Alternative Approaches to Economically Sustainable Mobility in India: Comparing Ahmedabad Bus Rapid Transit and Delhi Metro Systems

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Case study prepared for

Global Report on Human Settlements 2013

Available from http://www.unhabitat.org/grhs/2013

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Nairobi, 2011

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Introduction

In a world of rising urban traffic congestion, increasing air and noise pollution and worsening road safety, there is broad consensus on the value of mass transit as a sustainable solution to urban mobility (Jain, 2010; Sakamoto et al, 2010). In recent years, the global mass transit debate has been cast as a choice between two investment options – light rail/metro networks versus bus rapid transit (BRT) systems (Baltes, 2002; Currie, 2006). This case study aims to inform this debate by examining these two alternative approaches, controlling for country context by considering exemplary initiatives in India – specifically, the Delhi Metro in the nations capital, and the Janmarg Bus Rapid Transit system in Ahmedabad.

India offers a unique opportunity for exploring the application of metro and BRT systems in a developing country context. Both the Delhi Metro and Janmarg BRT are recently implemented initiatives that have received international acclaim,[1] and demonstrate a new standard of public transportation for the country that is viable, sustainable and affordable (IANS, 2010; Rediff, 2010). The schemes are also interesting for the support that they have received from the national Government, particularly since 2006 with the issuance of India's National Urban Transport Policy (NUTP) (Tiwari and Jain, 2010). This case study will investigate the evolution, implementation and operation of the two schemes. The aim is not to argue the relative merits of metro vs. BRT approaches, but rather to draw on the experiences in Delhi and Ahmedabad to develop insights on viable policy principles for enhancing the positive economic impacts of urban transport (in terms of minimizing social cost and maximizing social benefits). It will also identify strengths and weaknesses of the two approaches and highlight successful practices for sustainable financing of urban transport (including what works, what doesn't, and ideas for successful innovation).

Background

India faces serious challenges in its predominantly road-based urban transportation sector (Pucher et al, 2004). Over the last decade it is estimated that the rate of growth of the motor vehicle fleet in India has been 10 per cent per year. In 2002, 58.8 million vehicles plied India's roads, rising from an estimated 5.4 million in 1981 (Pucher et al, 2007; Singh, 2005). The majority of this growth has been concentrated in urban areas. Delhi and Ahmedabad each recorded 3.5 million and 0.8 million registered motor vehicles respectively in 2000, up from 2.5 million and 0.5 million a mere 5 years earlier (Singh, 2005). This situation has aggravated already severe traffic congestion, led to worsening urban air and noise quality, abysmal traffic safety records (Singh, 2005), and contributed to increasing energy use and declining mobility and productivity in urban centres (Badami and Haider, 2007; Singh, 2005; Jain et al, forthcoming).

Reliable, accessible, convenient and affordable public transit systems are critical to the urban mobility of India's growing population. In India, public transport plays an especially vital role

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1. Janmarg BRT is the recipient of the prestigious ITDP 2010 'Sustainable Transport Award' and the 2009 'Best Mass Rapid Transit System' awarded by the Government of India. In 2010 the Delhi Metro received both the 'Most Improved Metro' award from London-based Terrapin, and the 'Outstanding Civil Engineering Project Award' from the Asian Civil Engineering Coordination Council (ACECC).

Table 1. Growth of vehicles, population and road traffic fatalities in India

Year	Vehicles (millions)	Population (million)	Fatalities (1000s)	Fatalities per million population
1981	5.39	683	28.4	41.56
1985	9.17	772	39.2	50.76
1991	21.37	843	56.6	67.07
1992	23.51	862	59.7	69.28
1993	25.51	880	60.6	68.92
1994	27.66	897	64.0	71.33
1995	30.30	916	70.7	77.22
1996	33.56	934	71.9	76.96
1997	37.23	949	75.0	79.01
1998	41.37	966	80.0	82.85
1999	44.86	1001	82.0	82.0
2000	48.86	1016	78.9	77.65
2001	54.99	1027	80.0	77.89

Source: Modified from Jain et al, forthcoming, based on Ministry of Road Transport and Highways Statistics, 2003.

not only in mitigating environmental and social impacts of personal motor vehicle use; but as the only affordable transit option for low-income commuters who form a large majority of the urban population (Badami and Haider, 2007).

Unfortunately, whilst public transport services operate in all major Indian cities they are of poor quality and are completely overwhelmed by demand. Buses have historically dominated public transit (carrying over 90 per cent of public transit users in most cities in 2002) however these municipally-operated services are poorly managed, and suffer from endemic corruption that have contributed to rapidly rising operating deficits (Pucher et al, 2004). Buses themselves are dilapidated, chronically overcrowded, and provide an unreliable, slow, unsafe and uncomfortable service that lacks coordination (Pucher et al, 2004; Singh, 2005; Badami and Haider, 2007). Though fares remain low due to political pressure, routing fails to adequately serve those poor that can afford it (Pucher et al, 2004). Rail based public transit provides only limited coverage, serving at most 30 per cent of public transport passengers in the four cities that have service (Hossain, 2006). Large service gaps left by bus and rail systems are filled by a combination of largely unregulated minivans, taxis, and auto and cycle rickshaws (Pucher et al, 2004). Over time this has led to a fragmented and inefficient system with uneven coverage and little to no coordination between services, operators and governing agencies (Singh, 2005).

In response to the worsening situation the Government of India has taken a lead role in promoting sustainable urban transport development in recent decades. Cognizant of the considerable economic, environmental and social benefits of this approach they have promoted investment by cash-poor municipal governments using strong financial incentives (Tiwari and Jain, 2010). The first phase of the Delhi Metro can be considered an early example of these initiatives. This policy approach was subsequently formalized in the 2006 National Urban Transport Policy (NUTP) that explicitly shifted the focus from congestion relief through road and highway expansion to the promotion of non-motorized transport and improvement of public transport systems (Pucher et al, 2007). Importantly, this policy was funded under the seven year (2005–2011) Jawaharlal Nehru National Urban Renewal Mission (JnNURM) that provided centrally financed grants to urban transport projects in designated cities that complied with NUTP guidelines (GOI, 2005; Pai and Hidalgo, 2009). The Janmarg BRT in Ahmedabad and the Delhi Metro (Phase II) were amongst the first few projects to receive funding under this programme. The remainder of this case will discuss these two examples with the aim of drawing out implications for the policy and practice of economically sustainable urban transport development.

Janmarg Bus Rapid Transit (BRT)

Launched in October 2009 and funded under the JuNURM programme, the 'Janmarg' BRT in Ahmedabad City aptly translates to mean 'People's Way'. This successful and widely acclaimed scheme represents India's first experience with full bus rapid transit service, incorporating median stations, dedicated lanes and curbside ticketing (ITDP, 2009).[2] Little more than a year into operation the service comprises an impressive city-wide network of over 40 kilometres with a daily ridership of 100,000 persons a day in the city (DNA, 2010a). Janmarg has received international and national awards, including amongst others, the Government of India's 2009 'Best Mass Rapid Transit System' award and the ITDP Sustainable Transport Award for 2010 (DNA, 2009; DNA, 2010b). The development and implementation of Janmarg BRT offer some valuable insights into the potential and practice of sustainable urban transport in developing countries.

Overview

Ahmedabad is the commercial and educational centre of the State of Gujarat in India. It is a compact but growing city with a mixed pattern of land use across its 466 square kilometres area. Urban transportation relies on road infrastructure, which includes 5 ring roads, and 17 well developed radials (Swamy, 2010). Though its current population is estimated to be 5.6 M, both the population and city area are expected to more than double in the next two decades due to urbanization and the gradual agglomeration of the city with surrounding urban centres (Wikipedia, 2011).

The city has a long tradition of public transport operations with buses dominating service. These have been publicly operated by the Ahmedabad Municipal Transport System (AMTS) since 1945 (Swamy, 2010). Yet despite many decades of experience, bus service in the city is poor, and ridership on the public transport remains low at 15 per cent of passenger trips (Pai and Hidalgo 2009). Dissatisfied with public transport, Ahmedabad commuters have increasingly relied on private vehicles – two-wheelers now represent 73 per cent of vehicle share on city streets to which an additional 430 vehicles are added each day (Swamy, 2010). This has led to increasing traffic congestion, pollution and dangerous road conditions (ADB 2010).

Design/Implementation

In response to Ahmedabad's growing transportation woes, municipal and state governments developed an Integrated Public Transit Plan for the city that included a proposal for a citywide bus-based public transport system with high-end BRT features. In 2005 the development of

2. Other systems have been implemented in Pune, Delhi and other cities (ADB, 2010). However Janmarg leads the nation in being the first operational closed BRT system in India (Tiwari and Jain, 2010).

the project concept was awarded to a prominent local university – the Centre of Environment Planning and Technology (CEPT). Little more than a year later, in May of 2006, the Janmarg BRT system received its first round of funding under JnNURM. The alignment of local, state and national commitment facilitated implementation of the scheme, enabling operations to commence on parts of the BRT system by 2009, only 3 years later (Pai and Hidalgo, 2009; Pai and Lokre, 2010).

The initial BRT master plan included 88km of closed BRT system corridors, identified based on socioeconomic needs, rights-of-way, mobility and traffic demand, existing routes, land use and future development plans (Kadri, 2010; Swamy, 2010; Tiwari and Jain, 2010). The aim was to create a multi-modal system that served both dense and dispersed areas and catered for bicyclists and pedestrians (Kadri, 2010). Modeled on the successful 'Curitiba BRT model' developed in Brazil, the Janmarg is the first closed system in India (Pai and Hidalgo, 2009). Bus lanes are separated from the main carriageway by railings (except at intersections/ roundabouts), with bus stops spaced at an average distance of 800 meters on central island platforms that service both directions (Tiwari and Jain, 2010). Platforms are built up approximately 0.9 meter from the road surface to facilitate quick, safe and level boarding. Inside buses are also mostly level. This assists passenger mobility, particularly for the physically impaired as well as sari-clad women (ADB, 2010; Kadri, 2010) To maintain flow and minimize delays bus stops are located at the far-side of intersections and include overtaking lanes (ADB, 2010).

To support financial sustainability and mobility goals, key upgrades were made to the design and technology of bus services. These innovations aimed to reduce operating costs and enhance ridership by improving the efficiency of operations and comfort and safety of passengers (Pai and Hidalgo, 2009). In response to emerging BRT demand in Indian cities, buses were redesigned by domestic manufacturers to include low floors, wide entries and improved seating with dual sided access (ADB, 2010; Tiwari and Jain, 2010). All buses were also equipped with global positioning systems (GPS) that send data to a central Intelligent Transport System (ITS) so that vehicles can be tracked and monitored. This information is then fed back to digital displays at stations to alert passengers of wait time for buses (ADB, 2010). To enhance off board fare collection and promote mode integration the Ahmedabad Janmarg Limited (AJL) is developing a smart card system for commuters that will be valid across Janmarg, State Transport and AMTS services. In the interim however fare collection occurs mostly at station ticket counters prior to boarding (Wikipedia, 2011).

Integration of the BRT corridor system with other modes of transit was a particularly important consideration in planning and design. Closed systems in particular are heavily reliant on a strong feeder service, particularly for areas where ridership is lower and trunk services are not financially viable (Tiwari and Jain, 2010). The existing municipal bus service (AMTS) is thus being upgraded and reorganized to serve as a feeder to the Janmarg BRT and technologies for fare collection and vehicle tracking are being introduced and streamlined with BRT operations (Pai and Hidalgo, 2009). Sidewalks for pedestrians (and bicycle lanes in some segments) are also constructed along bus corridors (ADB, 2010). Zebra crossings and pedestrian activated traffic signals have been provided at junctions and platforms to enable safe access, with grade separated facilities at high demand locations (Tiwari and Jain, 2010). Finally, free parking facilities for auto-rickshaws and other informal service providers have been integrated with bus stops and junctions to aid transfers, and paid on-street parking is available for other motorized vehicles (Tiwari and Jain, 2010).

Another impressive feature of the Janmarg BRT is how rapidly it was implemented, and its strategic use of phased construction. CEPT carefully planned an incremental process with the aim of garnering public support and maximizing ridership. Construction commenced with a 12km demonstration corridor (Phase IA), followed by the remainder of the first 58km of Phase I. The outstanding 30km of the network will be completed under Phase II (Pai and Hidalgo, 2009).

The 12km demonstration corridor was especially instrumental in building public support for the new scheme. Firstly, to overcome critics concerns about congestion, this initial corridor was strategically placed on a lower congestion route with moderate bus volumes (ITDP 2009). This also allowed the system design to be tested and modified before moving onto more difficult routes. Additionally, trial rides on the demonstration corridor were offered to passengers free of charge in the 3 months leading up to formal launch, helping to familiarize commuters and increase consumer acceptance of the system (Pai and Hidalgo, 2009; ADB, 2010). Finally, concessions were made in operation during the initial phase. Despite its design as a closed system, buses were allowed to travel in mixed traffic outside the dedicated 12km stretch, to maintain connectivity for passengers in the initial phase (Pai and Hidalgo, 2009).

These initiatives ultimately proved successful. When commercial operations for Phase IA commenced on 14 October 2009, ridership immediately reached 12,000–19,000 passengers per day (ITDP, 2009). This was significantly higher than the municipal buses that previously travelled on the corridor. It is also notable that many of these riders were ‘new’ public transport users. Passenger surveys undertaken by the Times of India found that over one third of Janmarg riders previously used private motor vehicles or three wheeled rickshaws (ITDP, 2009) – however impacts on congestion have yet to be measured. Building on these initial successes, the second half of the first phase was inaugurated on 25 December 2009 – stretching phase I to Kankaria Lake and connecting the eastern part of the city to the network. A year later, the system now extends 40kms from RTO Circle to Jashodanagar (DNA 2010a), with the full 88km projected to be completed by March 2012 (Umarji, 2010). Today the BRT system has an estimated ridership of over 100,000 passengers daily (DNA, 2010a; Kaushik, 2010). Building on this success, a further network of roads covering about 155km has been identified for BRT system expansion (AMC, 2011; Wikipedia, 2011).

Institutional and Financing Arrangements

From its inception, the Janmarg BRT was a locally driven initiative – originated and designed in Ahmedabad and highly responsive to local conditions. The Ahmedabad Municipal Corporation (AMC) developed the initial proposal for the BRT.[3] This local government body remains the chief executing authority of the system (Tiwari and Jain, 2010). Concept design and implementation was led by CEPT University in Ahmedabad. Use of local expertise in lieu of international consultants not only ensured responsiveness to local conditions and technology transfer, but was also effective in keeping costs low (Pai and Hidalgo, 2009). This strong local ownership was matched at state and national levels with support provided through a steering committee under the State Urban Development and Urban Housing Ministry; and financial and other incentives at the national level through the JnNURM programme. This strong political commitment across levels was instrumental to success (Thite, 2010; Tiwari and Jain, 2010).

Institutional responsibilities for BRT system operation were also clearly defined. The Ahmedabad Janmarg Limited (AJL) was constituted as a special purpose vehicle by state and local authorities, to serve as a dedicated and independent agency with operating authority (Tiwari and Jain, 2010). ‘Ring-fencing’ of operations in this manner can facilitate monitoring

3. The AMC is the local municipal government body for the city of Ahmedabad.

and oversight and thus financial sustainability. Other functions have been strategically outsourced to maximize efficiencies. Bus operation and fare collection tasks have been competitively bid on a gross-cost per km seven year contract arrangement with in-built incentives and penalties for fleet maintenance, vehicle breakdown and cleanliness (TOI, 2007; ADB, 2010).

Financing of the BRT scheme was multi-tiered coming from different sources under varying terms. This has given AJL the flexibility to match financial obligations with revenue flows. The total cost of the first 12km phase of the Janmarg BRT system was approximately Rs960 million (or US$21 million), which equates to US$1.75 million per kilometre[4] (Chandran, 2010). AMC obtained grants for 35 per cent of total project costs under the Government of India's JnNURM programme. Under JnNURM guidelines for metropolitan cities such as Ahmedabad (according to population, size and GDP thresholds), the State Government of Gujarat provided an additional 15 per cent and the remaining funds 50 per cent funds were met by the Municipal Corporation (AMC) (Pai and Hidalgo, 2009). No bilateral funding was involved.

AJL revenues predominantly comprise passenger fares. Fares are higher than AMTS services, but still remain affordable at an average ticket price of Rs1 per km (or US$0.02 per km) (Umarji, 2010) for an average trip length of 5.4km (Pai and Hidalgo, 2009). In October 2010, average collection per bus per day was Rs10,000 which is three times higher than equivalent AMTS buses (Ahluwalia, 2010). At present ridership levels of 100,000 persons per day (January 2011), income generated from fares is approximately Rs600,000 per day (US$13,000 per day in current dollars) (Kaushik, 2010). Other AJL revenue sources are limited in scale but include fines (service lapses of out-sourced bus operators continue to be rigorously enforced), as well as advertising and parking charges (Ahluwalia, 2010; Rana, 2011). Combined, these sources of income are sufficient to ensure the AJL is able to cover current operating costs (Ahluwalia, 2010). Discussions continue on the possibility of generating additional revenue from land development and carbon credits (Vijayapalan, 2008; Rana, 2009).

Operations

Bus operation and efficiency benchmarks for the Janmarg BRT are favourable relative to other systems in India. Janmarg BRT boasts the highest peak average speed (24–25km/hr) of all 9 existing BRT systems in India with a 2.5 minute frequency, supplying 30 buses per hour per direction across the network (Tiwari and Jain, 2010). Customers express high levels of satisfaction with the system. The BRT is a popular way to commute for work, education and leisure and attracts both male and female passengers.[5] Consumer satisfaction surveys suggest that passengers find the BRT service reliable, comfortable and affordable (Swamy, 2010).

Delhi Metro

The Delhi Metro has been under operation since 2002 and offers another interesting example of a sustainable urban development initiative in India. Like Janmarg, the Delhi Metro was planned as an integral component of a larger multi-modal transport system for the city; its design and implementation engendered widespread political support and utilized innovative technology; and the scheme benefited from clear governance and multi-tiered financing

4. Figures given in 2009 Rs/US$.

5. Swamy (2010) documents a Times of India survey that shows gender composition of passengers as 42 per cent female and 58 per cent male.

arrangements. However, the scale of financing and implementation of the proposed 400 plus kilometre metro is markedly different from the Janmarg experience and is worthy of closer investigation. Implemented by the Government financed Delhi Metro Rail Corporation to serve 1.5 million passengers per day (Mohan, 2008) it is being promoted as a viable mass transit model for other large South Asian cities (Advani and Tiwari, 2005; Pandley, 2007; Yee, 2008).

Overview

Delhi is the capital of India, located in the National Capital Territory. It is a key political, cultural and commercial centre and is one of the fastest growing cities on earth (Murty et al, 2006). If this growth continues unchecked, the current estimated population of 13 million people is expected to increase to 23 million by 2021 (DDA, 2003). To accommodate this growth, the city has expanded beyond its traditional core in a dispersed poly-nucleated manner. In the absence of rail options, this pattern of growth has perpetuated the cities heavy reliance on road-based forms of transportation (Murty et al, 2006).

Publicly and privately run bus services have historically been the only mass mobility option for Delhi's citizens. And yet, bus service in Delhi is universally poor, with a litany of familiar maladies. Buses are overcrowded, unreliable, inconvenient, dangerous and uncomfortable and public services sustain losses that are a financial drain on municipal budgets. Increasingly passengers have turned to private motor vehicles as their transportation mode of choice. The combined influence of growing population and rising motor vehicle ownership has led to an increasingly chaotic traffic situation on Delhi's streets. This issue has failed to be abated by massive investment and expansion of the road network.[6] Growing congestion, pollution and alarming increases in traffic accidents have plagued the nations capital in recent decades and led to a search for mass transit alternatives (Pucher et al, 2004; Advani and Tiwari, 2005; Singh, 2005; Murty et al, 2006).

Design/Implementation

The need for a city metro has been debated in Delhi for decades. First proposed over 40 years ago in a 1969 traffic and travel characteristics study, the metro concept has since been the subject of countless studies (Siemiatycki, 2006). However, serious planning for a metro system did not commence until 1989, when it was reviewed as part of a feasibility study for an Integrated Multi Mode Mass Rapid Transit System (MRTS) for Delhi. Commissioned by the Government of the National Capital Territory of Delhi (GNCTD) the study was eventually completed in 1995 by Rail India Technical and Economic Services (Murty et al, 2006). The Delhi Metro was just one part of this integrated transportation plan that '*comprised a metro (6 corridors); a grade High Capacity Bus System (HCBS) (26 corridors), elevated LRT* [light rail transit] *(6 corridors), elevated monorail (3 corridors), and an integrated rail cum-bus transit (IRBT) (2 corridors)*' (Bhandari et al, 2009, p190).

From the outset, the Delhi Metro portion of the MRTS was an ambitious scheme, comprising four phases of underground, elevated and surface corridors with a total route length of approximately 415km to be constructed under, over and across a dense and congested city (Bhandari et al, 2009; Jain, 2010). After over 30 years of planning, ground was broken on Delhi Metro Phase I in 1998 (RT, 2011). It comprised 3 corridors of 8 sections with a

6. Total length of road network increased from 652km in 1981 to 1122km in 2001 – and is expected to grow to 1340km by 2021 (Murty et al, 2006). It is estimated that roads occupy 21 per cent of total city area of Delhi (Advani and Tiwari, 2005).

combined length of 65.1km (Murty et al, 2006). Efficient management, and carefully crafted performance contracts resulted in impressive construction results. Not only was Phase I completed 2.5 years ahead of schedule, but it was delivered under budget at an estimated final cost of US$2.3 billion (Hossain, 2006; Yee, 2008). In operation, the system was equally awe-inspiring. Trains were clean, timely and affordable and registered operating profits almost immediately (Pandley, 2007) – making it a rare operational and financial success. A review of the scheme by the Indian Institute of Management in Lucknow concluded that the Delhi Metro is one of only four metros in the world to have operating profits[7] (Pandley, 2007).

In 2006 construction commenced on Phase II (121km) of the metro with an expected completion date of 2010 (Murty et al, 2006; Jain 2010). Though largely operational, opening is currently delayed on some sections (DMRC 2011). Phase III (120km) is also presently under construction and will be followed by Phase IV (108.8km), serving the remaining parts of Delhi and extending services to Noida and Gurgaon in neighbouring states (Murty et al, 2006; Bhandari et al, 2009; Jain, 2010). The current operational network comprises six lines, encompassing 156kms of track and 132 stations (DMRC, 2011).

As with the Janmarg BRT, technology and modernization played an integral role in the development and efficient operation of the metro and its widespread acceptance by the public. This has aided financially sustainability by lowering operating costs and promoting ridership. The system incorporates advanced communication and train control systems that enable close monitoring of operations, ensuring reliability of service and safety of passengers. Coaches are equipped with state-of-the-art air conditioning systems; stations boast escalators for passenger comfort, and an automatic fare collection system facilitates rapid entry and exit from metro stations through flap doors operated by smart cards and contact-less tokens (DMRC, 2011). '*Inside the metro stations, aesthetics that include open concept layout, technologically advanced no-touch turnstiles, security cameras and well-appointed station trimmings project an image of progress, order, cleanliness and security. The silver trains with their sleek industrial design, automatic doors, digital signs and climate control are a tangible embodiment of the future*' (Siemiatycki, 2006, p285).

System integration and phased implementation were also important features of the Delhi Metro project. Like Janmarg, the Delhi Metro was designed as part of an integrated multi-modal transit system with streamlined passenger transfers. Initiatives such as an automatic fare collection system/smart card technology and the development of a feeder bus network have all helped to forge these linkages (DMRC, 2011; RT, 2011). Construction was strategically phased to manage costs, minimize disruption, whilst maintaining an operable network that would satisfy the public and promote ridership. The Delhi Metro project was also notable for its targeted and persuasive advertising campaign with tightly controlled image management. These efforts are credited with generating widespread public and passenger support for the scheme that has helped finances by improving ridership (Siemiatycki, 2006).

Institutional and Financing Arrangements

The Delhi Metro Rail Corporation (DMRC) has led the implementation and operation of the Metro Project. The Government of India and Government of the National Capital of Delhi established this special purpose vehicle in 1995 with equal equity participation. Though government backed, its singular purpose, independence and strong leadership has ensured that it has remained relatively protected from political interference and bureaucratic constraints (Yee, 2008, p10). The system was locally designed and is based on the city's integrated

7. According to the IIM report, other profitable metros are found in Singapore, Taipei and Hong Kong.

transportation plan (Siemiatycki, 2006; DMRC, 2011). For the most part engineering and construction functions were competitively outsourced. Initially, international firms with expertise in metro rail systems were sought out and contracted to support general planning, station design, construction management and rolling stock production. To promote technology exchange, they were required to partner with local Indian firms. The aim was to develop local expertise for later construction phases of the Delhi Metro as well as to develop and disseminate knowledge nationally to be applied to other proposed metro systems in India (Siemiatycki, 2006). An important attribute of these contracting arrangements was strong performance incentives. DMRC promoted a sense of efficiency and urgency throughout the implementation process. '*As a constant reminder, clocks counting down the seconds until the project was set to be inaugurated were given to each employee and displayed at many works sites* '(Siemiatycki, 2006). This strategy contributed to early and under-budget completion of the first phase of construction (HT, 2010; DMRC, 2011).

Financing for Phase I and II of the Delhi Metro is multi-tiered, originating from a combination of international, national, state and local sources. It is estimated that the cost of metro development of the first 118km was Rs144.32 billion at 1994 prices (Murty et al, 2006). This translates to approximately US$8.4 billion or 71.1 million US$ per kilometre of corridor, at 2009 prices.[8] Thirty per cent of these project costs was financed through equal equity contributions provided by the Government of India (National), and the Government of the National Capital Territory of Delhi (State). Both levels of Government agreed to finance an additional 5 per cent of project costs through an interest-free subordinate loan to cover the cost of land acquisition. However the vast majority of financing – 60 per cent of funds – was in the form of long-term loans from the state-sponsored Japanese Bank of International Cooperation (JBIC).[9] The final 3–5 per cent of project costs are to be met through revenue from development of adjacent property [10] (DMRC, 2003; Murty et al, 2006).

Currently, the Metro earns revenue from fares, property development, advertising, consultancy services and other associated activities (Pandley, 2007). The majority of this revenue comes from passenger fares, with current ridership levels of 1.6 million persons per day (November 2010) (DMRC, 2011). Delhi Metro is also one of the few transport initiatives in the world to access carbon financing under the Clean Development Mechanism – under the Kyoto Protocol – on the basis of energy savings from the adoption of regenerative braking technology. Funds received from sale of these carbon credits will be used to offset additional investment and operational costs of the project (RT, 2011).

Operations

Interestingly, despite highly lauded achievements and widespread public and customer satisfaction with operations (Bhandari et al, 2009), critical opinions of the Delhi Metro project are mixed (Advani and Tiwari, 2005; Murty et al, 2006; Siemiatycki, 2006; Pandley, 2007; Mohan, 2008; Bhandari et al, 2009). The DMRC not surprisingly tout myriad benefits including time savings for commuters, improved reliability and safety, reduction in pollution and accidents, reduced fuel consumption and vehicle operating costs, and increased average

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8. Cost estimates based on Average Annual CPI figures for Industrial Workers published by Royal Bank of India. Current exchange rate estimate of US$1 = Rs45.5 was applied to convert to US$.

9. JBIC loans were provided at low interest rates of 3 per cent or less, and included a 10 year moratorium period and 10 year repayment period.

10. Percentage contributions are approximate. Numbers are based on Phase I and Phase II funding, and account for marginal variations in proportional contributions between phases.

speed of road vehicles (DMRC, 2011) though data to evaluate these claims is limited. A social cost benefit analysis conducted by the Institute of Economic Growth in Delhi on 108km of operational network largely concur with these results. They calculate a financial internal rate of return on investments as 17 per cent whilst an economic rate of return of 24 per cent (which includes a reduction in urban air pollution) (Murty et al, 2006). Another study examining economic and equity implications show that the introduction of the metro improves equity of mobility and accessibility in Delhi (Bhandari et al, 2009). These are supported by a large-scale commuter survey by DMRC in 2006/2007 that shows high satisfaction ratings and a large number of commuters switching from alternate modes of transport due to improved comfort, time savings, and enhanced safety of metro transit (Bhandari et al, 2009).

Critics however are far more disparaging, pointing to high capital costs, lower than expected ridership, unaffordable tariffs and inadequate service coverage (Siemiatycki, 2006; Mohan, 2008). They claim that only 2.2 per cent of Delhi's population resides within a 0.5km corridor of the metro network, thus the majority of commuters must rely on inconvenient and time consuming transfers from feeder services to gain access to the system (Advani and Tiwari, 2005). Capital costs are indeed higher than comparative BRT systems. For example, the estimated per km cost of the Janmarg BRT is US$1.8 million per kilometre, compared with US$71.1 million per kilometre for the Delhi Metro. This is almost 40 times greater, and is fairly indicative of international metro rail versus BRT cost comparisons (USGAO, 2001; Hess et al, 2005). This difference is still significant even after accounting for the higher ridership levels observed on Delhi Metro.[11] For a full comparison of key data, including current ridership data on Janmarg BRT and Delhi Metro refer to Table 2.

Table 2. Summary data for Janmarg BRT and Delhi Metro (2011)

	Janmarg BRT	Delhi Metro
Key data		
City population	5.6 million	13 million
Current network length (2011)	40km	156km
Planned network length	88km + potential 155km expansion	415km
Current ridership	100,000 /day	1.6 million/day
Construction period	2006-present	1998-present
Operation commenced	2009	2002
Financing		
Government of India	Government of India/JnNURM: 35%	Government of India: 15% + 2–3% interest free loan
State Government.	Government of Gujarat: 15%	Government of the National Capital Territory of Delhi: 15% grant + 2–3% interest free loan
Other	Internal debt and accruals	JBIC: 60% long term loan Property development: 3–5%

11. It would be interesting to compare cost/km/rider for each system. Ongoing construction and shifting ridership patterns meant that this calculation cannot be formed with accuracy. In broad terms however, with 40 times higher construction costs, and 16 times higher ridership – the Delhi Metro system can be assumed to be about 2.5 times more expensive per person per km than the Janmarg BRT at the present time.

	Janmarg BRT	Delhi Metro
Costs		
Capital cost (in 2009 Rs/US$)	Phase I (12km): Rs960 million/ US$21 million	Phase I/part Phase II (118km): Rs383.51 billion/ US$8.4 billion
Estimated cost per km	US$1.8 million/km	US$71.2million/km
Revenue		
average fare	Rs1/km	Rs8–30/trip
Revenue sources	Fares supplemented by bus operator fines; advertising; parking (also exploring land development and carbon credits)	Fares, supplemented by carbon financing; property development; advertising, consulting services

Sources: DNA 2010a; AMC 2011; Pai and Hidalgo 2009; Chandran 2010; Advani and Tiwari 2005; DMRC 2003; DMRC 2011; Murty et al, 2006; DDA, 2003; Bhandari et al, 2009; Jain, 2010.

There is also some debate about the congestion and pollution benefits of metros. Numerous studies and empirical evidence from around the world suggest that there is a weak connection between road congestion relief, pollution abatement and metro construction (Mohan, 2008). Indeed, '*Metro CO_2 emissions turn out to be almost double (for coal, diesel or gas power plants) than for bus because of extra efficiency loss at the power plant and transmission losses*' (Mohan, 2008, p50)**.** Most importantly however, critics are concerned about the affordability and accessibility consequences of the metro. The Delhi Metro fare currently varies from Rs8–30 per trip, significantly higher than the equivalent public bus service as well as the Rs1 per kilometre fares charged on Janmarg. The fare structure and spatial accessibility of the metro largely preclude the poor. This is supported by ridership data that shows the majority of riders are higher and middle income earners (Kumar, 2006).

Conclusion/Lessons Learnt

The Janmarg BRT and Delhi Metro projects are two very different solutions to similar transport problems faced in two major Indian cities. Though of varying scale, mode and approach their analysis offers an insight into common successful principles for policy and practice of sustainable urban transport development.

Firstly, these cases show how supportive national policies accompanied by financial incentives can play a critical role in the adoption and implementation of more sustainable forms of urban transport. Both Delhi and Janmarg benefited from a supportive national government, backed by significant grant contributions towards capital costs. The economic, social and environmental externalities of this type of investment make it unreasonable to expect cash-poor municipal governments to adopt these sorts of strategies without national and state support. The reality is that subsidization is necessary to public transport operation even in the most highly favourable and highly efficient environments (Tang and Lo, 2010).

At a practice level, several key principles for investing in economically sustainable urban transport development can also be extracted from this analysis. These include:

- **Local buy-in.** Both Janmarg and Delhi Metro demonstrate the importance of local ownership of the project. Political commitment at all levels is vital to implementation success, but local level buy-in, particularly at the agency and bureaucratic level offers additional benefits. Local ownership can generate cost savings through better utilization of local resources, and improves the responsiveness of the design and construction process leading to better outcomes. A firm belief by local implementation teams in the benefits of their schemes is also important in building public acceptance.

- **Multi-tiered financing.** Financing of transport systems should be multi-tiered, combining various funding options according to relative comparative advantages of different funding actors and the short term and long term financing needs of the schemes (e.g capital investment versus recurrent expenditures). Delhi in particular was effective in drawing in alternative financing options from a variety of international, national, state and local stakeholders.
- **Dedicated agency.** Both schemes benefited from clear governance arrangements. The creation of a single purpose agency to implement and operate transit schemes minimized the need for coordination across multiple agencies thereby streamlining design and construction. In the operational phase, financial 'ring-fencing' also improves transparency and accountability. However under this arrangement extra care needs to be taken to ensure proper integration with other forms of transit.
- **Incremental implementation.** There are both physical and financial advantages to carefully planned, incremental implementation. Payoffs include improved design, time savings, cost savings through feedback and modification as well as greater public acceptance and increased ridership. Ahmedabad provided a particularly effective example of how incremental implementation of a demonstration corridor can be strategically used to broaden public support and overcome critics.
- **Innovative technology.** Technology can not only be a strategic tool for improving planning, construction management and enhancing operational efficiency and thereby financial sustainability, but can also play a role in public acceptance of a scheme. Modern communication and ticketing technology has the potential to greatly facilitate integration of transit modes and should be utilized to the full extent. But the value of 'modernization' also lies in its visual association with cleanliness, safety and comfort. This is particularly important in the developing world context where there are often greater aspirations for modernization.
- **Affordability/equity.** These issues are oft overlooked in the quest for financial cost-recovery, but they are critical concerns for sustainability and ultimately determine the effectiveness of urban transportation investment. There is limited and conflicting data on the affordability/equity measures of both the Delhi Metro and Janmarg BRT suggesting a need to more closely measure and evaluate this important metric.

References

ADB (Asian Development Bank) (2010) 'Urban development policy of India (Part 1): *Mobility of People by Bus Rapid Transit*', Urban Innovations and best practices, ADB, April, Manila

Advani, M. and G. Tiwari (2005) 'Evaluation of public transport systems: Case study of Delhi Metro, START-2005', IIT Kharagpur, India

Ahluwalia, I. J. (2010) 'Bringing speed to bus rides', *The Financial Express*, Indian Express Pty Ltd, Delhi

AMC (Ahmedabad Municipal Corporation) (2011) 'Janmarg BRT Homepage', http://www.ahmedabadbrts.com/, last accessed 13 January 2011

Badami, M. G. and M. Haider (2007) ‘An analysis of public bus transit performance in Indian cities’, *Transportation Research Part A* **41**(10): 961–981

Baltes, M. R. (2002) ‘BRT – mode du jour or long-term solution?’, *Metro Magazine,* November/December, Torrance, CA

Bhandari, K., H. Kato and Y. Hayashi (2009) ‘Economic and equity evaluation of Delhi Metro’, *International Journal of Urban Sciences* **13**(2): 187–203

Chandran, R. (2010) ‘Urban transport debate: Is BRTS the answer?’, *livemint.com*, HT Media Limited, Ahmedabad

Currie, G. (2006) ‘Bus transit oriented development – Strengths and challenges relative to rail’, *Journal of Public Transportation* **9**(4): 1–21

DDA (Delhi Development Authority) (2003) ‘Delhi Master Plan 2021’, http://delhi-masterplan.com/, last accessed 13 Jun. 2011

DMRC (Delhi Metro Rail Corporation) (2003)’Driving Delhi forward’, DMRC pamphlet, Delhi

DMRC (2011) ‘Delhi Metro Rail Corporation’, http://www.delhimetrorail.com/Default.aspx, last accessed, 13 June 2011

DNA (Daily News and Analysis) (2009) ‘Ahmedabad Janmarg BRTS brings honour to Gujarat’, *DNA*, Diligent Media Corporation, Ahmedabad

DNA (2010a) ‘Ahmedabad bus rapid transit system bags “Best Project” prize’, *DNA*, Ahmedabad, 4 December

DNA (2010b) ‘Janmarg take A’bad to elite global club’, *DNA*, Ahmedabad, 14 January

GOI (Government of India) (2005) ‘Jawaharlal Nehru National Urban Renewal Mission (JnNURM): Overview’, Ministry of Urban Employment and Poverty Alleviation and Ministry of Urban Development, New Delhi, http://jnnurm.nic.in/nurmudweb/toolkit/Overview.pdf, last accessed 13 June 2011

Hess, D. B., B. D. Taylor, and A.C. Yoh (2005) ‘Light rail lite or cost-effective improvements to bus service?’, *Transportation Research Record* **1927** (1): 22–30

Hossain, M. (2006) ‘The issues and realities of BRT planning initiatives in developing Asian cities’, *Journal of Public Transportation; BRT Special Edition*: **9**(3): 69–87

HT (Hindustan Times) (2010) ‘Delhi Metro wins civil engineering award’, *Hindustan Times*, Indo-Asian News Service, New Delhi

IANS (Indo-Asian News Service) (2010) ‘Ahmedabad wins sustainble transport award 2010’, *Indo-Asian News Service*, HT Media Ltd, Delhi

ITDP (Institute for Transportation and Development Policy) (2009) ‘Janmarg, the people’s way’, *Sustainable Transport*, ITDP, **Winter**, 2009, No 21, New York, pp 7–9

Jain, A. K. (2010) ‘Sustainable urban transport with specific reference to Southern Asia’, unpublished draft background regional study for 2013 Global Report on Human Settlements, UN-Habitat, Nairobi

Jain, M, A. Saxena, P. Singh, P.K. Saxena (forthcoming) ‘Developing bus rapid transit system in India’, http://www.mu.ac.in/arts/social_science/economics/t6.pdf, last accessed 13 June 2011

Kadri, M. (2010) ‘People’s way: Urban mobility in Ahmedabad’, The Design Observer Group, http://places.designobserver.com/entry.html?entry=12918, last accessed 13 June 2011

Kaushik, H. (2010) ‘Over 1 lakh board BRTS buses everyday now’, *The Times of India*, New Delhi

Kumar, D. A. (2006) ‘Equitable policies, inequitable outcomes and inequitable polices and inequitable outcomes: A case of land, housing and transport in Delhi’, *ITPI Journal* **3**(4): 1–14

Mohan, D. (2008) ‘Mythologies, metro rail systems and future urban transport’, *Economic and Political Weekly* **43** (4): 41–53

Murty, M. N., K. K. Dhavala, M. Ghosh and R. Singh (2006) ‘Social cost-benefit analysis of Delhi Metro’, Delhi University Enclave, on behalf of Planning Commission of India Institute of Economic Growth, India, Delhi

Pai, M. and D. Hidalgo (2009) 'Indian bus rapid transit systems funded by the Jawaharlal Nehru national urban renewal mission', *Transportation Research Record* **2114**: 10–18

Pai, M. and A. Lokre (2010) 'Ahmedadbad is the first city in India to adopt a bus rapid transit system', *City Mayors Transport*, City Mayors Foundation, London UK and Frieburg Germany

Pandley, R. (2007) 'Delhi Metro rail a success: IIM Lucknow study', *Rediff*, Delhi

Pucher, J., N. Korattyswaroopam and N. Ittyerah (2004) 'The crisis of public transport in India: Overwhelming needs but limited resources', *Journal of Public Transportation* **7**(4): 1–20

Pucher, J., Z.-R. Peng, N. Mittal, Y. Zhu and N. Korattyswaroopam (2007) 'Urban transport trends and policies in China and India: Impacts of rapid economic growth', *Transport Reviews* **27**(4): 379–410

Rana, N. (2009) 'BRTS buses to cut carbon, make green cash for AMC', *DNA Correspondent*, Diligent Media Corporation Ltd, Ahmedabad

Rana, N. (2011) 'Now pay to park near BRTS corridor in Ahmedabad', Diligent Media Corporation, Ahmedabad

Rediff (2010) 'Delhi Metro wins global award', *Rediff*, http://business.rediff.com/report/2010/mar/26/delhi-metro-wins-global-award.htm, last accessed 13 June 2011

RT (RailwatTechnology) (2011) 'Delhi Metro, India', http://www.railway-technology.com/projects/delhi/, last accessed 31 January 2011

Sakamoto, K., S. Belka and G. Metschies (2010) *Financing Sustainable Urban Transport, Transport Policy Advisory Services Module 1f*, GTZ, Eschborn, Germany

Siemiatycki, M. (2006) 'Message in a metro: Building urban rail infrastructure and image in Delhi, India', *International Journal of Urban and Regional Research* **30**(2): 277–292

Singh, S. K. (2005) 'Review of urban transportation in India', *Journal of Public Transportation* **8**(1): 79–97

Swamy, P. H. M. S. (2010) 'Janmarg – Bus rapid transit in Ahmedabad', Symposium on Public Transportation, UITP, 20 January, New Delhi

Tang, S. B. and H. K. Lo (2010) 'On the financial viability of mass transit development: the case of Hong Kong', *Transportation* **37**(2): 299–316

Thite, D. (2010) 'Ahmedabad BRTS successful due to strong political support', *Diligent Media Corporation*, Ahmedabad

Tiwari, G. and D. Jain (2010) 'Bus rapid transit projects in Indian cities: A status report', *Built Environment* **36**(3): 353–362

TOI (Times of India) (2007) 'Pvt firms to run buses on BRTS routes', *The Times of India*, Delhi

Umarji, V. (2010) 'Ahmedabad BRTS catches fancy of several countries'; *Business Standard*, Business Standard Ltd, 23 August, Ahmedabad

USGAO (US Government Accounting Office) (2001) '*Mass Transit: Bus Rapid Transit Shows Promise*', U.S.G.A. Office, Washington, DC

Vijayapalan, V. (2008) 'Posters to form backbone of BRTS publicity blitz', Diligent Media Corporation Ltd, Ahmedabad

Wikipedia (2011) 'Ahmedabad BRTS', http://en.wikipedia.org/wiki/Ahmedabad_BRTS, last accessed 13 June 2011

Yee, A. (2008) 'Delhi leads India's metro revival', *Financial Times*, London