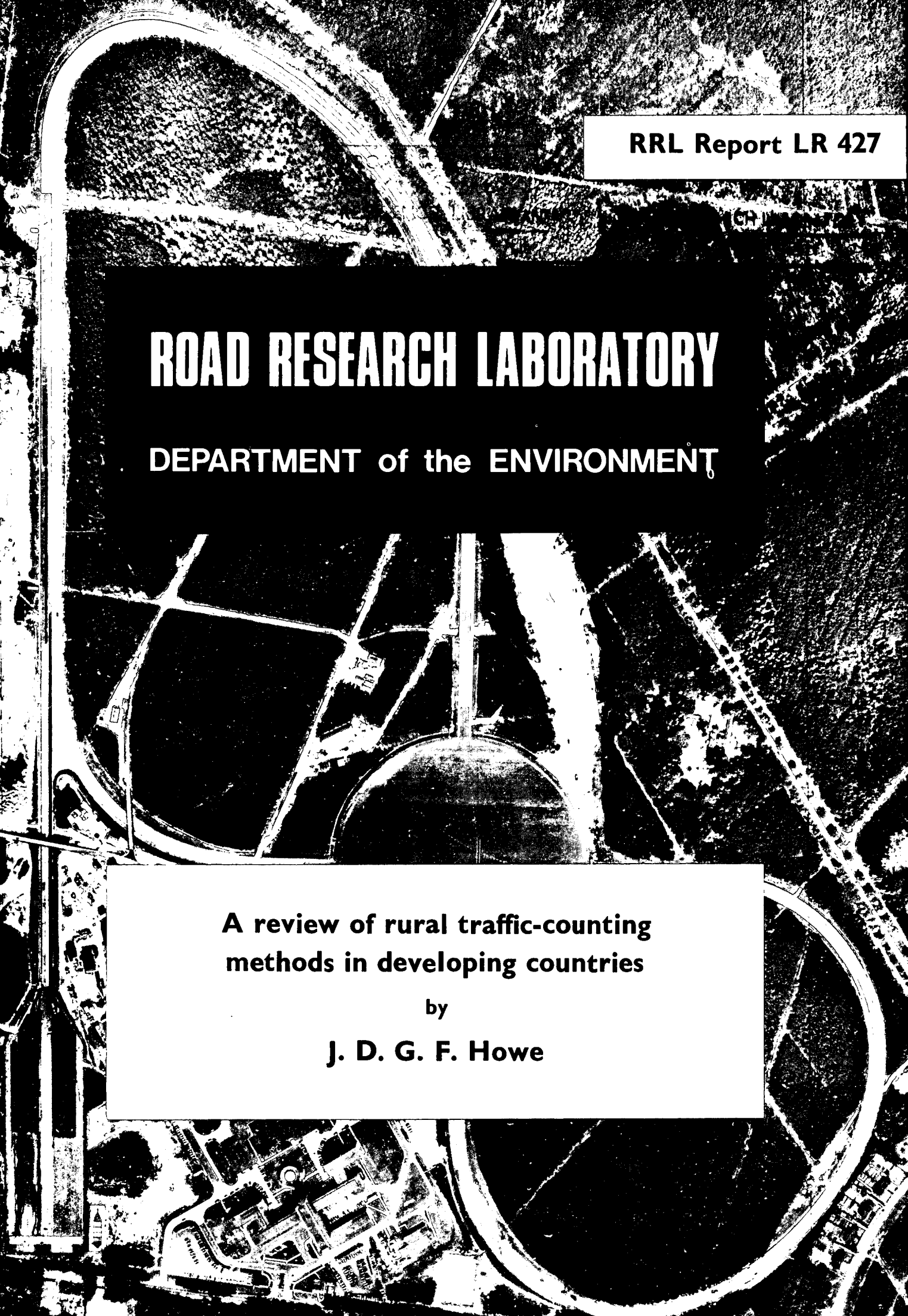

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ROAD RESEARCH LABORATORY

DEPARTMENT of the ENVIRONMENT

A review of rural traffic-counting methods in developing countries

by

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Department of the Environment

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A REVIEW OF RURAL TRAFFIC-COUNTING METHODS IN DEVELOPING COUNTRIES

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A REVIEW OF RURAL TRAFFIC COUNTING METHODS IN DEVELOPING COUNTRIES

ABSTRACT

This Report reviews methods of rural traffic counting currently used in developing countries and examines the accuracy of the resulting flow estimates.

The results of a questionnaire survey among a sample of developing countries suggest that decisions on the duration, frequency, and timing of counts are at present arbitrary. Consequently, estimated daily traffic flows can rarely be expected to lie within ± 30 per cent of the true value averaged over the whole year. Although repeating counts at intervals throughout the year increases the accuracy of traffic estimates, this is achieved only at a disproportionate increase in cost.

It is concluded that for any appreciable increase in the accuracy of rural traffic estimates much more needs to be known about the magnitude and causes of the variations in flow. This requires that automatic traffic counters be used on a wider scale than at present.

1. INTRODUCTION

This Report reviews the methods of rural traffic counting currently used in developing countries. The object of the review was to examine the accuracy of estimates of rural traffic flow resulting from the counting methods, and, if necessary, to make suggestions for their improvement. The Report is the first in a series that is considering the design of traffic survey methods suitable for developing countries.

Information on traffic flow is needed for many purposes, in determining the appropriate standards of layout and design for particular roads, in allotting the resources for maintenance and improvement between the different roads in a network and in making general planning decisions on the development of transport systems. Existing methods of traffic counting provide information that is often inadequate and of doubtful accuracy and this research has been undertaken to establish the most economical methods of survey to produce adequate and reliable data.

Information on the methods in use for counting rural traffic was obtained from a questionnaire circulated to a sample of developing countries in 1970. This was supplemented by information obtained during visits

and from technical publications.

The efficiency of the traffic counting methods was tested using continuous traffic measurements conducted by the Road Research Laboratory at 38 sites in Kenya. Comparative data were also obtained from two sites in Nigeria and 30 of the sites used in the United Kingdom 50-point census for 1969[1].

The Report first considers methods of traffic counting currently in use in developing countries. Next a brief discription is given of the Kenya experiment followed by an outline of the method of calculating errors in traffic counts.

Sample testing is then described and the results presented and discussed.

2. METHODS FOR COUNTING RURAL TRAFFIC IN DEVELOPING COUNTRIES

Appendix 1 summarises the information on methods for counting rural traffic in fourteen developing countries located in South America, Africa, the Middle East and the Far East. The information was correct at the time of the survey, but, as some countries are making changes in their traffic census methods, it may no longer be so in certain cases. Notwithstanding this, conclusions drawn from the results are probably still broadly correct. The aspects of particular interest to this study are the duration, frequency, and timing of counts.

2.1 Duration of counting

The duration of counting is standardised in about half the countries sampled. It ranges from a single 8-hour count (Turkey) to a continuous count for 15 days (Ethiopia), although the latter is exceptional, being for special counts only. The most common period is 12 hours (6am - 6pm or 7am - 7pm) repeated for 5 or 7 days. The complex 8-hour count each day for three weeks, that is proposed for some stations in Thailand, can be regarded as an effective 24-hour count for 7 days.

2.2 Frequency of counting

For 'national' censuses (counts made annually over the entire country) the frequency of counting varies considerably from country to country. One country states that the frequency of counting is irregular, two countries state once a year, four countries state twice a year, three countries state three times a year, and one country states four times a year. Where the frequency is more than once a year, it is usually related to the number of major climatic seasons.

2.3 Timing of counts

The timing of counts is not generally standardised, although for 'national' censuses some countries specify broad wet and dry (or harvest) seasons when counts will, or will not, be made. Thus, in respect of their timing, traffic counts in developing countries can be considered as random samples. The period for counting, however many hours and days it comprises, is effectively a random selection in that any period in the year other than a few containing obviously unusual activities, such as Easter or Christmas, can be chosen. Even when, as in some of the national censuses, certain months or periods are specified, sampling is still essentially random since there is no evidence that the period chosen is selected on the basis of a known pattern of seasonal variation. Also, experience has shown that in practice these periods are, regrettably, rarely adhered to.

In some developing countries, the purpose of traffic counts is not always clear. It might be to provide estimates of average daily traffic in the specified week, month, or year, or merely the average flow during the observation hours.

2.4 The quantity to be estimated

Although it is rarely explicitly stated, rural traffic counts usually attempt to measure average rather than peak usage. The commonest measure of average usage is the amount of daily traffic. However, the word 'daily' sometimes refers to a period of less than 24 hours. In the United Kingdom[2] rural traffic counts are taken to obtain the 16-hour (6am - 10pm), seven-day, average flow occurring in August. All current counting systems based on 'm-hour days' (where $m < 24$) suffer from a number of drawbacks. Since m varies so much between countries this suggests that the particular value chosen is arbitrary. Certainly it is not normally possible or meaningful to assign limits of error to the traffic estimates that result. Further, the 'm-hour' days are not natural periods of human activity such as the day, week or month. Thus, variations in traffic-flow characteristics, which can only add to estimation errors, are to be expected, e.g. the distribution of traffic through the hours of the day will vary with route characteristics: the distribution on a major trunk route carrying a large proportion of goods vehicles is unlikely to be the same as that on a farm-to-market road.

In the USA, the term 'daily' traffic has its normal meaning: the flow of vehicles passing a given location in 24 consecutive hours. The basis of American traffic observations is the quantity 'Average Annual Daily Traffic' (abbreviated to ADT), which is defined as the 'Annual average number of vehicles during 24 consecutive hours that pass a particular point on the road over the period 365 days'[3]. This term would seem to have a number of advantages not shared by the various 'm-hour' days. It is unambiguous, readily understandable, and corresponds with a natural period of human activity. Thus it eliminates those problems associated with variations in the hourly distribution of traffic in different locations. However, the most important advantage of the ADT concept is that it enables statistical methods to be applied to the problem of rural traffic counting. Generally, it would seem to be the most logical basis for traffic observations and is the one used in this analysis.

3. KENYA STUDY OF RURAL TRAFFIC FLOW

The objectives of the Kenya study were to provide the data necessary for a quantitative evaluation of current traffic count methods, and to allow various new counting strategies to be tested. The study can be separated into two stages:

(i) the measurement of the total pattern of traffic variation for a full year and the relation of this, if possible, to the level of flow, the type of road, and the economic and climatic characteristics of the region around each site: and

(ii) the statistical evaluation, using the results from (i), of optimum methods of counting traffic.

Observations were made from March 1968 to July 1970 using Fischer and Porter hourly recording counters at 26 sites, and from September 1968 to November 1970 using SYX-RRL non-recording counters - which were read daily by observers - at 12 sites. The sites were chosen to be representative of the general range of flow levels, road types, and climatic conditions found in Kenya.

4. ERRORS IN ESTIMATES OF ADT FROM SAMPLE COUNTS

Only where continuous counts are made under perfect conditions can a true ADT or total year's flow be computed with the expectation of its being absolutely accurate. It follows that any count of less than one-year's duration must be regarded as a sample, and the estimate of ADT or total years's flow made from it will be subject to error. The error of estimation is simply the difference between the estimated ADT and the true ADT. If the mean and the standard deviation of these errors are calculated, then probability analysis can be applied to determine, for a given level of confidence, how accurate an estimate of ADT is provided by a particular sample period or sampling procedure.

The method of error determination used in the analysis followed the above principles. For a given duration of counting, repeated samples were drawn from the actual flows recorded at each site in one complete year. From each estimated daily flow (ADT_E), the true value (ADT_T) was subtracted to give the error of estimate. The resulting errors were divided by ADT_T and multiplied by 100 to give the proportional error of estimate in percentage terms. This was done so that errors obtained at sites with different flow levels would be on a comparable basis.

Thus:

$$\text{proportional error of estimate} = 100 \left(\frac{ADT_E - ADT_T}{ADT_T} \right) \text{ per cent}$$

Finally the standard deviation and the coefficient of variation of the percentage errors were calculated.

4.1 Sample testing

The errors resulting from the following ADT sampling procedures were determined:

1. Random samples of 1, 2, 3, 4, 5, weekdays and 7 consecutive days for all possible periods in the year except those including a Public Holiday.

2. As in 1 for periods of 1, 2, 4, and 6 whole weeks.

3. Random samples of 1, 2, 3, 5 weekdays and 7 consecutive days repeated at regular intervals of three, four, and six months. To provide samples of a reasonable size it was necessary to group the sites by flow level as follows:

   Group 1 (ADT $<$ 75 vehs/day)

   Group 2 (ADT 76-200 ")

   Group 3 (ADT 201-600 ")

   Group 4 (ADT 601-1000 ")

   Group 5 (ADT $>$ 1001 ")

4.2 Desirable accuracy of estimates of traffic flow

To judge the results of the sample tests objectively, it is necessary to decide what level of accuracy estimates of traffic should attain. Specifically we must state within what range of error we wish our estimates of ADT to lie, and how certain we need to be that the estimates lie within the stated range. In the USA[3], the accepted standard is that there should be only a 1 in 20 chance (5 per cent level of probability) that the error of estimate will exceed ± 10 per cent at any sample count site carrying over 500 vehicles/day. For roads with lower flows, errors of up to ± 20 per cent are acceptable.

It might be felt that developing countries cannot afford such high standards as the USA, since, the more precise estimates must be, the greater the cost of obtaining them, However, it is considered that accuracy standards in developing countries should be similar to those quoted, and in fact should tend towards the higher of the two, even for roads with low traffic flows.

Whereas the use in the USA of lower accuracy standards of traffic counting for roads with low traffic flows is justified to some extent by the relative unimportance of such roads in the USA, the main aim of road improvements in most developing countries is progressively to upgrade earth and gravel roads to bituminous-surfaced roads, i.e. stage construction [4], when the level of traffic demands it. A reasonable standard of traffic estimation is therefore required even for roads with low traffic flows.

Lowering the confidence limits at which estimates are judged does not seem to be worthwhile since the results rapidly lose any real significance.

Until precise studies are completed of the cost-effectiveness of various methods of traffic counting and the sensitivity of the highway planning process to errors in traffic estimates, it will not be possible to specify desirable accuracy limits for developing countries. The USA standards will, however, serve as a criterion by which to judge the performance of estimating procedures elsewhere.

4.3 Practical limits to sample duration

The final point to be discussed before the results are examined is whether there are likely to be any practical limits to the duration of counting in developing countries. In this connection, the most critical consideration is whether counts will be made manually or by machines.

Experience of conditions in developing countries suggests that the great majority of counts will continue to be made manually. The use of automatic counters is at present uncommon and they are only gradually being introduced, mainly for the measurement of seasonal variation and long-term traffic trends. The more widespread use of automatic counters for general counting seems unlikely for some time to come since they are expensive to buy. Also, they require skilled supervision and maintenance if accurate results are to be obtained, and the necessary skills take time to acquire. Lastly, manual methods have the advantage of giving classified counts of traffic flow, and they may also be politically desirable because of the generally acute unemployment problems.

If manual methods of counting are used, then a one-week's continuous count is about the practicable maximum. Apart from the probable loss of accuracy caused by the boredom of the enumerators, longer counts at each point would reduce the coverage of the road system that was possible. In practice, many counts, although spanning seven days, will probably be for less than 24 hours on some, and possibly all, days. Night-time counts are unpopular and difficult to supervise effectively, especially in distant rural locations.

Cost-effectiveness considerations also indicate the need to keep the duration of counting as short as possible. Since wages are the main element, the cost of traffic counting can be assumed to increase in direct proportion to its duration. However, simple sampling theory suggests that the accuracy of the resulting ADT estimates is likely to increase in proportion to the square root (approximately) of the duration of counting, i.e. other things being equal, a count for four days will only double the accuracy of ADT estimation in comparison with that obtained from a single day's count, whereas the cost will have risen by a factor of four.

5. RESULTS

All estimate errors given in the results are at the 5 per cent level of confidence. Lower confidence limits 10 per cent (1 in 10 chance) or 20 per cent (1 in 5 chance), can be calculated by multiplying the results by 0.84 or 0.65 respectively.

5.1 Traffic variability and ADT

In the early stages of the analysis, it became apparent that the results were strongly influenced by the ADT at each sample site, so this effect was investigated first. The relationship between traffic variability and flow level is illustrated in Figure 1 which shows the coefficient of variation of daily flows (V) over a complete year, plotted against ADT.

From the Kenya data alone, it is clear that the coefficient of variation is inversely related to ADT - the curve has been fitted by inspection as a rough guide. A simple regression analysis based on the relationship,

$$V = \gamma \, (ADT)^{-\lambda} ,$$

where γ and λ are constants, showed that ADT accounts for approximately 55 per cent of the total variation in V. The implication is that, in Kenya at least, the main factor governing the variability of traffic is the average level of flow, and not the function of the road or the type of traffic it carries.

Excluding the most extreme of United Kingdom results, Figure 1 shows that traffic variability increases rapidly below flows of approximately 1000 vehicles per day. Partly this is a consequence of the law of small numbers: when the total flow is low a unit change has a proportionately bigger effect than when the total is large. Also, in practice, variation is inherently greater at low flows because the traffic stream is composed of fewer individual trip motivations, i.e. a flow of 20 vehicles per day on a given road may be motivated entirely by the travel demands of a small government administrative centre, a school, or a single agricultural enterprise. Any change in its activities, such as school holidays, or crop harvesting, can produce very large relative volume changes. Conversely, on roads carrying 500 or more vehicles per day, the trips are usually motivated by a wide range of activities whose operational variations tend to be mutually balancing. When the travel demand for one is high another will be low and vice-versa. Between these two extremes there is a gradual transition and one would expect a steady decrease in variation with increasing flow of traffic.

The increase in traffic variability below flows of approximately 1000 vehicles per day is significant because in many developing countries the majority of the rural road system carries daily flows less than this. In Jamaica (1964), Zambia (1964), and Kenya (1970), the percentages of the rural road system carrying less than 1000 vehicles per day were 95, 98 and 95 respectively [5]. Thus in developing countries rural traffic estimation is especially difficult because of the inherent variability of daily travel.

Generally the United Kingdom results do not exhibit any close relationship between traffic variability and flow level. Surprisingly, over a third of the United Kingdom results are characterised by a very much higher variability than equivalent sites in Kenya. It seems that the effects of climate in the United Kingdom, particularly snow, are much more disruptive than those in Kenya. Also, because the climatic contrast between winter and summer in the UK is very marked, sites located close to tourist or holiday centres are likely to experience larger relative changes in flow level than equivalent sites in Kenya. Inspection of the locations of sites in the United Kingdom showed that those sites with exceptionally high variability were located either close to tourist-holiday resorts or in areas likely to experience inclement weather.

5.2. Errors from random continuous counts of different durations

Table 1 gives the errors for ADT estimates obtained from random continuous counts of different durations. Generally, the errors in estimates fall as both the duration of counting and the ADT increase. There are, however, considerable variations between sites in the rates at which the errors decrease with respect to both the duration of counting and the ADT. Because of the magnitude of the variations, they are unlikely to be accidental and are probably related to site location and the function of the roads. To make the trends clearer, sites have been grouped into the five flow levels used for repeated sampling and the results averaged. Figure 2 shows that the errors in estimates fall rapidly as the duration of counting and the ADT are increased, but there is a marked decrease in the rate of fall when the duration of counting exceeds a week. This suggests that rural travel is dominated by weekly, rather than by daily or monthly activities. Another significant feature is the sharp fall in errors in estimates when the duration of counting is extended from five weekdays to one full week. As might be expected, the latter effect is more pronounced at the higher flow levels i.e. on roads that serve regional and district centres with distinctive weekend activities. Clearly, variations in flow at the weekend contribute significantly to total variability, and so if circumstances arise that allow only a count of 4 or 5 days this period should span the weekend rather than only weekdays. It should be recalled at this point that the suggested maximum practicable duration for a continuous manual count is one week (see 4.3). Figure 2 shows that large errors are associated with counts of only a few days' duration. The lowest flow-level group has errors in estimates ranging from $\pm$ 35 per cent for a one-week count to $\pm$ 62 per cent for a count of a single day. On roads carrying 1000 vehicles per day or less, errors in estimates are at best approximately $\pm$ 20 per cent for a one-week count and $\pm$ 30 per cent for a one-day count.

Clearly then, no practicable duration of random counting is likely to provide ADT estimates of an acceptable accuracy for the great majority of roads in developing countries.

5.3. Repeated random samples

Table 2 gives the errors for ADT estimates obtained from repeated random counts of different durations. The figures in brackets show the errors in estimates for continuous counts of equivalent durations. Inspection of the results suggests that the errors in estimates of repeated random counts are related to those obtained from single random counts. If a random count of duration d gives an error equal to $\pm x$, then repeating the count will reduce the error to $\pm \frac{0.94x}{\sqrt{n}}$, $(n > 1)$ where n is the number of repetitions (i.e. the errors from repeated counts are approximately proportional to the inverse of the square root of the overall duration of counting).

As might be expected, repeated counts give more accurate estimates of ADT than continuous counts of the same duration and the advantage increases with the number of repetitions. Also, repeating a count twice reduces the errors in estimates to approximately 22 per cent of their continuous count value, and repeating four times results in a 40 per cent reduction. However, only at the highest flow levels and for counts repeated four times do the errors in estimates approach the desirable standard of ± 10 per cent. Below traffic flows of 600 vehicles per day, repeating counts 3 or 4 times generally results in errors in estimates of between ± 10 and ± 20 per cent.

Because of organisational difficulties, repeated counts are unlikely to be regarded as a practical proposition for most data requirements, although they may be of use for one-off studies. Also they cannot generally be expected to produce estimates of a desirable accuracy.

5.4 Sampling errors for individual months

It seemed likely that random samples drawn from particular months might show errors considerably different from those drawn throughout the year. If a wet season falls consistently in a particular month and normal travel is likely to be interrupted by rain, then samples from that period can be expected to have higher-than-average errors. Conversely, other months, between seasons and away from Public Holidays, could have virtually constant near-average flows, and consequently very low sampling errors. To test this possibility, random samples were drawn separately from each month and the error in ADT estimate calculated as before. The results for one whole week are shown in Table 3.

There is considerable variation in errors in estimates from month to month. At any site, the ratio of the largest to the smallest monthly error has a range from approximately 2 to an exceptional 27. Generally, the ratio is in the range 3-12. Even at moderately high flow levels of 400-600 vehicles ADT, the maximum monthly error for one-week random counts can reach 48 per cent. In contrast, even at ADT's of less than 40 vehicles the minimum error in any month does not exceed 10 per cent. Generally, if the month, or months, could be predicted during which sampling errors were likely to be a minimum, then relatively short counts could produce ADT estimates of a high accuracy. Table 4 shows that counts for as few as three consecutive days have errors of 20 per cent or less if the observations are conducted during the month of minimum sampling error.

6. DISCUSSION

The magnitude of the errors clearly indicates the need for improvements in the methods of measuring traffic flow in developing countries. In considering how this might be done, it seems useful to examine the basis of methods of counting rural traffic in some developed countries.

6.1 Rural traffic counting in the United Kingdom

As mentioned in Section 2.4, rural road planning and design in the United Kingdom are based upon the average daily flow (7-day average, 6am-10pm) measured in August. Average factors are used to adjust any observations taken in other months to their August equivalent. August conditions are used as the basis for counting because average monthly travel demands have consistently been found to be at their highest then [1]. Although the method has worked satisfactorily in the United Kingdom, because it is based upon a 16-hour observation period it shares all the criticisms previously levelled at the other 'm-hour' counting systems. Furthermore, although the idea of conducting all counts during a single period of peak activity is attractive, the method does not seem suitable for use in a developing country, because it presumes that seasonal variations in traffic flow are the same everywhere, and remain so, year after year. Geographical considerations suggest that, in the mainly tropical or sub-tropical developing

countries, the climatic variations, and hence most of the likely traffic flow variations, are neither as simple nor as consistent as those experienced in the developed countries.

This suggestion is given some confirmation by Figures 3(a) and 3(b) which show the monthly patterns of flow variation recorded at 21 of the Kenya sites. No simple pattern emerges: the seasonal variation of traffic is highly variable both at individual sites and between sites. The causes of the monthly flow variations at each site and whether they recur are still being studied, but it is clear that the method of standardising traffic counts in the United Kingdom could not be used in Kenya, as there is not a single month when flows are near maximum at all sites at the same time.[

6.2 Rural traffic counting in the USA

As explained in Section 2.4, the object of rural traffic counts in the USA is to estimate ADT. When sample counts are made, usually for one or two consecutive days only, the results are adjusted to give ADT estimates, within the accuracy limits described in 4.2, by factors derived from a relatively small number of continuous counting stations called control stations. This procedure is based upon the fact that seasonal patterns of variation have been found to persist from year to year[3] on the same road sections and are similar:

(i) for long consecutive lengths of major road (ADT $>$500 vehicles) all of which are not necessarily on the same route;

and (ii) for all minor roads (ADT $<$ 500 vehicles) within a given economic (geographic) region.

Thus the seasonal patterns of traffic variation on all sections of road can be represented by those obtained from either 'route control stations' or 'area control stations'.

This system would seem to be the more promising of the two described as far as developing countries are concerned, but it would not be easy to implement. The present sophistication of traffic counting in the USA has been achieved only after many years of recording traffic flows. What is apparent is that the use of automatic traffic counters will be a necessary pre-requisite of any significant improvement in the accuracy of current traffic estimates in developing countries.

6.3 Use of automatic traffic counters in developing countries

When first introduced into developing countries, automatic counters should be operated continuously at fixed locations. These should be chosen to represent the major traffic routes and geographic areas; the method of doing this is described in a recent Report[5]. As well as monitoring long-term trends, the counter results will enable a study to be made of the magnitude, frequency, and causes of the day-to-day and month-to-month, fluctuations in flow. A clear understanding of these will enable methods of counting traffic to be designed along the lines indicated, so that ADT estimates of a prescribed accuracy can be made. After one or two years, additional counters could be obtained and a start made on the grouping of road sections according to their seasonal variation characteristics. In the USA seasonal variation counts are made for only one week in every month at a given location; with efficient organisation, a single counter can therefore cover four sites per year.

In the initial stages of such a system, there is no need for expensive makes of traffic counter to be used. The simple SYX-RRL Nos. 4A or 4B accumulating counter would be adequate and it costs approximately one-tenth as much as a recording counter. A recent report by the Road Research Laboratory describes the operation and maintenance of the SYX-RRL counters under tropical conditions[6].

7. CONCLUSIONS

1. Traffic counts in developing countries should seek to provide estimates of the Annual Average Daily Traffic (ADT) on a road.

2. If made manually neither simple random traffic counts nor replicated random counts of any practicable duration can provide estimates of ADT within desirable limits on the majority of roads in developing countries .

3. Any appreciable improvement in estimates of traffic flow in developing countries will require the use of automatic traffic counters operated continuously at fixed locations.

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TABLE 1

Errors in ADT estimates from random counts of varying duration (per cent)

ADT (vehicles)	Number of Weekdays					Number of Weeks			
	1	2	3	4	5	1	2	4	6
25	70.6	58.8	50.2	48.0	41.4	36.3	34.1	33.9	34.9
26	69.0	57.0	55.1	51.7	53.1	31.2	28.4	23.3	19.4
26	80.6	69.4	63.7	61.2	58.8	50.2	44.7	38.0	33.1
32	83.9	71.7	66.2	66.6	65.8	54.7	55.7	60.0	63.3
44	41.7	31.8	27.2	26.8	25.1	22.5	19.2	16.8	17.4
56	37.4	30.4	27.2	27.4	25.5	22.9	19.4	14.9	9.2
63	52.9	43.7	40.8	37.0	35.5	30.0	28.4	26.8	23.3
88	44.1	40.8	39.8	34.9	30.6	26.5	22.5	20.4	16.1
93	51.0	45.3	42.9	40.8	43.7	33.1	32.9	31.6	30.2
106	45.7	38.6	34.7	31.8	28.4	24.1	20.8	19.0	18.8
120	41.6	34.3	25.5	25.9	29.4	22.3	20.2	17.4	14.5
152	39.0	33.9	36.3	31.4	27.0	34.5	30.6	22.5	7.4
156	36.8	32.1	30.0	28.4	25.5	18.8	14.1	10.1	6.3
250	50.8	47.0	44.5	43.5	41.4	39.8	34.7	34.5	32.5
355	35.7	28.4	27.2	26.8	30.2	13.1	12.3	11.8	10.2
357	41.7	37.2	32.7	30.8	30.4	36.6	32.7	19.0	8.2
438	37.2	36.1	34.9	36.8	34.9	22.1	17.6	14.1	5.5
494	38.4	30.8	27.6	25.5	25.1	18.0	17.4	17.8	16.7
501	36.8	33.7	33.1	32.9	31.8	29.4	27.6	21.6	16.5

TABLE 1 (continued)

ADT (vehicles)	1	2	3	4	5	1	2	4	6
622	25.3	20.4	17.2	17.2	17.2	17.4	13.9	9.6	7.8
632	40.0	35.3	32.9	29.4	27.4	24.9	23.3	22.1	21.4
650	32.3	34.3	36.4	34.5	32.7	22.7	17.2	9.8	7.0
675	25.7	23.9	23.5	22.0	20.2	21.2	17.4	11.2	7.8
676	30.4	31.8	34.3	31.8	32.5	20.8	19.0	16.8	16.7
788	26.6	20.6	19.8	19.2	16.3	19.0	16.5	14.9	14.5
792	39.2	44.1	45.7	45.9	41.0	24.5	22.3	16.3	16.3
825	20.8	19.0	18.6	16.8	17.6	19.0	16.8	13.7	12.7
1109	24.5	21.8	19.4	17.8	15.3	16.1	14.3	14.7	14.5
1185	31.4	30.2	30.4	30.2	28.6	18.2	17.0	17.0	17.2
1250	35.3	28.0	26.7	22.0	21.2	15.3	13.5	11.0	9.6
1373	34.3	40.4	43.1	41.2	36.1	16.5	13.7	9.8	8.8
1751	30.0	27.2	26.5	25.1	22.2	18.0	17.0	17.8	17.4
1766	26.8	29.8	31.2	31.4	26.1	12.9	11.2	8.6	7.1
2846	31.2	29.0	28.4	29.0	27.0	16.3	12.7	7.8	6.9

TABLE 2

Errors in ADT estimates from repeated random counts of varying duration (per cent)

Flow level (vehicles/day)	Repetitions	Duration of counting				
		Number of weekdays				1 week
		1	2	3	5	
< 75	1	62.3	51.7	47.2	43.5	35.5
	2	46.6 (51.7)	36.4	31.4	28.8	23.5 (32.9)
	3	33.5 (47.2)	28.0	25.5	23.5	17.6
	4	25.9 (45.5)	24.3	22.1	20.4	16.1 (30.6)
75-200	1	43.1	37.4	34.9	30.8	26.6
	2	28.0 (37.4)	22.9	24.5	21.2	17.6 (23.5)
	3	23.7 (34.9)	18.6	17.4	15.7	14.3
	4	18.6 (32.1)	17.2	15.9	13.9	12.5 (20.2)
201-600	1	40.2	35.5	33.3	32.3	26.5
	2	32.7 (35.5)	27.8	25.1	21.6	17.6 (23.7)
	3	22.7 (33.3)	22.3	18.0	17.4	14.3
	4	21.8 (32.7)	20.2	15.7	15.1	12.5 (19.8)
601-1000	1	30.0	28.6	28.6	25.7	21.2
	2	19.2 (28.6)	15.5	17.6	17.0	13.9 (18.4)
	3	16.3 (28.6)	15.5	15.9	13.9	11.4
	4	14.3 (27.0)	11.2	12.3	12.2	10.0 (14.3)
>1000	1	30.6	29.4	29.4	25.3	16.3
	2	17.8 (29.4)	18.4	16.8	14.7	13.3 (14.3)
	3	15.7 (29.4)	15.7	14.9	12.9	11.8
	4	14.3 (29.0)	11.0	11.8	11.2	7.6 (12.3)

Figures in brackets are for continuous counts of an equivalent duration.

TABLE 3

Errors in ADT estimates from random counts of 1 week in different months (per cent)

ADT (Vehicles)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Average
25	48.8	15.9	27.4	13.3	10.0	27.0	7.0	23.9	21.4	17.4	27.2	26.1	36.3
26	31.8	22.5	8.4	23.1	33.3	18.0	64.3	22.3	25.1	38.4	34.7	35.5	50.2
32	13.9	40.6	39.8	28.6	23.3	11.8	9.6	14.1	14.5	14.1	18.8	12.9	54.7
44	10.8	4.9	16.1	15.9	11.4	21.8	9.8	12.0	13.1	7.0	18.4	5.7	21.8
88	6.9	12.0	25.3	14.7	36.1	11.8	11.0	21.6	14.1	15.5	17.6	23.9	26.5
93	10.0	8.8	12.9	5.5	18.8	6.1	9.0	10.8	31.0	26.6	20.8	45.7	33.1
106	23.9	22.5	34.3	12.3	17.8	6.3	7.6	16.3	14.5	20.8	30.0	15.3	24.1
156	18.2	6.7	10.0	31.4	28.0	5.5	12.0	6.3	20.2	5.9	11.8	9.8	18.8
250	11.0	8.4	8.0	17.4	8.6	18.8	9.2	5.7	18.0	19.6	45.5	18.4	39.8
349	6.7	9.6	9.6	5.9	5.5	7.0	5.5	7.4	9.2	8.2	9.2	8.0	13.1
357	9.2	5.3	8.2	11.0	78.0	4.3	9.2	23.5	4.3	2.9	10.2	17.6	36.6
438	10.8	4.7	13.9	5.3	9.4	4.7	5.1	3.5	10.0	10.4	7.8	28.6	22.1
494	6.7	9.0	28.6	12.5	8.4	6.9	6.5	7.6	6.9	16.5	9.8	14.1	18.0
501	13.7	3.3	8.6	19.8	11.2	5.1	8.8	11.6	9.2	7.4	10.4	48.0	29.4
622	9.0	3.9	38.8	4.3	7.4	12.2	4.3	15.9	10.6	20.0	17.6	6.7	17.4
632	8.6	6.9	8.0	13.5	5.1	21.2	8.4	18.4	25.5	25.9	7.0	9.6	24.9
675	17.6	10.8	6.1	5.5	6.3	14.7	8.0	3.7	13.1	14.5	5.7	15.9	16.7
676	7.6	4.1	6.3	3.7	8.0	2.4	17.2	17.4	9.0	4.3	19.0	15.3	20.8
788	15.5	2.4	6.3	3.7	9.2	6.7	12.9	6.9	5.9	6.5	8.2	30.4	19.0
792	6.1	10.2	9.2	5.3	11.8	6.1	21.8	8.0	11.0	35.5	7.6	8.4	24.5
825	9.0	8.6	7.4	7.4	9.0	3.7	6.9	5.5	6.5	10.2	8.4	20.0	19.0
1109	8.6	2.0	8.4	3.3	4.5	3.3	7.0	18.0	8.2	4.7	7.0	22.0	16.1
1185	3.9	8.6	8.2	4.3	7.8	8.6	7.2	8.2	17.2	6.1	26.6	10.0	18.2
1250	11.0	5.3	4.7	11.0	12.7	7.6	8.6	7.8	14.3	6.5	5.5	15.9	15.3
1751	17.2	10.8	4.3	3.1	11.4	4.9	9.0	5.9	8.8	10.0	5.9	19.2	18.0
2846	8.0	3.7	11.0	2.9	11.0	7.8	7.6	13.9	12.5	22.7	26.3	6.3	16.3

TABLE 4

Errors in ADT estimates from random counts of
3 consecutive weekdays in different months (per cent)

ADT (vehicles)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Yearly Average
25	82.3	17.0	33.3	23.1	19.2	21.2	21.4	39.6	22.5	17.4	29.0	64.7	50.2
26	42.7	37.6	17.4	31.0	54.5	36.1	103.7	38.4	23.5	38.6	35.1	38.0	63.7
32	31.8	54.1	71.0	52.7	31.0	22.7	20.0	21.4	31.4	33.1	31.9	30.0	66.2
44	17.2	10.2	20.2	18.8	14.3	32.9	14.9	19.0	23.5	19.0	34.5	18.6	27.2
88	13.9	25.1	37.2	33.5	54.9	23.1	15.3	28.0	19.2	42.7	20.6	19.0	40.2
93	13.5	16.7	17.6	15.1	30.6	13.1	14.7	14.1	33.3	41.9	35.9	49.2	42.9
106	22.0	32.1	51.5	17.2	30.6	16.7	16.1	18.8	16.7	17.8	40.2	29.0	34.7
156	21.0	6.7	9.8	54.1	42.3	12.0	19.4	14.1	19.6	12.9	17.4	10.0	30.0
250	28.8	25.1	11.4	14.9	19.6	30.2	13.3	10.6	25.5	25.1	65.8	42.9	44.5
349	8.6	14.5	13.3	8.8	9.0	11.2	10.2	14.3	13.7	15.9	13.5	15.3	27.2
357	12.3	9.2	13.1	33.5	69.6	4.9	11.8	31.4	6.7	6.7	20.4	17.0	32.7
438	18.8	13.5	16.1	6.9	7.8	6.1	7.4	8.0	14.1	20.6	11.4	53.9	34.9
494	7.6	13.3	29.4	11.0	7.8	12.9	13.9	14.5	12.7	24.1	18.8	32.9	27.6
501	11.8	5.9	10.2	23.5	14.7	5.9	12.7	18.4	15.7	12.9	8.2	53.7	33.1
622	12.3	10.0	28.4	9.6	16.8	6.5	8.6	24.9	15.1	14.5	20.8	17.2	17.2
632	10.8	12.5	11.0	19.2	6.3	23.3	10.8	18.8	29.4	38.6	13.7	15.3	32.9
675	20.4	7.8	6.1	18.2	10.6	22.9	13.7	5.1	18.8	16.5	8.2	25.7	25.1
676	4.9	4.5	9.2	6.7	8.2	3.9	22.7	31.0	8.2	4.3	20.0	29.8	34.3
788	15.1	5.5	6.7	12.0	18.0	12.9	13.5	7.8	7.2	18.6	11.6	28.8	19.8
792	9.0	12.3	9.6	13.9	11.4	10.0	25.9	11.8	12.2	35.5	9.2	22.0	45.9
825	15.3	8.4	12.3	9.8	8.6	6.9	10.4	5.3	13.1	12.2	10.4	11.4	17.6
1109	6.9	6.3	12.2	10.2	4.3	9.6	8.2	28.2	10.0	10.8	7.4	32.9	19.4
1185	7.2	8.2	4.9	12.9	6.9	7.8	10.6	14.1	18.8	7.0	25.5	32.7	30.4
1250	9.8	8.6	5.3	31.8	20.2	11.2	11.4	9.4	15.7	11.4	7.4	35.9	26.6
1751	19.0	13.7	5.1	17.0	10.4	8.2	14.9	9.0	11.4	16.3	6.3	28.4	26.5
2846	20.0	6.3	13.3	10.2	8.6	13.1	10.4	9.8	14.3	22.3	31.8	16.5	28.4

8. APPENDIX I

Questionnaire on national procedures for survey of rural traffic flow

COUNTRY	NATIONAL CENSUSES				GENERAL COUNTS			AUTOMATIC COUNTERS	
	Is there any form of national traffic census operating?	For how many hours and days are observations made during a survey?	How many surveys are made a year?	Are all classes of road covered?	For how many hours and days are observations made?	Is there any specific period, or periods, of the year when observations are made?	Does the Government set standards for traffic observations?	Are automatic traffic counters in use?	For what purpose?
COLOMBIA	Yes	24 hours a day for 7 days.	1	Only roads maintained by national Government (about 7 sites per year).	24 hours a day for 7 days mainly.	No.	Yes.	Yes.	As continuous counters at fixed locations.
CYPRUS	Yes	7 days continuously on some trunk roads; 92 hours spread over 5 days on others. 84 hours spread over 5 days on tourist and village roads, but varies from year to year.	3	Yes	Varies	Varied from place to place to coincide with local crop-harvesting period.	Yes	No	-
ETHOPIA	Yes	24 hours a day for 5 days.	3 Jan-April dry season; June-August wet season; Sept.-Dec. intermediate season.	All-weather roads built and maintained by the Imperial Highway Authority whether primary, secondary or feeder roads.	24 hours for 7 to 15 days.	No	Yes	No	-

APPENDIX I - continued (1)

COUNTRY	NATIONAL CENSUSES				GENERAL COUNTS			AUTOMATIC COUNTERS	
	Is there any form of national traffic census operating?	For how many hours and days are observations made during a survey?	How many surveys are made a year?	Are all classes of road covered?	For how many hours and days are observations made?	Is there any specific period, or periods, of the year when observations are made?	Does the Government set standards for traffic observations?	Are automatic traffic counters in use?	For what purpose?
GHANA	Yes	7 days 12 hours (6 a.m.-6p.m.) manually and 24 hours by automatic counter.	3 or 4 times a year.	Only primary and secondary roads.	16-or 24-hour counts for 1 week.	No.	No.	Yes.	As continuous counters at fixed locations.
IRAN	No	(one is proposed for 1971)			3 days 1st day: midnight-8 a.m. 2nd day: 8 a.m.-4 p.m. 3rd day: 4 p.m.-midnight.	Up to 2 times a year in each season	No.	To a limited extent.	
KENYA	Yes	12 hours (6 a.m.-6 p.m.) for 5 days in a week and 24 hours on the remaining 2 days.	4 February, May, August, November.	Yes	12 hours (6 a.m.-6 p.m.) for 7 days.	Wet weather and main annual social events avoided.	Yes	No	-
LESOTHO	Yes	12 hours a day for 7 days	Irregular	Mostly main roads.	12-hour 1 day counts.	No	No	No	-
MALAWI	Yes	1 day 12 hours manual and 24 hours automatic counter.	2 Wet and dry season.	Main and secondary roads only.				Yes	For short counts of one day's duration.

APPENDIX I - continued (2)

COUNTRY	NATIONAL CENSUSES				GENERAL COUNTS			AUTOMATIC COUNTERS	
	Is there any form of national traffic census operating?	For how many hours and days are observations made during a survey?	How many surveys are made a year?	Are all classes of road covered?	For how many hours and days are observations made?	Is there any specific period, or periods, of the year when observations are made?	Does the Government set standards for traffic observations?	Are automatic traffic counters in use?	For what purpose?
MAURITIUS	No	-	-	-	12 hours (6 a.m.-6 p.m.) for 7 days.	During sugar crop period July to December.	No	No	-
TANZANIA	Yes	72 hours	2	Yes	72 hours	No	No	No	-
THAILAND	Yes	New standards being introduced. All roads to be covered. Most counts 2 times a year, April and October, 8-hour counts (8 a.m.-4 p.m.) for 5 week-days. At a few sites 4 times a year January, April, July, October, 8-hour counts spanning 24 hours for a total duration of 3 weeks; i.e. an effective one-week count.			1 day 8 hours manual (8 a.m.-4 p.m.) and 24 hours by automatic counter.	No	-	Yes	In the past for short counts of one day's duration but permanent sites are to be set up.
TURKEY	Yes	Variable, majority are 1-day 8-hour counts. Some are for 24 hours 1 or 2 days.	8-hour counts usually 3 times a year but some just once or twice 24-hour counts repeated up to 15 times a year.	Only those which are the responsibility of the national highways department.	-	-	-	Only in urban areas.	-
UGANDA	Yes	24 hours a day for 7 days.	2	Only roads which are the responsibility of the Ministry of Works.	24 hours a day for 7 days.	No	Yes	Yes	For short counts of 7 days duration.

APPENDIX I - continued (3)

COUNTRY	NATIONAL CENSUSES				GENERAL COUNTS			AUTOMATIC COUNTERS	
	Is there any form of national traffic census operating?	For how many hours and days are observations made during a survey?	How many surveys are made a year?	Are all classes of road covered?	For how many hours and days are observations made?	Is there any specific period, or periods, of the year when observations are made?	Does the Government set standards for traffic observations?	Are automatic traffic counters in use?	For what purpose?
ZAMBIA	Yes	12 hours for 5 days in a week and 24 hours on the remaining 2 days.	Once a year in June.	Yes	Varies from 12 hours up to 7 days.	Dry season May-October	Yes	To a limited extent.	For short counts of 30 days duration.

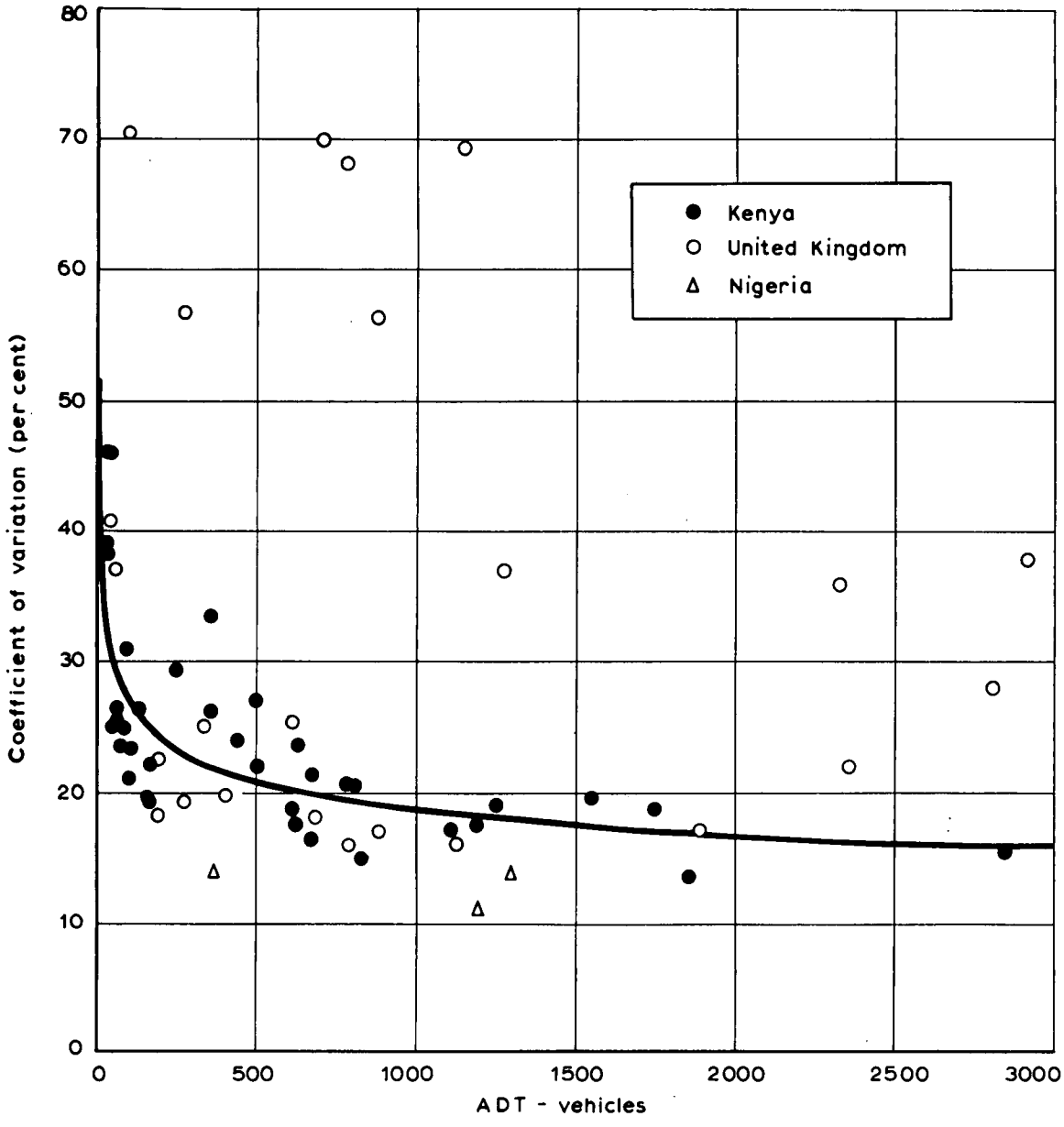

Fig.1. RELATIONSHIP BETWEEN DAILY VARIABILITY AND FLOW LEVEL

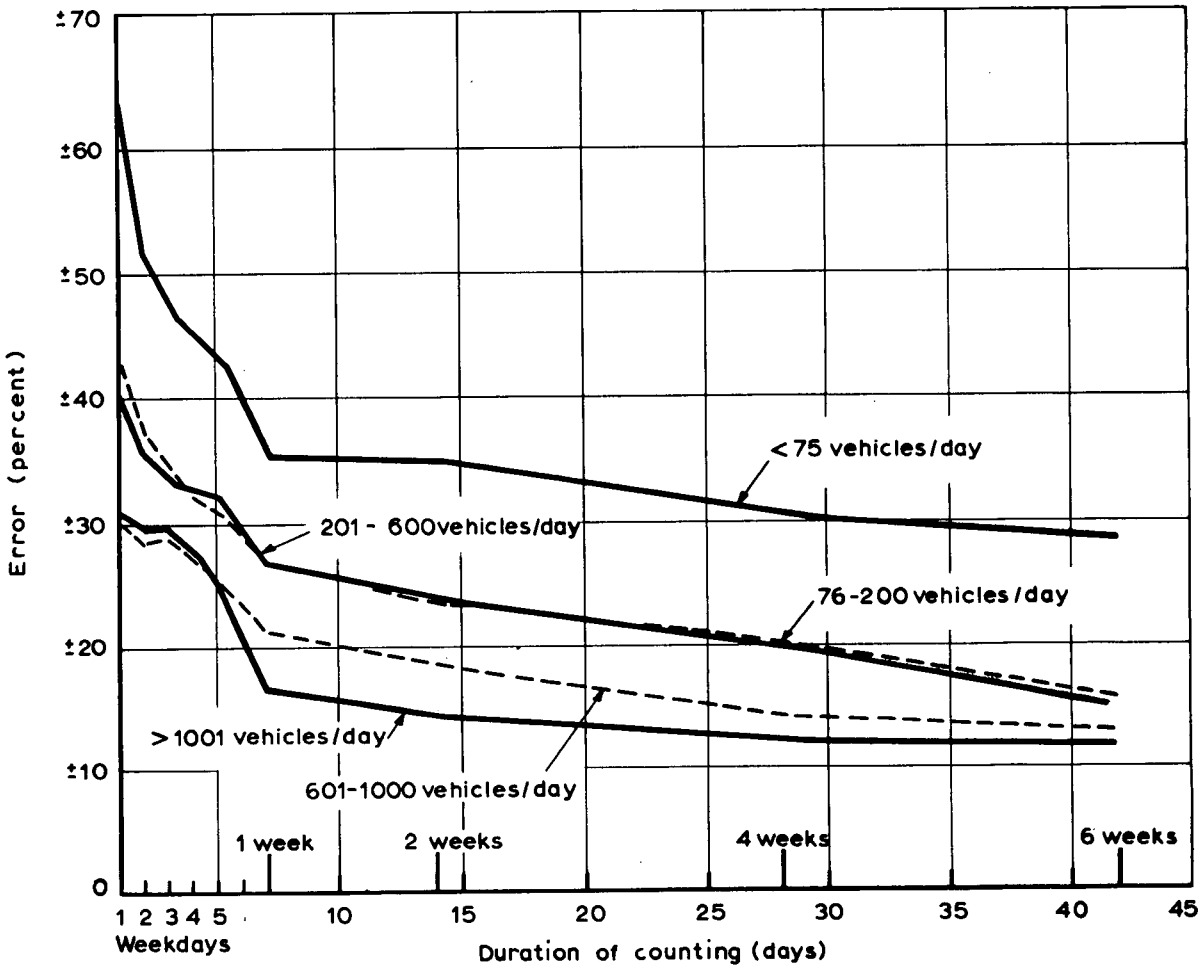

Fig.2. ERRORS IN ADT ESTIMATES FROM RANDOM COUNTS OF VARYING DURATION

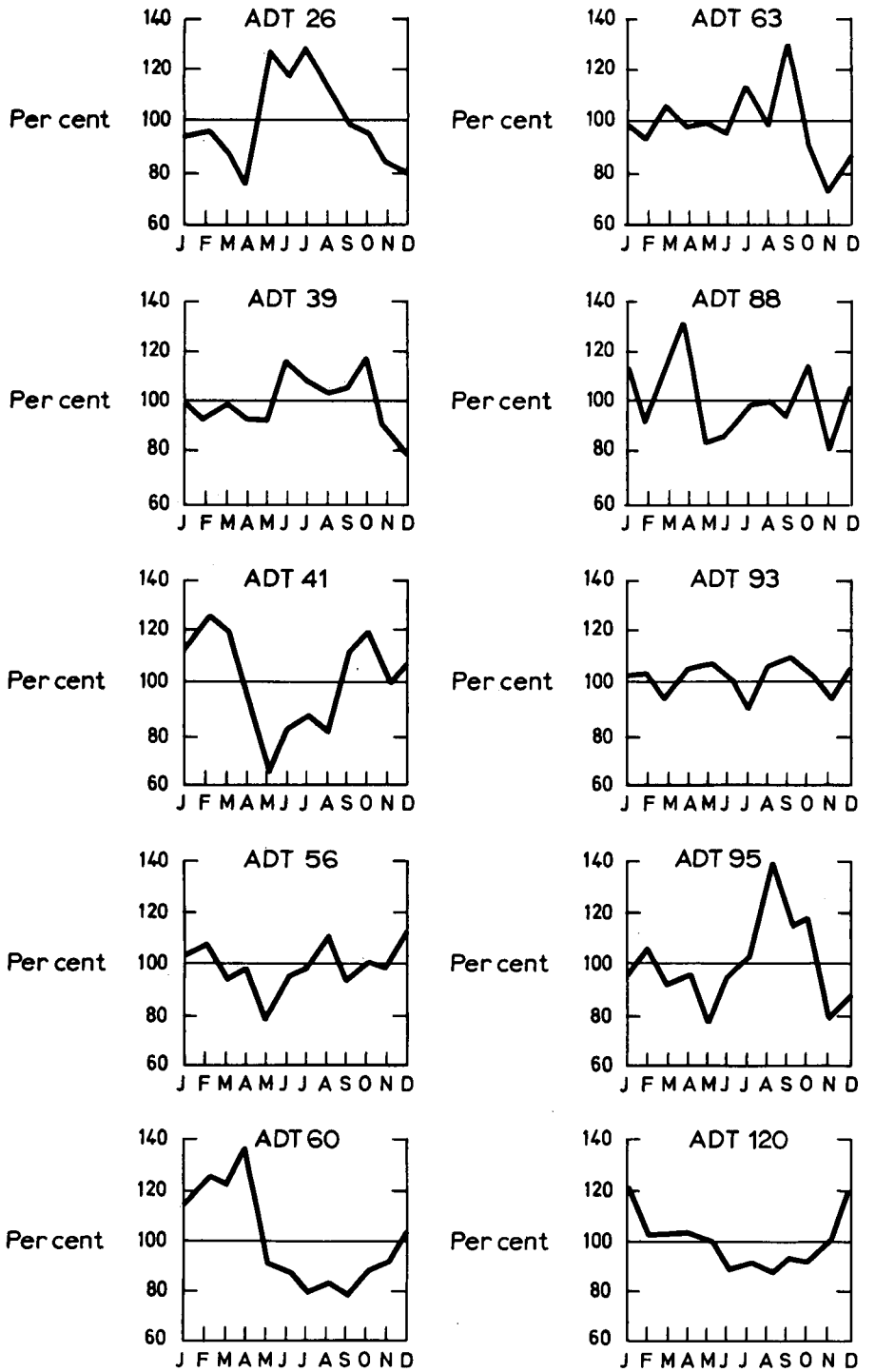

Fig. 3 (a) MONTH-TO-MONTH VARIATIONS IN AVERAGE TRAFFIC FLOW ON WEEKDAYS - KENYA (ADT 26-120)

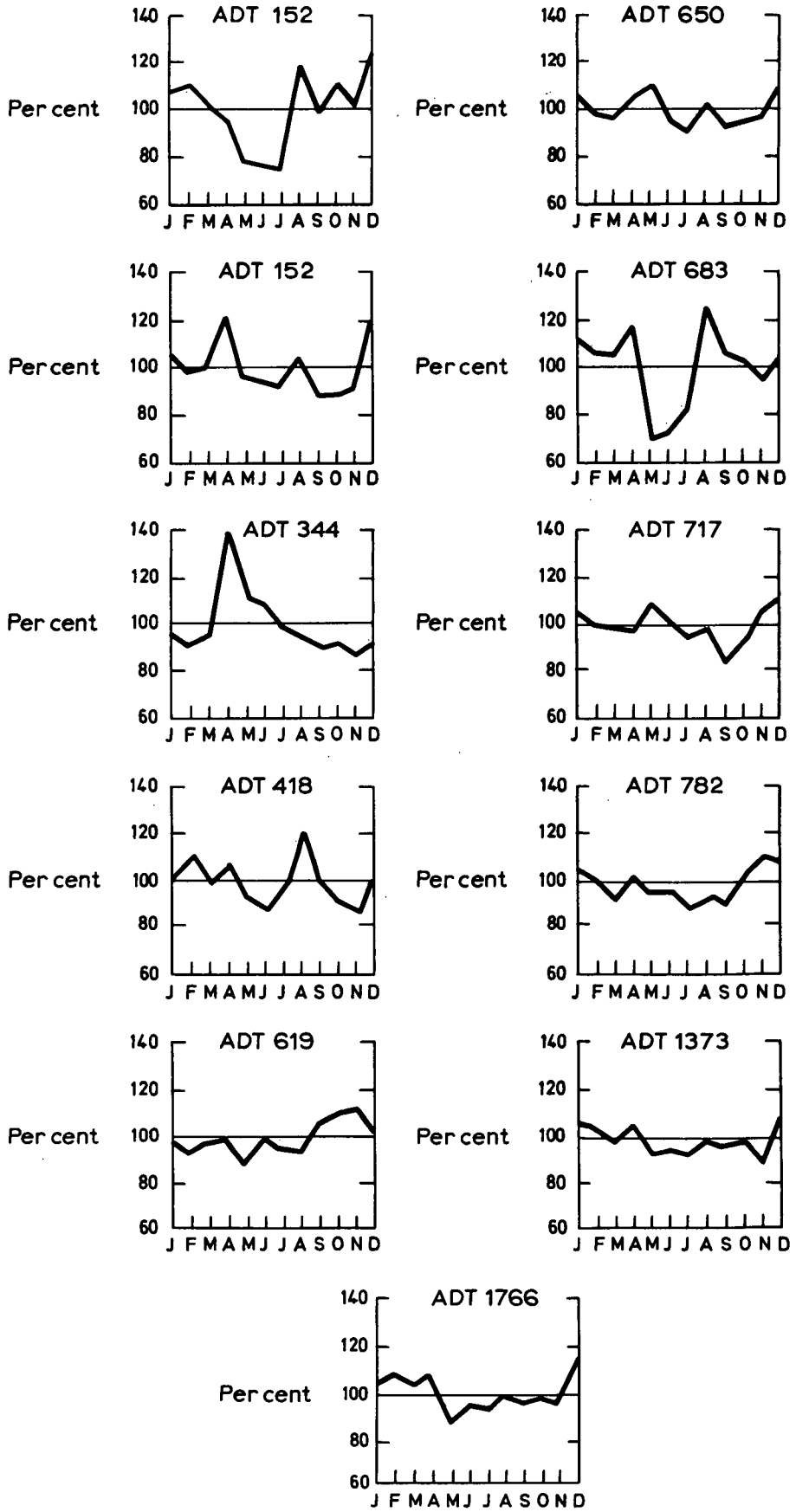

Fig. 3 (b) MONTH TO MONTH VARIATIONS IN AVERAGE TRAFFIC FLOW ON WEEKDAY - KENYA
(ADT 152-1766)

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ABSTRACT

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The results of a questionnaire survey among a sample of developing countries suggest that decisions on the duration, frequency, and timing of counts are at present arbitrary. Consequently, estimated daily traffic flows can rarely be expected to lie within ±30 per cent of the true value averaged over the whole year. Although repeating counts at intervals throughout the year increases the accuracy of traffic estimates, this is achieved only at a disproportionate increase in cost.

It is concluded that for any appreciable increase in the accuracy of rural traffic estimates much more needs to be known about the magnitude and causes of the variations in flow. This requires that automatic traffic counters be used on a wider scale than at present.

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