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THE SELECTION OF A LIGHT MASS RAPID TRANSIT SYSTEM IN DEVELOPING CITIES

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ABSTRACT

The objectives of the research are to compare the technical and economic merits of the two main light mass transit options, Light Rail Transit (LRT) and high capacity segregated busways.

A subsidiary objective is to use the data collected, together with review of the work of others, to investigate the decision making process. A modern mass transit system can require a multi-million dollar investment and involve multi-national conglomerates. There are considerable pressures on those charged with the task of deciding which type of system to implement. Those pressures appear to favour options that involve the highest cost, such as rail-based projects, even in poor countries.

The research sets out to test the following hypotheses:

1. In developing cities, Light Rail Transit (LRT) does not represent best value for investment of scarce funds. That is, that the relationship between the mass transit options does not always, as some have claimed, show Light Rail Transit to be superior to busways.

2. A second hypothesis is that there is a difference between what would appear justified according to general aid-approval procedures, and what is actually implemented. Standard evaluation methodology is, for some reason, only dealing with part of the decision-making process.

In order to test these hypotheses by several different means, the research uses extensive fieldwork, and examines the theory of decision-making in order to set the current practice in context.

The research described here was part of a larger programme on urban mass transport carried out by TRL for DfID. The funder required consideration of work by others on the metro rail option, but the thesis concentrates on work that was specifically carried out during the M.Phil research. This includes all of the work on Light Rail Transit and the comparative analysis with busways (using data also collected by the author).

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EXECUTIVE SUMMARY

The largest cities of the world are increasingly located in low income countries. If they are to develop and thrive, there will be a need to gain access to goods and services in these cities in the most efficient manner. As part of this, a transport system capable of moving large numbers of people along high volume corridors will be an important requirement.

The first part of this research therefore sets out to examine the options for mass transit, and in particular the Light Rail Transit (LRT) option. Of particular interest is the performance capability of this option, and especially how this relates to the demands of a developing city. The high-capacity segregated-busway is the most notable option against which LRT is compared. The thesis sets out to test the hypothesis that LRT is not suitable for a developing city, especially when compared with other available options. Extensive fieldwork is used from more than fifteen different cities around the world.

In the analysis presented here there is little to commend the LRT option for developing cities. The peak hour capacity as recorded in the case study cities is insufficient to cater for the very heavy public transport demand that is commonly found in low income countries. The commercial speed of case study LRT, though higher than a bus service in normal traffic, is not significantly higher than a segregated busway, once other factors are allowed for. This slightly surprising result is accounted for, in part, by the delays that beset LRT vehicles at stations in heavily populated areas unaccustomed to regimentation and order.

The need for a mass transit system presents developing cities with a major problem. The sheer scale of the demand requires large amounts of money, organisation, or more likely both. An urban rail mass transit system of the type most commonly built this decade can easily cost more than one billion dollars. To repay the costs of such an expensive system will require a government subsidy and even then may result in fares beyond the reach of ordinary people. Equally important are the opportunity costs of potentially more socially-desirable projects that could be built if mass transit is foregone.

It is therefore somewhat surprising that many cities choose to implement expensive rail mass transit options. The final part of the thesis tackles the very important question of why a city might decide to implement an expensive option that, according to the findings of the first part of this research, is not necessarily the best option. The research starts by investigating the concept of what is meant by ‘best’. The theory of human decision making is then used to guide a review of the motivations of decision makers in a developing city.

It is suggested that there are some benefits of a mass transit system that are not included in the

appraisal process and yet might bring genuine benefits for a city. This is most likely to be the case when a system is planned and integrated into a comprehensive development plan. There may also be cases where a legitimate political interpretation of citizens' wishes may result in a scheme which, though sub-optimal (especially by standard Western appraisal methods), is nevertheless popular and considered an affordable solution.

Most importantly, the research sounds a warning that the scale and complexity of the issue, together with the power of vested interests involved, mean that on some occasions promises of intangible benefits will be used to promote prestigious schemes in very low income countries where the need for investment in basic health and welfare is greater.

The final part of the thesis, following the recommendations of World Bank researchers and others, is the outline definition of a methodology that could be used as part of an improved appraisal process. This is based upon multi-criteria analysis and the research has gathered together a very comprehensive framework capable of investigating every conceivable benefit of a system, even those currently outside of standard appraisal practice.

One of the conclusions of the research is that decision making, especially in developing countries has too many factors preventing what technicians may consider to be logic and reason. It is necessary to accept this from the outset and look for ways of improving the process within existing boundaries. There is general agreement that increasing transparency of decision making is one way of doing this.

It appears that everyone has a different way of looking at things, especially when they come from different cultures. This will need to be accepted as part of the appraisal process and methods, such as decision support frameworks, used to provide a common language for discussion of precisely where disagreement might exist. While it will never be possible to provide a complete methodology for designing the perfect system, an improved appraisal system, as proposed in this research, might help to sift out projects that could bring serious financial hardship to a poor city.

1 INTRODUCTION

The title of the thesis is:

THE SELECTION OF A LIGHT MASS RAPID TRANSIT SYSTEM IN DEVELOPING CITIES.

The research presented here is submitted in partial fulfilment of an Master of Philosophy. The research has been carried out under the Public Research Institute/Industrial Research Laboratory arrangement. The author is a Principal Scientific Officer at the Transport Research Laboratory. Supervisors are Prof. Tony Ridley at Imperial College and Dr Goff Jacobs at TRL. This means that the research presented here formed part of a programme funded by, and to a certain extent directed by, the Department for International Development (DfID).

1.1 Aim of Thesis

The aim of the research is to increase the likelihood of developing cities obtaining appropriate solutions to their accessibility needs.

The objectives of the research are to compare the technical and economic merits of the two main light mass transit options, Light Rail Transit (LRT) and high capacity segregated busways.

The original contribution of the work stems from the first ever collection and statistical analysis of actual measured data from a large selection of light mass transit systems in developing cities.

A subsidiary objective is to use the data collected, together with review of the work of others, to investigate the decision making process. A modern mass transit system can require a billion dollar investment and involve multinational conglomerates. There are considerable pressures on those charged with the task of deciding which type of system to implement. Those pressures appear to favour options that involve the highest cost, such as rail-based projects.

The research sets out, therefore, to test the following hypotheses:

1. The principal hypothesis is that, in developing cities, Light Rail Transit (LRT) does not represent best value for investment of scarce funds. That is, that the relationship between the mass transit options does not always, as some have claimed, show Light Rail Transit to be superior to busways.

2. A secondary hypothesis is that there is a difference between what would appear justified according to general aid-approval procedures, and what is actually implemented. Standard technical and economic evaluation methodology is, for some reason, only dealing with part of the decision-making process.

In order to test these hypotheses by several different means, the research uses extensive fieldwork, and examines the theory of decision-making in order to set the current practice in context.

Until the present research, there was no published account of the actual performance of light mass transit systems in developing countries, and little objective analysis of the decision-making process specifically related to this subject.

The choice of a mass transit system is made according to many factors. These can be divided into two main categories; the first of these include 'practical' issues, such as transport planning and engineering, while the second category includes institutional and 'political' issues. The practical factors, such as system performance, will be measurable and, to some extent, predictable. Political effects, and other intangible factors such as for example 'civic pride', are more difficult to quantify and analyse, but appear to play a major part in influencing choice. Despite this difficulty, the research aims not to shy away from this important area but attempts to learn more about it and apply this in the field of mass transit selection.

The research described here was part of a larger research programme on all aspects of urban mass transport carried out by TRL for DfID. In order to provide context, the thesis draws upon work by others on the metro rail option, but concentrates on work that was

specifically carried out during the M.Phil research. This includes all of the work on Light Rail Transit and the comparative analysis with busways (using data also collected by the author). Some indication of how the sections of the thesis work together are shown in Diagram 1.

1.2 Background

Public transport is a growth sector in most developing cities. A World Bank estimate put the number of daily bus trips in 1980 at 600 million, with the expectation that this number would double by the year 2001 (Armstrong-Wright, 1986). As cities grow in size, so attention focuses on the mass movement of travellers along major corridors. Developing cities exist today that must provide for 10-15 million public transport trips per day; corridor flows can be more than one million passengers per day. To cope with this scale of demand requires a high-capacity transit system. There are three main options for such mass transit: metros, Light Rail Transit (LRT) and Busways.

1.2.1 Definitions

For the purposes of this report, the following definitions have been used to distinguish between the various rail-based mass transit options:

- **A metro** is often referred to as an underground railway, but can, in fact, be any grade-separated urban railway. The track and electric vehicles are similar to suburban railways, though with closer station spacing. Trains may have 6-8 cars, with a total capacity of up to 3,000 passengers. In some cases trains are operated over an extensive network (more than 100 km); more typically, however, network size in a developing city is around 20 km.

- **LRT** usually employs vehicles and track construction that are less substantial than a full metro. Some systems, including those of Manila and Istanbul, use lightweight vehicles on a system which has an exclusive track and high platforms similar to a metro. Other systems have at-grade crossings (with or without traffic signal priority) and low level platforms.

LRT trains may be made up of two or three cars, with a total capacity of up to 750 passengers.

- **Trams** are a basic form of LRT that have limited rights of way, sharing road space for much (if not all) of their route length with ordinary traffic. Tram cars are likely to have lower capacity than LRT cars, and are usually operated singly or in pairs.

- **Busway.** A Busway is a physically segregated area of roadspace reserved for the use of buses only. A busway transit system will include other special operational measures to enhance performance above that of a normal bus.

For conciseness this report will occasionally refer to all options together as Mass Rapid Transit (MRT) and the options of light rail transit and busways together as Light Mass Rapid Transit (LMRT). These terms will be used only where they avoid undue repetition. The term 'transit' also appears in the text and in quotations. This is normally used in the American sense where it means, basically, public transport.

Note also that the term Less Developed Country (LDC) or Developing City is sometimes used. This is not meant to be deprecatory but is considered to be less ambiguous than the more modern term 'The South'.

2 LITERATURE REVIEW

This section looks at the available recent literature on mass transit. It also considers past experience of light mass transit. The objectives of this are to provide background knowledge and to test whether similar work has been done by others. The objective of the historical review is to understand why it was that LRT (or as it was then the tramway) rapidly rose to prominence, but then equally quickly almost disappeared.

2.1 History of Tramways in Developed Countries.

Collective transit arrived with the 'omnibus' in 1829 in London when large numbers of people travelled together for the first time, in horse-drawn vehicles. The first major increase in passenger carrying capacity arrived with the tram. Trams began around 1852 in the USA

where poor road conditions for buses in the major cities such as New York and Chicago meant that the improvement in ride quality due to the use of steel rails was especially significant. Riding over the potholes, trams were able to attract passengers from other modes and, because of the reduced friction, one horse was able to pull more passengers, making operating costs lower. The tram was therefore able both to attract more passengers, and carry them more cheaply, thus increasing profit margins. (Barry, 1991)

Further expansion of tramways in the USA took place following the solution of technical problems relating to electric traction in around 1890. This, once again, produced improvements in operation and costs (and hence profits) which led to a massive growth in a very short time. US cities had little in the way of planning regulations to restrain growth.

In Europe, worries over the impact of the then quite heavy overhead power cables led to restrictions on use in the great European cities, and different companies tried different solutions to this problem, leading to technological fragmentation (including, for example the London Underground). Some companies did, however, achieve great commercial success; Siemens and Alsthom went on to become major multinationals, and Belgian industry financed more than 200 tramway systems all over the World, from Russia to Egypt.

During the first world war, there were great advances in automobile technology. This in turn led to developments in bus design which was not matched by tram improvements. The tram began to be seen as a down-market form of transport. Although still important for mass transport of low income earners, the car lobby in Britain in the 1930s was obviously influential; the royal commission on transport in 1929-1931 described trams as "obsolete",and a cause of congestion which "should gradually disappear and give place to other forms of transport". (Barry, 1991)

In post war Germany, efforts were made to reduce domestic fuel consumption, and the rebuilding of the German road network therefore included at the outset, space for parallel rail routes. This enabled trams to continue to supply a competitive service, and provided work in the large factories of Siemens and Duewag. For reasons also stemming from a desire to reduce imported fuel consumption and optimise the use of nuclear power, the French government in 1975 began to promote light rail. By this time, systems were required which were not necessarily going to make a profit for the operator, but which would

provide an attractive alternative to the car.

In North America, new systems in Edmonton(1978) and San Diego(1981) also marked the re-emergence of the tram as a light rail transit system. In such a low density area with high car-ownership, it was never likely that these would attract high ridership. However, both these cities are very image-conscious and introduced rail systems as a statement of civic image and as a means of trying to attract people out of their cars.

2.1.1 Historical Lessons

Looking back, then, it can be seen that in Developed Countries, the tram began as a purely commercial proposition. Widespread, rapid expansion followed technical advancements, and commercial operators were able to introduce many new systems and make large profits. When competitive road services began to challenge trams, and particularly when trams began to be seen as 'downmarket' the trams were withdrawn. Only where other factors such as local availability of energy, civic prestige and international trade were important did the tram continue as a serious form of transit.

The standard of public transport (and in many cases the quality of the roads) is such that the use of LRT in developing countries *could* bring some of the improvement in ride quality as it did in early New York. The income levels, and the growth rates are not similar, however. Also, like the early European cites, the level of intervention by bureaucratic city authorities is such that unhindered growth would be difficult even if the commercial possibilities did exist.

In developing countries, although systems were introduced in some cities, the market was not sufficient to produce large profits, and had little commercial influence. All of the developments in technology have, therefore, occurred in Europe or the USA. For the Western markets the requirements for an attractive alternative to cars have been different to those of developing countries which require a reliable form of mass transit for those without access to a car.

2.2 Bibliography

The research included a full literature survey and review of relevant work in progress by others. One difficulty faced in this research is the identification of reliable sources of information. Much of the available literature comes from two sources; feasibility studies by consultants, and articles by enthusiasts in specialist magazines. The latter, understandably, present a one-sided view, although they can be a useful source of basic data. More surprisingly, perhaps, are the professionally produced reports that appear to contain bias. This can be quite subtle, for example by erring on a particular side whenever an estimate is required (Guangzhou Municipality, 1989). More drastically, a certain mode (usually busway) can be excluded from the evaluation process (Government of Mauritius, 1991). This research will examine the severity and reasons for these omissions and exaggerations, and their implications for the hypotheses.

2.2.1 Mass Transit Comparisons;

One of the key reasons for undertaking the current research project is that very few people have made fair and exhaustive comparisons between the main mass transit options from an objective viewpoint.

One of the most helpful publications on this topic is by Armstrong-Wright and Thierez (1985). Called 'Guidelines for examining options', it contains a lot of useful data, and gives a calculation procedure for the estimation of costs. A full description of all options is given and there is even an outline terms of reference for a feasibility study making it the type of publication which can be **used**. The report, necessarily, uses reported rather than measured data, and uses broad range estimates of some of the parameters. Metro speeds, for example, are given as 'in the region of 30-35 km/hr.' Preliminary sensitivity analysis of some of the estimates used suggests that reliable estimates of speed can play an important part in the evaluation of a mode. The calculation procedures included in the book are rudimentary, and useful only for the broadest possible estimate of an option's worth. A more comprehensive procedure would permit better estimates, could make better use of existing information, could compare options and could permit rapid sensitivity testing of the main variables.

The World Bank, in its Urban Transport Policy Study (1986), covered a wide range of urban public transport options but (following an unsatisfactory outcome on the Porto Alegre MRT in Brazil) pointed to the high construction and operating costs, cost overruns,

overestimates of demand, inadequate revenues and attempts to suppress competition, commonly associated with metro projects. The Bank generally preferred to see money spent on more cost-effective solutions, in particular improvements to the capacity and operation of existing infrastructure.

This 'soft path' approach was widely criticised (by Henry, 1987, for example). The approach was alleged to overlook the wider and longer-term benefits of metros and to overrate the ability of less costly means of transport to meet the needs of developing cities, many of whom continue to clamour for metros, whether light or heavy, above or below ground.

The best examination of the technical aspects of alternative systems is contained in the comprehensive study of mass transit (particularly rail-based) by Vuchic (1981). This looks at every aspect of the design and performance of many different systems. Vuchic is one of the most respected researchers in the field of mass transit and is responsible for the often repeated diagram on the three main options as shown in Figure (1a). Vuchic is careful to define precisely the modes represented in the figure, for example using the term 'semi rapid transit' rather than LRT. Unfortunately this has been seized upon by other authors who wish to present the case for a particular mode, which has resulted in its simplification to the point of inaccuracy as shown in Barry (1991) and Bonz et al (1989) Fig 1b. This diagram is widely reproduced by system promoters. It can influence decisions costing billions of dollars, and yet there is little or no practical research evidence to support it.

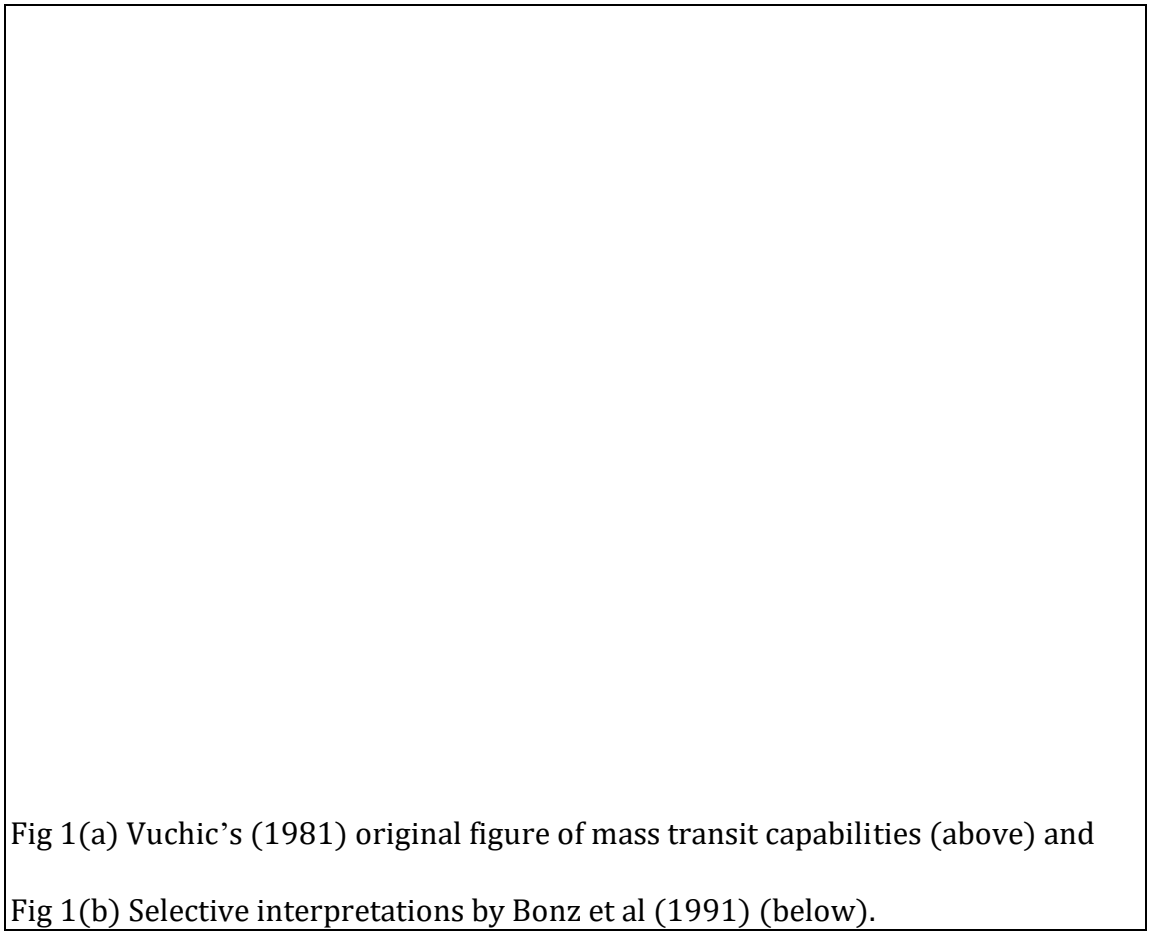


Fig 1(a) Vuchic's (1981) original figure of mass transit capabilities (above) and Fig 1(b) Selective interpretations by Bonz et al (1991) (below).

Vuchic (1981) also draws upon reported figures and estimates of performance in his comprehensive study of mass transit. There are two main reasons why such an approach is not acceptable for the current research; First, several studies have cast doubts on the accuracy of estimated figures (Fouracre et al. 1990, Walmsley and Pickett 1992, Gardner and Kuhn 1992); secondly, transport conditions in developing countries are much more unpredictable than those in Europe and the USA making modelling and forecasting more difficult (Gardner et al 1990, Gardner 1993).

Vuchic (1981) notes that pre-war German and Austrian streetcar systems were recorded as carrying between 20,000-25,000 passengers per hour per direction (pphd). This was under exceptional circumstances of excessive over-crowding, slow speed and absence of much competing road traffic. Other work by Ruger (1984) reported an absolute maximum of around 16,500 tram pass/h following a large sports event in Leipzig.

Surveys in Brazil (Gardner et al, 1991) have shown that busway flows higher than those

predicted by Vuchic's estimates are possible. Similarly, even in areas of high demand, no other authors before the present research had measured hourly light rail flows anywhere near the maxima predicted by Vuchic. This suggests that despite Vuchic's very scholarly predictions about the capacity of LRT relative to a busway, the actual situation in developing cities might be different, or even opposite. Collecting evidence to test the hypothesis on this will form an important part of this research.

Allport, as part of his Master's thesis and in subsequent papers (1981) also addresses the subject of comparing modes. This work was based on the Dutch city of Rotterdam, which has bus, metro and light rail services. Allport used a structured approach to estimate operating costs for all three modes based upon an analysis of their component costs. The cost-calculation models produced demonstrate that there are passenger flow ranges over which different modes will be the most cost-effective. Allport suggests that for developing countries 'a more fundamental analysis is required, building upon the costing model presented'.

One issue emphasised by Vuchic (1992) is the contribution of a transit system to the quality of life. This is a sentiment echoed by Ridley (1992) in his Institute of Civil Engineers Dugald Clerk lecture. Quality of life is an element that is not normally included in standard cost-benefit analysis, although it may be incorporated into an environmental appraisal. This raises other questions about the applicability of a standard cost-benefit approach in evaluating mass transit systems. It also raises the question of local decision-makers' ability to judge whether the particular political circumstances in their city justify the construction of a non-viable project. The research presented here, therefore, must be multi-disciplinary, considering decision-making and the assessment of unquantifiable elements alongside traditional technical measurements and cost-benefit analysis.

2.2.2 General Reviews & Feasibility Studies

The predominant source of modal comparison information can be derived from consultants' reports. Although usually referred to as feasibility studies, some of these appear, under scrutiny, to be justification exercises rather than a true test of alternative solutions. A recent French study for a mass transit system in Mauritius, for example, put the average speed of an LRT at nearly twice that of a busway, despite the fact that both were to share the same alignment, and to have the same junction and station spacing (Govt. of Mauritius 1991).

This type of unsubstantiated assumption is not useful for a true test of ‘feasibility’.

As will be demonstrated in this research, there are many components of a mass transit system, and many occasions where measurement will necessarily be approximate, or even impossible. At every occurrence of this uncertainty, judgement will be required. If every decision errs on the side which will favour one particular mode, then this mode can be shown to be superior, whereas decisions in the other direction may have denied the need. In a feasibility study for a metro, for example, Guangzhou Municipality (1989) estimated the salary of metro users to be slightly higher than the average for the city, as calculated by the UK appraisal team - thus increasing income (ODA, 1992). Meanwhile, the salaries of the metro drivers appeared to be slightly lower than the average - thus reducing costs. This pattern was repeated throughout the analysis.

Fouracre et al (1990) found that in almost all metro systems studies in developing cities, actual patronage was significantly less than projected in the original consultants reports. Pickrell(1989) in the USA and Walmsley and Pickett(1992) examining LRT in Europe, all found the same pattern. Fouracre suggests that;

> "The reasons for this stem largely from over-optimism in the planning phases: because integration has not been achieved on the scale expected, passengers have not been forced to use the metro as planners intended; private vehicle users have not switched to using the metro in the number expected; there has not been the growth in population or economic wealth that was predicted, and in some cases the alignment of the metro was poorly selected, which resulted in poor catchment".Fouracre et al(1990)

Given such large and important errors in metro and LRT planning, it is perhaps surprising that nobody questioned the accuracy of the predictions before it was too late. One of the reasons for this might be that the models used to predict demand can be so large and complex that they can only be understood by computer-literate planners. The large amount of data input means that it is difficult to 'see the wood for the trees', and decisions which are crucial to the project can go unchallenged. The unquestioning use of transport models has been criticised by Atkins(1986) and Stopher(1980) amongst others.

The World Bank (1995) published its latest policy paper ‘Focussing on Sustainable Transport’. This reviewed the work of others (including the research described here) but had a strong emphasis on privatisation. Minibuses in Ghana and road maintenance in

Tanzania were given extensive coverage. Urban transport received little attention, perhaps reflecting the fact that an inherently loss-making metro will not be an obvious candidate for privatisation (road safety issues also received little coverage). It did say, however, that it would "Develop strategies that enable urban mass rapid transit projects to be incorporated, in a cost-effective way, in the long-term development of growing conurbations." (World Bank, 1995).

There have been many interesting articles written on the way in which large projects can influence human decision making behaviour. In a most interesting analysis of the Los Angeles metro proposals, for example, Jonathon Richmond developed an analogy of the way potential benefits of rail take on almost mythological proportions:

> "Myths tacitly provide an alluring simplification. Telling simple but powerful stories, they point to specific cures. Those cures depend for success on the often invisible assumptions inherent in the myth"Richmond (1991)

Talking to more than 50 people involved in the decision-making process, he found very few people had a full understanding of the true facts, and yet a general air of optimism built up around the potential of the Blue Line to solve not only transport problems, but also reduce social exclusion.

In Texas, Wulkan found that "By and large the proponents of LRT in Austin have been citizens who perceive transit as a clear means of ending their current total dependency on automobiles and their victimization by Austin's growing traffic crisis. They are convinced that LRT offers certain unique benefits that will rate such a transit alternative attractive and viable". Wulkan & Henry (1985) The fact that such systems, once built, attract less than a few percent of US travellers suggests that everyone hopes LRT will solve someone else's transport problem leaving the road clear for themselves.

Bent Flyberg (1998) produced a most interesting research report (in the form of a novel) on the decision making surrounding a new traffic system for the city of Aalborg in Denmark. Like Richmond, he was particularly interested in the interplay between politics and reality, with politics tending to win: writing that "an emphasis on rationality leaves the modern project ignorant of how power works and therefore open to being dominated by power" (Flyberg, 1998).

There is a natural desire to see projects complete. Once a channel tunnel was half built, for example, it is almost inconceivable that it should not have been completed. The success of the Newcastle metro in winning funds rather than the Manchester PicVic line was reported by (Holt, 1992) to be at least partially due to the promoters of the Newcastle metro having started work before the announcement of the Government's decision on funding had been made.

2.2.3 Single Mode Studies

Many authors have looked at individual modes of transit, or have investigated components of a particular mode. These are more numerous than the comparisons of modes, but are of less value for this research, as many of them have been written by ardent enthusiasts of a particular mode. The monthly publication Light Rail (Ian Allen, 1999) for example is an excellent source of information on LRT and tramways, but rarely contains anything too critical of the mode or supportive of other options.

Metro Studies;

The most important piece of work in this area, and the study which has led directly to the present research is undoubtedly the one carried by consultants HFA for, and with, TRL. This looked at 22 metro systems in developing cities, and considered the performance and impact, compared to other similar metros, and compared to original predictions of their performance. This concluded;

> " One should not proceed with a metro system without first considering other ways of solving the same problems. The difficulty of providing public transport is just part of the wider socio-economic problem of the growth of large cities. In very big cities there may ultimately be no alternative other than forcing the city to adopt a more dispersed pattern of employment, retail trade, culture and entertainment. The problems of doing this, and the costs, would need careful analysis which is not part of this study...a temporary solution, which in small cities may be a permanent solution, may be afforded by light rail systems, busways, or general bus priorities including bus lanes."(Allport & Thomson, 1990)

Studies conducted by the French national research institute, INRETS have examined the socioeconomic aspects of metros in S. America (Henry, 1987). The aim of the French research being more concerned with how a city develops with and without metros, rather

than on whether a specific metro will be a success in cost-benefit terms. One conclusion was that “Cities of several million inhabitants even with poor (GDP) not only need metros and intermediary capacity systems: their extension, spatial segregation and centre-outskirts tensions justify regional rail systems to be implemented”. (Henry, 1987). There is no comprehensive account of costs and benefits in this report.

Henry and Kuhn (1996) also made a retrospective study of the Mexico City rail network into which, within less than three decades, the Mexican Government has invested about $12 billion. The French contribution to this represented “around 5% of the total amount of loans with bonus and public donation granted by France to all foreign States for 30 years. “ (Henry and Kuhn, 1996). Apart from the busiest three metro lines in Mexico City, however, some of the options introduced to try to reduce costs (such as the ‘pre-metro’) have not been successful, leading Henry to observe “The results show how difficult it is to combine the advantages of those three types of technologies or urban rail transport. It also may be considered that the variations of the basic metro design have regrettable consequences. They produce hybrid products which cannot satisfy the multiple objectives assigned to them and they don't serve any”(Henry and Kuhn, 1996).

Other useful sources of information on metro systems are the metro company annual statements of accounts. The Hong Kong document for example (HKMRT, 1995) not only includes award-winning photographs, but also contains accurate patronage and income levels, and gives a valuable insight into the complexity of financial arrangements necessary to establish a mass transit system. Nearly one hundred banks and financial institutions, for example, are listed as being involved in the Hong Kong metro.

Busways;

Although initially researched on the General Motors' test track in the early sixties (NATO, 1976) and preceded by bus lane studies in the UK (Department of Transport, 1991). Busways really came to prominence in Brazil in the 1970s (Lindau 1987, EBTU 1982)

Most studies which have looked at bus priority methods have found that they compare favourably with other options (Hounsell and McDonald 1988, Marler 1982, Wayte 1988). Given such favourable reports, it is perhaps surprising that more developing cities have not

opted for the busway alternative.

Lindau comments "existing criteria tended to indicate the value of exclusive bus lanes, but the potential for the introduction of such lanes in urban areas has not been properly established (Lindau, 1983). Lindau goes on to develop a comprehensive simulation model for studying the formation of bus convoys on exclusive lanes using calibration data from Southampton and Porto Alegre.

Other research work on busway capacity and especially the influence of bus stops has been completed by Tyler (1993) and Nelson and Hills (1990). Various detailed studies of bus lane and bus stop performance in Chile were reviewed in these studies. Studies such as these provide a very comprehensive account of the simulated potential performance. This helped to guide the present research that set out to add more case study evidence of the actual daily operational aspects in developing countries (rather than focus on more modelling).

In conversations with city authorities before the busway studies reported in this thesis, there were mixed messages presented. Some said that, in practical operation, busways were unreliable due to breakdowns, obstruction by cars. Other (unsubstantiated) reports claimed that figures of up to 40,000 passengers per hour per day were being transported in one direction (on Av. Amazonas in Belo Horizonte, Brazil)(Case study visit, Brazilian Urban Transport Organisation, EBTU,1989).

One of the aspects of bus transport that comes out clearly from work by Armstrong-Wright (1993) and others is that it is considered a very downmarket mode when compared to Light Rail (in contrast to the historical situation in developed countries referred to above). It is not uncommon for buses to be uncomfortable, ill-maintained, gross polluters and even unsafe (plate 1). As the public bus is the only type of bus that most local people can visualise, it is not surprising that proposals for bus- based LMRT systems conjure up images of an inferior technology. As Wilson & Neff (1983) put it, even in the UK, "Buses do not have the same image of reliability and acceptability that an underground or rail service enjoys. Travelling by train or tube is socially acceptable. Bus travel has a less attractive image among many car drivers."(Wilson & Neff, 1983).

Light Rail Transit;

Plate 1: The image of the bus. In a typical developing city (Karachi) a bus lacking even basic safety features struggles through chaotic traffic.

Plate 2: In contrast, the image of Light Rail Transit is one of an inherently superior technology

For Europe and the USA, reviews by Simpson (1990) and a book by Barry(1991) both provide comprehensive reviews of LRT. Of the two, Simpson is more scholarly, and provides reported data on LRT schemes which he has collected from a variety of sources. This is a useful source of reference for those interested in LRT schemes, even though it spends little time on alternative transport solutions.

Numerous short articles in journals (eg. Hellewell, 1977), and the occasional book (Holt,1992) provide useful, though not always entirely unbiased accounts of light rail transit in Britain. There have been very few worthwhile publications on the particular problems of developing countries. Taplin (1989) in an article on LRT in developing countries, actually describes the general attributes of LRT, rather than considering the peculiar requirements of transport in developing countries as described by Gardner et al (1990).

The book by Barry (1990) is a very readable account of the past, present and future of LRT schemes. Aspects such as the history and technology of LRT are covered in detail, but again the options are given scant attention, and many of the figures emphasise the qualities of LRT over other modes. Operating costs for buses are provided for comparison with LRT, but the example used is from San Diego which has very high bus costs.

The impact of LRT on land development was investigated by Walmsley and Perrett (1992) in which they conclude that an LRT, or even MRT, will not on its own influence the development of a city. In conjunction with a clear development strategy, and particularly when given strong public support, an LRT can help an area which is booming (though it cannot reverse a downward trend).

The problems for LRT in the USA were aptly described by Polzin: “The high frequencies needed to attract riders, the lower trip densities of many corridors under consideration, and the competition from cars where gasoline is cheap mean that LRT may fail to capture the economies of a "mass" mode and be increasingly reliant on accessibility and mobility benefits to justify their construction and operation“ (Polzin, 1977)

One publication on Light Rail, which includes an interesting collection of the views of UK professionals and interest groups, is the presentation to the House of Commons Select Committee on Transport (HMSO, 1991). This highlight’s the difficulty of a government (even a Western one) receiving accurate and unbiased data. Having rejected a submission on high-capacity busways from consultants TTC (TTC, 1991) the committee then listened to more than 20 submissions on LRT, receiving statements such as

> "Light rail has a higher capacity and speed than the bus...It is also more environmentally friendly with no polluting emissions and low noise levels"

From the Greater Manchester PTE: an organisation in whom the committee might reasonably be expected to have confidence. This gentle persuasion and over-enthusiasm in a UK environment can be magnified many times when conducted in Third World countries where decision making is less transparent.

Rail-based transport obviously has a special place in the hearts of many men. ‘Thomas the Tank Engine’ is a best-selling book and video, and there were no articles written by women in Light Rail Tramway magazine during 1998. As an indication of the interest in LRT, fig 2

shows a typical page of adverts from the LRT monthly magazine (Ian Allen, 1999). Of the 3000 titles listed by World of Magazines (2000) 24 took a rail theme whereas 4 were concerned with bus transport.

2.2.4 Bibliography Conclusion

This section describes the published work which has helped to shape the overall content of the current research. Items to support individual components of the study (for example the work on cost benefit analysis by Beesley et al, 1963) and references to the decision-making process are described in more detail in the relevant section.

The available literature confirms the view that although a mass transit system can cost in excess of one billion US dollars (and up to 12Bn), the quantity and quality of the research on the subject, particularly as it relates to developing countries is lacking. The objectivity of the work on particular modes, and even of consultants' feasibility studies, may not stand up to close scrutiny. The past history of forecasting accuracy is poor, even when allowance is made for the uncertainty of the subject.

Large projects in general, and rail transport in particular, appear to have a strong psychological appeal - especially for men. The confidence in rail to solve a city's problems (and not just its transport ones) appears to be significant.

It is therefore an important part of the current research to cross-examine the benefits of mass transit in developing cities. This should include testing of all of the available options, rather than simply trying to justify one particular choice. It should be comprehensive in content, without being over-complicated by unnecessary detail, and it should include both mathematical calculations (like Vuchic, 1981), observed data (like Gardner et al, 1991)and some mechanism for comparison with other systems as they actually perform (like Fouracre et al, 1990).

Fig 2: Adverts such as this give some indication of the level of interest that LRT attracts.

The ultimate aim of the research should be to produce a reference work that can be used to provide good advice to those in developing cities who wish to decide upon the most appropriate mass transit system. The evidence suggests that many politicians are happy to receive only information that supports their prejudice. The reasons for this will be examined, but ultimately the research can only ever inform, not dictate.

3 BACKGROUND ISSUES

Although the main concern of the research is to examine and compare the performance of modes, there are some background issues that must be kept in mind when considering the implications of options. These mainly focus on the peculiar circumstances of transport in developing cities, and includes issues concerned with the international aid process.

The objectives of this chapter are to set the context for the present research. A developing city can have significant differences from those in the West, notably in the magnitude of flows, but also in the formation of the urban area. It will be important in testing the first hypothesis that no assumptions are made based upon a Western viewpoint.

A further objective of this chapter is to establish the implications of overseas development aid for the choice of mass transit system. In order to test the second hypothesis about aid appraisal shortcomings, it is necessary to know what the current procedures are.

3.1 Transport and Land Use

The interrelationship between mass transit and urban development is a two-way process: the urban pattern will influence the type of mass transit system that will be appropriate. The shape and structure of a city will also be influenced by its choice of transport facilities. This can be most clearly illustrated by contrasting the urban sprawl of car-dominated Los Angeles with the much denser, public transport oriented cities of Europe.

One interesting development in recent years is the distinction now being made between transport and ‘access’.

> The Chicago Area Transport Study in 1959 said that `the dominant objective of a transport facilities plan ... is to reduce travel frictions by the construction of new facilities so that people and vehicles .. can move about within the study area as rapidly as possible'. (ICT, 1974).

This has now been challenged by an alternative view, namely that access, not movement, is the true aim of transport. The act of travel, with the time, cost and personal effort involved is something most people would normally prefer to avoid. Hence, a corridor flow that

supports the very high flows needed to justify a high capacity MRT should not necessarily be seen as a 'good' thing, without knowing what is the purpose and necessity of these trips.

In developing countries the predominant influence is growth. Anything and everything must be viewed against this background. Cities are major engines of growth in most developing countries, and urban populations are expanding at a very high rate (more than 6 percent annually). At comparable levels of income, industrial countries had few motorized vehicles. However, stimulated by growing per capita urban income, and lack of public transport alternatives, ownership of motor vehicles is increasing in developing countries at a much faster rate than the space devoted to roads. (World Bank 1995).

3.1.1 Less Developed Country Applications

There have been many transport planning studies made in US and European cities. Almost all the research and study of transport planning has been in highly developed countries; characteristics in developing cities can be very different. Modern developing cities present a range of development characteristics, dynamic growth patterns, transport infrastructure and operations, and social customs which defy all but the broadest generalisations. As a guide for those unfamiliar to the subject, the following main points provide some indication of the main issues and how they influence MRT choice. (Based on various references including Maunder(1986), World Bank(1995), Gardner(1993)).

City Structure and Urban Form

- Many developing cities, even some of the very largest, are of mono-centric spatial form.
- Limited resources encourages a compact structure
- A sizeable proportion of work trips are focussed on the city centre
- Some light industry may also be centrally located,
- Strong emphasis on radial movements towards the city centre

Transport Planning and Land Use

- The structure of urban areas differs. Frequently higher income earners live in the city rather than the suburbs
- There is not, physically, as much road space and roads are not always planned and

designed for efficient traffic use.

- The roads are called upon to perform a wide variety of functions which includes non-traffic use (for example, the coexistence of market stalls and through traffic on the same road space). Segregated footpaths are often poorly provided or used for other purposes, forcing pedestrians to use the roadway.

Mode Choice and Traffic Management

- A high proportion of the total trips made is on public transport, which has a high proportion of 'captive' riders due to low car ownership.
- Vehicle growth rates are very high (although from a low base).
- Vehicle mix can cover a wide range of types and characteristics, from bicycles and ox-carts to articulated trucks.
- Driver behaviour may be incompatible with the control techniques which have been developed; lane discipline and observance of signals are poor, while gap acceptance may be unsafe.
- Maintenance facilities and expertise for high technology equipment are limited.

Institutional

- Workers in the transport sector are predominantly government employees, and often without a professional career structure.
- The police and other regulatory bodies are seldom resourced sufficiently for effective enforcement of traffic related offences.
- There is little accumulated experience of modern traffic control equipment and strategies amongst police and engineers.
- Users spend a relatively high proportion of their income on transport. The political implications of high fares are thus enhanced
- Perhaps most importantly, the institutional framework for encouraging efficient highway use is often lacking.

Socio-Economic Characteristics

- Population growth slowing but rates of 4 per cent per annum are still common.
- Trend still towards urbanisation with small cities growing and large cities spreading
- Extended families and high birth rates give high average size of household
- Low incomes means low car ownership

- Little travel for leisure takes place

Each of these factors will determine the transport options required, but will also influence the probability of appropriate transport planning methods being successfully transferred to developing cities.

3.2 Theoretical Demand Patterns

As an indication of the impact of city form on travel demand, Table 1 presents projected estimates of total corridor flows for different city size and structure. In this analysis, cities are categorised as having one of three basic forms: circular, semicircular (where, for example, the city abuts onto sea) and linear. They are also subdivided by spatial structure: mono-centric (single, dominant central focus) and uniform poly-centric (with equal employment opportunities at both the centre and in a number of surrounding sub-centres). For any given city size, corridor flows are highest in mono-centric cities.

TABLE 1 ESTIMATED RADIAL CORRIDOR LOADINGS FOR DIFFERENT CITY FORMS (AFTER GOI, 1987).

Population (m)	*Corridor length (km)*	*Uniform, poly-centric: trips per day (m)*	*Mono-centric: trips per day (m)*
Circular cities			
>8	*15.18*	*4.7-9.6*	
4.0-8.0	*10.31*	*2.0-5.2*	
2.0-4.0	*7.29*	*1.0-1.9*	*1.0-3.4*
1.0-2.0	*5.15*	*0.4-0.8*	*0.4-1.5*
0.5-1.0	*3.64*	*0.2-0.40*	*0.2-0.7*
<0.5	*2.58*	*<0.1*	*<0.1*

Population (m)	*Corridor length (km)*	*Uniform, poly-centric: trips per day (m)*	*Mono-centric: trips per day (m)*
Semi-circular cities			
>8.0	*21.5*	*4.6-11.8*	
4.0-8.0	*14.6*	*2.0-5.4*	
2.0-4.0	*10.0*	*1.0-2.6*	*1.0-3.4*
1.0-2.0	*7.3*	*0.4-1.1*	*0.4-1.5*
0.5-1.0	*5.2*	*0.2-0.4*	*0.2-0.6*
<0.5	*3.6*	*<0.1*	*<0.1*
Linear cities			
>8.0	*61.5*	*1.5-7.6*	
4.0-8.0	*28.4*	*0.7-3.4*	
2.0-4.0	*14.2*	*0.3-1.6*	*0.3-1.7*
1.0-2.0	*7.1*	*0.1-0.7*	*0.1-0.8*
0.5-1.0	*3.6*	*0.1-0.3*	*0.1-0.3*
<0.5	*1.8*	*<0.1*	*<0.1*

This Table can be used to gain an approximate estimate of likely peak-hour, directional flows. For example, a circular city will typically have 6-8 radial corridors and peak hour directional flows which are 6 per cent of total daily flow; such a city with 3 million population would experience individual average peak-hour directional flows of between 10,000-30,000 passengers (six corridors), or 8,000-20,000 passengers (eight corridors). It is difficult to be precise, but the likelihood is that once a city reaches a population of 2-3 million, it will have at least one corridor which will require mass-transit facilities.

This notion is supported from a conceptual approach to the estimation of how many central area jobs can be sustained by a road-based transport system (with no priority track). It has been estimated (UN, 1993) that an ordinary bus service, supported by some private traffic, could feed 0.25 million travellers into a city centre during a 2.5 hour peak period; these, together with those workers resident in the city centre, would probably be generated by a city of about 2 million population. Larger cities would require a higher capacity transport system to support growth in employment at the city centre.

Because of its importance in everyday life, public transport receives a good deal of attention from local government. This usually takes the form of strong regulatory controls, particularly in respect of fare levels and subsidies to public-sector operators. It is not unknown for public disturbances to follow increases in bus fares which are seen as an important basic need for poor people (Armstrong-Wright, 1993).

3.3 Other modes

Walking, as a mode of transport, is limited in range by both its speed and energy requirement. Few trips of more than 5 km are made regularly. Even so, walking is a major mode of travel and can account for between 20 to 40 per cent of trips, or more if short trips are included (travel surveys often exclude very short trips). The impact of walking on travel demand derives from the numbers of the population who are dependent on it. Therefore, the limitations of walking are very powerful in the planning of local amenities and the transport network.

People in urban areas are very reluctant to walk more than 600m to a transport interchange, and bus stop spacings of around 400m reflect the walking limitations (White, 1995). This has an important influence on access to a mass transit system since a single line metro, for example, will have a catchment area of those living only within a 600m strip of the track, unless suitable transfer and integration methods can be put in place. Although they attract passengers from a narrower ‘strip’ of 400m, buses can separate to penetrate into the areas of highest demand before joining a busway for the section with highest need. Competing paratransit services have an even greater advantage in that a ‘hail and ride’ service offers potentially zero walk distances.

While personal vehicle ownership levels in developing countries are typically one tenth of ownership levels in the industrialised world, growth in motor vehicle numbers is high and congestion in large city centres is as bad as in any developed city (Thomson, 1983). Cars are mainly owned and operated by higher income groups. The burgeoning middle-income groups are also acquiring cars or motorcycles in increasing numbers. The impact of the private vehicle on the transport system seems to be immense, despite the fact that its share in modal choice is usually quite small. Most major urban transport infrastructure projects are designed to ease the flow of road traffic, a large proportion of which is made up of personal motor-vehicles (eg. The report on flyovers in Bangalore in the New Civil Engineer, 1998).

The impact of the car in developing cities over the next decade is likely to be substantial. Among the impacts will be a move towards decentralisation, and potentially an increase in the number of people regarding roadspace as their 'right'. Removing this roadspace (relatively easy when the first Brazilian busways were built) will then become exceedingly difficult.

3.4 Developed Cities

Trends in developed cities can be seen in a report published by Newman and Kenworthy (1991). This found an increasing tendency for cities to spread out over larger areas, and for employment densities to be falling in the traditional city centres accompanied by an increase in energy consumption.

Hall (1992) has looked at settlement patterns in and around London over the past forty years. He found what he described as a 'doughnut effect'. The population of the middle of London has been going down. The population of areas on the periphery, such as Bracknell, Milton Keynes and even as far away as Southampton increased, especially during the economic growth of the 1980s. Initially, workers will commute back to the city centre from their new homes in the suburbs. This is an unpopular practice, and eventually new employment will develop in the outer suburbs. Many people in Bracknell, for example, who used to work in London now travel only as far as Wokingham or Camberley, four or five miles away on B-class roads. The trip distribution pattern in cities like this no longer resembles a tree in which trunk movements are supportive of a high capacity mode. Instead a trip plot has been described (Hall, 1992) as looking like a box of matches dropped on the

floor. It is difficult to imagine any form of existing public transport being able to cope with these multiple trip destinations.

Although the 1980s saw some growth in the number of rail projects in the UK, the latest UK transport white paper has started to play down the importance of LRT saying that “less expensive solutions should be sought” (DETR, 1998).

3.5 Transportation Summary

Developing cities present a range of development characteristics, dynamic growth patterns, transport infrastructure and operations, and social customs which defy all but the broadest generalisations. Even so, it is important to try to understand the processes and interactions which

drive transport demand if transport planners are to contribute positively to the general debate about urban development.

Unlike developed cities where the need for a transit system is to be attractive to car owners, the main need in developing cities is to cope with high capacities.

As cities become larger travel demand grows and trip movements become focussed on corridors feeding into the city centre. Once a city reaches a population of about 2-3 million (increasingly common in developing countries) corridor flows will have reached around 20,000 passengers per hour per peak direction and will thus justify some form of mass transit system.

Bus public transport, potentially the most efficient carrier and that which serves the majority of travellers, suffers in competition with increasing car usage and because of low institutional capacity. It cannot deliver an effective service in these conditions; journey times and waiting times are long, irregular and unreliable. This increases operating costs and hence ticket prices to socially unacceptable levels.

The implications for the hypotheses are that even if busway and LRT prove to be technically similar, busway transit will be at a perceived disadvantage. This is because buses have a poor image and have suffered at the hands of increasing congestion, poor investment and low institutional capacity.

Ultimately, if the transport system cannot respond to these pressures, then other land-use developments may take control, leading to unstructured and diffuse city growth, and even the atrophy of the city centre. In order to sustain city centre growth, and accommodate the associated high levels of corridor travel, developing cities will need a very high capacity system, capable of satisfying a large and growing demand, particularly from low income people.

Regarding the appraisal hypothesis, there is a clear need to consider not just the local performance of a mass transit system, but also its wider impact on city structure and growth. It is not entirely obvious that a very high growth in trips that will support a mass transit service is necessarily a ‘good’ thing.

1.6 The Aid Funding of Projects

There has been rapid and continuing growth in the proposals for urban rail projects throughout the world (fig 3). Many of these proposals are from countries which have little hope of affording such

projects using entirely their own resources. As such, the availability of aid funding will be a crucial factor in determining whether a project gets built or not. It therefore has implications for the main hypotheses of this research.

One aim of this research is to increase the understanding of mass transit investment. The most direct, and most achievable, practical contribution of the research would arise from the improvement of the current UK practice in aid funding for large transport infrastructure projects. This section sets out the main points about international aid as it relates to mass transit funding.

FIG 3: The Demand for Urban Rail has been growing steadily and is now including many cities in low-income countries.

1.6.1 Aid Issues Background

Aid as a percentage of GNP in countries that are members of the OECD Development Assistance Committee (DAC) averaged 0.25% for 1995 (down from 0.31% in 1991). Donors vary widely from the average - from 0.20% for the United States to around 1% each for Denmark, Norway, and Sweden. While some countries, such as Finland, France, Japan,

and Switzerland, have raised their Aid/GNP ratios over the past decade, others, such as the United States, have reduced their aid in real terms. The total amount of aid money is around $55Bn and, of this, the largest proportion (13.7%) went to a category entitled transport and communication (German et al, 1998; DfID, 1998).

The structure of the UK aid effort changed during the course of this research. Until 1997 the Conservative government had an Overseas Development Administration (ODA), essentially a wing of the Foreign and Commonwealth Office. The incoming Labour administration then changed this to a full government Department for International Development (DfID) with cabinet status. There was also a change in stated objectives.

ODA aims included (ODA, 1993):

- to encourage sound development policies, efficient markets and good government;
- to enhance productive capacity and to conserve the environment; and
- to promote international policies for sustainable development and enhance the effectiveness of multilateral development institutions.

The DfID approach had overlapping general aims on health and education but was more focussed on the alleviation of poverty, with a stated aim to:

> "Refocus our international development efforts on the elimination of poverty and encouragement of economic growth which benefits the poor. We will do this through support for international sustainable development targets and policies which create sustainable livelihoods for poor people, promote human development and conserve the environment."(DfID, 1998)

The International Bank for Reconstruction and Development 'The World Bank', was set up after the Second World War to finance the rebuilding of Europe and is now the foremost international development institution. As the centre of development orthodoxy it is the primary actor in the propagation and dissemination of ideas about development, although as its critics say "on such issues as the lending capacity and the governing strategy of the bank, the only relevant debate was that within the United States" (Kieger, 1993). IBRD loans tend to be concentrated on higher income borrowers, commonly regarded as more credit-worthy.

There are two main types of aid funding:

Bilateral aid is normally provided under country programmes in response to official requests from individual recipient governments. It can also be used to finance activities including, for example, research and development projects, or support for a wide range of organisations working in fields related to developing countries, where more than one country may benefit.

Multilateral aid consists of contributions to international institutions (such as the World Bank, European Community and United Nations agencies) for use in, or on behalf of, developing countries.

In addition to money for capital projects, both bilateral and multilateral aid can be provided in the form of **Financial aid** or **Technical Cooperation**. Many projects or programmes will in fact involve a combination of both.

Aid has many advantages, although some disadvantages identified by ODA(1993) include:

A. The danger of the recipient perceiving the aid as "free" goods. For example, recipients of "free" equipment may be less alert to the need for sound maintenance than if they had to pay for it.
B. By supplying aid directly to the recipient body, and bypassing the central budgetary mechanism, aid can distort the central financial planning and management process. It reduces indigenous control of funds.
C. By undertaking all the organisation, procurement and delivery of goods and services, the giver takes away much of the feeling of ownership of the arrangements underpinning the project. The recipient government or agency may not feel the same commitment to the project as to one for which it has been more closely responsible.

ODA also remarked that " It is especially important that the technology used best fits the needs and circumstances of the beneficiaries of the project, and that target groups have been fully involved in project design. Special attention should be paid too to cross-cutting issues, including for example social, institutional and environmental factors." (ODA, 1993)

1.6.1.1 Disbursement

Disbursement is the term used to describe the action of getting the money processed through administrative systems from donor country to recipient. For very straightforward projects in countries with efficient administrations then this is easy. For projects that are in some way unusual, or for countries with a poor record for aid abuse, then it can be a considerable task. This can lead to one of the key (and unspoken) problems in aid giving, namely that it can be quite hard to physically give away enough money. DfID, for example, has 1650 staff and yet aims to give more than £2bn (DfID, 1998). Staff levels in all aid agencies are kept low, perhaps so as to avoid potentially embarrassing publicity on the ratio between the amount given away and the amount spent on administration. This may partially explain why multilateral aid is attractive for an organisation like DfID, in that it can pass on the problems of disbursement to organisations such as the EU. One problem with this approach is that, as (German & Randel, 1996) have discovered, there is some lack of transparency in multilateral disbursements between the EU and its member states.

The EU has become a key player relatively recently, but is already the second largest lender after the World Bank. The EU spends around 25% of its aid budget on transport facilities, including some very large projects. Despite having such large projects, underspending against commitments year on year is still a problem for the EU. This results in many member states clawing back allocations charged against EC development cooperation in their budgets, but never spent. This money does not, on the whole, re-enter a development cooperation budget, either bilaterally or multilaterally. The implications and the startling scale of this are explored by (German & Randel, 1996).

It can be seen that large projects in orderly cities with good project management structures set up (such as by a large consortium) will have an attraction for donor agencies' administrative staff.

1.6.2 Aid & Trade

A factor which is of central importance in the aid funding of large projects is the linking of aid to trade opportunities for businesses in the donor country. As an example, money given

to an African country might be on condition that they use it to buy British Land Rovers. This no longer exists in the UK, but is still pertinent to this research because other countries still consider it as a key part of their overseas aid. On average, 22% of all aid from OECD countries is given on the condition that it is used to purchase goods and services from the donor country (OECD, 1997).

Japan, as an example, was a major recipient of foreign aid only 30 years ago, but now has an Aid programme larger than that of the United States. In 1995 Japan was the world's largest international aid donor providing 14.49 billion US dollars. But Japan maintains one of the least concessional Aid programmes. This means that in terms of grants as a share of total Aid, Japan stood in 1995 at 46.6 percent compared with the average of 77.1% (UNDP, 1997).

Whatever the country offering an Aid and Trade Programme (ATP), a large number of countries tend to meet the economic criteria for ATP support, but in practice it gets concentrated on a limited group because:

a. Certain countries may be ineligible for any aid, including ATP, for political or other reasons (eg Iraq).

b. ATP is usually associated with export guarantees. If so, there must be sufficient cover available and some countries are "off-cover" because of the risks involved.

c. Because of the nature of ATP, it tends to be more suited to relatively better off developing countries; cases in least developed countries are rare.

It is noticeable that the concept of aid as a `competition' was evident even in the formal ODA procedures. The official aid manual included:

> "Projects must show a clear prospect of bringing benefits to UK industry and employment beyond the securing of the contract in question, either through follow-on business on normal commercial terms in the same country or elsewhere or through a demonstrable improvement in the competitiveness of the firm concerned" And "ATP began in 1977 as a response to the similar `competitive' actions of other countries." (ODA, 1993).

A large segment of aid money is therefore going to projects which are motivated/inspired by commercial interests. The process of securing ATP funding requires knowledge of and adeptness in formal administrative procedures, and often substantial lobbying of local and

foreign governments. Resources to do this might be unavailable outside of large multinational organisations.

1.6.3 Helsinki Agreement

In an attempt to control the use of aid to foster trade, the OECD has tried to introduce voluntary regulation. One OECD agreement, sometimes called the "Helsinki agreement," became effective in February 1992. The agreement did not attempt to eliminate tied aid but instead tried to minimize the trade distortions that could arise from its use. The agreement was designed to
(1) prohibit the use of tied aid for projects in countries whose per capita income was sufficiently high to make them ineligible for 17- or 20-year loans from the World Bank; (Examples of countries in this category are Argentina and Kuwait),
(2) restrict the use of tied aid for commercially viable projects (except for least-developed countries); (Examples of least-developed countries are Afghanistan and Bangladesh), and
(3) increase transparency (openness) about tied aid use by strengthening notification and consultation procedures.

Under the terms of the 1992 agreement, a participating member country planning to use tied aid must "notify" OECD. The agreement provides for a consultation process, during which other member countries may challenge the notifying country's tied aid offer if they believe it does not meet the agreement's guidelines. Once challenged, the initiating country must justify the use of tied aid to the member-countries opposing the offer on developmental grounds and show how the project does not meet the "commercial viability" test. A project is considered to be commercially viable if it is able to generate cash flow sufficient to cover the project's operating and capital costs (such as a power station) or if it can be financed by the private market or official export credits. A large public transport system that does not quite make a profit, therefore, is a good candidate for this type of funding.

Despite the Helsinki and other agreements, the aid world is rife with (unsupported) rumours about donor countries who do not always play by the rules.

1.6.4 New DfID Policies

The DfID White Paper (DfID 1998) has substantially shifted emphasis away from aid linked to trade. Instead it puts forward an approach that it says “recognises that overall private capital flows have come to dwarf official flows as a source of funds for development” even though they have so far focussed on only a few countries. According to the Financial Times of 27th January 1996 the total amount of private finance going to developing countries was $700bn between 1990-95 with around $170bn in 1995 alone. As the World Bank only controls $5bn directly, with leverage on a further $25bn, then its position is not as dominant as is often thought. In recognition of this, the World Bank now sees its role as that of a catalyst, using its funds to set up projects that will be taken onwards by others, or by the countries themselves.

The UK government states that there is a shared interest in a constructive approach between Government and business to support sustainable development. However, “Such an approach needs to avoid the distortion of development funds in pursuit of short-term commercial objectives, such as the previous government's support for the Pergau project or Westland helicopters. “(DfID, 1998).

There is an increasing emphasis being placed upon fair trade with developing countries through agreements related to the World Trade Organisation. According to the OECD (1997) the trade opportunities denied to developing regions by barriers are worth $221 billion per year - more than four times the current levels of aid. DfID in its first White Paper stated that “The Aid and Trade Provision (ATP) lacks poverty elimination as its central focus; no more applications will be accepted for ATP assistance, and the scheme will be closed.”(DfID, 1997).

The DfID cabinet minister Claire Short was attacked by the Conservatives and business leaders when she revealed she had refused to lobby for UK companies while on an overseas trip (BBC, 1998). Ms Short said she had gone to China to speak up for human rights and not to do deals for British exporters. She said civil servants had pressed her to put in a good word for several companies seeking contracts in China but she had declined. The Institute of Directors' policy chief, Ruth Lea, said she was "astounded and extremely disappointed" by Ms Short's remarks, and the Director General of the Institute of Exporters, Ian Campbell, condemned Ms Short's approach as simplistic, saying "Where we are giving substantial sums of money, as we are to certain developing countries, if that money is spent buying German

or Japanese or French goods, something is a bit adrift. If we are putting our aid into those countries, we would naturally in the business community expect to see some flow of business back from those donations."(BBC, 1998).

1.6.5 Aid Summary and Conclusions

The implications from the findings of this chapter on the hypotheses are:

Large transport projects in developing countries will almost inevitably need aid support.

Although receding in some countries (notably the UK) the tying of aid to trade is an important factor in world commerce

Large organisations are best placed to commit time to the necessary administration and lobbying needed to secure tied funds and this will favour rail promoters rather than bus projects.

Large organisations or consortia with efficient project management and supervision structures already set up will have appeal to aid organisations under pressure to disburse funds.

Conversely, a busway project will involve more local organisations and therefore will be institutionally more difficult to implement. The fact that there are usually separate companies responsible for 'track', bus stops and rolling stock means that there will not be a single powerful lobby to seek out and maximise tied aid opportunities.

4 THE MASS TRANSIT OPTIONS

4.1 Introduction

This chapter describes the three main options for mass transit in developing cities. The actual performance of each option is given, and estimates are made of the potential performance and on the suitability for developing city applications.

The wider research programme, of which this thesis forms part, evolved in stages as a deeper understanding was obtained of what function a mass transit is required to fulfill. The aim of the metro study (by Allport et al, 1990) was to:

- review the experience of building, planning and operating systems
- identify the conditions under which investment might be justified.

The literature review and visits during that study established conflicting views and contradictory information regarding the relative performance of alternatives to metros, particularly busways. Hence the objectives for the next stage (Gardner et al, 1991) were:

- to measure the performance of existing high-capacity bus schemes;
- to determine the key factors which influence performance, and hence
- predict the likely performance of other busway schemes.

The need for a third stage arose as the busway study began to suggest that a well-designed busway might be able to carry more passengers than an Light Rail Transit system. This counter-intuitive suggestion was contrary to almost all of the available literature. The final objectives of the overall research programme were therefore (Gardner et al, 1994):

- to measure the performance of existing LRT schemes;
- to determine the key factors which influence performance, and hence
- to establish the conditions under which LRT would be preferable to a busway.

As explained in section 1 the research for the thesis presented here concentrates on the Light Rail option, though the analysis of the busway data (collected by the author) also took place within the duration of the M.Phil. study. The funder of the research required a comparison to be made with previous work on metros by Fouracre et al (1990).

The aim of this chapter, therefore is:

- To present the latest knowledge on all of the mass transit options in order to set the context;
- to present factual information on the performance of busway and LRT;
- to compare busway and LRT in order to test the first hypothesis about their relative merits.

4.2 Metros

A Metro is a term used to describe metropolitan railways, usually with large sections segregated by means of underground or overhead construction. The most important review of metros made in recent years was the study by HFA consultants and TRL published as Allport and Thomson (1990) and summarised as Fouracre et al (1990). Although published nearly ten years ago, there has not been any subsequent follow up of this work. The report presents the findings of a worldwide study involving observations and data collected in 21 developing cities, and the analysis of that data using a strategic transport evaluation model. It explores the hopes expressed for metros, and the reality - particularly the common misconception that they will "cure" traffic congestion.

4.2.1 Metro Case Study Cities

Case studies were made in 21 developing cities covering a wide geographic, demographic and economic range. All contained more than a million people and most more than 3 million, and they included many of the world's largest cities. They included Singapore and Hong Kong, which are no longer developing cities but were classed as such when they started planning their metros.

Of the 21 cities, eight had metro systems with several years of operation - Hong Kong, Manila (an elevated LRT), Mexico City, Porto Alegre, Rio de Janeiro, Santiago, Sao Paulo and Seoul; 5 had systems that were incomplete but whose first stages had started revenue service - Cairo, Calcutta, Pusan, Singapore and Tunis (actually an LRT); 2 had metros under construction - Istanbul and Medellin; in the remaining 6 the systems were still in the planning stage - Bogota, Bombay, Delhi, Jakarta, Karachi and Kuala Lumpur. This meant there were 13 cities whose experience could be used as a quarry of material for case studies

of metro implementation and its social and economic impacts, while a further 8 cities added to the information about the basis on which metro systems were planned.

4.2.2 Planning and Land Use

Where the metro was located had a strong influence on the numbers of people travelling on the system. Misplacing the alignment by only 600m or 800m from an important destination such as the city centre could result in a substantial loss of patronage. Only a few city authorities provided evidence of measures to help build up metro patronage by planning for high-density housing development in the metro corridor or encouraging the growth of employment centres to be served by the metro. The clearest examples were in Hong Kong and Singapore, where the importance of integrated land use and transport planning has long been recognised as a means to obtaining a more efficient structure of development and a better match between social needs and transport supply. In some cities there were expectations that new urban development would follow the arrival of the metro, but these were often based on broad-brush strategies for distant planning horizons.

Most of the faults with the metros studied arose during their planning. Feasibility studies were sometimes not made, or were made badly, or had little influence on the system eventually built.

There were several examples of systems where the choice of route appeared to be at fault, since the metro either failed to penetrate the city centre, or was badly oriented in relation to high-density residential areas and key destinations, hence incurred the costs of an indirect alignment without gaining any offsetting benefits (in other words trying to save money by avoiding the city centre). Sometimes this, the worst error which can be made in developing a metro, occurred because transport planning was poor, and sometimes cost savings were sought in the face of financing problems without recognition of the major reduction in benefits. No example was found anywhere of a non-radial metro line with high levels of patronage, except for distributor lines within the city centre itself.

In almost all the cities, a clear distinction had been made between the ownership of the metro and its management. While ownership was in the hands of government, at either national, regional or metropolitan level, a new organisation - usually a public corporation - had been established to manage and operate the metro. It was generally recognised that this

organisation would work best if it were independent of existing transport operators and free of their vested interests and inherited attitudes to work practices and management procedures. But the independence of the metro operating agencies was inevitably limited by the fact that none of the metros were financially fully self-supporting.

4.2.3 Operational Performance

There were metro systems in revenue service in 13 of the cities studied, but only 5 of them - Hong Kong, Mexico City, Santiago, Sao Paulo and Seoul - had well-established networks. The others had opened only shortly before the date of study or were still incomplete, and so had not had time to build up their ridership to levels that could be regarded as fully representative of the demand.

Table 2 sets out basic estimates of metro ridership and related performance indicators as known at the time of the study. The established networks showed a wide variation both in estimated annual ridership (from 139m passengers in Santiago to 1450m in Mexico City) and in peak hourly flows (from 20,000 p/h/d in Santiago to 81,000 p/h/d in Hong Kong). The ridership statistics are dominated by the performance of the Mexico City metro: with average daily boardings of more than 4.5m, it carried more than twice as many passengers as the London Underground, and its ridership was surpassed only by that of the Moscow and Tokyo metros. The Hong Kong MTR and the metros in Sao Paulo and Seoul also rank among the world's largest in terms of passenger demand.

TABLE 2. INDICATORS OF METRO SYSTEM OPERATIONAL PERFORMANCE (FOURACRE ET AL, 1990)

System	Passengers carried Total p.a (millions)	Peak Per route km (millions)	Average Directional Load 000's/hour[5]	Average Commercial Speed Km/hr	Peak Trip	
					Length km	Headway min/sec
Cairo	150[3]	5.3	22[3]	..	9 app	7'30"[4]
Calcutta	19	1.9	5 approx	33	6 app	12'

Hong Kong	532	13.8	81	33	9.3	2'
Mexico City	1450[2]	11.0	65	35	9 app	1'55"
Porto Alegre	36	1.3	11 approx	41	11.1	6'
Pusan	79	3.7	13	32	7.6	5'
Rio de J.[1]	108	5.3	22		5.0	5'
- Line 1 only	102	9.1		29		
Santiago	139	5.3	20	32	5.4	2'40"
Sao Paulo	465	17.2	57	29-38	7.2	1'45"
Seoul	854	7.3	?	36.5	8.9	3'
Singapore[3]	80[2]	3.2	14	..	?	?

1. *1988 data (else 1987)*
2. *estimated from daily figures*
3. *estimates for 1988*
4. *early reduction to 6' planned*
5. *at the busiest section of the route*

The passenger/route km ratio gives an indication of how intensively the system was used. The Sao Paulo metro and Hong Kong MTR produced annual utilisation rates of over 17m and 13.8m passengers per route km respectively, making the Sao Paulo system the most intensively used metro in the world. Line 1 of the Mexico City metro recorded a rate of about 24m passengers per route km, probably the highest annual utilisation rate of any metro line in the world. By way of comparison, the world's two most extensive systems in terms of route length - London and New York - had rates of only 1.4m and 2.9m passengers/km respectively, while the smaller systems in other European cities typically attracted between 2m and 6m passengers per route km. If operational success is measured on the basis of utilisation, the metros in Sao Paulo, Hong Kong and Mexico City must be regarded as highly successful, while those in Seoul, Rio de Janeiro (Line 1) Manila, Santiago and Cairo have also performed well by international standards.

Peak hourly loads had reached the capacity limits of the systems in Hong Kong, Mexico City and Sao Paulo. Capacity was greater on the Hong Kong MTR than on the other heavily loaded metros because it used longer and wider trains, though the shortest peak headways (105 seconds) were recorded in Sao

Paulo. The peak directional load of 81,000 p/h/d reported from Hong Kong may represent the practical limit on full metro technology.

Table 2 also records peak headways. On most full metro systems the aim is to maintain headways of no longer than about 2 minutes in the peaks. Only in Sao Paulo, where at key stations passengers simultaneously alight and board from platforms either side of the car, are peak headways of 1.75 minutes achieved consistently over the peak period. Intervals of 2 minutes or less were recorded only on the three large systems operating at the limits of their practical capacity. Elsewhere peak headways ranged from 2½ minutes to 12 minutes Overcrowding in the peaks was common on most metros, and in some, notably Mexico City and Hong Kong, it was a cause for concern.

4.2.4 Passenger Attraction

In each of the cities studied, the metro system carried only a modest proportion of the total public transport passengers. The Mexico City metro was estimated to serve 35% of all passengers within the Distrito Federal, which includes less than half the population of the metropolitan area; in Santiago the proportion was 15%, and in Sao Paulo 12.6% (1986 estimate - the metro organisation claims that the proportion had risen to 14.8% by 1988).

The extent to which metro passengers in each city had switched from bus, car or other modes of transport can be judged only from detailed survey data, which were generally not available. Such information as Fouracre et al (1990) were able to obtain suggested that the situation varied widely between systems and that the degree of passenger attraction from the bus system, for example, was influenced principally by specific local factors. It was evident though that none of the metros had attracted more than a very small proportion of motorists: surveys in Porto Alegre shortly after the metro opened indicated that only 4% of the passengers had formerly travelled by car, while a survey taken in Sao Paulo suggested that only 1% of metro passengers arrived at the station by car.

For most cities the actual patronage for the metro was well below that originally forecast. Table 3 gives estimates of the extent to which there has been a shortfall. Only in Manila and Tunis has the forecast traffic been approximately achieved, while in Calcutta, Porto Alegre, Rio de Janeiro, Santiago, Pusan, and even Seoul, patronage has been well below target.

TABLE 3: SHOWING THE RELATIONSHIP BETWEEN PREDICTIONS AND ACTUALITIES (FOURACRE ET AL, 1990)

a) Outturn patronage

Percent difference from target	Number of cities
As forecast	1
0 to -20	1
-20 to -50	2
-50 to -60	2
-60 to -70	2
-70 to -90	1

b) Metro integration in the case study cities

	Planned	Achieved
Integrated fares	6	5(1)
New feeder routes	12	9(2)
Removal of competing bus routes	13	3(3)

Notes: (1).=significant in only 3 cases (2)= significant in 5 cases (3)=significant in only 2 cases

The reasons why patronage has fallen short of expectations on many lines stems largely from over-optimism in the planning phases: because integration has not been achieved on the scale expected, passengers have not been forced to use the metro as planners intended; private vehicle users have not switched to using the metro in the number expected; there has not been the growth in population or economic wealth that was predicted, and in some cases, as noted earlier, the alignment of the metro was poorly selected, which has been reflected in poor catchment.

4.2.5 Metro Conclusions

Fouracre et al (1990) conclude

> "while there is much to praise in the engineering and operation of Third World metros, much criticism can be justifiably be levelled at their planning and financial management. Few, if any, of them can be financially viable, but can give good economic returns in the right conditions. ...Since metros are highly expensive to build, they can place an enormous, long-term financial burden on administrations that have only limited investment resources, without ever yielding the benefits predicted for them. And in many cities that opt for a metro system, there may well be other development projects and programmes which a careful evaluation would reveal to have higher priority in terms of both the use of public sector funds and the likely return on investment". (Fouracre et al 1990).

The report suggests that what governments are appearing to do is to take for granted the benefits of building a metro, while at the same time ignoring the risks of the project and making optimistic assumptions about its affordability, the capability of implementing it on time and within budget, its effects on traffic conditions and its impacts on urban development.

Fouracre et al also conclude

> "A metro is an enormous investment for a developing city. Clearly it should not be built until other ways of solving the same problems have been properly studied. Bus lanes and other bus priorities, purpose-built busways, improvements to the road network (short of wholesale expansion), light rail systems, parking controls and various types of traffic restraint: all may help to solve - at much lower cost - the problems of ineffective bus services and traffic congestion. However ... there is a paucity of examples of the main public transport options to the metro being successfully implemented".Fouracre et al (1990)

It was this that led to the research programme being extended to cover the light mass transit modes.

4.3 Busways

Buses, which are the dominant form of public transport in most developing cities, are locked in the traffic congestion that constantly threatens the World's cities, and hence frequently fail to deliver an acceptable service. In order to free buses from this congestion, several cities have introduced innovative systems for providing a segregated running lane for buses. Such systems have many potential benefits, but relatively little is known about how well they perform.

The research described here began with the objectives to review the performance of existing bus priority systems, to determine their appropriateness and scope for general application and to establish relationships between passenger demand, design features and operation.

The impact of Bus Priority on general traffic is dependent upon the specific layout of a city's road network, and must be examined using standard transport planning techniques. This has been discussed elsewhere (for example by Holman et al (1991)) and was not included in the present study.

As many popular misconceptions exist over the capacity of buses relative to rail-based systems, a high emphasis was placed upon case study measurement of 8 busway schemes (Table 4). To ensure accuracy, all surveys were personally supervised by a member of a study team including the author and the consultants TTC.

TABLE 4: PHYSICAL CHARACTERISTICS OF BUSWAYS SURVEYED (Gardner et al, 1990)

CITY	LOCATION	LENGTH (KM)	AVERAGE STOP SPACING (m)	AVERAGE JUNCTION SPACING (m)	SPECIAL FEATURES
Abidjan	Bv Republique	1.27	400	160	none
Ankara	Besevler-	3.6	310	410	none
B.	Av. C Machado	8.57	610	920	overtaking at
Curitiba	Eixo Sul	9.5	430	430	trunk and feeder
Istanbul	Taksim-	2.27	310	410	none
Porto	Assis Brasil	4.5	580	410	bus ordering
Porto	Farrapos	2.8	560	390	bus ordering
Sao Paulo	Av. 9 de Julho	7.9	600	530	overtaking at

_ All median systems except Abidjan (lateral) and Istanbul (mixed).

4.3.1 Busway Features

The concept of a bus-lane is well-known, being an area of road space reserved for buses only by the use of paint and signs. This gives buses priority over other vehicles, leading to fewer delays, especially on the approach to junctions. A 'Busway' (as shown in Plate 3) includes some form of physical segregation.

A variety of layouts are possible, including 'lateral' busways in the nearside lane, and 'median' busways usually occupying the central reserve of a dual-carriageway. A typical busway might extend for 1 to 10 km, incorporating several stops and junctions. Bus stops for median busways are in the centre of the road, having pedestrian crossings to ensure safety.

In order to achieve high performance and to realise the full potential of a busway, good design, complemented by operational and management measures are necessary. With very high flows, management measures are also needed to ensure that buses at either end of the busway are fed into the normal street network, or into a terminal area with maximum efficiency.

General traffic may require diversion, but will usually travel alongside the busway, with crossing movements restricted using 'G' or 'Q' turns. In some cases, special detectors enable buses to be given preferential treatment at traffic signals. With very heavy flows, however, buses can arrive at a rate of one every fifteen seconds, producing a constant 'call' which renders simple vehicle actuation inoperative.

Plate 3: A Modern Median Busway in Sao Paulo, Brazil (above)

Plate 4: A Busy bus stop on the busway in Ankara (below)

Busway Transit is the term used to describe busway schemes which include a package of performance enhancing operational and design features to provide a full mass transit system. A Busway Transit system might have many of the attributes of a Metro, that is; fixed routes which are clearly named (for example 'central line', 'green line' etc.) dedicated named station/stops, and a corporate image for vehicles, timetables, publicity material etc.

4.3.2 Busway Performance:

On each of the case study busways, synchronised watches and number-plate matching techniques at points 1-5km apart, were used to measure speeds. Occupancies were measured on a 7-point scale, with judgements, where required, tending towards under-estimation. Key indicators of the performance of the busways are shown in Table 5.

TABLE 5: MAXIMUM SUSTAINED PEAK HOUR BUS FLOWS ALONG BUSWAY LINKS (Gardner et al, 1990)

CITY	PEAK PERIOD (AM/PM)	BUSES/HOUR DIRECTION	SPEED (Km/h)
Abidjan	AM	172	9.25
	PM	190	11.25
Ankara	AM	88	13.67
	PM	62	8.54
Belo Horizonte	AM	100	28.69
	PM	147	24.34
Curitiba	AM	87	21.38
	PM	71	21.01
Istanbul	AM	159	16.35
	PM	123	11.55
Assis Brasil	AM	303	21.55
	PM	249	17.26
Farapos	AM	356	19.87
	PM	286	17.71
Sao Paulo	AM	207	18.85
	PM	197	17.29

Bus Flows : Peak hourly bus flows per lane per direction ranged from 91 to 378 /hour in the morning peak and from 80 to 304 /hour during the evening peak. Maximum flows exceeded 200 /hour at 5 of the sites, and exceeded 300 /hour at two sites. This corresponds to a

maximum recorded number of available passenger places of 39,400 /hour (during the morning peak - taking nominal bus capacities, not crush loading).

Passenger Flows: The maximum recorded line-haul passenger throughput was 26,100 passengers per hour per direction (p/h/d) on Assis Brasil, Porto Alegre (during the morning peak when passengers at the busy city centre bus stops were predominantly alighting). The highest evening peak passenger throughputs were recorded in Sao Paulo (20,300 p/h/d) where an overtaking lane at bus stops facilitates high throughputs at acceptable speeds.

The highest recorded passenger throughput on a basic busway, ie. one without any special operational measures was 19,500 p/h/d in the predominantly boarding direction in Abidjan .This occurred under conditions of extensive bus queuing and severe crush loading during the evening peak.

Bus Speeds: Average bus commercial speeds along the case study busways ranged from 12.0 to 24.6 kmph during the morning peak and from 8.0 to 29.3 kmph during the evening peak (table 5). Bus stop and intersection spacing, and the provision of special operating features, would appear to be the main influence on bus speeds.

In the three city-centre sites, where stops and junctions occur frequently, average speeds were around 11 kmph. On the suburban busways, where longer distances exist between stops and intersections, averages of around 21 kmph were achieved. The suburban busways also tended to have special operating features.

4.3.3 Special Operational Measures

The study revealed that certain physical and operational characteristics are linked to busway performance. These include:

Trunk and Feeder Services. With trunk-and-feeder services, very short headways are used on the trunk routes on the busway, with other services re-routed to feed terminals at the end of the busway, rather than travelling through to the city centre.

As all passengers use the same trunk service, all passengers board the next arriving bus, each bus fills up, and very high load factors (ie. passengers carried/nominal capacity) can be

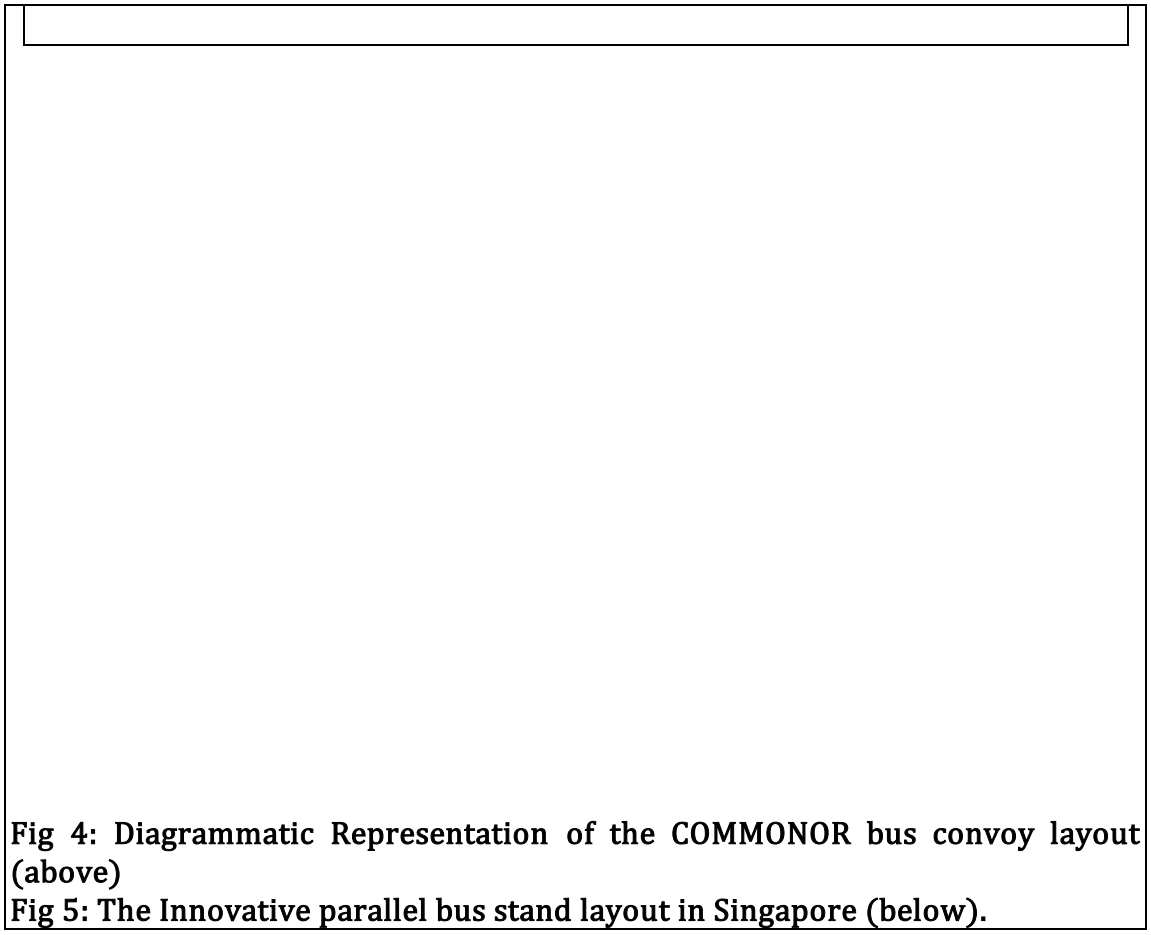


Fig 4: Diagrammatic Representation of the COMMONOR bus convoy layout (above)
Fig 5: The Innovative parallel bus stand layout in Singapore (below).

achieved. The limited number of routes, however, does result in enforced interchange for many passengers using the feeder buses, or a limited choice of destinations.

In Curitiba, these terminals are 'enclosed', such that tickets are purchased at the entry to the terminal, rather than on the bus. This reduces boarding times and provides free transfer for those interchanging inside the closed area.

COMMONOR or Bus Ordering: COMMONOR is a technique which involves assembling buses at the start of the busway into a sequence corresponding to the route and stand order at individual bus stops along the busway (Szasz, 1974). Buses then proceed along the Busway in a manner similar to a train, boarding of buses at all stands takes place concurrently, thus coordinating the time lost through deceleration etc. and reducing the queuing time associated with loading buses at the first stand holding up all others. (Fig 4)

COMMONOR was not in full operation during the present study, but the less formal bus ordering system which existed in Porto Alegre, whereby buses are assembled in a regular order, but not necessarily grouped into complete convoys, was associated with better performance than might otherwise have been expected.

4.3.4 Performance of Bus Stops

Plate 4 shows a very busy bus stop in Ankara which handles more than 4000 passengers in the peak hour (this is more than many stations on the London Underground). As buses usually have only one or two doors available to boarding passengers, passenger movements at stops have a large influence on line-haul performance. As the numbers of boarding/alighting passengers increase, so bus dwell times at stops increase, and this causes capacity limitation.

Bus Stop Surveys; A number of key bus stops were selected for detailed investigation. These were mostly on the case-study busways, but additional surveys took place at stops which had particularly interesting features, such as in Singapore (fig 5) and Hong Kong. The time of arrival at the approach and of the exit from the stop was noted, the times that the doors opened and closed were taken, and the number of passengers boarding and alighting was counted on a sample basis.

Passenger Flows and Travel Times; Three categories of bus stops were identified in the study, according to the number of passengers handled;

- "Very high volume" stops: - typically at city centre locations, with either boardings or alightings greater than or equal to 2,500 /hour;
- "High volume" stops: - typically in local centres, with maximum boardings or alightings less than 2,500 but greater than or equal to 1,000 /hour; and
- "Moderate volume" stops: - with both boardings and alightings less than 1,000 /hour.

(Note that these all represent extremely high volumes when compared to most European or American bus stops.)

Travel time was defined as from the moment the bus arrived at the queuing area, until it cleared the last bus stand. Large variations were found at each site: mean travel times varied

from 26 to 203 seconds and loading/unloading (ie door open to door close) times varied from 11 to 109 seconds.

Table 6: Bus Travel Times Through Selected Bus Stops

City	Location	Hour From	Pass/Hour Boarding	Alighting	Buses/ Hour	Bus Travel Times Mean (secs)	Total Dwell Time Mean (secs)	Loading/ Unloading Time (secs) Mean	% Travel Time At Stop	% time Loading/ Unloading
VERY HIGH VOLUME:										
B OR A>2500										
Ankara	Kizilay (westbound)	1700	3345	1020	61	203	172.5	109.1	85	54
Bangkok	Victory Monument	1715	3050	1905	267	66	29.4	28.2	45	4
Singapore	Raffle's Quay	0800	620	4190	308	44	23.1	20.7	53	47
Istanbul	Osmanbey	0830	380	4020	139	60	35.2	28	59	47
Bangkok	Ratchaprarop	0700	2140	3735	171	88	27.1	23.6	31	27
Ankara	Kizilay (eastbound)	1730	2880	3135	72	176	149.2	108.4	85	62
HIGH VOLUME:										
1000< MAX B OR A <2500										
Istanbul	Osmanbey	1745	2265	565	120	187	184.4	71.7	99	38
Sao Paulo	Estados Unidos	1745	1055	165	166	37	23.8	22.4	64	61
Istanbul	Harbiye	1745	1000	445	118	79	46.6	28.9	59	37
Sao Paulo	Estados Unidos	0800	260	1580	195	26	14.2	13.8	55	53
Istanbul	Harbiye	0815	785	1560	151	113	74.9	32.6	66	29
Hong Kong	King's Road	1745	135	1340	133	n/a	19	19	n/a	n/a
Curitiba	Portao	0645	390	1205	91	67	21.3	20.1	32	30
MODERATE VOLUME:										
B AND A<1000										
Istanbul	Sisli Cami	1645	905	805	115	82	45.3	26.1	55	32
Ankara	Maltepe	1700	775	195	76	61	46	43.6	75	71
Singapore	Raffle's Quay	1730	735	390	200	47	25.7	18.6	55	40

Belo Horizonte	Pimenta da Veiga	1715	605	25	108	27	14.2	14.2	53	53
Bangkok	Prachatipok	0745	540	320	223	28	12.5	11.1	45	40
Singapore	Serangoon Road	1715	435	275	173	91	60	40.1	66	44
Istanbul	Sisli Cami	0915	360	840	119	61	29.3	24.9	48	41
Ankara	Maltepe	0800	305	680	72	50	29.9	28.7	60	57
Istanbul	Tasitlar	1715	260	310	103	44	28.7	14.3	65	33

Note: Distances between entry and exit points vary from location to location.

(Source: Gardner et al, 1990).

As shown in table 6, although some of the variation in travel time was explained by passenger volumes, the presence of overtaking facilities was also important. Between 15 and 69 percent of bus time spent in the stop area was not associated with passenger movement, being mainly due to queues of buses on the approach to the stop and to traffic controls.

Overtaking at Stops: With very high flows of buses, queues can build up at stops, and all buses will then travel at the speed of the slowest until there is an overtaking opportunity.

All bus stops surveyed which had overtaking facilities, had lower overall delay times than those without. The innovatory parallel stands bus stop in Singapore (fig 5), for example had very much lower delays than comparable sites in Turkey.

Overtaking also permits the introduction of limited-stop and express services, making overtaking bays at stops one of the most cost-effective measures to improve capacity and commercial bus speeds under normal circumstances. (Unlike bus bays in the UK, buses being denied re-entry to their lane was not found to be a problem - as can be seen in the Video (TRRL 1990)). With overtaking facilities, a bus can leave as soon as boarding is complete, loading of several routes occurs concurrently and, with very short headways, supply can be matched closely to demand.

Boarding and Alighting Times: Boarding and alighting times were surveyed at a selection of stops; these varied considerably from one city to another. For example, average boarding times for a typical group of 10 passengers ranged from about 19 to 41 seconds. As shown in Table 7, boarding times per passenger where free entry onto the bus is permitted were lower, at around 1 second, than those where fare collection restricted entry at about 2 seconds per passenger. Alighting times measured were in the range 0.4 to 0.9 seconds per passenger, confirming the well-known fact that boarding times per passenger tend to be longer than alighting times - typically about double

TABLE 7: PASSENGER BOARDING TIMES BY CITY AND FARE COLLECTION ARRANGEMENTS

CITY	LOST TIME (secs)	TIME/ PAX* (secs)	ENTRY ARRANGEMENTS_	FARE COLLECTION METHOD

Abidjan	10.3	0.9	free entry	turnstile
Bangkok	9.8	1.2	free entry	conductor
Belo Horizonte	5.2	1.5	free entry	turnstile
Sao Paulo	8.6	1.3	free entry	turnstile
Ankara	23.0	1.8	driver supervised	paybox
Hong Kong	13.1	1.7	driver supervised	pay driver
Istanbul	9.3	2.3	driver supervised	paybox
Singapore	8.4	2.2	driver supervised	pay driver

_ Note: Driver supervised entry requires single-file boarding, otherwise full width of door available for passenger entry with fare collection on-board.

* PAX= Abbreviated term for Passengers

Lost time per bus (ie time when doors were open but no passengers were moving) appeared to be fairly constant at around 10 seconds, although this was greater at the very long bus stops (some were up to 70m long), and at the very busy bus stops such as in Ankara (Plate 4).

4.3.5 Busway Advantages and Disadvantages:

This study has shown that busways are capable of carrying high passenger flows at acceptable speeds. As shown in figure 6, the capacity of the busways studied compares very favourably with many of the Metros studied by Fouracre et al (1990), particularly when capital costs are taken into consideration. In addition, the advantages of busways for the city authorities are (Cornwell and Cracknell 1990):

- Self-enforcement: Because a busway physically segregates buses from general traffic, the priority for buses does not need to be enforced by a strong police presence.
- Flexibility and diversity: Since buses can join and leave a busway anywhere, routes from all over the city can use the busway for all or part of their journey. Passengers from a wide catchment area can therefore benefit from a faster service without having to transfer to a faster vehicle, as would be required with a fixed-track system.
- Affordability: An at-grade busway along an existing right-of-way is likely to cost US$400,000-1,000,000/km (end-1989 values), depending upon the need for utility relocation and other local factors.

- Since busways can be provided with locally available labour, materials and vehicles, the foreign exchange requirement for 'hard' currency is minimised.
- Scope for Incremental Development: Sections of even a few hundred metres of Busway can be useful (whereas rail transit needs a depot and a significant route length before it can attract passengers).
- Busway Transit can also be enhanced step-by-step (eg by adding grade separation at critical intersections; introducing off-bus ticketing etc.) as and when finance permits.
- Existing Experience: Busways enhance the use of buses, the predominant public transport mode in most cities, and can draw upon the wealth of experience and knowledge of bus operation which already exists.

One of the main disadvantages of busways are that being a mixture of highways, traffic and public transport, their implementation requires cooperation from a number of separate institutions, which is not always easy to achieve.

Busways can also be criticised for taking road space away from cars. For schemes with low passenger demand, as in the UK, careful transport planning evaluation would be necessary, on a case by case basis, to ensure optimum benefits. However, this study concentrated on corridors with extremely high passenger flows of up to 26,000 persons per hour per direction. Under these conditions, since a busway can carry between five and ten times more passengers than a general traffic lane, there would seem to be an overwhelming case, on technical grounds, for providing space for buses at the possible expense of other traffic.

Similarly, for such high passenger flows, a bus with a well-maintained diesel engine is clearly superior in environmental terms, than the equivalent number in private cars.

Perhaps the main disadvantage of busways is that they are perceived as being of an 'outdated' and 'unclean' technology. Irrespective of the potential demonstrated in this study, the Worldwide demand for rail-based mass transit systems continues unabated. There is little sign of potential support for segregated busways (except perhaps in some UK cities which have 'failed' to gain a Light Rail Transit system).

4.3.6 Busway Conclusions.

Given the right combination of operating features, it is possible for segregated busways to provide a high-capacity mass transit system.

For maximum throughput, care should be taken with all aspects of the design, but in particular with the layout of the bus stops which should, ideally, include overtaking facilities.

Operational measures such as bus ordering or trunk-and-feeder services can further enhance performance.

As demonstrated in Fig 6 the passenger carrying performance of busways compares very favourably with that of Light Rail, and even some Metros, and at substantially lower cost.

Against all of the arguments in favour of busways, the popularity of Metros has shown that it is not necessarily technical performance alone that determines the choice of public transport system, and the 'image' of the service can be critical. This will favour the more advanced technology of Light Rail Transit, hence the decision to study this as the next part of the research.

4.4 Light Rail Transit

Light Rail Transit (LRT) is an urban rail-based system with large capacity vehicles, fast acceleration and a smooth ride. Its high manoeuvrability allows for operation on more sinuous and higher gradient tracks than ordinary trains. It can also make use of track laid on ordinary roads, along a right-of-way which may be segregated from other road users by a fence, or even just road markings. LRT is a true mass transit system in the sense of being capable of conveying large volumes of passengers quickly and efficiently.

The research described here examines the performance of LRT; in particular, the passenger capacity and commercial speed of actual systems has been measured. A combination of case study and estimation techniques has been used to investigate factors influencing maximum passenger carrying capacity and commercial speed. Vehicle number plate matching techniques were used to establish commercial speeds, and on-board surveys revealed the amount of and reason for LRT delays. All surveys were supervised by the author or colleagues, and were made during typical days of operation.

4.4.1 Background

LRT, is a modern version of the traditional tramway. This has been proposed for several developing cities on the grounds that it can offer a high capacity service that combines an appealing, modern, image without the high costs of a full metro system. While there is no doubt as to the wisdom of the latter contentions concerning image and cost, there is little documented evidence to support the claims concerning LRT performance. This research, which complements the earlier studies of busway transit and metros, focuses on an examination of LRT performance and the justification for the high expectations of these systems in developing cities.

4.4.2 Scope of The Study

The main aims of the research have been:

- to measure the actual performance of existing LRT and tram systems
- to determine the key factors that critically influence performance, and hence
- to predict the likely performance of other specified schemes.

To achieve these aims, case studies were undertaken in several cities operating LRT or tramways. In each city, surveys were carried out to establish passenger carrying performance, general operating characteristics and the nature of the operating environment. As there are few LRT systems in Developing Countries, two East European cities were also included as case studies. Although European operating conditions are different, trams are still widely used and high levels of patronage had been reported. In the event, it became increasingly apparent, with the findings from each new case study, that in no example was the system being extended to its limits (or, perhaps more realistically, its expectations).

4.4.3 Design of LRT

Trams and LRT usually run on standard gauge track (1435 mm). For on-street operation the rails lie flush with the road surface. (Plate 5) Where the track is segregated from other road traffic, the tracks may be raised and laid on ballast, which allows for ease of maintenance.

(Ballast tracks also have the advantage of being difficult for other traffic to drive over). One characteristic of LRT that distinguishes it from a metro is that the minimum radius of curvature can be low. Radii as low as 10m (though more commonly 20m) allow the planning of systems in tight and sinuous rights-of-way. LRT can also work on steeper gradients (up to 8 per cent) than heavy metro systems.

As with busway track, an LRT track can have a lateral or median position within the road alignment. The transit-way can be delineated by 'paint-and-sign' or by physical barriers like curbs, fences or studs. If sharing road space, special provision must be made for boarding and alighting passengers, who may have to cross the path of oncoming traffic to access the tram.

Rolling stock is lightweight and usually powered by electric traction from overhead supply. The cars are operated singly or in trains of two or three. The earliest trams had a simple chassis with only two axles. Later, twin bogeys with two axles each were used. The most recent vehicles have multiple bogeys and articulated bodies. Passenger loads can vary from 100/180 on tram cars to 250 on a modern LRT car.

Delays to LRT can be critical at junctions: with multiple lines and on-street running there will inevitably be conflict at some point between road traffic and LRT vehicles, or between one LRT vehicle and another, competing for the same road space. This can be alleviated by limiting the number of crossing roads, eliminating right-turning traffic (or left-turning for drive-on-right) across the path of a tram, and by traffic signal priority measures. Long LRT vehicles need long green times and for safety sufficient clearance time must be allowed which reduces junction capacity. Grade-separation may be required at very busy junctions.

Trams and streetcars typically have high floors and steps to street level (like buses) while LRT systems may be designed for high level access from raised platforms. Some modern LRT cars have low floors, which improves access from the street. The ability to carry wheelchairs and child pushchairs has helped attract new passengers in areas of high car-ownership. In developing countries, however, where satisfying the existing demand is more important than attracting new passengers, the added cost and sophistication of low-floor vehicles may be difficult to justify.

Delays at tram stops are minimised by providing several wide access doors for each car. In the nature of a fixed-rail system, however, there is no possibility of overtaking at stations.

Plate 5: The Tunis LRT: A new street-running LRT system using modern European Vehicles (above)

Plate 6: A traditional tramway at a busy transport interchange in the Czech Republic (below).

Most tramways will be operated under manual vehicle control, ie. within the visual capabilities and judgement of the driver. The driver can close-follow a preceding vehicle, and headways can be very low (though speeds are correspondingly low). Most high-technology LRT schemes (particularly grade-separated) will be run under some form of automatic train protection: this involves a sophisticated (and expensive) signalling system that controls the spacing between successive trains.

4.5 LRT Case Studies

Two cities in East Europe (Prague and Budapest) were selected for study since these have well-developed tramway networks, and a tradition of public transport use (Plate 6). The Tunis system was selected as an example of a modern, at-grade LRT in a developing country (Plate 5), whilst Manila's LRT is similarly modern but has the advantage of complete grade separation (Plate 7). At the time of study, the network in Istanbul was not considered to have reached its normal operating capacity.

A number of older, well-established tram systems were also studied. Dalian, in China, was selected as having one of most highly patronised systems, and the two Egyptian cities, Alexandria and Cairo (plate 8), together with Calcutta, were chosen as good examples of Third World operating conditions. Both the Egyptian cities also have two separate systems, exhibiting different levels of protection from other road traffic. The general physical characteristics of each of the case study systems are recorded in Table 8, which groups the systems into those which are mostly street-running tramways (e.g. Prague), and those which have a high level of protection (ie. Manilla).

Practical considerations initially prevented survey work at the newer systems such as in Monterrey and Guadalajara, Mexico. Subsequent visits there suggested that full operating capacities were not being reached.

TABLE 8. PHYSICAL CHARACTERISTICS OF CASE STUDY LRT SYSTEMS.

City	*System Description, amount of segregation and junction control.*	*City Fleet size-cars*	*Cars per train*	*Nominal Train capacity (pax)*

Alex-El Madina	*Tramway - no segregation Police at junctions.*	*134*	*2*	*274*
		914	*2*	*200-396*
Budapest	*Extensive tram network. Signals, some with detectors.*	*95*	*2*	*304*
Cairo: CTA	*City tramway poor segregation. Police-controlled junctions.*	*382*	*2*	*197*
Calcutta	*City tramway poor segregation. Police controlled junctions*	*100*	*1*	*200*
Dalian	*Tramway -roadmarking segregation. Signalled junctions*	*991*	*2*	*200-396*
Prague	*Extensive tram network. Some detectors at signalised junctions*	*36*	*3*	*670*
Alex-El Raml	*Urban rail/tram 95% fenced. Police control at intersections.*	*107*	*2*	*473*
Cairo:Helio	*Urban rail/tram ballast track. Police control at intersections*	*64*	*2_*	*748*
Manila	*Modern pre-metro LRT. 100% Elevated on viaduct- no junctions*	*120*	*2_*	*286*
Tunis	*Modern LRT . Segregated by fence or kerbs. Priority at all signals.*			

_ *Double articulated cars with eight axles*

4.5.1 Prague and Budapest

A large number of cities in the former Eastern Block have maintained tramway systems. In some cases trams provide an extensive public transport service, and fulfil the role that buses perform in most cities. Prague, for example, has more than 50 tram routes operating on 250 km of track. In recent years the busiest tram lines in both Prague and Budapest have been replaced by metros, and there has also been a general decline in patronage due to economic difficulties.

The tram has helped to maintain the quality of several E. European cities (Plate 6). There is a tradition of public transport use in both cities; a high standard of service is provided, and

Plate 7: Manilla: A modern LRT running on a concrete viaduct above existing (and competing) paratransit vehicles. (Above)

Plate 8: Cairo: A street running LRT with little segregation from other traffic. Vehicles are modern, but in a poor state of repair (below).

many tram users are also car owners who choose to use their cars only for non work trips (Karlicky, 1991).

Budapest has a very comprehensive transport network which includes suburban rail, metro, bus and trolley bus, and tramways. Tram route 1 in Budapest is an example of a well-planned line which, with its wide stop-spacing, well-maintained track and modern vehicles, provides a good LRT-like service.

4.5.2 Cairo Alexandria, Dalian and Calcutta

There are two tram systems in Cairo; both date back to the early part of the twentieth century and both are clearly under-funded and in a poor state of repair. One (the

Heliopolis 'metro'), which is largely segregated, serves the Heliopolis and Nasr City suburbs, with a single connection to the city centre; the other (operated by the Cairo Transit Authority, CTA) is a city centre network, with extensive street running (Plate 8). In 1991 the two systems were integrated under the CTA. Since the late 1950s the CTA network has been extensively reduced. In the year to July 1991, the tram systems of Cairo were carrying just under a quarter of a million passengers per day (12 per cent of total public transport passenger trips in Greater Cairo).

Alexandria is a linear city, well suited to fixed-route transit. Although there is no metro, a suburban light railway (El Ramel) carries large numbers of passengers along a single corridor on a mainly-segregated line. There are several at-grade junctions at which police control tends to favour cars rather than trains. Trains are made up of three cars, with the central one being reserved for women. Alexandria also has a street tram system with high daily patronage, despite poor traffic conditions that hinder operations. Together the two systems carried about 630,000 passengers per day (year ending July 1991), representing almost 70 per cent of all passenger transport trips.

The Calcutta Tramways Company dates from the nineteenth century, and like many other tram systems in developing cities, was originally a private concern, but is now state-owned. In recent years the network has been substantially reduced, and is under constant threat of further reduction. In the financial year 1991/92 the tram system was carrying an average of 360,000 passengers per day. Trams are made up of two cars, the trailing car being reserved for first class passengers. A small number of seats are also reserved for women.

The Dalian tram network dates back to the early 1920s, and is currently carrying more than 15 per cent of trips in the city. Principal competition for the tram service comes from a high level of bicycle flows in addition to bus and trolley bus services. The fleet consists mainly of elderly single car trams with a capacity similar to a bus and with a driver and two conductors. Acceleration and top speed is low. The Dalian tram company does have its own factory where buses and trams are assembled including a new articulated tram of which 25 are now in service.

All of the tram systems in this group use cars with two or three entry/exits. Some have doors controlled by the driver, though often the control mechanism is broken and the doors

remain permanently open. Fares are collected on board by a roving (Cairo, Calcutta, Dalian) or seated (Alexandria) conductors.

4.5.3 Tunis and Manila

The two most modern examples of LRT in a developing city are in Tunis and Manila. Both systems have been built recently, with technologies, technical support and aid funds from Europe.

The LRT network in Tunis currently consists of four lines radiating from the city centre. These lines are almost entirely segregated from other traffic, though there is no grade-separation at junctions. Drivers have control over traffic signals and can 'call' for green on approach.

Most stations on the Tunis LRT system are at ground level; access to the cars is up steps. Doors are controlled by the driver, and have warning bells on closing. Tickets are pre-purchased, and self-cancelled in the vehicle. Daily patronage is about 255,000 trips per day, equivalent to almost 20 per cent of total public transport trips in the city.

Every effort has been made to make the Tunis system as efficient as possible. The vehicles appear identical to those used in German cities, and maintenance standards are good. The routes appear to be well chosen, and have a good balance of street running and segregation. (Plate 5)

The LRT in Manila is an elevated system (about 7 m above street level) giving full segregation from other traffic. Each station concourse must be approached from ground level by stairways. Access to the station platforms from the concourse is through turnstiles that are actuated by a pre-purchased token. Platforms are high-level, flush with the floor level of the cars. An advanced signalling system provides theoretical minimum headways of 85 seconds, though surveys suggest a current average headway of 167 seconds (Table 10).

The network in Manila consists of a single line passing through one of the central areas of the city. Patronage on the Manila LRT was, in1993, around 385,000 per day, representing about 3 per cent of all public transport trips in the city. Jeepneys (10-15 seat paratransit vehicles) provide the main competition to the LRT (Plate 7).

4.6 LRT Operational Performance

Surveys of LRT performance were undertaken in each of the case study cities. The survey locations were chosen (based on information reported by the local authorities) to reflect where the system achieves its maximum output. Where possible, survey sections were chosen which had constant cross section and/or similar flow levels. Performance was measured in terms of:

- train and passenger flows at selected points along the track
- train speeds between timing points
- journey time components and delay
- passenger handling characteristics at stations.

4.6.1 Vehicle and Passenger Flows

The peak hourly directional flows of trams and passengers at each survey station are shown in Table 9. Maximum tram vehicle flows on the street-running systems ranged between 19-49 per hour per peak direction, with the highest recorded one-way flow of vehicles in Dalian. Train flows on the protected systems ranged from 9-27 per hour per direction; high flows were recorded in Manila, Alexandria (El Ramel) and Tunis.

TABLE 9. OBSERVED MAXIMUM PEAK HOURLY FLOWS AND LOADING ON CASE STUDY SYSTEMS.

City	*Vehicle flow (per hour per peak direction)*	*Passenger flow (per hour per peak direction)*	*Average tram load factor (percent)*	*Average percentage of crush-loaded trams*
Alex-Madina	*46*	*6058*	*44.0*	*24.8*
Budapest	*34*	*6065*	*51.5*	*4.5*

Space left for fig 6

Cairo-CTA	*26*	*3042*	*27.1*	*0.7*
Calcutta	*19*	*3470*	*84.7*	*25.3*
Dalian	*49*	*5130*	*93.7*	*36.7*
Prague	*35*	*4585*	*34.7*	*0.9*
Alex-Raml	*27*	*13414*	*55.5*	*11.3*
Cairo-Helio'	*9*	*3000*	*68.9*	*18.8*
Manila	*27*	*18892*	*53.5*	*19.9*
Tunis	*26*	*9330*	*57.9*	*18.3*

The passenger throughput on each system broadly reflects the train flows; on the street-running systems, maximum flows range from just over 3000 passengers per hour per direction (pphd) in Cairo (CTA) to just over 6000 pphd in Alexandria (El Madina) and Budapest. The LRT systems were carrying maximum passenger flows of between 3000 - 19000 pphd, the upper figure being achieved on Manila's fully segregated system.

Table 9 also indicates the level of average loadings on each system: the average tram load factor indicates the percentage of nominal tram capacity (allowing for full seating and standees of 6 per sq. m) taken up by the maximum flow of passengers; the average percentage of crush-loaded trams indicates the proportion of all peak hour -peak direction trams which were carrying a crush load at the busiest sections. Apart from the systems in Calcutta and Dalian, most systems were operating with about 30-70 per cent load factors. While the proportion of crush-loaded trams varied widely (from 1-37 per cent) on the tram systems, there was great consistency (18-19 per cent) on the LRT systems.

There is little recorded information on the absolute maximum passenger handling performance of LRT systems. The case study work recorded in this report does very little to substantiate any of Vuchic (1981) claims that flows of up to 40,000 are possible.

There appear to be very few cities today where LRT or tramways are carrying large passenger flows. Only two of the case study systems demonstrated peak flows in excess of 10,000 pphd and one of these, Manila, verges on the status of a full metro.

4.6.2 Vehicle speeds

Speeds were measured using the number plate matching technique using observers with synchronised watches at three or more points along the route. The observed speeds of trams and LRT along the survey sections are shown in Table 10. Average tram speeds range from less than 5 km/h in Alexandria to over 20 km/h in Budapest and Dalian. For the more highly protected systems, the speed range was between 11 and 30 km/h, the highest speeds being achieved in Manila.

TABLE 10. AVERAGE SPEEDS AND HEADWAYS FROM PEAK HOUR SURVEYS OF CASE STUDY SYSTEMS.

City	*Peak hour speed. km/h*	*Headway (min)*	*Standard deviation of headway (min)*	*Coefficient of variation*
Alex-Madna	*5*	*1.4*	*1.03*	*0.75*
Budapest	*27*	*2.6*	*1.32*	*0.50*
Cairo-CTA	*11*	*2.4*	*2.25*	*0.93*
Calcutta	*11*	*3.2*	*2.65*	*0.83*
Dalian	*23*	*1.3*	*1.22*	*0.96*
Prague	*13*	*1.7*	*1.12*	*0.67*
Alex-Raml	*12*	*2.6*	*2.58*	*1.01*
Cairo-	*16*	*13.9*	*15.83*	*1.14*
Helio'	*29*	*2.3*	*0.75*	*0.33*
Manila	*17*	*4.1*	*1.99*	*0.49*
Tunis				

It is clear that the existing tramway systems are not providing a 'rapid' transit service. The Alex-Madina service, for example, is often slower than walking. The other tramways are also slow compared to other modes. Low standards of vehicle maintenance reduce acceleration and deceleration times. Top speed is limited, both by the vehicle and by the track standards. Even the new LRT in Tunis has a running speed that is not significantly different from a comparable busway.

Tram flow, on its own, appears to have no major influence on tram speed; no clear pattern was obtained for speed plotted against flow along the links surveyed. Other factors are

Figure 7: The proportion of an LRT journey that is spent stationary, with reasons

examined below.

4.6.3 Journey time components and delay.

A peak-hour survey of tram journey times was undertaken by on-vehicle observers. The observers recorded each time the wheels stopped, the time and the reason for the delay. The

results of this survey are shown in Figure 7 which shows the average proportion of journey time spent stationary. This is categorised into: time stopped due to ‘pax’ i.e passengers (boarding and alighting); signals and traffic (at junctions and on the route), and for other reasons (often due to rail-specific factors such as changing points).

Apart from in Dalian, delays due to passengers range from 10-25 percent of journey time. The enormous benefits of grade-separation in minimising other delays are illustrated by the almost complete absence of delay due to reasons other than passenger activity on the Manila LRT. On the other systems, these delays account for between 10-20 percent of journey time (and in the case of Calcutta's route 1, which has very little protection, more than 20 percent).

One significant feature of on-street rail operations in developing countries (as observed from the driver’s cabin and backed up with survey data) is that a ‘classic’ acceleration, cruise, deceleration profile rarely exists. Instead drivers are constantly aware of potential conflicts with cars, pedestrians, unaccompanied children, animals and a host of other hazards. Unable to steer out of trouble, their only resource is to brake. This was also found on the new Tuen Mun LRT service in Hong Kong where, after an initial fatality, drivers were unwilling to drive through green-light junctions as fast as they had been predicted to (Bodell & Huddart, 1987). This has two implications for the hypothesis in that overall speeds of LRT will be lower, and they will be less than theoretical predictions.

TABLE 11. JOURNEY TIMES AND TURN-ROUND TIMES.

City	*Journey time (mins)*	*Turn-round time (mins: secs)*	*Percentage time 'lost' at terminal.*
Alex-Madina	*67*	*6:50*	*9*
Budapest route1	*65*	*3:20*	*5*
Budapest others	*68*	*7:55*	*11*
Cairo-CTA	*83*	*1:05*	*1*
Dalian	*20*	*3:20*	*14*

Alex-Ramel	*61*	*6:00*	*9*
Cairo-Helio'	*67*	*7:50*	*11*
Manila	*30*	*2:05*	*6*

Table 11 shows the average route journey times and turn-round times. Typically, around 10 percent of productive time is 'lost' at terminals. Turn-round time is needed for crew facility time, timetabling reasons, and the necessary task of repositioning either the vehicle (around a loop track) or the driver (from one end of the train to the other). Turn-round halts are standard practice on any public transport operation, but there should be greater pressure on minimising LRT turn-round times because of the greater capital cost tied up in each vehicle and the need to maximise its productive use.

4.6.4 Station boarding and alighting characteristics

The total number of passengers boarding and alighting during the peak hours at each station surveyed is shown in Table 12. Categorisation of the stations is based on busway studies described above.

TABLE 12. PEAK HOUR PASSENGER BOARDINGS AND ALIGHTINGS AT SELECTED LRT STATIONS.

Category	*City - Station*	*Pass-engers boarding*	*Pass-engers alighting*	*Total move-ments*	*Trams per hour*	*Pax. move-ments per tram*
VERY HIGH	*Tunis-Barcelone*	*4530*	*310*	*4840*	*17*	*285*
	Budapest-Arpad hid	*967*	*2679*	*3646*	*21*	*174*
		765	*-*	*-*	*27*	*-*
	Prague-Branik	*2245*	*-*	*-*	*41*	*-*
HIGH	*Dalian-Rlway*	*168*	*1283*	*1451*	*14*	*104*

	Station	*515*	*120*	*635*	*10*	*64*
	Alex-El Shobane					
	Tunis-El Khadra	*86*	*249*	*335*	*10*	*44*
		204	*570*	*774*	*24*	*32*
MEDIU	*Calcutta-Sealdah*	*133*	*2*	*135*	*5*	*27*
M	*Manilla-Central*	*562*	*352*	*914*	*43*	*21*
	Cairo- Shubra	*415*	*158*	*573*	*43*	*13*
	Budpst-Bert.	*43*	*69*	*112*	*12*	*9*
	Lajos U					
	Alex-Boalino					
	Cairo-Bab El					
	Khalek					

Because trams cannot overtake each other at stations, it is important for maintaining good performances that dwell times at stations are minimal. Tram dwell time is taken to be the time between the moment when the tram wheels stop at a station and the moment when they start to move, following completion of passenger boarding and alighting activities.

This dwell time comprises 'lost' time and 'passenger-dependent' times. For trams, lost time may include:

-time between wheel stop and door activation (where doors are fitted and working).

-driver reaction time to completion of passenger activities.

In addition, because LRT vehicles are long, and drivers cannot always see every boarding passenger, some systems have a set minimum boarding time of, say, twenty seconds.

Passenger-dependent time is related to the numbers of boarding and alighting passengers, and to the efficiency of passenger transfer arrangements. High level floors with steps for access from low level stations, narrow doors, and payment on entry will all incur high transfer times.

The larger cars (in Budapest and on the LRT systems of Tunis and Manila) generally have lower boarding times per passenger, than the smaller tram cars. Dwell times vary between 9 and 28 secs. per stop, with no obvious relation to system type or car size. The very short

dwell times in Manila may be encouraged by the bonuses which are paid to drivers to keep to the timetable.

4.7 Simulated Performance at Stations

Even if a rail service is given a segregated track and priority at signals, there will still be a capacity restriction or 'bottleneck' at the stations. To investigate the capacity at a station, a simple queuing model was developed by Cornwell and adapted by the author to study LRT station performance.

The main inputs to this model were: the capacity of the tram or Mass Transit System vehicles, the minimum permissible headway between trains, the passenger boarding and alighting times (from Table 12) and any traffic signal timings in the station area. Real occupancy rates and boarding numbers were taken from three case study sites in Manilla, Tunis and Alexandria in order to calibrate the procedure, which was written as a spreadsheet macro. Real headway distributions were also used, since these reflect the level of variability under normal operations.

The basic principle of the model is that each vehicle can proceed to the platform only when it (the platform) is free, and whilst maintaining a safe headway. It will leave the platform when the last passenger has boarded. Times of driver reaction and travelling within the station area are also accounted for. The model was first calibrated on existing patterns of arrival headways, queuing and delay.

The results of the calculations are shown in Table 13. In order to estimate the maximum possible flow, the headway was decreased and vehicle occupancy increased until there was a load factor of 1.0. This represents an absolute limit since at this rate around half of the vehicles would be crush loaded which many passengers would find unacceptable. In order to maintain efficient vehicle use, no more than one queuing vehicle in Manilla, two in Tunis and four in Alexandria were allowed.

TABLE 13: ESTIMATIONS OF MAXIMUM THROUGHPUT ON LRT, METRO AND BUSWAYS

System	*Examples*	*Observed capacity (pphd) and speed (km/h)*	*Estimated capacity (pphd)*
Tram-high proportion of street running.	*Alex-Madina* *Calcutta*	*6.000/6* *3,500/12*	*8,500*
	Cairo (Heliopolis)	*12,800/14*	
Tram- high proportion of segregation.	*Tunis*	*9,300/16*	*13,000*
	Manila	*19,000/30*	*19,400*
LRT-grade-separated:	-	-	*26,700*
2 car trains			
3 car trains	*Hong Kong* *Santiago*	*80,000/33* *20,000/32*	_
Metro:			
high output			
low output	*Sao Paulo* *Ankara*	*19,000/20* *7,300/13*	*14,900-27,900__* *5,800-18,100__*
Busway transit			
high output			
low output			

_ Metro flows not simulated, results from Fouracre et al (1990). Hong Kong believed to be operating at maximum possible capacity

__ Estimated Maximum Busway values from Gardner et al (1991)

It is likely that local operating circumstances would result in the capacities of specific systems being different from these values. The difference is unlikely to be large (perhaps plus or minus 20 per cent). In the simulation exercise advised by the author but later published separately by Kuhn et al (1996) the capacity of the north and south lines of the Tunis LRT were estimated at 13,400 and 16800 pphd respectively, associated with maximum train flows of 30 per hour. At this level of flow some queuing of trains is apparent; the likelihood is that one train is waiting for another to clear a station every four or five stops.

As with the regression procedure below, the results of this calculation must be taken as a guide rather than as absolute numbers. It was not intended that this should be a principal conclusion of the research. It did support the findings of the research that station capacity and headway variability are of crucial importance in a mass transit system design.

4.8 Comparative Appraisal of Performance of Busways and LRT

Performance covers both output (speed, capacity, energy consumption, etc.) and impact on non-users (in terms of safety, pollution, and congestion). For a high-income European city the main performance criteria of interest might be comfort and the ability to attract car users. For a rapidly developing city, high capacity is more likely to be the primary concern.

The data collected enables a comparison to be made between the main modes of light mass rapid transit, busways and LRT.

Table 14 shows the commercial speeds of the systems studied. This also demonstrates that there is little measured difference between the busway and LRT modes. However, a straight comparison is difficult because of the influence of stop spacing and the number of road junctions.

Comparison of the speed of alternative schemes is essential for appraisal purposes. For a typical project, commercial speed has a major influence on initial investment costs, and on the level of time savings by users. As a significant proportion of costs are associated with

rolling stock, and as the travel time is a major determinant of how many people will use a mode, then commercial speed influences both costs and income.

System	Station spacing (metres)	Junction spacing (metres)	Av. speed. Km/h
Busway transit:			
B.Horizonte	610	920	27
Curitiba	430	430	21
Abidjan	400	160	11
Istanbul	310	410	12
LRT & Tram:			
Alexandria	175	286	6
Cairo	400	435	11
Alexandria	370	500	12
Cairo	500	667	16
Manila	634	-	29

TABLE 14: SPEEDS AND JUNCTION SPACINGS FOR A SELECTION OF LRT AND BUSWAYS

As an example, for a large underground railway project recently appraised by TRL, taking two equally plausible estimates of commercial speed at 26Km/hr or 34 Km/hr, made a difference in project cost of over US$82 million. Speed can be difficult to estimate, however, and feasibility studies obtained as part of this research show a scant regard for detail in this most important area.

4.8.1 Estimating Performance Values

Faced with the need to forecast key performance outputs of a proposed system, many scheme promoters will either try to calculate these from first principles, use comparative data from similar schemes, or use values loosely based upon prior knowledge. A recent French study for a mass transit system in Mauritius predicted the speed of LRT to be nearly twice that of a busway, despite both having the same junction and station spacing (GoM 1991). No technical reasons for this estimate or explanation of forecasting method are given. Improvement in the accuracy of forecasts might be possible if there was a method of estimating speed that takes into account the actual conditions found in developing cities. The research described here, therefore, set out to collect actual case study performance data

during normal operating conditions. The data collected also permit some exploration of the differences between the LRT/tramway and busway modes.

4.8.2 Data Analysis

From the surveys done especially for this research, data were grouped into fifteen minute segments. This permitted analysis of flows and speeds by time or by location. The flow on a link is taken to be the average of the flows at the stations at either end. Since survey sections were chosen to be at locations where flows do not change, it is assumed that this average flow applies to the whole length of the link.

The journey speeds along links surveyed was then plotted against the vehicle flow. This showed a slight trend but, overall, flow on its own is not a major influence on speed and this confirmed the need for further analysis. Similar results were found in a study of bus speeds in Indonesia by Poernomosidhi (1992).

Station performance has been described above. For the overall performance study, the main implication was that the number of stations, and their size are highly influential on performance and so must be included in the analysis. Full surveys at each station were not possible, but at least four sets of boarding and alighting surveys took place in each city.

From the sample surveys, stops were categorised into: *Large stops/stations,* that is those, typically in the centre of the city or near a large factory, where large numbers of people queue to board, pushing occurs, and the driver often cannot close the doors first time. *Small stops/stations,* was then the category used for all others. Some judgement was required at this stage, but as the large stops were handling more passengers than many metro stations (such as Victoria station in London) it was usually well known in the city where such massive crowds were assembling.

4.8.3 The Influence of Design and Operational Factors

There are several design and operational factors that will influence commercial speed. Information was collected on as many of these as possible. Some, such as the skill of the

drivers, cannot be easily measured. Others, such as the number of stops, can be obtained from maps or from operators' records. There was clearly a conflict in this exercise in that, ideally, many factors should have been measured. In practice, however, collecting this data required considerable cooperation and goodwill from the transit operators, and compromises had to be made. (Table 15)

nlink	Line No.	PR	Prague
llength	Line length (km)	PL	Plzen
ltimep	Peak journey time (min)	BP	Budapest
ltimeo	Off-peak journey time (min)	MC	Misoolo
sstops	No. of small stops	CO	Cairo
ljuncs	No. of signallised junctions	AL	Alexandria
sjuncs	No. of minor junctions	A	Abidjan
pseg	Proportion of route segregated	B	Belo Horizonte
tqual	Proportion of high quality track	C	Curitiba
trafvol	Proportion of route with high traffic volume	F	Farapos
zone	Area zone	I	Istanbul
lspeedp	Peak speed	K	Ankara
lspeedo	Off-peak speed	P	Porto Alegre
hills	graded High (3), Medium (2) or Low (1)	S	Sao Paulo
bends	graded High (3), Medium (2) or Low (1)		
vehqual	Standard or Modern		
added	Added min. speed limit		
lpaxp	Peak hourly passenger flow		
lpaxo	Off-peak hourly passenger flow		
tramp	Peak trams per hour		
tramo	Off-peak trams per hour		
dir	direction		
ttsurv	Source of data: timetable or survey		
vehtype	Bus (1), Trolleybus (2), Tram (3), Metro (4)		
sperk	stops per Km		
vehsize	Vehicle size		
walkdist	Walking distance from platform to door		
dcdb	Distance from city centre		
avst	Average speed		
sampl	Sample size		

TABLE 15: VARIABLES DESCRIPTION FOR DATA STUDIED

Large Junctions includes all junctions controlled by traffic lights, except those where automatic priority is given to buses/LRV. It includes traffic lights provided for pedestrian crossings.

Minor Junctions includes mainly non-signalised junctions (those where full priority is given to bus/LRV were included in this category to avoid requiring an extra category)

In order to make allowance for the difference in quality of the vehicles (for example the 1950s tramcars in Dalian compared to the 1990s LRT in Tunis) a variable was introduced which estimated the percentage of life-expectancy of the vehicle which had been reached. This ranged from 0 for a new

vehicle to 100 for one well passed its design life and was considered preferable to a simple indicator of 'modern' or 'traditional'.

Of the busways studied, several had specific design features to enhance performance. These included overtaking bays at bus stops, or the use of bus ordering at stops to reduce queuing. For the purpose of the analysis, these were grouped together into a single dummy variable *Feature*. In preliminary analysis this proved to be highly influential. However, the use of a single indicator such as this does not then permit the specific differentiation of the impact of these features, which would need more detailed study. Instead, additional sample surveys were used to estimate a variable '*walkdist*' that could be used to describe the activity at bus stops and stations. This was defined as 'the distance that must be walked from waiting place to the boarding door'. This was introduced because in some cases, particularly with busways, vehicle queuing at stops required passengers to walk considerable distances past other buses in order to reach the one they want. Conversely, for at LRT vehicles with multiple doors and at bus stops where some procedure was in place such as convoy operation or overtaking bays, there was not so far to walk.

Hills and Bends. For the preliminary analysis, categorisation of both hills and bends into 'Low' 'Medium' and 'High' was chosen. It was assumed that, should this prove critical, further surveys could measure these from accurate maps.

General traffic flows were grouped according to three categories: HIGH -A principal road, or busy road near the city centre. LOW -A quiet residential street with little through traffic. MEDIUM-All other roads. Considerable additional survey input would have been necessary to collect accurate data on all vehicles. Where mass transit was segregated, traffic had little or no influence, and in areas where interference was high, investigation by detailed simulation or special surveys was felt to be more appropriate than the multi-factor approach.

The differentiation between LRT and tramways is made by cross section type. Five categories were selected for analysis as shown in table 16. There were some occasions where the listed categories did not precisely match study section. In this case, the category was chosen that best represented how the trams and traffic interacted.

TABLE 16: THE CATEGORISATION OF TRACK CROSS-SECTIONS

A	Fully Segregated; this included sections where the track was separated from traffic by a fence or trees. It also included any section where the construction method meant that a car could not physically be driven over the track. The traditional railway layout, with sleepers and ballast is an example of this type.

B	Kerb Segregated; this included any section where a car can drive over the track, but where this would be difficult due to a kerb, step or other physical barrier.
C	White Line Segregation; this included any section where traffic is not permitted by law to use the transit lane, but where because there is no physical barrier, driving over is easy.
D	No segregation. Rail vehicles and traffic each have their own lanes. Traffic is permitted to drive over the rail tracks at any time.
E	Rail and traffic do not have their own lanes. Traffic must drive over the rail tracks at all times.
F	Pedestrian Street. No barriers to segregate transit and pedestrians.

Perhaps surprisingly, the preliminary analysis showed that this categorisation within the data was not highly significant. That is not to say that this does not influence speed, but reflects that systems have used segregation forms appropriate to the level of need, such that sites with the worst problems have the best segregation. Given that this equalisation reduced the validity of this variable it was thought reasonable to reduce it from a category variable into a continuous variable representing 'percentage of track that is 100% segregated.'

4.8.4 Multiple Linear Regression Analysis

Multiple linear regression is a technique suited to the examination of relationships between a single dependent variable and several other possible explanatory independent variables. It allows the influence of different components of the data collected to be investigated. There are many limitations to this type of approach, and the results should be interpreted as 'descriptive' rather than 'causative'. Nevertheless, it can be a useful tool for describing the performance of the systems surveyed in this study.

The procedure began by collecting all the data into a database and checking for inconsistencies and errors. A correlation matrix of all variables was then constructed to test for independence of the variables used.

Statistical analysis was performed using the SPSS stepwise-regression procedure. This took SPEED as the dependent variable which, though it is a ratio and thereby possibly less suitable to statistical manipulation, has the advantage of being easier to interpret. The stepwise process sequentially adds or removes variables in order to obtain the model that has

the best fit. Those variables that are not selected as part of this procedure are therefore those that, for the data in question, do not add to the accuracy of the model.

The model derived from this process is of the form:

SPEED = 28.6 +
+0.36 * Distance in Km from the CBD
+1.61 if in the direction where passengers are predominantly alighting (eg PM towards CBD)
- 0.10 * No. of large junctions on the link
-0.42 * No. of small junctions per Km
-3.63 * No. of large stops/stations per Km
-2.77 * No. small stops per Km
-0.83 * distance in metres to be walked to reach vehicle entrance

Where SPEED is the speed in km/hr along a link. Correlation coefficient (R-squared = 0.73, N= 173, all variables significant at the 1% level).

The biggest contribution to performance is the variable *walkdistance*. This is a coarse variable and may be acting as a proxy for a more general (and more difficult to measure) indicator of design quality. Without further research this cannot be broken down into specific details. However it does suggest that schemes where stations and stops are efficiently organised to minimise passenger access times can have a significant performance advantage over comparable schemes and should therefore be studied and if possible emulated.

Although the reason why some of the variables did not add enough to the model to be included were associated with practical difficulties of data collection (passenger flows were not always available, for example) it is revealing to look at those NOT selected for inclusion.

In these analyses, the variables PAXFLOW and BUSFLOW were omitted. For the schemes studied these contributed little to the explanatory ability of the formulae. This suggests that there is not a strong relationship between speed and the flow of vehicles. It should be noted that in the schemes studied, those with the highest flows also tended to be the best designed.

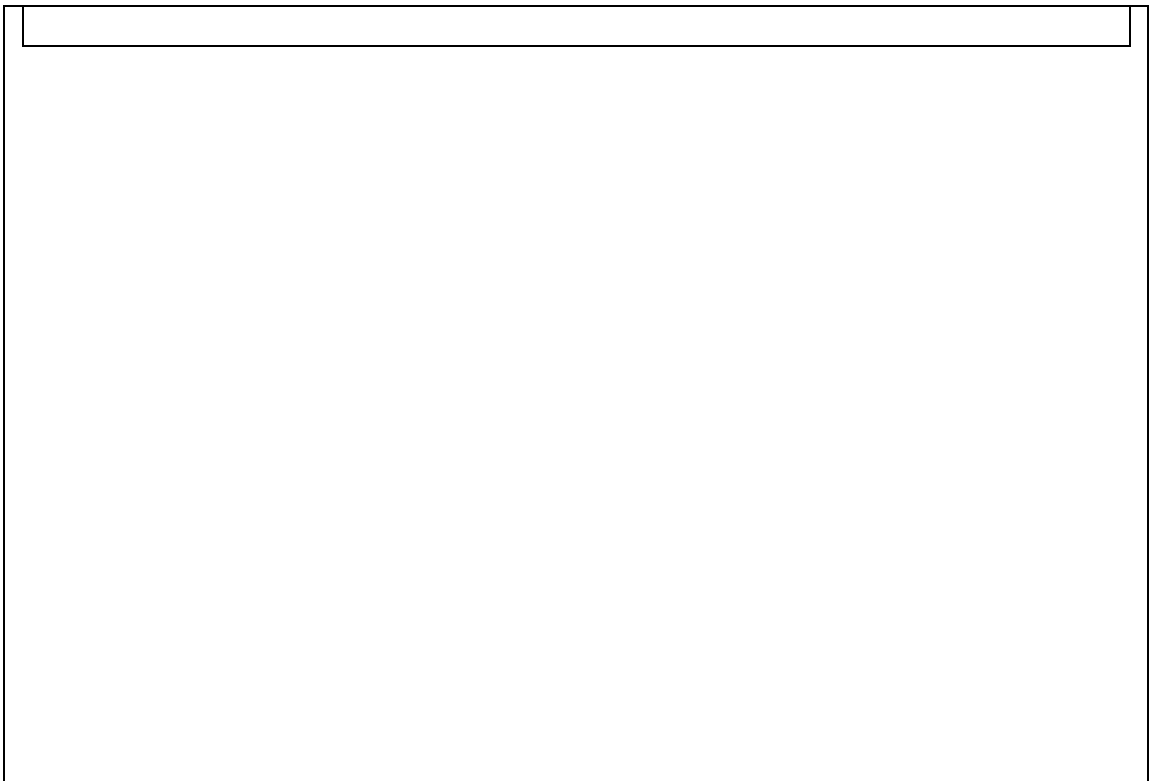


Figure 8: Passenger Boardings versus delay for Bus Stops and LRT stations (idealised) (above).

Figure 9: Influence of vehicle occupancy on arrival at station on delay time (Tunis, 12 Aout station) (below).

In order to test the difference between modes a variable ‘isbus’ and ‘istrain’ were given a value of 1 to indicate records for bus and rail systems respectively. These were not significant in adding to the model, suggesting that for the data studied here there is no inherent difference between modes once all other factors have been allowed for. This suggests that the commercial speed of a busway and an LRT (in the conditions of the case study cities) would be identical if the design and operation features were similar.

Clearly, all the above numbers represent an 'average' situation. Within individual schemes differences not accounted for in this exercise will prevail. Another drawback of this approach is that not every explanatory variable can be measured. Currently the regression coefficient suggests that there are other factors involved (R-squared is around 0.7). Generalisation of the findings outside the systems for which data were collected is also not recommended. However, the simplicity of this formula, with its inclusion of 'real

World' aspects make it a useful means of cross-checking estimates made by other more complex procedures.

4.8.5 Comparative performance of LRT and Busway Stops/Stations

The above comparative study suggested the importance of stops and stations on mass transit performance which was therefore subject of further investigation. An example of a plot of delay time at stops against passengers boarding (Fig. 8) illustrates the general linear nature of the relationship between dwell time and passenger activity. Simple linear regression has been used to obtain a relationship of the form:

Dwell time= Constant + Coefficient*No. of Boarders

- where the constant indicates the lost time, and the coefficient is the average boarding time per passenger. Because of the tendency for a safe minimum stopping period, the relationship between dwell and passenger numbers is not very strong (with a correlation coefficient typically in the region of 0.4-0.7). Table 17 shows the results of this analysis for the different systems, classified by type of system and vehicle size.

TABLE 17 COMPARISON OF LRT AND BUSWAY PASSENGER BOARDING TIMES

System/ vehicle size	**City**	**Dwell time constant (seconds)**	**Boarding time per passenger (seconds)**
Tramway/small	Alex and Cairo (avg) Dalian Calcutta Prague Budapest (route 7)	15 27 9 13 14	0.8 0.5 0.8 0.2 0.7

Tram-LRT/ large	Budapest (route 1) Tunis Manilla	22 28 13	0.4 0.1 0.3
Busway/ standard bus*	Sao Paulo Ankara	9 23	1.3 1.8

**from Gardner et al (1991)*

For comparative purposes, results of surveys carried out at typical 'good' and 'poor' bus stops (in Sao Paulo and Ankara respectively) along a busway are also shown. Bus boarding times per passenger are higher than those experienced on all types of tram car. This suggests that LRT has a time advantage over busways in terms of delays at busy loading points; conversely, for small numbers of passengers, a well-designed bus stop should have lower delay times.

However, precisely when the need for throughput is at its highest, this supposed linearity can 'break down'. In particular, if a tram is already heavily loaded on arrival at a station, it may take boarding passengers longer than average to squeeze in. The influence of crowding at stops and general overloading of the system (plate 9), can be seen in Fig. 9. This shows the relationship between stopped time and train occupancy for a station (13 Aout) on the Tunis LRT. The scatter of the observations shows how the stop time is larger for vehicles that arrive at the station when they are already full. The number of waiting passengers at stations is likely to be highest when problems with headways have led to a large queue assembling.

Buses and LRT react differently to very high demands at stations. One important limitation for LRT is that overtaking at stations is practically impossible. This means that a delayed vehicle holds up others and delays tend to be cumulative. At a bus stop with an overtaking bay, there is constant movement, a bus can leave as soon as boarding is complete, loading of several routes occurs concurrently and there is a steady flow of buses (albeit not the same ones) both into and out of the stop area. The capacity of an efficient overtaking bus stop can therefore be higher than a light rail station.

4.8.6 Influence of Headway Variability

Another subject worthy of further discussion in order to explain why LRT might have a lower throughput than busways is headway variability. One of the main strengths of a high technology segregated metro system is that a fast flow of vehicles carrying very large numbers of passengers can be provided. For maximum flow, the trains should travel at the shortest possible headway consistent with safety. Automatic train protection enables metro trains to operate at very high speeds (30-40 km/h) while maintaining headways as low as 90 seconds. Grade-separated LRT could theoretically benefit from the same control systems and achieve similar high speeds and low headways.

An inherent weakness of at-grade LRT and trams in general is that the interaction with other road users causes variability of headways. In developing cities, this may be even more pronounced due to the poor behaviour of other road users, non-motorised traffic, street traders and poor timekeeping. On the Tunis system, complex junctions between lines meant that LRT vehicles delayed each other.

Delays can lead to a heavy build-up in numbers (and frustrations) of waiting passengers. The first arriving vehicle may not have the capacity to clear the passengers quickly, and passenger-passenger interference leads to extra stopped time as described above. Because there are no overtaking opportunities, following vehicles have no alternative but to follow behind and will begin to bunch. Hence, as headways increase, performance diminishes cumulatively until the end of the peak period.

It was interesting to note that on the Budapest metro, a simple tripswitch-operated timer counted the number of minutes since a metro departed from the platform area. Following drivers knew whether to hurry or linger and, while not exactly having 'real time' predictions, regular travellers gained some indication of how long they may have to wait. Such a system may well have been a cost-effective means of controlling headways in a number of the case study cities. Other mechanisms discovered to control headways included 'inspectors' at stops and special training/incentives for drivers.

Table 10 records the headways, and variability of headways for the LRT case study systems. The coefficient of variation gives an indication of the randomness of headways: the closer its value to zero, the more regular the service. Several of the systems are evidently

Plate 9: A very busy LRT station. If headways are too long, crowds build up and crushing results. Doors are unable to close which causes further delays (Tunis) (above)

Plate 10: Bus station Curitiba, Brazil. Level boarding platforms and multiple door opening aim to make bus boarding easier and faster (below).

experiencing difficulty in maintaining a reliable service. Even in Manilla, the vehicles do not arrive at a precise headway. It is therefore not reliable to estimate the capacity of a system by simple calculations based upon scheduled headways.

On trunk and feeder bus routes the passenger can simply board the next arriving vehicle, which in some cases arrives every 15 seconds. Although no signal protection system exists to prevent accidents at this short spacing, as one operator said "if my driver hits the vehicle in front of him then he gets dismissed" (Sao Paulo Case Study visit, 1995). The precise relationship between headway and capacity is worthy of further investigation, perhaps using simulation modelling, although the random nature of delays would make this a complex task. The present research suggests that in the case study cities variability of headways is associated with reduction in capacity.

4.8.7 Case Study Institutional Issues

Other case study visits were made to cities that were in the process of developing or improving systems in order to gain an understanding of the decision making process. The following paragraphs are based upon conversations with local people and have been checked with them as a being a true representation (even where hard facts are missing).

In Bursa, Turkey, for example, it was revealed how a transport study which was 'donated' by the German government, led to the recommendation for a (German) LRT system. Although the project, by International rules, must go out to tender, there was a strong German influence in the process, and specifications were based on DIN standards. It was also specified in the tender that the system should run on steel wheels on tracks, thus excluding bus-based (or certain French Metro) options.

The Istanbul visit provided insight into the influence of electioneering on the decision making process. The Atakoy metro was introduced by mayor Dalan at a time when he was keen to be re-elected. For some reason (many suspect corruption but there is no proof) the rolling stock, which came from Sweden, was massively over-ordered. Several years after the due implementation date there were still Light Rail Vehicles (LRV) mothballed at Gothenburg docks.

Mayor Dalan, in fact, lost the election and a different party took over. This had the advantage of being from the same political party as the national government in Ankara. In a rare burst of synergy a mayor with a good knowledge of transport nominated a chief transport planner in the municipality who was keen on implementation. Many successful projects were implemented during this period and something was salvaged from the abandoned LRVs when they were adapted by local engineers to run as streetcars on a route which was 'known' to have a high corridor flow.

Curitiba also had a good coordination between mayor, chief of transport and chief of planning (all of whom went to the same school of architecture). Good local consultants with an acute sense of how to deal with (or avoid) Brazil's very weak public sector also helped. In construction of the busway trunk and feeder system, for example, the terminals were developed not so much as transport essentials, but sold on the basis that they had a captive audience of several hundred thousand potential customers per day.

The metro in Calcutta is a rather sorry tale of misplaced pride and natural and human disasters. Having decided that, as owners of the worlds biggest railway network, they could do everything without external expertise, consultants were employed with little direct experience of metros. The authorities compounded their difficulties by splitting the tenders between dozens of local contractors. Instead of avoiding patronage and corruption as was intended this simply managed to spread it around. As an example of the bad luck that dogged the project, no sooner had the expensive train units arrived from Melbourne and been lowered into the already massively over-running project, than the monsoon rains arrived and flowed over incomplete (or open) flood gates, thus submerging the trains up to their roofline.

4.8.8 Summary of Comparison of Options

Figure 6 shows the passenger throughput of the main mass transit systems studied as part of the wider research programme. It can be seen that (apart from two of the World's biggest cities and one of the World's most densely populated ones) there is little difference in carrying capacity between all of the modes. The regression analysis found little inherent statistically reliable difference between commercial speeds of LRT and Busway modes. This suggests that both the speed and the capacity of LRT are no better (and sometimes worse) than an equivalent busway. This is a rather surprising finding as the top speed and vehicle capacity is higher for an LRV than a bus or tram and so is worthy of some discussion.

One of the most likely explanations why LRT fails to achieve its potential appears to be because of the wide variation in headways. This leads to excessive delays and hence capacity limitation at stations. Characteristics that are common in developing cities cause delays to both LRT and busway vehicles, but the outcome differs. For example, car drivers have little respect for public transport of any kind; overloading of vehicles reduces acceleration and top speed; and the behaviour of passengers at overcrowded stops/stations increases the variability of headways. For an individual bus this causes delay, but other buses can overtake and there is continuous movement. For an LRT, delays to one vehicle can affect up to 1000 passengers and other vehicles behind are unable to overtake or move ahead. The flexibility of the bus would therefore appear more suited to developing city conditions.

The research shows that the interaction between the spacing, location and frequency of stops is critical to the success of a transit system. Passengers want to have short walking distances, and therefore need frequent stops, but this has been shown to adversely affect performance. This can be alleviated by using innovatory bus stop arrangements such as the parallel boarding stops as in Singapore (fig 5) or level boarding platforms in Curitiba (plate 10). Splitting major stops/stations into separate smaller halts, serving selected routes only, may also help to avoid the delays associated with large stops.

One interpretation of the results could be that the importance of stations and stops is so great as to diminish the problems of junctions with other traffic. This would imply that expensive grade-separation and even full route segregation may not be necessary. This would have significant implications for the cost of a system, since Kuhn et al (1992) has shown that grade separation costs 6 to 60 times more than at-grade. As most of the sample data were from sites that had route segregation and relatively low congestion levels, however, this interpretation cannot yet be fully supported.

The data collected by the author runs into approximately 100 MB of computer files. It has therefore been possible to examine this using a range of methods in order to test the first hypothesis. The surveys of LRT and busways were done using the same methodology and mostly supervised by the same person.

The hypothesis that was to be tested set out that in developing cities, the relationship between the mass transit options does not always, as some have claimed, show Light Rail Transit to be superior to busways. The results of the scientific measurement of passenger throughput, and the estimation of commercial speeds would appear to support this hypothesis. The statements above must be clarified by linking them to the data collected and that they are not intended to be predictive of other cases. It also must be specified that these measurements were made in the peculiar circumstances of Third World traffic conditions.

The statistical analysis of data from countries such as China and India runs the risk of endowing the transit systems with more reliability than is actually the case. No logical procedure could ever accurately reflect the chaos that is inherent in traffic system such as Cairo's. Lindau, after building his PhD on a simulation model of a busway still had to admit that "such a process can never be a true reflection of the actual conditions" (Lindau, 1983).

This is not to decry the use of analysis, however (and certainly not to cast doubt on Lindau's excellent thesis). The point to make is that the data analysis should serve as a guide to good practice, should indicate possible problem areas, and should increase understanding of the key issues. In this respect the work presented here has been a success.

The present research also adds weight to the argument that there is little merit in arguing about the relative performance of the mass transit technologies as each will have its place. It is better to use the definitions of Vuchic (1981) of rapid, semi-rapid transit etc. rather than distinguish between vehicles running on rubber or steel. It also should be noted that even the poorest performing mass transit system carries many times more passengers per hour than if the equivalent space was used by private cars.

5 FINANCIAL AND ECONOMIC ASPECTS

The first hypothesis is still not fully proven, as the performance comparison reported above does not take into account financial and economic factors. This section examines the financial costs of the mass transit options and the income generated by them. It then moves on to cover the economic benefits and methods available for their estimation. This is important for the testing of the second hypothesis in that the previous section has shown that there is little difference in technical performance between the two light mass transit options and yet, as this chapter will show, the financial differences are pronounced.

This chapter therefore has two objectives aimed (respectively) at the two main hypotheses.

To establish the differences in construction and operating costs of the main options, particularly busway and LRT

To investigate the reasons funding arrangements might include a bias in favour of options that are not necessarily those favoured by current appraisal methods.

The process of estimating costs and benefits is an extremely complex one. In keeping with its importance there are experts and specialist text books that devote considerable attention to this particular issue. For the purposes of this research, the aim will be to cover the basic principles and to explain how current practice might be influencing the choice of mass transit in developing cities.

There are two main elements of an investment in an MRT which should be evaluated. Firstly, its viability as a simple business venture should be looked at. Will the real income ever be sufficient for those investing in it be able to make a profit? This is known as the financial viability.

Secondly, the benefits to the city as a whole can be assessed. This assumes that all of the changes in a city which would not have occurred without the MRT can be given a value. In the UK, since the pioneering work by Beesley and Foster(1963) it has become accepted that appraisals of an investment in public transport should take into account these economic social cost-benefits in addition to the purely financial returns.

5.1 Financial Expenditure

The main influences on the financial performance are the construction costs, operating costs and ticket income. Other sources of income and expenditure do exist, and in some specific circumstances can be important.

5.1.1 Capital Costs

The high level of sophistication of modern urban rail systems has led to very high costs of both construction and operation. Even though labour costs in developing cities are low, lower productivity and the need to import technology means that total cost of construction can be similar to Western amounts. Table18 shows some typical construction costs.

The main factors determining costs are the degree of segregation, and the complexity of the rolling stock. Tunnelling and elevation are the most common methods of providing full segregation, but these can add greatly to construction costs. Kuhn et al. (1992) estimated that track construction for one kilometre of LRT in tunnel costs 3 times more than on viaduct and up to 5 times more than an equivalent surface-running section.

There is little doubt that a metro system will be one of the biggest investments a city will ever make. A typical single line metro system might cost around one billion dollars, and this can easily double if project management does not go well. A small network involving

underground construction can easily exceed two billion US dollars (the World's most expensive metros, such as Taipei cost around US6 billion and Mexico City has spend 12Bn so far). At such prices city, and even national, economies can be affected.

Out-turn cost data vary according to design standards, construction procedures, exchange rate variations, and so on. The more grade-separation, tunnelling, use of heavy rolling stock and sophisticated control equipment, the higher the cost.

Table 18. Capital costs of mass transit schemes: costs in US$ millions (1993 prices)

	Bus lane	*Busway transit_*	*Tram*	*LRT*	*Metro__*
Capital cost per route km.	*< 0.5*	*2.0-10.0*	*5.0-15.0*	*10.0-30.0*	*40.0-140.0*

Note: includes rolling stock, except in case of bus lanes _ Gardner et al (1990), __ Fouracre et al(1990)

There is little doubt, then, that a metro is an order of magnitude more expensive than a busway.

Most systems are financed by countries themselves, some with supplier credits for the rolling stock, typically with some form of bilateral backing.

The rail rolling stock manufacturers are predominantly based in modern industrialised nations. Developments in vehicle design have concentrated on making vehicles more attractive to countries with high car-ownership. This has resulted in sophistication, and hence costs. A single LRT vehicle (LRV) can cost one million US dollars and a system may require more than 50 of these (Black, 1995).

5.1.2 Loan, Finance & Depreciation Costs

Rail based systems tend to include a large component of imported materials and equipment, and so payment in a hard currency will be necessary. Although Western donor agencies may be able to give some grant assistance towards the project, and low-cost finance may be available from agencies such as the World Bank, there will still be charges to be met. On a typical project, finance charges can amount to up to 35% of the total costs (Fouracre et al, 1990). It is very important for a scheme developer to borrow at the best possible rate, since

total costs are very sensitive to variations in interest paid on borrowed capital. The Hong Kong metro mentions the support of nearly one hundred banks and financial institutions in its annual report for 1995 (HKMRT, 1996). Interest charges for the Hong Kong system were around 1.5 billion HK dollars (200 million US) almost half of the revenue. Under such circumstances, the relationship of the inflation rate (and hence the rate of increase of fares) and the bank interest rates can be critical to the success of the system.

In countries with a GNP per capita of 4000 US dollars or less, then World Bank loans may be available (OECD, 1997). These, typically have an interest rate of 7-8% with repayment over 15-20 years. The government of Japan, and to a lesser extent European nations have also contributed to metro systems in the past. Within Europe, the European Community may contribute towards schemes in some less-wealthy parts of the region. Total amounts available from the EC are typically low, amounting for example, for less than 6% of the Newcastle Metro (although the Athens metro managed to get substantially more (Efremidis, C & S Koukoutas, 1996).

Each of the components of a Mass Transit System will have a different life expectancy. Although a typical appraisal will be over twenty years, for some elements such as land acquisition and earthworks, a life of 100 years might reasonably be expected. Other components, such as the vehicles, may require replacement or a major refurbishment after only 15-20 years. This is a difference between rail and bus projects, since buses are normally depreciated over a shorter time period (say 8 years). This is important conceptually, and clearly the London Underground is still providing benefits after 100 years, but the cost-benefit calculation process takes very little account of future benefits beyond 20 years.

In an ideal World, operators would set aside a sufficient amount each year for the replacement of assets when required (this is generally referred to as 'depreciation' funds which are tax deductible against profit). In practice, few operators make an operating surplus, and each asset replacement is subject to negotiation with governments. For appraisal purposes, some allowance should be made for the replacement of assets at the end of their useful life.

5.2 Operating Costs

The key components of operating a transit system are labour, energy and replacement of materials. Estimates of operating cost per passenger km are given in Table 19. These costs include depreciation on equipment, but not on the initial infrastructure or any financial charges. Given that capital costs can equal operating costs over the lifetime of a rail project, it is clear that operating cost alone is not a good indicator of the price a city will pay.

Table 19. Operating costs of mass transit systems costs in US cents (1993 prices).

	Bus on bus lane –	*Busway transit* –	*Tram*	*LRT*	*Metro* —
*Operating cost per passenger km.**	*3-8*	*8-12*	*3-12*	*12-15*	*15-23*

* *excludes depreciation and interest charges (extensive in the case of metro)*

– *Gardner et al (1990),* — *Fouracre et al(1990)*

Little is known of the financial performance of low-cost mass transit schemes. In the case of busways, the scheme's performance is usually subsumed within the total financial performance of the participating bus company; neither would it be normal for the capital costs of the track to be included in bus company accounts.

Very few public-sector bus or rail services, if any, are able to rely entirely on direct revenue. Table 20 gives some indication of the cost recovery that can be expected from typical systems. Very different results can be achieved from LRT and Metros according to the income of passengers, population density, and depending on the political decision of whether to maximise occupancy or minimise the subsidy.

Table 20: Approximate estimated ratio of operating costs recovered from farebox.

	Buses with Privately operators –	*Public Sector Buses* –	*Tram / LRT*	*Metro* —
Percentage of costs	*100%+*	*62%*	*40-60%*	*20-160%*

recovered from farebox				

– *Armstrong-Wright (1993), — Fouracre et al(1990)*

Fouracre et (1990) provides three indicators which help to explain operating costs:

- staffing ratios, the relationship between the number of staff employed on metro activities and the number of passengers using the system: this factor is of key importance because labour costs normally account for at least half the total annual operating costs of a metro.
- wage rates, using a city's estimated gross per capita product as a proxy
- utilisation rates, in terms of passengers per year per route km of infrastructure.

Low operating costs, resulting from a combination of modest staffing ratios, low wage rates and high utilisation rates are typical as in Manila, Mexico City, Santiago and Sao Paulo. Anomalies in any one of these factors could be offset by variations in another: for example, the Seoul metro recorded low operating costs despite the city's relatively high wage rates which were offset by a particularly low ratio of staff to annual passenger volumes.

5.3 Financial Income

5.3.1 Farebox Revenues

The principal source of income normally comes from the sale of passenger tickets. The main factors influencing income from passenger revenue are ticket prices and passenger demand. The setting of passenger fares will necessarily reflect local political interests, but should ideally be calculated according to economic theory and 'willingness-to-pay' studies. Passenger demand is critically dependent upon the land use and density but also on:

a) Urban Form; High density cities will tend to have high levels of traffic congestion, giving an advantage to segregated systems. Walking distances to transit stops will be short, which also favours public transport. People living in high density apartments may also spend less time at home and more time travelling to city centre attractions, particularly at night, when transport modes might otherwise be under-used.

b) Route Structure; The route of the transit system should always pass through the areas of highest demand. If any deviation is introduced, for example to save money, then patronage can fall drastically. City centre routes have the highest patronage, and some systems (Lyon, Grenoble and Edmonton) terminate systems before the suburbs. This, however, requires good harmonisation and integration with feeder buses. London provides

extensive suburban services, but these are strongly 'tidal' with one direction always under-used (and hence not profitable).

c) Alternative modes; In the USA, the provisions made for the private car are so well established that there is little incentive to switch to any new mode. In Manila competition from paratransit has adversely affected ridership of the LRT, and in Newcastle de-regulation of buses led to the virtual elimination of a combined metro-bus ticket, thus reducing the attractiveness of a two-mode journey.

D) Income distribution will affect patronage. Best returns will come from areas where people are rich enough to travel but poor enough not to have a car.

The elasticity of demand relative to ticket price can vary for different users, and efforts should be made to identify areas in which pricing can help to make effective use of the system. Tickets should be graduated with respect to distance and perhaps time of day. Integration of tickets with other modes is desirable, but this involves complex negotiations between operators, since rail operators prefer costs to be shared on a per kilometre basis whereas bus operators prefer it on a per passenger basis. This requires good (and honest) information on numbers and types of journeys.

A particular problem with all forms of public transport in less developed countries is that price rises can lead to severe public protest. Some operators arrange the announcement of their annual increase to coincide with the announcement of wage increases in an effort to reduce this problem. (Armstrong-Wright, 1993). The ability to pay a high ticket price can be a major influence on system success. As Fouracre et al point out:

> "metro benefits are closely related to income levels. In contrast, capital costs are much less sensitive to income, because of the large proportion of foreign exchange and the relatively low proportion of local labour in the total cost. This, more than anything, explains why financial viability is only likely in countries which are not poor." (Fouracre et al, 1990).

Ticket prices should take into account the price of alternative forms of transport. Although in some cases the government may initially withdraw public buses from competing routes, there may be competition from private mini-buses and shared taxis which can provide a premium fare alternative to the metro.

5.3.2 Funding from taxation

Most local rapid transit schemes receive funding in the form of grants from a national or regional government. These grants are funded from general taxation, and therefore the burden is borne by the population of the state generally. If a government decides that it wishes to fund a project, then it may choose to pay for all or part of it. Most governments will have rules regarding the funding of large infrastructure projects, Walmsley suggests that there is a greater chance of rules being 'bent' in the case of a scheme which is thought to have substantial benefits in terms of bringing prestige and honour to a country (Walmsley and Pickett, 1992).

5.3.2.1 Hypothecated Revenue;

In some cases, where the government is very anxious to see a system constructed, it may allow the setting up of additional revenue gathering methods, the income from which will be specially allocated (or hypothecated) for the Mass Transit System company. These might include a supplementary petrol tax, central area road-pricing or inner-city toll roads. An increase in land or employee tax in areas benefiting from the Mass Transit System may also be considered. In France, Versement Transport (VT) is one of the principal sources of finance for urban transport. VT is a payroll tax levied on all employers and earmarked for expenditure on transport (Walmsley and Perrett, 1993).

The USA has a long tradition of dedicated, or 'earmarked' taxes. These are often introduced following a public vote, and specify, for example, that a certain percentage of the income from a sales or income tax will be used only for the benefit of public transport. In West Germany there is a fuel tax (Mineralolsteuer) which can be used for capital (but not operating) costs of transport projects.

Dedicated taxes have a number of advantages and disadvantages which can be summarised as follows;
The advantages are;
- they provide a stable and reliable source of funds
- they can help secure cheaper borrowing
- they often increase the overall level of funds available.

The disadvantages are;

- they can reduce accountability to voters
- they reduce competition which may lead to increased costs
- additional special taxes are more expensive to collect than standard methods

Any form of taxation or subsidy that is differentiated from normal government funds will be very visible to the tax payer. It may then come under more scrutiny. Perversely, this might favour a prestigious scheme which could be seen as 'being worth it'.

5.3.3 Operating Cost Subsidies;

Most rapid transit systems in Europe fail to cover their operating costs from revenues, but some lose less money than others. Typically, the transport network as a whole covers 50-60 per cent of its operating cost from the farebox (White, 1995). Developing countries have lower wage rates, but lower ability to pay high ticket prices. Most transport networks therefore require some subsidy.

If a decision is taken by the government of a city or country that the provision of an effective public transport system is a basic social necessity, then that government may be willing to guarantee a subsidy for the system operators. As this represents an actual payment to the operators it can be treated as a financial income.

The actual amount of subsidy received will vary according to both the extent of the need for money, at least to maintain viability, and will also depend upon political decisions. This makes subsidies an essential, albeit unreliable, source of income.

5.3.4 Policy Choices & Income;

Urban public transport systems are often expected to fulfil social and public service objectives. The extent to which revenue covers operating and capital costs could, in most cities, be increased substantially if a more commercially-orientated fares policy with the objective of maximising revenue were adopted. The choice of where to strike the balance between public service and financial performance is a political one.

On the Hong Kong MTR there is an explicit policy of maximising income. Most other metro systems, as a general rule, have the declared objective of covering their annual costs, but recognise the need to maintain fares at affordable levels, and so are constrained in their ability to fulfil this financial objective. Other systems, most notably Mexico City, are guided by the social objective of maximising patronage, especially during peak periods, and their practice was to set fares at artificially low levels that would not deter passengers from using the metro as long as spare capacity existed (Henry, 1987).

5.3.5 **Covert Subsidies.**

Once a city has built an expensive project, it will have an understandable desire to see it succeed. If the project proves to be non-profitable, then some form of intervention, either explicit or covert may be necessary.

One of the most common forms of public intervention in a high profile scheme is to bail it out in the event of financial difficulties. This may take many forms, sometimes direct (as with the extra funds given to the Newcastle metro when it faced ground condition and labour problems (Howard, 1979) and sometimes indirect, such as the improvement of the publicly owned links to the privately operated Channel tunnel. Sometimes public funding for a metro project can be seen as essential for non-transport reasons. Public investment in the Los Angeles metro, for example, was seen as a visible attempt to improve conditions for citizens in a poor district affected by racial riots (Richmond 1991).

An additional form of benefit may be the promise of more subsidies in the future. In many cases, governments and local authorities underwrite the risk to operators by their commitment to public transport and by providing grants and subsidies. This has a number of advantages. It makes it possible for the operator to plan ahead with a reasonable assurance that the system will actually be built and will operate successfully when built. This then breeds confidence which encourages developers to pursue development opportunities and contribute to ancillary features.

Other forms of covert government funding exist, the most common being the carrying of interest, asset replacement and depreciation costs. Government-sponsored projects, if they pay tax at all, will do so at a lower rate than private institutions. Various forms of leasing arrangements are possible which take advantage of this situation, with the result that some

parts of the transport systems can be provided at lower than commercial rates of interest. This can represent a substantial saving, and can mean that a system appears to be a success (in that it covers its own operating costs) while having high hidden cost borne by the government.

Such covert support is much more likely to support or bale out a prestigious public undertaking such as a rail system than it would be for a lower cost (and possibly privately operated) bus option.

5.3.6 Private Sector Inputs

As an urban transport project can be a very complex mixture of civil, mechanical and electrical works, it is becoming increasingly common for a single contract to be placed with a consortium who are able to co-ordinate the whole project on a turnkey basis. A typical consortium would include companies with an expertise in construction, rolling stock manufacture and perhaps property development. This has advantages in that each organisation can bring its own specialisation to the project.

With schemes that have a very high probability of financial viability, a private sector consortium may be willing to enter into an agreement whereby they will construct the scheme, take responsibility for its bringing on-stream, and then its operation for a set length of time. The extent of the period of operation will be set so that the consortium can recoup all of the construction costs and some degree of normal profit. After this period, the complete scheme is transferred into public ownership, the authorities thus having obtained a 'free' asset. This type of arrangement is known as 'Build-Operate-Transfer' or BOT. Further involvement of the private sector into the design and maintenance stages results in DBOM contracts. (Augenblick and Custer, 1990).

The desire to obtain new markets, technologically or geographically, may encourage manufacturers to absorb some of the costs of production. Thus, the first transport project by a new manufacturer, or the first system of its type in a potentially lucrative new marketplace may be priced accordingly. There can be no doubt that the VAL system in Lille has been a major showcase for French industry in general, and the company MATRA in particular. How much of these benefits were passed on to the city is hard to judge. The total cost of

around $20 m per Km (1989) was around twice that of the Nantes LRT and Newcastle Metro (Kuhn et al, 1992).

In countries with good financial stability, supplier credits can be an important part of the financing package. The carrying of the many risk elements associated with a large project will also represent an actual cost which may or may not be borne by contractors. The consortia which built the Manchester LRT are believed to have contributed 7 million US dollars 'in respect of the operating franchise'(Holt, 1992).

In practice, urban transit schemes will not normally be attractive to the private sector in their own right. Some form of 'sweetener' must be provided by the government, either in the form of land bonuses, tax exemption or financial safeguards. The exact definition and negotiation of government safeguards for private involvement is likely to be one of the greatest challenges facing cities thinking of investing in new systems: get it right and the full benefits of an efficient private sector can be maximised; get it wrong and the private consortium will either go bankrupt or get rich at the city's expense. BOT has been called ‘an expensive form of hire purchase’ (Atkinson, 1996), and it is important to weigh the real costs against the partially illusory benefits of appearing to transfer risk.

5.3.7 **Ancillary revenues.**

A Mass Transit System, as a focal point for a large number of potential 'customers', can be an attraction for non-transport companies. This would include advertising, concessions and commercial activities in stations. This may be an important part of the financing package. However, it can also be an over-estimated one. With the exception of areas experiencing major and rapid growth (such as Hong Kong) it is unlikely that this can supplement the funds available for a transport scheme by more than 10% of operating costs. Even then, considerable concessions (which other commercial actors may find unfair) must be given by the government in terms of favourable rents, tax relief etc.

Plate 11: The Hong Kong Tramway, demonstrating the effective use of additional revenue from advertising (above)

Plate 12: An advertising billboard in Budapest showing an artists impression of an LRT station as a major attraction for investors (below),

One of the advantages of street-running LRT is that it is highly visible. This means that it can add to the 'image' of a development, and also that it can act as a mobile advertising board. Advertising is a major source of revenue for the Hong Kong tramway company (Plate 11), but is perhaps unlikely to produce such a significant income on less visible vehicles.

5.3.8 Funding from Land Use Changes and land value capture

As public funding for mass transit is reduced throughout the World, efforts are being increased to find other sources of income and to capture some of the benefits of public expenditure on a rapid transit system by capturing the increases in land values which result. This 'betterment' can be recouped in three ways. Firstly, the developer could make a contribution either as a direct payment (before or after the line is built) or by entering into partnership in constructing the line. Secondly, the local authority can acquire land and thus recoup the benefit themselves. Thirdly, betterment can be recouped by means of additional taxation on those who benefit (Walmsley and Perrett, 1992).

It has been found in a number of examples that developers prefer to pay for specific parts of the system such as extensions, connections to stations or road access, rather than contribute to the general overall cost. It has also been found that developers do not want to be urban pioneers; they hesitate to make a commitment to invest in land around new rapid transit lines until they see construction actually proceeding. Payments from developers could form a useful contribution to the funding of a rapid transit line, but that they are not likely to form a major part of the "up-front" capital for the project. It is estimated (Walmsley and Perrett, 1992) that developer contributions could cover perhaps 10 or 20 per cent of the cost.

It is commonly believed that improvements in the local economy and in business and communications will occur as benefits of rapid transit. However, there is little hard evidence to this effect. Firms locate in an area because of many factors, of which public transport is only a minor one. They could, if deterred by high taxes or requirements to contribute to the costs of a rapid transit line, decide to relocate in adjoining municipalities or in another town. In 'Can Rail Save the City? ' Hall and Hass Klau (1985) concluded 'transport improvements by themselves can never achieve anything; they merely facilitate urban change'. Simpson reached a similar conclusion after studying metro and LRT systems in Europe and N. America. He stated that "if there is interest in developing in the locality, urban railways

usually attract development: if there is no interest, urban railways will not create any". Simpson (1990)

It is often said that the implementation of a metro can boost the confidence of a city, and thus encourage property development. In the USA it was found that even *non*-users consider a visible above-ground LRT a symbol of civic improvement equal to more expensive, but hidden, underground systems (TGM, 1990). The appeal of a rail scheme to developers can be seen in the advertising hoarding for a development in Budapest (Plate 12) that shows a modern LRT station as part of the attraction of the site (whilst an actual bus stop nearby has been airbrushed out).

The flexibility that is the hallmark of busway transit can then be a disadvantage. Property developers will be reluctant to invest in land benefiting from an adjacent transport facility if they think this can be removed at the whim of future politicians.

A distinction should be drawn between two quite different approaches to the funding of an MRT through capturing the increase in land values.

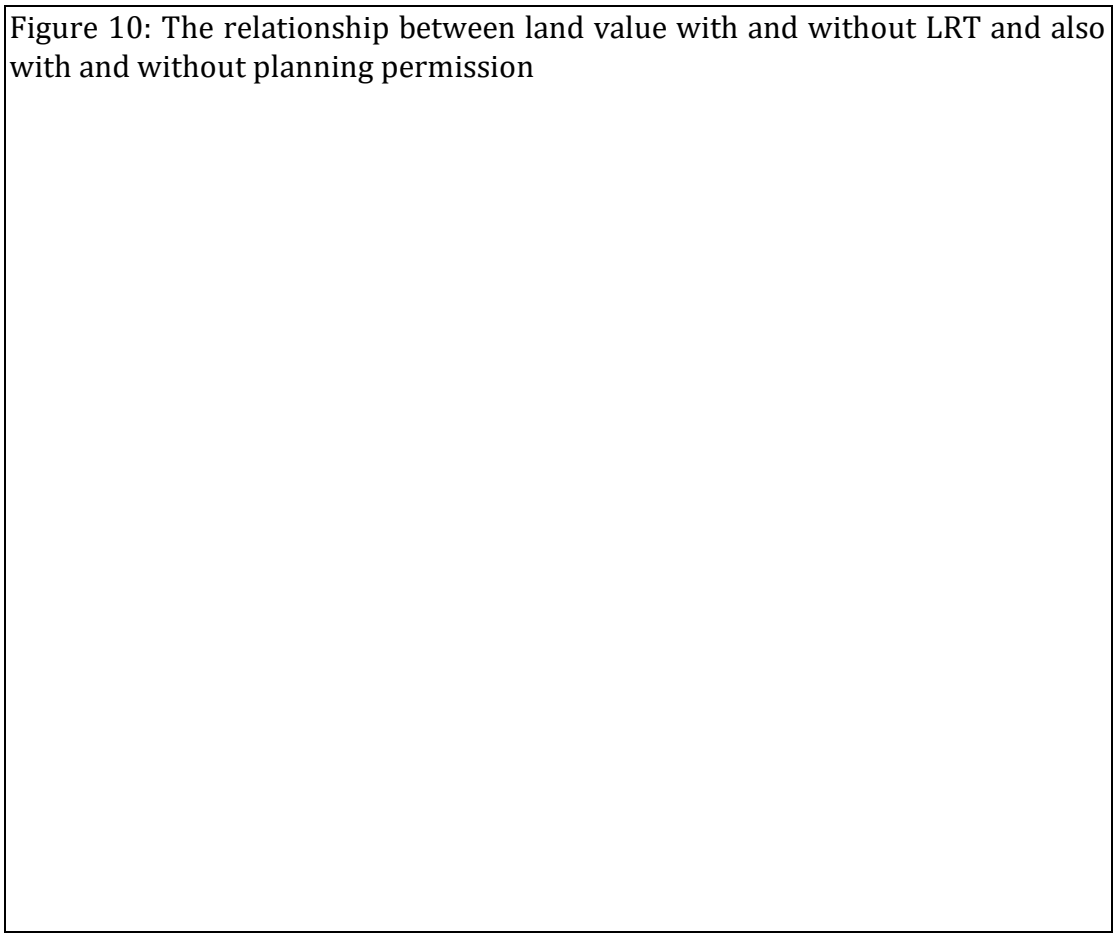
a) Diverting towards the promoters that part of the addition in land value solely due to the construction of the rail scheme. This is likely to be a relatively small amount especially when compared with other changes in land values associated with national and regional trends.

b) The relaxation, or removal, of planning restriction is an entirely different matter. The difference between land which is, for example, protected as green belt or park, and the same land with unrestricted planning permission will be enormous. Permitting the construction of high-density, high-income dwellings on a site such as Hyde Park in London would generate enough money to build a rail line (anywhere in the UK), but this would hardly be acceptable in a democracy.

In many rapidly developing cities good development land is a valuable resource (Mangla, 1996). In such cities, the gift of sufficiently large parcels of public land, or planning permission for developers' own land, can make the difference between profit and loss for an urban rail promoter. This situation is illustrated in Figure 10 (adapted from Warmsley and

Gardner, 1993). The loser here will be the quality of life for residents of the city, and it must

Figure 10: The relationship between land value with and without LRT and also with and without planning permission



be hoped that they get some say in the decision process.

Because such land deals involve the rail company not in transport but in land speculation, it may overall be more efficient for the government to separate the issues and to use professional land developers to maximise revenues which can then be given as a cash subsidy to the rail operator.

5.3.9 Financial Cost-benefit Analysis

It should be possible to take all of the financial costs, to estimate them with reasonable accuracy and to compare these with the estimated financial benefits. In the case of an urban rail project this would typically result in a shortfall of costs which would be covered by some form of assistance from the public purse. The extent of the benefits would then have to be decided in some way to see if they justified this expense.

Financial cost benefit analysis has fewer opportunity for major deviations from the truth, though it will still be dependent on patronage forecasts, eg. to estimate rolling stock requirements. Stopher and Meyburg suggest that "where the price mechanism can be used, a cost-profit analysis appears to be the easier tool to handle, especially as the `worthwhileness' of public sector actions cannot be measured in a format similar to those of the private sector (Stopher & Meyburg, 1976).

A city could be presented with a clear statement that the project will require a subsidy of N million dollars per year. The decision can then be made on whether the city can afford to spend that much money on that sort of project. In the case of Singapore the answer might be 'yes' to quite large amounts, whereas in Pakistan the ability to afford expensive projects will be much less. The decision might still be taken to go ahead with an expensive project, but at least some estimate of how much it will cost the city can be made public.

Fouracre et al (1990) found that city decision makers were relatively easily persuaded that a metro would have enough passengers to make them financially viable without a subsidy and hence were not too concerned with the shortcomings of economic analysis listed below. Sadly, as shown in table 3 this optimism was misplaced, to the cost of subsequent city residents. There is no reason that a public transport should be a profit-making concern. However, in a country where funds are in short supply, decision makers should be in a position where they know what they are committing themselves to. As Fouracre puts it:

> "The point is that most governments were led to believe that their metros would be financially viable, which they certainly are not, and, other than in exceptional circumstances, cannot be."(Fouracre et al, 1990)

5.4 Economic Benefits

In addition to the real financial costs described above, there will be other advantages of a mass transit system that will be of value to the community. These are termed the economic benefits, and can be considerable.

The most important economic benefits for a transport project, such as a mass transit system, are the following:

5.4.1 Time savings

It is a fundamental assumption that any new transport scheme will have as one of its objectives the saving of time. It is then assumed that this represents a saving that has some monetary worth, since although travel time cannot in fact be ‘saved', it can be spent in an alternative manner that would be of greater worth. The principal beneficiaries of time savings are;

a) MRT passengers who have diverted from other modes for whom the journey time is now shorter.

b) Local bus passengers who do not divert to the new mode should still benefit as a result of less overcrowding and less delays at bus stops.

c) Other road users should also benefit from the reduced road-based traffic, making existing journeys easier.

d) Generated passengers on both the new mode and the buses will have some benefits accruing to them. Such benefits might be more complex than time savings alone (such as new job opportunities) but are conventionally (and imperfectly) regarded as being half of normal time savings (Allport & Thomson, 1990).

The benefits of time savings depend upon a notional value being applied to the time saved by members of the travelling public as a result of the new mode. Such a process clearly involves a large amount of estimation, and there is often little research (or indeed any justification study at all) to say what is a reasonable value of one hour of time.

5.4.2 Value of Time

The valuation of time is an important component in the appraisal and evaluation of any passenger transport scheme. There is some agreement that some types of time should have a value. Time spent during business hours is generally acknowledged to have a value. Estimates are usually based upon the national wage rate with occasionally allowances for the overheads of employers (Stubbs et al, 1980).

As an example of the importance of time savings, fig 11 shows the breakdown of what type of benefits the metro was forecast to bring in a study by SEMALY (1985) for Guangzhou, China. This shows that around 70% of the benefits of the whole project were expected to

accrue from time savings. In contrast, the savings associated with road accident changes amounted to only around one percent. (Despite this differential, however, the number of pages in the study devoted to valuation of time and accident savings was identical.)

From a strict economic viewpoint, non-working time (which includes travel to or from work) should have no value, unless any part saved is used in productive work. This is reported by Stopher (1980) to be accepted in some non-Western countries, but most developed countries accept that a 'social viewpoint' holds. Non-work time has a value if people are willing to trade off travel time and money or some other valuable commodity.

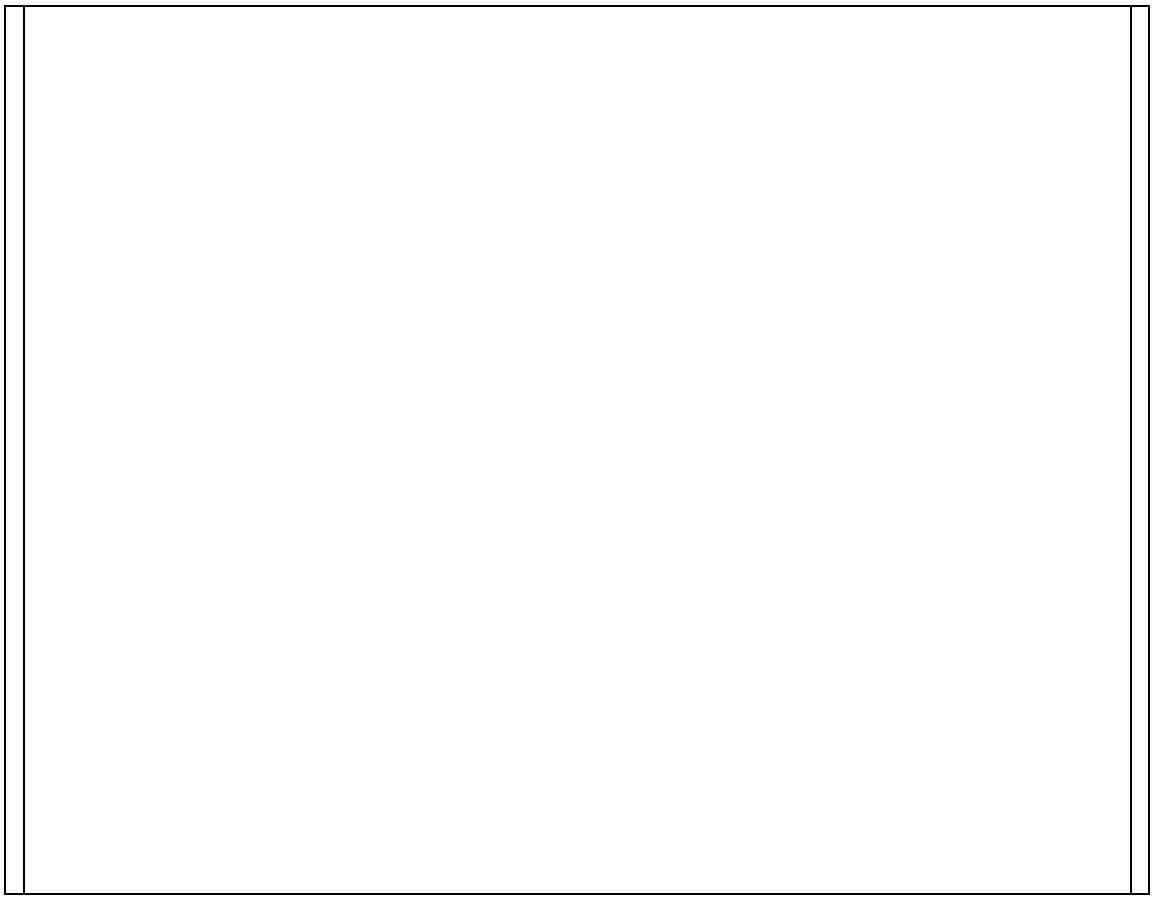
In addition to the value of time used in appraisals, it is important for the planning of transport systems to consider the value of time in travel forecasting. This could result in two different values of time. For example, if there are two or more choices that are well matched, small differences in generalised cost (which includes time) can make estimating models switch large numbers of passengers from one mode to another. Poor estimates in VoT estimation can therefore cause errors in two stages of the project process.

As Stopher says "Given these facts, some concern with the theory and empiricism of time values appears to be warranted if economic evaluation is considered to be a useful element of an evaluation process"(Stopher and Meyburg, 1976).

During the lifetime of a project the value of time (over and above inflation) may change. This variability is an indicator of the real growth of a nation making it especially hard to predict, raising as it does key questions about a country's development. Some countries, such as Thailand and South Korea have in recent years experienced growth in real terms of over 12% (UN, 1997). Others, such as Ethiopia and most of Africa have experienced low, or even negative, real growth rates. Yet despite being one of the hardest things to predict, fig 13 below demonstrates that time growth rates are one of the most influential factors on benefits.

Entire books have been written about the difficulties of valuing benefits, with Winpenny (1991) and Tinch (1995) for example, providing a comprehensive reading lists. A full discussion of the pros and cons of time valuation is given in the chapter on decision making below.

Figure 11: Pie chart showing sources of benefits of a typical urban rail project (Guangzhou)



5.4.3 Resource Savings

Some benefits of constructing a mass transit system might be already in monetary terms, but hard to quantify because of an uncertain extent. If a Mass Transit System is constructed, then some savings in other areas of public transportation may be possible. For example, the number of stage buses required on the Mass Transit System corridor will be reduced, as will the amount of new road construction. Often it is assumed that reduction in congestion will occur thus leading to operating cost savings for all other road users.

The total value attributed to these savings is uncertain. It is likely that, despite expectations to the contrary, the amount of congestion on the roads will continue to rise, and that newly generated car trips will fill up the road space vacated by new Mass Transit System passengers. (Jackson and Laidler, 1995).

For large public bus fleets, savings in bus investment will benefit the local community. For smaller, private fleets the savings will be more dispersed, and some of the operators losing trade may well not consider the new Mass Transit System a benefit at all.

5.4.4 Accident Savings

Some benefits are difficult to quantify, although methods have been developed to such a stage that standard and agreed procedures are available. The cost of accidents in the UK, for example, has a standard value published periodically by DETR (1998). Transport-related accidents are an obvious source of concern. The influence of accidents on the choice of mass transit mode, however, appears not to be a significant one. One possible reason for this is that (although reliable data is difficult to obtain) all modes are susceptible to some form of accident, whether this is due to falls from metro platforms, or pedestrian injuries from buses or trams. The greatest influence on road safety is likely to be the ability of good public transport to attract people from the less safe private modes such as cars and, especially, two-wheelers.

Travel by public transport modes tends to be safer than by private car (Black, 1995). Rail travel is safer still, and as LRT travels at a low speed, it should be the safest of all. Accurate data on any kind of road accidents in developing countries is difficult to obtain, and often unreliable and incomplete. It is therefore very difficult to know how safe Mass Transit System systems are. It is likely that at least some of the inherent safety benefits of a rail service are consumed by the lack of segregation over some or all of the track, whilst the high proportion of pedestrians and animals in some developing cities will further erode the safety benefits.

5.4.5 Comfort and Convenience

There is little doubt that travelling in a modern LRT on a newly-constructed track is one of the most comfortable forms of land transport. Even the elderly E. European trams provide a service which is considered comfortable by a large proportion of users surveyed for this research with the Technical University of Budapest, and the Czech research institute USMD. Buses, in general traffic, are less comfortable, though segregation can improve both passenger comfort and vehicle wear and tear.

Many passenger surveys have shown that waiting time is an important consideration (Stubs et al, 1980). Metros have a short headway time, and therefore have low waiting times. However, systems are often planned on the assumption that passengers will interchange which is generally unpopular.

Walking time is also unpopular (and hence valued highly) by passengers (White, 1995). In this respect metros score less well as they have limited routes and longer stop spacings than buses. On of the biggest disadvantages for passengers is the need to interchange. This is bad enough in that it can require effort (and heat or cold) but if there is insufficient integration then costs can also be incurred. This helps to explain the popularity of competing paratransit, and in transport planning studies should be allowed for by including an interchange penalty 'cost'.

Transport planning methods can allow for the reduction in trips caused by extra time or distance travelled. It is more difficult to allow for the 'comfort and convenience' offered by a particular mode, or for individuals' peculiar preferences. Most feasibility studies in the UK for new systems will use opinion surveys to investigate the monetary value of such intangible factors. (Wilson & Neff, 1983) In the MRTAP model (Allport and Thompson, 1990) an assumption has been made that the extra comfort of metro travel is equivalent to a time saving of fourteen minutes though this result relies to a large extent on professional judgement.

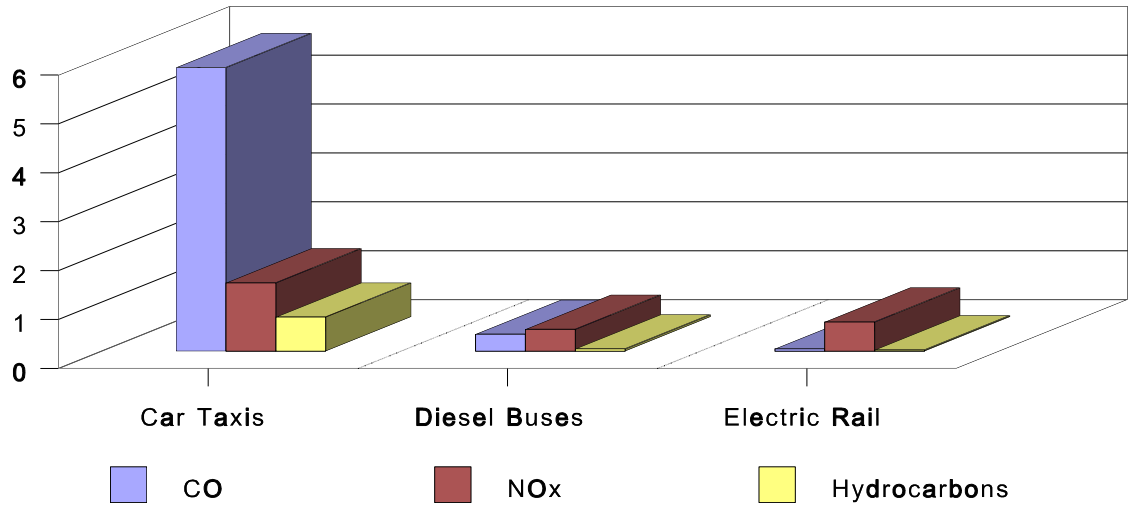
Studies by Smyth (1994) in Essen have shown that potential MRT passengers when asked before a scheme is constructed will tend to favour rail-based systems. When the scheme has been in place for several years, however, the preference for mode is determined by more local issues such as cost and walk/wait times. This casts doubt on the stated preference research often used as part of LRT feasibility studies in the UK. (Crampin, 1996)

5.4.6 Energy and Environmental Impact

Although difficult to quantify, these issues have, rightly, become of increasing importance in recent years, and arrangements are usually in place for some form of inclusion into the analysis of benefits. The level of environmental impact of a mass transit system will depend

Figure 12: Emissions from Public Transport Vehicles

Source: Test (1991), Sinha et al (1989) & Reno-Brixby (1985)



upon the mode chosen. Two main vehicle types are used for mass transit; buses which are usually powered with diesel engines; and rail vehicles, which, for urban services, are normally electric-powered. Fig 12 shows emissions in grams per passenger-km for each of these options.

Electric vehicles have a major advantage in that the energy used for their propulsion is generated remotely. There are therefore no local emissions - though this does not mean (as sometimes inferred) that they have zero pollution. In the Czech republic, electricity for transport is generated using brown coal, which is responsible for some of the worst pollution in Europe. Buses, if poorly maintained, can be a highly visible source of emissions. This is frequently given as a reason for pursuing a rail-based system (and less often for improving existing buses).

In considering pollution, a better indication (if data were available) would be to look at the total life impact of a system. This would consider everything from emissions during the construction phase, for example, through to the impacts of tunnelling on groundwater. This is incorporated into the best appraisal studies, but is difficult to do and so is often omitted (and did not exist in any of the case studies examined). Table 21 therefore presents the best of the available data representing the current state of knowledge.

TABLE 21: APPROXIMATE ESTIMATED EMISSION LEVELS FOR SELECTED SYSTEMS

Emissions (mg per passenger-km)	*Motor car*	*Bus*	*LRT*	*Metro*
SOx	*34a-54f*	*40a-251b*	*0c-279c*	*0c-173c*
NOx	*430d-2480a*	*232b-960d*	*0a-74c*	*23c-46c*
Hydrocarbons	*430d-2423f*	*60e-160a*	*0c-6d*	*0c-1c*

Figures based on the following sources:
a ETSU, 1994, b Walsh, 1989, c Reno & Bixby, 1985, d APTA, 1989, e Sinha et al, 1989 and DTp, 1989
f BC Transit, 1990.

The main polluter is, undoubtedly, the private vehicle. Any improvement in mass transit that can attract people from their cars, or more realistically, slows the growth in car use, will result in environmental improvements, whatever the mass transit type.

Table 22 shows typical levels of energy consumption per place provided. If data were available, a better indicator would be consumption per place used. This would favour a system that is flexible enough to match supply to demand, and thus keep occupancy levels high (eg buses). Given that the figures for buses are for operation in normal traffic, the reduction in stops and starts afforded by segregation would improve the position of buses still further.

TABLE 22: APPROXIMATE ESTIMATED ENERGY CONSUMPTION OF SELECTED SYSTEMS

	Private car	*Urban buses*	*Metros*	*Trams/LRT*	*Trolley-buses*

	(urban)				
Energy consumption per passenger km offered (MJ).	*4.2-5.7*	*0.6-1.6*	*1.3-1.6*	*1.6-1.9*	*1.9-2.3*

(based on Beauvais & Pillet, 1981)

Hearth & Stoilov (1985) found that energy losses at each LRT substation can be of the order of 285kwh per day. A typical LRT vehicle with 84 seats uses 12 kWh/vehicle mile. In cold countries winter operating costs can be as much as 60% greater than summer operating costs and approximately one half of each fare can go to cover just the propulsion power costs. Thus (in Cleveland) during low ridership times the LRT will not even cover its propulsion power costs. A late night trip probably fails to generate the average $18 in fare revenue needed for the trip. Energy operating costs have risen to the point where they may be as great or greater than the labour cost for vehicle operation (Polzin, 1985).

Other forms of pollution come from the visual impact of LRT overhead catenaries. Because of the weight of the cable, roadside poles must be substantial, and can be a potential road safety problem and an aesthetic distraction. Buses are normally noisier than LRT, but some tramways in Eastern Europe have high levels of track noise. The rails are laid on slabs in what is sometimes called the Hungarian construction method. When water washes out the sand supporting these slabs an acoustically resonant cavity is formed.

5.5 Cost Benefit Analysis

Having made all the estimates of potential benefits and associated them with some form of monetary value, these can then be compared using Cost-Benefit Analysis (CBA). This is a broad term covering analysis that compares the costs and benefits of a particular action: the most comprehensive form being social-cost benefit analysis. This has become an accepted method for evaluating major projects since the work of Beesley & Foster (1963). There are many inputs to this process, and several variants in methodology related to what should be included, and how it should be costed (ODA, 1993a).

The measure of cost benefit that is most commonly used in feasibility studies is the Internal Rate of Return (IRR). This is defined as the discount rate that equates the cash inflows and outflows of an investment project, resulting in a net present value of zero. This can be conveniently compared with the interest rate that would be obtained by simply leaving the money in a bank. The ultimate scheme promoter (usually a government) can therefore set a test discount rate whereby a scheme must achieve an IRR above a certain level (typically 12%) before going ahead. Although other indicators are available (for example the Net Present Value) the IRR is often used by scheme appraisers.

ODA, for example, required that all of their projects should have an economic appraisal. This had to include:

- The identification and (where possible) consistent measurement of all costs and benefits.
- Allowance for the phasing of costs and benefits over time.
- The application of standard decision criteria (including reference to IRR) (ODA, 1993)

Cost-benefit analysis attempts to reduce as many as possible of the disparate public values to a common currency, ie money. Although far from perfect as a valuation device, there are some merits in this approach since where an actual cost is not associated with an item, cost estimates from revealed or stated preference can be used. Typically this involves costing how much people would pay to gain benefits or avoid or mitigate disbenefits.

Social Cost Benefit analysis aims to secure optimum resource allocation from the point of view of society as a whole, so as to maximise the social welfare function of the whole community. It is used where "market imperfections require that a wider viewpoint be taken than that of simple profit maximisation. It attempts to answer a variety of questions. Is a given investment worth undertaking? is one project preferable to another? when would be the best time to start a project or close an existing facility?" (Stubs et al 1980).

The ODA Guide to Aid Procedures (GAP) Manual sheds more light on why a rational method is required; "HMG auditors will also have to be satisfied through appropriate certification arrangements that the funds have been disbursed in accordance with their stated purpose" (ODA, 1993).

Initially, CBA was seen as in improvement on the earlier methods based predominantly on intuition (Thomson, 1975). It also helped to increase awareness of the extent of non-user costs and benefits, and to identify who the non-users are (Stopher, 1980). However, since then failings have been increasingly noted (see discussion later), and even ODA admitted "The definition of the project used in the economic analysis may differ from the concept used by project planners or sponsors. The internal rate of return (IRR) is often used as an alternative to the net present value criterion but also fails to encapsulate the unquantifiable costs and benefits"(ODA, 1993).

5.6 Intangible Benefits

The appraisal of benefits may, or may not, make sound attempts to estimate unquantifiable benefits. However, there are many other elements to be considered in the appraisal process. These range from things that are highly noticeable, but difficult to quantify, such as visual pollution, through to things that are difficult even to comprehend and yet may be significant, such as civic pride.

This section attempts a more explicit consideration of the benefits which are not included in the appraisal. Some of these may have a universal merit (such as the impact on urban form), others may have particular worthiness because of aid policy objectives of a donor country. The latter are not fixed, but have changed over previous decades, with the impact on women, for example, carrying a lot more weight now than it did 20 years ago.
An obvious difficulty for research arises here in that precisely because they are unquantifiable, they are difficult for practitioners to include in an appraisal. There is also no opportunity for quantified research. However, the main impact areas can be flagged up for further research, which is in itself useful, particularly as none of the other research texts have considered this specific area.

5.6.1 Civic Pride

In 1976, Glasgow's Lord Provost Mr. Michael Kelly started a programme to improve the image of the city using a "Glasgow's_Miles Better" logo. This was reckoned to be highly succesful and one of the benefits from a raising of the city's image in the intervening period has been an increase in tourist numbers from 0.7 to 3.0 million between 1982 and 1990

bringing material benefit to the city far surpassing the costs of the initial campaign (Glasgow Herald, 1996).

Another UK city with an image problem has been Manchester. During the 1980s efforts to improve the city's image, culminated most noticeably in the bid for the 2000 Olympic games. As part of this improvement, the new LRT system may have contributed significant benefits if it can help to promote the image of a modern European (rather than a rainy Northern English city, Jackson & Laidler, 1995).

Having potentially even more valuable results was the decision by Singapore to build an underground metro, rather than a busway. The president himself was reported to have made this decision, even though studies at the time (Massam, 1978) suggested a busway would have been more cost-effective. Construction occurred when Singapore had a GNP per capita placing it in the category of a developing country. Singapore is now a highly-developed modern state. If the 'image' of a metro helped to convince investors of national quality and high technology, then this will have brought untold benefits. The city certainly has pride in its metro system as can be seen in plate 13

Plate 13: The Singapore Metro gives the appearance of being a source of pride for the nation (above).

Plate 14: The Monterrey elevated LRT in Mexico, when viewed from this angle, is reminiscent of a Medieval Cathedral

It is not possible to measure the impact of civic pride on the decision to build a mass transit system. It does appear that a new metro can be a powerful symbol of a city's status, disproportionate to its function as a people mover. Comparisons might be drawn with Medieval cathedrals (Plate 14) and Victorian town halls, whose size and grandeur far exceed their practical functional requirements.

The prestige of high-cost high-technology infrastructure is frequently mentioned in the literature. Lord Beswick Head of British Aerospace stated (when discussing Concorde) "There is a psychological spin-off, a constructive feeling of pride, a stimulating sense of prestige, if one's own society can claim to lead in any given field"(in Adams, 81).

5.6.2 Regional Development;

The annual growth rate for the value of time has been shown to be a key factor in the justification of an improved transport system. In order to achieve high growth rates, the urban area must be allowed, and indeed encouraged, to grow at a higher rate than the rest of the country. In small segregated areas like Hong Kong and Singapore, this may not be a

problem: elsewhere, urban migration may distort labour markets, allowing average salaries to remain low, In extreme cases, the encouragement of one area at the expense of another can lead to civil unrest (said to be a particular concern during the case study work in Dalian - an area of China growing up to five times faster than some poorer parts of the country).

If it is decided that the central area must be preserved as the primary functional space (as suggested by Jacobs, 1961) then the ability of a very high capacity system, especially an underground one, to support a vibrant town centre is a real benefit that will have real unquantifiable costs.

5.6.3 Culture and Heritage:

The demolition of buildings to make way for a new transport system, if done unsympathetically, can lead to the loss of buildings and monuments which may be an irreplaceable part of a country's heritage. Total numbers of demolished property, and some indication of their 'worth' should be considered but rarely are. This would favour a greater benefit to underground systems.

In the case study cities, the demolition of traditional Ottoman housing in the Beyoglu district of Istanbul to build an ill-conceived bus lane is a particularly sad loss of heritage attributed to mass transit provision.

5.7 Sensitivity Analysis

One way of dealing with uncertainty of the type inherent in trying to allocate costs to unquantifiable benefits of the type described above, is to use sensitivity analysis. This involves making a first estimate using the best calculation procedure available. Each of the input values used in the calculation can then be varied incrementally up or down from the base value whilst the impact of doing this is noted. The factors that, when changed, cause the most deviation in the end product are those that merit the most attention (and priority for any available resources to re-estimate input values).

As part of the work programme of which the research described here forms part, it was necessary to accompany a UK aid mission on a visit Guangzhou in China to complete an

Space left for sensitivity diagram

appraisal of a proposal for an underground railway. This offered an interesting insight into the appraisal process and offered useful background information on both political and technical aspects. One requirement of the mission was to examine, and use sensitivity analysis on, the cost benefit analysis prepared by the French consultants SEMALY (the operators of the Lyon Metro).

The SEMALY cost benefit table for the metro proposal was based on information of varying levels of complexity contained within 15 volumes of text and calculations. Rather than review and recalculate all of these, it was decided to produce a new cost benefit table on a spreadsheet using basic principles and best approximate estimates. The Internal Rate of Return (both financial and economic) was the output of the model and the inputs included basic values but also allowed for the use of defaults based upon international norms. Initially the model recreated the SEMALY figures, but then adjusted these to take into account other scenario interpretation and to allow the impact to be estimated of using alternative base values.

The spreadsheet included estimation of costs and benefits calculated from component parts (such as length of track, speed of operation etc.). This means that once the cost benefit analysis of a base situation has been derived, changing a selected input value will automatically recalculate the outputs. In order to automate this still further and permit multiple testing of all input variables, a macro was written to produce a sensitivity chart. This shows how IRR changes from its base value as the input values are changed through a range of from 60% of their original value up to 135% of their original value.

The chart produced from the sensitivity testing is shown in fig 13. This shows that construction cost and the value of time are the two items that make most difference to IRR (though construction time is also linked into this). In contrast, the value of accident savings, and individual cost items such as the cost of a workshop make very little difference to the end result. Another change which had no impact was extending the period of appraisal beyond the normal 20 (sometimes 25) years typically used. Some have said that tunnels in particular should be appraised over their lifetime of up to 100 years, but in practice the use of IRR as an indicator means that benefits after 20 years

diminish and become negligible.It is noteworthy that the estimation of Internal Rate of Return for the Guangzhou metro was originally exactly 12%. Reviewing these figures suggested that 8% was more likely, but that if the same service was provided using a busway then a rate of return of more than 40% was predicted. More work would be required to come up with a definitive comparison of a range of demand characteristics to estimate at what stage a rail system might produce a comparable rate of return to a busway.

Sensitivity testing was a recommendation of both Armstrong-Wright(1985) and Dotson and Mitric (1998) though it is was not used in any of the feasibility studies examined and it is not clear to what extent it has reached common practice.

5.8 Summary of Financial Findings

This section demonstrate what computer programmers have known for a long time. Namely that if one takes a sophisticated procedure with hundreds of complex inputs, two things will happen. Firstly, nobody except the programmer (or transport consultant) will completely understand what it is all about. Secondly, if results do not fit preconceptions then, by tweaking inputs to plausible ranges either side of the mean, different answers can be achieved.

A further advantage of such a sophisticated process is that it is relatively easy to hide wood behind trees and pull wool over eyes. Thus a twenty-page calculation of depot costs can be used to divert attention away from the fact that the estimate of value of time is actually based predominantly on guesswork (Bursa Case Study, 1995).

With regard to the hypotheses, therefore, it is easy to see how LRT can have been presented as superior to busways for so many years. It is easy to take low estimates of bus performance and compare these with high estimates for rail. The value of time is the most significant influence on a scheme's viability. Given that even this process is at such an infant stage, it is not surprising that promoters can find ways of submitting highly plausible methods to calculate values that support their particular arguments.

In fact, as the previous section shows, there is little difference in technical performance between LRT and busway once other factors have been allowed for. This chapter has shown that LRT construction costs can be around 5 to 25 times more expensive than a busway. Little confidence would appear to be justified in estimates of economic performance, but even here a busway will perform better. It would appear, therefore, that the first hypothesis asserting that LRT in developing countries has been over-rated is supported.

The notion of 'betterment' assumes that private interests are willing to pay for the benefits which they might gain as a result of the railway having been built. Sources depending on betterment are unpredictable and closely dependent on the state of the local economy. Urban rail rarely has more than a marginal effect and if confused with changes in planning legislation it can be overestimated. Many alternative sources of funding will work out less efficient than the straightforward use of public funds. It should be realised, therefore, that the use of a novel taxation method may be more politically acceptable, but it can have a real cost to the community.

This then raises the question, which is relevant to the second hypothesis, of how approval is obtained to go ahead with a project that is more expensive to build and yet has similar (or even lower) performance. All of the projects built have been through some form of an appraisal beforehand and these procedures should have helped to sift out inappropriate proposals. In practice, there seems to be a gap between what objective appraisal would suggest is beneficial, and what is actually built.

Financial cost-benefit analysis, aimed at estimating the ‘affordability’ of a project would appear to have many advantages for a poor city, and could make decision making more transparent. In setting out the basic rationale of cost-benefit analysis it must be conceded that there are serious problems concerning selecting and then reliably estimating the relevant factors for an appraisal. Also,

> “The economist may conclude that an investment offers a potential Pareto improvement. However, the ultimate decision is political; and if the political decision must take account of the social equity of the investment, the economist should make explicit the likely distributional consequences of the investment" (Stubbs et al, 1980).

This is a very important concept, and the need to make transport decisions more transparent is one of the driving forces for the present research.

6 APPRAISAL & DECISION MAKING

As shown in figure 3, many of the countries wishing to have an urban rail service are located in countries where internal funding is unlikely to be available. A critical factor in obtaining funding is therefore whether the proposal will satisfy the requirements of agencies providing aid.

6.1 Aid Appraisal Process

Large transport projects are normally designed by the host city and presented to a funding agency for appraisal. Appraisal is central to any aid agency's procedures for managing its resources. It is the process by which decisions are made on which activities to fund, as well as the most appropriate form and extent of support. A thorough appraisal is the agency's best guarantee that its aid resources will be effectively used to produce the most beneficial impact.

It is at this stage that differences can arise between the two parties. The methods for design will vary according to local practice. Some projects may go through a strict local feasibility testing process before submission; others may be less scrupulous, such as those by the Government of Mauritius(1990) and Guanzhou Municipality (1989). Similarly donor agency procedures can vary as outlined above.

Project proposals are passed to the funding agencies for evaluation as a 'fait accompli' (ODA, 1993) at which point UK appraisal procedures seek to ensure that the aid programme resources will be effectively used to produce the most beneficial results. Main areas to be covered are;

- Technical,
- Economic and Financial,
- Environmental,
- Social and Institutional.

Account is also taken of Good Government issues and Project-Related Training.

Evaluations review how and why projects succeeded, failed or were changed. Use of the term 'evaluation' varies from one institution to another. In the UK it generally refers to a study carried out **after** a project or other activity has been completed. Some agencies

(mainly Francophone) instead use the term to cover the initial assessment of a proposed project (the stage termed as appraisal in the UK) and the post-completion assessment. In this thesis (unless otherwise stated) the UK term 'appraisal' will be used throughout.

The ODA appraisal guide stated that "In all countries the number of worthwhile development activities invariably exceeds the resources available. In order to maximise the impact of aid it is therefore important that only those activities of the highest priority should be tackled first...Do the benefits that will accrue from the project exceed the costs of undertaking it? There is often a range of alternatives available and the one first put forward may not necessarily be the best, for example a river can be crossed by a ferry, a bridge, a tunnel or a ford. The most appropriate type of project will depend on the particular circumstances of the case. The process of appraisal cannot be separated from that of design; improvements can often be made to the design of a project by thorough technical appraisal."(ODA, 1993).

There are many facets of urban living that can be affected by the construction of a large project such as urban mass transit and many of these are incorporated into the cost benefit analysis described above. The primary elements that may make the difference between a system being judged (in some way) as a potential 'success' or failure' by an aid organisation such as DfID are likely to be the following:

6.1.1 Urban Poor.

Income clearly affects the way in which people choose to travel. It sets the limit on their capacity to acquire a personal vehicle and also, given that trip making is relatively inelastic to income, it sets the limit on how much of a particular mode they can 'consume' in order to achieve their desired level of travel. Urban poverty is a particular concern of almost all of the aid agencies. The distributional effects of a project on the urban poor might therefore have an impact wider than simply whether they become riders or not.

It is quite common for low-income commuters to switch their normal mode of travel from bus to walking towards the end of their pay-period as money runs out (Maunder, 1986). It is not unusual to find that 5-10 per cent of household income is spent on transport; sometimes the figure is as high as 15 per cent. At this level of expenditure per capita annual

incomes of between US$ 600-1500 can just support fare levels of 20-50 cents (for a typical round trip of 10 km.). As shown above, this will not be a feasible fare level to maintain a rail-based transit system without a financial subsidy.

The most obvious disadvantage to the urban poor will be if a service they must use has a ticket price they cannot afford. Another major problem will be (as certainly appears to be the case in Cairo) that a prestige metro system will divert money away from the local bus services on which they depend.

In order to provide both the best route for a Mass Transit System, and perhaps to have it associated with some urban 'improvement', the proposals for a scheme will often include some housing demolition. For economic reasons, this will usually be restricted to areas of low-grade buildings in the central area. This is precisely the sort of area in which the urban poor will accumulate: in the centre so as to reduce travel costs, and to work in low paid jobs, particularly in the service sector, which tend to accumulate in the Central business District (CBD).

These changes to living patterns of the urban poor will not normally be incorporated into the appraisal, or if they do their financial weight may not necessarily reflect their social impact.

6.1.2 Other Socially Excluded Groups

"Social" is a general term to refer to the way that individuals and groups organise themselves (institutions) and give value to their activities (culture and beliefs). A social appraisal would seek to answer questions including:

- Is the project really needed by the people who are supposed to benefit?
- Is it affordable to specific target groups, such as the poor or women?
- Are vulnerable groups made more insecure or poorer?
- Does the project fit the cultural environment? Is the technology appropriate? (ODA, 1993).

Women are over-represented among the urban poor and are thus more likely to be affected by moves towards a more expensive urban transport scheme. However, research has also found (Fouracre and Turner, 1995) that a greater percentage of women are likely to be

employed within walking distance of their home. They are also less likely to be travelling at peak periods.

In a developing city context in which existing buses are usually full to capacity (and beyond), it is those unable to fight for a place on a bus, ie the young, elderly and women who are the first to be denied access to the public transport network. Where personal finances allow, women have been found to make greater use of premium fare services, such as urban rail or paratransit, where they can be guaranteed a seat in relative comfort and security. However, even if a superior service is provided, the 'head of household' (ie the man) is likely to have first call on the family budget to improve his own transport comfort. While a move towards comfort is therefore beneficial, a move towards higher fares might not always benefit women (Fouracre and Turner, 1995).

German and Randel (1996) found that the incorporation of Gender into appraisals, for example, is slowly becoming mainstreamed in policy, but much less so in practice, with the EU in particular, despite a council resolution on gender and development cooperation in 1996 having “patchy” implementation.

6.1.3 Institutional Capacity

Projects are implemented and operated by institutions. The way in which these institutions operate has a material impact upon the effectiveness of the project. Numerous projects which have appeared sound from technical, economic and financial viewpoints have been partly or wholly frustrated by institutional constraints (Barrett, 1984). Hence the anticipation of institutional impacts can influence appraisal outcomes.

Institutional factors include:

- Organisational Structure. Numbers of people, how it is divided into units, kinds of control and reporting, suitability of work patterns and objectives.
- Policy and Decision Making Patterns. Areas of policy and decision making, strengths and weaknesses.
- Procedural Factors. Work flows, communications patterns, organisation style.
- Manpower Resources. Critical skill needs, sources and deficiencies, salary grading, promotion, motivation and moral.

- Political Background. Political significance of the institution, government ideology, regional factors.
- Social Background. Caste or tribal orientation, personal value systems, family ties, gender factors. (ODA, 1993).

The most commonly quoted institutional benefit for a modern MRT is in the technology transfer from the supplier country to the recipient. This was seen as a vitally important part of the Korean high-speed railway between Pusan and Seoul, although it has had only partial success (IRJ, 1997). The construction and operation of a large scheme such as an urban metro can require a cultural change. Countries which have different concepts of time, efficiency and contractual obligations are forced to work together, possibly to the advantage of both (see Taipei: Wu et al, 1993).

Sophisticated project management techniques and modern management methods will be needed to ensure that the project is completed on-time and to schedule (though as the Channel tunnel has shown, even this cannot guarantee success). This will have real costs that can be accounted for during construction, but the continuing benefits may represent an unseen gain to the country that has widened its experience.

6.2 Other trends in Aid Policy Objectives

Even if a method could be found to incorporate the benefits listed above that are associated with a mass transit system, there may be other factors that influence the appraisal process. A project that is good in all other respects may still fail to gain funding from an aid agency if, for some reason, it is outside of the agencies stated objectives.

It would therefore be reasonable to suppose that the projects that most closely support these aims would have the most chance of being accepted for funding, despite an otherwise lower than specified cost-benefit ratio. As an example, the ODA system of appraisal of projects was via Policy Indicator Markers (PIMs). These were mandatory for projects over £100,000. As shown in the box below these included a wide range of socio-economic objectives. Schemes were supposed to be judged against these before receiving funding.

POLICY MARKERS

Priority Objectives		**Other Markers**
01 Economic Liberalisation	:	10 Illicit Drug Control:
02 Enhancing Productive Capacity	:	11 HIV/AIDS :
03 Good Government		: 12 Urban Development :
04 Poverty Reduction	:	13 Private Sector Development:
05 Human Development - Education	:	14 Research
06 Human Development - Health	:	**Rio Markers**
07 Human Dev-Children by choice	:	15 Energy Efficiency
08 Women in Development	:	16 Sustainable Forest M'gment:
09 Environment	:	17 Biodiversity
	:	18 Sustainable Agriculture

These, with their inclusion of liberalisation and productive capacity, gave some support to large projects with industrial partners. In contrast the new aid policies detailed in the White Paper (DfID, 1997) place increased emphasis on poverty alleviation, on working with partners including the EU and Non-Governmental Organisations (NGOs) and on phasing out the Aid and Trade Provision in favour of supporting the Commonwealth Development Commission. NGOs have traditionally focussed on rural projects and have no tradition of dealing with large urban transport problems (the Oxfam annual report for 1998, for example makes no mention of urban transport - Oxfam, 1999). It is too early to say how this will influence aid to urban areas.

A warning note on the effectiveness of stated aims comes from a report prepared by NGOs called ‘ Reality of Aid’ (Randel & German, 1998). This report reflects fairly positively on some donors' intentions to increase the attention paid to poverty. But even at the level of objectives this is not universal, especially among the largest donors. The USA, for example, has only the fifth of five USAID objectives focussing on interests other than those of the USA itself - and the word poverty is not mentioned. While Japan allocates some aid for basic human needs as a 'safety net' for the poor, the Japanese basically “regard aid as a promoter of growth through industrialisation and expansion of exports of industrial goods. In France, sustainable development and the reduction of poverty have been reaffirmed as 'priority objectives', but “it is almost impossible to find any logic linking the distribution of French aid with these objectives. The majority of donors will need to make a great effort to translate policy statements into effective implementation” (Randel & German, 1998).

6.2.1 Other Issues

The times at which the benefits of a new transport system can be enjoyed are important in the evaluation of a project. Most people place a higher value on early payback on an investment. In economic terms this is allowed for by a discount factor that reduces the value of future benefits. In order to compensate for risk, a funding agency may insist upon a higher discount factor than is otherwise used.

The influence of timeliness and the ability of urban rail to be a temporal landmark can be seen in the linkages between systems and events of national or international importance. Thus, the Manchester metro was a visible part of the bid for Olympic Games, as was the Sydney metro and the Kuala Lumpur LRT was linked to the Commonwealth Games.

In the Guangzhou case study visit it was somewhat ironic that having spent three months deliberating over whether a UK contribution was justified (to what looked like an marginally viable project) the German government stepped in with a guarantee of aid three times higher than the UK offer. The announcement was timed to coincide with the German Chancellors state visit.

There is another important institutional and political dimension: the term of office of the decision makers in a city is usually limited, and a very high value may be placed upon a prestigious scheme such as a metro if it opens at the right time. Conversely, a negative impact that occurs later, such as loan repayments deferred until after a presidential term (when the President may be in exile) might not be a major consideration (Henao, 1998).

6.3 Appraisal Conclusions and Discussion

There does appear to be elements associated with a mass transit that have some form of impact and yet will not be included in the appraisal process, particularly the one used to identify aid-funded projects. The need for an appraisal method to supplement cost benefit analysis is clear. There are elements that are unquantifiable and yet which appear to be influential in the decision making process. The aid agencies do have requirements for non-quantifiables to be considered in the appraisal process, particularly where they are part of their specific objectives. These objectives can vary and are not necessarily comprehensive

meaning, for example, that important subsidiary impacts (such as the impact on urban spread) may be overlooked. Other benefits may also be overlooked, especially they are unquantifiable and have no obvious links with other aid policy markers such as urban poverty.

The unquantifiable elements considered above would in some cases (such as for the urban poor) favour busways and in others (for example civic pride) favour rail options. Unfortunately, being unquantifiable, it is impossible to measure the extent of influence of each category. Some improvements in measurement methods may permit some progress to be made in some areas; until then it is only possible to speculate. It is possible (and would certainly be human nature) that aid priority markers are seen simply as obstacles to be overcome by token gestures, rather than a guide to a worthwhile project. In contrast, for factors which have direct political implications (such as riding on a wave of civic pride) then the impact will be much stronger.

Whatever the stated objectives of funding agencies, and whatever the best estimate of unquantifiables concludes, the fact of the matter (as shown in fig3) is that there has been real growth in the number of expensive rail-based schemes. Not all of these would stand up to a full and fair appraisal using best available methods. Some of the possible reasons for this gap, as put forward in the second hypothesis, will be examined in the next chapter.

7 DECISION MAKING

The second main hypothesis of the present research is that

> " Evaluation methods used by Western aid-agencies do not satisfactorily explain the choices made of mass transit systems in developing cities. There is a clear gap between what seems justified technically and economically, and what is implemented. "

The previous chapters have given some support to this hypothesis. The case study experience also suggests that there has been some kind of 'failure' of local decision makers to take the proper course of action.

An alternate view is that the local politicians are not wrong, but are simply applying decision criteria that are different (not worse) from those used in the West. This section, therefore, considers different approaches to problem solving and looks at the field of problem analysis with the specific purpose of identifying practical approaches to the issue of mass transit decision making.

7.1.1 Definitions

In choosing between different options to reach a goal, individuals or organisations are required to make decisions. A choice is needed that is consistent with the beliefs and values of the decision maker. Decision making can be defined as the selection of a particular option that best satisfies a given set of objectives.

Decision theory has been described as "a broad spectrum of concepts and techniques which have been developed to both describe and rationalise the process of decision making, that is, making a choice among several possible alternatives" (McGraw-Hill, 1987).

Decision theory is an analytic and systematic approach to studying decision making. The decision theory literature is (understandably) united in the recommendation of the use of some form of decision analysis or support system to fit some form of structure to ill-structured problems. What is encouraging is how few specialists regard actually reaching a decision as an end in itself. Rather, comments are made such as:

> "It should be emphasized that the main role of our analysis is to enable the decision maker to gain an increased understanding of his or her decision problem. If at the end of this analysis no single best course of action has been identified, this does not mean that the analysis was worthless. Often the insights gained may suggest other approaches to the problem or lead to a greater common understanding among a heterogeneous group of decision makers" Philips (1984).

And "The role of decision theory is to provide a supportive framework to assist people reach consistency. In doing so they can provide a common language, a focus for discussion, and a means for the exploration of different values leading to a better understanding of the situation and of others' perceptions of it" (Belton and Ackermann, 1997).

The present research, therefore, can make a valuable contribution to the knowledge of the mass transit appraisal process, even if it does not produce a definitive answer to the choice problem.

A definition of a 'problem', given by Keeney and Raiffa (1976), is that it is the failure to reach a set of objectives. An 'objective' is defined as an indication of the preferred direction of movement. Problem solving, then, is a process of transforming an initial situation into a desired situation, the goal.

The first step is to identify and agree what the objectives might be, and against which a project should be judged. This is a critically important stage, and yet one that the case-study evidence suggests may have been neglected. Some insight into the possible differences between an Eastern and Western view on this critical process has been given by Drucker (1974):

> "The Westerner and the Japanese mean something different when they talk about making a decision ...To the Japanese, the important element in decision-making is *defining the question* ... The answer to the question (what the West considers *the* decision) follows from its definition."

This thesis therefore sets out to explore the possibility of putting the best possible structure to the unstructured problem of investment appraisal for developing countries, in the hope that en route to this solution our knowledge in this area might be expanded.

Perhaps the most well-known framework for examining problems is Simon's intelligence-design-choice trichotomy (in Klein & Methlie, 1995). Simon's framework consists of three

phases:

(1) Problem Definition: searching the environment for conditions that call for a decision - the *intelligence* activity
(2) Solution Development: inventing, developing and analysing possible courses of action - the *design* activity
(3) The Selection Process: selecting a particular course of action from those available - the *choice* activity

This conceptual framework has been taken as a basis for much of the work that has been carried out on decision support systems (see, for example, Sprague and Carlson, 1982). The framework also offers a logical method of approaching the present research.

7.1 Problem Definition

If a problem is a failure to meet goals, then in order to define the problem it is necessary to establish what these goals should be. At the detailed level, there may be some disagreements about what are the goals, especially when each project varies and there are many interested parties involved. In order to reach agreement on realistic and universally accepted goals, we must look at what fundamental concepts everyone can agree upon. One (of many) theories of what humans actually want is based upon a study of basic human and social needs by Maslow (1976), in his basic hierarchy of human motivation.

Maslow suggests that it is in trying to reach agreement on higher-order needs that disagreements might occur. For example, to whom should the benefits accrue? Is a disbenefit to a poor/old/disabled person equal to someone who is (or even who considers themselves to be) more economically 'important?' Similarly, is there a fundamentally 'correct' view on the desirability of travel and land use? A land-use that promotes travel to out-of-town sites even by metro might be considered undesirable. The Hong Kong metro, for example, is one of the most efficient in the world because (in addition to being well organised) it serves an area of very high density housing and business with corridor demands of over 100,000 trips/hour/direction. The question then arises of whether living at this density is a desirable condition for humans.

These are quite philosophical points. Most of the issues are covered during the following section. For the purposes of the definition of the problem, two assumptions will be made in the pursuit of some form of consensus view. Firstly, the condition of a city will be assumed to be a desirable one. This is in keeping with the widely-respected work of Jacobs(1961). It is assumed that people will reject living patterns that they are not content with, and that there will be a natural balance of land use and travel patterns. Secondly, the principle of "Economic man" will be accepted. As outlined by Simon (1957) this assumes that people make decisions which maximise their "profit" in economic terms. Although much derided, even its critics accept that it is useful as a principle for comparison with other methods (Luthans, 1984). The goals of a mass transit system then become as shown in the box below.

1. To provide a system that will not have a negative impact on the environment
2. To be a service that the city can sustain.
3. To carry people, safely, in as large a number as they wish to travel.
4. To support, but not distort, land-use patterns.
5. To produce benefits that outweigh the disbenefits

Having accepted these as goals, then, we can say that a system that does reach these goals is 'better' than a one that does not. Similarly, we can say that the failure to reach these goals represents some form of 'problem'. Having accepted that there is a problem (and the case studies suggest ample evidence of failure of some sort) then we can investigate what methods others have used to study, and ultimately solve, problems.

7.1.1 Problem Diagnosis and Analysis

Problem Diagnosis, according to Mintzberg (1979), requires that the real problem and its causes and its boundaries should be identified. This is a highly important recommendation, and mirrors the advice given in management textbooks about 'getting the facts straight' before embarking upon disciplinary action (Worrall, 1980).

The diagnosis stage consists of putting the problem under scrutiny to establish exactly what is the problem. This is a very important stage since it is possible that there might not actually be a problem, or the perceptions of it from one viewpoint might be very different from another. Belton stresses the need for problem structuring and points out that as problem

structuring is very broad in scope, one might adopt a recognised framework such as Kepner Tregoe's problem analysis (Belton, 1990).

Potential sources of problems: Kepner & Tregoe (in Von Winterfeldt & Edwards, 1986)	Problem Analysis Steps (Kepner & Tregoe, 1981)
(a) people (motivation, skills, health), (b) organization (relationships, communications), (c) external influences (economic trends, competition, legal and government), (d) facilities and equipment (space, flexibility, location), (e) ideas and processes (security, adaptability), (f) material (sources and availability, quality, handling and storage), (g) money (capital, costs and expenses, return), (h) output (quality, quantity, pace and timing), and (I) personal influences (goals and plans, family interests).	1. Identify Problem Areas by comparing actual performance with what should be happening. 2. Examine the problem areas, establish priorities and select a key problem issue to deal with. Inspect the urgency, seriousness and general trend and growth potential. 3. Determine the problem identity, location, time and extent: Determine the extent of any deviation from expected, where is it occurring and when 4. Identify those characteristics that distinguish what the problem is from what it is not. 5. Determine relevant changes that could have caused the problem. 6. Using the relevant changes identified, deduce possible causes of the problem 7. Test the possible causes of the problem by determining the extent to which they explain what is and what is not characteristic of the problem.

TABLE 23: PROBLEM IDENTIFICATION AND ANALYSIS

The Kepner and Tregoe method (Von Winterfeldt & Edwards, 1986) helps to make clear the problem boundaries. There are not only spatial boundaries but also boundaries in the dimensions of time, responsibility and ownership. In a separate piece of work Kepner and Tregoe (1981) suggest a seven-stage problem analysis cycle. In this way the problem can be more clearly defined.

Table 23 shows problem sources and analysis stages as recommended in the two separate publications by Kepner & Tregoe. Combining these two tables (although not done by Kepner & Tregoe themselves) gives 63 combinations of analysing a problem. This can help in the development of an enormous and comprehensive checklist to ensure that no element

of a problem area is left unexplored.

For the purposes of this research the issues surrounding mass transit appraisal were reviewed in association with contacts in the case study cities. This method of problem analysis proved to be a highly effective guide to assist digging deeply into a problem area. The method is therefore likely to have useful implications for other areas of study.

7.1.2 Problem Categorisation

In order to make sense of the enormous list of possible problem areas produced by the Kepner -Tregoe analysis described above it was necessary that they should be sorted, sifted, and gathered together into manageable categories. Mintzberg (1979) defines three routines that are suitable to help approach a problem.

(1) **Decision control routines** involve planning the *process*, selecting the correct plan of the process and choosing the sequence of steps that is appropriate in the current situation.

(2) **Decision communication routines** involve *information* processing: scanning for general information, searching for specific, special-purpose information, and the dissemination of information about progress in the decision process.

(3) **Political routines** involve bargaining among those who have some control over choices, persuasion and cooperation. *Political* activities reflect the influence of individuals who seek to satisfy their personal and institutional needs by using the decision that has been made.

This offers a suitable structure to help categorise the long list of problem areas identified. The result of this action is the problem categories shown below. This is an important list as this encapsulates all of the possible problem areas that are currently thought possible in the field of mass transit decision making.

Categorisation of Problem Areas in Mass Transit Infrastructure Investment Decision Making.

1. **The Control Process:**
   - A There is not a problem, the decision only appears wrong due to Western biases regarding appraisal procedures.
   - B The problem only appears because there are real benefits to the people which are not properly quantified in the evaluation process.
2. **The Communication Process**
   - A A correctly planned project becomes a 'failure' due to problems that genuinely could not have been foreseen.
   - B Political leaders make an incorrect decision due to lack of knowledge or poor advice.
   - C Poor internal organisation is preventing good decisions from being made
3. **Political Routines**
   - A Decision makers correctly represent the view of their people, but this is does not agree with Western approval procedures.
   - B Political leaders make an incorrect decision because of non-altruistic motives.
   - C Projects that would normally be local issues are affected by national or even global politics because of their size.

Many of these will be interrelated, and some will have more influence than others, depending on the circumstances. The topic headings in some cases cover a very wide range of possible problem areas.

7.1.3 Choosing the Right Appraisal Methodology - Problem 1A.

One of the reasons for the evaluation gap may be because of the evaluation process itself: either because the method itself is flawed, or because insufficient information is considered by it. A full account of the evaluation and appraisal methods used for UK aid project has been given above and notes the difficulty of reconciling the need to be flexible and yet accountable.

Belton (1990) provides definitions to distinguish between two types of decision for which a support methodology is needed. First, an *appraisal* decision is concerned with the appraisal of, and subsequent choice between, discretely defined alternatives. A *Design* decision is concerned with the identification of a preferred alternative from the potentially infinite set of

alternatives implicitly defined by a set of constraints. Regarding mass transit, for example, a *design* problem would have as its basis the objective of finding a solution to the access requirements of people. An *appraisal* by the city authorities might decide between three or four distinct preferred options that have already been selected.

At this stage it is already possible to identify a deficiency in the present arrangements for the appraisal of aid projects. What is presented to the aid agencies for 'appraisal' is actually a single option, a fait accompli, or what (Belton, 1990) calls a dominant choice. Using DfID's own definitions, it would be more accurate to describe the 'appraisal' as a pre-implementation evaluation. The aid agencies (or their advisers) are asked to predict the success of a single project, rather than to choose between alternatives. As Watson and Buede (1987) note, prediction is a difficult task which adds uncertainty to the process. Additionally, an opportunity is lost for the aid agency experts, using the 'shared language' of the structured problem, to contribute ideas and experience at the design stage.

7.1.3.1 Specification of Problem

Failure is possible in the decision process if the question is incorrectly specified. This results in the inability to reach a solution due to lack of understanding of the problem or the selection of the wrong solution. In classic hypothesis testing a type 1 error is rejecting *Ho* when it is true, type 2 is accepting *Ho* when it is false. Tukey reported in Raiffa (1969) suggests a third type 'solving the wrong problem' to which Raiffa adds a fourth 'solving the right problem too late'.

One of the criticisms of UK transport policy has been "There is a basic lack of agreement (or even hard systematic thought) on exactly what are the goals, priorities and objectives for the nation and its urban areas"Hanna & Mogridge (1992). This suggests lack of agreement on what is the question to be answered, which inevitably restricts the chance of a good solution. A clear recommendation for any decision, then, is to clarify and agree with all interested parties what the decision is really all about. It is uncertain how different would have been the reaction to the Newbury bypass in England, for example, if somehow clarification could have been made whether this was a local bypass, or a statement of UK transport policy.

As Drucker (1974) points out "To determine what is a fact requires first a decision on the criteria of relevance, especially on the appropriate measurement". Only when there is agreement on what the problem is can progress be made towards a solution.

One of the greatest criticisms of several MRT projects (Fouracre et al 1990) is that they fail to address the more fundamental problem of what is needed in a city. Although they may be well-built, popular and well-maintained, metros frequently fail to address the problems of access, mobility and traffic congestion.

7.1.3.2 Aid Priorities

The aid priorities described earlier in this thesis are typical for many aid agencies. Many of the priority indicators at first glance appear to have a rather tenuous connection with a large urban transport scheme. However, very large projects will have far reaching implications not just in what they do but in their opportunity cost (that is what might be done with the money if not spent on the project).

In total, Third world debt rose from $100 billion US in 1970 to $2 trillion in 1997. With the total World aid budget of $292 billion being almost matched by the $269 billion that Southern countries paid to the North for debt servicing (Rehnby, 1999).

In contrast to this enormous global financial trough of money being manipulated by hugely powerful men, the UK aid policy is moving towards the support of NGOs and helping the poor. NGOs are, by their charitable status, forbidden to become involved in what might be interpreted as 'politics' and have a long tradition of aid work working closely with local people. This does raise the possibility, however, of a scenario in which, for example, funding is sought for a small village water pump. There might be an imbalance between the attention and priority given by UK experts to the small and outwardly desirable project when compared with that given to monitoring and regulating the vast amounts of money being loaned by UK banks for a prestigious white elephant project in the same country.

Without access to aid agency schedules it is not possible to test this observation. However, it does seem possible that a method of aid appraisal that relies upon priority markers may put more emphasis on promoting 'good' schemes than on controlling 'bad' ones.

7.1.4 Appraisal Method Choice - Cost benefit analysis:

As more fully described earlier, cost-benefit analysis is a broad term covering the analysis that compares the costs and benefits of a particular action, and social cost-benefit analysis attempts to quantify all of the benefits of a project. There are many inputs to this process, and some disagreement exists over what should be included. One of the largest inputs is the value of the time saved as a result of the new investment.

Value of time is a concept that is difficult to quantify accurately, and yet it is a key to the economic feasibility of most transport schemes. Figure 11 showed how much of a scheme's estimated benefits will be due to time savings. Some have questioned the basic philosophy of costing a large number of small time savings made by poor people in a developing country. Sherlock considers that "It is arbitrary, to say the least, to value time saved by a financier as more valuable than a teacher, simply because one earns more per minute than the other"(in Stopher, 1980). Mitric (1996) states that,
within reason, a government should be free to choose a value of time for its people - an 'incorrect' value of time might, for example, place investment in a set of traffic signals (which save a large number of small time periods) ahead of a clean drinking water well in a drought stricken area.

De Weille (1966) found, in reviewing early World Bank reports, that one "includes one sentence in 100 pages stating that `Academic distinctions are sometimes made between `productive' and `unproductive' ... This study, however, assumes that leisure time is equally valuable as work time. In this one assumption a transport project can change from a `failure' to a success (De Weille,1966).

It is highly likely that two economists could make a reasonable case for two separate values of time, one giving net benefits above, and one below, the test discount rate. The output from an analysis can therefore relatively easily be made to fit the political or commercially expedient. It is therefore very difficult for an expert, let alone a politician, to decide who is right and who is wrong. According to the well-known US management 'guru' Peter Drucker "The good statistician distrusts all figures - he either knows the fellow who found them or does not know him: in either case he is suspicious." Drucker(1974).

One of the most vigorous critics of Cost Benefit Analysis (COBA) has been Dr John Adams, from University college London. According to Adams.

> "Cost benefit analysis is a nonsense. It stands even less chance of reducing the basic elements of transport planning decisions to gold than did the rituals of the medieval alchemists who attempted to perform a similar feat with rather more tangible base elements.... Science has been called the art of the soluble; COBA is one of the black arts of the insoluble" (Adams, 1981).

A more balanced view is given by Mitric in a World Bank discussion paper, Mitric says that "In truth, neither the state of the art of economic evaluation of metro projects, nor its quality as practised by consultants working in developing countries, are strong enough to justify treating the assessed rate of return as both necessary and sufficient condition for project acceptance." (Mitric,1997)

The use of cost benefit analysis is unlikely to change fundamentally in the near future. Whilst recognising the faults inherent in cost benefit analysis, therefore, this research has taken the pragmatic path of accepting it as a central part of any evaluation process. The objective has been to add to it and supplement it, rather than replace it. This approach is also now being taken by the UK Department of Environment, Transport and the Regions (DETR) in their New Approach to the Appraisal of Road Projects (DETR, 1998). It also supports the recommendation of Dotson & Mitric (1997) that cost benefit analysis should be used as a part of the exploratory component of the decision making and sensitivity testing process, rather than seen as the generator of a single number answer.

One of the findings of the case study fieldwork was that financial affordability should be a key indicator to be considered in the appraisal process. Although several authors have also suggested this, there is no sign as yet of it having been tried in practice.

7.1.5 Inputs to evaluation - Problem Type 1B

As more fully discussed above, for the full benefits of a scheme to be assessed, every possible benefit and disbenefit should be considered. An objective assessment of a project (such as cost-benefit analysis) will frequently exclude those items that are not possible to quantify. Entire conferences have been devoted to the topic of how to improve the

quantification of difficult areas, not always with success (Winpenny, 1991).

The time scale of an evaluation can mean that even where methods exist they may not get used. Although ODA recommended that standard approval procedures be followed, it admitted (when referring to Aid and Trade schemes):

> "It may however be impossible for ODA to carry out detailed appraisal, or greatly to influence design. This might be because of inadequate knowledge of the economy, institutional capacities and so on of the country concerned; or because the firm had already reached an advanced stage in agreeing project design with the customer; or it might also be because of the need to make speedy decisions if it is to be worth making the offer at all." (ODA, 1993)

There are other factors that are not just difficult to quantify but which are actually impalpable or intangible. Some intangible elements associated with a project may be positive, for example where the project acts as a catalyst for other beneficial things. If these elements are not accounted for, a project that could bring real benefits to a city might be rejected because its benefits are not considered.

In the same way that some effects may not be included, however, there is the chance that some factors (or even the same factors in different cities) can be exaggerated. Promises of intangible benefits, such as an image boost for example, can be used to promote a scheme. Although this may be acceptable in the West, it is debatable, for example, whether a city with a serious humanitarian problems and an image problem even in its own country (such as Calcutta) will change noticeably simply as a result of a metro.

7.1.6 Values

It is interesting that the importance of values in judgements is one of the newer factors influencing decision making theory. Having been involved in decision theory since its early days, the greatest change in Keeney's later works is that he now stresses the primacy of the decision maker's values in the decision-making process. Values provide the very motivation for decision-making in the first place. "Although it sounds trite and oversimplified, 'When in doubt, think about what your values are!' is very good advice for anyone who faces a difficult decision or who has the vague uneasy feeling that things could be better" (Keeney, 1992).

According to Drucker(1974) The effective decision-maker knows that he starts out with opinions. The only choice he has is between using opinions as a productive factor in the decision-making process, or alternatively of deceiving himself into false objectivity:

> "People inevitably start out with an opinion; to ask them to search for the facts first is even undesirable. They will simply do what everyone is far too prone to do anyhow: look for the facts that fit the conclusion they have already reached. And no one has ever failed to find the facts he is looking for" Drucker(1974).

The same task may be represented in many different ways by different individuals, depending on experience, values and situations. Kelly's (1955) personal construct theory states that "There is no such thing as an absolute truth or objective reality, but only a range of alternative ways of constructing events."

These different internal representations may have a large impact on the problem solving process, as well as the solutions that are arrived at. Humans from different cultures and backgrounds will have different values and beliefs, and therefore will have a different approach to decision making. It is inevitable that a cross-cultural multinational cross-sectoral project, such as a mass transit system, will include people with different opinions and values. Knowledge and recognition of this can give some insight into why decisions made by others may appear to be 'wrong' and help turn this to a constructive advantage.

7.2 Problem Type 2 - Communication Procedures

The second part of Mintzberg's framework is concerned with information processing and the dissemination of information about the problem. For the purposes of this research, this has been broadened to include all of the issues surrounding communication in the mass transit investment field.

There are as many different ways of communication patterns in government as there are governments. There can be a very high level of public participation, such as Los Angeles where a specific ballot was held regarding the 'Blue Line' (Richmond, 1991). At the opposite extreme, there can be a dictatorial decision by one person, or ruling group. According to the Guangzhou metro study "The people's committee decided that a metro was the only possible solution for Guangzhou" (Guangzhou Municipality, 1989).

Figure 14: The Decision Making Process as Viewed by Perrera in Brazil.

Only a very general and idealised representation of this process can be made, therefore. Fig 14 (by a Brazilian in one of the case study cities) shows the flow of information in the process leading to the construction of large projects in Brazil. Both the Federal Government internally, and the external funding agencies would be involved only in the appraisal process not the decision itself. Newell & Simon's problem space (Newell & Simon, 1972) where the decision is actually formulated, therefore, is local to the Mayor and the influences on him with little contact with those having experience of similar projects until the proposal is at an advanced (perhaps too far) stage. These influences will come from a range of sources, as examined below.

7.2.1 Unforseen Circumstances - Problem 2A

Even for the best informed planners, when preparing a large project such as a metro, the decision process should accommodate uncertainty and it should be clear to everyone involved that there are risks involved. Strict Bayesian methods can be used for this and modern methods are becoming available that incorporate chaos theory (Teng & Tzeng, 1996a).

The need for clear identification of risk in the decision process is shown in the case study reports: many of the World's metros have been built despite a catalogue of disastrous events that beset them. These include natural catastrophes such as rockfalls, floods, personnel issue and strikes, financial problems, and almost every other type of difficulty (Fouracre et al, 1990 and Pickrell, 1989).

TABLE 24: COST AND CONSTRUCTION TIME ESTIMATES

Per cent difference from target cost	Number of metros	
	Capital cost overruns	Construction time overruns
- 10 to + 10	3	3

+ 10 to + 20	1	2
+ 20 to + 50	3	2
+ 50 to + 100	4	2
+ 100 to + 500	2	3

(Fouracre et al, 1990)

The extent to which risk analysis has been (or could have been) used to accommodate this is not known. An examination of table 3 on patronage forecasts and table 24 showing the predicted and actual construction costs and duration of twenty metro systems does suggest that forecasts have been particularly optimistic. Pickrell(1989) from the USA tells a similar story (though others have cast doubt on these results, Vuchic, 1992).

7.2.2 Availability of Knowledge - Problem 2B

Although reliable information is an essential requirement of the decision communication process, the research described here represents one of the first known examples of a comparison of modes using real surveyed data from developing cities. Time savings, suggested in fig 11 as typically being responsible for around 70% of all benefits still have no universally accepted means of quantification. The Guangzhou Metro Appraisal (ODA, 1992), for example, used several methods to produce plausible estimates of hourly time value ranging from 3 yuan up to 12 yuan. Despite these substantial gaps in current knowledge, there is no shortage of advice, either commissioned or unwanted, regarding the merits of MRT.

It is the exception rather than the rule for politicians to be technical experts in the field of transport and engineering. The quality of decision made, therefore, can depend upon the quality of information and advice that is available to them. In order to investigate the quality of this information, the following sources have been examined:

1) MRT feasibility studies produced by consultants
2) Conference papers and other influential material
3) Manufacturers' sales and marketing materials

7.2.2.1 Consultancy reports

Some form of transportation consultants were employed by all of the scheme promoters of the modern rail schemes in tables 3 & 24. The relationship between forecast and actual out-turn figures for construction costs and patronage suggests that the results of the feasibility studies were at best inaccurate, and at worst totally false. Despite this, there is no record of any recrimination against those who produced the inaccurate forecasts.

Pre-feasibility studies are also produced by consultants for the lending agencies. In this respect, the International Bank for Reconstruction and Development (the World Bank) has a good track record. Several reports commissioned by them have rigorously examined the case for an MRT. In the case of Karachi, Nairobi and Lagos (Barrett, 1993), these studies recommended that cities pursue mass transit projects that are more realistic than the prestigious schemes promoted internally.

The Karachi Mass Transit study (Gray, 1990) for example, by the UK Maunsell Consulting group recommended that a system of busways would be the most suitable form of mass transit. In acknowledgement of the desire for a rail system it proposed that the busway track should be convertible in the future. There is no reason to think that this was an incorrect finding, and it would certainly agree with the findings of the technical capabilities of the mass transit options contained in this research. It was clearly not popular with the local decision-makers, however, who immediately began to look for alternative sources of funding for the system they appear to have favoured. Looney (1998) reported that Karachi is to introduce the first phase of a light rail system, using Japanese funding.

As the market for advice becomes more competitive, there will be pressures upon professional bodies to give answers that are popular in some way: As Rossi(1967) puts it:

> "Planning agencies are usually service operators rather than centres of political power; as a result they tend to bend easily under pressure. The planner, unless he becomes thoroughly embittered, is congenitally and sometimes almost pathetically optimistic about the future, his current project, and the possibility of educating the uneducable'. The planner's immediate future, including promotions and status, is derived from the employing agency, it is natural for him to adjust his outlook and actions accordingly, even if this requires adjusting his professional conscience to fit his environment" Rossi (1967).

Alternatively, professionals may exert an influence on the politicians. The planner and travel demand forecasters are dependent on policy matters to guide them in the possible results of

transport changes. If the politicians fail to provide a coherent set of policy assumptions, the forecaster can either refuse to do the job, or he can provide his own assumptions. Since forecasters have a natural desire for growth, these forecasts become a “mathematized form of wishful thinking” (Adams, 1981).

7.2.2.2 Conference papers and technical literature

Technical advisors to decision makers may have no direct experience of similar projects, and therefore may be influenced by articles presented at conferences and in the technical literature. Fig 1a and 1b are an example of this influence at work. Professor Vukan Vuchic is highly respected in the field, and is responsible for the often-repeated diagram of mass transit options shown in Figure 1a. Vuchic(1981) is careful to define precisely the modes represented in the figure, for example using the term 'segregated rapid transit' rather than LRT. As shown, however, it is not certain that these findings are universal, particularly for developing cities. More seriously, Vuchic's work has been seized upon by other authors who wish to present the case for a particular mode. The diagram has been greatly simplified, perhaps to the point of inaccuracy by Bonz et al. (1989) and Barry (1991) (Figure 1b). This diagram is widely reproduced by system promoters. It can influence decisions costing billions of dollars, and yet there is little or no practical research evidence to support it.

7.2.2.3 Sales and Marketing Communication

Until the middle of the twentieth century, it was relatively uncommon for a company to have a major influence outside of its own national or colonial boundaries. Trade barriers or tariffs and the difficulties of global communication made export difficult (though not impossible).

Recent trade agreements and communication improvements mean that it is a very different case today. Two of the most important companies in rail provision GEC-Alsthom and Adtranz both originate from more than one country, and along with Siemens and Bombardier have factories around the world. Companies are large enough to accommodate a wide variety of supply terms. Joint manufacturing is common, for example, which is popular for the benefits it can bring to a developing country in terms of employment and technology transfer.

Figure 15: An example of the type of publicity material produced by Rail manufacturers

The aims of these corporations are not always altruistic, however. Lopez (1995) found that cost savings from railcar standardisation are rarely passed back to customers and suggested that 'cooperation' between GEC and Siemens in high-speed train supply is motivated by the need to avoid expensive bid competition rather than efficiency gains.

The international rail business is a multi-billion dollar industry as shown in table 25. All of the top companies, naturally, employ large teams of specialist marketing and sales professionals. Teams of skilful negotiators and advocates can be called upon to entertain city officials, to organise study-tours to Paris and Vancouver, and to produce attractive and persuasive publicity material. Examples of promotional materials are shown in figure 15. Common themes running through them are the ability to 'solve' congestion.

TABLE 25: SIZE AND TURNOVER OF TOP RAILWAY COMPANIES

	Transportation Division		**Worldwide Group**	
	Turnover $US Billions	**Staff (000s)**	**Turnover US Billions**	**Staff (000s)**
Siemens	3.7	12	64	400
Alsthom	3.2	25	15	92
Adtranz	3.2	22	138	444
Bombardier	2.1	15		

Source: Alsthom,Daimler Chrysler (Adtranz) , Bombardier, Siemans (all 1999)

It is not just the companies who are active in promoting rail projects but their respective governments. The French and German governments are particularly keen to push their industrial partners, as shown in the Tunis and Guangzhou case studies. The French and German governments have long argued that commercial returns from the aid budget are part of the price of political support for the development contribution (German and Randel, 1996).

7.2.2.4 Heuristic Problem Solving

There is another theory that might explain why a decision maker may not give "sufficient" thought to a decision. The history of human problem solving behaviour illustrates the fact that people apply very few general, formal principles and they violate normative rules. Yet, they seem to progress successfully. The answer seems to be that human problem solving is **heuristic**. That is, people employ procedures that are efficient and that work most of the time, even though they sometimes lead to errors. This becomes more apparent as the complexity, that is the unstructuredness, of the task increases (Watson and Buede,1987).

In the mind's problem space, where problem solving takes place, a subjective model of the task is built. Due to the bounded rationality of humans, normally, the problem space is a very simplified model of the task. Problem solving proceeds by a selective search within the problem space, using rules of thumb (heuristics) to guide the search. Tversky and Kahneman (1971) showed that people rely on a limited number of heuristic principles, which reduce the complex tasks of assessing probabilities and predicting values to simpler judgmental operations. Eventually these simple heuristics can sometimes lead to systematic and severe errors of the type shown in the box below. All of these result in people believing that they have a much better picture of the truth than they really do.

The types of error possible from Heuristic Judgements include:

* Misjudging sample implications: people's intuitions seemed to satisfy a `law of small numbers,' which means that the `law of large numbers' applies to small samples as well as large ones. (e.g., having seen two good metros in Hong Kong and Paris, assuming that they will always be good)

* Errors of prediction: People seem to rely almost exclusively on specific information and neglect prior probabilities. (e.g., expecting the output from a computer model to be accurate)

* Availability bias: An event is judged likely or frequent if it is easy to imagine or recall relevant instances. (e.g., assuming buses are dangerous because of a recent sighting of an accident)

* Anchoring bias: A natural starting point is used as a first approximation to the judgement. This anchor is then adjusted to accommodate the implications of additional information. (E.g., LRT vehicles are bigger than buses, therefore they must carry more people)

* Hindsight bias: Being told that some event happened increases our feeling that it was inevitable. (e.g., the disasters of the Calcutta metro were sure to happen - to them)

* Overconfidence: We tend to estimate much higher probabilities than are warranted. We often reach conclusions by reconstructing knowledge from fragments of information. (e.g., I know our system will be successful because somebody once told me it would be)

There is also a natural desire for humans to see a 'completeness' in many areas of life that

psychologists refer to as ‘closure’ (Worrall, 1980). Proposals in London for the Archway road widening had a cost for property acquisition of £380,000 in 1978 but had involved Department of Transport staff since 1951 at a cost of £2M. This provides a measure of the interest that those who have worked on the project might be expected to have in seeing it through to completion (Adams, 1981).

It is therefore perhaps a little unfair to single out decision makers for doing what most of us do throughout our daily lives. Rather, it is necessary to allow for this and to devise means of working around it.

7.2.3 Internal Organisation - Problem Type 2C

The capability of countries to organise, integrate and implement any infrastructure project is dependent on the institutional structures in place and their level of accountability for the goals or objectives. Mass transit activities are usually the responsibility of several different government agencies and private bodies. Each of these will have their own priorities and preferences.

In donor countries one, quite natural, outcome of the aid process is that there are limited resources available for an appraisal. Often a decision will be pressing (perhaps because of other aid ‘competitors’ or to tie in with a state visit, for example) and aid agency staff are often out of the office. The time given to an appraisal will therefore, of necessity, be limited and this will tend to favour schemes that are either familiar to the available staff, or where the case for going ahead ‘appears’ to be sound.

Many cities in transition have difficulty in ensuring institutional cooperation, and this can lead to irrational decisions being made. Equally important, lack of cooperation can hinder any kind of decision being made - this has been a particular problem in Bangkok (Dodson & Nourbaksh, 1998). Institutional problems have contributed to several metro projects running over-budget. Operationally however, most metros studied by Fouracre et al(1990) were well organised and well maintained.

Busways are also subject to institutional problems which can prevent rational decisions being made. As they require the active cooperation of the highway authority, the licensing authorities, the police and bus operators, many cities find implementation impossible. There

is not the weight of an effective lobby to promote cheaper bus schemes (although the Transcraft-Stagecoach consortium are trying to change this). Paradoxically, it appears that from the city's point of view it is easier to approve the building of a one billion-dollar metro (and worry about paying for it later) than it is to reach agreement to build a ten million-dollar busway (Transcraft,1996).

The flow of information, which should be direct, unbiased and unambiguous, can be influenced by the relative status of the professionals involved. As Mowitz & Wright (1976) point out "Area transportation planning, like other subjects that most people find both complex and boring, is relegated to professionals. Decisions are frequently made in back rooms on the basis of narrow technical criteria far removed from public discussion". This appears to be less so once a highly visible project such as a transit system is proposed. In this case, the interaction between the politicians and their professional advisors becomes very important.

Professional advisors, even in developed countries, do not always present themselves in the best light, so as to impress decision makers with their abilities. Levin and Abend studied conflicts between professional groups:

> "Considerable money was wasted in the Penn-Jersey study in an attempt to produce a land-use model that would provide a basis for transportation planning for eventual use in other areas. However, the new suburban site for the University of Buffalo, the largest single public investment in the region for a generation, was selected with no reference at all to the transportation plan.....While this chaotic state of affairs exists, decisions will continue to be made by a process of drift, piecemeal plans, and acquiescence to powerful single-interest agencies."Levin and Abend (1971)

The relative status can influence the degree of acceptance of advice. In some countries such as France, there is a respect for the decisions of highly educated technocrats from the Ecoles Polytechniques which contrasts with the lower status of engineers relative to financial advisors found in the UK (Powell, 1995). Engineers in France and their client politicians are likely to, literally, speak the same language.

In the case-study cities, Curitiba clearly has very high quality retained advisors, several of whom were university contemporaries of the political leader Jamie Learner. This close linkage between the political and the technical is a potent force. Other examples of this come from Istanbul in 1988-9 with Ismail Acar and Mayor Gedezlioglu, and in Edinburgh, Scotland, with George Hazel and David Begg.

A commonly held criticism of governments in developed and especially developing countries is that they are bureaucratic. Reports from the Korean Times add to this notion and indicate how difficult it might be to make progressive and efficient decisions.

> "According to a recent survey conducted by the Korean Customs administration, one trade

> transaction requires the involvement of up to 27 Government agencies and organisations. It also includes up to 50 different paper documents, an average of 200 data elements to be input, with 60 to 70 per cent of data having to be re-keyed in the processing." (Korean Times, Nov. 23, 1991, p12)

One of the characteristics of a bureaucracy appears to be a basic conflict between the power of authority and the power of specialist, modern knowledge (Luthans, 1984). Any leader who is accustomed to an authoritarian, top-down bureaucratic regime is likely to be at least distrustful and at worst fundamentally opposed to specialist advice coming to him from a source which is inferior, new, and/or foreign. The mayor from a bureaucratic system who has decided he wants a metro, therefore, will be very unlikely to change his mind in the face of specialist advice from the World Bank, or anywhere else.

7.3 Problem Type 3 - Political Routines

Mintzberg's third element is the 'political routine'. This is concerned with the bargaining among those who have some control over choices, persuasion and cooperation (Mintzberg, 1979). As Drucker puts it:

"Everybody is a special pleader, trying - often in perfectly good faith - to obtain the decision he favours. This is true whether the decision-maker is the President of the USA or the most junior engineer working on a design modification" (Drucker, 1974).

There is a natural tendency for people to favour a particular decision at the outset. This holds true not just for the politicians, but for those who should normally be impartial advisors to the decision makers. Levin (1979) found:

> "After an unsuccessful attempt to model the Penn-Jersey area, the model at least pleased the highway engineers by satisfying critics that highways were needed. Unlike the planners, the highway engineers were sure of their conclusions in advance. They had no interest in developing an elite corps of planners to challenge them on their home ground" (Levin, 1979).

Hall and Quinn (1983, in Klein & Methlie, 1995) promote a political science model which sees organizational decision making as a result of the interplay of pressure groups who have different views and different powers. The outcome of the decision is determined by negotiation among groups of people and the exploitation of the influence and power that they have at their command. Drucker suggests that political bargaining can have an impact upon the chances of the decision actually being implemented:

> "After making a decision, we in the West spend much time 'selling it' and getting

> people to act on it. Only too often either the decision is sabotaged by the organisation or, what may be worse, it takes so long to make the decision truly effective that it becomes obsolete, if not outright wrong by the time the people in the organisation actually make it operational. Drucker (1974).

The implication being that time spent on the planning and appraisal stage of a project is not wasted.

7.3.1 Representation and Governance - Problem 3A

In order to avoid considering a decision incorrect simply because it does not coincide with our political beliefs, it is necessary to search for some universal measure of political quality. This should allow for decisions that may appear to be 'wrong' but are in fact a true representation of the mood and values of the people being represented.

The World Bank has learned from experience that "physical completion of projects does not in itself generate the expected benefits if institutions are weak and the policy framework is inadequate" (World Bank, 1995). It is a difficult subject to research, and in which to make improvements. However, in recognition of the problem ODA designated "Good Government" as one of its priority areas for the 1990s (ODA, 1993b). Careful descriptions of the problem such as those by Barrett (1984) and Allport (1988) can help.

A World Bank report, drawing on Webster's New Universal Unabridged Dictionary, provides a specific definition of Governance relevant for Bank purposes as: "the manner in which power is exercised in the management of a country's economic and social resources for development." (Fritshchak, 1993). It is difficult for Westerners to make judgments about the quality or otherwise of a government in parts of the World which have a very different background and culture. The UK Minister for Overseas Development did attempt a definition of 'Good Governance' in 1995:

> "Good governance defies brief definition but in essence it covers respect for human rights and the rule of law, independence of the judiciary, the freedom of the press, political pluralism and the freedom to express dissenting views. Good governance means transparency on the part of those who govern, explaining policies, and presenting the annual budget to parliament and when the time comes for re-election putting their economic record to the people. Good governance is an essential framework within which business can flourish and jobs are created."(Chalker, 1993)

A recent internal report from the World Bank produced a call for improvements in the way

that governments exercise the management of a country's social and economic resources, stating that Bank staff should:

> "encourage governments to create the legal and institutional framework for transparency, predictability and competence in the conduct of public affairs and the management of economic development."(Fritshchak, 1993)

If one accepts these ODA/World Bank definitions of Good Governance, it follows that countries where this is not present are 'badly' governed. The need for transparency in decision making occurs throughout the good governance literature and reinforces the need for this present research.

7.3.2 Political Misguidance - Problem 3B

It is possible, and perhaps common, for decision makers to consider a situation according to the political implications for themselves instead of purely according to the good it might bring to the people they represent.

A particularly difficult balance can be the excusable desire to obtain the maximum benefit for an electoral constituency versus what is best for the nation as a whole. This is reported to cause disenchantment in some countries, such as Indonesia where the regions complain about the dominance of the 'system Jakarta' (Hartanto, 1997). The political desire to 'do something' to build a city's image, bolster support, or to reward past favours may also influence the choice of system. The Istanbul rail system, for example, was only possible when the city government were from the same political party as the national government. This patronage would likely favour prestige projects such as modern rail systems, even when these might not be the best practical or cost-effective solution.

Cox (1997) considers that if public transport is legitimately a public service, then the public money entrusted to it must be committed, without dilution, to the achievement of the public purpose. If conflicting objectives are served, the public purpose is nullified or diluted. This is so regardless of the perceived value of the conflict. One particular form of dilution of purpose has been (in the USA):

> "The pursuit of high cost capital projects that may make a more attractive city and enhance city pride, but which make little, if any difference in the percentage of trips taken on public transport. Inordinately expensive capital projects invariably limit the ability of public transport to reduce traffic congestion, air pollution and energy

> consumption, because more comprehensive lower cost capital approaches could produce better results in the context of the entire community. "(Cox, 1997)

In addition to the problem of politicians receiving bad advice, there is the possibility that advice might be ignored or used selectively resulting in 'bad' decisions. Sometimes such decisions are far removed from what technicians would consider 'logic' (Flyberg, 1998). Almost every system has its own peculiar factors that have influenced implementation. It is therefore difficult to generalise on the relative influence of what often appear to be random events. Some metro systems, for example, were reported to have been influenced by the birthplace of the president: others have been built on a 'me too' basis in the nation's second cities. In Prague, the city's underground metro was built during the 'Cold War', and in what appeared to be an attempt to make recompense following the Soviet invasion of the city. (Pucher, 1998).

Some of the irrational influences may prove, with the passage of time, to be fortuitous, others have resulted in financial and economic hardship. Some of the reasons for poor decision making may be opportunism at a time of change. Others may be symptomatic of deep-seated characteristics of the country and its political system.

7.3.2.1 Accountable and Transparent Decision Making

As there is such agreement on the need for transparency in decision making it is worth considering this is slightly more detail. If one accepts that the sign of a good society is one in which decisions are taken for the benefit of the maximum number of people, then the benefits of any public investment should be evenly distributed. In this respect, any public transport system *should* score highly, as it can bring widespread benefits. The problem occurs when a public transport project requires large amounts of money and when the people are not aware of the consequences. One of the great tragedies of the mass transit implementation process is that it represents such a significant diversion of funds away from other potentially more worthwhile projects. The box below shows one local estimate of the range of alternative public services that could have been provided with the money used to build the Medellin Metro.

The US$3 Billion spent on the Medellin Metro could have been used for either of

these alternatives:
120 Hospitals - reducing access distances from 10 to 3.5km
3000 Schools - reducing class sizes from 43 to less than 30
300,000 homes could have clean water and sewerage supplies,
21,000 children could have university education each year using only the interest payments on the loan (Henao, 1997)

There is no evidence that the ordinary public were aware of the trade-offs between these options. As far as the public are concerned, the choice appears to be a choice between having a metro (and therefore becoming more like their advanced neighbours) or not. Levin & Abend (1971) describes it as the syndrome of 'if we don't get one Baltimore will'. The real implications only become obvious later in the form of higher tax payments. In Medellin this was reported (Henao, 1997) to be twenty-five US dollars per family per year in the whole country - even in the Amazonas region where nothing is known of the scheme's existence.

7.3.2.2 Corrupt Decisions

Least excusable is the influence of non-altruistic decision making. There are many pressures on political leaders, not least in developing countries, to choose a particular mass transit option. The status or image benefits that a modern transit system can bring to a city appear to have a significant part to play in the decision making process. Furthermore, in some societies where "commissions" and informal payments can add around 10 percent to a project cost, the attractions of a billion-dollar metro are obvious. In Italy, the former prime minister Craxi has been accused of accepting payments in connection with the building of Milan's underground railway (Hooper, 1994). It is not yet known whether such payments influence the choice of system, or simply add to the costs of the preferred option.

Textbooks on white-collar crime have identified at least three varieties of official corruption. These are:

non feasance - failing to perform a required duty at all (such as enforcement of building regulations)

malfeasance - the commission of some act which is positively unlawful (such as the demanding of improper supplementary fees)

misfeasance - the improper performance of some act which a man may properly do

> which may result in either improper results (such as a false fire certificate) or proper results by improper means (such as ordering serviceable ambulances from a favoured supplier). (Giersch, 1991)

In one of the best-investigated examples in Wincanton County, Wisconsin, USA, the state research laboratory (Gardiner, 1977) examined the extent to which the corruption extended, and how it was viewed. They found that relatively few officials were involved in producing an extensive and serious wave of corruption throughout the county. Only 10 out of 155 police officers, for example, were on the payroll of the indicted mayor. To 'buy' 10 senior officials in a poor city in a developing country would be a minuscule fraction of the profit on a large public project.

Transparency International (1999) is an organisation dedicated to rooting out corruption and claims to have had some influence through the publication, on the Internet of a list of those countries that are consistently perceived to be the most corrupt. They produce the annual top ten of corrupt countries (Table 26). Countries with, or with proposals for, expensive metros feature strongly in this list.

TABLE 26: CORRUPTION PERCEPTION INDEX (Worst first)

Rank	Country	Score	SD	No. of Surveys
99	Cameroon	1.5	0.5	4
99	Nigeria	1.6	0.8	5
96	Indonesia	1.7	0.9	12
90	Kenya	2.0	0.5	4
87	Uganda	2.2	0.7	5
87	Pakistan	2.2	0.7	3
84	Albania	2.3	0.3	5
84	Kazakhstan	2.3	1.3	5
82	Russia	2.4	1.0	13
82	Ecuador	2.4	1.3	4
80	Bolivia	2.5	1.1	6
80	Armenia	2.5	0.4	4
75	Venezuela	2.6	0.8	9
75	Vietnam	2.6	0.5	8
75	Ukraine	2.6	1.4	10
75	Moldova	2.6	0.8	5
75	Ivory Coast	2.6	1.0	4
74	Croatia	2.7	0.9	5
72	India	2.9	0.6	14
72	Colombia	2.9	0.5	11

** relates to perceptions of the degree of corruption as seen by business people, risk analysts and the general public, and ranges between 10 (highly clean) and 0 (highly corrupt).*

In fairness to the developing countries, it takes two parties to make a corrupt transaction. Transparency

International has now started including an index of bribe payers (Table 27). Major rail exporters such as Japan, France and Spain are in the top ten of this list.

TABLE 27: THE TRANSPARENCY INTERNATIONAL BRIBE PAYERS INDEX (WORST FIRST).

Bribe Payers Index (BPI)		
Rank	**Country**	**Score**
19	China (including Hong Kong)	3.1
18	South Korea	3.4
17	Taiwan	3.5
16	Italy	3.7
15	Malaysia	3.9
14	Japan	5.1
13	France	5.2
12	Spain	5.3
11	Singapore	5.7
11	United States	6.2
9	Germany	6.2
8	Belgium	6.8
7	United Kingdom	7.2
6	Netherlands	7.4
5	Switzerland	7.7
4	Austria	7.8
2	Canada	8.1
2	Australia	8.1
1	Sweden	8.3

** The questions related to leading exporters paying bribes to senior public officials. The standard error in the results was 0.2 or less. In the scoring: 10 represents a perceived level of negligible bribery, while 0 represents responses indicating very high levels of bribery.*

Although there is little in the formal literature, there is considerable anecdotal evidence and newspaper reports on corrupt decision making suggesting that it is a major influence. The numbers involved are certainly huge. It is estimated that President Mobutu of Zaire, described by Margolis (1996) as a 'kleptomaniac', had a personal fortune of $5-7 Billion. Rehnby (1999) estimates that around one third of all loans to the Philippines were pocketed by president Marcos and his friends giving him a personal wealth of $10 billion. Exceeding even this were the $40 billion in loans borrowed by Argentina's military dictatorship from 1976 to 1983 for which there are no expenditure records (Rehnby, 1999).

It is therefore timely to look for reasons (though not excuses) for this type of behaviour. As before, we can usefully use the simplified model of Maslow(1975) to gain some insight into the human characteristics that influences a city and its leaders. The motivation of the residents of a city, and the city Mayor can be examined according to this hierarchy. Regarding first-order needs, Fouracre et al (1990) suggest that a metro can help the very survival of a city as a focus for an urban area. Against this background, it is hardly surprising that city residents and businesses would be in favour of large-scale expenditure, particularly if this ensured the preservation of the city and their investment in it. In

addition to the patriarchal desire for the city to thrive, mayors will also be concerned about their own electoral survival.

It is important for Western participants in aid-funded projects to understand and to accept the factors which may be motivating a developing city leader. For the aid-agency staff the project may fulfil a higher order need, but for the mayor it may represent the very survival of the city (and themselves). Any organism will fight harder (and if necessary dirtier) in order to survive.

The distance (spatially and temporally) covered after satisfying the physiological needs might also be important. If a mayor comes from a society in which the majority are still poor, the apparent greed which fires corruption may actually represent an understandable desire for security against a future return to recently abandoned poverty.

7.3.3 Global and National Politics - Problem 3C

Finally, in order to understand better the current situation, it is helpful to look briefly at the most important historical influences on developing countries.

7.3.3.1 Colonialism

Many of the world's developing countries have at some time during their past been under colonial rule. The legacy of this has varied according to characteristics of the two parties. The Ottoman empire ruled
by assimilating local people into the ruling class by persuasion and reward. The Turkish influence on modern twentieth century life is thus not visibly far-reaching or long-lasting. In contrast, the European colonisation of countries as diverse as Chile (Spain) and India (UK) has left a legacy not least of language, but also in the legal and education system.

Decolonization sometimes followed the action of local representative such as Gandhi in India or more recently ‘solidarity’ in Poland. In much of sub-Saharan Africa the Europeans

relinquished power before it was demanded by well-organised nationalist groups able to make representative decision based upon full knowledge of the facts. This "explains a good measure of the different experiences previously colonized peoples have had since independence".(Krieger, 1993)

One concrete reminder of the colonial past is that bi-lateral aid either is directly targeted on the countries of the former empires or has a tendency to concentrate support in countries with a common language. Thus, it was the Spanish who built the metro in Medellin, for example. Around 60% of bilateral UK aid goes to support the 46 commonwealth countries in the developing world (DfID, 1998).

More recently, Global trends have appeared in aid giving. Currently, for example China and the former Soviet Block are a priority for many agencies. Shortly after independence, for example, the Czech republic in general and Prague in particular was the focus of a great deal of attention, not all of it well seen to be directed. One architectural advisor to the Czech President Vaclav Havel bemoaning the negative influences of foreign aid on the quality of local government said;

> ".....If I could spend the development money Prague is receiving, such as that from the Prince Charles Heritage Fund, I would use it to build a modern, intelligent, creative, city council. Both our town, and our historic buildings would benefit." *Miroslav Masak, (in Kennedy, 1993)*

Inferring that money spent on strengthening institutions to make their own choices would be better than a sudden influx of misguided aid.

7.3.3.2 The Oil Boom

In the late 1960s and 1970s, the world economy was greatly affected by the emerging of the Oil Producers Export Council (OPEC). OPEC was created by Iran, Iraq, Kuwait, Saudi Arabia, and Venezuela in Baghdad on Sept. 14, 1960, to counter oil price cuts of American and European oil companies. The OPEC nations contain 77 percent of the world's proven oil reserves, and the organization is likely to remain important. (Groliers, 1995)

Following the Egypt-Israel war in 1973 oil prices quadrupled and the OPEC countries' current account surplus rose from $6.2bn to $66.7bn in 1974. Unable to spend the surplus, the OPEC countries invested on the US and London money markets. The rise in inflation in developed countries due to the oil price meant that real interest rates were low or even negative. "The view prevalent among the international banking community that Latin America was set for high rates of economic growth led to a 'recycling' of the petro dollars in the form of massive lending to Less Developed Countries". (Pilbeam, 1992).

Following the second oil crisis in 1979 when OPEC countries doubled the price of oil, developed countries took measures to find alternatives and to conserve stocks. Less Developed Countries, however, continued to borrow in order to avoid politically unpopular International Monetary Fund re-structuring, and to continue to fund inefficient state enterprises, maintain artificially high consumption levels, and to construct prestigious projects (including metros). Borrowing increased up to the point where on 12/8/92 the Mexican Government announced it could not pay its debts. Although the internal LDC politics and mis-management may have contributed to the debt problem, "the extent and close-timing of debtors' problems suggests that common external factors played a significant part in the crisis ... In large part the crisis reflected excessive lending by the commercial banks" (Bird, 1989).

With geo-political pressures of this sort, it is not surprising that decisions were taken to build projects such as the Mexico City Metro. Indeed it might be argued that if Saudi oil-money did need reinvesting, there are worse ways of doing this than building a metro. The drawback now is that debt-management is providing serious problems for many developing nations (and some Western Banks).

7.4 Summary of Decision Making Review

There is some evidence to suggest that there is a problem in the area of mass transit appraisal. The use of a structured problem analysis method has helped to identify and categorise the possible problem areas.

One of the first areas in which there is a problem is that the appraisal methods used are not currently optimal. Social Cost Benefit Analysis (CBA) forms an important part of current appraisal methodology and yet has been widely criticised, not just by campaigners but also by influential experts. Financial CBA is less open to criticism but is only just beginning to be accepted as a means of ensuring a project's affordability.

New appraisal methods will be needed that incorporate other appraisal techniques alongside CBA. This will help to overcome another problem in that they could allow consideration of unquantifiable and intangible items that are sometimes excluded from the current process, thus excluding some 'worthy' schemes and including some 'unworthy' ones.

As with any human faced with a decision to make, politicians have many objectives of their own, in addition to the need to represent their constituents. This can easily, either directly or indirectly, divert them towards a capital intensive prestigious scheme, rather than a more appropriate option.

A problem does arise in the lack of good quality, independent advice. It appears that there are more people around who are publishing material that accepts unquestioningly the primacy of rail. As the rail lobby is influential and powerful, then the simple existence of good advice about an alternative option will not ensure its implementation.

The link between government and advisors appears to be important. In the case study cities that have made timely progress, this has usually been accompanied by an 'understanding' in every sense of the term, between politicians and their advisors. In contrast, from a social point of view, a Third World mayor and a visiting World Bank consultant will see the same issues through very different eyes.

In the political bargaining that accompanies decisions, it is fair to say that everyone is a special pleader. The most universally recommended means of counteracting this problem,

and guaranteeing a fair decision that is acceptable whatever the political regime, will be to ensure complete transparency.

Corruption does appear to be an important part of the problem, although there is an understandable reluctance to document this too closely. It does appear that theoretical consideration of motivational issues might be able to shed some light on the reasons for this, though this neither excuses it nor yet goes far enough to fully understand it.

Finally, it appears that due to the enormous amounts of money involved, there is a problem regarding the influence of outside bodies in what should be a local transport problem. Big projects will always be prone to big pressures. Some of these will prove fortuitous, others less so.

8 RECOMMENDED APPROACH

One last piece of theoretical review is necessary in order to find a possible approach to the appraisal 'problem' identified above.

8.1 Multi Criteria Analysis

The unaided decision maker has limited information processing capacity when faced with an ill-structured problem such as choosing a mass transit system for a low income country. Newell & Simon's (1972) work on human problem solving showed that when faced with complex, unprogrammed situations, a decision maker tends to reduce the problem into sub problems for which there are familiar procedures or rules. By splitting the problem into small parts and focussing on each part separately a better understanding can be gained compared to views taken holistically. People deal with unstructured problems by factoring them into familiar structurable elements.

In order to make it easier for people to use heuristic methods for problem solving through organisation, synthesis and appropriate presentation of information, a variety of techniques have been developed to help break down a problem into manageable sizes. The most common of these methods is commonly referred to as multiple objective decision making (Hwang & Masud, 1979). Multiple criteria approaches seek to take explicit account of multiple, conflicting criteria in aiding decision making.

As outlined above an 'objective' is an indication of the preferred direction of movement. Thus it is commonly used in association with words such as `maximise' or `minimise'. An attribute is used to measure performance in relation to an objective. Thus the extent to which each component of a proposal meets its objectives can be measured by examining the individual attributes. Belton suggests that in the first instance multiple attribute utility analysis may be incorporated within a methodology used to establish preferred strategic directions, "these may then be incorporated in an evaluation model, or guidelines for decision making at a tactical or operational level. Examples of this arise in all organisations having a major role in the allocation of limited funds or awards; government departments allocating overseas aid, research councils allocating grants, design councils granting awards" (Belton, 1990).

Van Neumann & Morganstern in 1944 first developed the idea of how people could use utilities to evaluate options about which they were uncertain (in Klein & Methlie, 1995). The US business schools in the 1960s and 1970s saw a great deal of work on rational decision analysis. Three schools in particular stand out, including Keeney who was one of the first to use a method of combining utility functions into a Multi Attribute Utility Theory (MAUT), described in detail by Keeney and Raiffa (1976). Raiffa (1969) incorporated the idea of subjective expected utility into MAUT to allow for how people react to the utility of options in which some form of risk is associated with the outcome. Saaty represented the decisions in a tree-like structure in his Analytic Hierarchy Process (Saaty, 1980).

The most widely used method in practice seems to be based upon the work of Edwards and Newman (1982). Multi-attribute utility theory was initially criticised (von Winterfeldt and Edwards, 1986) by many practitioners on the grounds of being too complex and requiring judgements that are difficult to elicit from decision makers. It was this that led Edwards to condense many of the more complex theories available at that time into a Simple Multi Attribute Rating Technique or 'SMART' (Edwards and Newman, 1982). Initially this was justified by its simplicity, later by studies that demonstrated its robustness, and still later by studies giving it theoretical support (Van Winterfeld & Edwards, 1986).

The concepts of fuzzy sets have been incorporated in both aggregation approaches and outranking approaches. Belton briefly reviews some of the approaches which have been suggested. The major contribution of these fuzzy analyses is to emphasise that judgements are not precise and to seek to incorporate this in the analysis in an explicit way. However, few practical applications have been reported (Belton, 1990) although Teng and Tzeng have begun work in this area (1996).

8.2 Requirements for a Revised Approach

The technical appraisal required by aid agencies was specified by ODA as providing "a comprehensive description of the project, including plans, diagrams and outline specifications. It should investigate physical and institutional conditions under which the project will operate and examine all practical options and advise on their technological suitability and appropriateness generally. In considering the conditions under which the

project will operate, the appraisal should pay particular attention to probable sustainability" (ODA, 1993). Any method to be used to guide decision making for donors should, therefore, be capable of this.

Watson and Buede (1987) considered the basic requirements for supporting any decision maker to be:

(1) A set of rules for decision making must be defined in order that we may know what it is like to be rational.

(2) The rules must address the values of the problem owners. It must be possible to articulate their preferences and perceptions.

(3) The rules must state what it is to be rational in the face of perception of uncertainty.

(4) The rules must provide a calculus for steering the thinking of the decision makers through complex problems.

Also, consideration has been given to the recommendations of Edwards & Newman(1982):

1) The most useful approaches are conceptually simple and transparent.
2) There is a skill in making effective use of a simple tool in a potentially complex environment.
3) The process leads to better considered, justifiable and explainable decisions.

Discussion with case study experts leads to the following requirements for a decision support system for the present research:

1) It should increase understanding and lead to a better considered, justifiable and explainable decision.
2) It should be comprehensive enough to allow for the wide range of decision components and the combination of output solutions.
3) It should not be a 'black box' but should retain transparency of operation.
4) It should allow for the human nature of all participants involved in the process.
5) It should recognise the limits on evaluation and study time and resources.

Given the support in the literature for the SMART technique, and given that it appears to meet the requirements outlined above, this method has been chosen for use in the present research. The objectives and attributes for a complex project (particularly one that has

impact on a wide range of people) can best be seen as a hierarchical structure. This leads to the use of a value tree rather than a simple list.

8.3 Using the Revised Method

The exact method chosen represents a combination of the simple multi attribute rating theory (MAUT) developed by Edwards and Newman (1982) and the analytic hierarchy process developed by (Saaty, 1980). These have been tried and tested in a variety of applications, most relevantly in the work by Ross in creating his DEE technique (Ross, 1992). The present research represents the first time these have been combined in an appraisal framework for the study of large aid-funded mass transit projects in developing cities.

The method requires the identification of every possible utility attribute applicable to mass transit, then to establish their relative importance within a hierarchy, and finally to discover how they link together. The end result is a very large appraisal ‘tree’ in which key appraisal issues are steadily broken down into their component parts. A full version of this has been prepared and is in appendix 1, a summary table is shown below (table 28). This tree has immediate value as a comprehensive checklist of every item that is known to affect, or be affected by, a mass transit scheme.

8.3.1 Weightings Survey

Having decided to use a multi-attribute method to investigate the decision process surrounding transport investment, the next step is to add weightings to the attribute ‘tree'. These indicate the relative importance of each component and its related elements and are, for convenience, allocated within a total score of 100. The three apprisal components in the first column of table 28 would have a total of 100 allocated between them, for example, as would the three (or two) elements associated with each component (as shown in column 2) and so on.

It is necessary here to make some re-emphasis of the objectives of this process. It is not the intention to derive a single score that encompasses the entire benefits of a project. Rather it is a means of reducing the complex procedure of appraising a large transport infrastructure project into its component parts and to examine the importance of these in a structured manner.

It must also be carefully borne in mind exactly where this exercise takes place in the overall appraisal process. This is not, for example, the point at which the detailed environmental or social benefits of a scheme are assessed, nor is it a detailed financial appraisal. Rather it is the beginning of a broad investigation that must cover every aspect of a proposed project in a timely (typically 6 weeks) cost-effective manner. It is envisaged that it would be used by generalist aid appraisers to highlight areas for further examination by specialist sub-contractors.

COMPONENT	ELEMENT
PROJECT VIABILITY The economic viability - that is the present value of the time and resource savings as a ratio to the investment costs. The financial viability and the need for subsidy The technical suitability. The ability of the project to do the job that it was intended for (APV)	MONETARY The economic viability of the project - that is the value of time savings and other quantifiable benefits The financial viability, and the likelihood of the project to make or lose money. The affordability of the project and its running costs (BFE)
	TECHNICAL The ability of the project to do the job for which it is intended(ie transport large numbers of people) The suitability of technology chosen The quality and appropriateness of construction method (BTI)
PROJECT IMPACT The impact of the project on the lives of the people in the recipient area. The impact on disadvantaged groups including women and the urban poor. The impact on the environment and the physical planning of the city The impact on the government and institutional structure of the city (AIM)	INSTITUTIONAL & SOCIAL The impact on the social development and welfare of the citizens, with particular emphasis on disadvantaged groups such as women and the urban poor. The impact on the quality of the government and institutional structure of the city The impact on the economic structure of the city and the impact on the ratio of private to public ownership and involvement. (CIS)
	ENVIRONMENTAL & URBAN The impact on urban air quality. The influence on energy usage The impact on other environmental indicators including noise, groundwater and landtake. The influence on road safety The ability of the project to enhance urban development and efficiency The opportunities for improvements to the city centre (CEU)
	INTANGIBLE The ability of the project to bring benefits that can not be measured directly. The improvement in re-election chances of incumbent politicians The opportunity to reward 'deserving' individuals or regions The improvement in civic pride for residents The improvement in external appearance for potential investors The outward symbol of a non-car transport policy (CIT)
AID PROCESS ISSUES The extent to which the giver considers the	DONOR ISSUES The administrative requirements for transferring and monitoring the aid

receiving institutions worthy and able to benefit from the finance. The liability of the project to lead to benefits (real or in kind) for the **giver**. The availability and ease of administrative channels Strategic political and historic affiliations (AAP)	The strategic, political or historic links to the recipient country The potential for future real or perceived benefits financially or 'in kind' for the aid giving country. (DED)
	LOCAL EFFICACY The institutional capacity for receiving and sustaining the sums involved. The degree to which the politics of the recipient are considered rational and equitable by the aid giving country. The extent to which the recipient leaders are considered rational and reasonable The ability of the recipient leaders to represent people of all socio-economic groups (DLS)

Table 28: Extract from Multiple Attribute Utility Hierarchy Tree. The full table has four more columns dividing the influences still further down to specific 'measurable' components (see Appendix 1).

The collection of weights, in addition to helping clarify the importance and structure of the utility tree, acted as a topic guide for structured depth interviews. This, for the present research, gave it the edge over other socio-numerical techniques such as personal construct theory (Kelly, 1955). The development of personal construct 'ladders' also requires interviews that take longer (and are more arduous) (Gardner & Lakin, 2000).

8.3.2 Fieldwork Interviews.

In order to provide a substantiated judgment on the weightings to be applied, an expert group was assembled. The group chosen was small but represented a good range of background and interests as shown in table 29.

Name	Affiliation
Slobodan Mitric	World Bank, Transport Advisor
Richard Barrett	World Bank, Values and Ethics Advisor
John Flora	World Bank, Transport Advisor
Suzanne Holst	Government of Germany, Aid advisor
John Hine	Principal Economist, TRL
Chris Lawrence	Principal Scientist, TRL
Francis Kuhn	Aid advisor to French Government
Alan Cannel	Transport Consultant, Curitiba, Brazil
Ferenc Fuzy	Academic, Hungary
Ismail Ali Acar	Head of Transportation, Istanbul Municipality

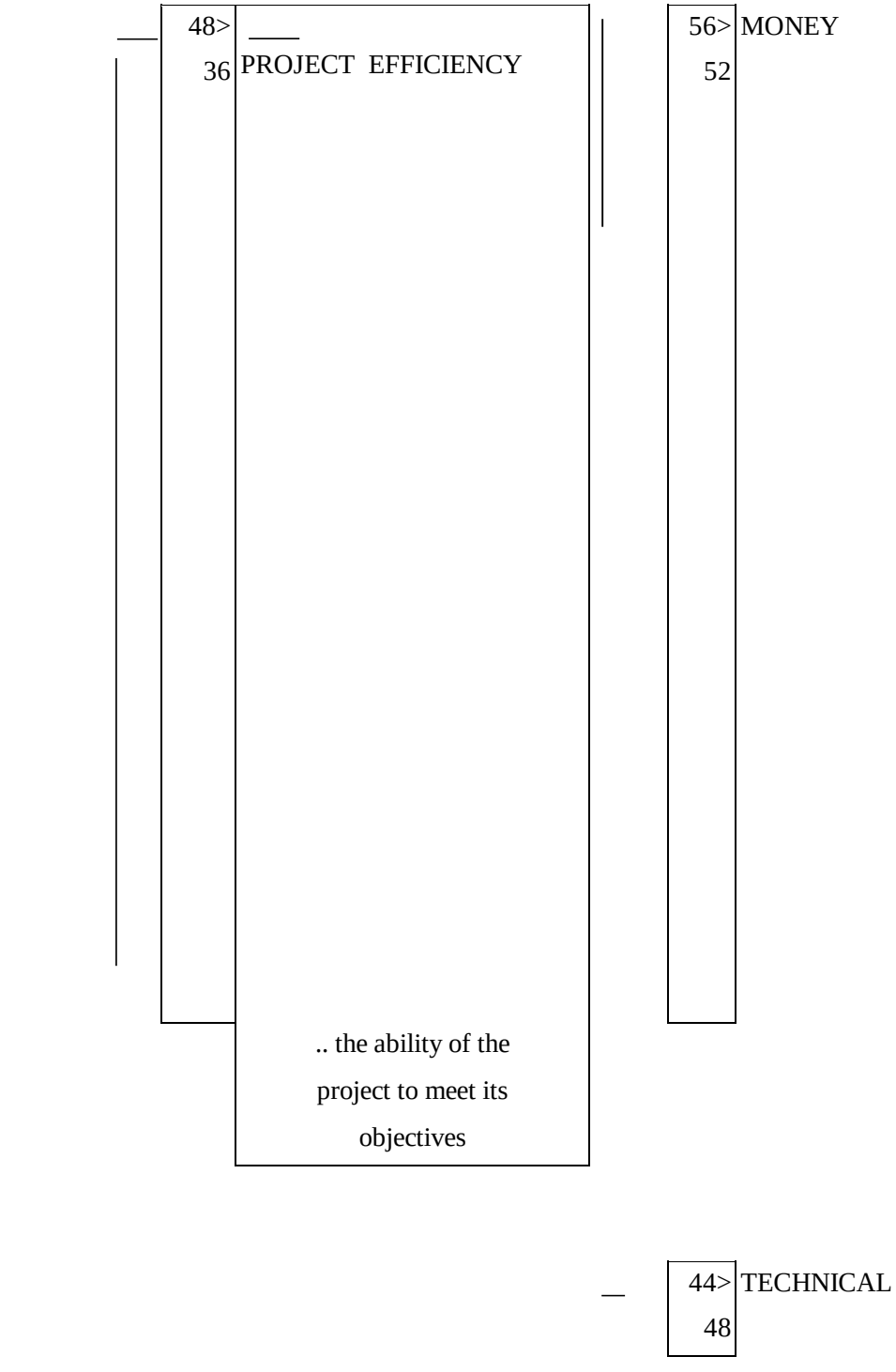
Table 29: Participants in Expert Group Providing Multi Attribute Weightings

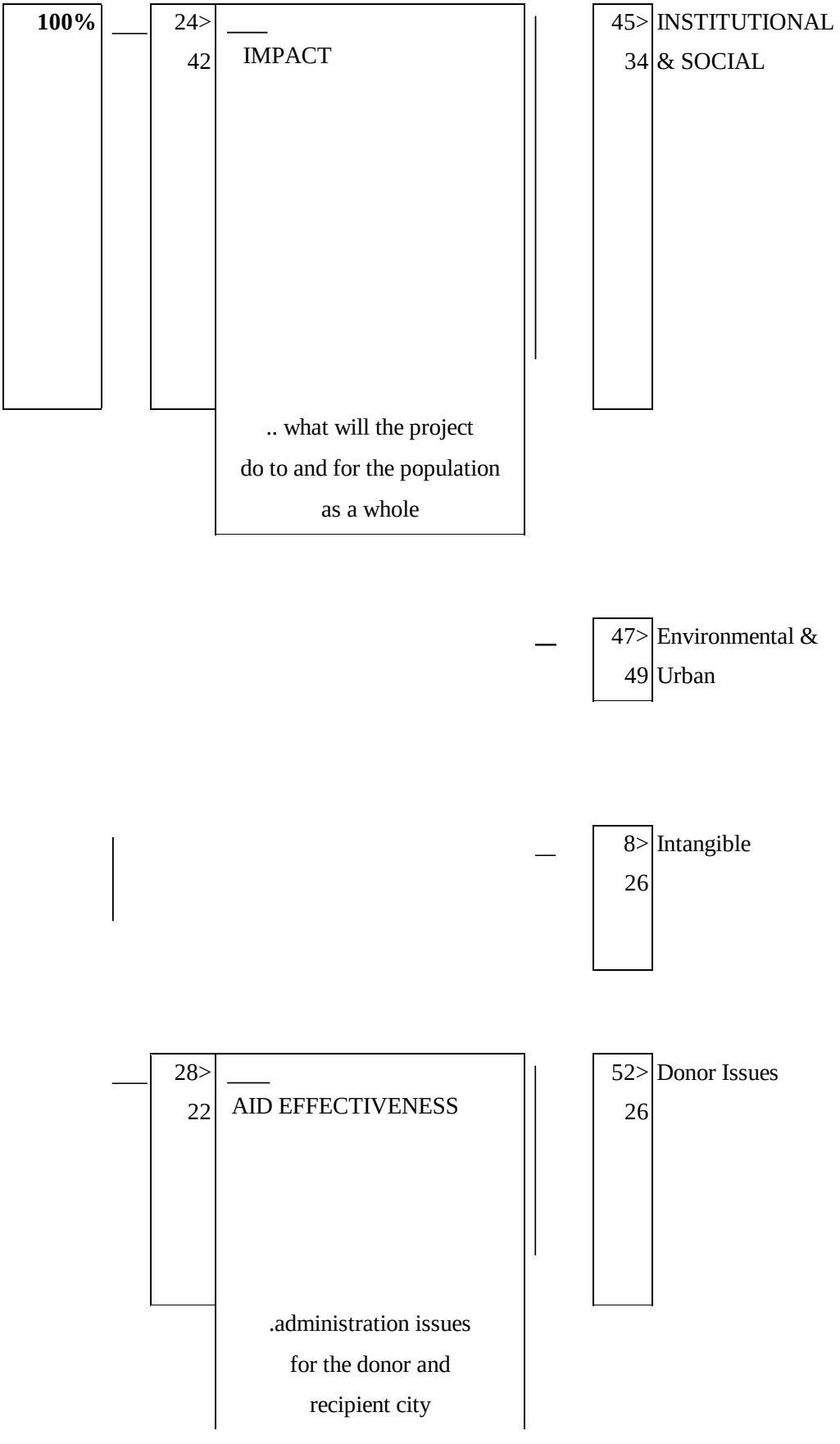
Respondents were given a selection of cards that presented the different components of an appraisal. They were then asked to give some indication of their relative importance by allocating to each of them a weighting factor so that the total adds up to 100. Considerable explanation of how to do this and its implications was given in a structured manner (reproduced in Appendix 1).

In practice, the topic cards acted as a focus for detailed discussion and as cue cars to ensure that all key areas were covered. Notes were taken and respondents were asked to comment if they thought the methodology was misleading or if any areas were misrepresented. Respondents were first asked for a weighting on the appraisal components and elements that represent how the existing process actually operates (with all of its associated faults and omissions). As an addition to the research (never, knowingly, tried before) respondents were asked for one extra piece of information. They were asked also to provide weightings that would represent a possible improved situation, to show how they would ideally like the appraisal to be (whilst still taking into account the practical problems of the real world).

8.3.3 Indicative Results of Pilot Survey

The results of the first round of interviews are shown in figure 16 and detailed in Appendix 1. Some areas produced a greater variation of response than others. Without knowing the reasons for the deviation of some respondents, it would be wrong either to rely totally on the simple averages or to delete the outliers. It is possible, for example, that the outliers know more about the subject than the others. Ideally, in order to gain a consensus view, the Delphi technique would have been used. This is a method developed by the Rand Corporation in the 1950s to gather expert opinion on atomic bomb damage (Luthans, 1984). The essential feature of the method is that a group of participants are surveyed once, and then the anonymous results of the group response are fed back to each participant. The participants are then questioned again to see whether they would like to modify their original answer in the light of this new knowledge and outliers are asked if they would like to explain their response. Thus providing iteratively improving consensus, whilst confirming that respondents have understood the question correctly, and also frequently revealing new insights that might not have arisen from one round of surveys. Sadly, funding limitations and the extreme difficulty of gaining access to such influential people for a second round of interviews made this impossible. The results given here should therefore be treated as a pilot for the method and as a means of initial exploration of the issues


TOTAL
COMPONENT
ELEMENT
48>
36
PROJECT EFFICIENCY
56>
52
MONEY
.. the ability of the project to meet its objectives
44>
48
TECHNICAL


100%
24>
42
IMPACT
.. what will the project
do to and for the population
as a whole
45>
34
INSTITUTIONAL
& SOCIAL
47>
49
Environmental &
Urban
8>
26
Intangible
28>
22
AID EFFECTIVENESS
.administration issues
for the donor and
recipient city
52>
26
Donor Issues

KEY: 28>	Avg weighting for current method	__	48>	Local Efficacy
22	Avg weighting for preferred method		74	

Fig 16: Diagram to Show the Multi-criteria Analysis Tree and Preliminary Results from Pilot Survey

Analysis of the weights given, their variation, and the differences between existing and 'idealised future' scenarios can suggest some topic areas that would be suitable for more authoritative investigation. Subject to the limitations of the methods, the following points are of interest:

The single element that was allocated highest average weighting was in the project efficiency component and related to 'response to need'. The group were unanimous in emphasising the importance of a system meeting, in the broadest sense, a city's accessibility needs. Satisfying such needs was thought to require a comprehensive urban plan and not just a system for moving people.

The second-highest weighted element was Institutional Capacity. This recognises the key requirement that a recipient government should be in some way able 'to make best use' of the aid funds. It also addresses the capability of scheme promoters to cope with such a large undertaking.

One of the lowest rated elements was that associated with intangible benefits: the ability of a project to bring benefits that cannot be measured directly. This includes some positive aspects such as civic pride but also attracts some dubious claimed advantages. Interestingly this was, by a long way, the score that received the highest increase when respondents were asked for future weightings. This supports the view that the current method of dealing with intangibles in the appraisal process is not as good as respondents would like it to be.

Comparison between the scores for the present and idealised future scenario gave indication of other areas where respondents would like to see improvements in appraisal procedures. The assessment of technological appropriateness and actual quality of the project were highly rated in this respect, as was the overall component related to project impact on users and non-users.

The element that most respondents would like to see receive less weight in the appraisal process was in donor administration. All recognised that under the existing system such things as disbursability were important, but most thought that in an improved system this would be less influential on the end result. Other areas that respondents would like to see receive less emphasis included the dominance of economic benefits and the use of 'economic reform' as a target (since diminished by the 1998 DfID White Paper). Party politics would, as might be expected, exert a lesser influence for all respondents under their ideal future scenarios.

Perhaps understandably the area that attracted the most amount of disagreement was in the weighting that should be applied to intangible benefits. By definition such areas are difficult to quantify and can mean different things to different people. Another area in which weightings were diverse was in the influence of national and colonial interests - though not necessarily (or stereotypically) from the French

or German respondents. It would, in theory, be possible to use the weightings from the pilot survey to calibrate a tree and produce a 'score' that could be used for the comparison of the options. Appendix 1 does show how the appraisal table goes down two further stages to a point where actual measurement (or at least estimation) is possible. Apart from the inadvisability of using a pilot survey for this type of activity, this has been avoided for the reason that it confers on the method an appearance of being a numerical measurement tool. Others may wish to explore this further and perhaps develop the use of fuzzy logic as trialed elsewhere by Teng and Tzeng (1996).

8.4 Multi-Attribute Rating Summary.

The primary aim of this part of the research has been to increase the level of understanding by encapsulating all relevant points for consideration into a single framework. This framework has been prepared based upon literature review, direct experience and contact with experts in the case study cities. It can now be considered unlikely that there are benefits or disbenefits of a mass transit system that have been overlooked. The appraisal framework in this thesis represents a significant repository of collective wisdom, obtained from, reviewed and refined with experts in the field, in lending agencies, universities and consultants.

The numerical weightings survey itself has proven to be a most interesting exercise. In general the weightings assigned by the respondent group supported, and gave dimension to, views given in open-ended interviews. It will always be necessary, however, to make full use of the supporting interview data before placing too much emphasis on the results of this exercise. As an example, one of the lowest scoring elements was related to the impact on social development and welfare. This does not mean the respondents value this lowly (far from it) but is more a representation of the process and how they were informed of the availability of a separate full social appraisal.

The overall advantages and disadvantages of this approach are summarised below:

Advantages

1. The creation of the hierarchy stimulates all those involved to scrutinize every aspect of the problem. One is forced to consider and compare the interactions between every item.
2. It enables the collection and the communication of ideas from all those with expertise in the subject. Advice and estimates can be given in a structured quantitative manner.

3. The relative importance of the essential data inputs can be determined, and used to help prioritise the evaluation activities.
4. The influence of risk and uncertainty can be examined and separated from the biases and risk tendencies of the decision makers (Luthans, 1984).
5. Hence, the real difference and areas of variation between alternative solutions can be compared.
6. Analysis brings to light factors that might otherwise not be included, or alternatively exert too much influence.
7. In the case of disagreements, problems can be broken down to the precise point at which disagreement occurs, and then it can be further broken down.
8. It can be used as a tool for planning, monitoring and evaluating.

Disadvantages

1. Disaggregation implies that factors can be re-aggregated. It is not clear that this is so.
2. Single criteria questions can be philosophically difficult, and can force experts to reveal things they would prefer to submerge in other criteria.
3. "The human brain can be a magnificent synthesizer of disparate pieces of nebulous information, and often formal techniques and procedures thwart and inhibit this mysterious mechanism from operating efficiently". (Raiffa 69).
4. The temptation to focus on measurables, can ignore the social side.
5. "There never exists a solution which is the best simultaneously from all points of view, therefore we should use the term 'aid' rather than suggesting a standard Operational Research technique for optimisation" (Vinke, 1992)

Overall, the comments of Belton appear to be the most relevant. She comments;

> "The benefits from model building are obtained to a considerable degree even if the decision maker never actually makes the final step of computing an overall utility score. Models are aids to thinking; in complex decision situations, their development leads to insights and understanding that would not otherwise be available" (Belton, 1990).

During the scope of the research presented here for the M.Phil thesis, it has not been possible to take forward the appraisal framework. It does, however, have a very valid potential role not least as a structuring device for directed depth interviews. It has been pilot tested and found to be a good method of ensuring every aspect of the decision making process is discussed openly. Whilst not without its faults, this method does appear to have added to the knowledge in the current research area. As a pilot survey it can therefore be viewed as a success. More respondents and a Delphic iteration would certainly be a fruitful source of further research.

9 CONCLUSIONS AND RECOMMENDATIONS

The nature of this research is that a scientific study of the performance of the mass transit options has been combined with consideration of the institutional setting. There is, therefore, a mixture of factual recommendations and considered assessments.

9.1 Technical Recommendations

The overall research programme on mass transit has produced some rough practical guidelines to the prospects of selecting a mass transit system in a developing city. They cannot, of course, be taken as universal rules, but subject to exceptional circumstances, the present research found nothing to contradict Fouracre et al's(1990) conclusions that a metro is not likely to produce a good economic return unless most of the following conditions hold:

"a) Corridor size: all successful lines serve radial corridors to the city centre, with total corridor flows of over 700,000 trips per day before the metro opens. This recognises the presence of at least one major road, with minor parallel roads, in the corridor and some turnover of passengers along the corridor. It implies very high peak flows of close to 15,000 bus passengers/hour/direction, at the busiest section of the corridor.

b) City size: corridors of this magnitude are found only in cities of at least 5 million inhabitants unless the city is highly linear and contains only two main corridors, eg. Pusan or Medellin or Singapore which has only three main corridors.

c) Income: cities with successful heavy metros have annual average city incomes above US $1800/head, except for Cairo where the situation was unusually favourable for a metro. Cities with incomes of this level are unlikely to be found unless the national level is at least US $1000/head.

d) Growth prospects: the economic viability of most of the metros tested depends on future growth of population and income. Massive influx of immigrant population tends to depress average incomes, however; so the ideal prospect comes with steady population growth combined with strong economic growth.

e) City centre growth: growth of metro traffic is directly associated with growth of the city centre. The ideal condition is when the city is a national capital and centre of a large, populous economic region.

f) City management: building a metro through the middle of a large congested city is a profoundly demanding task. Considerable expertise is required to achieve success and much can go wrong. The expertise of city authorities in achieving small improvements (eg in traffic management or controlling bus operations) provides an indicator of this institutional capability, which is essential in implementing a metro.

g) Metro management: once operational, economic success depends vitally on good management. Most of the new metros are run by new companies or corporations, independent of government departments, national railways or bus operators, and free to choose their own staff, set their conditions of employment and set up modern management systems.

h) Financial support: fares must be reasonably competitive with the buses, which means that they must be either graduated, on both buses and metro, or integrated (ie. with through-tickets), and the metro fares must be set low enough to compete. In practice this will seldom be possible without financial support to cover capital costs and at least part of depreciation (asset replacement)." (Fouracre et al, 1990)

Where a metro is not justified, then the most likely option to be suitable for a developing city is a busway. These have considerable advantages as shown below (based on Gardner, 1993):

a) Self-enforcement: Because a busway physically segregates buses from general traffic, the priority for buses does not need to be enforced by a strong police presence.

b) Flexibility and diversity: Since buses can join and leave a busway anywhere, routes from all over the city can use the busway for all or part of their journey. Passengers from a wide catchment area can therefore benefit from a faster service without having to transfer to a faster vehicle, as would be required with a fixed-track system.

c) Affordability: An at-grade busway along an existing right-of-way is likely to cost US$600,000-1,400,000/km (1999 values), depending upon the need for utility relocation and other local factors.

d) Since busways can be provided with locally available labour, materials and vehicles, the foreign exchange requirement for 'hard' currency is minimised.

e) Scope for Incremental Development: Sections of even a few hundred metres of Busway can be useful (whereas rail transit needs a depot and a significant route length before it can attract passengers.)

f) Busway Transit can also be enhanced step-by-step (eg by adding grade separation at critical intersections; introducing off-bus ticketing etc.) as and when finance permits

g) Existing Experience: busways enhance the use of buses, the predominant public transport mode in most cities, and can draw upon the wealth of experience and knowledge of bus operation which already exists.

In order to achieve high performance and to realise the full potential of a busway, good design, complemented by operational and management measures are necessary. With very high flows, management measures are also needed to ensure that buses at either end of the busway are fed into the normal street network, or into a terminal area with maximum efficiency. Provided that this is done, the research suggests that busways can achieve similar, or superior, commercial speed and passenger throughput compared to LRT.

The costs and performance under developing city conditions of LRT suggest that it will rarely be justifiable if evaluated fairly using current appraisal methods. LRT has been proposed for several developing cities on the grounds that it can offer a service that combines an appealing, modern, image

without the high costs of a full metro system. While there is no doubt as to the contentions concerning image, this is currently unquantifiable and to justify an LRT in a developing city would need a revised method of including additional benefits in appraisal methods.

An LRT system may be required, often for reasons other than strict technical ones. In such cases, the recommendations would be:

a) Keep the network fairly short and ensure that it includes main attractions, especially the city centre.
b) Stay within a very dense area where substantial numbers of passengers can come from within 600m walking distance.
c) Whilst maintaining sufficient distance for good commercial speeds, space the stations so that no one station becomes a bottleneck.
d) At busy stations use some form of control to minimise passenger crushing and hence delays
e) Introduce some mechanism for encouraging strict timetabling, or at least find a way of maintaining regular headways.
f) Maximise the image potential of LRT by incorporating service into new high quality developments (whilst protecting natural and urban heritage).
g) Design from the outset a turn-around mechanism that minimises stopped time.
h) Avoid, as far as possible complex junctions where LRV and cars must interact.
i) Do not assume a high commercial speed in areas where other road users may encroach into the swept envelope.

9.2 General Observations

There is a very high growth rate in developing cities that in turn leads to a demand for a mass transit service. There are three options for a mass transit service, each of which have strengths and weaknesses. Indeed it must constantly be acknowledged that the biggest mistake a city can make is not so much choosing the 'wrong' system, but in assuming (despite the lessons of Los Angeles) that the private car might be a viable mass transit option.

Unfortunately, as is the case with so much research, there are things that we still do not know. For example, how would London, or Seoul, have developed in the absence of a large urban rail system? It may be that they could have survived with bus transit, but would they have been as economically important? These are important questions. The main concern of this research, however, has been not to deliberate over the subtleties of cities at the margin (and that which arguably can afford to make mistakes) but rather to tackle gross negligence inflicted on much poorer cities.

The heavy rail option would appear to be the only one for the very largest and most densely populated cities. However, it will always be very expensive, and in order to be affordable to a city may well require ticket prices that are out of the reach of ordinary travellers.

To build a rail system costs an order of magnitude more than an equivalent bus system. The findings of this research suggest that the differences in performance, in the widest possible sense, do not justify this difference in cost.

One of the reasons why rail may have been implemented in so many poor cities is that the bus in these cities is seen as a lumbering failure. Large, slow, constantly delayed by traffic and rarely maintained even to basic minimum safety standards. Unless decision makers have seen for themselves that a mass transit bus system can operate well (eg in Curitiba, Brazil, plate 10) it will be hard for them to imagine how the bus could be a serious alternative to LRT (eg compare with plate 1 Karachi).

Conversely, it is easy to imagine that LRT would be better than a bus system. A light rail vehicle is larger and has better acceleration and higher top speed than a bus. LRT can be run in trains of two or more cars and only needs one driver. Again, in order to appreciate the differences it is necessary to see the army of maintenance staff, or stand with a stopwatch as an LRV driver struggles to close the doors at a busy stop while others queue behind.

One area in which urban rail is very much stronger than the bus alternative is in the lobbying and marketing that it receives. Measuring the precise influence of this is not possible, but it is safe to say that if it did not work then it would not be done by some of the world's largest conglomerates.

Corruption is widely held to be the reason for so many decisions in the Third World. It is not necessary to persuade many people to gain a favourable decision, and decision makers in low income countries where democracy and institutional capacity is less advanced, will be more open to accusations of corruption.

The poor countries will always need some form of aid support for rail mass transit. For as long as some donors consider tied aid to be a political necessity then French aid money (for example) will continue to support French rail companies. For multi-lateral organisations

such as the EU the pressures to disburse large amounts of aid will make a professionally managed rail consortium an attractive proposition. Other international aid and trade patterns, for example involving growing markets in China, will also take precedence over some appraisal considerations.

It therefore seems that rail projects have an unassailable position. They will be perceived as a preferable solution by public, industry and politicians at local and international level. Only a small minority of authors in the literature review for this research raised dissenting voices (and those were mainly in the USA).

9.3 Recommendations

The overall conclusion must therefore acknowledge that what is needed is an adjustment, within a realistic timescale and extent, of the current practice.

Firstly, it should be recognised that it is as important to prevent bad schemes going ahead as it is to promote good ones. The problems of Third World debt may not be solved by giving more aid, but they might be greatly eased if other cities can avoid borrowing 12 billion dollars to build a metro network (as was the case in Mexico City). UK banking expertise is likely to be of equal (or more) value to heavily indebted countries than UK expertise in low-cost aid projects.

Support for any transport system should acknowledge the current debate (at least in the West) about the desirability of travel per se. Equally, the link between travel and land use should be recognised. A project that will help ensure the efficiency of a city may be desirable, but not if making it viable requires housing density levels above human acceptability.

In the Istanbul case study, and possibly elsewhere, senior decision makers were more interested in the purchase of expensive technology than in its use. This should (clearly) be resisted and a rail system must be seen as an integral part of a city development plan. If it can be made to serve the city, to maximise demand, and to enhance the local environment, then even a loss-making system might be seen as more beneficial than some other forms of public spending.

The low demand for the busway option does not appear justified on technical grounds, and points to a lack of credibility in bus technology. As there is no powerful lobby for a mass transit system using buses, this is one area in which government to government assistance might be justified. Those requesting aid should always be encouraged to include a Busway as a comparative option.

Cost benefit analysis has been criticised for its inability to cope with projects that depend to a large extent upon time savings. However, it is perhaps not realistic to assume that improvements in forecasting and more scrupulous social cost-benefit analysis can be made. Further guidance should be prepared to enable cities to obtain a financial statement that demonstrates clearly how much money they are willing and able to spend on subsidising loss-making schemes.

There appears no shortage of advisors able to provide 'feasibility' studies that, with time, prove to be woefully inadequate, if not misleading. The ease with which it is possible to 'tweak' cost benefit calculations to provide the best results should be known to all.

Overall it appears that decision making, especially in developing countries, is not entirely a logical process. It is best to remember this and not to be deceived into thinking that some form of reasoning for actions will be possible. Technicians should therefore use their best efforts to work within this limitations and do the best they can. This might best be channelled into making the whole procedure more accountable and more transparent. Increasing the dialogue between parties, for example by involving appraisal experts at the beginning of the process, rather than when it is a fait accompli, would also help.

What is recommended instead is a wider appraisal process. The focus of future research should enhance the ability of technical advice to clarify what is actually possible and at what actual cost. The cost of building, servicing loans and operation should be clearly presented to decision makers. The clear presentation of the financial implications of a project should be the basis of the decision making process for large projects. This could demonstrate to city leaders exactly how much they will have to pay in subsidies for a project and would provide guidance on its 'affordability'.

Cost benefit analysis will necessarily continue to play a part, but this should be as a tool for exploration, along with other methods such as multiple criteria analysis.
A preliminary multiple attribute rating technique framework has been prepared as part of this research which offers potential for guiding a more informed decision. The intention of this is to provide some structure to a complex area, to ensure that as many criteria as possible are included, but also importantly to provide a basis for discussion negotiation and cooperation among the many disparate bodies with an interest in the subject. Further work would be necessary to refine and test this methodology, preferably on a real case study proposal.

The fact that decisions are made with substantial consideration of individual and cultural values means that for almost every decision made there will be someone, somewhere, who, for whatever reason, will have a different, or even an opposite, view. A decision making framework will not necessarily 'solve' a problem, but it will certainly facilitate dialogue and discussion in a guided manner that may lead to more understanding between the Peruvian Mayor and the World Bank consultant (for example).

9.4 Closing Remarks

This research confirms the general belief that urban rail systems in developing cities cannot be financially viable. Light Rail does not appear to be a compromise between metro and bus; instead it appears to be have inherent disadvantages, especially in developing country conditions.

The choice of a mass transit system is influenced by 'practical' issues, such as transport planning and engineering, and by institutional and 'political' issues. The research presented here appears to show that there is a gap between what a strict application of current appraisal methods would find technically 'best' and what decision makers in recipient cities want. If a project benefits the world's finance houses and multinational industries, if it supports an incumbent decision-maker, and if donor country and recipient national governments have political and administrative reasons to support a project, then the technical rights or wrongs of the project itself may be of relatively little importance.

There is evidence that some benefits are not included in current appraisal methodology, and continuing research is needed to ensure that all possible benefits and disbenefits are considered fairly. However, promises of intangible benefits should not be used to support projects which could be seriously detrimental to a city.

It is clear that decision making is a complex process. So complex, indeed, that most people prefer to simply do their best and hope for a satisfactory outcome. The use of a multiple criteria framework might be able to facilitate this. Certainly its creation and calibration has proven to be a useful tool to guide discussions with an expert group as part of the present research, proving to be an almost perfect topic guide to facilitate an open, and yet guided, discussion.

Most rail mass transit proponents make extravagant claims for their schemes. The research will achieve its aim if it helps to screen out projects that are non-viable but with mitigating factors, from those that would cause a developing city severe problems.

Spending one billion dollars in a poor country is not something that should be undertaken lightly. Hospitals, schools and clean water projects may all have to be foregone if a mass transit project goes ahead. It is an urgent responsibility for those who understand the true implications of this type of investment to ensure that local decision makers can share this understanding. Irrespective of the decision they then go on to make.

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APPENDIX 1

An important part of the research programme was detailed consultation with a range of experts who have direct knowledge of the mass transit scene, particularly as it relates to developing countries.

As a means of encapsulating this knowledge with a view to producing an improved assessment framework, the following methodology was used. Described here in some detail.

THE MULTI-ATTRIBUTE TREE

Having decided to use a multi-attribute method to investigate the decision process the next step is to create an attribute 'tree'. This should include all of the major elements to be considered in looking at an investment proposal, taking into consideration the requirement to be structured, open and yet flexible .

The creation and structure of the appraisal framework have been described in the main text. This section describes each branch of the attribute tree, and the reason for its inclusion. Some comments from the expert group are reproduced here, though the caveats mentioned in the main text still apply.

Although there is an obvious tendency for the branches of the tree to be considered as 'choices', it was meticulously pointed out to respondents that these were in fact attributes for which the relative utilities were under consideration. They were not being asked to 'compare' economic and financial elements, for example, since these are clearly not mutually exclusive, and more of one does not mean less of the other. Although it may have simplified the discussion to have had each tree stem having unique and exclusive trade offs in each branch, in practice it is not always possible, nor necessarily desirable.

INTRODUCTION:

This part of the research required the selection of experts who were available for interview. The criteria used to identify an expert are as given below:

* More that 15 years experience of transport issues
* more than ten years experience of aid-funding issues
* familiar with aid appraisal procedures
* Previous involvement with mass transit appraisal studies

In several cases the ideal combination of all of these were met. Where there was one area of deficiency but this was compensated for by strength in other areas then this was accepted.

The interviews took place mainly at the place of work of the respondents. The first stage was an initial explanation of the reasons for the research (though without giving away any findings that might prejudice response). As a means of getting background information on each respondent, where time permitted, an open-ended questionnaire covering general opinions was also used.

METHOD

The multi attribute tree, was printed onto cards that could be easily laid out on a desk. Although the framework as a whole was available for reference, in practice it was observed that focussing on specific sets enabled a more detailed consideration of that particular issue. In order to introduce the survey in a fixed and re-producible manner, the introductory speech was read from a standard script as shown below:

The Standard Introduction used in Interviews regarding the Multiple Attribute Utility Tree

Good Morning/Afternoon

I am interested in your views on the provision of aid finance for mass transit systems in developing cities. By mass transit I mean segregated busways, Light Rail Transit and underground metro railways. (Are you familiar with these terms ?)
The scenario I would like to talk to you about is based upon what we might think of as a preliminary 'appraisal –' of a proposal to fund a large scale infrastructure project, with special reference to mass transit systems such as metros, light rail, or busways.

I know that in reality, project planning and evaluation is a linear process: at any time a single event (such as financial limits) may cause an entire project to be rejected. Even in this linear process, however, there are implicit trade-offs made in selecting the points where choices will be made. It is the size, or the 'weight' of the trade-off values that I am interested in.
I am assuming that all the relevant advisors would be available for specialist assessment of the essential areas such as environmental, social issues etc. I therefore am interested in how you would approach the subject from your own viewpoint. Although I shall be asking for numerical values these are to represent weights that you assign to them, rather than specific measurements. I am as much interested in the reasons for your choice, and I shall be noting these.
I am assuming that the request for aid has already been checked by your local representatives and your central office to eliminate any possible major difficulties (such as big environmental concerns, current political problems etc). We are therefore faced with a project that has every possibility of being funded. We also can assume that following our appraisal there are resources for a proper study to be made by specialist consultants. So it is really just your ideas that we are looking for.

I am going to give you a selection of cards that present the different components of an appraisal. I will then ask you to give me some indication of the relative importance of the topics within each group. I will ask you to do this by allocating each of them a weighting factor so that the total adds up to 100. This again needs some clarification. It is not exactly a numerical score that I am looking for. I am not intending to calculate a sum total for a particular scheme. However, I need to measure the degree of importance that you place on each factor, so that I can build up a picture of where to concentrate my research input.

I would first like to use the cards as a focus for discussion. I would like your views on how each of the topics is covered in the appraisal process, and what you feel are important issues surrounding each card. You might consider them as cue cars to ensure that I cover all of the areas that are of interest to me. These will not necessarily be completely mutually exclusive, but will represent generally different areas. These areas have been selected after consultation with other experts, but if you think that I have selected any that do not adequately represent the true picture, then please tell me and I will note it down. Also please let me know if you consider that there is any double-counting that you consider unrepresentative.

As a further piece of research, I am interested to get from you one more piece of information. I will ask firstly how you think the existing process works (with all of its associated faults and omissions). Additionally, I would then like to ask you about a possible improved situation - though still taking into account the practical problems of the real world as we know it. (is that clear). The first ranking then will be according to what you consider to be the method that is used today. Please state according to what experience you are basing this on, either general or specific. I would particularly like to know about the out-turn situation, rather than the desired policy state.

For the second ranking, I would like you to make a recommendation of how the evaluation process should be done. This should take into account the imperfections of the World, and accept that a perfect process is not always attainable. I would prefer your judgement based upon your professional position, taking into consideration the needs of your organisation, as well as the possibly conflicting, requirements of others.

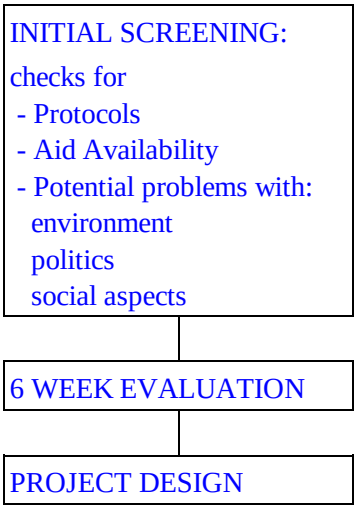
Please let me know if you disagree with the groupings chosen. Note that the existence of 'double-counting' is not a problem, as this simply represents the wide-ranging importance of some factors such as 'environment' . I have tried to be unbiased in the presentation. Please let me know if you feel any questions are 'leading' or if you feel that you are being asked to make an unusual or unnatural judgement, then please also let me know.

– *The word 'evaluation' was used instead of 'appraisal' in countries where this terminology was more familiar.*

The first card given to the survey group used a graphical representation to support the text that was read to them. It explains that the process to be examined is the first appraisal. This occurs after the initial screening of proposals to identify potentially serious problems. The initial screening would reject at an

early stage projects that were outside stated policy objectives and also those for which finance is not available. The initial screening would also identify and flag for specialist advice projects likely to be particularly difficult or require sensitive handling. This would include, for example, high-profile environmentally sensitive areas such as rain forests, and politically difficult areas such as war zones.

First card shown - to explain the overall process and where the appraisal fits in



THE STRUCTURE OF THE TREE

The overall structure of the Multiple Attribute tree is as shown in figure 16 and table 28 in the main text. For this detailed explanation in order to identify the different levels, the terminology 'sector and sub-sector' as suggested by Ross (1992) has been followed although in the main text the terms components and elements are used as being more explanatory for this particular case. The Ross terminology had the advantage of already being familiar to several of the expert group.

SUB SECTORS

This is the main areas in which the project should have objectives against which it can be judged. The transport analysis process has been divided into three main sub sectors. The first considers how the project is built, the second examines the impact of the project, and the third groups together non-project, but important, considerations.

Of interest here is how the expert group regards the fundamental value of overseas aid projects. How important was it, for example, that a project is technically good (such as a dam that is very good at holding back large amounts of water?) Also considered is the impact on the people who are the recipients of the project, and others affected by it (such as those living below and above the dam). Finally, the influence of the administrative process on the likelihood of aid being given was investigated, since the administrative processes involved in transferring billions of dollars between countries can be a significant obstacle, irrespective of a project's worth.

The card used to present the sub-sectors and the main points used to define them is shown below.

RANKING	CARD A: Description of Category	Weight %
	PROJECT VIABILITY The economic viability - that is the present value of the time and resource savings as a ratio to the investment costs. The financial viability and the need for subsidy The technical suitability. The ability of the project to do the job that it was intended for (APV) PROJECT IMPACT The impact of the project on the lives of the people in the recipient area. The impact on disadvantaged groups including women and the urban poor. The impact on the environment and the physical planning of the city The impact on the government and institutional structure of the city (AIM) AID PROCESS ISSUES The extent to which the giver considers the receiving institutions worthy and able to benefit from the finance. The liability of the project to lead to benefits (real or in kind) for the **giver**. The availability and ease of administrative channels Strategic political and historic affiliations (AAP)	

These are very fundamental questions, and provoked much discussion. It was also one area in which the difference between what actually happens and what might happen was particularly marked.

PROJECT EFFICIENCY SUB-SECTOR

The first sub-sector to be examined was that which examined the relative importance of technical capability and cost issues. In the transport field, there are often engineering solutions available that are a very elegant solution to a practical problem. However, in the peculiar circumstances of a developing country, they may be costly and non-viable. Conversely, even with poor construction, a road (for example) might be considered a success if it provides a lifeline for a rural community.

RANKING	PROJECT EFFICIENCY SUB-SECTOR: The ability of a project to meet its objectives	Weight %
	MONETARY The economic viability of the project - that is the value of time savings and other quantifiable benefits The financial viability, and the likelihood of the project to make or lose money. The affordability of the project and its running costs (BFE) TECHNICAL The ability of the project to do the job for which it is intended(ie transport large numbers of people) The suitability of technology chosen The quality and appropriateness of construction method (BTI)	

This was a difficult question with which to start, but did allow more explanation of the process to be introduced at this stage. It also raised the subject of who the project is to benefit, and the issue of high-technology schemes finding favour in developing countries.

IMPACT SUB-SECTOR

The next sub-sector to be examined related to the impact of the project on its target population. This focussed on the key areas of; Institutional aspects such as institutional capacity and good governance; Environmental and urban sustainability issues; and the intangible aspects such as the civic pride and image of an investment. The aim was to discover how much difference did the project make to the people who it was trying to help. Despite the best efforts of aid agencies over the past ten years, focussing aid on those most in need is still difficult to achieve to everyones' satisfaction. This was illustrated by the fact that in the discussion of current practice, nobody said that the impact of a project actually has a weighting of 100%. However, most respondents said that this was one are that they would like to see improve.

RANKING	IMPACT SUB-SECTOR: What will the project do to and for the population as a whole	Weight %
	INSTITUTIONAL & SOCIAL The impact on the social development and welfare of the citizens, with particular emphasis on disadvantaged groups such as women and the urban poor. The impact on the quality of the government and institutional structure of the city The impact on the economic structure of the city and the impact on the ratio of private to public ownership and involvement. (CIS) ENVIRONMENTAL & URBAN The impact on urban air quality. The influence on energy usage The impact on other environmental indicators including noise, groundwater and land take. The influence on road safety The ability of the project to enhance urban development and efficiency The opportunities for improvements to the city centre (CEU) INTANGIBLE The ability of the project to bring benefits that can not be measured directly. The improvement in re-election chances of incumbent politicians The opportunity to reward 'deserving' individuals or regions The improvement in civic pride for residents The improvement in external appearance for potential investors The outward symbol of a non-car transport policy (CIT)	

AID EFFECTIVENESS SUB-SECTOR

The aid effectiveness sub sector looks at the practical issues surrounding the aid process itself, and also factors influencing whether aid will be considered to be 'money well spent'. With large amounts to be disbursed and overhead costs constantly being cut, the administrative effort required of the donor organisation can be important. A small complex, but worthy, project might take more administration than a project for which major multi-nationals will take on the bulk of the project management. It also considers the process by which a project becomes a reality. A good project that could be of benefit may not go ahead if there are insurmountable institutional and administrative problems associated with either the host or the donor country.

RANKING	AID EFFECTIVENESS SUB-SECTOR: Administrative issues for the donor and the recipient city	Weight %
	DONOR ISSUES The administrative requirements for transferring and monitoring the aid The strategic, political or historic links to the recipient country The potential for future real or perceived benefits financially or 'in kind' for the aid giving country. (DED) LOCAL EFFICACY The institutional capacity for receiving and sustaining the sums involved. The degree to which the politics of the recipient are considered rational and equitable by the aid giving country. The extent to which the recipient leaders are considered rational and reasonable The ability of the recipient leaders to represent people of all socio-economic groups (DLS)	

KEY AREAS

The next part of the analysis process considers 'Key Areas'. These are principal components of the sub-sectors that are recognisable and easily differentiated for consideration by the survey group.

PROJECT EFFICIENCY KEY AREAS

The first key area follows from the monetary sub sector, and looks at the ratio between the importance of Economic and Financial aspects. Financial referring to the potential of the project to cover its capital and running costs, Economic factors take into account other aspects such as the value of time savings.

One feature that was often mentioned by those with the greatest experience of overseas aid was 'affordability'. Two projects that have the same economic benefits might be quite different if one is in a rapidly growing market and the other in a poor African country.

RANKING	PROJECT EFFICIENCY SUB-SECTOR MONETARY Key Area	Weight %

	ECONOMIC The value of the benefits to all members of the community including users and non-users, with costs estimated for time savings, accident savings and other benefits. The suitability of the 'do-nothing' option chosen for comparison The reliability of the input figures chosen (EEB) FINANCIAL The difference between the income from fares and other revenue earning sources and the costs of the system to operate, maintain and renew. The ability of the country to afford the capital and operating costs The validity of the estimates (EFS)	

The next key area examines the relationship between the quality of the project itself and the extent to which it meets the transport needs of the city. This branch was introduced in response to a specific recommendation from one expert in the pilot survey, though others found it harder to comprehend. The intention of the question was to shed light on whether donor countries have a tendency to get carried away by the appeals of technological solutions, rather than addressing the fundamental solution to the problem itself. One example of this would be in aid going to computerised traffic signals, rather than to low-cost alternatives (Gardner, 1993). This key area promoted much discussion of the difference between 'intermediate' and 'appropriate' technology.

RANKING	PROJECT EFFICIENCY SUB-SECTOR: TECHNICAL Key Area	Weight %
	TECHNOLOGICAL QUALITY The technical quality of design and construction of the project The appropriateness of the levels of operation and maintenance required (FCS) RESPONSE TO NEED Ability to improve transport services for new and existing users The benefits to other travellers in the same city The benefits to the city and its government (FTP)	

IMPACT SUB-SECTOR KEY AREAS

The first key area of the impact sub-sector looked at Institutional and social issues. The project might, for example, improve the capacity of government, either as a result of technology transfer, by training, or as a result of catalytic effects in raising the profile of the field of activity. Direct health and welfare benefits are clearly of prime concern to all. Their inclusion as a key area rather than a sub-sector was not to downgrade their importance, but because the main appraisal is done by specialist social advisors. *Economic reforms* was included as a sub area because it was one of the specified aims of ODA (ODA, 1993).

RANKING	PROJECT IMPACT SUB-SECTOR INSTITUTIONAL AND SOCIAL Key Areas	Weight %
	GOOD GOVERNMENT The ability of the project to enhance institutional capacity The policy improvements that are likely to result from the project The benefits for staff development and training (GGG) SOCIAL ISSUES The developmental benefits for all social groups including the urban poor and women. The impact on general education levels The health and welfare of the general population (GSW) ECONOMIC REFORMS The resulting economic liberalisation from the project The opportunity for the project to develop the private sector Enhanced productive capacity (GER)	

The key area of environmental and urban considerations were grouped together. Although environmental concerns are obviously highly-rated, for this particular aspect of the appraisal process it was considered that the most important involvement of environmental issues takes place not in the general appraisal, but either at the screening stage, or during the specialist review. Also, as with social issues, the main appraisal would take place by specialist advisors, not as part of the general appraisal described here. Urban issues involve the consideration of the impact of the project on the shape, size and development of an urban area.

RANKING	PROJECT IMPACT SUB-SECTOR ENVIRONMENTAL AND URBAN Key Areas	Weight %
	POLLUTION Air Quality and emissions Energy use Noise visual disturbance groundwater and land take (HPL) URBAN DEVELOPMENT Sustaining the city as a focus for growth Maintaining the quality of the city centre maintaining the urban economic efficiency (HUD)	

In the important area of the intangible impacts of a project, the focus was on the factors which are difficult to measure, but which nonetheless have a major impact on the possibility of a project going ahead. These include positive reasons, such as civic pride, but also include negative ones such as political manoeuvring.

RANKING	PROJECT IMPACT SUB-SECTOR INTANGIBLES Key Area	Weight %

	POLITICIANS BENEFITS Re-election chances An opportunity to reward Favours or benefit preferred groups. Genuine representation of what the people want Corruption (IPB) CIVIC BENEFITS Civic pride Image for external investors Quality of life (ICB)	

AID EFFECTIVENESS SUB-SECTOR KEY AREAS

The key areas examined under the aid effectiveness sub-sector questioned to what extent aid was influenced by the practical process of administration of the money. Another related area examined was the influence of national interests in aid. This includes historic ties to countries such as former colonies, and also includes strategic and business alliances such as the new tiger economies of Asia.

RANKING	AID EFFECTIVENESS SUB-SECTOR DONOR ISSUES Key Area	Weight %
	NATIONAL INTERESTS Strategic policies related to areas with political or trade opportunities Colonial or historic Loyalties Aid & Trade opportunities of the project itself(JNI) ADMINISTRATIVE ISSUES Funding channels already in place including local offices multi lateral issues Monitoring workload Evaluation workload (JAI)	

Under the local efficacy key area was examined the ability of a country to really benefit from the proposed aid. There are many examples around the developing world of projects which, in hindsight, were a complete waste of money (Barrett, 1984). Although much of the blame for this does not lie with the recipient, the donor countries will still try to avoid countries which they perceive to be a bad risk. Nigeria, for example, is regarded by many countries as a high risk.

Representation is an element of Good Governance. In some countries with political viewpoints different to the aid donors (such as Eastern Bloc countries during the post war era) no aid would be given, irrespective of the project. Even today, world alliances and political interests have been rumoured to be responsible for aid to countries such as Turkey during the Gulf war.

RANKING	AID EFFECTIVENESS SUB-SECTOR LOCAL EFFICACY Key Area	Weight %
	INSTITUTIONAL CAPACITY The intentions of the recipient government to 'make the best use' of aid. The likelihood of mis-use or mis-management by the treasury The capacity of the scheme and its promoters (KIC) REPRESENTATION: Whether the government is considered prone to 'irrational' behaviour Whether the distribution of income is considered 'equitable'. (KRP)	

MULTI ATTRIBUTE ANALYSIS TREE (LOWER BRANCHES)

The main categories used in the fieldwork analysis to construct the multi-attribute utility tree are the ones described above. For clarity and completeness the lower-order utility levels which were developed by a smaller expert group are presented here.

It is helpful to use the terminology suggested by Ross(1992) and think of the aspects being defined by a 'desired situation'. The current standing of a project can then be compared to the desired situation by comparison with indicators that provide a means of verification.

The aim has been to make as many as possible of the indicators to be objective, or at least replicable. However, it is the nature of a public project that there will be many factors that are difficult to measure and even intangible. Under these circumstances it will be necessary to make the best possible judgement guided, if possible, by expert advice. The combined weighting factor for each element does provide a guide as to the factors that should receive the closes scrutiny.

PROJECT EFFICIENCY SUB SECTOR

The first key area in this sub-sector is entitled 'monetary', this has sub-areas 'economics and 'finance'.

The aspects to be covered as part of the Economic sub area are the outputs and the inputs. This attempts to assess the relative importance of the accuracy, and suitability, of data input into the process. It is clear from some of the case-study literature for example that the inputs to some projects were based upon unreliable and ill-researched data. Considerable effort and importance is given in an appraisal to the economic indicators such as Internal Rate of Return. However, close scrutiny can reveal that, as in the case of the Guangzhou metro scant regard was given to the input values (such as value of time) on which the output was critically dependent.

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %
Outputs	EIRR is above threshold	What is the EIRR	

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %
	NPV is above threshold	What is the NPV	
Inputs	All alternatives studied Reliability of Estimates Correct VoT estimate	Evidence of alternatives tested Realistic 'do-nothing' Reliable sources Sensitivity analysis VoT measured well	

Similar categories were used for the financial sub areas.

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %
Outputs	FIRR is above threshold NPV above threshold	What is the FIRR What is the NPV	
Other	The project is affordable Local Sustainability Reliability of Estimates	Likely losses as a proportion of GNP Other spending commitments sources of revenue realistic forecasts	

In the technology sub area it is interesting to consider the balance between the construction quality and appropriateness, and the operational factors. In the example of a waste disposal plant, for example the construction may be to a good standard, but fail to anticipate the operational difficulties of processing waste in countries with a low paper content.

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %
Construction	Appropriate technology reliable estimates of cost and duration	tried and tested locally history of construction problems	
Operation	Able to be Maintained Suitable for local Operation	spare parts likely to be obtainable similar local expertise available	

In the Transport Needs sub area, the benefits from the scheme will accrue to two groups, the users and the non-users. Although the output from a transport model can sometimes dominate proposals for a scheme, their inclusion at this relatively low level indicates how many other factors are involved in the actual appraisal process. A more realistic approach might have been to separate out the transport modelling into the screening process. Their inclusion here enabled some consideration and discussion to be made of the relative importance given to elements such as benefits to users and non-users. This was discussed during the interviews and led to much discussion centring upon the UK governments requirements for Section 56 approval and also on the benefits that car users hope will accrue from other people transferring from the car mode.

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %
Users	Increased Time savings - work Increased Time Savings - non work cost savings accident savings improved comfort & convenience	est. from reliable model as part of CBA ditto ditto ditto from Stated Preference surveys (or estimated)	
Non-users	Congestion time savings - cars time savings - buses accident reduction bus/road investment savings energy savings environment improved land use more efficient	Estimated from reliable model ditto ditto ditto ditto expert consensus judgement	

A clear difficulty at this stage is that some judgement needs to be made regarding the quality of the transport model used to investigate these values. Some knowledge of the past history of the model and the people using it can help, and it is also informative to check the input values used, particularly for key factors such as the value of time. However, with a complex modelling procedure it is always possible to camouflage some of the calculation procedures in order to ensure the output value is as required. For this reason it would always be advisable to check the calculation procedure using a simplified estimation procedure such as MRTAP Fouracre et al, 1990) in order to check that the results are at least of the correct order.

IMPACT SUB SECTOR

The first key area in this sub-sector was Institutional & Social, and the first sub area is entitled Good Governance.

A large public transport infrastructure project can influence good governance in several ways. Firstly it can be a statement by a government of a policy that is well-focussed and directed towards sensible, sustainable policies. Secondly, it can be valuable opportunity for government workers to gain from collaborative working with external experts. Technology transfer in both professional practice and in manufacturing should also be possible.

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %
Policies	supports good policies	evidence of good urban/transport strategy	

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %
Staff	developmental benefits	proposals to involve local staff at every level	

Economic reforms was included as a sub area because of current ODA interests. It is a slightly subjective issue in this context, and it is difficult to make judgements on another country's regime with respect to the influence of a single project. As privatisation is another subject that many aid agencies are encouraging this was included as an aspect at this point.

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %
Economic Reforms	Helps Economic liberalisation Enhances productive capacity	Is the project under strict government control Will the project increase access to markets will there be construction spin-offs	
Privatisation	Promotes private sector	Will the public sector be involved	

Social aspects cover a wide range of elements and are, almost by definition, impossible to quantify or make comparative assessments of. Although clearly essential to be included in the analysis process, most of the primary consideration would be done by specialist advisors. For convenience the grouping has been made between Health/Welfare and Education/development.

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %
Health & Welfare	Helps disadvantaged groups Includes Public participation	helping the urban poor helping women	
Education & Development	Includes Local work training "Children by Choice" "HIV" "Drugs Control"	evidence of involvement no adverse impact ditto ditto	

On the assumption that environmental issues that would be dealt with separately, the sub area pollution was grouped into only three aspects. Emissions into the air and water, Energy policy (showing that the title pollution is not well used) and other issues such as noise and loss of visual amenity.

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %
Emissions	reductions On-street general improvements Indirect improvements	reductions predicted by reliable model ditto ditto	
Energy Policy	Direct savings Indirect savings	estimated from reliable model ditto	
Other	R. Safety improved Noise lessened visual amenity improved Land take minimal heritage preserved	expert consensus est. From reliable model best expert judgement ditto ditto	

The urban development sub area was divided into the influence on the city centre itself, which some say depends on a metro for its survival and on the urban region as a whole. This incorporates, and led to, arguments about the nature of the city and the desirability of mega-centres or satellite cities.

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %
City Centre	Helps to define a city centre Improves urban Quality of life	best expert judgement ditto	
Urban Region	Improves as Economic focus Promotes Continued growth real land price increases	evidence of planning strategy comparison with general trends estimates from local agencies	

The ‘intangible’ key area was one of the most difficult to subdivide, and one of the most talked about during the discussions. There is clearly the need to differentiate between the good and bad aspects of politics. At its best the representation of the people is universally acknowledged as being an essential part of ‘good governance’. Less productive for the city, but a very important influence, is party politics - actions that are based upon survival in office rather than benefits to the public. It is not envisaged that accurate analysis should be made by an outsider, but the inclusion of these aspects ensures that the matter is at least considered.

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %
Party Politics	Is NOT just to reward favours Is NOT just for Electioneering	judgement / local knowledge ditto	

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %
Local Representatives	Local people do want it will advancement quality of leadership	evidence / local knowledge or surveys judgement	

Loosely grouped into the 'people' sub area are aspects that consider the methods by which the people, through their various channels, can exert influence on a decision. The pride inherent in living in a city with modern facilities can be a real, though immeasurable, benefit. When this spills over into influencing the image to outside investors, then these benefits can become real. The intangible transport aspects would include the visible statement that a city is prepared to invest in a public transport system, rather than pay the same, or more, for roads mainly to benefit cars.

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %
Local Civic Pride	provides local pride ready for it	judgement based upon comparison of need relative to supply ditto	
External Image	attracts external investors is a catalyst for growth	judgement signs of interest from investors	
Transport Issues	comfort for more discernable market sign of enlightenment re cars enhanced community spirit	judgement based on comparison of existing transport modes judgement based on stated policies judgement / local evidence	

AID EFFECTIVENESS SUB SECTOR ASPECTS

This sub-sector gathers together all the aspects that are not directly related to the project and its impact. As many people who have worked on aid projects know, these can be highly influential in the success or failure of an application for aid funding.

Covering first the key area related to the donor country, the Disbursability sub area considers the aspects faced by donor agency executives when considering investments. This includes the slightly paradoxical situation where an expensive project can be considered to be more attractive than a cheaper one because of the administrative burden. In some cases, aid agencies have concentrated their efforts into certain sectors and regions such that a good project outside of these will have little chance of approval.

Aspects related to the risk of failure are also considered at this point. This might include the broader definition of 'failure' (as might be found in embassies in exporting nations) whereby a project is cost-effective and well built, but fails to bring any kudos or recognition to the donor country.

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %
Administrati on Burden	able to be reliably evaluated initial investment is within budget monitoring will not be problematical	knowledge of resources available latest figures availability of advisors	
Risk of Failure	forecast risk is low past record is good	judgement and consensus local knowledge	

The donor issues key area has a sub area representing National Interests. This considers aspects such as loyalties to former colonies. It also looks at the more modern phenomenon of linking aid to trade.

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %
Aid leading to trade	supports donor country specialist ability good market opportunity strategic importance	judgement by Trade advisors ditto ditto	
Loyalties	has historic importance- eg colony regional support- eg EU favoured International - eg World Bank favoured	from stated policies consensus ditto	

Under the Local Efficacy key area, the institutional sub area looks at how this will influence the decision. Three aspects are considered, the institutional capacity of the decision makers themselves, the capacity within the country to maintain and operate the investment, and the confidence that a donor can have in the recipient country treasury.

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %
Policy Makers	Indicates good Urban Policy Indicates good Transport Policy	judged from stated policies from transport advisor	
Treasury	Able to handle size of Investment Able to sustain operations	judgement / history judgement / history	

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %
	and depreciation		

The confidence in the treasury may, or may not, be due to the risk of corruption, suspected as being a major hazard. The next sub area looks at representation, where the fairness and the basic honesty of the politicians can be considered. The two aspects cover the rationality of the decision makers, and their equatability in allocating resources between different groups.

ASPECT	DESIRED SITUATION	INDICATORS/ MEANS OF VERIFICATION	Score %
Rational	Decision is likely to be Sustainable no evidence of illogical decisions	judgement / history local knowledge	
Equitable	government is representative government is democratic	judgement published constitution	

SUMMARY OF PILOT RESULTS

The main text cautions against treating the results of the pilot exercise as anything but indicative. However, for completeness, the results of the exercise are shown below. This is intended to illustrate the type of data that can be collected. With a larger sample size, some exploration of distribution and association could be made.

Sector/ sub-sector	Present Avg	Future Avg	Present STD	Future STD
AAP	28	22	15	16
AIM	24	43	10	13
APV	48	36	7	9
BFE	56	52	10	10
BTI	44	48	10	10
CEU	47	49	11	10
CIS	45	34	8	12
CIT	8	26	12	12
DED	52	26	18	12
DLS	48	74	18	12
EEB	58	38	10	10
EFS	42	62	10	10
FCS	28	50	15	28
FTP	73	50	31	28
GER	46	30	8	9
GGG	34	45	10	9
GSW	20	25	6	12
HPL	44	47	16	12
HUD	56	53	16	12
ICB	61	75	31	32
IPB	39	25	24	14
JAI	60	53	31	23
JNL	43	48	28	21
KIC	62	63	15	19
KLR	38	37	15	19

The sector references are as given in the descriptions above. Averages and standard deviations are shown for the weightings that respondents said applied to the present methods of appraisal and also to how they would alike a future appraisal method to look. (See main text for more description of these distinctions).

CONCLUSION OF APPRAISAL FRAMEWORK

The development of this framework has been a constructive experience in that it has helped talk through the complex issues of the benefits of a mass transit system with a wide range of influential and highly intelligent people. It has proven, in practice, to be too complex an issue to neatly encapsulate into a single conclusion, not least because the people who can add most to the process are the ones who are most in demand, and hence most difficult to get together in one place. Even at this stage, however, the method has helped to identify key issues in the process and this is reflected in the conclusions of the main report.

Should further resources be made available by the research funding agency then this appraisal framework would offer a potentially valuable means of exploring in more detail the process involved in funding large transport infrastructure projects such as mass transit.