Hand Book of Rail Based Urban Transit Systems

.Part 1

The book incorporates wide ranging experience of the author with rail based transit systems in India and abroad. of transit projects under planning, construction and operation ,highlighting initial problems encountered and resolved ,through trials and errors.

This provides a valuable insight in respect of selection of most suitable transit mode , planning of network layout, intermodal coordination, ,customer facilitation ,security ,safety ,cost control ,property development and a large number of other issues having a direct bearing on overall efficiency of metros The book provides an in depth insight in those areas which need to be internalized in the planning of new rail based transit system in a developing economy

.Govind Ballabh

Introductory
Advent of Rail Transport in India (1853) within 28 years of the first rail journey in the world in England in1825 was a significant historical event, bringing about a sea change in its industrial and economic up surge, transforming mediaeval India into a unified modern nation poised for industrial revolution..
Whereas, the rail net- work planned by the British rulers was mainly for long distance movement of goods and passengers, mainly for transporting Indian cotton and other raw material to UK mills and administrative and strategic movement of men and material for expansion of British empire in Asia, in course of time, it became the backbone of long distance, suburban and , intercity , movement of indigenous produce from the surplus area to the needy regions. .In the emerging mega cities it also became the back bone of city transport played ,a massive role in suburban transport that it continues to play in all mega cities even after the advent of metro rail systems..
The construction of Kolkata metro with Russian support was marred by numerous hardships to the people and the Indian railways whose project it was .As a result , after the opening of Kolkata metro in 1985 ,there was a considerable reluctance on the part of the government to go in for prohibitively expensive metro rail systems.
Emergence of Delhi metro in 2002 had stupendous success in making the national capital city comparable to other world class cities
Its progressive expansion in the national capital city and neighbourhood., its pioneering leadership role in guiding a whole chain of upcoming metros in other mega cities has ushered in an era of metro construction in India in a big way, covering all the mega cities and a few high density urban centres.
In its short span by expanding its network and maintaining the service quality it has attained the rank of 13 th largest metro system in the world..
Delhi Metro also did a pioneering work in guiding all upcoming metros in the country in project formulation, technology selection ,network design ,staff training and actively participated in construction and commissioning of other metros.
In 2016, India had 324 km of operational metro lines. A further 520 km of metro lines are under construction. Metro rail lines in India are mainly standard gauge. except for metro lines of the Kolkata Metro and initial lines of Delhi Metro which are broad gauge. .Rest of the existing metro systems and all future metros are planned to be standard gauge .

Urban Transport Policy

As per latest policy decision, the union government would provide financial assistance, for implementation of a metro rail system, to cities having population of more than 1 million. Accordingly the Union Urban Development Ministry has ' proposed to implement metro rail systems in about 50 cities.

Majority of the planned projects shall be implement through special purpose vehicles, which will be established as 50:50 joint ventures between the Union and respective State Governments. The Union Government will invest an estimated ₹5 lakh crores (US$78 billion) on metro projects.

Current per km cost of metro lines in India works out to about 700 crores for elevated lines and about 560 crores for under ground lines .,As metro is capital intensive ,the central

government would consider **metro rail** as the "last option" to be implemented after considering other possible options of mass rapid transit systems ..

Currently there are nine operating metro/rapid transit systems in the country as under-

Kolkata Metro	Kolkata	24 October 1984
Chennai MRTS	Chennai	1 November 1995
Delhi Metro	Delhi NCR	24 December 2002
Namma Metro	Bengaluru	20 October 2011
Rapid Metro Rail Gurgaon	Gurgaon	14 November 2013
Mumbai Metro	Mumbai	Maharashtra 8 June 2014
Jaipur Metro	Jaipur	Rajasthan 3 June 2015
Chennai Metro	Chennai	Tamil Nadu 29 June 2015
Kochi Metro	Kochi	Kerala 17 June 2017

Kolkata Metro and **Chennai Mass Rapid Transit System**, are state-owned subsidiaries of Indian Railways,

Chennai Mass Rapid Transit System. is a metropolitan elevated railway line operated by Southern Railways. It is the first elevated railway line in the country. Although it is

segregated from the Chennai Suburban Railway, the two systems are operated by Southern Railway and are integrated in a wider urban rail network.

Built at a cost of ₹ 11,710 million. The line runs within the city limits from Chennai Beach to Velachery, covering a distance of 19.34 kms with 18 stations, and has an average daily

ridership oove one lac commuters per day. Connecting the central business area of old Madras with the IT corridor, the section has a potential of carrying twice the number of passengers a day, with 134 trains plying across all the 17 stations.The MRTS is proposed to be taken over by the Chennai Metro Rail Limited thereby bringing all the elevated tracks and underground tracks inside the city under one organisation. Upon completion of the takeover, all current MRTS trains would become air conditioned and consequently, the fares would be raised to match that of the Chennai Metro. The takeover is expected to be completed by the year 2021

Metro plans have been finalised for the following 28 cities--

1 Lucknow Metro

2Noida Metro

3Ghaziabad Metro

4Navi Mumbai Metro

5Hyderabad Metro

6Nagpur Metro

7Metro-Link Express for Gandhinagar and Ahmedabad (MEGA)

8Varanasi Metro

9Kanpur Metro

10Pune Metro

11Vijayawada Metro

12Patna Metro

13Meerut Metro

14Guwahati Metro

15Chandigarh Metro

16Bhopal Metro

17Kozhikode Light Metro

5

18Indore Metro

19Thiruvananthapuram Light Metro

20Agra Metro

21Coimbatore metro

22Visakhapatnam Metro

23Surat Metro

24Srinagar Metro

25Greater Gwalior Metro

26Jabalpur Metro
27Kozhikode light metro
28.WR elevated corridor

. There has been a pressing demand for construction of metros in a large number of other cities which are not covered by the governments current eligibility criterion. Urban centres affected by the policy vacuum include the following -

Firozabad, - Bareilly Gorakhpur, Aligarh, Jalandhar Jamshedpur, Bhilai Nagar Durgapur Asansol,, , Amravati , Warangal, Mysore Tiruchirappalli, Salem, Belgaum Bhavnagar ,Jalgaon Mehsana, Bikaner Ajmer, Gaya Muzaffarpur Ranchi, Mangalore , Sangli , Miraj, Kupwad,a , ,Ambattur, ,Nanded Guntur Kolhapur, Tirunelveli, Malegoan,

, , .(The list is indicative and not exhaustive)

Rail based transit systems: global View

Urban rail transit is an all-encompassing term for various types of local rail systems providing passenger service within and around urban or suburban areas. The set of urban rail systems can be roughly subdivided into the following categories, which sometimes overlap because some systems or lines have aspects of multiple types.

Tram

A tram, streetcar or trolley system is a rail-based transit system that runs mainly or completely along streets (i.e. with street running), with a relatively low capacity and frequent stops. Passengers usually board at street- or curb-level, although low-floor trams may allow

level boarding. Longer-distance lines are called *inter urbans* or *radial railways*. Few inter urban lines remain, most having been upgraded to commuter rail or light rail or abandoned.

The term "tram" is used in most parts of the world. In North America, these systems are referred to as "streetcar" or "trolley" systems; in Germany, such systems are called "Straßenbahn" which literally translates as "street train" or "street railway".

In recent decades, tram networks in countries including Britain, Ireland, France, Germany, Spain and Portugal have grown considerably. The Netherlands, which already makes extensive use of trams, has plans to expand tram services to two additional cities.[1]
Germany did not undergo the extensive tramway closure programmes that were carried out in other European countries and many cities retain their original tram networks. In some places, tram networks have been added or expanded through the introduction of hybrid tram-train or stadtbahn systems which may combine standard railway, on-street and underground operations. Notable examples include the systems in Cologne and Karlsruhe. In Frankfurt-am-Main, many tram lines were transferred to U-Bahn operation.
In the United Kingdom, investment in public transport in the late 1980s turned to light rail as an alternative to more costly underground railway solutions, with the opening of the Tyne and Wear Metro (1980) and the Docklands Light Railway in London (1987) systems. However, the first British city to reintroduce on-street trams was Manchester, with the opening of its Metrolink network in 1992.[2] Several other UK cities followed with their own modern tram systems, including Sheffield (Supertram, opened 1994), Birmingham and Wolverhampton (Midland Metro, opened 1999), London (London Tramlink, opened 2000) and Nottingham (Nottingham Express Transit, opened 2004). Many of these tram cities are planning or building network extensions (construction is in progress in Manchester, Nottingham and Birmingham/Wolverhampton) and several more tram systems are being proposed or are under construction, such as Edinburgh Trams, Belfast EWAY (proposed) and Liverpool Merseytram (proposed). Other tramway projects have not made it beyond the proposal stage because of funding problems, for example London's Cross River Tramand the Leeds Supertram, which is now to be a trolleybus system.
Paris has currently 12 tram lines and many French cities have seen a similar revival, European Union has decided to build .

Light rail

A light rail system is a rail-based transit system that has higher capacity and speed than a tram, usually by operating in an exclusive right-of-way separated from automobile traffic, but which is not fully grade-separated from other traffic like rapid transit is. Light rail also generally operates with multiple unit trains rather than single tramcars. It emerged as an evolution of trams/streetcars. Light rail systems vary significantly in terms of speed and capacity. They range from slightly improved tram systems to systems that are essentially rapid transit but with some level crossings.

Rapid transit/Metro

Under ground or elevated the metro is the final solution for mega cities like London ,New york Mumbai Paris ,Shanghai ,Beijing etc.

A rapid transit, underground, subway, tube, elevated, metro or Mass Rapid Transit (MRT) system is a railway—usually in an urban area—with high passenger capacities and frequency of service, and (usually) full grade separation from other traffic (including other rail traffic). It is often known as "heavy rail" to distinguish it from light rail.. In most parts of the world these systems are known as "metro" which is short for "metropolitan". The term "subway" is used in many American systems.In London it is called the Undergroundand New York it is called the . Subway

Monorail

A monorail is a railway in which the track consists of a single rail, as opposed to the traditional track with two parallel rails.

Commuter rail

A commuter rail, regional rail, suburban rail or local rail system operates on mainline tracks which may be shared with intercity rail and freight trains. Systems tend to operate at lower frequencies than rapid transit or light rail systems, but tend to travel at higher speeds and cover longer distances. Though many European and East Asian commuter rail systems operate with frequencies and rolling stock similar to that of rapid transit, they do not qualify as such because they share tracks with intercity or freight trains.Indian citie like Mumbai ,Kolkata ,Delhi .,Chennai and others have a very wide net of suburban trains .

Cable car

A cable car in the context of mass transit is a system using rail cars that are hauled by a continuously moving cable running at a constant speed. Individual cars stop and start by releasing and gripping this cable as required. Cable cars are distinct from funiculars, where the cars are permanently attached to the cable and cable railways, which are similar to funiculars, but the rail vehicles are attached and detached manually.

Economics of rail transit public rail transit provides the fastest and safest means of public transport in all cities where the roads are congested and travel time is very high .

Rail transport is energy efficient .

It causes least pollution compared to road transport burning fuel and emitting smoke .In most Asian countries which do not have electric /hybrid cars, road transport produces 6 times more of environmental pollution. as compared to rail based systems...

.A group of economists in US ,however, claim that, contrary to popular belief, rail transit has failed to improve the environment, serve the poor, or reduce highway congestion .This could be a fall out of poor service quality ,unaffordable chargeable fare and inadequate coverage of less developed areas inhabited by economically weaker sections of the community.

Urban Transport in Indian Cities

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Urban travel modes in Indian cities include walking, cycling and public transport, including intermediate public transport (IPT). Despite high growth rates of motorised two wheelers and cars in the last two decades.

Other than the megacities (Delhi, Mumbai, Kolkata and Chennai, Bangalore Pune, Hyderabad ,Baroda and Ahmedabadi etc)i.n which municipal corporations have been running significant number of buses., other cities have skeletal bus services provided by the city municipality.

Intermediate public transport (IPT) modes like three wheelers ,cars and cycle rickshaws assume importance as they are necessary to meet travel demands in medium size cities in India like Lucknow, Hubli, Varanasi, Kanpur and Vijayawada. These vehicles have minimal regulations in terms of road worthiness certifications issued by the transport authorities. Their operations have been left to the private operator. Often they have been found to cause serious emission and safety violations.

Since transport is a state subject,, central government did not have a policy or investment plan for urban transport infrastructure until 2006. City governments attempted to solve transport crises as isolated road improvement projects. Despite investments in road infrastructure and plans for land use and transport development, all cities continue to face the problem of acute congestion, traffic accidents and air and noise pollution ,

The renaissance of Tram Ways :A Global Trend

Tram has fallen victim to India’s new found love with metros(costing Rs 570 crores per km for underground sections and Rs.270 crores per km for elevated sections-Delhi Metro phase 3 costs). These costs are bound to. increase. with passage of time, mild inflation being essential for any developing economy.

Every metro city in India wants metro services, while the last remaining operational tram service in India — in Kolkata — is on its last legs.The untold global story is that

ther resulted in the construction of tramways in multiple other French urban areas., This expansion of tramway systems remains an on going project in Strasbourg and throughout France. and Europe.

The last decade, in fact has been rightly called one of renaissance of modern tram ways capable of **handling city transport with the efficiency of heavy metros at one third the construction costs.**

In those cities and urban aglomerations of India which will not justify metro systems for next ten years,urban transport planners must look at this option with an open mind..This low cost option is more suited to public private participation than capital intensive metros. Our experience of Delhi Airport Express Line and Mumbai Metro confirms that heavy metro does not suit private enterprise due to regulatory mechanisms built in its safety norms and govt involvement in its pricing controls and un reliability of private sector players in demanding inflated viability gap funding in the sector where most operators are making reasonable profits.

Two tier cities of India also need world class urban mobility for which modern trams are the most cost effective solution as demonstrated by the success of Strassbourg tram revival and expansion of this transport model throughout Europe and China ..

As per current policy in EU tramways and rail based systems running at 40km/h speed are exempt of the domain of Health and Safety Regulatory Authority. These rail based transit systems only need to be registered in the national record of rail systems do not need any certification This makes commissioning of such systems free of uncertainty and delays about project completion. .It is certain that given the transparency , flexibility ,short gestation period and easy manageability. trams will attract very large private investment .

It will definitely be a historical day when the government lays down a policy defining the broad principles of provision of modern trams equipped with cars as elegant as modern metros providing efficient and environment friendly public transport at affordable prices managed by Local entrepreneurs who know what the people need.

To test the market response Govt. may like to issue a seed paper containing policy directives for cities which may not qualify for metro systems in near future, can go in for modern trams ,clearly defining roles and responsiblities of the central and state govts .. spelling out the support of the central &state govts for identifiable components like land acquisition, provision of rolling stock and waiver of import duties and taxes as has been done for metro systems.

Let us take a few concrete examples .Ancient cities like Gaya ,Mathura,Haridwar,Ayodhya Gorakhpur,,Ajmer,Muzaffarpur,Darbhanga Bareilly etc shall never qualify for a modern metro systems strictly .in terms of night population of these cities.

Whereas the holy city of Gaya has the distinction of having the world famous Mahabodhi temple ,the most important shrine of Buddhism in the world at Bodh Gaya which attracts pilgrims from all the world over .One can easily visualize ordeal of such visitors for the last mile connectivity provided by three wheelers , rikshwas,taxis, all waiting to cheat and plunder the innocent tourists..

The famous temple of Visnu Pad also the only temple of Hinduism in the world gets pilgrims from within the country as well as sizeable number of NRIs who come at least ones in their life time for performing ancestral rites of their forefathers at this famous shrine

.A 15 to 20 km of Tram line from Gaya railway station to Bodh Gaya via Vishnu Pad will make the city a star attraction to tourists from all over the world at one fourth the cost of the metros which are being planned in 40 cities as a part of public policy .

Other ancient cities and tourist towns throughout this vast country have the same problem of extreme congestion with clogged internal movements inside the city. For these cities environment friendly and moderately priced public transport needs, tramways is the most suitable option.

The following chart shows a continuity of opening of new generations trams in Paris.

Line	Opening	Length	Stations	Operator
T1	1992	17 km	36	RATP
T2	1997	17.9 km	24	RATP
T3a	2006	12.2 km	25	RATP
T3b	2012	9.9 km	18	RATP
T4	2006	8 km	11	SNCF
T5	2013	6.6 km	16	RATP
T6	2014	14 km	21	RATP
T7	2013	11.2 km	18	RATP
T8	2014	8.5 km	17	RATP
TOTAL:		**104.7 km**	**186**	

That the city of PARIS has switched back to Trams worked by the world class urban transport provider RATP should be an assurance that modern tram is the most suitable mode of city travel in the coming future.

This would clearly indicate that developing economies like India must consider modern trams as an ideal city transport option for its two tier cities becoming smart cities.

Cities with populations of about 10 lacs and expected daily ridership of 5 lacs will be most efficiently served by modern trams which are under construction in France ,UK and other developed nations .Evaluating the Tramway option along with regular metros will bring out the relative cost efficiency and adequacy of system capacity of these modern trams .A rough estimate indicates that per km cost of moderm trams could be les than one sixth of the metro.

The European Union plans to build three times more of tramways network as compared to heavy metros in next 15 years as shown below-

Metro under construction (k.m)	Light rail/Tram under construction (Sk.m)	Metro network under planning (k.m)	Light Rail/Tram under planning (k.m)
792	976	793	2202

It is, therefore, a happy augury for city transport in india and the national capital that planners are working towards revival of cost efficient and customer friendly tram system in the city of Delhi, which had an operational tram system till 1963,The planning to revive it, in the crowded Old Delhi area is in keeping with revival of tramways throughout the world .. If it works, it may just inspire urban planners in other Indian cities to look at a relatively low-cost, pollution-free LRTs. Modern light rail systems — as trams are technically classified — are a far cry from the museum pieces trundling around in Kolkata. They are now modern, high-technology and high capacity systems, which can operate at speeds rivalling traditional metros if they enjoy a reserved right of way.

There is something incredibly reassuring about a train moving through the roads, sharing space with other vehicles and pedestrians. Hong Kong, which has a world class metro system, still runs its more than a century-old tramway. It's half as expensive as the metro to ride and is ideal for down town Hong Kong's densely populated retail district, where trams offer much more conveniently spaced options for boarding or alighting. Central and East European cities have discovered that re-engineered tram services offer a much cheaper option to modernise Soviet-era transit systems, while it also acts as a tourism magnet.

Most Indian cities are tailor-made for trams. Legacy road networks and exploding vehicle populations means that average traffic speeds during peak hours is already down to around 15 kmph in cities like Delhi, Mumbai or Bengaluru, with average speeds projected to slow to just 10 kmph by 2020-. trams offer the option to

significantly enhance commuter speeds, while also markedly cutiing down pollution. It's time our cities put them on the drawing board.

The urban centers directly affected by the policy vacuum include

- Bareilly ,Mysore Aligarh, Jalandhar, Tiruchirappalli, Salem
Gorakhpur, Amravati ,Jamshedpur, Bhilai Nagar, Warangal,

Firozabad, Belgaum Bhavnagar , Guntur, Bikaner,

Durgapur ,Jalgaon , Mangalore , Sangli , Miraj,

Kupwad, Mehsana, Gaya ,Ambattur, Asansol ,Nanded

Kolapur, Ajmer Tirunelveli, Malegoan(The list is indicative and not exhaustive)

Urban Transport Planning for Two Tier cities of India

Most of these cities could be called district towns of importance Such cities . do not have a regular bus service for local destinations All buses are private and serve to link the city to satellite towns within 10 to30kms approximately .

For within city travel the only option is two wheelers .private cars or three wheelers .It is for 100 such cities that tramways is the most appropriate solution ….

Trams in China Planned and under construction

As of 2017, Beijing, Chengdu, Sanya, Wuyishan and Haikou have new tram systems under construction. The modern tramcars will travel at up to 70 km/hr and have a capacity of between 300 and 500 passengers per tram.[5] While Ningbo, Quanzhou, Zhengzhou, Kunshan, Baotou and Lanzhou New Area[6] are planning tram networks for the future.

Hong Kong SAR

The Chinese Special Administrative Region of Hong Kong has had a tramway system since 1904. The Hong Kong Tramway is a traditional British Isles-style double-decker tramway with street running, along the north shore of Hong Kong Island.

Recent introduction of Trams and Light rail in Europe

The worldwide surge in the development of light rail transit (LRT) is nowhere as vigorous as in Europe, where enthusiasm for LRT – especially urban tramways (high-quality streetcar

services) – just keeps mounting. As in the USA and other nations, this seems to represent a *strong vote of confidence* by urban planners and decision makers in LRT as a particularly effective public transport solution to the mobility problems of their urban areas and interurban regions.

Europe's widespread deployment of tramway technology is of particular interest because, in most cases, it utilizes this relatively very cost-effective mode as a *rapid tramway* (*rapid streetcar*, in North American parlance). This means that the tram, or streetcar, is deployed not merely as a street-based, relatively slow, circulator or shuttle system, confined to a central area, but rather as a moderate-speed means of efficient, "green" surface transport, reaching out and connecting more far-flung sections of the urban area with relatively frequent stops to enhance accessibility to the service.

It should be noted that, because of this relatively very short average station spacing – significantly shorter than is typical for North American LRT systems – and also the constraint of the old, narrow streets found in most European cities, average schedule speeds on European surface public transport (including LRT tramways) is typically lower than in North American cities. Buses often operate at average schedule speeds in the range of 8-10 kph (5-6 mph). Thus, tramway speeds of 15-20 kph (9-12 mph, more typical of the systemwide *base norm* in North America) often represent a *significant improvement* in public transport service.

Since the beginning of 2004 alone, Europe has seen no less than four totally new LRT tramway startup systems go into public service. Here's a quick overview of developments in Nottingham, Barcelona, Dublin, and Athens.

Nottingham
Newest British tramway is a big hit

As on 8-9 March 2004 the medium-sized East Midlands city of Nottingham launched its new tramway system, marking the return of trams (light rail) to Nottingham for the first time in nearly 70 years. Nottingham Express Transit (NET) Line 1 runs from the city center's railway station northwards some 14 km (about 8.7 miles) to the communities of Bulwell and Hucknall, with a short westward branch serving the suburb of Cinderhill and a park-and-ride site at Phoenix Park. In total, the line has 23 stations.
[Photo: Stephen Dee]

While ridership for this first line is forecast at 11 million boardings per year (roughly, about 35,500 per day), passenger-trip figures for the first six months of operation have been so encouraging that in August NET decided to improve the system timetable by nearly 10% to cope with demand. Beginning on September 6th, NET starting running more trams, more often, on both weekdays and weekends.

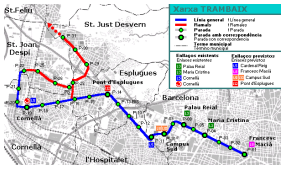
Barcelona

Two separate tramway systems launched

"With over 100 trains running simultaneously during rush hours, Barcelona is one of Europe's foremost Metro cities"). Certainly, it's an urban area which can readily justify an extensive multi-modal public transport network. Spain's second-largest city, and the capital of Catalonia, Barcelona has a population of 1,510,000, with its total metro area population coming to more than 4,000,000 when outlying regional communities are also included.]

According to *T&UT*, the metropolitan area not only has dozens of miles of interurban and regional railways, but an 84-km (52-mile) urban metro system; and, in December 2003, the first 2 km (1.2 miles) of "mini-metro" (a light-capacity metro) opened. (The "mini-metro" is targeted for imminent conversion to fully automatic operation.) But grade-separated metros, even "mini-metros", are extremely expensive. So, with an eye on the massive expansion of light rail tramway systems taking place in other European cities like Nantes and Strasbourg – and, undoubtedly, Paris (which has begun reinstalling tramways to supplement its own metros) – Barcelona's transportation authorities opted to start reinstalling what their predecessors had ripped out decades before – a tramway system, aimed at providing fast, efficient, high-quality, and attractive transit over predominantly surface alignments (where most of the people spend most of their time).

In a hurry to put these systems in place where they were most needed, in the spring of 2004 Barcelona opened, not one, but *two* totally separate, albeit technically identical, LRT tramway systems, both mostly utilizing existing major arterial road right-of-way. With a total line mileage of 29.3 km (19.2 miles), Barcelona's two LRT startup projects cost a combined total of Eur 451 – amounting to about $19 million/km, or $30 million/mile.



· Trambaix – Opened on 3 April 2004, this system is located in the southwestern part of Barcelona, linking the university area with the Baix Llobregat suburbs on the southern edge of the city. (See map, right; click on map for a larger image.) Total line length is 15.8 km (9.8 mi), with 28 station-stops. Capital cost was Eur 246, or about US$320 million. With 3 route permutations, this system is expected to carry about 7.6 million rider-trips annually (roughly, 24,500 per day). Schedule speeds for the three route services average about 19 kph, or 12 mph. That may seem slow by North American standards, but it's a major improvement for public transport in an older European city.

· Trambesos – Opened on 8 May 2004, this system is located in the northeastern part of Barcelona, in the Badalona and Sant Adria de Besos districts of the urban area, serving the environs near the 1992 Olympic Village. (See map, right; click on map for a larger image.) Total line length is 13.5 km (8.4 mi), with 27 station-stops. Capital cost was Eur 205, or about US$266 million. There are two route permutations on this line, with schedule speeds averaging about 20-21 kph (13 mph).

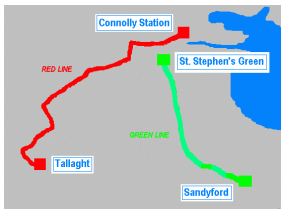
Dublin

Tramway mobility returns to ireland

On 30 June 2004, the irish capital city of Dublin opened the Green Line – the first of several new lines in its Luas ("Speed") tramway network. Marking the return to Dublin of the unique, quality mobility provided by tramway service after an absence of 45 years, this historic event was followed by the opening of the Red Line on 4 October. Both systems serve an urban area with a population slightly over one million, with about 200,000 residents located within one km of the Luas "catchment area".
[Photo: Buses in ireland]

Ultimately, a network of several surface light rail lines is envisioned, with a mixture of street running, reserved track, and dedicated exclusive right-of-way. This will be complemented by a metro system (also under construction) on totally grade-separated track including underground tunnels in the city center. All these systems will be integrated into Dublin's already-existing network of regional rail and urban and regional bus services.
[LRTA website 26 June 2004]

With a total route length of 24 km (15 mi), the Luas project has cost Eur 800 million, or about US$1.04 billion. That calculates to a unit capital cost of about $43 million/km, or $69 million/mile – certainly, one of the more expensive surface LRT projects in the world.



The two current routes are shown in the graphic at right (click on it to see a larger image). Here are further details (based on information from the Light Rail Transit Association):

· **Green Line** – Opened on 30 June 2004, this 9-km (5.6-mile) line follows the former route of the now-closed Harcourt Street railway line from the city center to Sandyford, serving Balally, Dundrum, Milltown, and Ranelagh. There is a short section (1 km, or about 0.6 mile) of street running along Harcourt Street and St. Stephen's Green West in the city center. According to the system plan, 13 low-floor trams are expected to carry 3,000 passengers/hour in each direction with 5-minute intervals between vehicles at peak time (15 minutes at offpeak times). End-to-end trip time over the Green Line is 22 minutes, resulting in an average schedule speed of about 24 kph (15 mph). it should be noted that, in an unusual practice, the Green Line has been built to a standard to accommodate "heavy rail" metro trains which, at a future date, may tunnel underground through the city center from Ranelagh.

· **Red Line** – Opened on 4 October 2004, this 15-km (9.3-mile) travels from Connolly Station in downtown Dublin, through the north inner-city, crossing the river south at Heuston rail station, and then serving the neighborhoods and communities of St. James, Rialto, Drimnagh, Bluebell, Red Cow, Cookstown, and Tallaght. Of the total alignment, 8 km (5 mi) of track is on-street, the balance being on dedicated alignments and on the central reservation of the main Naas road (N7). Ultimately, 20 low-floor trams are expected to carry 2,800 passengers/hour in each direction, with 5-minute headways, at peak times. End-to-end journey time is 38 minutes, resulting in an average schedule speed of about 24 kph (15 mph) – the same as for the Green Line.

The Luas trams (light rail vehicles) are designed for a maximum speed of 70 kph (about 45 mph). Because the first two LRT lines have been built physically separate, there are two

vehicle storage-maintenance depots accessible to each tramway, at Red Cow on the Red Line and at Sandyford for the Green Line.
[LRTA website 26 June 2004]

The Luas LRT system was projected to carry 6 million rider-trips by the end of its first year of full operation. That's roughly 20,000 boardings per day. Currently both Green and Red Lines together are carrying about about 40,000 passenger-trips each day.
[*ireland On-Line,* 2004/11/21]

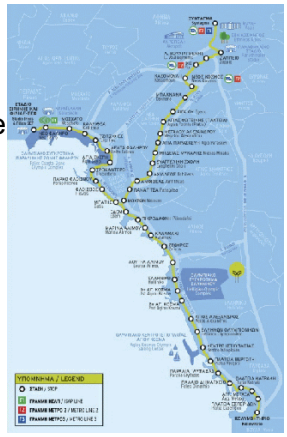
Athens

New LRT tramway system performs Olympic service

One of Europe's oldest and largest capitals, with more than 3 million inhabitants, Athens already has a metro network consisting of three lines. These include one line in operation since 1869, plus two modern lines opened only a few years ago. The total length of the metro network is 52 km (approximately 32 miles) with a total of 48 stations.
[UrbanRail.net: Athens, Nov. 2004]

In consonance with its position as host city for the Summer 2004 Olympics, Athens gave its public transport a major overhaul. in particular, the city's remaining archaic metro facilities were brought into the 21st century, and a modern light rail tramway system was installed.
[Photo: Athens Tram Project]

Thus, 44 years after the tram last ran in central Athens, on Monday, 19 July 2004, light rail transit made what the LRTA calls "a triumphal reappearance". Within the first three hours alone, the new tramway had carried more than 20,000 people, according to officials.
[Light Rail Transit Association, 20 July 2004]



Covering more than 26 km (16 miles) with 47 stops, the new system comprises three lines (Syntagma-Neo Faliron, Syntagma-Glyfada, and Neo Faliron-Glyfada), serving mostly the southern coastal suburbs (see map). It is expected that a total of some 80,000 passenger-trips a day will be made using the 24-hour tram service. The system includes 35 AnsaldoBreda Sirio trams, designed to transport up to 2,500 passengers along the lines during peak hours.
[Light Rail Transit Association, 20 July 2004; Greece Now Project, Nov. 2004]

The project cost Eur 380 million, or about US $494 million – approximately $19 million/km, or $31 million/mile. Certainly, this an amazingly moderate capital cost for a predominantly in-street rail transit facility within one of the largest cities in Europe.
[Light Rail Transit Association, 20 July 2004]

Expansion plans for the tramway system have already been unveiled. These include extensions of the service to Piraeus (from Neo Faliron), along Patission Avenue to Ano Patissia, and from Larissis Station to the university campus at Zografou via Goudi.
[Kathimerini, 16 December 2003]

A list of modern trams in Asia and Europe shows an upsurge for light rail systems world wide is attached as annexure .

The **Haizhu Island Circular New Tram** (Chinese: 海珠环岛新型有轨电车; pinyin: *Hǎizhū Huándǎo Xīnxíng Yǒuguǐ Diànchē*), line **THZ1**, or **YoungTram** is a tram system mainly serving the Haizhu area in Guangzhou, China, between Canton Tower and Wanshengwei Station. It is an at-grade tram system. The whole line (except Party Pier station) began operation on 31 December 2014.[1] Party Pier stop was added on 21 October 2015.[2]

The Haizhu Tram is the first of seven planned lines operated by Guangzhou Trams to open.

Zhangjiang Tram

Zhangjiang Tram is the only tram line operating in Shanghai today, utilizing a system manufactured by the French Translohr company. It is a rubber-tired tram system, second both in China and Asia.

Shanghai originally had a steel wheeled electric tramway network. Routes expanded gradually, and it reached its largest extent in 1925 with 328 tramcars; this tram system shut

down in 1975. Tram service returned to Shanghai in 2009, with commercial service resuming in 2010. Unlike the standard tramway, it chose a modern rubber-tired system.

Zhangjiang Tram started construction on December 23, 2007. Construction was originally planned to be completed on December 2008, but this was delayed a year, until December 31, 2009 when it was opened to traffic. Passenger operations started on January 1, 2010. Zhangjiang Tram runs from Zhangjiang Hi-Tech Park Station of the Shanghai Metro Line 2 to Heqing Town. Now the 10 km (6.2 mi)-long 1st phase, which runs from Zhangjiang Hi-Tech Park Station to Jinqiu Road is in service, and has 15 stops, two of which are interchanges to Shanghai Metro Line 2 (Zhangjiang Hi-Tech Park, the current terminal of the line and Jinke Road station). The next phase of the project is the Zhangjiang tram division multiple-phase construction, a project in the east Greenfield Road, from Zu Chong Zhi Road (Shanghai Metro Line 2 Zhangjiang Hi-tech station), west to Osmanthus Road Autumn Road, which covers a distance of about 10 km, with a total of 15 stops, 1 depot. It will be followed by an extension in the direction of Tang Zhen-Qing.

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The End of part 1