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TITLE: **Experiences from Metro Schemes in Developing Countries**

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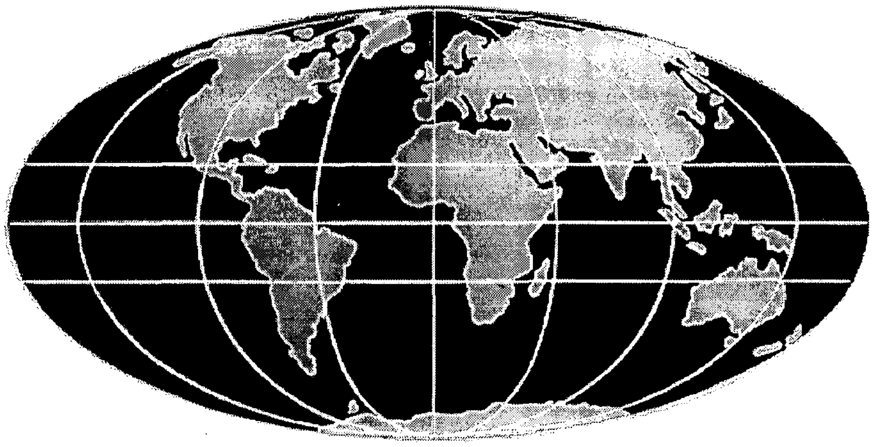

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Experiences from metro schemes in developing countries

by

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Introduction

There are few that would doubt the efficiency and environmental benefits of moving travellers from private cars to public transport. Many cities, faced with the threat of ever-increasing traffic-generated pollution and congestion, have adopted policies and strategies to encourage this shift. A less obvious benefit, though possibly no less important in the long term, is that public transport, with its far greater capacity for moving people, can be effectively used to support urban development policies and programmes. For example, as cities grow in size, the maintenance of a strong and thriving city centre calls for daily inward and outward movement of increasingly large volumes of commuters, tourists, shoppers and others, all benefiting from the economies and necessities of central location. Public transport can more easily meet this mass access need, as compared to private cars.

Most city public transport is road-based, but the major cities of the world have a long history of building and developing rail-based schemes to provide the backbone of public transport supply along key corridors. Road-based public transport, given adequate operational support (e.g. dedicated tracks, off-line bus-stands, trunk-and-feeder routing, etc.) is adequate to handle peak corridor flows up to about 25,000 passengers per hour per direction, but higher flows necessitate a rail-based system which has higher capacity. Rail (particularly the light rail and tram systems) is also justified (in preference to a road-based system) for lower passenger flows on such grounds as being less polluting and presenting a better urban image.

Despite the obvious attractions of urban rail transport, schemes are invariably beset by problems of sustainability. A rail-based system requires high capital input (typically US$ 50 million per km.), and carries substantial risks both in construction and operation. Most, if not all, schemes have had to rely on government support both for their implementation and for their continued survival. In these circumstances, what lessons can be learned from past experience, and what are the conditions for sustainable urban rail systems? This article addresses this theme on the basis of evidence that the Transport Research Laboratory (TRL) has amassed as part of its research programme for the Department for International Development (DFID) on urban mass transit in developing cities.

The principal risks associated with the financial viability of any urban rail scheme are:

- Major unforeseen design changes
- Large cost and time over-runs during construction
- Lower patronage than expected
- Financing and debt repayment

Major unforeseen design changes

Major design changes should be avoidable with adequate planning and project management. Designs should allow for future system expansion and modifications. The power supply system, for example, should be designed with this in mind. The use of very 'high-tech' equipment that has not been proved elsewhere should be avoided in the technical specifications. Major design changes could impact on capital and/or operating costs, demand levels, and funding.

Cost and time over-runs

Cost and time over-runs tend to go together. They occur for a number of reasons including the following:

- Unforeseen ground conditions, which applies particularly to the tunnel costs, but is a risk in all civil engineering works.
- Relocation of services (electric cables, water pipes, etc) not identified in detailed design work.
- Disruptions in supply and servicing of equipment and materials.
- Disruptions in labour supply and
- The flow of funds.

To gauge the impact on metro construction costs of these factors, the table below sets out the likely variation which they may cause. These confirm that much risk is associated with ground conditions, the identification and relocation of utilities, and financial costs.

Comparative metro system capital costs

Total cost per route km: -at grade -elevated -underground	US$ at 1998 prices 10 - 40 million 30 - 80 million 70 - 220 million
Factors influencing cost: -ground conditions -system features -urban constraints (utilities diversions, proximity to buildings, ability to divert traffic, environmental constraints) -land costs -labour costs -taxes and duties -competition in construction and equipment supply market -finance costs -quality of project management	Impact on unit cost: Very large (spread up to 50%) Small/moderate (spread of 5-10%) Large (up to 30%) Moderate (up to 10%) Moderate (up to 10%) Small (up to 5%) Moderate (up to 10%) Very large (spread up to 35%) Moderate/large (10-15%)

Of 13 newly built metros that TRL have data on, only three were completed as scheduled while 6 had construction time over-runs of up to 50% (typically in the range 0.5 to two years), and the remaining four over-ran by between 50 and 500% (typically in the range 2 to 5 years, but some very much more). Furthermore, three were completed within budget, four experienced cost over-runs of between 10 and 50%, while six had cost over-runs of between 50 and 500%.

Lower than expected patronage

This is a major risk for the financial viability of the project. Over-optimistic forecasts of patronage, on the basis of which a metro is economically and financially justified, are the result of many assumptions that cannot always be realised. Of the newly built metros in nine cities for which data were available, only one achieved its expected ridership levels, while three achieved only half, and five had patronage that was between 50 and 90% lower than expected.

The need for bus-metro integration is critical to success. With such a highly capital intensive system as a metro it is important that its patronage should be maximised. Integration, which should have the effect of widening the catchment area for the metro, can be brought about in many ways, including:

- Physical integration in which the metro station entrances and exits are conveniently located near to bus stops, taxi services and car parks.
- Bus route integration whereby bus routes either directly 'feed' the metro, or serve the metro stations from its potential catchment area, and operating timetables are geared to minimum transfer times.
- Route protection in which buses are prohibited from providing parallel or competing services to the metro.
- Fares integration or through-ticketing in which passengers who have to make a transfer between bus and metro are given a single ticket to cover the journey, the ticket usually being discounted on the aggregate of the individual bus and metro fares.

The provision of feeder and complementary bus services is unlikely to happen automatically, since it may require significant changes to the bus network, and by its nature implies that the bus operators may lose some of their long-distance passengers to the metro. The metro operator may need to provide incentives to the bus operators to induce them to provide these services. Some metro operators have even gone to the extent of either operating their own feeder services or contracting bus operators to provide feeder services.

Restriction of parallel bus operations is also complex, since it has negative implications for both the passengers and operators of the existing bus services. These restrictions will certainly 'drive' passengers onto the metro, but in doing so may increase both their travel costs and their journey times, because it will involve at least one transfer and in all probability an extra travel leg. The travellers' resentment in the face of such changes may be matched by that of the bus operators who lose their customer base to the metro.

Fare integration may go some way to overcoming bus passenger and operator resistance to change. However, to be attractive to the traveller, a fare level is required which is competitive with the rival all-bus fare. At the same time, the through-ticket must provide adequate value to the bus operator, who will want to be no worse off than when providing his previous service. The problem becomes one of revenue sharing (between the bus and metro operator) a combined fare that may be substantially less than the individual bus and metro fares combined. Inevitably this causes friction, particularly where the metro and bus operators are different organisations.

From the foregoing discussion, it is not surprising that few urban transport systems have achieved significant integration between different modes. The evidence indicates that:

- Feeder-bus services are most evident where the metro company has taken responsibility for their provision.
- Through-ticketing is not a significant development, and is strongest where the metro company is closely allied to the participating Bus Company. Where it is in use, there is typically a flat fare on both bus and metro, and the metro takes a smaller proportion of the combined fare.
- The restriction of parallel bus operations has only been achieved successfully where the municipality has strong regulatory powers to coerce private operators, or where private operators are not a significant element of the network.

Financing and debt repayment.

Many metro schemes have experienced severe financing and debt repayment problems. The issue has been exacerbated where debt has been raised in foreign 'hard' currencies that have unexpectedly appreciated against the local currency. Such problems can impact negatively on the national economy because of the scale of finance involved in funding a metro. This has been evident in a number of metro schemes, including Mexico City, Manila and Pusan.

Few metro schemes in the past have generated sufficient revenues to cover more than direct operating costs and perhaps depreciation on equipment. Thus while they can be justified in economic cost-benefit terms, the financial return is likely to be poor, and government will inevitably have to be involved in the financial support of the project.
The main lessons from these experiences are:

- Government must be prepared to fund most of the capital cost, as metro revenues will be insufficient to meet loan repayments.
- Income from associated developments (primarily property) may provide some long-term support to metro revenues (and even capital costs if developers can be persuaded to contribute to joint station/office development), but it will not be large and may add to the initial risk of the project.

The conditions for sustainability

Based on the lessons learned, an urban rail system can succeed if most of the following conditions are in place:

- **Demand.** There should be high existing demand for public transport along the corridor (s). In all probability the first line will be radial from the city centre along the alignment of the main traffic corridor. Better still would be an alignment along two opposed radials, providing a cross-city link through the city centre. To complement this, the city should have a strategy of encouraging city centre growth. There should also be sustained population growth in the catchment area, and rising personal incomes.

- **Cost.** The rail system should be low-cost, using at-grade and elevated track in preference to underground works. Cost and time over-runs should be minimised through strong project management. Sharing these risks with private enterprise may not be possible, but the opportunities should be explored. Government should expect to have to find much of the equity, on which its return is likely to be negligible. Some of this equity may be in the form of providing land. Local Government could also provide some of the equity through various local tax instruments. Government may also expect to have to guarantee much of the loan finance.

- **Fares policy.** There is a need to balance the conflicting aims of providing affordable transport for the urban poor, and funding the metro. The metro should be expected to generate revenues which fund direct operating costs, asset replacement costs, and debt service costs. Any privately held equity should also be covered by a reasonable return. To address these conflicting aims requires a highly flexible fares system that can maximise yield by discriminating between time of day, distance travelled, and the elasticity of markets.

- **Organisation.** Operating an urban rail company is an ideal opportunity for private participation, and would be an integral part of any private funding arrangement (BOT, etc). A concessioning agreement must pin down roles and responsibilities of the parties. The concessionaire should be responsible for the financial sustainability of the project, enjoying no privileged access to operating subsidies, but having full control over fares policy.

Conclusions

An urban rail system is an ecologically and economically efficient way of moving large volumes of passengers in big cities. There are, however, many financial uncertainties associated with such capital intensive projects that must be addressed with careful planning, project management and effective operational management policies. Government support for the capital funding of the project is likely to be essential for the project's successful financial viability, with private participation contributing in both the execution and operation of the scheme. Integration with other transport modes is also essential, but must be achieved in a sensitive manner that recognises the right of choice for the traveller. This requires careful planning of fares policy, through-ticketing arrangements, and feeder-bus services, which may initially have to be developed by the Rail Company.

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Bibliography

Allport R J, Creating civilised cities - the role of mass transit policy and the private sector. In: Urban Transport Policy, pp129-134. Proceedings of the International Conference, CODATU VIII. A A Balkema/Rotterdam/Brookfield.

Armstrong-Wright A., 1993. Public Transport in Third World Cities. TRL State of the Art Review 10. HMSO, London.

Dalvi M Q and P G Patankar, 1998. Financing a metro rail through private sector initiative: the Mumbai metro. In: Urban Transport Policy, pp129-134. Proceedings of the International Conference, CODATU VIII. A A Balkema/Rotterdam/Brookfield.

Fouracre P R and G Gardner, 1992. Mass transit in developing cities: the role of high performance bus systems. Proceedings of the Institution of Mechanical Engineers Conference: The expanding role of buses towards the 21st century, March, 1992. IME, London.

Fouracre P R, R J Allport, and J M Thomson, 1990. The performance and impact of rail mass transit in developing countries. TRRL Research Report RR278. Transport Research Laboratory, Crowthorne.

Gardner G, 1994. The performance and potential of light rail transit in developing cities. TRL Project Report 69. Transport Research Laboratory, Crowthorne.

Institution of Civil Engineers, 1987. Moving people in tomorrows world; Proceedings of conference organised by ICE, October, 1986. Thomas Telford, London.

Walmsley D A and K E Perrett, 1992. The effects of rapid transit on public transport and development. TRL State of the Art Review 6. HMSO, London.

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