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From Suburban Railways to Regional Rail Systems

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Abstract
In recent decades rail systems serving cities and their suburbs have undergone a major expansion and evolution. As one of the oldest modes of mechanized urban transportation, suburban or commuter railways were specialized services for commuters operated by railway companies which primarily operated long-distance passenger and freight transport. Today most of these railways have grown into regional rail systems - regular transit services which meet the need for high quality multicentered transportation throughout growing metropolitan areas.

Disciplines
Engineering | Systems Engineering | Transportation Engineering

FROM SUBURBAN RAILWAYS TO REGIONAL RAIL SYSTEMS

VON DER VORORTBAHN ZUR S-BAHN

DU CHEMIN DE FER DE BANLIEUE AU R.E.R.

DALLA FERROVIA CLASSICA ALLA FERROVIA REGIONALE

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In recent decades rail systems serving cities and their suburbs have undergone a major expansion and evolution. As one of the oldest modes of mechanized urban transportation, **suburban or commuter railways** were specialized services for commuters operated by railway companies which primarily operated long-distance passenger and freight transport. Today most of these railways have grown into **regional rail systems** - regular transit services which meet the need for high quality multicentered transportation throughout growing metropolitan areas.

1. The Classical Suburban/Commuter Railways

Most suburban or commuter railways initially consisted of radial railway lines converging from suburbs into one or several terminals in central city. Owned and operated by railway companies, these lines generally served commuters traveling to and from work in the center of the city.

These lines were characterized by mostly cumulative boarding of the radial lines toward the city ("many-to-one" pattern) and a very sharp temporal peaking of demand. While frequent services were offered during the peaks, only infrequent and often irregular services were offered at other times.

Most of the classical commuter railways were operated and considered as systems separated from transit systems which consisted of metros, streetcars/light rail, trolleybuses and buses. While they did have joint terminals, fares and often even information for the two systems were independent of each other.

2. Evolution and Recent Developments of Regional Rail

Several trends which have taken place in most cities around the world have resulted in a steady increase of interest in the regional rail. Two major factors have resulted in the increasing role of this transportation mode.

First, with the spreading of cities and growth of suburban populations, the highest growth of demand for transit has occurred in the areas served primarily by regional rail networks. Thus, as cities grow into regions, there is a need to develop urban transit into regional transit, and regional rail represents the most important mode with its "skeleton" network.

Second, regional rail offers a very high quality of service (particularly speed, reliability, riding comfort and image), so that it can compete with the private automobile much better than other transit modes.

As a result of these developments, the need for expansions and improvements of regional rail has intensified in recent years. The status of this mode in many cities - separation from regular transit, ownership by railway companies which have many other duties and concerns, and inadequate funding - has often presented obstacles to regional rail improvements; yet, many cities have resolved these problems and achieved a remarkable progress in upgrading their systems from classical commuter railways into regional rail systems. A brief review of these developments by geographic area will be followed here by an analysis of the types of upgrading and evolution of contemporary regional rail systems.

2.1 Western Europe. The development of regional rail systems in several West European countries is rather well known. S-Bahn systems in **Berlin** and **Hamburg**, designed from the beginning as regional rail, serving not only commuter, but all trips, like a "bigger cousin" of the U-Bahn, have been joined by new similar systems in **München, Frankfurt, Nürnberg** and several other cities. In addition to continuous technological improvements, the S-Bahn services have been fully integrated with regular transit, enhancing total regional mobility of the population.

Paris is an interesting case for studying characteristics of regional rail systems. It has a range of types of rail systems - from suburban railways with locomotive-hauled trains and double-decker cars to multiple-unit high-performance regional rail systems with metro-type high-frequency operation and very high capacity. Moreover, there is an organizational variety: one **RER** line is operated by the **French Railways (SNCF)**, another by **SNCF** jointly with **RATP**, and one by **RATP** alone. All three are, however, fully integrated with regular transit, so that the passengers have no problems with different operating agencies.

Integration of regional rail services with transit services has been done to a large degree in virtually all European countries (**Austria, Belgium, Netherlands, Norway, Sweden, Switzerland** and others), with exception of the aberration of **Great Britain**. The recent deregulation in that country represents the unique case that legislation has been brought which has **forced disintegration** of agencies and modes (all rail and bus companies have been forced to separate). This move was aimed at improving short-term economic results, in spite of its obvious negative effects on network services to passengers.

Despite this retrogressive change in Great Britain, rail ridership has generally increased, partly because in some areas, such as **London**, bus services have been affected even more negatively by deregulation than rail, which is physically not conducive to parcelization and institutional deregulation.

Following the highly successful conversion of a former commuter rail systems into light rail transit (LRT) in **Newcastle**, another interesting transit system design innovation is presently being implemented in **Manchester**: three regional rail lines are being converted to LRT operation, which allows them to penetrate center city and operate on streets, greatly

improving passenger distribution. Together with **San Diego in California** and **Karlsruhe in Germany**, this development is an interesting innovation of combining features of LRT and regional rail to improve efficiency of operations and quality of service. Sharing tracks by conventional railways and LRT vehicles, often considered technically infeasible, is becoming a reality.

Other interesting developments of combining the features of traditionally different rail transit modes, specifically LRT and metros, are found in the cities of **Amsterdam, Rotterdam** and **Stockholm**. Until recently this type of intermodal combination was limited mostly to the numerous types of transitions between streetcars and LRT, found in many West European cities.

2.2 North America. What has been happening with commuter/regional railways in heavily auto-oriented countries?

Very interesting developments of regional rail transit mode have also taken place in North America. Most of the old **"commuter railroads"** have been modernized and some have been expanded and reorganized into the systems that can be more properly designated as **regional rail**. Several particularly interesting developments exemplify the significant improvements that have taken place in North American cities during the last two or three decades.

New York City and its region are served by three large regional rail systems: **Metro North**, serving the northern suburbs in New York State and Connecticut; **Long Island Rail Road (LIRR)**, consisting of a number of lines from the City toward the east, extending to the eastern end of Long Island; and **New Jersey Transit (NJT)**, which has about 10 lines radiating from Manhattan, Hoboken and Newark to the large area of New Jersey suburbs. These systems carry a total of over 800,000 daily passengers.

In spite of continuous financial constraints, a number of major improvements have been made on these systems. **Metro North, LIRR** and **NJT** were reorganized into public agencies and they introduced several technical/operational improvements, such as:

- Extension of electrification to nearly complete networks;
- Construction of high-level platforms on all main lines;
- Building of new yards and control centers;
- Upgrading of stations and expansion of park-and-ride (P+R) lots;
- Improved coordination and transfers with local transit;
- A major new transfer station between Newark and New York will provide an important connection between two sets of **NJT** lines, increasing their operational efficiency and service convenience.

LIRR has made a number of improvements to increase capacity at the convergence of lines toward Manhattan, needed because of increasing ridership. In addition to operational improvements, **LIRR** will soon have new dual-powered locomotive (Diesel/electric) and double-decker cars.

Chicago's Metra, **MARC** in **Washington-Baltimore** and **Caltrain** in **San Francisco** have all improved services through new rolling stock purchases (including double-decker cars), increased reliability, station improvements, construction of P+R lots and marketing of services. In spite of sharp fare increases, ridership has responded positively to such improvements on these systems, which are still nearly exclusively Diesel-powered.

Yet, the most impressive has been the progress of **MBTA** in **Boston**, where a rather extensive system with Diesel traction and rather long headways has succeeded through improvements of service quality to more than double its ridership in the last decade: from 30,000 to 72,000 daily passengers.

Philadelphia has had the most fundamental upgrading of the regional rail system among all U.S. cities: a tunnel in the center city has been constructed that transformed two independent radial networks into an integrated network consisting of seven diametrical electrified lines. Also, the system has been taken over by the transit agency, **SEPTA**, and it is now largely integrated with other transit modes. However, in spite of service improvements, the ridership has not increased greatly because of high fares, insufficient P+R facilities and long service intervals.

Toronto has steadily expanded its regional rail services, so that it now carries about 113,000 daily riders, the third highest volume on the continent, following New York and Chicago.

At this time, the most interesting developments in regional rail in North America are taking place in the **Los Angeles Region**. After decades of construction of extensive freeway networks and total adaptation of the entire urban area to the private automobile, traffic congestion, air pollution and other problems have increased so much, that it became obvious that the basic transportation policies must be changed.

Several popular referenda have approved funds for transit and specifically for construction of rail transit systems. Thus, one LRT line has been recently opened, another one and a metro line are under construction. Parallel with these efforts, there is a major activity in planning a new regional rail system. Recently, the agency planning transit systems has purchased 177 km of railroad rights-of-way for use by regional rail. The final regional network will consist of 547 km of tracks on which 663 km of lines will be operated, serving 67 stations. The first line will open in 1992.

Table 1 presents the basic data on regional rail systems in North America.

2.3 Japan. This industrial giant in the Far East is certainly in the forefront of many concepts in regional rail systems. In **Tokyo** alone **Japanese Railways** and a number of **private railway companies** carry some 20 million daily riders, a volume probably not exceeded by any entire continent.

The range of railway services in **Tokyo** varies from metro-type rolling stock and operations to commuter-oriented railways. Technical precision and reliability of operations place these systems among the leaders in the world. **Yamanote Line** carries passenger

TABLE 1

NORTH AMERICAN CITIES WITH COMMUTER RAIL SERVICE IN OPERATION (1989-1990 DATA)

City	Transit Agency	Rail Operator	Average Weekday Ridership	Annual Ridership
Atlantic City, NJ	NJT	NJT	(See Newark)	
Baltimore, MD	MARC	Amtrak	15,000	3,456,000
	MARC	CSX		
Boston, MA	MBTA	Amtrak	72,000	18,738,000
Chicago, IL	Metra	Metra, BN, CNW, NS	275,000	71,112,000
Martinsburg, WV	W VDOT/MARC	CSX	(See Baltimore)	
Kenosha, WI	Metra	CNW	(See Chicago)	
Miami, FL	TRI-RAIL	UTDC	6,000	1,632,000
Montreal, Québec	STCUM	CN	15,000	3,900,000
	STCUM	CP	16,000	4,300,000
New Haven, CT	ConnDOT/MTA	Metro North	(See New York)	
	ConnDOT	Amtrak	(new in 1990)	
Newark, NJ	NJT	NJT	170,000	43,957,000
New York, NY	MTA	Metro North	200,000	56,975,000
	MTA	LIRR	292,000	75,417,000
	NJT	NJT	(See Newark)	
Providence, RI	RIDOT/MBTA	Amtrak	(See Boston)	
Philadelphia, PA	SEPTA	SEPTA	94,000	24,228,000
San Francisco, CA	CalTrans	SP	22,000	5,591,000
San Jose, CA	CalTrans	SP	(See San Francisco)	
Santa Ana, CA	OCTC	Amtrak	(New in 1990)	
South Bend, IN	NICTD/Metra	CSSSB	10,000	2,261,000
Toronto, Ontario	GO Transit	CN	113,000	29,120,000
	GO Transit	CP		
Wilmington, DE	DTA/SEPTA	SEPTA	(See Philadelphia)	
Washington, DC	MARC	Amtrak	(See Baltimore)	
	MARC	CSX		
			1,300,000	340,984,000
			Daily Passengers	Annual Passengers

Source. American Public Transit Association (APTA).

volumes exceeding 60,000 persons per hour on a circular line, a geometric form which several other cities have claimed not to be conducive to reliable operation!

While institutionally fractionalized among a number of public and private agencies (two operating subways, Japanese Railways and many private railways, many bus companies) and few connection between buses and rail lines, rail operations are uniquely integrated. Having built two subway lines with standard gauge and third rail, the **TEITO** Company changed in the 1950s to railway standards - narrow gauge (1.067 m) and overhead catenary - in order to allow integration. Today a number of subway lines are served by both subway and railway agencies' rolling stock.

2.4 **Developing Countries**. Commuter and regional railways play a very significant, and increasing role in many rapidly growing cities of developing countries. With their large capacity, superior economy in carrying large passenger volumes and rugged durability, railways in many forms provide extensive service and play crucial roles in cities like **Sao Paolo, Bombay, Cape Town, Johannesburg** and **Jakarta.**

2.5 **Other Countries**. Major regional rail systems are found in a number of other cities and countries, such as **Australia** (most large cities), **Hong Kong, Italy, Portugal, Spain, Eastern Europe,** and, of course, the **Soviet Union.** Space does not allow description of all these systems. **Switzerland,** which is clearly one of the world's leaders in railway development in all respects - technical, operational, organizational and in transportation policy - is not included here because it will be covered in many other papers at this Conference.

3. Analysis of Developments and Innovations

Selected major aspects of commuter railway developments and its upgrading into regional rail, which have been made in many cities, will be briefly reviewed here.

3.1 **Network Developments**. Several types of rail network developments have taken place in many cities.

- **Electrification of lines** to improve performance and economic efficiency has been done in many countries. While many cities in Western Europe have electrified their entire regional rail networks (e.g., Zürich, Amsterdam, München), North America lags behind in this development due to low-cost diesel fuel and lack of government assistance for capital improvements.

- **Cross-city links**, connecting radial networks on different sides of center city, have been built or are under construction in many cities: **Brussels, Frankfurt, Hamburg, Manchester, München, Oslo, Paris** and **Philadelphia.** Although very logical, this type of connection is being only now considered for London.

The cross-city links have been generally very successful. Increasing connectivity of the region, they have often represented the critical element for upgrading commuter railways

(mostly for commuting) into regional rail systems, serving trips which are more dispersed, both spatially and temporally. Operational gains include elimination of terminal times and reduced need for large storage yards on prime center city land parcels.

The potential impact of new rail lines on land use development and intensification has been particularly strongly materialized with center city links. For example, in the center of **Philadelphia** there has been a period of intensive construction of new offices, retail facilities and a new convention center, which has been closely linked to the opening of the regional rail tunnel. The **S-Bahn Verbindungstunnel** in **München** was a major component of transportation restructuring of the center city in the early 1970s.

- **Line extensions** have often been built outward, as cities grew spatially, or within cities, acquiring new rights-of-way as the demand for more lines increased.

- **Airport rail lines** have been built in a number of cities with varying success. Generally, **extensions** of metro or regional rail lines to airports have been successful in attracting sizable ridership. Examples of these are the metro lines in **Cleveland, London/Heathrow** and **Chicago/O'Hare**, and regional rail lines in **Frankfurt** and **Paris (Orly** and **de Gaulle**). However, designs of some **exclusive** airport lines were based on a belief that airport passengers would not tolerate any stopping of trains between center city and the Airport. Therefore, a non-stop service must be provided. The lines based on this belief, such as the regional rail lines in **Philadelphia** and the recently opened one in **Rome**, perform far below their potential and cannot be described as successful. They actually pass through areas with large potential ridership without stations to serve it.

Experiences from many cities clearly show that air travelers value reliability and frequency of service far more than saving 10-12 minutes by non-stop operation between two points only.

- **Network integration with other transit modes** has proved to be a key element of passenger increases. Cities with high regional rail usage generally have these systems fully integrated with other transit modes: networks with transfer points, joint stations, coordinated schedules and information, joint fares, etc. Truly regional rail networks (e.g., **Hamburg, Frankfurt, Vienna and Zürich S-Bahn,** and **Paris RER**), serve central areas with a number of stations and have much stronger intermodal integration than the systems design as suburban commuter lines (e.g., **San Francisco Caltrain, London** and **Lisbon**).

<u>3.2 Rolling Stock</u>. Network characteristics, physical and operating conditions of regional rail systems vary widely. This diversity has led to numerous innovations in rolling stock development in recent years. A brief review of some major developments will illustrate this trend.

- **Traction:** there has been a clear trend to electrify regional rail lines. Many systems are fully electrified **(München, Philadelphia, Zürich)**. In some cities diesel traction remains on outlying sections with light traffic volumes **(New York/Long Island, Hamburg)**. Finally, some major regional rail systems, particularly those in the countries with cheap oil and limited investment funds, remain mostly or exclusively with Diesel

traction (**Boston, Chicago, Toronto**).

- **Car types:** multiple-unit (MU) rolling stock is the most common type, particularly on electrified networks. Locomotive with trailers are usually operated as push-pull units, with a driving cab on the last car for reverse travel. **Dual power** (electric and Diesel) locomotives have recently been ordered for some lines in **New York** (**Metro North** and **LIRR**).

Double-decker cars, a rarity a couple of decades ago, have become rapidly more popular in recent years. The need to provide more capacity for increasing passenger volumes and greater comfort (higher seating/standing ratios) has led many cities which have sufficient profile clearances to introduce double-deck and gallery cars. They have been adopted in many European and North American cities. **Toronto's** famous double-decker has been adopted in **Miami** and for the new regional rail lines in **Los Angeles**.

- **Platform heights** also vary among cities between low, medium and high levels. Several systems have recently constructed high platforms at all stations; others, which still have a mixture of low and high platforms at different stations, have developed some ingenious vehicle designs and operations.

3.3 Ownership and Operation. Most regional rail systems remain special divisions of railway organizations. They usually operate under a contract with the transit agency; or, there is a transit federation, a body that specifies the required quantity and quality of service which the transit agency and the railway agency operate. Finally, in some cities the transit agency has taken over the regional rail system and operates it as an integral part of its total system (**Philadelphial**, partially **Paris**). Many systems have gradually made their operations similar to regular transit through introduction of shorter and regular headways, increased use of prepaid fares, smaller crew sizes and better integration with other modes.

4. Problems and Obstacles to Development

Regional rail systems, by their nature, involve a rather complex set of requirements, organizational and operational conditions. Their operation and improvements therefore must often overcome a variety of problems and obstacles. Those common for many systems are listed here.

- **Very high peak/base ratio of passenger volumes.** Although the change from commuter to regional rail type of service tends to increase off-peak ridership, most regional rail systems still have very sharp peaks. This results in very low utilization of the large portion of the rolling stock. Actually, on some systems off-peak and weekend services can be operated by less than 25% of the fleet. This is the main reason for high unit costs ($/passenger) of regional rail.

This condition often leads to the incorrect conclusion that regional rail mode is very expensive to operate. Actually, it is expensive to serve very sharp peaks, and regional rail is often the most economical mode to serve such high volumes with high service quality.

- **Fare collection** is difficult because it is labor intensive, and under some conditions it is difficult to introduce self-service fare collection on a system that has uncontrolled stations.

- **Labor intensive nature** makes operation of few large trains economical, resulting in long headways which are unattractive for the public. Moreover, labor unions sometimes represent an obstacle to automation and introduction of more efficient operations.

- **Managements** are often oriented toward long distance transportation and have little interest in promoting and improving regional rail services.

- **Federal railway technical standards**, designed for long distance operations, include many which are excessive for regional services and represent a burden that causes delays and costs which could be avoided.

- **Complex regional jurisdictions and parochial mentalities** make often serious obstacles to introduction of changes that would benefit the region. Examples of this are opposition to strong land use controls or to provision of P+R facilities at stations.

- **Deeply rooted "hidden" favoring of private automobile**, such as subsidized parking, business- or tax-supported use of automobile and lack of charges for the social and environmental costs which auto use in cities causes, represent by far the most serious obstacle to the development of all transit, including regional rail.

5. Needed Further Improvements and Innovations

The preceding discussion shows some of the major problems many regional rail agencies are facing today. The most common needs for improvements in services and operating efficiency, partly aimed at solving the existing problems and partly directed toward innovative concepts are defined here.

- **Increasing reverse commuting, intrasuburban and off-peak ridership,** which greatly improves operating ratios (revenue/expenses), should be achieved by further conversion to transit-type services. One of the basic elements to achieve this is an increase in service frequency during off-peak hours. This requires **lowering of operating costs for minimum train size operation.**

Many regional rail systems operate 3-car trains as minimum units; some have two or three persons as the minimum crew. Both of these must be reduced through various measures which allow operations similar to those of light rail transit: design of cars and signals which permit single-car, driver-only operation with good security supervision, easy fare collection and convenient information for passengers. Further automation in coupling and uncoupling of cars in operation is also desirable.

- **Adaptation of technical standards to the needs of regional rail systems** should eliminate physical and design rules that are not applicable for regional lines and that can be

eliminated without compromising safety.

- **Improvements of suburban access**, which presently often represents the main obstacle to the use of regional rail. Depending on local conditions, these improvements should focus on a few or all of the potential access modes, such as walking, bicycles (very successfully used in some cities, neglected in others), bus transit, kiss-and-ride (passenger drop-off) and P+R (the last one is extremely important in many North American cities).

- **Institutional changes** that will allow full integration of services for passenger convenience, where this has not yet been achieved.

- **Fully coordinate urban and transportation planning.** The fact that rail systems have a very strong interaction with urban design is used in some countries, ignored in others. Design of major activities centers around stations, leading to multinucleated developments focused on the rail network is a basic element for permanent functional and economic success of a regional rail system.

- **Development of rational transportation policies and financing methods.** In spite of the frequent crisis situations in highway congestion, environmental problems and negative effects on quality of life, very few countries have yet resolved the main problem of urban transportation: introduction of charges for each mode which reflect full costs and benefits of its usage, including contributions to mobility and economic efficiency on the positive side, and congestion and negative externalities on the negative side.

6. The Present Family of Regional Rail Systems

The classical suburban railways have been generally very successful in meeting the growing needs for high-quality transit services for entire regions. The response to this need has been achieved through diversification of physical and operating concepts to the extent that the systems classified today as **commuter or regional rail** include a broad range of systems from diesel-powered commuter trains providing peak hour services to center city only, to regional rail systems with frequent electric trains serving extensive network similar to regular transit.

On the "higher side" with respect to capacity and frequency, regional rail has transition into modern high-speed regional metro systems, such as the **JR lines in Tokyo, San Francisco BART** and **Washington Metro**; on the "lower side," regional rail will be adapted to better penetrate urban areas by introduction of LRT-type rolling stock and street operations, with **Newcastle, Karlsruhe** and **Manchester** as the leaders in this concept.

All indications are that with the increasing highway congestion and recognition of the need to better coordinate urban planning and transportation, regional rail mode will have an increasing role in shaping the cities and increasing their vitality. Further expansion and innovations in this classical mode of urban transport should be expected in the future.