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THE COSTS AND PATRONAGE OF RAPID TRANSIT SYSTEMS COMPARED WITH FORECASTS

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ABSTRACT

This is the third report of a TRL study of urban rapid transit systems in other countries. In this report, the actual capital costs, operating costs and patronage levels of a number of existing rapid transit systems are compared with forecasts made when the systems were planned and grants were being sought. The report draws on information obtained during a TRL study tour of rapid transit systems and on other published material. It summarises a study of ten US rapid transit systems, and also includes 3 case studies.

The report concludes that on the whole, the rapid transit systems studied cost more than forecast and carry fewer passengers. Of the systems studied only one system was constructed for less than its forecast cost and only two carried the forecast number of passengers or more. The report discusses some possible reasons for these discrepancies and how forecasts might be improved.

1. INTRODUCTION

There has been an expanding development of rapid transit systems throughout the world in recent years as planners and local authorities perceive an advantage in using rapid transit systems as part of an overall strategy to improve public transport and enhance the environment of their areas.

The planning of a major construction project includes an assessment of the costs of construction (including the cost of loans to ensure completion within a reasonable timescale), costs of operating the project when completed and the income likely to be generated by the project. Applied to a new rapid transit system, this assessment involves making forecasts of the cost of building the system, the cost of operating the system on a day to day basis, and the revenue generated by passengers. Secondary elements of the assessment might include the benefit to the community at large (local, regional or national) in terms of fewer road accidents, reduced traffic congestion, increased property values etc.

In this report, the actual capital costs, operating costs and patronage levels of a number of existing rapid transit systems are compared with forecasts made when the systems were planned and grants were being sought. The report draws on discussions held and material obtained during a TRL study tour of rapid transit systems. It also draws on other published material, in particular a study of ten rapid transit systems in the United States carried out by the US Department of Transportation for UMTA (Pickrell 1989), a study carried out for TRL by Simpson (1990) on the costs and funding of rapid transit, and an earlier study by TRL and others on the Tyne and Wear Metro (The Metro Report: TRL et al 1986).

This is the third report of a TRL study of urban rapid transit systems in other countries. The study was carried out because there are proposals for new rapid transit schemes in a number of British cities, and the experience of similar systems abroad is of relevance in assessing these schemes.

The first report from the study (Walmsley and Perrett 1991, Walmsley and Perrett 1992) dealt mainly with the effects of new rapid transit systems on public transport and urban development, concentrating mainly on France, the USA and Canada. Visits were made to a number of cities in these countries, and discussions were held with the transport operator, local authority and town planning agency in each city, and with Government Departments and research agencies. The systems visited on the study tour were the Metros in Marseille, Lyon, Washington, Baltimore, Atlanta, Toronto and Montreal, the light rail systems in Nantes, Grenoble, San Diego, Sacramento, Calgary, Edmonton and Toronto, and the automated rapid transit system in Lille.

The second report (Walmsley 1992) dealt with the subject of light rail safety. Records of accidents involving light rail vehicles were obtained from the operators and local authorities in a number of cities in Europe and North America. The report covered in detail a number of target cities where a light rail system had recently begun operating (Grenoble and Nantes in France, Essen in Germany, Zurich in Switzerland, Utrecht in the Netherlands, Buffalo, Portland, Sacramento and San Diego in the United States, and Calgary in Canada). It also included a large number of other cities with light rail or tramway systems. The accident rates for light rail were compared with those for buses and other transport modes in the same cities.

2. SOME DIFFICULTIES IN COMPARING COSTS AND PATRONAGE WITH FORECASTS

There are two main difficulties in comparing costs and patronage with forecasts. One is that (perhaps surprisingly) there is a lack of suitable data; it has not proved possible to obtain details of forecasts for most of the systems in the study tour. Rather than attempt a wide ranging analysis, this report therefore contains case studies of three systems for which data are available (Grenoble, San Diego and Tyne and Wear). It also summarises and draws on a study (Pickrell 1989) of ten rapid transit systems in the United States, made by the US Dept of Transportation for the Urban Mass Transportation Administration (UMTA).

The second difficulty lies in deciding which particular forecast to choose, because many are made during the evolution of a project right up to the time when it opens, and which set of costs and patronage to compare it with, because actual systems are opened in phases and there may be no one particular phase which corresponds exactly with the system as originally planned. The approach used by Pickrell was to take the forecast on which the decision was made to proceed with that particular system, and compare it with the phase of the actual system which corresponds as closely as possible with the forecast. For example, the 60.5 mile, 57 station configuration of the Washington Metro that operated from 1984 to 1986 resembled the 62.1 mile, 60 station system originally scheduled for 1976, so it was these systems which were compared. As far as possible, the same approach has been used in the case studies.

It is also important to remember that capital costs themselves vary widely according to many different factors, including the type and size of the rapid transit system concerned. Various authors (PTEG 1988, Dickins 1987,1988, for example) have attempted to summarize these costs in terms of a cost per kilometre for different types of system, but no single measure is entirely satisfactory. Especially when comparing costs from different countries and different years, there are a number of problems:

- No two rapid transit networks are identical. There is always a choice of technologies for the various subsystems of the network, which will considerably affect the cost.

- Many systems use new technology and the market price will conceal research and development costs.

- Rapid transit projects often include a package of environmental improvements. It may be difficult to separate the costs of these additional works from the actual costs of the system itself.

- Costs of systems built in different years and in different countries cannot be compared unless they are converted to a common base. There are two problems associated with this conversion. Firstly, exchange rates are not constant, so converting the costs at time of expenditure and then inflating, will produce different results from allowing for inflation and then converting the currency. Secondly, inflation rates vary from country to country. This means that costs of systems built at the same time, but in different countries, will need to be inflated by different rates to convert to a base year.

- Interest rates also vary, not only between countries but also with time. The contractual conditions (fixed interest or variable rates), and in some countries the availability of reduced rate loans from central government, will also affect the cost.

- Capital costs usually include various taxes, such as company taxes or VAT on materials, which differ from country to country.

- The availability of labour, materials and products may have an important effect on the costs of a rapid transit system. These items can vary significantly over quite short periods of time, as well as between, and often within, countries.

- Legal provisions such as compensation payable for blight and disturbance will have an important effect on the capital costs of a rapid transit system, especially in central areas of cities.

Some of the problems mentioned here may have only a minor effect on the total capital cost of any rapid transit system. Other problems, while significant, may affect all systems in similar ways, so the precise details of the currency conversion and the correction for inflation may not be important in making a comparison between different systems. However, all these problems should be borne in mind when studying the detailed comparisons in this report.

3. COMPARISON OF ACTUAL COSTS AND PATRONAGE WITH FORECASTS IN 10 US CITIES

In a recent study, Pickrell (1989) undertook a comparison of the actual and forecast costs and level of usage of ten rapid transit projects in the United States. The ten systems were the metros in Washington, Atlanta, Baltimore and Miami, the light rail projects in Buffalo, Pittsburgh, Portland and Sacramento, and the downtown people-movers in Miami and Detroit. The US Government contributed nearly $12 billion through federal government grants, administered by UMTA, to support these US cities' investment in new rapid transit facilities.

The process of obtaining a federal grant in the US is described briefly in section 3.1, and results of Pickrell's study are described in the following sections. The data used were converted by Pickrell to a 1988 base to permit comparisons between the different systems.

3.1 PROCESS FOR APPLYING FOR FEDERAL GRANT

In the United States, UMTA has attempted to establish selection criteria to ensure that federal discretionary grants go only to those projects which are cost-effective and which have adequate financial resources for operations and maintenance.

Urban areas seeking federal funds for major capital projects are required to conduct a systems planning study, which identifies high priority corridors and explores the options for improving transit in these corridors. If a major investment appears warranted, a priority corridor is identified and UMTA undertakes an Alternatives Analysis. This examines the potential ridership and cost of a number of options in the selected corridor, including the Transportation Systems Management (TSM) option which incorporates low capital cost improvements, such as upgrading the bus service, priority lanes and other service enhancement techniques.

To enter the Alternatives Analysis, a corridor must satisfy two criteria. It must have a current daily patronage of more than 15,000 public transport journeys, and must also achieve a total cost of less than $10 per additional rider, based on generous estimates of the operating cost, parking cost and travel time savings.

At the end of Alternatives Analysis, the local agency identifies the preferred option, which must satisfy three criteria. The project must produce a gain in ridership compared with the TSM alternative, and there must be no other option which would produce more additional riders for less money. The project must also at this stage achieve a total cost of less than $6 per additional rider.

When the preferred alternative has been selected, and provided adequate funding, both locally and federally, is available to complete the project and ensure its operation, the local agency requests permission to begin preliminary engineering. Usually federal funding is requested for this stage. Once projects pass to preliminary engineering, they are almost certain to receive funding for the full system.

One result of this process is an emphasis on the capacity of a new system for attracting additional riders, and therefore on the forecasts of future patronage. There could thus be a tendency for forecasts to be based on the most favourable conditions which produce optimistic estimates of patronage.

3.2 RESULTS FOR 10 US SYSTEMS

3.2.1 Patronage

Figure 1 illustrates the actual levels of weekday patronage compared with the levels of patronage forecast for the rapid transit systems investigated by Pickrell. None of the nine systems for which data are available (there are no data for Atlanta) carried more passengers than was originally forecast. Washington achieved at least 70 per cent of the original forecast level. The remaining eight systems achieved patronage ranging from 14 to 46 per cent of the levels forecast.

3.2.2 Capital costs

Figure 2 details the actual and forecast capital costs of each of the ten systems. Nine of the ten systems were found to have exceeded their forecast cost. The exception to this general trend of overspending was Pittsburgh,

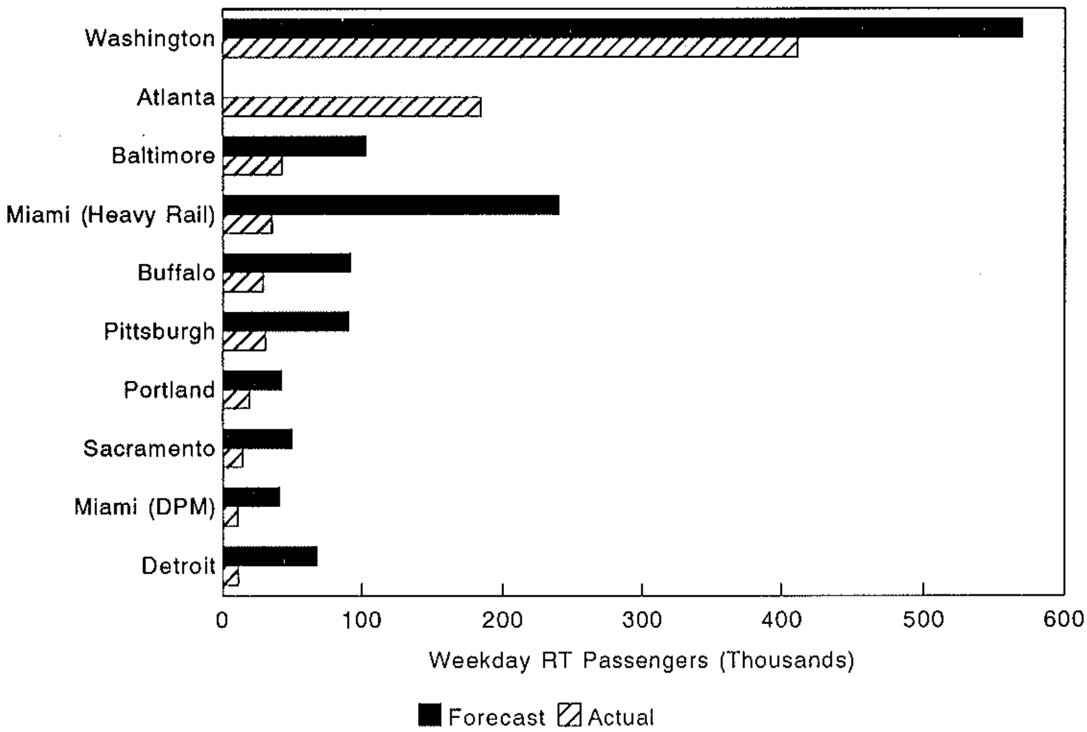

Fig 1: Comparison of patronage with forecast - 10 US Cities

Source: Pickrell (1989)

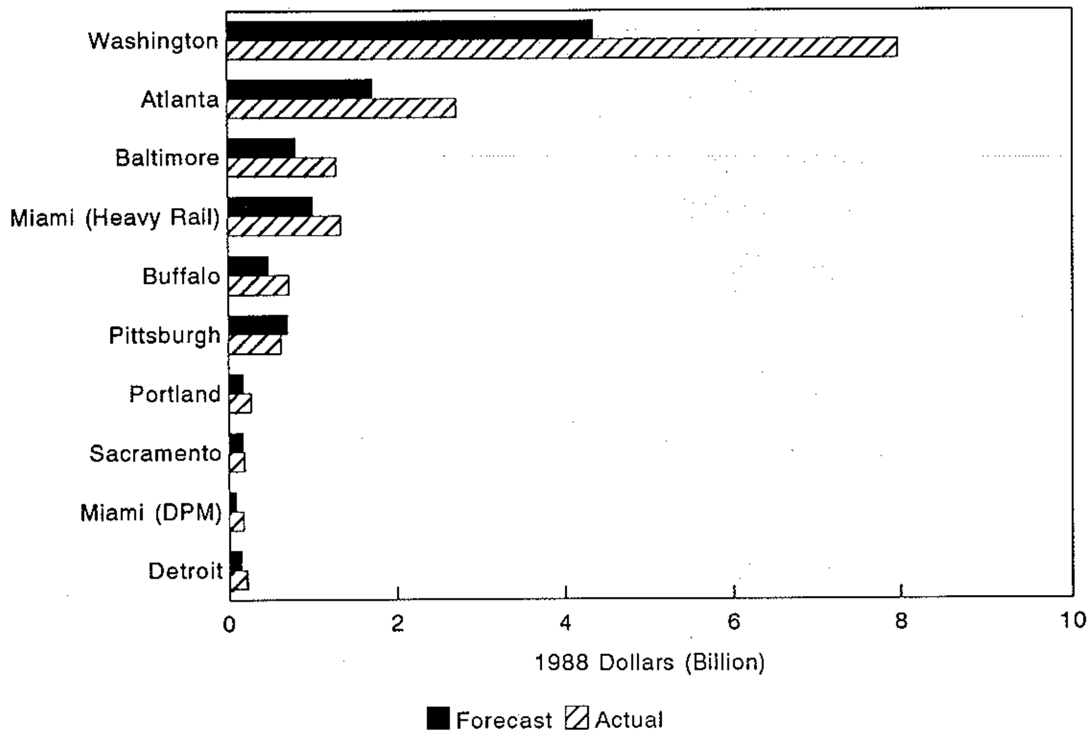

Fig 2: Comparison of capital cost with forecast - 10 US cities

Source: Pickrell (1989)

where costs were 89 per cent of forecast. Excess costs varied from 14 per cent (Sacramento) to more than twice the original estimate (Miami Downtown People Mover).

3.2.3 Operating costs

Figure 3 illustrates the actual and forecast operating costs for eight of the ten systems (forecast operating costs for Baltimore and Pittsburgh are not available). Of the eight systems, that in Sacramento came close to meeting its operating cost forecast, and the forecast in Buffalo was exceeded by only 12 per cent, while in Washington and Atlanta the operating costs were three times the original estimate.

3.2.4 Cost of system per passenger carried

The cost per passenger carried is a convenient summary statistic since it combines the capital cost, operating cost and patronage. The effect of excess capital cost and operating cost and reduced patronage compound to produce a value for each system which is significantly in excess of the value calculated from the forecast data. Figure 4 details the forecast and actual cost per passenger carried. All seven systems for which data are available exceeded the original forecast, ranging from 88 per cent (Washington) to nearly nine times the original estimate (Miami metro).

3.3 DISCUSSION

The conclusion from Pickrell's study is that virtually all the systems studied cost more and carry fewer passengers than forecast. There are, however, some points to be made about this conclusion.

One is that the US forecasts were made at a relatively early stage of the design process - that of Alternatives Analysis. The comparison of actual performance with forecasts made at Alternatives Analysis stage has the advantage that it uses the information that was available for making the decision to proceed. However, later forecasts would almost certainly be more accurate, as they would be made with shorter time horizons and more detail known about the proposed system. They would also be subject to greater scrutiny than is possible at Alternatives Analysis stage, where a number of options must be evaluated.

It can also be argued that at Alternatives Analysis stage absolute accuracy is not so important as the relative accuracy of the estimates for the individual options - in other words, the parameters need not be accurate provided all the options are affected in the same way so that the right choice is made. However, underestimates of costs and overestimates of patronage are likely to favour a high cost system such as rapid transit, so the choice could be biased.

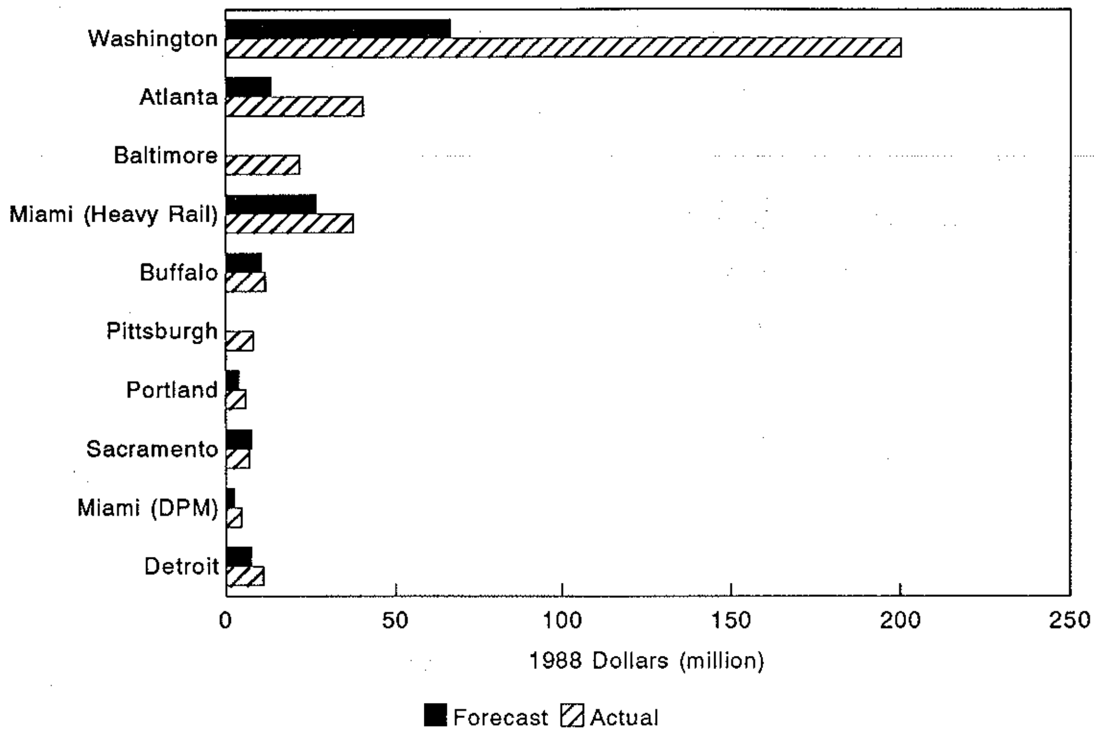

Fig 3: Comparison of operating costs with forecast - 10 US cities

Source: Pickrell (1989)

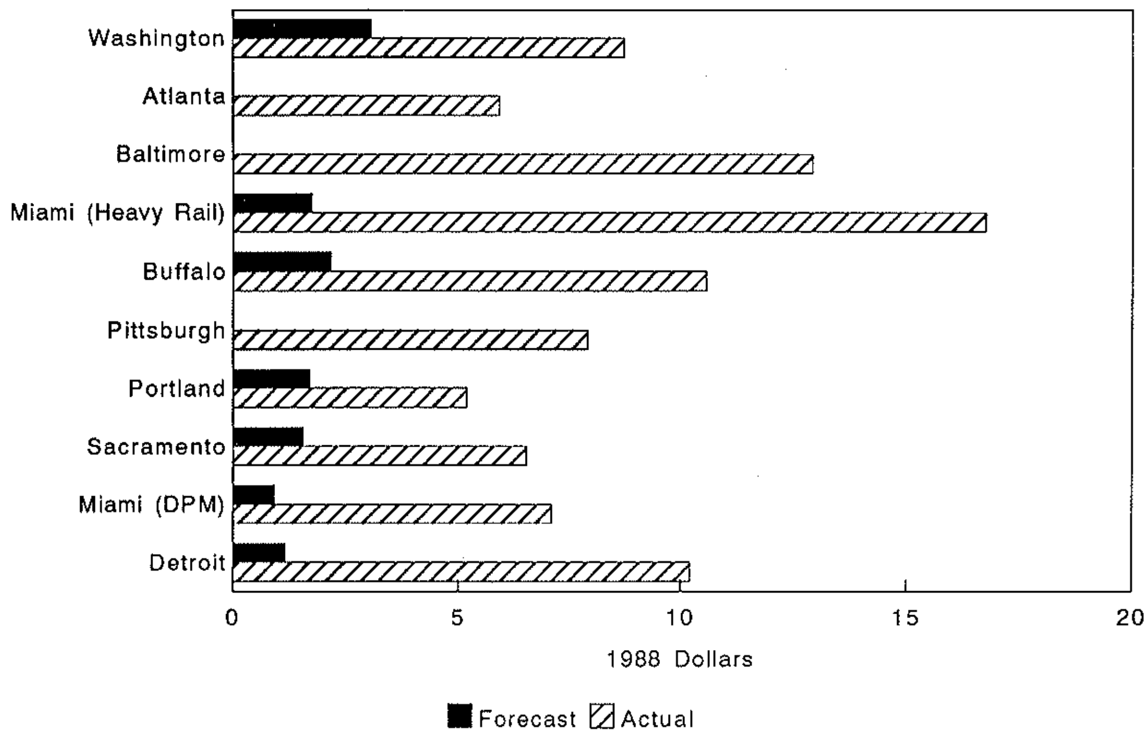

Fig 4: Comparison of cost per passenger with forecast - 10 US cities

Source: Pickrell (1989)

The process of converting capital costs to a base year can introduce a further inaccuracy, because construction costs may not increase at the same rate as costs generally. Pickrell estimated that construction costs in the US increased at 6.2 to 6.4 per cent per annum over the period 1971-88 (covering the construction of the projects studied), compared with 6.17 per cent for the US Gross Domestic Product, but concluded that the effect of this discrepancy was minor.

4. COMPARISON OF ACTUAL COSTS AND PATRONAGE WITH FORECASTS IN 3 CASE STUDIES

In this section, a more detailed comparison is made between forecast and actual costs and patronage for two cities from the study tour (Grenoble in France and San Diego in USA) and for the Tyne & Wear Metro in the UK. Each of these systems is described in greater detail in the following sections.

4.1 GRENOBLE

Grenoble is the main town of the Department of Isère in France. The conurbation, including adjacent communities, has a population of 391,000. A tramway, 8.8km long, was opened in 1987 serving the town centre, a large exhibition centre (Alpexpo), shopping developments, car parks etc. A second line, 5.8km long, opened in December 1990, but only data for Line 1 are used in this report.

The tramway was initially conceived as a means of improving public transport. The new system was planned to ease overloading on the buses, arrest operating subsidies, improve productivity and reduce operating costs. The tramway would also relieve the town's southern corridor of sixty buses per hour. A secondary consideration was to develop the tramway as part of a plan to turn Grenoble into a "pilot town" for experiments in the fields of art, social reform and technological developments.

4.1.1 Sources of funds

The tramway was built with the aid of state grants and Versement Transport, a payroll tax which is levied on employers in proportion to the total salary costs of a company. The rate was increased in April 1986 from 1 per cent to 1.5 per cent of the total salary cost in order to provide funds for the tramway.

When the system was planned, it was anticipated that state grants would contribute slightly less than 40 per cent of the total cost (that is, 50 per cent of the infrastructure cost). The remainder would be raised by loans and auto-financing. Versement Transport was to be used to repay the loans.

4.1.2 Forecast costs and patronage

When the decision to proceed with the construction of the tramway was made in 1983, it was estimated that the first line would cost 800mFF (see Figure 5) (AURG 1983). This is equivalent to 958mFF at 1987 prices. Infrastructure would account for over 60 per cent of the total cost with rolling stock accounting for a further 19 per cent. This initial estimate did not include any provision for the extra cost involved in constructing the vehicles to ensure easier access for handicapped persons, a modification which was added later in the planning process but which required a fundamental redesign of the vehicles.

The first line was planned to serve a population of 67,000 who lived within a 400 metre corridor along the line and 60,000 who worked within that corridor. It was estimated that, once the tramway was opened, total public transport patronage in Grenoble would increase by 18 per cent, from 38m journeys to 45m journeys per annum. The number of tramway passengers forecast for the evening peak period was 13,100, which implies a daily total boardings figure of 41,000.

4.1.3 Actual patronage

Sixteen trams per hour operated on the first line when the system opened. This replaced 46 buses per hour which previously operated along the corridor served by the tramway.

In the first quarter after the system opened (September - December 1987) total public transport patronage in the Grenoble conurbation increased by 15 per cent over the previous year. Patronage in the tramway corridor increased by 1.5 to two times the level prior to its opening. Ridership on the tramway itself was around 41,000 passengers per day which is equivalent to 18m per annum.

The daily ridership therefore matches the forecast figure, but the increase in public transport patronage, 15 per cent, is not as large as the forecast 18 per cent. However, these data relate to a period before the tramway was opened between Louis Maisonnet and Fontaine La Poya. Patronage in 1986 was also depressed by 5 per cent through engineering work on the tramway.

Data obtained on generated patronage indicate (see Table 1) that of the 12% of tramway passengers who did not previously travel by public transport, 5% transferred from car.

4.1.4 Actual capital costs

The first tramway line cost 1372mFF to build (see Figure 5). Of this total 27 per cent was funded by state grant, the remainder being raised through loans and Versement Transport. The state grant included a sum for improving accessibility of the trams for handicapped persons.

The outturn cost of 1372mFF compares with a forecast of 800mFF which is equivalent to 958mFF in 1987 prices. The reasons for the increase can be found in a cost

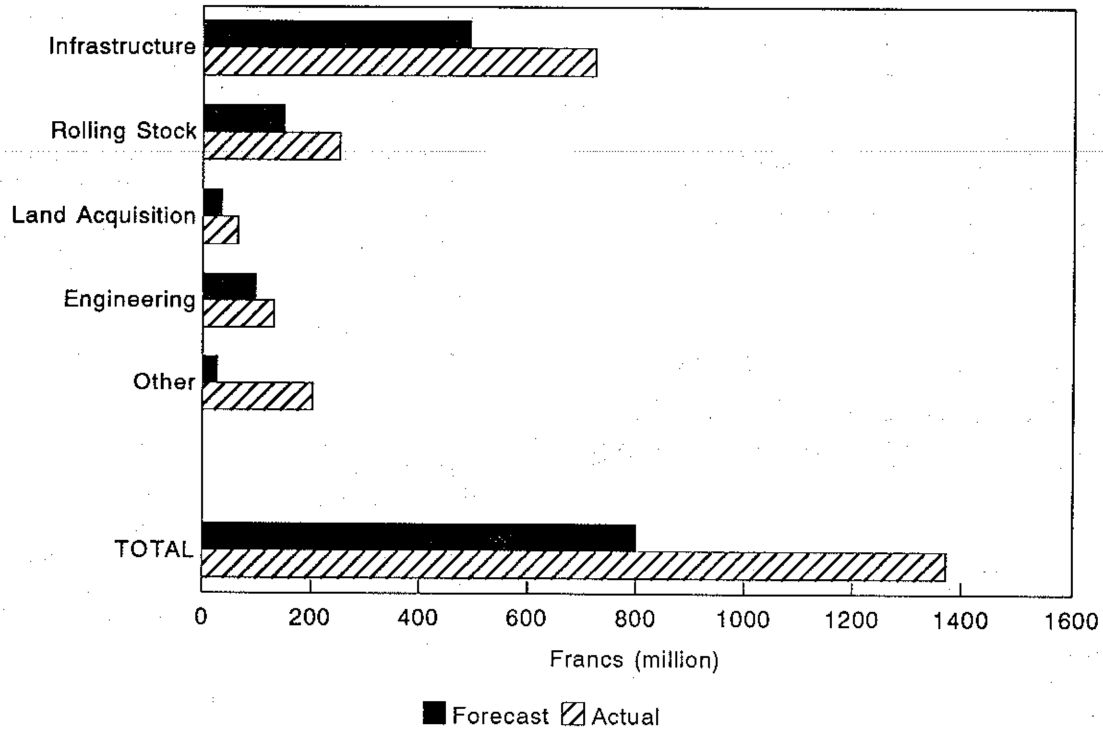

Fig 5: Comparison of capital cost with forecast - Grenoble Tramway Line 1

Source: AURG (1983)

TABLE 1

Grenoble Tramway:
Breakdown of new passengers

Increased patronage on tramway	%
Generated by tramway	4
Transfer from car	5
Transfer from walk and bicycle	3

TABLE 2

Grenoble Tramway:
Breakdown of increased construction cost

	mFF
Original Forecast	800
Original Forecast in 1987 prices	958
Better construction	+90
Vibration and noise reduction	+17
Improved access for disabled	+23
Extra for electrification, tracks and replanning of main-line station	+35
Development of properties	+179
Environmental improvements	+23
REVISED ESTIMATE	1398
ACTUAL COST (1987 prices)	1372

breakdown in the Impact Study for Line 2 (AURG 1988) and in a press article written at the time that the tramway opened (Eysseric, 1987). A revised estimate based on this figures is shown in Table 2.

4.1.5 Discussion

In summary, the forecasts for patronage on the Grenoble tramway were largely realised, in contrast to the ten US systems described previously. As far as the costs of the tramway itself is concerned, the original forecast was largely correct. Most of the extra expenditure was for the extra cost of improvements to meet noise and environmental requirements, and to fit the tramway into the urban fabric.

One reason why the Grenoble forecasts appear to have been more accurate than the 10 US systems discussed in section 3 is the stage at which the forecasts are made. The forecasts from the 10 US systems are taken from the Alternatives Analysis, where the systems are evaluated in comparison with other options. By its nature, this comparison must be done at an early stage before detailed engineering design work has been done.

The Grenoble forecasts, by contrast, are taken from the Impact Study. The nature of the Impact Study (see below) is such that it cannot be carried out until many precise details of the construction and layout of the system are known. The uncertainties attached to the forecasts are therefore likely to be less than those of the US systems.

The Impact Study is a document prepared for a public enquiry and comprises an evaluation of the impacts of the project and a presentation of the measures to be taken to compensate for, reduce or suppress any undesirable consequences for the environment. The way in which the chosen system is expected to improve traffic flow, reduce noise and aid accessibility for disabled people is emphasised. The Impact Study also contains estimates of the expected patronage and the effects on road traffic, bus network, and urban planning, using results from transportation models. Its main purpose is to demonstrate that all possible adverse effects of the chosen system have been taken into account, rather than to justify the choice of this option in preference to any other (or no) option.

4.2 SAN DIEGO

San Diego County covers 4,200 square miles and is located at the southern end of California adjacent to the Mexican border. Approximately two million people live in the county. The population of the County has expanded rapidly during the past two decades, and increased by 37 per cent. between 1970 and 1980.

In the mid-1970s traffic congestion within the city centre was beginning to cause severe problems and the existing public transport network could not cope with the extra demand. A large naval base was also generating large traffic flows. It was therefore proposed that a mass transit system should be built to relieve the roads infrastructure (roads, car parks, intersections etc) of some of the extra journeys that were being generated.

4.2.1 The San Diego trolley

The San Diego Metropolitan Transit Development Board (MTDB) was established in 1975 by state law to plan and implement a fixed guideway system for the area. The Development Board designed the San Diego Trolley which was planned to link the city centre with some of the rapidly developing suburbs and to replace some of the bus services.

The first section of line, called the South Line, opened in mid-1981. This line runs south from the city centre to the Mexican border. The system has subsequently expanded to include an East Line; the first 4.5 miles opening in 1986. A further 11.1 miles of the East line opened in 1989; further lines are under construction or planned.

4.2.2 Sources of funds

The transit system was funded by tax revenue; 90 per cent of the funding came from the Californian state petrol tax with the remainder coming from the state sales tax.

4.2.3 Costs and patronage forecasts

The 1979 budget for the South line was $85.8m.

Initial estimates of patronage on the South Line were 9800 passengers per day during the first year, increasing to 28,000 by 1995.

4.2.4 Patronage on the trolley

A straight line projection of the forecasts shows a growth in expected patronage from 9800 in 1981 to 28000 by 1995. Actual patronage on the Trolley during the first four years was quite close to this projection. From 1986, an increase in train frequency to 4 trains per hour increased patronage above the forecast projection, so that by 1990 the 1995 estimate of 28,000 daily journeys had already been met.

One reason for this healthy growth in patronage is that the Trolley is heavily used by tourists and by Mexican residents who work and shop in San Diego. Saturday patronage is about 90 per cent of weekday levels and on Sundays the Trolley carries about 75 per cent of passengers carried on weekdays.

A survey conducted during the third quarter of 1981, soon after the first line was opened, established that 56 per cent of passengers were diverted from bus, 30 per cent from car and 10 per cent did not make their journey before the Trolley system was opened.

4.2.5 Revenues and actual financial performance

The actual cost of the South line was $81.6m, a saving of $4.2m on the budget, due largely to interest forgiven on an advance from the State of California. Subsequent double tracking ($25.5m) and purchase of ten additional vehicles ($9.5m) brought the final cost up to $116.6m.

The system has been built economically and carries a large patronage. As a result, it covers almost all of its operating costs.

In summary, San Diego can be regarded as a successful system in terms of costs and patronage. It was built within its budget, and patronage has exceeded forecasts. The cost of double-tracking and added vehicles mentioned above can be regarded as a penalty for success, being required to meet the increased patronage.

4.3 TYNE & WEAR

Tyne and Wear is a conurbation of 1.1m population in north east England. A light rapid transit system, called Metro, was opened in August 1980. The system was opened in stages; being fully opened by March 1984. The Metro serves 44 stations and has a total of 55km. of track, of which 42km is converted BR track.

4.3.1 Justification for the scheme

In the 1960s the large metropolitan conurbations, including Tyne and Wear, were required to establish Passenger Transport Authorities (PTAs) and Passenger Transport

Executives (PTEs). These bodies were responsible for managing public transport in their areas. The 1968 Transport Act empowered PTAs to take control of rail services in their areas, reimbursing British Rail for the costs involved.

The Tyne & Wear PTA decided that the grant necessary to support BR services in its area was large in proportion to the conurbation's resources. Studies were initiated, as a result, which concluded that a rapid transit system, as part of an integrated transport network, would be a more cost effective method of providing public transport in Tyne and Wear.

The new Metro was planned to replace the two life-expired BR lines radiating from Newcastle (North Tyne Loop and South Shields line). Tunnels were to be constructed under Newcastle to provide improved access into the city centre, and a freight line to Kenton Bankfoot was opened to passenger services.

4.3.2 Costs and patronage forecasts

Initial estimates indicated that the Metro would cost £65.5m, at 1972 prices, to build.

The Tyne and Wear Plan (Voorhees 1972a) forecast that the Metro would attract 55,000 peak hour boardings on weekdays. This estimate was later amended to 49,800 boardings by the subsequent Rapid Transit Analysis (Voorhees 1972b).

4.3.3 Funding for the Metro

The PTE applied to the Department of Transport for a 75% grant towards the construction of the system. The grant application was accepted by the Department.

Soon after construction started there were indications of the likelihood of a significant overspend on the project. Following discussion between the Government and the County Council, it was agreed that the construction programme should continue subject to strict financial controls, and a cost ceiling of £161m at 1975 prices was fixed. Additionally, the design of the Metro was amended to reduce its capital costs without impairing the level of service. These economies included shorter trains and platforms, and achieved a saving of £9.2m. Extra funds were also sought and secured from two other sources, the European Regional Development Fund as a 30 per cent (£9m) contribution to the South Shields line, and Tyne and Wear County Council for various efficiency measures and special features such as provision for the disabled. These brought the estimated construction costs to £179m in 1975 prices (The Metro Report: TRRL et al 1986).

4.3.4 Metro patronage

Patronage on the Metro is less than had been predicted (see above). Surveys of passengers undertaken in Spring 1984 indicate that approximately 27,300 passengers travelled in the morning peak period between 7am and 9am. This is approximately 50 per cent of the original estimate.

Figure 6 indicates that Metro patronage peaked at 61m passenger boardings in 1984/5, the first complete financial year that the whole system was in operation. Patronage subsequently declined to around 45m in 1987-88, mainly as a result of fare increases around the time of deregulation of bus services in October 1986, and partly as a result of the Metro no longer being marketed as part of an integrated transport system following deregulation, though integrated ticketing was maintained. By 1990, annual patronage had stabilised at around 50m.

4.3.5 Revenues and actual financial performance

Revenue generated and costs of operating the system are presented in Figure 7 for 1983/4 to 1986/7. This shows that operating costs exceeded revenue by between 15 to 30 per cent. Currently, revenues on the Tyne and Wear Metro are 84 per cent of direct operating costs (TWPTE 1990). Although the Tyne and Wear Metro does not completely cover its operating costs, it comes closer to doing so than most other systems in the world (European metros typically cover 50-60 per cent of their operating costs). It also performs better than did public transport (bus and Metro) services in Tyne and Wear before deregulation in 1986, which covered about 70 per cent of their operating costs.

4.3.6 Discussion

There was a significant overspend on the original estimates for building the system. Much of this overspend has been attributed to the cost of tunnelling under Newcastle city centre and under Gateshead. Soil conditions under Newcastle were more difficult than had been anticipated. In Gateshead old mine workings were discovered which were not on any maps. In addition, various bridge works on the converted railway needed attention.

The actual outturn expenditure on the Metro to 1984 was £284m. This is equivalent to £179m at 1975 prices, being the cost ceiling of £161m plus additional works as described above. The costs of building the Tyne and Wear Metro therefore were kept within the limits agreed when the system was reassessed in 1976. However, construction of the Metro was by then well under way, so this reassessed cost estimate is not that on which the decision to proceed was made, in contrast to the US cases discussed earlier. The outturn expenditure is equivalent to about £550m in 1989 prices.

The cost reductions were designed not to affect passenger traffic. Nevertheless, it is possible that the reduction in frequencies and train lengths reduced the attractiveness of the system to the passenger, which may account for some of the discrepancy between the forecast and actual patronage. Even with the current levels of patronage, however, the Metro suffers from overcrowding at peak times, and it is difficult to see how the system could carry the forecast number of passengers.

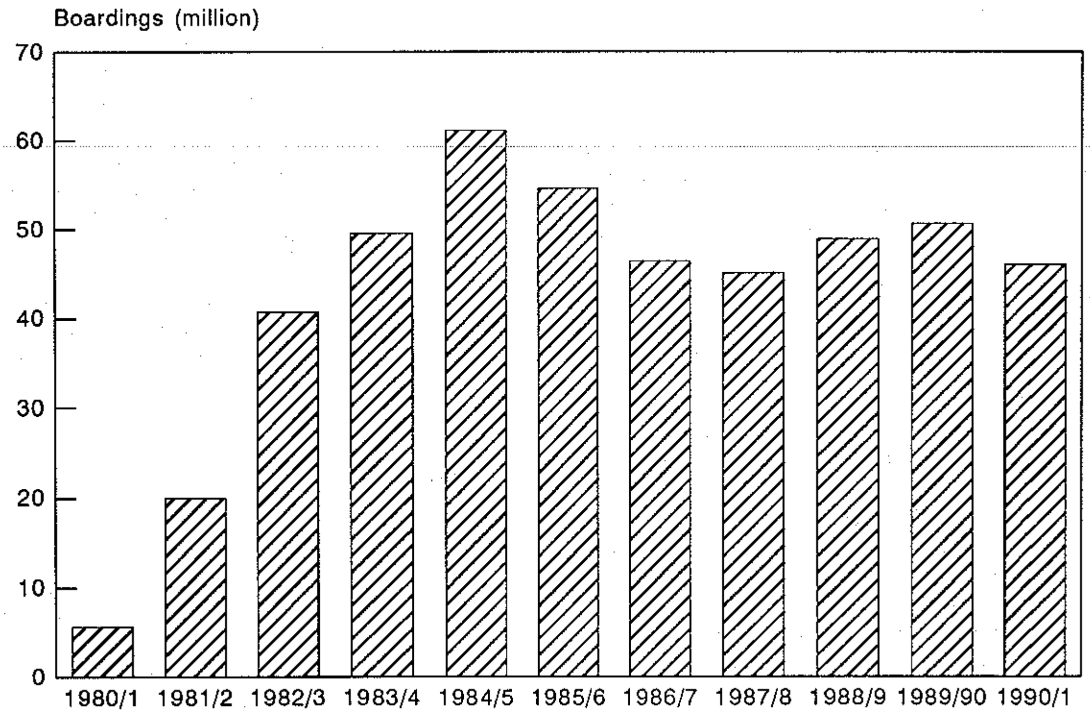

Fig 6: Tyne and Wear Metro Patronage

Source: Transport Statistics Gt Britain

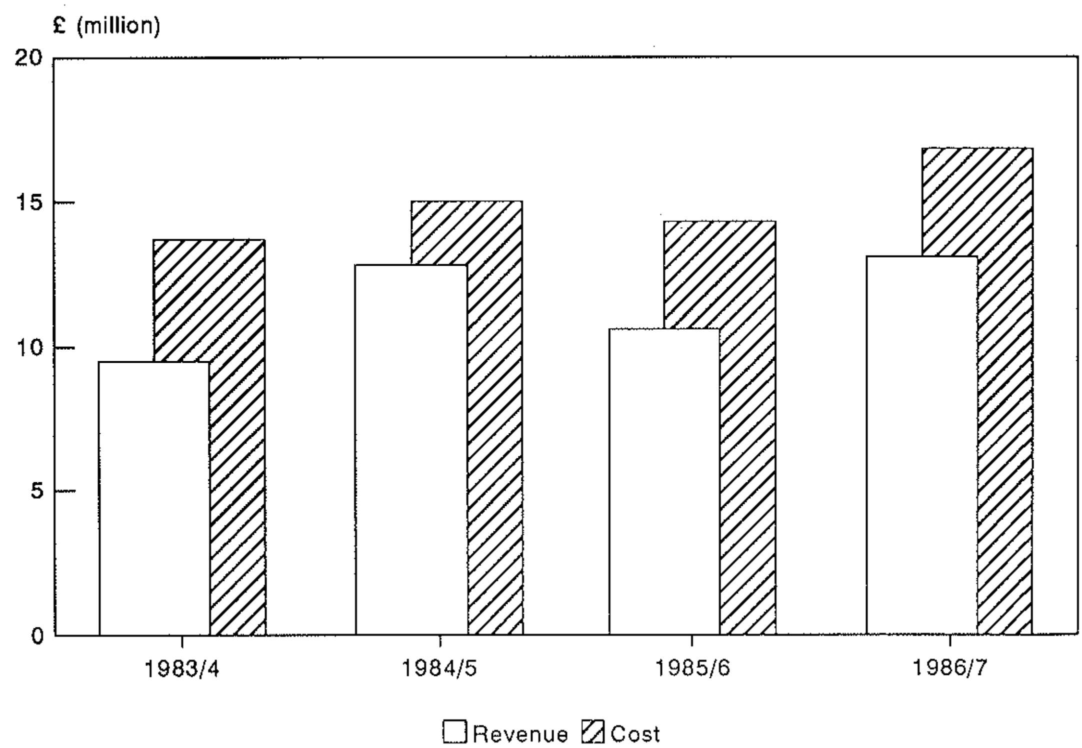

Fig 7: Tyne and Wear Metro Revenues and Operating Costs

Source: TWPTE Public Tpt Plans

5. CONCLUSIONS

5.1 OVERALL SUMMARY

This report has described how the costs and patronage of a number of rapid transit systems compare with the forecasts made at the time the systems were planned. The data are necessarily rather sparse because it has not proved possible to obtain details of forecasts for most of the systems studied. This may be because many transport operators, once a system is built, have little interest in going back to see whether the forecasts were realistic, so they tend not to have earlier documents readily available. They may, indeed, be positively reluctant to supply such information, which is understandable given that few systems entirely live up to their expectations.

By averaging the data which are available, we can deduce that, on the whole, the best of the rapid transit systems studied cost around 20 per cent more than forecast and carry 20 per cent fewer passengers, the average systems cost around 50 per cent more than forecast and carry 50 per cent fewer passengers, and a few are very much worse. Out of the systems studied by Pickrell (1989) and the three case studies, only one system (Pittsburgh) was constructed for less than its forecast cost and only two (San Diego and Grenoble) carried the forecast number of passengers or more.

5.2 REASONS FOR DIFFERENCES BETWEEN FORECASTS AND OUTTURN

There are a number of reasons why the outturn costs or patronage of a rapid transit system might not achieve the forecast levels. For one thing, many systems are not, in fact, implemented exactly as originally proposed; changes are made to the extent of the system, the phasing of its introduction and the way in which it is integrated into the city which affect the frequency of service, the speeds, the impact on cars and buses, and so on. Such changes are usually occasioned by unforeseen difficulties or the need for economy, and generally have the effect of increasing its cost or downgrading its attractiveness to passengers. The cost of environmental improvements in Grenoble, and discovery of tunnelling difficulties in Tyne and Wear, are examples.

In addition, to avoid a cost overrun, systems are often operated at service levels lower than those originally envisaged - typically at one third to half the frequency, as in Tyne and Wear - so errors in cost estimation have an impact on patronage as well. Another reason for the shortfall in patronage is that delays in the opening of a system might mean that when the target date for a forecast is reached, the system might still be fairly new and patronage might not yet have reached its full potential. In the case of newer systems such as Buffalo and Sacramento, the forecast target date had not even yet been reached.

However, Pickrell (1989) concluded that such effects do not account for the full differences between forecasts and actual experience. As far as capital costs are concerned, although all systems undergo some changes in construction from what was planned, these are mostly minor and are usually made with the objective of reducing cost, so they could not account for the errors. The overrun is mostly a product of many small changes in design or performance standards, none of them costly in themselves but cumulatively causing substantial delays to the programme which increase the overall cost.

As far as patronage forecasts are concerned, errors can be caused by inaccuracies in the basic demographic inputs to the models, for instance if population, employment and car ownership do not grow as expected. Pickrell concluded that such factors account for less than half the errors. The rest occurred because the quality of service in respect of frequencies, speeds and feeder buses is less than expected.

As far as operating costs are concerned, Pickrell found that projected savings are not always realised. Many rapid transit systems were justified on the grounds that the capital expenditure would be offset by savings in operating cost, but in many cases operating costs actually increased, because labour productivity was not as high as expected.

Most of the differences between forecasts and outturns must be put down to errors in forecasting itself. There is, perhaps, an understandable enthusiasm on the part of rapid transit proposers to expect that their new system will be more attractive to passengers, especially those who currently travel by car, than is realistic, and to underestimate the need for contingencies in cost estimation. Any forecasting procedure, whether for costs or patronage, will produce a range of estimates, and proposers may - consciously or not - be tempted to plump for the optimistic end of the range in every case. This is especially likely to happen if it makes approval for funding more likely, as in the case of the US systems where grant approval is based on the forecasts of additional passengers, with apparently no penalty for over-optimistic forecasting.

6. DISCUSSION - HOW CAN FORECASTS BE IMPROVED?

6.1 THE IMPORTANCE OF ACCURATE FORECASTING

Errors in forecasting are important. If patronage is lower than was forecast when the scheme was approved, the benefits to be obtained from the system are also likely to be low. Escalation in capital costs increases the financial burden on the funding agencies, resulting in the postponement or cancellation of other projects, or in an increase in loan repayments to be repaid from revenues. Higher-than-expected operating costs can increase the requirement for subsidies or require cuts in other services to keep within a budget.

Perhaps most worryingly, if the difference between the project's forecast and actual cost-effectiveness exceeds the margin by which the chosen alternative was preferred to other projects, the planning process may not have led to the most desirable solution. Even though all the alternatives were probably subject to similar errors, underestimates of capital costs will result in a bias towards high-capital projects whose benefits are only realised at high passenger volumes.

6.2 MAKING MORE REALISTIC FORECASTS

In the past, proposals for rapid transit systems have tended to concentrate on the technical aspects, with perhaps less emphasis on the financial and operational aspects, which includes making patronage forecasts. A study of the methods of financing transport operations in France (CETUR 1989) found that this can happen when the impetus behind a rapid transit system comes from technical people who may not have expertise of the financial world or of operating a transport system.

The CETUR study noted that several recent French projects have ben proposed by a tripartite consortium of engineer, financier and operator. This process began with collaboration over the Channel Tunnel, and has continued in various other transport projects, including rapid transit systems such as that being constructed in Toulouse. There can be some confidence that forecasts of capital and operating costs of a rapid transit system might become more realistic when all parties involved in the design, construction, funding and operation of the system are involved from the start.

6.3 IMPROVING TECHNICAL ACCURACY

Among other reasons for inaccuracies in forecasting, Pickrell's study (1989) concluded that the structure of forecasting models, their application and interpretation could be at fault, and identified a number of ways in which the technical accuracy of forecasts could be improved. These included using a nearer horizon year which would help to avoid errors in the demographic inputs to a model becoming too large. It was also considered important to use a forecasting procedure that enabled the influence of individual factors to be examined separately, in order to identify likely sources of errors, and to carry out sensitivity analyses.

It is also important to check the reasonableness of forecasts of construction and operating costs and of patronage by comparing them to what happened in previous projects. While no two systems are directly comparable, it should be possible to compare a proposed system with one in a similar area, and to require any significant differences to be justified. The use of cost parameters such as cost per km of track, per vehicle, per station etc based on data from existing systems could be of assistance in this area as a means of estimating a range of probable costs.

Pickrell recommended another potentially effective strategy, namely to subject the forecasts and the model assumptions to review and verification by independent experts. This would offer the potential for bringing valuable judgement and experience to bear on selecting and implementing a worthwhile project.

6.4 IMPROVING PATRONAGE MODELS

Forecasts of patronage on a new rapid transit system are traditionally made using a standard transportation model. Such models were originally designed for forecasting highway traffic, and have been reasonably successful in that aim. Difficulties arise, however, when using a model to predict patronage on a public transport mode, because it is necessary to model the mechanism by which passengers choose between public transport and car. Car travel has many attractive features which are not amenable to modelling, such as comfort, ability to listen to the radio or to choose one's company, availability at the destination, and so on, as well as being costed in a different way. These features are not so important when one car journey is being compared with another, as in highway modelling, but become fundamental when the choice is between car and bus.

The problem becomes even more acute when a third mode, rapid transit, is considered, because this has characteristics which are different from both car and bus. It is a well established, if unexplained, phenomenon that rapid transit is seen by the passenger as a different form of public transport to bus; it attracts a different type of passenger, particularly former car drivers. Estimating this diversion of travellers from car is fundamental to the success of forecasting rapid transit patronage.

The typical procedure would be to set up a model of a city based on its existing modes, that is car, bus and perhaps heavy rail, and then to insert a rapid transit mode. Depending on the form of model, it may be necessary to identify the rapid transit mode as either a "fast bus" or a "slow train". Neither is entirely satisfactory. What is really needed is to insert rapid transit as a separate mode, but in the traditional model this requires the definition of separate modal constants.

This therefore points to the need for continuing research in the area of forecasting patronage on rapid transit systems. Two types of technique are used in an investigation of this kind. One is Stated Preference (SP), a survey and modelling technique designed to present respondents with a range of realistic choices between real or hypothetical products - in this case transport modes. Respondents are asked to express preferences or make selections, often, for statistical accuracy, between several similar pairs presented in slightly differing ways . By analyzing these choices, the importance of the various characteristics (frequencies, fares, quality of service, etc) of the modes on offer can be ascertained. These results can then be used to forecast consumer behaviour when a new mode is introduced.

The second technique - often contrastingly referred to as Revealed Preference - is to draw on experience of systems which have opened in recent years where before and after data may be available. Extensive studies were made when the Tyne and Wear Metro and the refurbished Glasgow underground opened in Britain, and of the BART system in San Francisco. Some studies have been made in the French cities, and a comprehensive before and after study of the Manchester Metrolink is under way. Some recent modelling work in this country has been based on experience of new transport links in the Netherlands. Data from these studies should provide some valuable information about the effects of a real rapid transit system, especially of its effects on car travellers, against which to set the modelling results.

6.5 LIVING WITH UNCERTAINTY

One way of allowing for uncertainties in capital costs would be to include a generous contingency allowance in all costing schemes. Although cost estimates do normally include such an allowance, it is clear that in most cases it is inadequate. Previous projects should be examined in order to estimate what escalation in cost might typically be expected, and a contingency allowance to cover unforeseen developments should be included in the budget for a project.

Whatever improvements are made to procedures for forecasting costs and patronage, it is unlikely that errors will ever be eliminated completely. It is therefore best to acknowledge that uncertainties are unavoidable and to plan accordingly. One way of doing this would be to carry out sensitivity analyses and present all forecasts as a likely range of estimates. This would give decision makers more information and make it clear, either that a particular project is clearly the most cost-effective alternative even taking account of the uncertainties surrounding the estimates, or that no clear-cut preferred option exists and decision makers must choose on the basis of other, unquantifiable, criteria. This would be a more honest, if less satisfactory, presentation of the case.

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