - LRT transition and development

high density city centers as well as numerous corridors radiating into suburbs, often also providing high-speed links among towns ("Interurbans" or "Light Railways"). In many cities they had separate rights-of-way, but their infrastructure was generally rather simple, reliable and durable. In large cities metros, or rapid transit systems, were built, providing higher capacity, speed and reliability than streetcars could offer. Gradually, buses and trolleybuses also began to complement streetcars on lightly traveled routes.

## **1.2 Phase II: Street Congestion and the Developing Crisis**

When the private automobile came into extensive use, street congestion became a chronic problem. It was compounded by the deterioration of transit. Streetcar travel was impeded by car traffic. Moreover, as some of its riders were diverted to cars, transit experienced lower revenues. Thus, transit companies faced financial problems and began to disinvest in streetcar systems. At that time in many countries extensive government funds began to flow into construction of wider streets and freeways, while public assistance to transit was limited or non-existent. Streetcar systems began to suffer from poor maintenance and obsolescence. This situation led to serious problems in urban transportation in general.

The United States, leading in the wide use of the private car, came into this phase of development already during the 1930's and again during the 1950's, when the same phenomenon appeared in Western Europe. Some developing countries followed a similar pattern a few decades later. In East European countries car ownership is presently rapidly increasing and transit is undergoing a restructuring, so that many elements of the typical street congestion crisis are becoming more common and creating problems.

## **1.3 Phase III: Two Different Policies and Transit Restructuring**

The response to this deterioration of travel by all modes - cars and transit - varied among cities, but two general policies can be defined as quite typical.

**Car accommodation policies** were based on the belief that cities must be adjusted to allow extensive use of private cars. Wider streets, extensive freeways and parking must be provided to alleviate congestion. Transit must be made more "flexible" to fit in the heavy vehicular traffic.

Most transit agencies, facing lower reliability of operations and decreasing ridership, found that buses require less investment than streetcars; that they are more "flexible" and thus less impeded by traffic than rail vehicles. At the same time many cities were pressing for converting transit rights-of-way into traffic lanes. The fact that such **lane conversion measures increase capacities for vehicular traffic, but actually decrease capacity for transport of persons**, were either not understood or ignored, because the pressure to accommodate vehicles was stronger than the demand for high quality transit services.

Many conversions of lightly used streetcar lines to buses were logical: buses became economically superior for such services and their lines could be easily extended or changed in suburban areas. However, conversion of streetcars on separate rights-of-way (category B) into bus lines in streets (category C), as was done in Detroit, Pittsburgh, Glasgow and many other cities, resulted only in temporary reductions of traffic congestion. Such reductions in street congestion were quickly dissipated by rapid increase in car use. Lower ability of transit to compete with car travel further aggravated street congestion.

**Balanced transportation policies** were based on a longer-range view of transportation and cities. The philosophy of these policies is that transportation services provided by a coordinated system of private and public transportation, which also protects and stimulates pedestrian traffic and human element in urban design, is much more efficient and desirable than urban transportation systems based on private car only, with a minor, merely social role for transit (serving mostly non-car owners).

The two policies - car accommodation and balanced transportation - led to very different developments of not only transit systems and pedestrians, but also the functioning efficiency of cities and metropolitan areas and, ultimately, the quality of urban life.

#### **1.4 Phase IV: Multimodal Transit Systems Development**

During the 1990's, most cities with balanced transportation systems have several transit modes. The intermediate system, most typically LRT, is the dominant mode in many medium-size cities (Frankfurt, Gothenburg, Rotterdam); this mode is also being built in very large cities (Berlin, Paris, Hong Kong); and it is becoming the main transit carrier in many cities which had initially pursued the car accommodation policies (San Diego, Sacramento, Dallas), as well as in the cities of developing countries which need much better service than buses and jitneys can offer, but cannot afford the high investment costs of metro systems (Tunis, Guadalajara, Manila, Kuala Lumpur).

## **2. TRANSIT DEVELOPMENTS IN CITIES WITH CAR ACCOMMODATION POLICIES**

During the period of rapid growth of car ownership it was logical that streets had to be redesigned, major highways constructed in metropolitan areas, parking be built, etc. Some cities, however, focused on these measures while neglecting improvements for other modes, particularly transit, pedestrians and bicycles. This was a result of inadequate understanding of transportation as a system and its relationship to cities and metropolitan areas; however, a strong influence of various special interests, particularly the auto/highway groups, also contributed to these developments.

### **2.1 Policies and Planning**

The **car accommodation policies** were actually based on a belief that because the car is the most attractive mode from most individuals' points of view, the future role of transit in all except very large cities will be reduced to services for those who cannot drive. The macro-scale aspect of this



situation - the problem of physical incompatibility of concentrated activities in cities with extensive car use - was sometimes recognized, but no realistic solutions to it were provided. Thus, Buchanan (1963) in his report "Traffic in Towns" pointed out the problems created by cars in cities, but failed to recommend any realistic solution to it, except for historic cities, where cars would be rerouted and centers kept mostly for pedestrians. He did not recognize the crucial role of high-quality, competitive transit in maintaining efficient activities in urban areas.

Interestingly, some architects and urban planners who emphasized the importance of human orientation of cities failed to understand the impacts of different transportation modes on the character and functioning of cities. They designed urban areas which were dominated by cars, thus creating a scale of development which is actually extremely unfriendly to pedestrians. For example, Le Corbusier (1929) in his utopian vision of high rise buildings encircled by major streets and highways stated "The tramway has no right to exist in the heart of the modern city"; recent developments in many cities have clearly shown how misguided his transportation planning was. The designs of the new city of Brasilia, and of the Renaissance Center in Detroit similarly display lack of understanding of the impacts of different transportation modes on urban scale and environment. Specifically, many architects failed to understand the crucial role of transit and pedestrians for creating livable cities.

Many political and civic leaders joined the "progressive thinking" of the 1950's that streetcars are "obsolete" and have no place in the car-dominated society. For example, the powerful builder of many public facilities in New York City Robert Moses, who totally disregarded the need for improvements of transit in this transit-based city, influenced the popular Mayor LaGuardia to exert his influence to speed up elimination of streetcars from the city. Spanish dictator Franco issued an order that tramways should be banned in all Spanish cities.

## **2.2 Transit Planning Extremism: "Two Transit Modes" Theory**

Even some transit experts claimed that rail transit can only operate on exclusive rights-of-way (category A), because any contacts between rail and highway vehicles, even where separated medians can be provided (category B), are unacceptable. Thus, large cities should have metros supplemented by buses, while medium and small cities should have buses only. This "two-transit-modes" theory very quickly proved very inadequate for most cities. Except for a few large cities which have dense metro networks, such as Paris, Tokyo and New York, this mode cannot offer sufficient area coverage. Buses in mixed traffic are adequate for local travel, but they cannot adequately supplement limited metro networks for serving longer trips throughout metropolitan areas.

In the former Soviet Union, transit planning also suffered from a basically two-mode type of policy: cities were served by streetcars, trolleybuses and buses, without much upgrading of their operations and provisions for higher speed on separate rights-of-way. When any city reached a population size of one million, a metro system was planned and built. Thus, practically no intermediate modes were used. In spite of the great need for it, the concept of LRT has only recently been introduced in a few cities (Kiev, Volgograd).

Many cities which remained only with buses and tried to provide high-quality transit only by building metro networks approached these plans very unrealistically. Facing the very high investment costs of metro lines, many cities could not build them. The result was protracted construction during which bus, and in some cases trolleybus and streetcar networks were badly neglected (Warsaw, Sofia, Calcutta), or metro was not built at all and cities remained with buses on streets only, or some HOV facilities which serve commuter services only (Honolulu, Seattle, Houston).

Urban transportation problems were also aggravated in many metropolitan areas by incorrect methodologies of transportation planning. For example, in most U.S. cities **planning consisted of extrapolation of previous trends and development of plans to accommodate and thus encourage such trends, regardless on whether they are desirable or not.** Produced in the period of rapid increase in car ownership, these plans resulted in construction of extensive freeway networks and neglect of all transportation modes except private cars.

With respect to transit planning, it became obvious during the 1960's and 1970's that buses on streets cannot compete with cars and that in some major corridors high-quality transit lines should be built. Ridership projections were, however, often predicted assuming a steady growth of population and travel over several future decades. With compounded growth, the "design volumes" some 20 years in the future are usually so large, that metro becomes the only appropriate technology. This unrealistic planning methodology in many cases leads to the misleading conclusions that intermediate-capacity systems are inadequate. In many cities in both developed and developing countries this kind of planning resulted in no improvements when funding for metros could not be procured. The result was that transit deteriorated further, hurting the economic and social viability of the entire metropolitan areas.

Transit services consisting of low investment/low quality bus lines and high investment/high quality metros proved inadequate for an increasing number of cities. The need for higher quality, competitive transit, greatly increased, as it was realized that reliance on cars only leads to many problems. Clearly, **intermediate transit mode with service considerably better than buses on streets can offer, at investment cost lower than metros require, was needed in most cities.** The diagram in Figure 2 shows the "gap" between buses on streets and metro modes which is filled by intermediate-performance modes. In the cities with car-oriented policies the tendency was to meet the need for intermediate systems by upgrading buses.

### **2.3 Bus Upgrading Efforts**

Incremental improvements of transit by upgrading buses through construction of exclusive bus lanes and busways was attempted in a number of cities in various countries. Examples of these innovations were found in North America - Washington, DC - Shirley Busway, Los Angeles - El Monte, Mexico and Ottawa; in South America - Sao Paulo, Curitiba and Lima; in Europe - Birmingham and several French cities, and in Australia - Adelaide. The results of these upgraded bus systems varied considerably, as the following review shows.

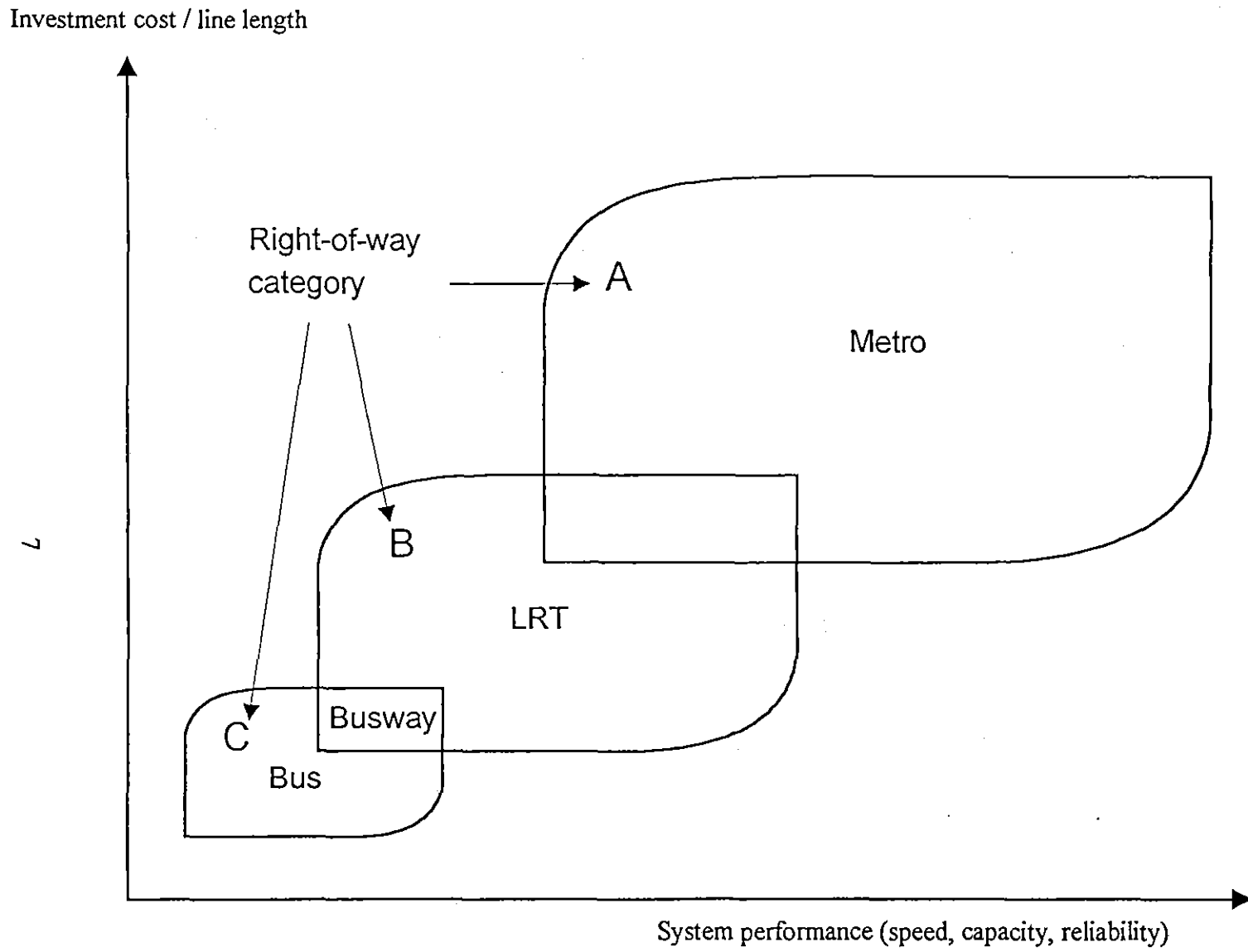


Figure 2. Intermediate systems filling the "gap" between street transit and metros

- **Consistent planning, implementation and strict enforcement of preferential and exclusive bus facilities** resulted in excellent bus semirapid transit systems in Ottawa, Curitiba, several cities in France and other countries.
- **O-Bahn line (Adelaide) is successful in its separation**, but in most cases regular busways are preferred to O-Bahn because of ability of buses to overtake each other.
- **Inadequate enforcement of reserved bus and trolleybus facilities** resulted in the failures of bus upgrading in Mexico and many U.S. cities.
- **Deregulation of buses, destroying discipline and control of bus facilities**, resulted in abandonment of busways and bus lanes in Lima, Birmingham and many other cities where deregulation was introduced.
- **Conversion of busways into "High-Occupancy Vehicle (HOV) Facilities"**, introduced in virtually all U.S. cities except in Pittsburgh, resulted in downgrading of busways to non-competitive service levels, because HOV facilities assist their competition - vans and cars. The Shirley, El Monte and nearly all other busways in the U.S. are now roads on which transit buses are mixed with many other vehicle categories, so that they do not represent distinct transit facilities.

These developments show that upgrading of buses, primarily through provision of exclusive bus facilities, can be a very economical solution which allows gradual improvements and may create a high-quality intermediate transit system (Ottawa and Curitiba are the best examples). However, such upgrading requires not only good planning of transit, but strong cooperation of highway authorities and permanent participation of traffic police to enforce exclusive bus facilities and maintenance of bus priorities. These supports often do not exist. Moreover, auto-highway lobbies, which often argue that buses are preferred to rail modes, exert strong pressures to convert bus facilities into HOV lanes and roads, which eliminate the most important advantages of buses - their independence from general traffic.

As a consequence, upgrading of buses has proven to be very difficult to implement and maintain for organizational and political reasons. Moreover, the experiences show that many such facilities have low permanence: some initially successful facilities have later been downgraded due to pressures of car-oriented authorities.

Seeing the remarkable developments of LRT systems in the cities with balanced transportation policies (see the next section), many cities which basically followed car-oriented policies began to plan LRT as the dominant intermediate mode. This happened in cities like Los Angeles, San Jose and Dallas. Similar adoption of LRT happened in many cities which were not heavily car-oriented, but which had neglected to improve transit for several decades. Examples of this development are found in many French, Italian, Spanish and British cities: Strasbourg, Genoa, Valencia, Sheffield and a number of others.

### 3. CITIES DEVELOPING BALANCED MULTIMODAL TRANSPORTATION

Faced with the congestion problem in Phase II, countries and cities pursuing the **balanced multimodal transportation policies** focused their efforts not on replacement, but on upgrading of their streetcar/tramway systems. The basic difference between these two policies was that instead of attempting to adapt transit to general traffic and thus subject it to congestion and downgrading, the cities with balanced transportation policies insisted on making transit competitive with car. The only way to achieve this was to place transit on separate rights-of-way, and this is achieved much more effectively by rail systems than by buses.

#### 3.1 Evolution of Light Rail Transit

Upgrading of old-fashioned streetcars from 1950's in most cities of Germany, Netherlands, Belgium, Switzerland and several other countries was gradual, but so significant, that by the 1970's these systems evolved into a new mode - Light Rail Transit. **Modern LRT systems, such as the ones in Cologne, Hannover or Calgary, are actually more similar in their performance to urban metro systems than to typical streetcar systems from the 1950's.** Major concepts followed and elements used in upgrading can be summarized as follows.

**Partially or fully separated rights-of-way** were initially placed directly under streets, keeping the same curves as on streets. This "underground streetcar" concept was then replaced by somewhat higher standards which allow higher speeds, but retain simple, economical stations.

**Priority treatments at intersections** allowed greater use of surface alignments and in many cities LRT runs in pedestrian malls without excessive reduction of speed. This solution is not only much less costly, but it can be built in much shorter time period, and it is very popular with passengers because it eliminates negotiation of stairways. Mannheim, Zurich and Bremen were later followed with these solutions by Calgary, Buffalo and San Jose.

**High-capacity articulated cars with high comfort, low noise and attractive appearance,** developed since mid-1950's, have become very popular with passengers and made not only at-grade, but also aerial alignments for LRT acceptable (Cologne, Bremen, Sacramento).

**Articulated cars and self-service fare collection** allowed operation of trains with up to 720 spaces by one person. This is 10 times greater than the vehicle capacity per person found in streetcars with driver and one conductor per small car, which were operated in many cities until the 1950's. With operating speeds about twice higher, the labor productivity of LRT, measured in person-km per train crew member, is up to 20 times greater than on classical streetcars. This is one of the basic factors that allows LRT to offer high quality services at a low to moderate operating cost, and to utilize much greater economies of scale than buses.

**Low-floor LRT vehicle technology,** developed only since mid-1980's, has brought another major step in the evolution of this mode. While there was a tendency to make LRT trains bigger, with

high platforms and larger stations, the low-floor vehicles have now enabled design of less intrusive stations and thus more passenger-friendly alignments in city streets, pedestrian malls, etc. This is another step in **making LRT a distinct element, even a symbol, of transportation for livable, human-oriented cities.**

Figure 3 shows a contemporary LRT vehicle which incorporates a number of recent innovations. Low floor, single wheels which are steerable and have no rotating axle; very attractive body interior and large panoramic windows are only some of the major technical features which have been developed since 1985.

### **3.2 Diverse Applications of LRT Systems**

As a result of the numerous innovations and developments of the LRT mode during the last two-three decades, there are presently many different applications and forms of LRT systems. A review of seven major types of LRT systems is presented here.

**1. Modernized Tramway Systems:** many cities have retained classical streetcar/tramway systems. Their operation in mixed traffic and on some separated rights-of-way has been improved through various innovative designs, transit priorities at intersections and transit lines running through pedestrian areas and malls. Examples of tramway systems with extensive networks are Amsterdam, Melbourne, Oslo, Vienna and Zurich.

**2. New Tramway Systems:** since the invention of low-floor rail transit cars in the mid-1980's, a growing number of cities has become interested in building new systems which operate not only on partially separated rights-of-way, but also in streets and pedestrian areas. Thus, these systems are basically modern tramways, rather than LRT systems. Examples of such new tramway systems, which have many new track layout, vehicle technical and operational features, are those in Grenoble and in Valencia, Spain.

**3. Evolutionary LRT Systems:** most extensive LRT networks, which represent the basic transit mode in their cities, are those which were upgraded from streetcars over the last two-three decades. Examples are Cologne, Frankfurt, Gothenburg, Hannover, Rotterdam, San Francisco and Stuttgart.

**4. New LRT Systems:** since the late 1970's, the number of cities building new LRT systems has been steadily increasing. Most of these systems still consist of only a few lines, but these often go into farther suburbs than the classical tramways, but a number of these lines also operate in pedestrian zones in central cities. They have higher speed and comfort and often integrated feeder buses and park-and-ride facilities. North America has the greatest number of these systems: Calgary, Edmonton, Guadalajara, Buffalo, Portland, San Diego and a number of others. In Europe, Utrecht was followed by Nantes, Grenoble, Lausanne, Paris, Sheffield and other cities in building entirely new LRT systems. There have been similar developments of LRT in the cities on other continents, such as Tunis, Ankara, Kuala Lumpur, Sydney, Tuen Mun in Hong Kong and others.

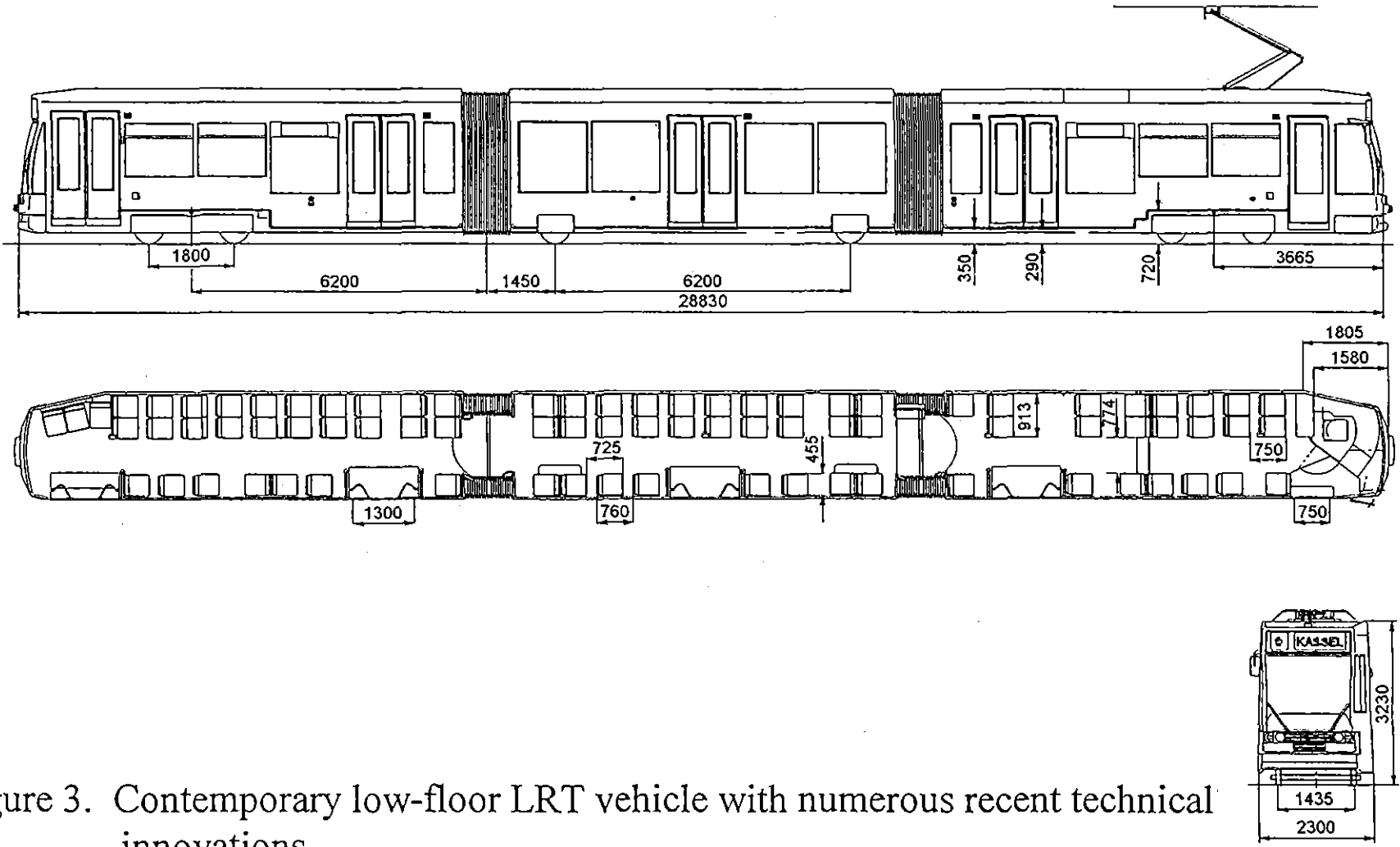


Figure 3. Contemporary low-floor LRT vehicle with numerous recent technical innovations

Courtesy: DUEWAG

**5. Mini-Metro Type LRT:** Several old as well as recently built LRT systems are fully grade separated and actually represent mini-metro systems. Lines that belong in this category include the Norristown Line in Philadelphia and several lines in Gothenburg, Essen, Manila and Mexico.

**6. AGT-Type LRT Systems:** The most elaborate version of LRT mode is represented by several systems which not only operate on exclusive rights-of-way only, but are fully automated. The representatives of this category are the systems in London/Docklands and Vancouver; several others are planned.

**7. LRT-Regional Rail Integrated Systems:** With the diversification of the design and operational concepts of transit modes, some LRT systems represent transitional concepts toward the metro mode, while others have been developed to fully “bridge the gap” between urban transit and regional rail. The two recent developments of such systems - Manchester and Karlsruhe - have already become renowned by their innovations in organizational and operational concepts.

### **3.3 Integration with Other Modes**

Light rail transit systems are increasingly integrated with other transit modes. Major progress has been made in recent decades in designing terminals and coordinating operations of LRT with metro networks (Rotterdam, Munich, San Francisco), with buses (most German and Swiss cities), as well as with cars through park-and-ride facilities (Sacramento, Baltimore).

## **4. HOW DID THE “UGLY DUCKLING” BECOME A “SWAN”?**

The evolution of surface rail transit, from the classical streetcars to modern LRT, is quite remarkable. During the “Transit Restructuring Phase” many cities worked on gradual modernization and improvements of streetcars, used moderate but consistent investments and transit priority policies and achieved a continuous progress not only in transit services, but in livable urban environment. Other cities totally eliminated streetcars and replaced them mainly by buses, which they considered to be far superior to “old fashioned rail technology”. After deterioration of transit and worsening congestion, many of these cities realized that the future lies not in lower-quality transit, but in competitive transit, which must be largely independent of congestion, and LRT is far better suited for that role than buses.

Thus, while the cities with balanced transportation policies made a logical evolution of their transit systems, those with car accommodation policies went from treating streetcars as an “ugly duckling”, to the introduction of their successor, LRT, as a newly discovered “swan”. How could such a drastic change occur? A review of the conditions and policies from the eras of streetcar elimination and LRT introduction presents answers to this question.

Few areas in technical, economic and social developments in recent history can offer such interesting lessons as these recent developments in urban transportation. The cities pursuing balanced transportation policies have obviously had a more comprehensive view of the impacts of transportation on cities and metropolitan areas than the cities which adopted the car accommodation



Table 1 - Prevailing conditions and attitudes toward rail modes in U.S., French and British cities in 1950's and in 1990's

Item	Reasons for closing streetcars, 1950's	Reasons for building LRT's, 1990's
<b>Policies:</b>		
Transit vehicle relation to traffic	Flexible movement to mix with traffic	Maximum separation desirable
Major cause of congestion	Streetcars and tracks	Cars
Transportation policies	Provide more space for cars - highways and parking	Car disincentives, transit priorities
<b>Transit Systems:</b>		
Right-of-way categories	Mostly C (streets)	B or A (partially or fully separated, resp.)
Service quality	Slow, unreliable (mixed traffic)	Good speed, reliability
Comparison of comfort	1930's streetcars inferior to 1950's buses	1990's LRT vehicles superior to 1990's buses
Investment cost	Higher for streetcar than for bus - unjustified	Higher for LRT than for bus - worth for superior service
Capacity	Streetcars decrease street capacity in <i>vehicles</i> /hour	LRT increases capacity in <i>persons</i> /hour
<b>Prevailing Attitudes:</b>		
System image	Streetcars are obsolete; bus is a symbol of the future	LRT is modern, symbolizes livable city

policies, sacrificing other modes. The "rebirth" of tramways in the form of LRT clearly shows that the latter group of cities, which includes most cities in the U.S., France, Britain and a number of other countries, is trying to correct former mistakes as summarized in Table 1.

It is important to note that many cities which have lagged in urban transportation developments for various reasons find themselves now in Phase II and entering Phase III of urban transportation developments. Examples are most cities in Eastern Europe, such as those in Poland, Yugoslavia and Bulgaria, as well as most cities in the countries of the former Soviet Union; Calcutta

is in a similar situation. These cities are experiencing some of the same attitudes: “trams are old fashioned”, “people want cars”, “flexible buses are superior to rail systems”, or - “metros must be built to utilize benefits of rail technology” - are opinions which may lead to the repetition of the costly mistakes which car accommodation policies carry with them.

Extensive discussions and extreme views of proponents of “two modes only” policies occurred in many cities and often delayed progress in modernizing transit systems. Such debates cannot be avoided, but they can be reduced and reaching constructive policies and solutions can be facilitated if transit planners, political leaders and public at large are better informed about these valuable experiences: superior results achieved by the balanced transportation policies as compared to car accommodation policies. With respect to transit, developments of recent decades clearly show the major role of intermediate systems in most medium and large cities, and the dominant role of LRT as the most diversified and innovative intermediate mode.

Most importantly, with the increasing recognition of the importance of transit for human orientation and livable cities, LRT is the most distinct symbol of this development. Its introduction in the centers of Portland, Sacramento, Grenoble, Strasbourg and many other cities symbolizes reorientation from the previous car-only policies.

Transportation engineering professionals and organizations such as UITP have a major role in informing other professionals, politicians and public about these critical developments for cities at the time when our civilization increasingly depends on the quality of life in metropolitan areas.

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