Access to Bus Services by Social Group.

Robin Morphet

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1.   BACKGROUND: BUS SERVICES IN LONDON

This paper describes some of the work carried out on bus
availability in two London Boroughs, Greenwich and Lambeth, where
the author has worked.   The studies examine the relationship
between bus availability and other indices of the social character-
istics of small areas.

1.2 London has in the past had a reputation of possessing one of
the best public transport services in the world.   However, this
reputation would be hard to defend today when public transport
suffers increasing competition from private transport.   In the
case of bus services this has resulted in increased congestion on
the roads and a declining market share.   Revenue support for
transport has increased from zero in 1973 to £86.5 million per
annum today.

1.3 In the past local authorities in London were relatively
unconcerned about the level of provision of public transport.   The
County of London Plan, 1943, (1) which included the areas of
Lambeth and Greenwich, made almost no mention of bus or tram
services although its road plan was one of its most important
components.   The Greater London Development Plan, thirty five
years later, was more conscious of the role of bus services, seeing
them as necessary for local journeys in the context of private car
restraint.

1.4 At the local level as bus services have declined and reliab-
ility worsened, the level of provision of bus services has assumed
greater importance.   At a political level there have been public
complaints which have drawn local authorities into specific studies
(3) on existing or potential routes.   For the purposes of land use
planning it can no longer be assumed that new developments will
automatically attract new bus services of an acceptable standard
since London Transport judge new services against their criterion
of maximising passenger miles (4).   In outer London, where bus
routes are less dense, one local authority has gone so far as to
finance routes on its own (5).

1.5 As district level local authorities become more interested in
the distribution and level of service of buses, a need arises to
identify the particular areas and groups who are most in need of
bus services.   Traditionally, land use planners have assessed the
need for bus services simply by measuring distance from the bus
route or stop.   This has usually been at the design stage of new
development to ensure reasonable walking distances.   In a time of
decline in service, although walking distance is still important,
some index of the level of service is also needed.   Further, when
it is necessary for routes to be curtailed or abandoned, local
authorities need to be in a position to defend the needs of their
residents against the claims of others.

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2. THE GREENWICH STUDY

2.1 The study of bus services in Greenwich arose partly out of complaints from residents, partly out of the perceived need for better public transport services. However, the need for a comprehensive view of bus services arises since such a view is not taken by either the Greater London Council or London Transport. The Greater London Council in its strategic transport planning role is not well placed to examine the local characteristics of bus services in relation to the distribution of population. London Transport tends to view its routes simply in terms of revenue generated and takes little account of need. Indeed it is no longer under a duty to provide an adequate system of passenger transport as was the case before municipalisation under the Transport (London) Act 1969. However, some of the routing philosophy still appears based on the old half mile rule, under which anywhere within half a mile of a bus route was considered to be 'served'.(6)

2.2 The London Borough of Greenwich has been singled out (7) as typifying Greater London as a whole. It has three major centres, Woolwich and Greenwich in the north and Eltham in the south, all of which are bus nodes. The major centre is Woolwich, located at the eastern end of the riverside industrial belt. This industrial area has seen a rapid decline in economic activity and employment typified by closures of firms such as AEI and Matchless Motorcycles. Before and since the war the Borough had one of the largest house building programmes (12) and at present Thamesmead, overlapping the north east corner of the Borough, is still under construction and when completed will house some 40-50,000 people. The population of the Borough shows both Inner and Outer London characteristics with Inner London characteristics being concentrated towards the north of the Borough and Outer London characteristics being concentrated in the south around Eltham.

2.3 The bus route pattern in the Borough is one that is predominantly radial, converging on Central London, overlaid on which are the routes converging radially on the local centres.

The Borough forms part of the area of London's Docklands and is likely to be affected by a number of transport schemes such as the Jubilee Line, East London River Crossing and Rochester Way Relief Road. There has been only a limited study of bus services (8) although enhanced services are proposed within the Docklands Partnership.

2.4 Aims of the Study

A study was required which would produce indications of level of service that could be related to the socio-economic characteristics of the population so that areas of poor service could be identified, the service provision to different groups examined and the contribution made by particular services assessed. The study needed to be easily repeatable for the purposes of monitoring.

2.5 Study Method

The major problem in a study of this kind is to define level of

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service.   It was decided to use indices of waiting and walking time although such indices do not take into account the demands of the public for particular destinations.   It might be argued that the routes reflect the pattern of demand, particularly since the centres are well established, because the operators will adjust only those routes with low revenue.   This argument may apply to routes as a whole but is more difficult to argue at the level of small local areas. In addition, the waiting and walking time measures take no account of the need to change buses with further walking and waiting time penalties.

However, waiting and walking time are easily comprehended measures and given that most bus journeys are short, their defects may not be too great.   It is however, advisable to consider them as indices of level of service, i.e. as relative rather than absolute measures.

2.6   These relatively simple indices have the further advantage over conventional accessibility measures of transport studies that they can be related to very small areas.   In the Greenwich Study the basic area of analysis was the enumeration district.   There are over 400 enumeration districts in the Borough in comparison with the alternative spatial units, namely wards and traffic sub zones of which there are 27 and 86 respectively.

2.7   The population data used in the study was taken from the 1971 Census Small Area Tables and from the classification of enumeration districts and produced from them by the Centre for Environmental Studies.(9) Enumeration districts are chosen to be of equal population size and as a result overall population levels in enumeration districts are normally distributed.

2.8   In determining levels of service it was necessary to decide on an appropriate source.   The alternative sources of information on frequencies are:

(i)   frequencies measured by survey

(ii)   published timetables

(iii)   operators' timetables

For ease of monitoring and to reduce cost, direct surveys were ruled out.   Operators' timetables show every bus that it is planned to run, including services over and above those advertised. However, at the time of study and today, London Transport still have difficulty in keeping up to their published timetables and it was decided that these would be most realistic.   They also have the advantage that they represent the customers' level of information and are a public commitment, though not perhaps a very firm one. In addition, the published timetables are easily obtained for monitoring.

2.9   Using 1976 timetables against 1971 population data gives an unavoidable mismatch.   However, in terms of the conclusions reached in this particular study the mismatch would appear to give errors on the conservative side.   The same may not be true in other areas.

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The most conspicuous absentees from the 1971 Census are residents in the major public housing developments of Thamesmead & the Ferrier Estate.

2.10 With the assistance of London Transport all the bus stops in the Borough together with some outside (a total of 170 stops) were listed together with their grid references and the routes stopping at them.

2.11 Four time periods of analysis were defined as follows:

    Peak   07.00 am - 09.00 am weekday
    Off Peak 10.00 am - 12.00 noon weekday
    Saturday 09.30 am - 11.30 am Saturday
    Sunday   10.00 am - 12.00 noon Sunday

    These were intended to reflect the journey purposes of work during the peak, shopping in the off-peak and shopping and leisure trips at the weekend. In addition the periods contain relatively homogenous frequencies allowing the use of average frequencies.

2.12 In some cases route frequencies changed at particular locations. In such cases the route was split into two notional routes. From a total of 40 routes 54 notional routes were defined. Their headways were then calculated from the published timetables for the four analysis periods.

2.13 The basic method of producing the indices was to relate the table of headways to the table of bus stop locations and routes to get walking, waiting and walking and waiting time indices for each enumeration district. The calculation of walking times required the estimation of the airline distance between each enumeration district centroid and each bus stop. A bus stop was considered to be within five minutes' walk. To estimate this a walking speed of 3.5 mph was assumed, giving a distance of 470 metres and it was necessary to estimate a coefficient to convert airline distance into walking distance. A sample of origins and destinations was taken from a 1:1250 Ordnance Survey sheets and airline and walking distances measured. The factor estimated was 1.34 with a standard deviation of 0.36. This compares with the factor of 1.27 estimated by Smeed (10) in London Vehicle movement studies. There was some evidence that the factor decreased with distance and the value of 1.27 was used. The use of five minutes as a standard is familiar although relatively unjustified. It is included in current design guidance from central government (11) although assuming a speed of 3 mph. The 400 metre walking standard used, to which this corresponds, contrasts with the 470 metres used in this study. The longer distance is conservative and possibly more appropriate for an already developed area. A mean waiting time for bus stops within reach was estimated for each enumeration district.

2.14 In calculating waiting time for the four analysis periods the headway was estimated from the frequencies and divided by two. The assumption of a waiting time of half the headway is reasonable for the more frequent services but may overestimate waiting times on less frequent routes and on Sundays. The shorter waiting times for the less frequent services are generally assumed because passengers plan their journeys in accordance with the timetable. This can

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only be done when services are reliable which, during 1976, they were not.   Some 2.9 million miles (1.4%) of scheduled services were lost in 1976.   The calculated waiting times allowed a mean waiting time to be estimated for each stop.   Then for each enumeration district a mean of means was estimated for bus stops within reach.

Two problems arise in estimating frequencies, the problem of directionality and the problem of circular routes.   From the schedules for each route there are two frequencies corresponding to different directions.   To overcome this the conservative assumption of using the highest frequency was made.   Partly this reflects the pattern of demand and partly, since it was expected that the conclusions were likely to be critical of the level of bus service, conservative assumptions were chosen to ensure that such criticisms could be well founded.

For the 54 notional routes the following directionality factors were calculated:

Period	Mean	Standard Deviation
Peak	1.110	0.029
Off Peak	1.074	0.024
Saturday	1.074	0.024
Sunday	1.032	0.019

Table 1: Directionality Factors

On the question of circular routes the problem here is that of calculating the mean waiting or walking time for an enumeration district.   Normally, bus stops are approximately distributed opposite one another on either side of the road.   When the mean is calculated both inbound and outbound stops are included.   In the case of circular routes, since there is only one stop, the contribution of their frequency to the overall frequency is reduced. Where circular routes serve isolated areas this is not a problem because they are the only route within reach of the enumeration district and hence there is no biassing of the mean.   In the case of the Greenwich study there were only two circular routes, one of which fell into this category.   Longer distance circular routes may cause problems in other areas but the only long distance circular route in Greenwich runs buses in both directions and is not therefore a cause of bias.

In estimating bus stops within reach it was found that some (6%) of the enumeration districts had no bus stops within reach using the definition of walking distance already described.   This is important from the point of view of determining policy but makes analysis more difficult.   In the discussion that follows, these enumeration districts are ignored.   It could be argued that the criteria of what is or is not within reach should be altered so that all enumeration districts are included, and it would be a simple matter to do this.   However, where area comparisons are being undertaken, some commonly agreed standard is necessary.   The alternative of using a weighting function for distance so that all possible stops within reach are included, begs the question of which weighting function to use.   Empirical research in this area would

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be valuable.

2.16 The analyses were carried out on the ICL 1902A at Thames Polytechnic, using a set of programmes written by the author.

3.0 ANALYSIS OF THE INDICES

In the first analysis:

3.01 The twelve sets of indices (4 periods x 3 time penalties) for each enumeration district were arrayed against the following socio-economic variables:

1. Total population
2. 0-4 year population
3. 5-9 year population
4. 10-14 year population
5. Pensioners
6. Non working population over 40 years
7. New Commonwealth Immigrant population
8. Working population
9. Total households
10. Car owning households
11. Non car owning households
12. Workers with journey to work by bus
13. Workers with journey to work by car

To produce Borough and ward level indices for each population group the indices for each enumeration district were weighted by the number of people in the group in question and the indices were averaged. The unweighted indices are also shown since they represent the indices for an evenly distributed population.

3.2 It can be seen that in all cases the clustering of the population produces indices in excess of that for a uniformly distributed population. It is difficult to say at this stage whether this is due to a failure of land use or transport policy. In the case of walking time to bus stops it could have been argued that an evenly distributed population could not have an optimum level of service because of the radial nature of the route structure. It is perhaps surprising that the distribution of population increases the travel penalties. However, the variance of the indices is reduced in comparison with that for the unweighted population suggesting that some of the worst areas have not been settled. This reflects the relatively poor levels of service to open space in the Borough.

It is useful to compare the penalties for the different groups with that for population and for households. Groups such as mothers with young children (represented by the 0-4 child distribution), old age pensioners and New Commonwealth immigrants are relatively well off in terms of walking time. This suggests that the better frequencies in higher density areas are to some extent offset by competing land uses of these and other services, which force individuals to live further from the main routes. At the household level for both indices, zero car owning households are relatively better served than the household population as a whole. Similarly

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those individuals travelling to work by bus are relatively well
served.

Population Category	Peak	Off Peak	Saturday	Sunday
1. Population	3.39	3.40	3.40	3.42
2. 0-4 children	3.41	3.41	3.42	3.43
3. 5-9 children	3.42	3.42	3.43	3.44
4. 10-14 children	3.41	3.41	3.42	3.43
5. Male OAPs	3.39	3.39	3.39	3.42
6. Female OAPs	3.38	3.38	3.38	3.40
7. Immigrants	3.46	3.46	3.45	3.46
8. Working popn	3.39	3.39	3.39	3.41
9. Households	3.39	3.39	3.40	3.41
10. 1 car households	3.40	3.40	3.40	3.43
11. 2+car households	3.42	3.42	3.43	3.45
12. Wk.Journey bus	3.36	3.36	3.37	3.37
13. 0/car households	3.38	3.38	3.40	3.39
14. Wk.Journey car	3.41	3.41	3.41	3.44
Unweighted	3.11	3.11	3.11	3.09

Table 2: Walking time in Minutes.

Population Category	Peak	Off Peak	Saturday	Sunday
1. Population	2.91	5.00	4.06	7.72
2. 0-4 children	2.85	4.87	3.95	7.72
3. 5-9 children	3.01	5.16	4.13	7.90
4. 10-14 children	3.09	5.30	4.24	7.99
5. Male OAPs	2.78	4.83	3.93	7.66
6. Female OAPs	2.75	4.81	3.90	7.26
7. Immigrants	2.72	4.50	3.75	7.56
8. Working popn.	2.91	5.02	4.08	7.68
9. Households	2.87	4.94	4.01	7.63
10. 1 car households	2.97	5.11	4.17	7.83
11. 2+car households	3.03	5.28	4.40	8.03
12. Wk.Journey bus	2.87	4.94	3.98	7.71
13. 0/car households	2.78	4.79	3.86	7.45
14. Wk.Journey car	3.03	5.20	4.32	7.98
Unweighted	2.58	4.44	3.63	6.80

Table 3: Waiting Time in Minutes.

The walking times, as might be expected, are normally distrib-
uted over the enumeration districts.   However, the waiting times
have a bimodal distribution, skewed to the left.   This may reflect
the diversion of the population into two classes;   those living in
the dense well served areas around the major centres, and those

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living in the suburban areas.

As might be expected, the waiting times are lower in the Peak and Saturday periods and highest on Sundays. This reflects both the lower frequencies and the withdrawal of services. The withdrawal of services means that some stops are out of use, particularly on Sundays and this explains the changes in walking times over the four time periods. It is perhaps surprising that the unweighted mean shows a reduced walking time on Sundays, suggesting that stops are taken out of use where they are most out of reach but that this effect is outweighed by the effect of population clustering. This is interpreted as meaning that the stops taken out of use are not only those of longest walking time but are also in the least densely populated areas. This would support the casual observation that those areas with the most dispersed routes are most vulnerable to service withdrawals out of the peak periods.

Since the mean values quoted apply only to the population within reach, it is valuable to look at those areas out of reach. Those figures are shown in Table 4, and indicate that the 5-14 age groups are particularly vulnerable to loss of services during Saturday and Sunday when leisure trips might be important. Otherwise the more vulnerable groups, such as non car owners and old people fare relatively well, although it is disturbing that nearly 10% of old people are out of reach of a bus on Sunday, since walking distance is likely to be a relatively severe deterrent to them.

3.3 The indices of walking and waiting time were plotted at enumeration district and at ward level. In the case of walking time, much of the mosaic of the walking time pattern is lost at ward level. In the case of waiting time, although the spatial pattern does not show so much variation, the pattern that shows is rather different from the ward based pattern because of the arbitrary boundaries of the wards. The same conclusions apply to traffic zones which are similar in size to wards and which, because their boundaries follow roads, are also likely to even out variations in the pattern of waiting and walking penalties.

The between ward variation for population waiting time is less than one percent of the between enumeration district variation. This however, is an underestimate of the total loss of information through aggregation since it neglects the spatial or pattern variation which is important, particularly for walking time. It may be concluded that aggregation of this order is unsuitable for the examination of bus services. Enumeration districts are the smallest units available at the time of study. Further work on levels of aggregation using grid square data might be useful in determining cost effective levels of study.

3.4 Social Area Analysis

The second analysis was a social area analysis using the classification of enumeration districts (9) into eight categories as follows:
1. Rural areas
2. Areas of established high status and elderly population

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TABLE 4: Population In and Out of Reach by Period.

		Peak			Off Peak			Saturday			Sunday		
		In Reach	Out Reach	% out reach	In Reach	Out Reach	% out reach	In Reach	Out Reach	% out reach	In Reach	Out Reach	% out reach
Population	1.	199577	17844	8.94	199477	17844	8.94	198862	18559	9.33	197136	20285	10.29
0-4	2.	14957	1118	7.47	14957	1118	7.47	14905	1170	7.85	14813	1262	8.52
5-9	3.	15827	1505	9.51	15827	1505	9.51	15748	1584	10.06	15579	1753	11.25
10-14	4.	14423	1339	9.28	14423	1339	9.28	14347	1415	9.86	14186	1576	11.11
Male OAPs	5.	1876	164	8.74	1876	164	8.74	1872	168	8.97	1857	183	9.85
Female OAPs	6.	3261	285	8.73	3261	285	8.73	3257	289	8.87	3235	311	9.61
Immigrants	7.	6979	507	7.26	6979	507	7.26	6972	514	7.37	6980	506	7.25
Work Pop.	8.	97567	9248	9.48	97567	9248	9.48	97218	9597	9.87	96378	10437	10.82
Households	9.	69490	5951	8.56	69490	5951	8.56	69261	6180	8.92	68720	6721	9.78
1 car	10.	26716	2624	9.82	26716	2824	9.82	26619	2721	10.22	26326	3014	11.45
2+ car	11.	4202	538	12.80	4202	538	12.80	4197	543	12.94	4154	586	14.11
Work J. by bus	12.	23330	1700	7.29	23330	1700	7.29	23210	1820	7.84	23040	1990	8.64
0/car households	13.	38577	2789	7.23	38577	2789	7.23	38450	2916	7.58	38245	3121	8.16
Work.J.by car	14.	24720	2580	10.44	24720	2580	10.44	24660	2640	10.71	24450	2850	11.66

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3.   New owner occupied estates of high status and young age
      structure.
4.   Areas of older terraced housing and mixed tenure.
5.   Areas of extensive public housing.
6.   Areas of extensive public housing and acute social stress.
7.   Areas of low status multi-occupied housing with serious
      social stress.
8.   Areas of high status rented housing, students and other
      single people.

The technique adopted was one way analysis of variance over the
eight levels.   The results are presented in tables 5 and 6.

In analysing social area data in this way the assumption being
made is that individuals in a given area have the characteristics of
that type of area.   This is a common assumption in planning and
because it is generally incorrect, it goes under the name of 'the
ecological fallacy'.   In favour of this kind of analysis for the
study of bus services, there are two arguments.   First, the areas
considered are very small and therefore more likely to be homog-
eneous.   Second, every bus stop serves an area and in attempting to
differentiate its market a bus operator must, for better or worse,
distinguish different areas.   Thus in committing the ecological
fallacy the study simply reflects the procedures available to bus
service operators.

Social Area	Peak	Off Peak	Saturday	Sunday
1	3.75	3.75	3.75	3.75
2	3.37	3.37	3.37	3.44
3	3.37	3.37	3.37	3.36
4	3.33	3.33	3.36	3.40
5	3.43	3.43	3.44	3.42
6	3.15	3.14	3.15	3.14
7	3.41	3.43	3.41	3.43
8	3.34	3.34	3.34	3.30
R-squared %	0.69	0.72	0.74	0.77

Table 5: Mean Walking Times by Social Area.

Social Area	Peak	Off Peak	Saturday	Sunday
1	1.97	4.67	3.46	4.62
2	3.10	5.25	4.38	8.66
3	3.16	5.08	3.93	8.34
4	2.34	3.92	3.25	5.80
5	3.02	5.24	3.96	7.73
6	3.11	5.04	4.02	8.89
7	2.63	4.81	3.94	6.75
8	2.27	3.74	2.79	7.60
R-squared %	4.36	4.26	6.60	6.47

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Table 6: Mean Waiting Times by Social Area

The results of the analysis of variance are interesting.   The
areas of high status, in which one would expect the least dependence
on public transport are the least well served in terms of frequency.
However, the next worst served types of area are those of public
housing including public housing with acute social stress.   Since
public housing is that over which local authorities have most
control and possibly most interest, the lack of bus services
represents something of a failure of either land use or transport
planning or both.

3.5 Analysis of variance is a traditional marketing technique
usually aimed at distinguishing the acceptability of different types
of product, (13).   In this case the product is analysed in relation
to a categorisation of the market.   Ideally, one would expect to
see that the variation in the product would match the variation in
market.   It is an important result of this study that the R-squared
values indicate that bus services take very little account of the
different types of market area.   Reinforcing this view, it is
likely that the values of R-squared are inflated due to the presence
of spatial autocorrelation, particularly in the index of bus
frequency, (14).

The seemingly poor level of differentiation of different types
of area is unfortunate, whether one sees public transport as a
social service or as a free market commodity.   However, the values
of R-squared are statistically significant, so the differences in
index between groups are real differences.   It may be concluded
that the bus services do not respond greatly to social area, but to the
extent that they do the differentiation works against the interests
of those in public housing.

The same conclusions apply generally to the indices for walking
time, only here the values for public housing under acute social
stress are rather better than those for public housing as a whole.
This supports the view that the older public housing estates which
now house relatively deprived tenants, are located closer to major
transport routes than are the newer estates which, as developable
sites become scarcer, are sited less advantageously.   However, some
of this advantage would appear to be lost in the relative lack of
frequency suffered in these areas.

4.   THE LAMBETH STUDY

4.1 The London Borough of Lambeth is one of the most densely popul-
ated Inner London Boroughs.   In common with other areas of Inner
London, it has since 1945, lost much of its economic base, together
with some of its population.   In recognition of its particular Inner
City problems, the major part of the Borough has been designated as
a Special Area under the Inner Urban Areas Act 1978 and the local
authority is a Partnership authority.

4.2 The study undertaken in Lambeth was an improved version of the
conventional planning analysis in that rather than simply defining
areas of need as those further than 400 metres from a bus stop, some
analysis of their social characteristics has been attempted.   The

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limitations of this kind of analysis are that no comparisons of
walking or waiting time are possible.   Nevertheless, the results of th
the Greenwich Study set out in Table 4 can be used as a basis of
comparison.

4.3 Study Method

Bus stops within Lambeth were identified on a 1:10,000 map and
areas within 400 metres defined manually by identifying from the map,
potential pedestrian routes to the bus stop.   The areas which fell
outside the 400 metre limit were approximated using enumeration
districts from the 1971 Census and aggregations of the census data
were compiled for each bus deficiency area.   Similar aggregations
for land use data were compiled using the computerised land use
system, CLUSTER.

4.4 Study Results

The results quoted below are for the purposes of comparison with
the Greenwich Study and do not cover all the findings for Lambeth.
Seventeen bus deficiency areas were identified of which eight were
in the Inner Area of Need defined, for the purposes of the Partner-
ship, as the area which should have a priority claim on resources to
improve living conditions.   The bus deficiency areas contain over
14% of the population of Lambeth, (4.5% in the Outer Area, 9.5% in
the Inner Area).   These areas occupy 15.9% of the total area of the
Borough (12.3% in the Outer Area, 3.6% in the Inner Area).

Table 7 sets out a comparison of Inner and Outer Areas together
with a comparison between Lambeth as a whole and Greenwich.   As
might be expected rather greater proportions of the population are
out of reach of bus services in the Outer Areas of Lambeth than in
the Inner Area.   This would be less of a problem if the Outer Area
comprised a homogeneous population of affluent car owning households.
However, this is not the case and transport services for the relat-
ively under-privileged in Outer Areas seem to be considerably worse
than in Inner Areas, as a result of the concentration of public trans-
port routes towards the centre.

| Group | L.B. of Lambeth | | | L.B. of Greenwich |
	Inner	Outer	Total	Total
Population	8.10	27.80	14.06	8.94
Male OAPs	7.37	27.00	14.10	8.74
Female OAPs	7.34	25.67	14.20	8.73
Working Popn.	7.35	26.95	13.58·	9.48
Households	7.82	26.27	14.01	8.56
0/Car households	7.93	25.37	13.03	7.23
1 Car households	7.66	27.30	15.71	9.82
2+ car households	6.68	28.83	17.99	12.80
Journeys to work by bus	6.55	26.81	11.54	7.29
Journeys to work by car	6.48	28.11	16.19	10.44

Table 7: Percentages of Population Groups out of Reach of a
         Bus Stop.

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In comparing Lambeth and Greenwich it should be borne in mind that in Lambeth the 400 metre standard is used but that in Greenwich the rule is effectively one of 470metres. This would reinforce the view that in bus access terms, Greenwich is not dissimilar from the Lambeth Inner Area and that Lambeth as a whole appears much less well served on this index because of the poor access in its relatively small Outer Area.

5.0 CONCLUSIONS

5.1 No absolute statements can be made concerning whether bus services are good or bad. However, relative levels of service between areas and groups can be compared. In the analysis of the groups the bus services appear to be directed in favour of the non-car owning. However, the often quoted flexibility of bus routing and timetabling, does not appear to be able to match the spatial variation in the distribution of population. In terms of bus routing this may be attributed partly to the lack of suitable roads, since most suitable roads in Inner London already carry bus services. Variations in bus frequency to match variations in the distribution of the population depend on the different groups in the population living in relatively homogeneous areas of sufficient size to accept routes tailored to their needs. In particular, one might expect this in the case of large areas of public housing. However, it is precisely this group which seems badly served.

5.2 The failure of the variation in bus services to match the variation in the area type is disappointing. It would be wrong however, to lay all the blame for this at the door of London Transport since the integration of land use and transport planning is achieved more in policy than in practise. Furthermore, London Transport in a post war transport environment, is serving pre war public housing designed long before the link between transport and land use had attained its present status.

5.3 The question of whether the distribution of population is not matching the bus services or vice versa is difficult to answer. The failures in respect of public housing would suggest the former. One way of looking at this is to take the population distribution and the bus service   distribution and compute the relative goodness of fit using expected information (or relative entropy, $\sum p \log p/q$), with population as the prior and services as the posterior distribution, and vice versa. When this is done then for all indices (waiting time, walking time, waiting and walking time) the fit is better if population is taken as prior. This would support the contention that bus services follow population rather better than population follows bus services. The full results are not presented here since the argument, although inter-esting, is not rigorous.

Nevertheless, the scarcity of housing sites within reach of the Inner Areas would suggest that transport considerations will not weigh heavily in future location decisions. The Lambeth Inner Area Study (15) supported the view that those Inner Area residents who wished to should be enabled to move out of the Inner Area. This may prove to be a good policy, but new housing construction in Outer London could suffer the accessibility disadvantages of inter war

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public housing. The best policy here may be to ensure that bus services are provided or that rent rebates or other household based financial supports are available to compensate for loss of mobility. A rent rebate system might assist in ensuring that accessibilty is taken into account at an early stage, before final decisions on the location of new development are taken.

5.4 The method of looking at bus stop accessibility in terms of distance from a bus stop, as in the Lambeth Study, is useful but limited. Its value lies in being able to determine the desirable location of new pedestrian links and in its simplicity.

The advantage of the Greenwich Study lies in the inclusion of frequencies. This is of some advantage in monitoring since it enables the impact of the gradual withdrawal of services to be assessed. In looking at distance to a bus stop the loss of an entire route would make little difference to the analysis if, as is generally the case in Inner London, that route shared its stops with other routes. Furthermore, although analysis of those out of reach is possible in the Greenwich type of study, the analysis concentrates on the majority of the population, namely those within reach. Computer-isation of the analysis makes monitoring quicker, easier and more flexible, in particular the specific distance rule of 400 metres or otherwise can be varied for different groups as required, and market analyses for particular routes picked out. However, these advantag-es have not been fully exploited in the Greenwich Study and may be difficult to exploit elsewhere while district planning authorities have limited computing capabilities.

5.5 The Greenwich type of study could usefully be extended to cover Greater London, to assist in both decisions on the location of development and in comparing different bus networks and schedules. There are however, deficiencies in the analysis, notably the assess-ment of demand for different destinations. The relatively concen-trated destinations in the town centres of Outer London, may mean that bus services there are somewhat better than the indices indicate, despite the lower density of housing. In Inner London the greater diffusion of destinations caused by mixed development, may limit the effectiveness of bus services, particularly for non-radial journeys. It would be highly desirable if such effects could be included in the indices used.

Given that one possible objective of designing networks and schedules might be to maximise R-squared in a social area analysis, it would be desirable to have some estimate of what the maximum value might be for particular network and land use configurations. It may be that low values are all that can be achieved with a pre-dominantly radial system. Further work is also desirable on the appropriate walking speeds for different groups.

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