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PUBLIC TRANSPORT FOR INDIAN URBAN AGGLOMERATIONS:A CASE FOR CENTRAL ROLE FOR SURFACE RAIL

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PUBLIC TRANSPORT FOR INDIAN URBAN AGGLOMERATIONS: A CASE FOR CENTRAL ROLE FOR SURFACE RAIL

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ABSTRACT

Objective

Emerging economies like India are investing heavily in rapid development of urban transport infrastructure for public transport. Though the initial efforts started with three modes - metro rail, Bus Rapid Transit (BRT) and surface rail; currently investments are being made mainly in metro rail and BRT. In spite of lack of patronage, surface rail, which helped develop many cities in India, is playing a prominent role in movement of urban commuters.

The objective of research is to assess the viability of surface rail for movement of urban commuters in comparison to metro rail and BRT. To achieve this objective research questions asked were:

- How do cost, capacity and cost per unit capacity compare between metro rail, surface rail and BRT systems?
- What is the current urban form of Indian cities and policy framework to accommodate future urbanisation?
- What does this imply for planning of public transport?
- Can the surface rail serve the city core in addition to serving the peripheral areas?
- If so, what should be the planning strategies for the surface rail systems?
- What are the implications for public transport in India and can the BRT, metro rail and surface rail be symbiotically combined to generate a more purposeful and distinct Public transport for Indian UAs? If so, what are the investment implications?
- If the answer to the above is affirmative, what policy measures are required to integrate surface rail into transit systems of Indian UAs?

Methodology

The methodology adapted was :

- Comparative assessment of cost, capacity and cost per unit capacity for the three modes which established that cost per unit capacity for surface rail is one twentieth of metro and one fourth of BRT
- Review of urbanisation trends and policies
- Finally, review of rail network in the 50 urban agglomerations (UAs) with population more than million to see the extent of rail network serving them and whether it can serve the core city.

Results

The results indicate that during the 12th plan 747 kilometres (kms) of metro rail and 989 kms of regional rail systems are being developed to serve 10 large UAs. As against this, by reallocation of the resources a more elaborate urban rail network of 6628 kms can be upgraded and 3000 kms of new system can be added in all the 49 UAs. Another major finding is the hidden benefits given to metro rail compared to surface rail systems.

Implications for Policy

Immediate policy implication is to undertake surface rail development on priority before metro rail development is taken up. Policy implication would be to set up an institutional mechanism for fast development of surface rail. This would be possible if apex policy making bodies of Ministry of Urban Development (MoUD) for urban transport, Ministry of Railways (MoR) for surface rail and the Planning Commissions jointly review and formulate guidelines for surface rail and metro rail projects. This would facilitate concerted action for development of surface rail at all levels.

Keywords: Surface rail, urban transit, Bus rapid transit, Metro rail, Urban Agglomerations, India

> Mass rapid transit can contribute … to city efficiency…, but it can also impose a heavy fiscal burden. Alternative technologies should be evaluated both in operational and fiscal terms. More **expensive rail-based systems** (emphasis added) should only be adopted within an integrated planning and financing structure. (Blurb at the beginning of Chapter on Mass Rapid Transit, World Bank, 2002, p. 109)

> Despite … problems, several [surface rail] systems could be converted **into surface metros at a fraction of the cost of underground or elevated systems** (emphasis added), even if there is a need to add an underground or elevated link to the central business district or any other populated area. Several Asian cities … and African cities … are possible candidates for conversion of suburban railways into modern systems… (World Bank, 2002, Pg 114-115)

INTRODUCTION

In the last ten years urban transport in India has been a major area of focus. National Urban Transport Policy (NUTP) of Government of India (Ministry of Urban Development, 2006) resonates with increasing concerns of global warming and green house gas emissions and lays down policies for reduction of private travel, increasing public transport and non motorised travel. Federal, state and local governments have also invested on public transport infrastructure; especially on metro rail systems and Bus Rapid Transit (BRT) systems. However, surface rail based transit systems, though they are more cost effective and ubiquitous in India and have facilitated growth of Indian cities, have not received the same attention and investment. Focus of this paper is to assess the viability of surface rail as an urban transit and, if found viable, look at the conditions which would enable its integration into urban transit while simultaneously meeting the needs of long distance traffic.

National Urban Transport Policy and Choices for Public Transport

Though NUTP lists various public transport options such as the metro rail (either elevated or underground), Bus Rapid Transit (BRT) systems, conventional bus, electric bus, monorail, and the conventional rail systems that run on surface[1], it does not lay down a criteria on the choice of public transport. However, the policy concludes that surface rail is not suitable for urban transport and relegates it to suburban areas of large cities (Ministry of Urban Development, 2006).

However, works on surface rail, metro and BRT systems started around the same time; Hyderabad with surface rail system in 2000, Delhi with metro in 1998, and Delhi and Ahmadabad with BRT in early 2000. Following this there is intense debate on the choice of public transport; mainly between metro rail and BRT. In this intense debate surface rail and Hyderabad's experiment with surface rail was lost (see box 1 for comparison of Hyderabad Multi Modal Transport System (MMTS) and Delhi metro rail).

[1] This is also referred to as conventional rail or at grade rail by different authors. In this article surface rail includes all systems run by Ministry of Railways. They are usually run at surface level.

Box 1: Case of an Orphan and Pampered Child: Comparison of Hyderabad Multimodal Transport System (MMTS) and Delhi Metro Rail System

Both started around the same time; MMTS in Hyderabad in 2003 and metro rail in Delhi 2002. MMTS, plan for upgradation of surface rail for suburban operations, cost Rs 1.78 billion to upgrade 43 km section for suburban operations. It now carries around 150 thousand passengers per day; a capital investment of 13,700 per passenger carried. Lack of interest on the project by the original promoters prompted a news paper to report "Orphaned' MMTS chugs on" (The Hindu, March 6, 2006) showing how public patronized the system even though no investment were flowing into it. Phase 2, covering 107 kms of length for Rs 6.3 billion, was sanctioned after a gap of 9 years in 2012 (Times of India, March 2, 2012).

DMRC cost Rs 300 billion for a 190 km track and carries around 1.8 million passengers per day; an investment of Rs 167, 000 - 12.5 times the investment on Hyderabad project. The encomiums Delhi metro received are a legion. Now the 3rd phase has been sanctioned for 107 km costing Rs 350 billion (Jagran Post, Jan 1, 2012).
Source: "Multi-Modal Transport System (Hyderabad)", 2012; Delhi Metro Rail Corporation Limited, 2012; and discussions with company officials
Note: Rs or Rupee is the Indian currency. As on 31/10/2012, 1 $ = Rs 54.

The metro system caught the imagination of the Indian urban population both due to its convenience and excellent project managing skills of Delhi Metro Rail Corporation (DMRC) under the leadership of Dr Sreedharan. Thus clamour for metro rail has reached a crescendo and currently 22 cities are working on metro projects and another 15 are toying with monorail projects (Tiwari, 2011; "Rapid Transit in India", 2012). The proponents of metro have made it near mandatory for cities with more than 1 million population[2]. The new fad for metro is termed as "Metro Mania" by the chairman of National Transport Policy Development Committee (NTPDC), an apex committee constituted by Indian Government on development of transport policy for the country (Mohan, 2012, p. 42).

Though BRT systems have been late starters in Indian cities, the system has established itself in the Indian scenario owing to numerous advantages of the system and vigorous support by prominent academicians and advocacy organisations (Mohan, 2008). Advocates of BRT have concluded that "…bus rapid transit systems with dedicated lanes seem to be the only choice for providing affordable mass transport in our cities" (Mohan, 2008, p, 1). As on date, BRT systems are operational in 6 cities, under construction in 7 cities and planned in 7 more cities ("Bus Rapid Transit", 2012).

Planning Commission, apex policy formulation and review body of Government of India, appointed a working group to recommend a strategy for development of urban transport for the 12th five year plan. The committee has recommended the following guidelines for urban transport:

- Add BRTS @ 20 km/1 Million population in 51 cities with population> 1 Million;

[2] "It has been observed that in developed countries, planning for mass transit system starts when city population size exceeds 1 million; the system is in position by the time the city population is 2 to 3 million and once the population exceeds 4 million or so, planned extensions to the Mass Rapid Transit Systems is vigorously taken up (Delhi Metro Rail Corporation Limited, 2012a, para 2). Sreedharan (2004) also states that "A rail based Metro System is inescapable… World-over the practice is that when the population of a city reaches 1 million mark, the studies and investigations needed for a Metro System are taken up" (quoted by Mohan, 2008).

- Add rail transit @ 10 km/Million Population, start planning rail transit projects in cities with population in excess of 2 Million, and start construction in cities with population in excess of 3 Million.
- Expand rail transit in existing mega cities i.e. 4 Million +, @ 10 km per/yr. i.e. 50 km in 12th five year plan, (Planning Commission, 2012, p. 31)
- Developing hierarchical road network in newly developing areas (Planning Commission, 2012, p. 6)

Based on the above the committee recommends an investment of Rupees[3] (Rs) 1307 billion on Metro rail, Rs 296 billion on BRT, and Rs 197 billion on regional rail system (Planning Commission, 2012, p, 32). The regional rail system is different from the conventional rail systems and is limited to cities with 4 million plus population.

Surface Rail and Urban Transport

Though metro rail and BRT have found favour with policy formulators and that NUTP does not find it suitable for urban transport, extensive surface rail network of Indian Railways has been carrying urban commuters since a long time. In year 2010-11, in the three mega cities of Mumbai, Kolkatta and Chennai and on the ring rail of New Delhi, surface rail carried 4.06 billion passengers - a daily average of 11.1 million passengers (Indian Railways, 2011, p 112). As by definition passengers in other urban agglomerations are classified as non suburban by Indian Railways, a large number of urban commuters travelling in other cities are not captured in Indian Railway's estimate of suburban passengers. As per Author's estimates the figure would be at least a billion passengers per annum.

Thus beyond the pale of NUTP, surface rail systems have been carrying a large chunk of urban commuters since a long time. However, as the systems are not recognised as urban transport projects, investments are not flowing from the Ministry of Urban Development (MoUD) for the surface rail projects. The neglect is distorting the investment patterns.

Objective

Primary objective of the paper is to review the viability of surface rail to cater to Indian urban commuters and also identify the areas where it needs to be nurtured. To address the above objective the research questions being addressed are:

- How do cost, capacity and cost per unit capacity compare between metro rail, surface rail and BRT systems?
- What is the current urban form of Indian cities and policy framework to accommodate future urbanisation?
- What does this imply for planning of public transport?
- Can the surface rail serve the city core in addition to serving the peripheral areas?
- If so, what should be the planning strategies for the surface rail systems?
- What are the implications for public transport in India and can the BRT, metro rail and surface rail be symbiotically combined to generate a more purposeful and distinct Public transport for Indian UAs? If so, what are the investment implications?

[3] Rupees (or Rs) is the Indian currency. As on 31/10/2012, 1 $ = Rs 54.

- If the answer to the above is affirmative, what policy measures are required to integrate surface rail into transit systems of Indian UAs?

The paper is divided into 7 sections. The next section provides the relative merits and demerits of metro rail, BRT and surface rail. Section 3 discusses the changes in Indian urban form and the how public transport should be planned to serve such an urban form. Section 4 examines the surface rail systems across various cities of the country and the potential it has for serving the UAs. Section 5 brings out the implications for public transport systems and proposes how systems can be planned. Section 6 discusses the various policy measures to develop the surface rail based urban transport systems. Section 7 finally concludes and discusses on directions for future work.

PUBLIC TRANSPORT OPTIONS: A COMPARATIVE ASSESSMENT

THE BRT and metro rail options are extensively discussed and compared in the literature and it is a general consensus that metro rail has higher capacity (30-50000 people per hour per direction) compared to BRT (10-30,000 people per hour per direction) (Wright and Fjellstrom, 2005, p. 5). However, metro rail costs around 20 times higher than a BRT system (Mohan, 2008). Metro rail needs less space at the ground level compared to BRT. However, the potential for of surface rail has not been rigorously analysed vis-à-vis metro rail and BRT. The section first compares surface rail and metro rail on cost and capacity and then compares surface rail with BRT.

Comparison of Metro Rail with Surface Rail

Capacity

Capacity is a product of three factors; length of the moving unit, width of the moving unit and frequency. In India, barring a few exceptions, metro systems are generally designed for a 6 coach length trains as the platforms for elevated and underground systems are very costly (Chennai Metro Rail Limited, n. d; Bangalore Metro Rail Corporation Limited, n. d). Comparatively, surface rail trains are very flexible as the platforms are at the ground level. For example Mumbai suburban trains had 9 coaches for very long but they were gradually upgraded to 15 coaches (Western Railway, 2012b). The conventional trains are 24 coach length (Western Railway, 2012a). Thus it is practical to have 16 coach length urban trains, if not longer. Hence surface trains are 2.67 times longer than the metro trains (16/6).

As metro trains are run on standard gauge, the width of coaches is 2.88 metres against the 3.66 meter wide broad gauge coaches of surface rail (Ravibabu, 2006). Thus surface rail trains are 26 % wider than metro trains. Combining the two data capacity of a surface rail train is 3.3 times of a metro train (1*2.67*1.26=3.36).

Third important parameter is frequency. Metro systems are designed with high cost and latest signalling systems permitting trains to run at a 3 minute frequency, though some of the systems

do speak of two and a half minute or 2 minute frequency. Thus in an hour one can run 20 metro trains normally. As against this, surface rail systems have varied frequencies as the signal systems differ widely. The minimum headway achieved is 3.6 minutes on Western Railway suburban system (Varma and Jain, n. d.; Western Railway, 2012b; and discussions with officers of Western Railway). For practical reasons even if we assume a 5 minute frequency one can run 12 trains in an hour.

Combining all the three, a metro rail has capacity of 20 metro train per hour while a surface rail system has an equivalent capacity of running 40 (12 trains per hour * 3.3) metro trains. Thus a surface rail system has capacity twice that of metro system. Even if 50 per cent of surface rail capacity is used for urban traffic, the rest can left out for conventional trains. Exact pattern of train running would be decided by the traffic pattern; intercity and intra city.

Cost

The surface rail is an upgradation of the existing system for running suburban trains. As Indian Railways has varied systems and cost upgradation varies for each system a system requiring highest investment is selected for comparison purpose - a single line non electrified conventional signalling system. The total investment works out to Rs 200 million per km[4].

Metro costs differ depending on whether it is elevated, underground or at surface level. Elevated metros are the most prominent accounting for the 70 percent of route length, with underground being around 25 percent and 5 percent being at grade. Hence the costs of elevated metro rail are considered for comparison. As underground costs are around 50 % higher and at grade systems cost one tenth, the costs of metro rail would be higher than the estimates used in the paper.

Table 1 gives the cost estimates of elevated metro corridors in different cities of India. Though costs vary widely the estimate used by the 12th plan working is much lower than estimates of individual projects. The cost is assumed to be 2500 million an average figure of the 12th plan estimates and Bangalore project. Out of this around 25 % of the costs are earmarked for rolling stock[5] and the cost of fixed infrastructure works out to Rs 2000 million per km.

[4] The investment components and the estimated investment required are as follows:

- Doubling the line: Rs 100 million per km
- Electrification of the system: Rs 25 million per km
- Automatic signalling: Rs 15 million per km
- Introduction of new stations and upgradation of existing stations: Rs 30 million per km
- Other expenditure (ticketing, passenger amenities, parking etc): Rs 30 million per km
- Total: Rs 200 million per km (Indian Railways, 2012 and discussions with various railway officers)

[5] Assumed based on data for international projects used in Flyvbjerg, Bruzelius, van Wee (2008), and share of rolling stock costs in different metro projects in India (Hyderabad Metro Rail, n. d.; p 29, 79 and 81 of the document; Indian Railways 2012, p 32)

Table 1: Assessment of cost of elevated metro rail corridors in different cities

City	Corridor length* (kms)	Cost (Rs billion)	Year of estimate	Cost per km (Rs million)	Remarks
Hyderabad	71	121	2008	1704	Year not stated in the source and hence based on news paper reports
Chennai	22	51	2007	2318	As per project report
Bangalore Phase 2	50	153	2011	3060	Year not stated in the source and hence based on news paper reports
12th Plan working group estimates			2012	1750	As report

*: Estimates of elevated corridors only considered.
Sources: Hyderabad Metro rail 2012; Chennai - Chennai Metro Rail Limited, n. d.; Bangalore - Bangalore Metro Rail Corporation Limited, n. d; 12th Plan: Planning Commission (2012)

Thus per kilometre cost of construction of an elevated metro is 10 times that of the surface rail. As the capacity created by surface rail system is twice that of the metro system, actual cost per unit throughput of a metro system is 20 times that of the surface rail.

Comparison of BRT with Surface Rail

Comparing BRT costs and capacity with surface rail becomes more complicated as capacities of BRT systems vary widely depending on the design. As per Breithaupt (2010) BRT throughputs are around 5,000 at the lower end, around 20,000 in the mid range and around 45,000 at the highest category. Assuming the mid range figure, BRT throughputs are around half of the metro rail and one fourth of surface rail. As per the 12th plan estimates a BRT costs around Rs 200 million per km (Planning Commission, 2012), one tenth of a metro or same as a surface rail system. Thus per unit throughput costs for a BRT would be around four times that of a surface rail.

Summary

Table 2 shows the capacity and cost of metro rail, surface rail and BRT per unit capacity created. Cost and capacity of metro rail is normalised to 100 and the value for surface rail and BRT are worked out in reference to these units. The last column shows that surface rail uses resources 20 times better than a metro rail and four times better than a BRT. BRT is five times better than metro.

Table 2: The cost, capacity and cost per unit capacity for metro rail, surface rail and BRT.

	Cost	Capacity	Cost per unit capacity created
Metro	100	100	100
Surface rail	10	200	5
BRT	10	50	20

Note: as the values are normalised with reference to metro rail no units are mentioned

Surface Rail: Complementarities with Metro Rail and BRT

Important strength of railway system is it does not take up additional space but optimally uses the existing right of way. When compared BRT takes up at least 10 meters right of way and metro at least 2 meters. Surface rail weakness lies in its inability to enter already developed areas leaving voids in the network. The voids should be filled by BRT or metro rail.

Another important strength of the surface rail systems is the ability to reach mofussil and outlying areas where urbanisation is occurring now. Metro by its cost and nature cannot reach such outlying areas and mofussil towns surrounding a city. Though BRT can ideally reach such areas the operational cost would be much higher.

Form the foregoing highest priority should be given for upgrading surface rail systems, followed by BRT systems. Metro should only be provided at places of missing links where traffic is volumes are high and BRT cannot handle such traffic.

URBAN GROWTH AND CHANGING FORMS

Urban population in India, as per the 2011 census, is 337 million; 31 per cent of the total population increasing from 27.8 per cent in 2001. As per the 2011 census, towns and cities with population more than 100,000 are 393 in number of these 53 urban agglomerations (UAs) have population more than 1 million (Registrar General of India, 2011). The urban population would continue to grow and is estimated to be 590 million by 2030 with 68 urban agglomerations estimated to have population more than 1 million (Mckinsey Global Institute, 2010).

In addition to rapid growth of population are the variations in the growth pattern. As Kundu (2011) has demonstrated the share of cities and towns with more than 100, 000 out of the total population has increased from around 26 % in 1901 to 68 % in 2001. Kundu attributes the higher demographic growth to increase in migration and areal expansion. Out of these cities the metro cities have grown at a faster rate compared to the rest.

Another important factor is the differential growth between the city core and peripheral areas. Sita and Bhagat (2007) have shown that in the two decade period from 1981-91 and 1991 to 2001 out of the 35 UAs in majority cases (47 out of 70 possible cases) UAs have grown faster than city proper. In 16 out of the 70 cases city proper grew faster than the UAs and in 7 cases growth rates same. This indicates that barring few cities the general tendency is for the people to cluster to peripheral areas compared to the city core.

Another limitation on the growth of the core urban areas is the higher population densities in Indian cities (varying around 200 persons per hectare) compared to the other global cities (with most North American and Australian cities reporting around 10-40 persons per hectare and European cities varying from 30-60 persons per hectare) (Barter, 1999 pp. 190-196).

Such a spread of Indian UAs is also actively encouraged by the official policy of Government of India. The 8th five plan (1992-97) strategy was to spatially distribute the population and it is observed that “Particular emphasis will be placed on the development of small and medium towns which serve as an important link between the village and the large cities … the small and

medium towns have to act as important centres of attraction, …to the potential migrants" (Planning Commission, n.d., point no 13.4.2 (c)).

This policy of spatial distribution of urban growth is continued and stated explicitly in the National Urban Housing and Habitat Policy enunciated by Ministry of Housing & Urban Poverty Alleviation, (2007). The policy talks of a symbiotic development of rural and urban areas by adopting "a Regional Planning approach" with an objective to develop rural-urban continuum (Ministry of Housing & Urban Poverty Alleviation, 2007, p. 5). The policy further talks of developing green field towns closer to the cities and connecting them with mass rapid transport corridors.

The corridor based growth is prominently noticed in large number of urban clusters. Sivaramakrishnan and Singh (2003) have quoted earlier study by Centre for Policy research. The study reviewed five states - Maharashtra, Gujarat, Tamil Nadu, Andhra Pradesh, and Karnataka; and reported presence of corridors of urban development. The authors further extended the results identified presence of such corridors in large parts of the country.

To conclude the Indian urbanisation has shown the following distinct trends:

- It is growing rapidly
- The growth is not uniform but concentrated in large towns and cities.
- Within the large UAs, in around 70 % of cases the peripheral areas are growing faster than the core areas
- Owing to high density of population in core areas Government policies are also encouraging spread of the cities
- Such a spread is noticed prominently along transport corridors

Implications of the above conclusions for development of public transport in Indian cities are immense. As urbanisation proceeds peripheral areas of a city will gain in equal prominence as garnered by core areas now. The towns in the suburbs will effectively merge into metropolitan areas. The transport plans cannot be limited to the city cores alone but focus equally on suburbs and towns and cities in the metropolitan regions. The public transport should be such that it should be able to cater to the core and periphery equally efficiently.

RAILWAY NETWORK AND URBAN AGGLOMERATIONS

Development of railway network in India in the early period followed the classical Rimmer (1977) model; where the railway network facilitated penetration of British Empire into the country. Further, native rulers added rail network in their dominions further strengthening the rail network. As consequence by the turn of independence most cities had an extensive rail network connecting the adjoining cities and towns. However, after the independence in the 60 year period from 1951 to 2011 network grew only by 20 per cent to 64,460 kilometres; an annual compound growth rate of 0.3 per cent. Compared to this the road network grew from 0.4 million kilometres in 1951 to 3.6 million kms in 2004 (RITES, 2009). Thus what was predominantly rail based network in early fifties became road and rail network based country.

It is in this context the viability of surface rail based urban transit systems demand a systematic investigation. India has 53 UAs with a population of 1 million or more but the list reduces to 50

as three UAs fall within the metropolitan jurisdiction of a bigger UA close by (Registrar General of India, 2011). The cities and their population ranges are given in Table 3. The break up indicates that 3 cities have more than 10 million population, 15 cities have population between 7 and 2 million, and 32 cities have population between 1 and 2 million.

Table 3: Urban Agglomerations and the population range

population range (in millions)	Number of UAs
> 10	3
> 7 up to 10	3
> 4 up to 6	3
> 2 up to 4	9
> 1 up to 2	32
Total	50

The rail net work in an UA is assessed by the number of directions in which railway lines serve the UA. Data gleaned from various sources (Primary data sources like the railway zonal and divisional maps, internet sources like Goole maps and Google earth, and secondary sources like railway atlas compiled by Samit, 2008) for each UA is Summarised in Table 4. It gives the population class wise number of directions the railway lines serve an UA.

Table 4: UAs with number of rail lines serving the UA

Number of directions	Population Range (in millions)					Grand Total
	> 10	> 7 up to 10	> 4 up to 6	> 2 up to 4	> 1 up to 2	
0	0	0	0	0	1	1
2	0	0	0	1	5	6
3	0	0	0	2	11	15
4	0	2	0	2	11	15
5	1	1	1	2	4	9
7	1	0	0	2	0	3
10	1	0	0	0	0	1
Grand Total	3	3	3	9	32	50

Only one UA is not serviced by the rail network and the rest of cities are serviced by rail network from 2 or more directions. 6 UAs have bi-directional railway network servicing them. 15 UAs are serviced by 3 and 4 routes of rail network. 9 UAs are serviced by 5 directions and 3 UAs are serviced by seven directions. Kolkatta is serviced by rail network from ten different directions. Thus all the UAs except one are well served by the surface rail network.

Another question of relevance is whether the city central core can be served by the railway network. The growth of Indian cities during the British period was similar to transit oriented typology presented by Newman and Hogan (1987) (quoted by Barter, 1999). As discussed by Barter (1999) a string of small towns and cities grew around the large city and they were connected by the rail system. Internal movement within the smaller towns was either on foot or by bicycle. However, as roads improved and availability of motor vehicles improved dependence on private transport increased and the predominance of rail reduced in many cities. However, due to the socio-economic characteristics of the Indian population and the growth pattern of UAs, Railways have remained relevant mode of transport around these cities.

This can be discerned from a quick perusal of the rail network and the central business district of the 50 UAs. Out of the 50 UAs, in only three UAs; namely Malappuram, Srinagar and Chandigarh, railway network does not serve the core area. It may be relevant to mention that Malappuram does not have railway station in the city, Chandigarh city was built after independence, and Srinagar got connected to the railway network in 2008 ("Srinagar railway station" 2012). Thus in all the older UAs railway network services the city core area.

Capability of Surface Rail in Existing Areas

The total length of surface rail systems which can be used for urban and suburban traffic depends on the size of the UA and its topography. While this assessment is to be done separately for each city current assessment is presented to give a macro picture of the potential. Extent of rail length in the 4 mega UAs of Bombay, Delhi, Kolkatta and Chennai, is the total of individual lengths of sections where suburban services are run. This is cross verified with various other sources (Railway time tables, Wikipedia entries for all the cities).

To estimate the rail length in the other 46 UAs the following method is adapted:

- Railway maps; both print and online (sources: Zonal and divisional railway maps; Samit , 2010; Google maps, Google earth, Wikimapia, IRFCA website); were analysed to assess number of directions railway lines run and the length of intra city railway network
- Depending on the population urban area core limits are defined for UAs; it is 50 km for large UAs with population between 4 and 10 million, 25 km for UAs with population between 2 and 4 million, and 15 km for UAs with population between 1 and 2 million. The suburban limits are assumed double that of core limits; 100 km for larger UAs and 50 km for smaller UAs.
- The core distance is multiplied with number of directions and then intra-city lines are added to get feasible urban network for the UAs. Similar procedure is followed to get the suburban distance.

From the assessment we find that it is feasible to open 6,610 kms of rail system for urban operations and 10,233 kms for suburban operations. As the 4 mega UAs have suburban operations and need separate plans the rest of the 46 UAs have 3910 kms of urban network and 7515 kms of suburban network. Details of the urban rail network and suburban rail network for all the 50 UAs is given in Table 5.

Table 5: Assessment of total distance of surface rail which can be used for suburban operations

			In kilometres				
Cities and population (In millions)	**Number of UAs 1**	**Number of directions (cumulative) 2**	**Urban radius 3**	**Total intra UA lines 4**	**Total urban network 5 (2*3+4)**	**peripheral radius 6**	**Total suburban network 7 (2*6+4)**
4 mega UAs	4			2718	2718		2718
> 10	3	Not applicable		2108	2108	Not applicable	2108
> 7 up to 10	1			611	611		611
Other UAs	46			305	3910		7515
> 7 up to 10	2	9	50	45	495	100	945
> 4 up to 6	3	11	50	30	580	100	1130
> 2 up to 4	9	40	25	70	1070	50	2070
> 1 up to 2	32	107	15	160	1765	30	3370
Grand Total	50	167		3023	6628		10233

Expansion to New Areas

For expansion to new areas of the city 12th plan Working Group recommends development of roads alone with funds provided by property developers (Planning Commission, 2012, p 5). This policy is definitely at variance with the spirit of NUTP and also in the spirit of the group's other recommendations. This needs to be corrected and mass transit systems should be planned in new expanding areas.

As roads provide the basis for BRT systems planning of surface rail based mass transit systems would be essential. Such a system should be funded from the property developers as is done for new roads. 50 per cent of the funds earmarked for road development should transferred to rail based transit systems to target 50 % of the passenger kilometres by the transit system. Such an expansion of network is essential for the development of transit systems.

The group also recommends 15 % of the land in new developing areas to be left for road development. Exclusive development of roads has been source of the present urban transport problem (Barter, 1999). If Indian cities have to learn from others it is necessary to develop public transit systems as the city expands, Hence land should be reserved for rail corridors in the master plans. If such initiatives are not taken then creation of rapid transit systems later would be highly complicated. Hence, it is necessary to reserve land for rail transit systems in the new areas. Land reserved should be around 3 % or one fifth of total land reserved for transport.

In addition to the above, more important is the role of rail network in developing the urban and suburban areas seamlessly. The BRT or metro rail systems would not be able to cater to the suburban areas as the former would be costly operationally and the later prohibitively costly to build. Hence, surface rail becomes sine qua non to develop urban and suburban areas in an integrated manner.

Strategies for Surface Rail Systems: Facilitating urban and interurban movement

Two major issues issue in opening surface rail systems for urban transport is the creation of adequate capacity. The capacity problem can be solved in three distinct phases:

- **Phase 1 - Upgradation of the existing urban network to its full capacity:** As seen in section on 'Capacity' earlier it is possible to upgrade system to run trains with 5 minute headway. Out of this 50 per cent capacity would equal the metro rail system capacity and the rest can be shared between interurban passenger trains and freight trains. The suburban areas also would be connected with suburban trains

- **Phase 2 – Development of internal ring system**: As the urban systems develop more capacity would be occupied by the urban systems hence it is worthwhile to create a new ring rail network to carry urban traffic and inter urban traffic. Total ring rail required for the 50 UAs would be 6000 kilometres (Authors' calculations). This however, can be developed in phases if the land is reserved. Probably in the 12th plan work should commence on half the ring i.e. on around 3,000 kms.

- **Phase 3 - Long term strategy:** The strategy is to develop a seamless integration of urban and suburban areas by extending frequent train services to the suburban areas. This would also require development of an outer ring system around UA and connect these peripheral areas without touching the core. They would also provide alternate path for movement freight trains on the system. This work can be taken up after the radial rails and inner ring are about to reach saturation level. However, the state governments should reserve the land as this becomes critical component for any future planning.

With this strategy it is possible to upgrade the urban surface rail system to meet the demands of urban trains, suburban trains, interurban passenger trains and freight trains for a considerable period of time.

IMPLICATIONS: POLICY AND INVESTMENT

It is established that surface rail is cost effective and can be modified to cater to urban and suburban traffic. Based on the above analyses, this section brings out the modifications to be made to public transport policy and its implications for investment.

Implications on Policy

From the above implications the first foremost implication for the public transport policy would to undertake development of surface rail to carry urban and suburban traffic. Develop

BRTs to connect to surface rail systems and areas not connected by surface rail. As the city areas expand plan for new surface rail corridors both as ring rails and radial rails

Most important implication to policy would be the review of metro rail development. As metro is cost intensive, it should be developed only when it becomes totally unavoidable. Some of the potential instances where metro rail becomes extremely inescapable would include i) volumes are very high and surface rail is not a viable option, ii) though volumes are not high space constraints preclude provision of BRTs and iii) short distance extensions of surface rail to major traffic generating centres. Wherever metro is developed, it should be integrated with surface rail systems - either physically with the network or with shared terminals.

As per 12th plan working group physical targets to be achieved during the plan are 1480, 747 and 989 kms of BRT, metro and regional rail system respectively. However, as per the proposed plan metro needs to be taken up only after the capacity of surface rail is exhausted. Based on this, assuming that surface rail costs one tenth of metro rail then 7470 kilometres of surface rail can be upgraded to cater to the urban and inter urban transport needs of UAs. This will be a great jump for most of the UAs.

In the current proposals metro rail is to be built only in ten UAs having population more than 3 million. As against this the surface rail can be planned for all the 50 UAs having population more than one million as they have total surface rail network of 6628 kms. This would facilitate development of UAs uniformly across the country instead focussing on select UAs.

Implications on Investment and Funding

Implications on investment in the new strategy would be reviewed based on 12th plan working group estimates. As per the 12th plan estimates the total investment on network creation and upgradation, given in Table 6, is Rs 3046 billion. From the foregoing discussion in the Section on Cost the metro costs are revised to Rs 2000 million per km excluding the rolling stock costs. The revised investment on network improvement work out to Rs 3233 billion for the plan period. The revised figures are shown in Table 6.

Table 6: 12th plan investment proposals for roads and public transport and reallocation proposed for surface rail

Infrastructure	Investment (in Rs billion)	Revised estimate (in Rs billion)	Reduced on reallocation in %	Reallocated investment (in Rs billion)
Street Network – new	859	859	50	429.5
Street Network – Upgradation	387	387	0	387
BRTS Network	296	296	0	296
Metro Network	1307	1494	100	0
Regional rail	197	197	100	0
Sub Total	3046	3233		1057.5
Sub urban rail	0	0	-	2120.5
Grand total	3046	3233		3233

The plan is to restructure the total investment optimally based on the discussions in the previous sections. Investment in BRTS network and street upgradation in existing areas is not reduced as surface rail does not supplant these works. Metro and regional network plans are scrapped completely as they will be supplanted by surface rail.

Street network in new areas is reduced by 50 per cent. As explained earlier in Section on "Expansion to New Areas", new areas should be served by creating sufficient surface rail capacity. The main commuting needs must be met by surface rail and the road network should cater to the remaining traffic. Hence half the amount dedicated for roads in new areas is assigned to surface rail.

By this reassignment a total investment of Rs 2120.5 billion will be available for surface rail fixed infrastructure, i.e. upgradation of network and addition of new lines. A break of the investment is given in Table 7. As seen earlier, upgradation of 3910 km of rail track in 46 UAs would work out to Rs 782 billion. In addition, each UA would need additional investment to improve the terminals and provide rail flyovers for ease of multidirectional movement. For this a lump sum amount of Rs 5 billion is allotted per UA working out to Rs 230 billion. Further, to improve the access to the stations and connectivity to adjacent colonies an amount of Rs 1 billion is allocated for each UA. As medium term strategy an initiative to girdle all the 46 UAs, semi circle of inner ring rail with a total length of 3000 km is planned at an estimated cost of Rs 600 billion. This would facilitate movement of intercity trains without interfering with urban traffic.

The left over amount of Rs 462.5 billion is assigned to the 4 metro cities for the upgradation of the network. However, detailing the investment needs of the 4 UAs is beyond the scope of the present work.

Table 7: Break up of proposed surface rail investments

	Units	cost per unit (Rs billion)	quantity	Total cost (Rs billion)
For 46 UAs				
Upgradation of rail network	Km	0.2	3910	782
Terminal improvements and flyovers	per UA	5	46	230
Facilities to improve station access	per UA	1	46	46
Inner ring rails	Km	0.2	3000	600
4 mega UAs	Lump sum		4	462.5
Total				2120.5

12th Plan working group has assessed the funding pattern with funds flowing from centre, state, local bodies, loans from domestic and foreign agencies, private sector, and from property development. It has also proposed fresh levies to reduce private vehicle usage and also to generate additional revenue[6]. As the proposal is on deployment of funds, funding pattern will remain unaltered.

[6] Additional levies recommended are:

- A Green Surcharge of Rs. 2 on petrol sold across the country

POLICY MEASURES TO INTEGRATE SURFACE RAIL IN TRANSIT PLANS OF URBAN AGGLOMERATIONS

> "the most serious impediments to suburban railways (to be operated for urban transport – Authors' remarks) are frequently institutional" (World Bank, 2002, p 115).

In India, urban transport was under the policy domain of Ministry of Railways (MoR) till 1986. To facilitate integrated development of urban transport the subject was transferred to Ministry of Urban Development (MoUD). Further, as MoR has to make projects with 14 % return on investment and as urban transport projects were not giving the same return, MoR was generally wary of taking up urban transport projects.

Though all projects in an UA would cater its needs of UAs different ministries have approached in different ways. Broadly speaking MoR does everything under its umbrella while MoUD plays the role of a facilitator and partial fund giver with local governments playing a prominent role. The difference can be classified in two stages; the project sanction and execution stage, and the project operation and maintenance stage. Some of the divergences are highlighted in Table 8. From the Table urban projects get better financial terms which are not extended if the projects are executed by MoR.

If MoR has to participate in urban projects it is necessary for both ministries to come to a common understanding to facilitate a joint work.

Table 8: Differences in approaches to urban transport and surface rail projects

Issue	Urban transport projects	Surface rail projects
Project Sanction and Execution		
Policy	Central Level: Ministry of Urban Development (MoUD) and Planning Commission State and local level: State Government and Local self government	Ministry of Railways (MoR) and Planning Commission
Funding	Grants, subordinates debt and concessional loans	Internal accruals and budget payments. Dividend is paid on budgetary payment. However, in some projects state governments share project costs.

- A Green Cess on existing personalised vehicles at the rate of 3 percent of the annual insured value both for car and two wheelers.
- Urban Transport Tax on purchase of new cars and two wheelers: at 7.5% of the total cost of the petrol vehicles and 20% for personal diesel cars.

The total annual yield from the three sources is estimated to be Rs 422 billion in the first year and Rs 1935 billion in four years of 12th Five Year Plan period (Planning Commissions, 2012, P 42).

Issue	Urban transport projects	Surface rail projects
Financial viability	FIRR Not fixed. FIRR's are very low[7].	Minimum FIRR is 14 % unless a project is declared socially desirable. Urban transport projects are not included in this category.
Tax concessions construction cost	Waival of duties and taxes by state government[8].	No such concessions
Project management skills	DMRC was an excellent example of project management. Most officers were on deputation from Indian Railways. May not be valid for all the projects.	Though MoR had a number of showcase examples in the past current reputation is bad. Potential is high if good environment is provided and it is proved in Delhi Metro.
Operation and maintenance		
Operational Responsibility	Local Government and State government MoUD oversees as it funds many of the projects	State has no role MoR completely responsible
Other sources of revenue	Yes. Includes property development and allocation of additional land[9].	No
Operational and Maintenance concessions	Yes[10]. Power supplied at concession price.	No. Power charged higher than commercial rate
Freedom in pricing	Yes.	Heavily regulated

Suggested policy modifications

MoR, MoUD and Planning Commission should first recognise the role of surface rail and its advantages to the nation in general and to urban systems specifically. Based on this MOUD, MoR and Planning Commission should come to a common understanding which should include the terms under which the ministries work jointly and specify roles of different participants in the process. The suggested roles should be:

[7] Chennai Metro has FIRR of 1.4 % with taxes and 0.86 % without taxes (Chennai Metro Rail Limited, n. d, p XIX) For Bangalore metro Phase 2 the FIRR is between 4 and 6 % (Bangalore Metro rail Corporation Limited, n. d., p. 9).

[8] For example in Chennai and Hyderabad Metro projects taxes accounted for 13 % of capital costs (Chennai Metro Rail Limited, n. d, p XIX, Hyderabad Metro rail, n. d, para 5.1.4 of corridor 3). DMRC is "exempted" from the following taxes: Property Tax, Sales Tax, Works' contract Tax, Income Tax, Capital Gains Tax, Customs and Excise (Tiwari, 2011, p 14).

[9] Hyderabad metro rail project includes property development rights for 18.5 million sq. ft. on 269 acres of land (Hyderabad Metro rail, 2012). For Delhi Metro Rail Corporation revenue from property development was 46%, 24%, 34%, and 4% for the financial years ending March of 2007, 2008, 2009 and 2010 (see pg 14, Tiwari, 2011)

[10] Compared to tariff charged to Indian Railways, Delhi Metro is charged 50 % and 39 % less for Demand and energy charges respectively (Indian Railways, n.d). Bangalore is charged Rs 4.4 per unit on the principle of no profit no loss (Abraham, 2011).

- MoR, MoUD, state governments and the local self government should prepare Detailed Project reports for each city on how surface rail can be opened for suburban traffic.
- MoUD and State Governments should extend the finances on similar terms and conditions given to metro rail projects
- MoR should commit itself to number of trains to be run and the vehicle kilometres and they should not be less than those possible under a metro rail project
- As taking up work under traffic will be extremely difficult, initial execution of brown field projects should be taken up by MoR. Based on the experience it can be reviewed to improve the working.
- Green field projects can be taken under a set up agreeable to all the parties.
- Train operation will remain with MoR but MoR will commit to number and nature services at the project formulation stage itself.
- Commercial functions including pricing can be off loaded to an organisation as the pricing and integration with other modes is vital for planning urban traffic. Railways can be paid the operational cost on per kilometres basis.

With sets base realising surface rail potential fully making it vital not only for urban transport but also for inter city transport.

CONCLUSIONS

Development of public transport has received a prominent place in NUTP enunciated by Government of India. In pursuance of this policy governments at all levels are actively promoting BRT and Metro rail as viable options for public transport. This is also being advocated by various advocacy groups and commercial interests. In the process, surface rail, operated by Indian railways, historically closely intertwined with development of many cities and carries substantial urban commuters, is totally sidelined.

The article established that unit cost of capacity created by surface rail is one twentieth of metro rail system and one fourth of a BRT system. Further, as it is upgradation of existing system additional space required would be minimal. However, as surface rail does not reach already built up areas, BRT systems or metro rail would be required to complement the surface rail system.

A review of the 50 urban agglomerations (UAs) having population more than 1 million has indicated that surface rail can be useful in 49 UAs to carry urban and suburban traffic. The UAs have 6628 kilometres of rail network which can be upgraded to carry urban traffic in addition to the interurban traffic. Compared to this with same investment current proposal is to create a metro network of 747 kms in 10 UAs and a regional rail network of 989 kms limited to 9 UAs. As evidenced by the substantial advantage the paper suggests that in 12th five year plan the proposed investment on metro rail, regional rail and 50 % of investment on new roads should be diverted for upgradation of surface rail.

The above investment, after revising for metro rail costs, works out to Rs 2120.5 billion and would be available for upgradation of surface rail and associated infrastructure. With this investment it would be possible to upgrade 6628 kms of suburban rail network, create new

suburban network of 3000 km around some of the important UAs and also upgrade terminals in the UAs.

Despite the seeming advantages, the most important bottleneck in achieving this is identified to be the institutional arrangement. To facilitate a new institutional framework paper recommends setting up of joint review committee of the three apex policy making bodies of Ministry of Urban Development, Ministry of railways, and Planning Commission. This would facilitate placing a new regime where the central ministries and state governments can work together to develop a more citizen friendly urban transport system.

What is presented is macro picture at the national level which provide the basis for an appropriate policy. However, for any work to be initiated at ground level lot of preparatory work would be necessary. Hence immediate action should be initiated to take up work at UAs level. This should be done by the urban local bodies and local railway set ups under the guidance of the policy formulating agencies.

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