THE DEPARTMENT
OF TRANSPORT

Transport Statistics Report

Road Traffic in Great Britain
Review of Estimates

Prepared by the Government Statistical Service

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Government Statistical Service

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1 INTRODUCTION

This statistical report announces the introduction of a new method of estimating total annual traffic flows, and a revision to the historical series. For convenience the two changes are being made at the same time but they are largely unconnected. The change of method is being made to simplify the calculations required, increase robustness and allow consistent sub-national estimates to be produced. The revision to past figures stems partly from the discovery of an error in the previous (1983) revision of the 1973 benchmark and, partly from analysis of the larger samples taken on minor roads sisnce 1985, which has shown that previous figures based on the much less adequate samples for earlier years substantially underestimated traffic on this class of road.

2 ESTIMATION METHOD

During the late 1970s the statistical system for monitoring national traffic flows was changed. The earlier system based on occasional benchmarks linked by estimates of trend was replaced by one which uses two regular sets of counts each year (taken in the 'neutral' months April/May and September/October) to establish levels, and a number of continuously monitored 'core' sites to estimate monthly trends.

For major roads (Motorways and 'A' roads) the levels counts are taken on individual links (a link being the length between junctions with other major roads), in six year rotation - the 'rotating' census. For minor roads an independent sample of points is taken each year.

2.1 The Maximum Likelihood Method

The method first chosen to link these two sets of data used the statistical technique known as 'maximum likelihood'. This method first identifies for rotating census months the series of traffic estimates which are 'most probable' given both the observed counts for those months and the intervening trends as recorded at core sites. Estimates for other months are then derived by interpolation using the core census changes to give the trend pattern. A full description of the system is in [1].

For the years from 1974 to 1983 traffic figures were calculated using this maximum likelihood method taking the flow levels (as revised in 1983) from the benchmark counts for October 1973 and March 1974 as the starting point. However, its use was then suspended and provisional figures for 1984 and subsequent years have been derived by simply trending forward from 1983 using only the core census changes. This procedure was adopted because, in practice, the maximum likelihood system did not fulfil expectations. It took some time to get the system fully operational after which a number of problems were found. In particular:

a) the relatively small sample sizes for individual classes of road and vehicle types could lead to marked changes in the maximum likelihood estimates from period to period, and to significant changes in earlier results. Initial expectations that revisions would be small enough to

be ignored were not met.

b) Insufficient data are available to use the method at regional level. Where regional and county data are needed the so-called 'bottom-up' approach (see below) must be used, and the results constrained to national totals. This works reasonably well for total traffic in a particular year, but not for detailed breakdowns nor for changes over time - for example the results for London suggest a slow downward trend which conflicts with other evidence.

c) There can also be problems in explaining changes in traffic, as maximum likelihood is something of a 'black box' in which many factors are taken into account in arriving at the final traffic levels. This can make it difficult to relate count data to final results, and to explain to users why revisions to previous estimates are necessary.

d) Because the technique assumes a random sample it is not possible to increase the data coverage (and hence increase the stability of estimates) by using other information which the department collects on traffic flows.

The suspension of the maximum likelihood method was originally intended as an interim measure until more data from the rotating census could be brought to bear on the system. However, the degree of stability necessary to gain the confidence of users has not been achieved and, with the expansion of the roads programme, the need for sub-national figures becomes more pressing.

2.2 The New Method: Bottom-up

An alternative approach has been developed which, for major roads, uses estimates of the annual average daily flows (AADFs) on individual links of the network as building blocks for county, regional, and national estimates. The method is set out more fully in Appendix B but in essence the estimated AADFs for each link (and now most links have been counted at least once) are multiplied by the link length to give estimates of traffic on that link. These traffic estimates are then added together to give the traffic for a particular type of road in a county, region, etc. As the same data are used at any level of aggregation the figures are always internally consistent. For minor roads, where the concept of a link is not used, estimates are made on the assumption that the sites selected for the minor roads sample in a particular year are a random sample of points on the network. On this basis it is possible to estimate the mean flow on that type of road, and to multiply by the appropriate road length to arrive at an estimate of traffic. In practice the minor road sample is not large enough to support regional level estimates and, therefore, minor road traffic figures are only computed for Great Britain.

Where extra information is available about the flows on a major road - either more recent counts or expansion factors calculated specifically for that region - it can be incorporated into the AADF and thus into the overall estimates. This may introduce a bias in the estimate of average flows because non-census counts will not in general have been collected randomly. For instance if the extra counts were taken disproportionately on high-growth links, the average flow on all links will be biased upwards. However, the

bias is "self-correcting" over six years because all major road links are covered by the rotating census within that period. Furthermore, comparisons of estimates made with and without additional count data indicate that the bias is likely to be small, and a worthwhile price to pay for the improvement in traffic estimates for individual links.

The bottom-up approach has these advantages:

a) any aggregations of the data will be consistent.

b) it is easy to explain to users how the figures have been derived. Calculations use only simple arithmetic and, compared with maximum likelihood estimates, it is easy to trace the source of any unexpected movements in the results.

c) it is possible to take into account any new information about the flows on a particular section of road - even if these come from non-standard sources. New software developed by the department allows estimates of the AADF to be easily prepared.

d) regional factors for year-on-year growth and for day to week, etc can be incorporated where the necessary data are available.

It will, however, tend to take data at its 'face value' without allowing for its reliability in the way that maximum likelihood does (by weighting observations in inverse proportion to sample variances). Validation checks on the basic data gathered at link level have been increased accordingly - not only in respect of the traffic counts but also for road type, road length, etc.

For major roads the bottom-up method has been used to estimate annual traffic series from 1983 onwards, this being the first year for which reliable rotating census counts are available for an adequate number of links. Figures for earlier years have then been calculated by interpolation between the 1973 benchmark and 1983 on the basis of growth trends recorded at core census sites.

For minor roads bottom-up estimates have so far been produced only for 1987 and to achieve an adequate sample, the counts taken in 1985 and 1986 have been growth factored and pooled with the 1987 counts (too few counts were taken before 1985 for it to be worth including them). Pre-1987 estimates have been made by interpolation from the 1973 benchmark according to core census trends. It is planned to extend pooling to six years as the necessary count data become available.

2.3 Comparison Of Bottom-up And Maximum Likelihood Estimates

The changes from previously published figures resulting from the switch to the bottom-up method of estimation are generally small at aggregate level. They are discussed in section 5 which also looks at changes to published figures for earlier years. However, it is also of interest to examine how bottom-up figures differ from maximum likelihood estimates produced from the same observed data. Table 1 below compares the time series from 1983 to 1987 - because this is the the period for which sufficient rotating census data are

available. The maximum likelihood estimates have been computed starting from the new revised 1973 benchmark discussed in section 3. However, for minor roads, bottom-up figures prior to 1987 have been estimated by interpolation.

Table 1 Estimates of traffic: 1983-1987 using ML and BU methods (bn. km)

	1983	1984	1985	1986	1987	% change 1983-87
Major roads						
ML	176	188	193	206	223	+27
BUp	177	188	191	199	217	+23
Minor roads						
ML	117	122	123	129	142	+21
BUp	112	115	119	126	133	+20
Cars						
ML	238	251	258	273	297	+25
BUp	231	244	251	265	284	+23
HGVs						
ML	21	22	22	24	25	+19
BUp	22	22	23	24	26	+21
All vehicles/roads						
ML	294	310	317	335	364	+24
BUp	288	303	310	325	350	+22

Note : components and totals rounded separately

At the aggregate level both sets of figures tell the same story, with very similar levels of traffic and growth rates over this period.

The maximum likelihood model will not be abandoned entirely. It will be retained for internal use as a cross check on the longer run of estimates from the bottom-up approach. This will be needed to ensure that the use of non-census data does not substantially bias the overall results (through, say, a proponderance of extra sites from a particular region which may have an atypical growth rate). There is no evidence for this so far but as more data are used it will be necessary to monitor changes carefully.

3 HISTORICAL SERIES

3.1 1973 Benchmark

Though the move to a bottom-up method of estimation leads to some small changes to the traffic series for recent years, the main reasons for amendment to the back series are the incorporation of data from the larger samples of counts taken on minor roads from 1985 onwards-which indicates that traffic on this road class was previously underestimated-and the discovery of an error in the 1983 revision of the traffic estimates from the 1973 benchmark census.

A fuller description of the problem with the 1973 benchmark and its solution is given in Appendix A. In essence, the sites for the 1973 study were chosen on the basis of an urban/rural classification of roads which depended upon local authority boundaries for the definition of particular sites. In 1974 these local authority categories were abolished and it was decided that future traffic estimates should be based on roads defined as 'built-up' - having a speed limit of 40 mph or less - or 'non built-up'. A problem arose in the re-estimation of the 1973 traffic based on this definition because of an apparent bias in the sites selected in 1973 towards those on built-up roads.

This was exacerbated by a lack of good data about the lengths of roads in the new categories. The first traffic estimates on a built/non built split [2] did not allow for the bias because all results were scaled to the urban/rural total. A subsequent revision [3], attempted in the early 1980s, had to make assumptions about the built/non-built mileage of roads within urban/rural classes.

New work by Watson in the course of research for a volume of historical transport statistics has derived reasonable estimates of the needed mileages from a previously untapped source and has shown that the 1983 revision underestimated traffic.

The revisions to the currently published estimates for 1973 are as follows:

Table 2 Revisions to traffic data for 1973 (Billion v.km.)

	Original	1983 Rev.	Watson
Motorways	18.0	15.9	18.6
Trunk	44.8	39.3	41.3
Principal	82.2	80.6	84.4
All major	145.0	135.8	144.3
All minor	102.1	76.5	89.7
All roads	247.1	212.3	234.0

Sources: Original - TSGB 1970-80 (table 2.2)
1983 Rev. - TSGB 1973-83 (table 2.1) for total, STC for road class.
Watson - internal paper by A H Watson.

3.2 1938-1973

At the time of the 1983 revision to the 1973 benchmark the earlier published estimates (see, for example, [7]) for years back to 1938 were revised downwards so that the long run growth trend would remain unchanged. The present revisions recognise that the original estimates for the years 1938 to 1966 are the best that can be made from the data available. This results from work by Watson on data from the 1960 and 1966 benchmark surveys: work on data

for the period between 1966 and 1973 has led to minor revisions to the estimates for these years. The full run of data for years from 1938 is given in Appendix C.

4 CHANGES TO PREVIOUSLY PUBLISHED FIGURES

4.1 The Revised Data

The previous and new time series for main categories of roads and of vehicle types are shown in Tables 3 and 5. A graph of the series is given in chart A. A full time series of revised figures is given in Appendix C.

Table 3 Estimates of traffic volumes by type of road: 1966-1987 (bn. km.)

	1966	1973	1983	1987	Percentage growth 66-73	73-83	83-87	73-87
	a	b	c	d	e	f	g	h
All motor vehicles								
Major roads								
previous:	na	136	176	213	na	30	21	57
revised :	101	144	177	217	43	22	23	51
% change:		+6	-	+2				
Minor roads								
previous:	na	76	88	104	na	16	17	37
revised :	72	90	112	133	25	24	20	49
% change:		+17	+26	+29				
All roads								
previous:	153	212	264	317	38	24	20	49
revised :	173	234	288	350	35	23	22	50
% change:	+13	+10	+9	+11				

Note: Columns a-d show the vehicle kilometres previously published, the new series and the percentage change implied by the revisions. Columns e-h show th growth between different years for the previous and revised series.

The effect on total traffic is an increase of about 10 per cent throughout the period 1966-1987 (13 per cent in 1966 and 11 per cent in 1987) leaving overall growth rates very slightly lower. However, most of the increase in level (and, in the 1980s, all of it) is in traffic on minor roads. For these roads the revision is greater in the 1980s so that longer term growth rates are higher in the revised series (49 per cent between 1973 and 1987 compared with the previous estimate of 37 per cent) and more similar to growth on major roads. For the more recent past - 1983 to 1987 - the old and new rates of change are more comparable, at 17 and 20 per cent, in the old and new series respectively.

The revisions to major road traffic levels have reduced the 1973-1987 growth

from 57 per cent to 50 per cent; but the growth from 1983 to 1987 is very similar (21 and 23 per cent).

The different impact of the changes on major and minor roads has had some effect on the distribution of traffic by vehicle type. Table 4 shows the previous and revised figures for 1987.

Table 4 The distribution of traffic by vehicle type in 1987 - previous and revised estimates (per cent)

	Previous	Revised
Cars	80.5	79.9
LGV	8.4	8.1
HGV	7.4	7.3
Buses	1.1	1.1
Motorbikes, etc	1.6	1.9
Pedal cycles	1.0	1.6

The changes show a reduction in the proportions of car and goods vehicle traffic and an increase in that of two-wheeled vehicles - a consequence of the lower use of minor roads by goods vehicles and their higher use by two-wheeled vehicles. The dominance of cars in overall traffic, however, leaves the broad picture of traffic by type of vehicle little changed.

Table 5 Estimates of traffic volumes by vehicle type: 1966-1987 (bn km)

	1966	1973	1983	1987	Percentage growth 66-73	73-83	83-87	73-87
	a	b	c	d	e	f	g	h
Vehicle types:								
Cars and taxis								
All roads								
previous:	112	167	213	258	50	27	21	54
revised :	127	184	231	285	45	26	23	55
% change:	+13	+10	+9	+10				
LGVs								
All roads								
previous:	16	19	21	27	17	14	25	43
revised :	18	21	23	29	18	9	30	41
% change:	+13	+14	+8	+12				
HGVs								
All roads								
previous:	17	20	20	24	14	4	17	21
revised :	18	21	22	26	15	1	22	22
change %:	+8	+9	+7	+10				
Buses								
All roads								
previous:	3	3	3	3	-10	-1	11	10
revised :	4	3	4	4	-11	5	12	18
% change:	13	+10	+17	+18				
Motorcycles, etc.								
All roads								
previous:	5	3	6	5	-40	110	-19	70
revised :	6	4	8	7	-35	113	-19	72
% change:	+20	+30	+32	+31				
Pedal cycles								
All roads								
previous:	6	3	5	4	-46	60	-16	35
revised :	6	4	6	6	-40	71	-10	53
% change:	5	+16	+23	+32				

Note: Columns a-d show the vehicle kilometres previously published, the revised figures and the percentage change implied by the revisions. Columns e-h show the growth between different years for the previous and revised series.

The detail of the revisions also shows a shift in HGV traffic from major to minor roads. The absolute levels of these flows remains small and as the errors attached to the figures will be high, use of such disaggregated data needs to be treated with caution.

5 CONSEQUENCES FOR USE OF TRAFFIC DATA

The amendments to the traffic series have consequences for users of the data. Three of the main uses within the department are considered below.

5.1 Accidents

For some purposes it is useful to consider accident statistics in terms of the number of accidents per distance travelled by road users. The revisions to the series will have an impact on these rates. Table 6 gives some of the relevant figures for 1983 and 1987.

Table 6 Changes in accident rates per 100m veh km. 1983 and 1987

	1983	1987	% change
Built-up roads			
A roads: old	129	118	-9
new	132	116	-12
B roads: old	162	122	-24
new	155	128	-17
Other roads: old	177	155	-13
new	141	112	-20
Non built-up roads			
A roads: old	39	34	-11
new	38	34	-11
B roads: old	68	60	-12
new	50	41	-16
Other roads: old	71	56	-21
new	52	44	-15
Cycles: all roads			
old	590	600	+2
new	478	456	+4
TWMV: all roads			
old	917	825	-10
new	695	628	-10

The general picture is that the absolute level of accident rates is lower than before - but that the change in rates has remained almost the same for all road classes and types of user. Charts B and C show some of the main effects of the revisions.

5.2 Traffic Forecasts

The National Road Traffic Forecasts are estimates of growth factors to be applied to the latest available actual data. The increase in the 1988 base implies a corresponging increase in the forecast of total national traffic for future years (Chart F). The main application of the NRTF is in the appraisal of specific road schemes, for which growth factors - adjusted to reflect local cicumstances - are applied to actual counts for the sections of road in question. These counts are unaffected by the revision to the estimate of total traffic on all roads.

The revisions do not affect the forecast national growth rates or the local rates derived from them. There are two reasons. The first is that the basic stages in the forecasting process - the estimates of future rates of car ownership and of road freight tonne kilometres - are dependent on other statistical series. The second is that where traffic statistics enter the traffic forecasting process, at a later stage, it is their growth rate which is relevant. The growth rates from 1970 to 1987 in the new series are very close to those of the old. Further information on the NRTF can be found in [4].

The recently published traffic forecasts [4] used the 'old' traffic series as a base because full details of the revisions to the series were not known. However, use of the revised series would have given almost identical results.

5.3 Track Costs

The Department assess the use of roads made by different vehicles in order to help determine the allocation of road costs (maintenance, policing, etc) as an input to the procedures for setting vehicle excise duty rates [5]. Information from the traffic census is used to estimate the mileage and use of different road types by classes of vehicle.

The increase in minor road traffic is the revision which most affects track costs. The overall effect is to bring costs per vehicle kilometre on these roads more into line with other road types. However, for some types of goods vehicle there is a marked increase in the proportion of mileage travelled on minor roads - which have relatively high costs - and this could imply a higher allocation of total road costs to those vehicles. Table 7 shows the effect in 1987 for the types of vehicle most affected.

Table 7 Proportions of travel by road class and HGV type

	Major roads		Minor roads	
	Old	New	Old	New
Rigids:				
3 axle	81	72	19	28
4 axle	89	72	11	28
Artics:				
4 axle	95	93	5	7
5 axle	99	95	1	5

For other categories of vehicles the revised figures do not imply any major change in the allocation procedure.

6 COMPARISONS WITH OTHER SERIES

The estimated trends in traffic can be compared in an approximate way with data on fuel consumption and vehicle stock. Charts D and E show that, at aggregate level the three series imply a gradual increase in the average annual mileage per vehicle (of all types) and in the average miles per gallon.

It is also possible to compare the traffic data with other series for particular vehicle types. In particular, estimates for goods vehicles can be made from the Continuing Survey of Road Goods Transport (CSRGT); bus statistics are available for public service vehicle operators; and the National Travel Survey makes estimates of household travel in cars.

In each of these cases the comparisons are beset with problems of definition. For example, the traffic census covers foreign vehicles and vehicles operating without an excise licence. The goods vehicle and bus sources exclude such vehicles, and the NTS survey coverage is unlikely to be complete. However, some preliminary investigations show that at the detailed level of traffic for particular vehicle types there are discrepancies between the various sources which deserve further study. We aim to publish a more extensive study of the different sources of traffic data in a later Statistics Report.

7 REFERENCES

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[5] The Allocation of Road Track Costs 1989/90 U.K., Department of Transport.

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8 GLOSSARY

The following definitions and abbreviations are used in this report.

AADF - annual average daily flow: the estimated flow of traffic on an average day during the year.

Major roads - 'A' class roads and motorways.

Minor roads - 'B', 'C' class roads and all unclassified roads.

Built-up roads - roads with a speed limit of 40 mph or less.

Non built-up roads - roads with a speed limit of over 40 mph.

Trunk roads - roads (including motorways) which are the responsibility of the Department of Transport.

Principal roads - 'A' class roads which are not designated as trunk roads.

Abbreviations:

MT	Motorway
TN	Trunk - non built-up
TB	Trunk - built-up
PN	Principal - non built-up
PB	Principal - built-up

and similarly for B, C, and U (unclassified) roads.

Chart A
Comparison of Old and New traffic series
Major, minor and all roads

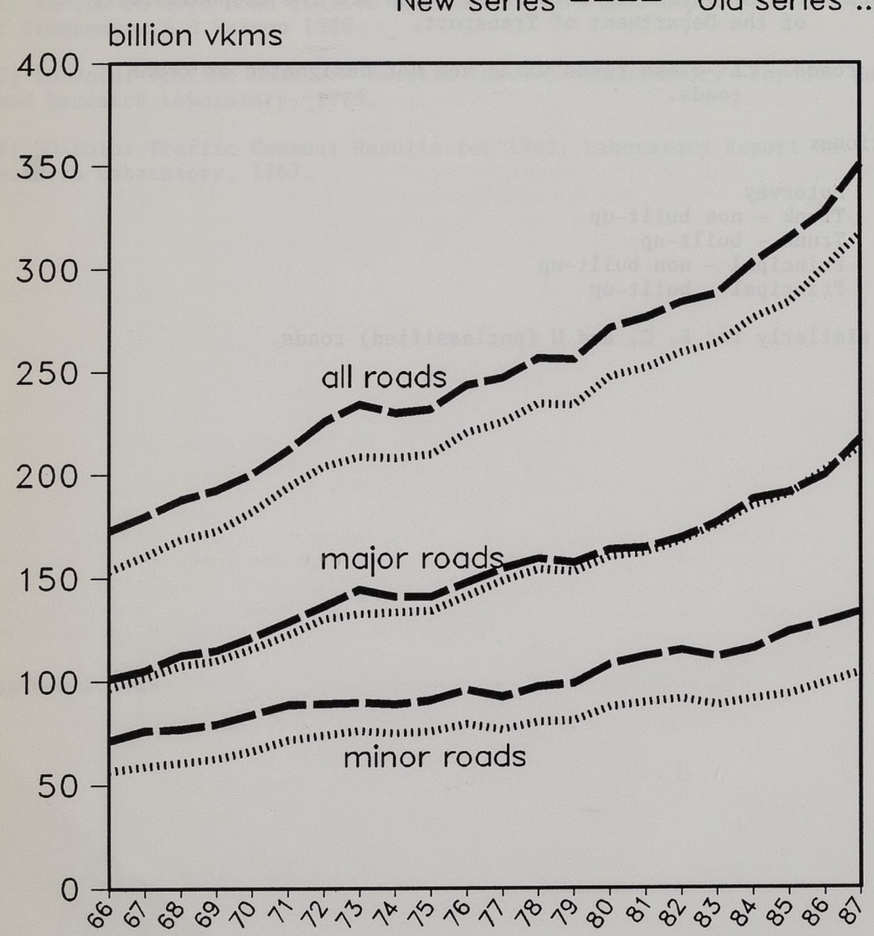


Chart B
Old and revised accident rates by road class : GB
rates per 100 million vehicle km

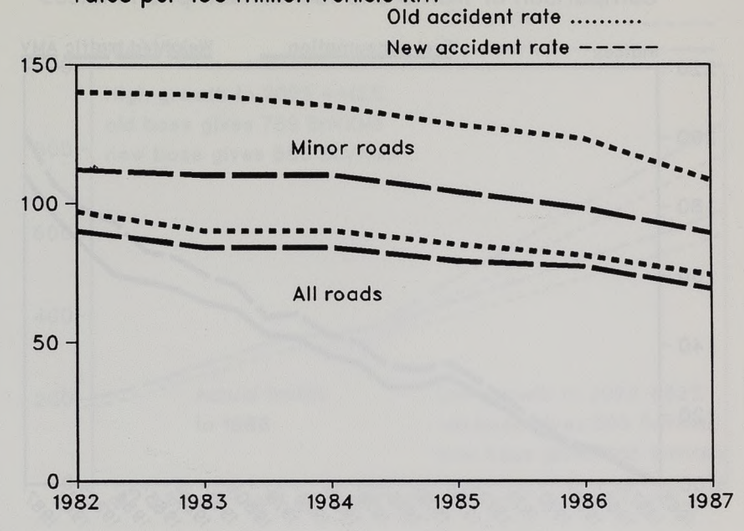


Chart C
Old and revised casualty rates by road user : GB
rates per 100 million passenger km

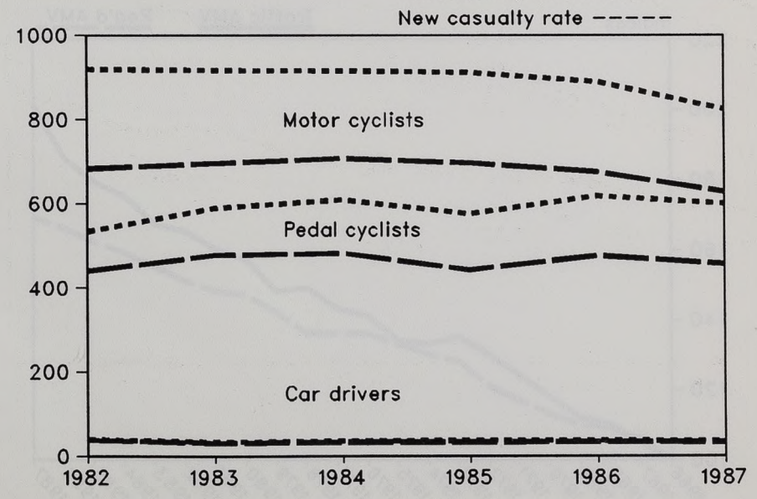


Chart D
Comparison of traffic and fuel consumption indices

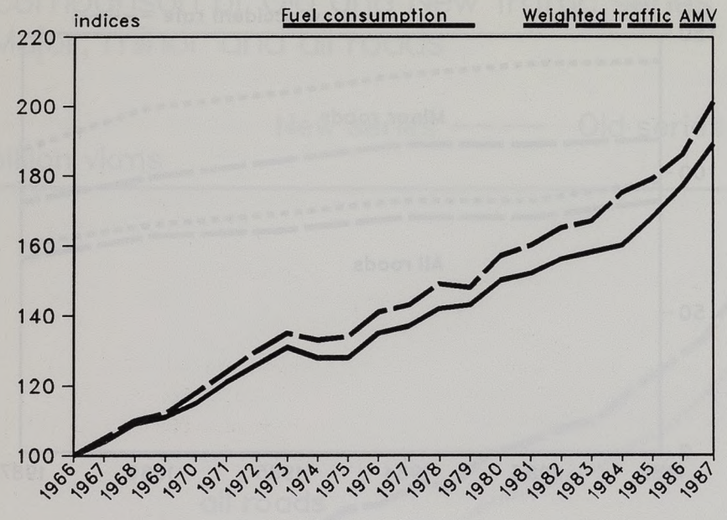


Chart E
Comparison of traffic and vehicles licensed indices

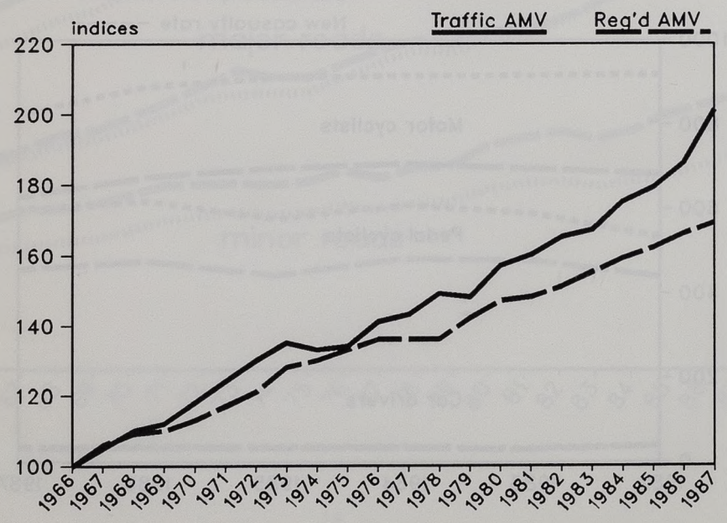
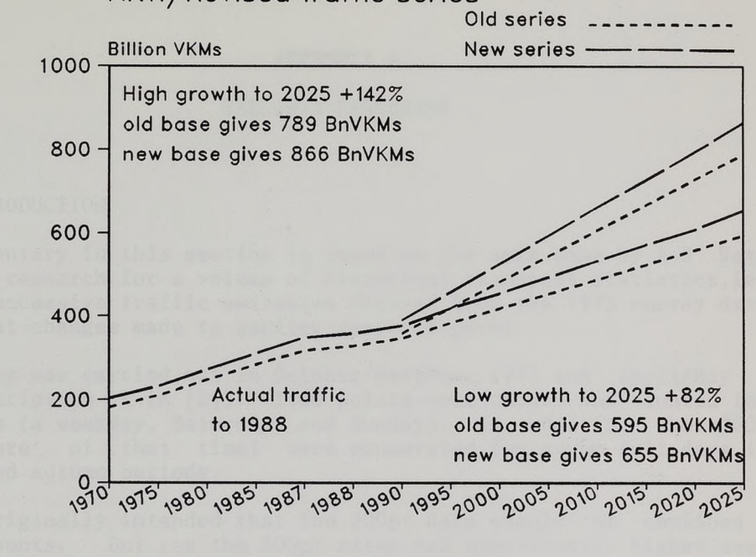


CHART F
NRTF/Revised traffic series



APPENDIX A

THE 1973 BENCHMARK

A.1 INTRODUCTION

The commentary in this section is based on the work done by A H Watson, much of it in research for a volume of historical transport statistics,in appraisal of the successive traffic estimates derived from the 1973 survey data and the consequent changes made to earlier years' figures.

The survey was carried out in October/November 1973 and April/May 1974. (A full description is in [2]). 1100 points were chosen and counted for three 16 hour days (a weekday, Saturday, and Sunday). In addition the 200pt census (the 'core' of that time) were enumerated for seven full days in both the spring and autumn periods.

It was originally intended that the 200pt data should be combined with the other counts. But as the 200pt sites had consistently higher average flows than the remaining sites it was decided to omit them from the 'levels' estimates made for 1973. However, the 16-24 hour and day/week factors from the 200pts were used to estimate the AADFs in the census.

The preparation of the results was complicated by the change in local authority boundaries made in 1974 - which led to different regional boundaries for most English regions - and by the consequent move to the use of roads defined as built-up/non built-up, as opposed to the rural/urban definition - which was based on the now defunct local authority classification. In practice the B/NB mileages were not available until 1977, and these were used to estimate mileages in 1973.

The first estimates for 1973 based on the 1100 point data were compared with the figures for 1973 derived from the 1966 benchmark data trended forward using the 200pt data. For classified roads (the 200pt census did not cover U roads) the overall total traffic was within three per cent of the trend estimate - though there were, of course, larger discrepancies in the detailed cells. It was decided that the best estimate of 1973 would be made by combining the trend and census estimates to give the, so-called, 'hybrid' set of figures. These data were then taken as definitve for 1973.

Subsequent analysis has shown that the 1973 benchmark survey sample was heavily biased towards sites on built-up roads. Because the estimates of

total traffic were made on an urban/rural classification of roads no correction was made for the bias towards the more heavily trafficked built-up roads. When an alternative estimate for built-up/non built-up roads (a stratification which would have largely removed the bias) was made the results were scaled to agree with the previously calculated urban/rural totals - thus maintaining the error.

A.1.1 The 1983 Revision

In the early 1980's it was decided to look again at the 1973 figures. This was to take account of further information about the built-up and non built-up road mileages collected during the late 1970s, and because of the over-representation of built-up sites in the 1973 survey .

The precise method underlying the 1983 revision is not now clear, but it involved a re-weighting of urban/rural flows, within road class by built/non-built categories. The breakdown of built/non-built road mileages between urban and rural roads was not known but the census points could be allocated to the appropriate road class.

It is important to note that estimates were available for road mileage by class for built-up/non built-up roads, and for urban/rural roads - but **not** for urban/rural within built/non-built. The number of points (and the associated AADFs) were known for each cell, and the question was how the urban and rural mean flows should be weighted to provide the figures for traffic.

The method seems to have been, in effect, to split the total mileage for a particular built/non-built road class into estimated urban and rural mileage weights by assuming that the ratio of miles per point between urban and rural roads for, say, all trunk roads could be applied equally to the urban/rural breakdown of built-up roads and non built-up within that class. Unfortunately, as Watson showed later, such an assumption is untenable and could not yield acceptable estimates. The actual ratios can differ considerably and the only satisfactory way forward is to use direct estimates of the mileages within each category of road.

This is the method used by Watson described in the next section.

A.1.2 New Revised Figures For 1973

In recent months, at STC's invitation, Watson has investigated the 1973 data still available and has prepared a new revised estimate using the data for flows at individual points. The problem of weighting the flow data to give built/non-built figures has been tackled by using the direct estimates of mileage for each of the cells in the urban/rural and built/non-built matrix for each road class which he had developed earlier. This had been done by using data from the road condition survey carried out in advance of the 1959/60 Traffic Census and using the same points. The condition survey noted whether the speed limit of the road was 40 mph or less. Using these data Watson was able to build up estimates of the probable mileages of built/non-built roads within the urban and rural classification constrained to

the total built/non-built mileages estimated for 1973 from the mileage surveys in the mid-1970s. Although a range of values are possible depending on the assumptions about changes since the 1960 study, Watson has shown that traffic estimates based on their use as weights are minimally sensitive to a choice of value over the probable range. Central values have generally been used for the new estimates.

Data were available from STC on mean site flows from the 1100 pt. counts in the 1973 survey. Some working sheets were also found showing, by regions, the mean flows for built/non-built road classes. From these it was possible to reconstruct the average flows underlying the original 1973 estimates of vehicle-mileages on built/non-built roads before they were scaled up to the overestimated urban/rural levels.

Pooling these various sources on flows, and using the new estimates of road mileages, Watson [6] has been able to construct a new estimate of 1973 traffic levels.

A.1.3 Estimates For Earlier Years

There are consequences for earlier years from accepting the revised figures. Watson has reworked the time series back to 1966, making use of the close agreement for motorways and for trunk and classified road traffic between the new 1973 estimates and the original 1973 estimates based on the 1966 benchmark trended forward using 200 pt. data.

For trunk and classified roads minor adjustments were made to the original 200 pt. based series by vehicle type for consistency with the new 1973 figures. These figures were then scaled up to give the series for for all roads other than motorways using the same method (described in [8] p32 and 34), in the absence of counts and trend figures for unclassified roads, as used for the original 200 pt. based series. This employs a set of scaling factors for each vehicle type derived initially as the ratios between the 1966 all non-motorway roads figures from the full benchmark sample and the data for trunk and classified roads from the 200 pt. sample. These were adjusted progressively to be consistent with the corresponding new 1973 ratios. It should be noted that the difference between the series for trunk and classified roads and that for all roads other than motorways does not give a reliable series for unclassified roads because of the large sampling errors involved in such a residual calculation.

From new work on the 1960 and 1966 benchmark data Watson also concluded that the original estimates for the years 1938-1966, as published before the 1983 revision, remain the best estimates that can be made for those years.

A.2 CONCLUSION

The Watson figures have been well researched and probably represent the best estimate for 1973 and earlier years that can now be made.

The results for 1973 are given in Table 2 of the main text and the full historical series from 1938 is in Appendix C.

APPENDIX B

ESTIMATES FOR THE 1980S

B.1 INTRODUCTION

As explained in the main report a number of changes in method took place in the late 1970s in the way in which the traffic figures were compiled. For these reasons much of the comparison of methods in this annex deals with the period between 1983 and 1987.

B.1.1 Maximum Likelihood

The maximum likelihood method aims to produce the most probable estimate of the population figure given the sample estimates, their variances, and an assumption about the population distribution from which the sample was drawn. For the period from 1973 to 1983 the published series are based on a maximum likelihood method.

The method uses the neutral month estimates for October 1973, May 1974, and the rotating census results from September 1979 (major roads) and September 1980 (minor roads). The intervening period (and all months between neutral months in any year) are interpolated using the 200pt or core census changes as the basis for the interpolation.

A full explanation of the solution of the maximum likelihood equations for the traffic census data is given in [1]. However, in essence the solution depends upon expressing the maximum likelihood(ml) estimate as a weighted mean of the observed value in period i, the growth from the ml estimate in i-1, and the growth to the ml estimate in i+1. The weights used are the estimated variance of the observed level and the variances of the two changes. An initial estimate is made from the observed values and the process is then iterative, normally converging after four rounds.

The solution of the maximum likelihood weighting equations is complex [1]. Added to this is the fact that the amount of data needed to run the system sensibly is large (estimates are made for road classes X vehicle types) so that only national level estimates can be made. This is what the census was designed to do, but there are increasing demands for regional, and even county

level data. Our current estimates rely on the 'bottom-up' method for sub-national figures which are then scaled to national totals. This produces anomalies and, in practice, we have never 'published' any figures below the national level - though estimates are used in the grant related expenditure formulae and some figures were included in the NAO report on roads. All this has led us to consider using the bottom-up method as a means of establishing estimates of traffic levels which are simpler to compute and can be built-up from sub-national to national totals in a consistent way.

B.1.2 Bottom-up

Now that a complete cycle of counts on major roads has been taken it is possible to estimate the traffic on these roads by summing the estimates obtained for each link. Although only one sixth of the sites are counted each year, estimates for the current year are obtained by factoring forward the last count using core census trends.

More precisely the estimates ,for a particular vehicle type and major road class, within a given county are calculated as follows:

$$T = \bar{f}_w * L * 365$$

and

$$\bar{f}_w = \frac{\Sigma f_i l_i}{\Sigma l_i}$$

where

T = annual traffic in vehicle kilometres

f_i = average annual average daily flow (AADF) on link i

$\bar{f}_w$ = mean link weighted annual average daily flow

L = total road length for the class from the annual road length survey. (This allows for any missing link level data).

For minor roads estimates are calculated for each road class and vehicle type but at national level only as follows:

$$T = \bar{f} * L * 365$$

and

$$\bar{f} = \frac{\Sigma f_p}{n}$$

where

f_p = average annual daily flow at point p

n = number of counts

$\bar{f}$ = mean AADF

The bottom-up series has a certain amount of in-built stability because five-sixths of the sites have AADFs which are simply trended forwards from the previous year using factors from the core census. Thus the method places a

good deal of reliance on having sound core census year-to-year factors.

A potential problem is that, if the core sites are by chance a biased selection (in terms of growth rates), then this bias will be carried into a substantial proportion of the bottom-up site AADFs and thence into the traffic levels estimates. One way of examining the problem is to compare the growth rates shown by the rotating census sites - treating these as a freshly drawn sample each year - with the growth shown by the core sites. The results obtained for the period 1983-1987 are as follows:

% change 1983-87 based on rotating census counts and on core sites

	'Census'	'Core'
Road class:		
BB	22	29
BN	31	32
CB	20	19
CN	4	24
UB	-4	21
TB	16	15
TN	24	31
PB	9	10
PN	26	24
MT	45	55

The estimated coefficient of variation (cv) of the change is very high (50-60%) for the link based estimates on CN and UB roads - for other classes the cv is generally of the order of 5-10%. The reason for this variability is being investigated. The cv of core site changes are all between 2 and 7% apart from UB roads, which is 13%. On the whole this comparison suggests good correspondence between core and rotating based estimates of growth - and for the two road classes for which this is not the case the core estimates look reasonable.

APPENDIX C

REVISED ESTIMATES FROM 1938 BY VEHICLE CLASS

Road traffic by vehicle class 1938-1988 (billion vehicle kms.)

Year	Cars and taxis	Motor-cycles	Buses	Light goods	Heavy goods vehicles	All motor vehicles vehicles	Pedal cycles
1938	27.8	3.1	3.1	< 12.7 >		46.7	27.5
1949	20.3	3.1	4.1	6.5	12.5	46.5	23.6
1950	25.6	4.4	4.1	7.8	11.2	53.1	19.9
1951	29.3	5.5	4.2	8.2	11.7	58.9	20.8
1952	30.6	6.0	4.2	8.7	11.2	60.8	22.9
1953	33.4	6.7	4.2	9.1	11.5	64.9	20.8
1954	37.1	6.9	4.2	9.3	12.2	69.7	18.8
1955	42.3	7.5	4.2	9.8	13.2	77.0	18.2
1956	46.2	7.4	4.2	10.0	13.0	80.9	16.2
1957	45.2	8.3	4.0	10.2	12.6	80.4	16.0
1958	55.4	8.4	3.9	11.7	13.7	93.0	14.1
1959	62.2	9.7	4.0	13.5	14.8	104.2	13.6
1960	68.0	10.0	3.9	14.7	15.7	112.3	12.0
1961	76.9	9.7	4.0	15.9	15.9	122.4	10.9
1962	83.7	8.6	4.0	16.0	16.0	128.4	9.3
1963	91.4	7.6	4.0	16.9	16.4	136.3	8.2
1964	105.7	7.5	3.9	17.0	18.2	152.3	8.0
1965	115.8	6.7	3.9	18.1	18.2	162.7	7.0
1966	126.5	6.0	3.9	18.0	18.5	172.8	6.2
1967	135.7	5.2	3.8	17.7	18.2	180.5	5.6
1968	142.7	4.7	3.8	17.7	18.8	187.7	5.0
1969	147.9	4.2	3.8	18.0	18.7	192.6	4.5
1970	155.0	4.0	3.6	18.9	19.0	200.5	4.4
1971	165.0	3.9	3.5	19.7	19.7	211.8	4.3
1972	174.7	3.7	3.5	20.4	20.2	222.5	3.9
1973	184.0	3.9	3.5	21.3	21.3	234.0	3.7
1974	179.9	4.2	3.3	21.6	20.7	229.8	3.8
1975	181.6	5.1	3.2	21.3	20.5	231.7	4.4
1976	190.4	6.3	3.3	21.8	21.6	243.5	5.0
1977	194.1	6.2	3.2	22.1	21.2	246.9	6.1
1978	202.4	6.2	3.3	22.0	22.0	256.5	5.1
1979	201.4	6.4	3.3	22.4	22.3	255.9	4.6
1980	215.2	7.7	3.5	23.1	21.9	271.4	5.1
1981	219.6	8.9	3.5	23.4	20.9	276.3	5.5
1982	227.5	9.3	3.5	23.2	20.5	283.9	6.4
1983	231.4	8.3	3.6	23.1	21.6	288.1	6.4
1984	244.3	8.2	3.8	24.5	22.3	303.1	6.4
1985	250.8	7.4	3.6	25.2	22.8	309.8	6.1
1986	264.8	7.1	3.6	26.5	23.1	325.1	5.5
1987	284.6	6.7	4.1	29.0	26.1	350.5	5.7
1988	295.4	5.4	4.2	31.1	27.0	363.1	5.0

APPENDIX D

REVISED ESTIMATES FROM 1973 BY ROAD CLASS

Road traffic by type of road 1973-1988 (billion vehicle kms.)

Year	Motorway	Trunk roads	Principal roads	Major roads	Minor roads	All roads
1973	18.6	41.3	84.4	144.3	89.7	234.0
1974	20.3	39.4	81.1	140.9	88.9	229.8
1975	21.7	38.5	80.7	140.9	90.8	231.7
1976	24.1	40.1	83.5	147.7	95.8	243.5
1977	25.6	41.7	87.2	154.5	92.4	246.9
1978	27.6	41.6	90.0	159.2	97.3	256.5
1979	27.7	40.9	88.4	157.0	98.8	255.9
1980	29.2	42.6	91.7	163.5	107.9	271.4
1981	29.2	43.7	91.6	164.5	111.8	276.3
1982	30.1	45.7	93.4	169.2	114.7	283.9
1983	31.9	48.7	96.0	176.6	111.5	288.1
1984	36.3	51.1	100.3	187.7	115.4	303.1
1985	38.0	51.8	101.3	191.1	118.7	309.8
1986	40.8	55.7	102.9	199.4	125.8	325.1
1987	50.1	59.1	107.9	217.2	133.3	350.5
1988	51.9	61.0	112.0	225.0	138.2	363.1

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