The London Transportation Study: methods and techniques

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Mr J. O. Tresidder

At the end of phase 2 of the London Traffic Survey we were left with a situation where it had been demonstrated that the predicted demand for travel was substantially in excess of the physical facilities which would be provided by an extensive system of urban motorways. A method was therefore needed to equate the predicted demand for travel to any system put forward for examination. We have developed a method for dealing with an overload on the system which will reflect the results of applying methods of control other than that in which congestion is allowed to control the system. Other methods of control than those chosen could also be simulated.

114. It is only relatively recently in Britain and abroad that more attention has been paid to public transport; nevertheless the London Transportation Study enabled us to make much progress in this field. We developed computer programs to enable us to take account of the various elements which go to make up a public transport journey; by means of these we can now examine specific parts of the system and represent many of the factors which help to determine choice of route.

115. In the London Transportation Study, essentially a strategic study, there is little need, though it may be desirable, to apply public transport techniques beyond the point which establishes the general level of movement by public transport. Fig. 2 compares the percentage of travel by public transport with the time which it takes to go by public transport and the time taken by private transport. It will be seen that where the journey time is equal by both methods, 93% will travel to work by public transport, so that when we talk of the improvement of access to the central area we are talking about the last 7%. If we double the time by public transport compared with private transport, 70% will go to the centre by public transport. In other words, the system is not very sensitive to very large changes in the time taken between the two methods of travel.

116. We found that the rates of economic benefit derived from the public transport element in the study were smaller than for the roads for two reasons. One is that we had the opportunity only to compare two possible plans and not to make a comparison with the situation as it is at the present time. Secondly, the rate of return on public transport investment does not make any allowance for the improved comfort of passengers applied to the public transport systems which we tested. This element of comfort is important. With the further development of our techniques, some quantification of this aspect could be derived. Although the rates of return on investment in motorways have been found to be generally higher than those in public transport, I should like to make it clear that the comparative rates of return on the overall investment do not mean that particular investments in individual parts of the public transport system would not have very much higher rates of return.

Mr J. E. Burrell

Perhaps the best way of seeing in perspective the mathematical model used in the study is to compare it with previous models, such as that used in phase 2 of the London Traffic Survey. I think there are three main ways in which the model can be regarded as having advanced the evolution of transportation planning.

118. Firstly, it is more comprehensive than earlier models, in the sense that it includes more of the relationships that occur in the real world. For example, the relationship between speed and flow of traffic was considered, as was the relationship between the total capacity of the network and the number of people able to use it. Secondly, it is more behavioural than many earlier models. In particular, choice of mode was dependent on the relative travel times of the modes for the journey being considered, rather than simply household parameters such as car ownership. Thirdly, it was concerned with policy questions as well as the provision of transport networks. Thus the results included an estimate of the level of restraint that would be needed for a given network in different parts of London.

119. No doubt many weaknesses remain in the model: for example, there is no differentiation between peak and off-peak conditions, there are problems of speed-flow relationships, there is the lack of explicit assumptions about the type of traffic restraint being applied. In spite of all these difficulties, the model produced results which seemed sensible and realistic. However, I think it is fair to say that no-one is more fully conscious of these limitations of the model than are the people who have devised and used it.

Mr T. Powell

I want to make three points about the potential use of the results of the economic evaluation process.

121. First, the results are entirely dependent upon the assumptions on which they are based: not only assumptions in the final economic analysis, but equally important assumptions made at the traffic forecasting stage. Of these, the crucial one is the decision to regulate the use of the networks by legislative or fiscal controls rather than by the inherently more wasteful method of control by natural congestion. If this assumption had not been made, the return on the larger road plans would have been very much greater. This is an example of the obvious fact that the more efficiently one learns to use one's existing assets, the less need there is to replace them by new assets.

122. The second point that must be stressed is that the rate of return leaves out many important factors such as comfort, convenience, noise, and visual intrusion, which may be crucial to the final decision. This is largely because we cannot adequately measure such factors and also because we do not know how to turn such measures into the pseudo-monetary values used for cost-benefit analysis. Even our present analysis is really mixing apples with plums and calling the result fruit: to mix plums with potatoes and call the resultant mixture food would be even less helpful.

123. The last point that should be made is that even if we could quantify all the unquantifiables to obtain a pure absolute rate of return, we still do not know how high a pure rate of return has to be before it is high enough. In other words we do not know what the true opportunity cost of capital really is.

124. In this case one might well ask what is the point of going through all this process. The major advantage is that it compares like with like. The crucial question is how unlike can like things be. Obviously it would be very useful to compare the results of this process in London with the results of a similar process applied in Birmingham, Manchester, Glasgow and Liverpool. Equally the process would prove very useful in comparing the returns of alternative road plans in a given town. It would also prove useful, although not by any means decisive, to compare the apparent returns on urban or rural transport, and certain facets of the return on private and public transport. It is not very useful in comparing the returns on roads as opposed to schools, houses, factories, pubs, or whatever else the community needs.

125. At the moment we have a potentially useful tool to compare like alternatives, one set of results, and nothing elsewhere to compare them with.

Mr D. A. Meyers

One of the subjects discussed in the Paper is the costing of alternative schemes. In the case of the two public transport plans tested, many of the additions to the 1962 system were common and it was only necessary for the purpose of the economic evaluation to consider the difference in cost between the two plans. The difference in capital costs amounted to about £175 million, of which over £150 million were due to the tunnels and ramps for the main line cross-links between Paddington and Liverpool Street, and between Victoria and London Bridge shown in Fig. 7. Together these links involved just over 13 miles of tunnels plus an additional two miles of ramp.

127. Special reference should perhaps be made to the motorway routes within the box, where much of the construction would have to be below ground level. Routes of dual three-lane and dual four-lane capacity were contemplated, and it was necessary to consider the possibility of multiple tunnels or ultra-large tunnels. It was of course evident that problems would be encountered in profusion in the central area and that the costs of such routes would be very high. Consequently, it was decided that the routes would be limited to dual two-lane construction. The average rate shown for bored tunnel for plan 3 routes, £5.344 million/lane mile, applies to tunnels which were generally under the Thames, so that compressed air working was allowed for. A somewhat lower average rate, just under £4 million/lane mile, applied to the bored tunnels within the box, where compressed air working was assumed to be largely unnecessary.

Dr T. M. Ridley, Dept of Highways and Transportation, GLC

The Paper is a discussion of methods and techniques. Some results of the study are given, but it is important to emphasize that the results contained in it are not the Consultants' or the Client's forecasts of what will happen in 1981. What will happen will depend on a number of policy and investment decisions made between now and then. What has been examined is a range of transport alternatives with assumptions about changes in population, employment, income, etc.

129. Now that the methods have been developed more specific and firmer plans are already being examined. The data from the study are being used for the design of specific parts of our transport system and the results are being used in the formulation of the GLC transport policy. The results do not make the policy however; the results of the study can only be a guide to policy formulation.

130. Conclusions of importance can already be drawn from the London Transportation Study, though the views which I express must be personal since the final report has not yet been produced by the Consultants. Given certain assumptions about future population, employment and income growth in London, even with a much higher expenditure on roads than is the Council's present intention, it will not be possible to meet in full the potential demand for movement by road. Secondly, whatever investment is made in the road network it will be necessary to exercise control over road movement. Thirdly, opportunities for the improvement of public transport by major new links in the network are limited in number, and most benefits are likely to result from improvements to the existing system.

131. With the same assumptions, and given the present intended road investment system, as well as investment to speed up and increase the reliability of rail travel, it is not likely that the number of people using public transport in the London area will fall substantially, which is at variance with the results of phase 2 of the London Traffic Survey. Because of the very rapidly increasing car ownership, there will be very much more movement by road, but the individual car owner may not have the same freedom to use his car as the present smaller number of car owners have. This faces all of us, whether we are professionals, politicians or public, with a very important choice: either we must spend substantial sums of money or we must face a

degree of control over our use of the motor vehicle which we have not yet begun to contemplate.

132. At the end of the Paper the Authors kindly acknowledge the contribution and considerable help received from a large number of bodies during the course of the study. This has been one of the most important side benefits. When the study was first mooted, in 1961, a number of authorities had responsibility for transport in London. Through working together, many people of very different backgrounds have come to have sympathy for each other's planning problems. Within the Department of Highways and Transportation of the Greater London Council the work will be continued, in conjunction with our colleagues from London Transport and British Railways. The co-operation which took place in the study has now given us the opportunity to carry out the type of close co-operation envisaged in the recent White Paper *Transport in London*.

Mr E. R. Ellen, Planning Officer, London Transport

It will not, I think, come as any surprise to the Authors if my comments on their most interesting Paper are made very much from the point of view of the public transport operator.

134. Road plan 3, as tested in the study, is an urban motorway network of greater capacity than the road plan published by the Greater London Council for completion by about 1983; yet the Authors tell us that, with road plan 3, the potential private car demand in 1981 will need to be restrained, by parking controls or otherwise, to keep traffic volumes within maximum road capacity. It seems to me, therefore, that improvements in public transport are essential if car owners are to accept it as a satisfactory alternative to their own cars for a significant number of journeys.

135. Indeed, Table 5 shows that in 1981, even after major motorway construction, there will be a small overall increase in peak-hour journeys by public transport compared with 1962. Road plan 3 provides no road space for any significant increase in car commuting to the centre. This makes sense, because to do so would be to destroy the environment of Inner London. It follows that the majority of the commuters to the West End and City will continue to travel by train, as 75% do at present. In future, London's surface and underground railways must be developed to cater more adequately than they do today for this movement, which is vital to the business life of the capital. It is public transport, even after road plan 3, which will do the great bulk of work in moving people to and from Central London.

136. There is nothing in this Paper to indicate that the improvements in public transport should be produced only by speeding up and improved interchange, rather than by the provision of new facilities. The Authors have referred to the tests of improved public transport networks and say that the results of the economic evaluation of these must be treated with considerable caution, because the question arises of making allowance for changes in factors such as comfort and convenience. I agree. The Authors also draw attention to the exclusion from the analysis, for both road and public transport plans, of factors such as noise and other effects on environmental planning. They are right to raise this point, which seems particularly relevant to any comparison of the benefits of investment in road construction as against underground railway development. No form of transportation infrastructure could intrude on the environment more than an urban motorway; none less than an underground railway.

137. I am afraid that it is on economic evaluation that I have my greatest quarrel with the Paper. The Authors have been careful to set out the shortcomings of their economic analysis, but in their Paper they quote in §§ 95 and 97 a 'rate of return' on the extra investment in road plan 3 over road plan 1 of the order of either 10% or 20%, dependent on whether it would be practicable to restrain traffic volumes under plan 1. In § 34 they explain, however, that these figures mean that the value of the benefits occurring in one year, after construction is completed, amounts to 10% or

20% of the initial capital cost. It seems to me that to call this a 'rate of return' is to assume that the whole cost of constructing the network has been paid, the network built and the benefits obtained, all in one moment of time; or, to put it in another way, the capital is all provided interest-free, both during construction and thereafter.

138. This is of particular interest, because this concept is so different from the criteria laid down by the Government for investment by nationalized industries, including public transport. There it has to be shown that the expected benefits over the life of the proposed railway after construction, discounted back to present values at 8% per year, exceed the present value of the capital and working costs; again discounted back at 8% per year in relation to the dates at which expenditure will actually be incurred. This can make a very great difference to the rate of return. If in the case of road plan 3 allowance were to be made in this way for the time-lag between spending the money and obtaining the benefits, the 'rate of return' would look very different. The requirements which I have mentioned in respect of public transport investment are derived from a Government White Paper.³ It is of interest that in the recent report of a British Road Federation study on road finance and administration it is suggested in § 107 that the investment programme of a suggested National Roads Authority should be subject to control in the way laid down in the White Paper to which I have referred.

139. The Authors state that traffic flows on the base roads giving direct access to the motorway system may cause considerable problems in some instances. London Transport are particularly concerned about possible traffic conditions on the ordinary roads used by buses in the vicinity of motorway access points. How will buses or any other vehicles move in, for example, Finchley Road or Peckham High Street when the motorway box traffic descends upon such already congested streets? Until the implications of this problem of motorway access at points throughout the study area have been assessed it seems premature to put any figures at all on the value of the motorway plans in themselves.

140. In conclusion, I should like to say a word about Transitnet, the interesting new computer program developed in the study to assign public transport journeys to routes in relation to journey time, with allowance for such factors as service frequency, walking time and waiting time. In dealing with the road traffic assignment process, the Authors hint that there might be a need for a more sophisticated assumption than that people go by the quickest route available irrespective of journey length and other considerations. This is certainly true in the case of public transport. Examination of travel behaviour on the existing London Underground railway system shows that a proportional assignment is necessary, splitting the passenger traffic between alternative routes in relation to the difference in journey time by each alternative. In addition, a penalty needs to be included in the calculations to represent the nuisance value of any interchange between one vehicle and another, over and above the actual time taken to make the change.

141. The Authors have emphasized that Transitnet is a new type of computer program. I think that consideration needs to be given to the points which I have mentioned and to certain other features if a satisfactory model is to be produced for practical application in planning public transport developments in London.

Mr P. T. McIntosh, Assistant Divisional Engineer, Networks, GLC

I wish to touch briefly on two of the main areas of the results given in the Paper:

- (a) the total movement and ease of movement likely to be found in the 1980s
- (b) the value for money from the investment.

In both cases I will compare the situation with respect to the alternative plans described in the Paper with the more likely real situation which will appertain, particularly that relating to the motorway plans published by the GLC.

143. A forecast based on planning and income assumptions suggests an increase of household real income of some 80% from the early 1960s to the early 1980s, and an increase in car ownership from about 35–40% of households to some 70%. The increase in car-owning households will be from round about 1 million to about 2 million.

144. Faced with such a large growth, some aggravation of the problems on the road is inevitable. Let us consider first the central road plan in Fig. 5, plan 3, in conjunction with the public transport plan C2/B in Fig. 7. In view of the growth of demand for travel compared with the provision for it, this will clearly entail some dampening of demand, but we think that this will be mainly at peak periods, and at peak periods future car owners may be able to make perhaps 5% fewer trips per car than the average in recent years. This, of course, represents a great increase in total trips due to the increase in the number of cars owned.

145. The GLC have published plans for a primary road network costing about half the plan 3 network. This will entail substantially greater restriction, which possibly at peak times will amount to 20%. On the public transport side the peak demand may show a 5% increase. We conclude, therefore, that in the early 1980s the part of public transport will be of the same order as today and the use of cars will be greatly increased, but that movement by individual car users may be more difficult at peak periods than at the present day.

146. It has been suggested that the 10–20% quoted in the Paper for the return of plan 3 over plan 1 is not adequate when considering the return which the nationalized industries are required to make. In the early years the return will be lower than the 10% quoted in the Paper, but the demand and incomes will grow beyond the study year and the return on a particular investment will increase rapidly. Comparing plans 1 and 3, the 10–20% return depends on the measure of control which it is possible to operate. The London roads objective, published by the GLC, is smaller than plan 3 and it would seem likely that its rate of return will be of the same order as, or possibly greater than, the return of plan 3 over plan 1.

Mr G. Lamb, Senior Research Officer, GLC

The transportation planning model developed in the London Transportation Study is a complex and on the whole flexible implement for the comprehensive analysis of alternative land use plans and networks, capable of providing the necessary data on which to base policy decisions. Some problems, however, still remain.

148. First, with regard to trip-end estimation, the use of category analysis rather than regression equations for the calculation of generations based on 'home-end' parameters seems to be an improvement, getting round the problems of the discrete interdependent variables which are used for home-end forecasting. Attractions are generally related to employment, which, when broken down by type, can reasonably be considered as a continuous independent variable more suited to regression analysis.

149. In addition, generations reflect increasing income and car ownership; attractions do not, and at the design year there will be considerably greater changes in generations than in attractions, which means that the latter will have to be factored to control totals, which could well introduce bias into the results. Also, the breakdown between car-owning and non-car-owning attractions has to be made, since this occurs automatically with category analysis. Both these problems reflect lack of information which could have been obtained only at considerably increased expense, unless information from income tax returns could be made available. Even so, there would still be difficulties, particularly at the lower end of the income scale.

150. The basic assumption in this form of trip-end analysis is that for a given category future trips will be the same as at present, independent of the type of employment in the households moving into or out of the category. This assumption is inevitable unless more information is available to enable distributions by type of employment to be made, and this would produce many more problems. The effect

would be shown in journeys for business purposes and perhaps non-home-based journeys, which are possibly overestimated. The growth in these two types is likely to be over 2 million between 1962 and 1981. It is also likely that patterns of social movement will be distorted.

151. The whole problem of making forecasts of the necessary planning data needs emphasis. Category analysis for LTS internal journeys requires 15 066 separate forecasts at a district level or 80 919 at a zonal level. The problem of the quantification of all these data must be faced, and until successful land use models are operational, quantifying even existing trends is at best only approximate. Doing the same with major divergences from these trends is even more hazardous. At the moment the relative sophistication and complexity of the transportation planning process is out of balance with the sophistication of its inputs, and the answer must be a major effort in producing urban models, not a holding back of transportation planning.

152. Secondly, I would mention speed/flow relationships. Phase 2 of the London Transportation Study attempted to relate congestion to trip-end calculation by making the modal split calculations part of the category analysis. This failed to take adequate account of congestion, and phase 3 introduced a series of internal iterative loops, independent of trip-end calculation, and one final one which linked back via the restraint procedures to trip ends. Distribution takes place on the internal loops, but not on the final one, perhaps illogically. The whole process is expensive—the model costs between £1200 and £1500 in computer time for one complete run—and it is not clear what the resulting trip-making patterns mean in terms of the basic household relationships originally assumed. There is scope for research here in formulating more logically these relationships and making the land-use-trip-end-congestion interdependencies more easily handleable.

153. Further, capacities, flows and restraint are calculated on a 24 h basis, and all raise serious problems of interpretation of overloading and the restraint itself. Does 10% restraint on a 24 h figure imply that this is all in the peak hours or part peak and part off-peak, the latter being difficult to justify? The implications are important, particularly in the economic evaluation, and must be carefully assessed.

154. Thirdly, with regard to the modal split calculations, the technique adopted here has been to use travel time ratios as the determinant and aggregated data are shown in Fig. 2. Unfortunately, when broken down to attraction sectors the data showed much greater variability. Just how behavioural these are is open to question, but what is certain is that the situation in London is extremely complex. Some detailed analysis of modal choice carried out in the past 18 months showed that, in trying to explain why people with a car available should choose either the car or a public transport mode for the journey to work, time and cost differences between the two alternatives accounted for less than 15% of the variation in making journeys to the central area and less than 20% for non-central-area destinations. The problem here is and remains the development of a relatively simple method which is behavioural and does not require uneconomic quantities of data.

155. Transportation planning in Britain is now on a much sounder basis than it was six or seven years ago and our understanding of the problems and motivations of travel in urban areas is much broader. The greater part of the credit for this great improvement and for highlighting remaining problems must go to the Authors and their predecessors on the LTS. The brief of the Research Group is to try further to improve the techniques which we have inherited and at the same time to use the techniques which are available, which are still those described in the Paper, to provide evidence on which the Council can base its policy decisions. This is a continuing process and whilst problems remain, at least there is now a procedure which will throw some light on the alternatives available.

Mr Robin Stelfox, Department of Highways and Transportation, GLC

As one of the sources of information mentioned by the Authors, I should like to

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enlarge on the methods used by the Department of Highways and Transportation in arriving at the costs for the construction of the network of roads under consideration.

157. When it was agreed that the GLC would carry out these estimates, the Valuation and Estates Departments dealt with the property costs and it was my province to deal with the construction costs. To this end the design section produced typical layouts of elevated and sunken motorways to 105 and 130 ft bond widths, from which we took off quantities and prepared short bills of quantities. These were then priced, all to about the same degree of accuracy as that required by the Ministry of Transport for submitting a scheme for grant application.

158. On the elevated designs an allowance was made for piling to the foundations on the basis that 50% of all such structures in the Greater London area would require piling. For sunken roads we had two basic costs, one assuming that the sides of the excavation had to be retained during construction owing to the proximity of existing buildings, and one assuming that the working space allowed for the construction of the works in battered-sided excavation, which could be back-filled on completion.

159. In addition, further work-ups were carried out on typical road works to the two standard widths (a) basically at ground level, assuming no more than about 5–6 ft of relatively balanced cut and fill; (b) still relatively balanced cut and fill, but to depths and heights of about 20 ft for the urban and outer areas. Finally, the cost of elevated sections of motorway on retained fill, as opposed to structures was calculated.

160. As the work progressed, other forms of construction were met with, such as cut-and-cover sections of tunnel for which we had excellent cost records from the Hyde Park Underpass; bored tunnels, for which we could look to the Blackwall Tunnel; and various types of bridge over and under existing roads and railways. If these could not be duplicated in the Department's own records, colleagues throughout the country were able to supply relevant details. These bridges were up to and including long-span bridges suitable for Thames crossings. The only type of construction for which no access to personal records could be obtained was a sunken tube tunnel, but the Design Section did an exercise for the Thames crossing at Woolwich, for which a bill of quantities and estimate were produced, and this, coupled with research on several such projects being built elsewhere at present, enabled an estimate to be made with reasonable confidence.

161. From these work-ups and records a set of prices, all based on areas of completed works, was evolved and applied throughout to the plans supplied by the Consultants. Throughout the full range of estimates for all the works, each separate length of motorway between nodes has been itemized and every bridge or structure has also been abstracted and costed individually, as were all the accommodation roads brought about by realignment. Equally, every road has been priced individually along with all its structures, main and slip roads, so that there is a complete and full build-up for all the estimates.

162. In the first operation of costing phase 3 of the LTS there were 39 sections, mostly drawn to 2500 scale and covering some 350 miles of road, ranging from the outer D ring inwards to, and including, the motorway box. This total amounted to some £1200 million. We also considered a network of roads within the box, covered by a further nine sections for about 80 miles, costing about £750 million. The total time taken to evaluate these 48 sections, costing £2000 million, was roughly from June 1966 to May 1967, and, including all the work-ups and research, it represented a little over three man-years of work by my section.

163. As a result of this, a library and a method of work has been established which makes it possible to estimate very quickly for any major scheme in the early planning stages, and where these estimates have been checked, either against outside opinion or the cost of works actually under construction, the accuracy of the LTS type of estimate has been quite remarkable. As examples, the estimate of the alternative Woolwich crossings at Thamesmeade, a tunnel and a bridge, agreed very closely with the findings of the independent consultants, who were appointed to report

to the Council on the respective costs, while the check on such large contracts as the Western Avenue Extension at over £15 million, Blackwall Tunnel Southern Approach at over £4 million, and Wandsworth Bridge Southern Approach at over £2 million, produced accuracies within 5% of the tender figures.

Mr J. M. Thomson, London School of Economics

I should like to congratulate the Authors on producing an important paper which, for the first time, attempts to introduce economic factors realistically into the assessment of a major urban roads plan. They have made a pioneering effort to tackle some difficult problems, which are very like those I have met on a similar study in another city.

165. It is therefore in a sympathetic rather than a critical spirit that I venture to point out some weaknesses in the Paper. My main point concerns what they call 'taxation benefit'. You will have seen that one-third of the total benefit from plan 3 (when compared with plan 1) comes from taxation benefit. Some people may have thought it strange that the loss of restraint tax occurring under plan 3 was not counted as a loss, whereas the gain of fuel tax was counted as a gain. But in principle this is right. The theory is that the reduced tax revenue from 'existing' road users does not represent any change in the use of resources and is therefore a pure transfer payment; hence it is not relevant to the assessment of real costs. The additional fuel tax, however, comes from new road users and represents a disparity between the money paid by these road users and the value of resources used on their behalf. If, in the alternative situation (which is plan 1), this money were spent on other forms of consumption for which there was no disparity between price and the value of resources used, then there would be a saving in resources equal to the amount of the tax.

166. So we must ask ourselves what forms of consumption would in fact be sacrificed in favour of extra road travel. If it were the consumption of whisky and tobacco there would be a transfer from two highly taxed products to another and there might be no saving in resources. If it were from the consumption of food, clothing and furniture, the price of which is more or less equal to the value of resources employed in their production, then there would undoubtedly be a saving in resources and hence a taxation benefit.

167. What sort of expenditure, then, is likely to be reduced in order to make possible the expenditure on additional road travel? This will depend on how the Government recovers its tax loss. The Authors understandably make no assumptions about this crucial point but they do assume that the effect will be an equal proportionate reduction in all other forms of consumption. This seems most unlikely. No matter how the Government decided to increase taxation, the impact would be mostly on luxury, and hence highly taxed, goods. So the shift in consumption would be largely from one group of highly taxed products to another.

168. It follows that the 'taxation benefit' could be small or even negative. It could be a taxation loss. Deeper investigation is necessary before one can accept the large item of taxation benefit, which pushes the rate of return up from 6½% to 10%.

169. My second point concerns the speed, and hence the cost, of traffic using the old road network, called the base network by the Authors. Near the beginning of the Paper they assume that speeds would not fall below the existing level on the base network, because they consider that this level is the minimum that motorists would tolerate. In other words the volume of traffic would not increase on these roads because motorists would not find it worthwhile to travel in the ensuing conditions of congestion. But later in the Paper, when the Authors find their motorways also suffering from congestion, they transfer some of the traffic to the base network, thus, as I understand it, raising the volume of traffic on those roads above the assumed maximum. They do not appear to have allowed for the consequent increase in congestion costs to the traffic.

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170. Finally, could I ask the Authors if they have evaluated the inner ring, i.e. the motorway box, separately from the rest of the system? Even if the rate of return on plan 3 (over plan 1) is as high as 10%, this is only just an acceptable rate. Since some parts of the plan are bound to give a better return than others, one urgently needs to know which parts give a lower, and hence unacceptable, return. The Authors have stressed the enormous cost of the motorway box relative to the C ring and the outer radials. They have not given any reasons to suggest that the benefits from the box would be proportionately high. One suspects, therefore, that the return on the box would be below average, and the return on the C ring above average. Have the Authors investigated this? If so, what is the rate of return on the motorway box? I fear that when my above points are taken into account the return on the box could be as low as 2% or 3%.

Mr N. Borg, City of Birmingham

One essential element in a study of this kind is the correctness of the parameters chosen in the first place, and great time and effort must be put into this. The question which I want to ask the Authors is, are there any signs yet that their assumptions are measurably wrong, and have they drawn any conclusions from this? After what interval of time is it possible to check assumptions with the possibility of making any corrections, or once started is one committed to a programme which may be too large and therefore have a longer economic life?

172. It is not possible to draw lessons from the London area for application elsewhere in relation to behaviour characteristics. It is not possible for example to compare the congestion in London with that in Liverpool or Birmingham. We are really concerned, however, with the limits of accuracy in road design, and a difference of 1% in volume may affect the number of lanes to be provided. The steps in design are very coarse. Is it possible to do an evaluation using the 'run and jump' approach and evaluate parameters in their degrees of significance?

Written contributions

Mr G. J. Roth, International Bank for Reconstruction and Development

I am currently serving in the Projects Department of the World Bank, but the following comments represent my own views only.

174. The *economic* rates of return obtainable on the extra investment in plan 3 over plan 1, and in plan 9 over plan 3, are estimated (in § 95) to be about 10%. *Financial* rates of return (that is, rates of return that measure only profits to suppliers, and ignore benefits to users) of 10% are obtainable from many investments in Britain, and therefore a 10% *economic* rate of return may not be particularly attractive. However, about one-third of the 'benefits' appear to be due to tax payments which are usually excluded from cost-benefit calculations. Taxes are transfers from one set of people to another set and do not, in themselves, represent savings in the use of resources. If the tax transfers are excluded from the benefits, the economic rate of return falls to 6-7%, which suggests that neither plan 3 nor plan 9 is justified.

175. It is unfortunate that the Authors give no rate of return for plan 1. This omission might lead sceptics to the conclusion that there is no economic case for major road improvements in London. They would be mistaken. My own very rough calculations suggest that if road users were charged economic prices for the use of congested roads in London, they would produce a surplus available for investment of about £100 million a year, even at 1964 conditions and prices. This surplus is an indication of the magnitude of the investment for which road users would be prepared to pay.

176. It is disquieting that after six years and an expenditure approaching £1 million, neither the authorities nor their advisors are willing to commit themselves

to a rate of return on major road improvements in London. It would not be fair to blame the Consultants for this. Had the Ministry of Transport and the LCC, when they set up these studies in 1961/62, asked the right questions, it is probable that by now the right answers would have been forthcoming.

177. But what are the right questions? In a society in which most goods and services are distributed by means of the price mechanism, the first question to ask should have been: if road users in London were charged economic prices for the use of roads, how much would they *choose* to spend on increasing the capacity of the road system? The point here is not whether a public service should be 'nationalized' or not, but the extent to which the users of a service are enabled to influence the amount provided. By and large, the users of the gas, electricity, and telephone services are charged prices that reflect important costs, and to this extent the investment in capital facilities is influenced by public demand as expressed through the surpluses earned by these services.

178. In the case of urban roads, the users are not required to pay the costs of provision and are therefore in no position to influence the amount invested. Instead, the level of road provision is decided by officials on administrative grounds, and inevitably their decisions are based on arbitrary assumptions regarding acceptable speeds (§ 83), time valuation (§ 96) and other basic matters. This heavy reliance on arbitrary assumptions makes it difficult to justify much of the detailed work lavished on this study.

Mr J. D. Richards, Melbourne Metropolitan Transportation Study

Messrs Tresidder, Meyers, Burrell and Powell have presented a most interesting paper on an important project, and I would like to compliment them on it.

180. It is noted that the independent variable used to split the trips between private and public transport was the ratio of travel time by public transport to that by private transport. Perhaps the Authors might care to enlarge on the choice of a ratio rather than the travel time difference and to discuss any other variables which were considered and rejected, before selecting the ratio of travel times.

181. It seems to me that the traveller is more likely to consider the actual time (and/or money) saved by a course of action rather than the ratio of the times or costs. The longer journeys would mean greater differences of travel time at the same time ratio for the shorter journeys. It would seem desirable for the independent variable (travel time ratio) to be weighted in some way when splitting journeys of varying length between transport modes.

182. Generally throughout the Paper, the Authors have referred to public transport as if it were one system, but in § 92 reference is made to a diversion of trips within public transport. How was this diversion achieved? Was it before or during the assignment process and on what basis?

183. In Melbourne, Australia, the estimated splitting of trips between the public and private transport systems has been achieved using formulae based on a combination of travel cost differences and travel time differences and the placing of households in car ownership categories (nil, one car, and more than one car per household). The formulae successfully reproduced the base year traffic patterns and can be used to estimate the effects of changes in service speeds, frequencies, fares and costs.

Messrs Tresidder, Meyers, Burrell and Powell

We would like to thank all the contributors for the interesting and varied points they have raised.

185. **Dr Ridley** and **Mr McIntosh** have both made helpful comments as to the interpretation that should be placed on our analysis. We strongly agree with Dr Ridley that the results given in the Paper should not be treated as forecasts of what will inevitably happen in 1981 but only as forecasts of what would happen on the

basis of certain specified assumptions. The actual flows on transport links in 1981 will depend on a continued series of policy and investment decisions that cannot all be formulated so far in advance. However, it is clear, as Dr Ridley and Mr McIntosh have stated, that expenditure of very large sums of money on new road systems will not be sufficient to obviate the need for some regulation of the use of private transport, at least in the peak period. As Mr Ellen suggests, such regulation may prove much more acceptable if an adequate alternative public transport system is available.

186. Mr Lamb, Mr Richards and Mr Ellen have all raised questions about the mechanics of the various trip forecasting procedures used in the study. We certainly agree with Mr Lamb about the difficulties of determining the best balance between theoretical consistency, accurate forecasts and computational expense. In many ways this is the central problem of the transportation planning process. Any improvement in our understanding of either the principles on which trip making is based, or of the sensitivity of the mathematical models to various inputs, will always be welcome. Mr Lamb raises the problem of peak hour calculations. In the London Transportation Study all calculations refer to a 24 h period. This includes the percentage of traffic restrained. No calculations were made to allocate the restraint between peak and off-peak traffic. This could be important, especially in relation to the economic evaluation, and if time and expense had permitted we would have liked to investigate this matter further.

187. Mr Richards raises the question of whether the split between private and public transport should be made in terms of the ratio of travel times between the two modes, or the difference between the two modes. Although, as he suggests, the time difference might be expected to be of great importance, in fact the data indicated that behaviour depended mainly on the time ratio.

188. As regards Mr Richards's point about the diversion of trips between bus and rail, the method used was to code both these systems together into one public transport network. Trips were then assigned using the assumption that each trip uses its quickest possible route, and thus the loading in terms of trips/day is obtained for each link of the bus system and each link of the rail system.

189. Mr Ellen has suggested that there is a need for a proportional assignment technique for both public and private transport assignment. Such techniques are now being developed. We would also accept his point about the desirability of incorporating into the assignment procedure boarding penalties which represent the nuisance value of interchange. The Transitnet program has been designed with this in mind.

190. Mr Thomson, Mr Roth and Mr Ellen have all raised questions about the economic evaluation procedure. Mr Roth suggests that the 'taxation benefit' should be eliminated from the calculations on the grounds that the taxes are transfers from one set of people to another set and do not, in themselves, represent savings in the use of resources. It is perfectly true that any change in the taxation paid by existing road users does not represent any real benefit, but merely an extra cost to road users which generates an equal and opposite benefit to the Government. Nevertheless, for accounting purposes, so long as users are considered to suffer the cost of taxation, it is essential to assume that the Government receives a benefit from the revenue collected. However, the vast bulk of the extra taxation comes not from existing road users but from newly generated traffic. Here the taxation benefit does represent a real benefit. An extra trip is generated if, and only if, the cost to the user of making the trip is less than the potential benefit from travel. However, the cost to the user includes not only real costs, such as petrol, wear and tear, etc. and other personal costs such as time consumed, but also the transfer payment of taxation to the central Government. In these circumstances there is not only a benefit to the individual from extra travel but also a benefit to the Government from the extra taxation collected. To assess, as is common, the benefit from generated traffic as half the cost saving (net of taxation) is a substantial underestimate of the total community

benefit, because it ignores the fact that indirect taxation on travel has the distortive effect (common to all indirect taxes) of reducing the demand for travel below the economically efficient level.

191. Mr Thomson accepts this point (and, in fact, explains it very succinctly in his contribution). We agree with him that it is, in fact, necessary to take the argument a stage further and allow for the indirect taxation element in the alternative expenditure foregone to make possible the additional expenditure on road travel. We have taken a neutral position that there will be an equal proportionate reduction on all other forms of consumption. Mr Thomson suggests that, in fact, there will be some tendency for the alternative consumption given up to have above average rates of taxation, thus minimizing the taxation benefit. This is probably true and if anything, our taxation benefit is likely for this reason to be an over- rather than an underestimate. How great an overestimate is a matter of conjecture; we suspect that our neutral assumption on tax rates leads to only a slight overestimate of the taxation benefit. Mr Thomson's suggestion that, in fact, the taxation benefit could be small or even negative is possible, but we would suggest highly improbable. The argument can only be resolved by an investigation of changes in the pattern of consumption of all other goods in response to a change in the cost of private motoring.

192. Mr Thomson also suggests that we may have omitted to allow for increased congestion on the base network. This is not in fact so. It is true that at the end of the speed reduction process (see § 19) both the motorways and the existing street system were assumed to be equally overloaded, but when the final selective reduction of trips was completed (see §§ 25-27), the flows on both the motorway and the existing street system were in general reduced to about the level of their defined capacity.

193. Mr Ellen does not like the concept of an annual (1981) rate of return, preferring some form of time discounted calculation which allows for the time stream of costs and benefits. In the particular case of the London Transportation Study such a calculation would have been impossible, because we have not carried out enough tests on partially completed networks to determine the time stream of costs and benefits over, say, a 30 year period. Even if it had been possible it must be remembered that the aim of the evaluation process was to compare alternative transportation plans as a guide to future transport investment policy. The simple annual benefit : capital cost ratio does this adequately by showing in a given year what the return on the capital invested in that system would be. If the return on the system is high in relation to the expected opportunity cost of capital, there is a strong case for planning to reach that type of network by the specified date. If in contrast the return were low in relation to the opportunity cost of capital, this is an indication that either the system contains some unwanted or unnecessary elements or else that it is too large to be appropriate to the year being considered. The simple annual benefit : capital cost ratio is thus a useful guide to the type and size of network that should be planned for the study area. It is not intended to be used as the basis for total commitment to one rigorously defined plan but rather as a strategic evaluation of that type of plan. Each individual element of that plan would then be subject to a detailed investment appraisal and modification before authorization of that stage of construction of the plan were implemented. At this stage of detailed appraisal of parts of plans, time discounted cost and benefit calculations are of much greater importance. The specific magic number of 8% return laid down by the Government appears to be only an arbitrarily determined rationing device which may or may not equate with the true opportunity cost of capital.

194. Mr Thomson, Mr Roth and Mr McIntosh appear willing to use the concept of an annual rate of return and would like to know what the return on parts of the plans would have been. Both Mr McIntosh and Mr Roth have suggested that the return on plans smaller than plan 3 might be greater than that given for plan 3 (as compared with plan 1). Whilst it is natural to think in terms of decreasing returns

to scale from extra investment, limited tests carried out as part of the study suggest that, in fact, the complementary nature of the various road proposals in plan 3 is greater than the competitive nature. In other words, the return on the whole system may be greater than the return on any parts of the system considered in isolation. This could mean, in answer to Mr Thomson's question, that the return on either the motorway box or a system containing the C ring plus the outer radials, could, if considered in isolation, be less than 10%. The returns on such individual elements of the plan 3 network have not, however, been tested. We would not agree with Mr Roth that the return on plan 1 should have been tested. In our view, plan 1 represented a minimum cost solution to London's transport problems against which other more expensive schemes should be judged. It is, however, unfortunate that it was not possible to test a plan midway in size between plan 1 and plan 3. This might have answered some of the points Mr Thomson has raised about the merits of different parts of the plan 3 network.

195. **Mr Stelfox** mentioned the extensive amount of work which went into the estimation of the costs of constructing the road networks under consideration. Whilst this exercise was an essential element of the whole study, we are sure that it has also proved extremely valuable in its own right. A wealth of information has been obtained on the likely cost of alternative forms of road construction in different types of areas. This information will, we are sure, prove invaluable for many years to come.

196. **Mr Borg** has asked whether there are yet any signs that our predictions are measurably wrong. The brief answer would be no. Since the start of the London Transportation Study in 1962 there has been some re-thinking of the likely future growth of population and employment in London (particularly in the light of the 1966 census results), but the differences between forecasts made five years ago about the likely level of activity in London and forecasts made today are not great and would certainly not affect the general conclusions of the study. It is also possible that present-day forecasts of the rate of growth of national wealth are a little more pessimistic than they once were. Again, this does not materially affect the general conclusions of our analysis.

197. It is sometimes alleged that because, according to certain statistics, the *usage* of roads in certain areas has not increased as fast as we predicted that the *demand* for travel in those areas would increase, our forecasts are wrong. This is to miss the essential point of phase 2 of the London Transportation Study: that it is a demand predictor, not a usage predictor. Obviously if roads are not provided to carry the traffic, or regulations are altered to prevent traffic parking where it wants to park, the actual usage of the road system will be less than the demand initially predicted as wanting to use a rather better road system.

198. Mr Borg has also raised the question of when the results of transportation studies should be checked. We think that transportation studies should be continually monitored. New facts and policies about population growth, income distribution and future land use characteristics are continually appearing. Whilst changes in any one factor taken in isolation are unlikely to affect the broad conclusions of the study, it is just such changes which could affect the number of lanes to be provided on a particular length of motorway or the priority between different parts of the overall plan. The importance of such factors is likely to be much better appreciated if a small team is continuously employed using and updating the study results than if every five or ten years there is a sudden decision to take the study out of mothballs for a full-scale revision. At all events, whatever the specific procedure, an opportunity should be taken at least every five years to review the study in the light of census results.

199. Just as important as the updating, however, is the continuous work of refining the broad strategy developed by the transportation study into detailed

proposals. At every stage in the course of this, specific alterations in the design of the transport system are called for which, in turn, may require some modifications to be made to the initial traffic forecasts.

Reference

3. *Nationalized industries: a review of economic and financial objectives.* (Cmnd 3437), London, HMSO, Nov. 1967.