as a decrease in speed. Thus, the second group of signs did well on both awareness of the situation and reaction to it (because of other similarities among signs 4, 5, and 6, it is assumed that motorist response to sign 5 would have been similar to the response to signs 4 and 6).

A review of all of the analyses done reveals that differences among signs 4-6 were not always apparent or consistent. In general, however, sign 6 seemed to be the most effective in several instances. In a field application, however, the deployment of equipment for sign 6 would be quite complex. Sensing devices would be required on both side roads at a four-way intersection, and these devices would have to be linked to the sign several hundred meters down the road. In addition, failure of the sign could result in a serious situation at the intersection. A question thus arises as to whether the marginal increase in effectiveness is worth the additional cost of installation, maintenance, and risk associated with sign 6. It is my conclusion, based on effectiveness and anticipated cost, that either sign 4 or sign 5 would be a better choice than sign 6.

The overall conclusion of the experiment can be stated as follows: The regulatory speed-zone configuration (sign 4) and the continuously lighted VEHICLES ENTERING configuration (sign 5) appear to be superior to typical warning signs, such as the standard cross or plain VEHICLES ENTERING sign, in increasing motorist awareness of a hazard and inducing a physical reaction to it. Speed reductions in response to signs 4 and 5 appeared to be about two to three times those normally experienced with the more conventional signs, and awareness (as measured by sign recall and observation of the vehicle in the intersection) was increased by an overall factor of approximately two.

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Improving the Accuracy of Information on Direction Signs

H. J. WOOTTON AND R. S. BURTON

Recent studies in Great Britain have suggested that more than £700 million/year (£1 = U.S. $1.80) is being "wasted" by drivers traveling longer distances than are strictly necessary. Most drivers state that they are seeking the shortest or quickest route to their destination, yet studies show that only 50 percent achieve their stated objective. Direction signs and maps are the most common and simplest form of route guidance. An analysis of data collected in Gloucestershire suggests that 86 percent of travelers follow a route that is signposted, that less than 50 percent of the signposted routes are minimum-cost routes, and that to change the signs to make them indicate the minimum-cost routes would require 7 place-name changes/junction, 3 distance or route-number changes/junction, and 1 directional change every 6 junctions. The cost of modifying all the signs in Great Britain to provide more accurate information is estimated at £70 million, and the annual savings that are likely to result from this investment are estimated to be in excess of £180 million. It is possible that the annual savings in fuel and accidents alone will cover the total investment.

In the recent past, four independent studies in Great Britain (1-5) have suggested that in 1976 (in 1976 currency, £1 = U.S. $1.80) between £700 million and £960 million was wasted in terms of fuel, operating costs, and time by drivers traveling distances in excess of those that were strictly necessary. Although one of the studies (1) was able to suggest that some of the excess could be attributed to "limitations in maps and road signs", none of the studies were able to identify deficiencies in existing signing or propose improvements.

The purpose of the work reported in this paper was to determine the importance of existing direction signs in driver route choice, to identify deficiencies and propose improvements, and to estimate the costs and benefits to be obtained by improving direction signs. This study used an existing set of travel information from the British counties of Gloucestershire and Avon (4) that was originally collected to determine drivers' route-choice criteria in terms of time or distance. To these data we added information from the existing direction signs and analyzed all the data by using a

Table 1. Reasons cited by drivers for choice of actual route.

	Percentage of Sample Citing Reason					
Trip Purpose	Quicker	Shorter	Scenic	Antimotorway	Route Was Specified	No Known Alternative
Journey to work	76.0	11.4	0.9	0.1	0.5	10.4
Company business	73.6	9.3	3.5	1.0	2.8	10.0
Commercial vehicle	68.6	8.5	0.8	0.4	15.4	6.5
Leisure	47.9	10.3	28.8	1.5	0.8	10.9

Table 2. Driver inefficiency in choosing a route.

	Percentage of Drivers Who Achieved Their Purpose for Selecting a Route		Percentage of Cost in Excess of Minimum That Was Strictly Necessary
Trip Purpose	Quicker	Shorter	
Journey to work	50.3	57.3	6.5
Company business	50.3	36.2	5.0
Commercial vehicle	49.1	40.1	6.0
Leisure	49.6	54.0	8.0

special suite of computer programs--SIGNPOST--that had been developed independently as a spin-off from the traditional traffic assignment models. The results suggest that there are important deficiencies in the existing signs, that more drivers (86 percent) follow direction signs than satisfy any other route-choice criteria, and that the benefits gained in a few months from improving the accuracy and consistency of information on direction signs will cover the costs of improvement.

EXISTING STANDARDS FOR PREPARATION OF DIRECTION SIGNS

The information given by a direction sign should be clear and accurate. Over many years the content, design, layout, and siting of traffic signs have been carefully studied, and most countries have adopted standards to cover these aspects of signposting. Consequently, most direction signs give their information clearly.

In the United Kingdom, the Traffic Signs Manual (6) gives guidelines for the preparation of direction signs. On motorways the signs should have a blue background with white lettering, and on other primary routes the signs should be green with white lettering for names and yellow lettering for route numbers. On these primary routes, the Traffic Signs Manual encourages the engineer to select the place names from a published list of "primary destinations". It is suggested that the engineer select from the list of primary destinations a name of a place that is nearest to the sign and then ensure that the name appears on subsequent signs.

Other direction signs are used on nonprimary routes and for local signing. These nonprimary signs are white with black lettering and surrounds, and the place names that appear are usually those of significant towns. Any other direction sign gives very local information and is used to indicate small towns and villages or local features such as car parks, libraries, or railway stations.

In all direction signing, the traffic engineer is given no formal guidance on the direction to be signed and must also use judgment in interpreting other constraints, such as the number of names to be included on a sign. Confusion may arise where different authorities are responsible for different roads and, hence, different signs. It is not unknown for nonprimary or local signs to be placed on the same mounting as primary signs, increasing the list of names to be scanned, implying conflicting directions, and assuming that drivers understand the relevance of different colors. There seems to be no certainty that direction signs will be consistent or efficient in the route they suggest.

GLOUCESTERSHIRE AND AVON SURVEYS

In 1976, the U.K. Department of Transport commissioned a study to establish the criteria used by drivers in selecting a route for their journeys and the extent to which the route driven satisfied drivers' criteria. A survey was carried out in Gloucestershire and Avon in which 7009 drivers were interviewed. The sample was selected by calling at 68 different sites within the study area and interviewing drivers immediately after they completed their journeys. More than 60 of the sites were industrial establishments or offices employing significant numbers of people.

The remaining sites were recreational areas, beauty spots, wildlife parks, and similar areas that attracted leisure trips. The surveys were designed to collect equal numbers of interviews for each of four trip-purpose categories: journey to work, leisure, company business, and commercial vehicles. The information collected included the origin and destination of the journey, the journey purpose, the frequency of the journey (daily, weekly, monthly, occasionally, or first time), the reason for the choice of route (quicker, shorter, scenic, specified, antimotorway, or no known alternative), and details of the actual routes followed. All of the journeys recorded took place between the hours of 9:00 a.m. and 4:00 p.m. and were more than 3 miles in length. No information was collected about the values or use of direction signs.

At the same time as the interviews were carried out, the average journey speeds were measured (by using the moving-observer technique) along each of the links that made up the road network in the survey area. The lengths of the links were also measured. The data were then used to compare the routes actually driven with those that satisfied the drivers' criteria for route choice and other general criteria such as minimum generalized costs, distance, or time. The reasons given by drivers for selecting a particular route are summarized in Table 1 (5). The success drivers had in satisfying their desired criteria is given in Table 2 (5,8).

Table 1 shows that an overwhelming majority of drivers try to select the quickest route, that approximately 10 percent try to select the shortest route, and that 10 percent have no known alternative. The other important choices are scenic routes for leisure trips and specified routes for commercial vehicles. Almost 30 percent of drivers choose a scenic route for leisure trips, and an even higher percentage desire a scenic route if they are away from home on a holiday.

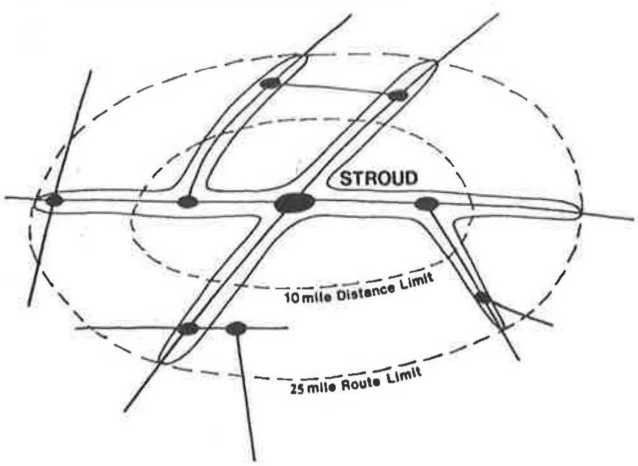
Table 2 demonstrates the inability of drivers to satisfy their own optimum criteria or the more general system criteria of minimizing generalized cost. Only 50 percent of drivers apparently

Figure 1. Example of output from SIGN program.

ENTERING NODE 125 FROM DIRECTION SE
(NODE 126) ALONG THE A 433

```
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
I                                               I
I    *                B4014                     I
I   ***    STROUD              ( A  46 )        I
I  * * *   NAILSWORTH            B4014          I
I    *     AVENING               B4014          I
I    *                                          I
I                                               I
I-----------------------------------------------I
I                                               I
I    *     DURSLEY               A4135          I
I   *                                           I
I  *****                                        I
I   *                                           I
I    *                                          I
I                                               I
I-----------------------------------------------I
I                                               I
I          CIRENCESTER           A 433      *   I
I                                            *  I
I                                        *****  I
I                                            *  I
I                                           *   I
I                                               I
IIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIIII
```

Figure 2. Distance limits for the town of Stroud.



followed a route that was the same as the minimum-travel-time route calculated from the measured average speeds in the network. A similar though more variable percentage of drivers were able to follow the shortest-distance route. The excess cost above the minimum generalized cost was calculated by comparing the weighted sum of the distance and average time along actual routes followed with the minimum weighted sum of distance and time between the origin and destination. The weights attached to the distance and time were those implied by the survey data and conform to the concept of generalized cost. The percentage of excess costs observed in this survey are entirely compatible with the estimates given in three other independent studies (1-3), which range from 5 to 6.5 percent.

SIGNPOST SUITE OF PROGRAMS AND PLACE NAMES

During 1975 and 1976, independently of the studies discussed in this paper, a series of computer programs was developed to select names for signposts by using minimum-cost, minimum-distance, or minimum-time routes obtained from a suitably coded network.

Table 3. Distance and route limits for place-name categories.

Level	Distance Limit (miles)	Route Limit (miles)	Category of Place Name	Example
1	10	50	Regional destinations and "super primaries"	Southwest London
2	10	25	Primary place names	Gloucester, Stroud
3	5	10	Motorways	Motorway (M4)
4	3	10	Market towns Local centers	Chipping, Sodbury Tetbury
5	2	5	Small towns and other important destinations	Avonmouth, Stonehouse
6	1	3	Villages	Westonbirt
7	0.5	1	Hamlets	Dodington

These programs provided the opportunity to compare the routes driven by drivers in Gloucestershire and Avon with the signposted routes and were an important tool in the further analyses we carried out.

Originally, there were three programs in the SIGNPOST suite, but during the analysis of the Gloucestershire data it was necessary to collect information on the existing signs, and a fourth program was added. The functions of the programs are as follows:

1. The ROAD program is used to define the road network and the place names. The network is defined to the computer as a series of nodes and links. Every intersection is defined as a node and is given a unique number. The sections of road between intersections (nodes) are the links, and the characteristics required are length, travel time or speed, class of road, the direction in which the link leaves a node, and the route number. Place names are attached to nodes and given a level in a hierarchy of names. Several names, each of a different level, can be associated with the same node. The hierarchical structure is intended to give a finer definition of places with decreasing distance.
2. The GROUND program prepares a file of existing sign data from user-supplied information on the places signed at each node. This file can then be compared with sets of signs prepared by the SIGN program. GROUND can also print a pro forma for recording an inventory of existing signs. This program was added to the suite during analysis of the Gloucestershire data.
3. The SIGN program selects the place names to be signed at each node (intersection) in the network. The program prints direction signs for each of the arms entering a node (see Figure 1); these signs show the places reached by leaving on each of the other arms. The program also prints confirmatory signs for each of the arms leaving a node. Minimum distance, time, or cost can be used as the basis for route selection, and names can be selected on varying distance limits. The program can also compare two sets of signs to assess the changes needed in direction signs following changes in the network.
4. The GUIDE program prints route instructions for a particular journey, including details of which arm to take at an intersection and names to follow on signposts.

All of the road network data for our analyses existed in the original Gloucestershire study except for directions, route numbers, and place names. The original road network comprised the roads used by the drivers interviewed in the surveys and

differentiated between trunk roads, principal A-class roads, other A-class roads, and unclassified roads. We reclassified these roads into primary roads and other A-class and unclassified roads because of the different standards for signs on primary routes and nonprimary routes. We also added a small number of nodes and links to give a proper representation of turning restrictions at some intersections.

The coding of directions was a straightforward process. The SIGNPOST programs allow the direction of each link of the network to be coded, as it leaves each intersection, to an eight-point compass bearing. To produce route numbers on signposts, the route numbers are added to the link descriptions. When one route number is temporarily replaced by another (the former often appearing in brackets), both route numbers are coded--e.g., A429 (A433).

To allow place names to be printed on the signs, the SIGNPOST programs require a name to be allocated to a node (intersection) in the network that most accurately represents its geographic location. Each name is given a "level" code to represent the importance of the name being signed. This allows a larger town or city to be signed from a greater distance than smaller towns or villages.

To illustrate the concepts of distance limits, Figure 2 shows how the town of Stroud, which is in the center of the Gloucestershire study area, will be signed at all intersections within 10 miles of the intersection designated as STROUD and how the limit is in this instance extended to 25 miles along continuously named routes that enter the Stroud area of influence. Since a name can be defined at any one of eight levels, great flexibility in naming is provided.

A list of place names was prepared from the names that were observed on existing signs so that a set of "idealized" signs could be produced. In a number of cases, the network was too coarse to include all of the place names that appeared on existing signs. Modifying the network to accommodate these place names was not considered feasible because the network would no longer have been compatible with the route data in the driver interview file. The final selection of place names, levels, and name structures was influenced by the type of sign on which they appeared. Thus, names in the list of primary destinations were always included and were assigned a higher level, and thus greater importance, than place names that appeared on nonprimary and local direction signs. The final classification, together with the distance and route limits, is given in Table 3. In all, more than 200 place names were included in the study-area network.

SIGNPOSTED ROUTES

The original surveys in Gloucestershire and Avon did not collect information on existing direction signs, nor were drivers asked specific questions about their use of signs. During 1978, this situation was partly remedied by making an inventory of the information on existing direction signs in part of the Gloucestershire study area. Only roads and intersections that were included in the road network were surveyed, and it was assumed that there had been no changes since the original survey data were collected in 1976.

The main objectives of collecting the signpost data were (a) to determine how well the actual routes were signposted, (b) to determine inconsistencies in the existing signs, (c) to prepare a set of idealized direction signs, (d) to compare the idealized signs with the actual signs, and (e) to establish the cost-effectiveness of implementing the idealized signs.

To determine how well drivers' actual routes were signposted, it was necessary to construct a file of equivalent signposted routes for each journey. A sample of 508 journeys was selected, and an approximately equal number were analyzed from each of the four journey purposes. The place name that corresponded to the destination was identified for each journey, and a search was made for this name in the existing signpost inventory at each intersection along the driver's actual route. If the name was found and the direction indicated on the signs was the same as the route chosen by the driver, it was assumed that the route driven was also the signed route. Alternatively, if the existing signposts indicated a different direction for that place name, the intersections on the driver's actual route were replaced by the intersections on the signed route until the destination point was reached. In some cases, a partial deviation from the driver's route was effected, whereas in others the whole route was modified.

For destinations represented by local place names, the signs frequently failed to mention the appropriate name at the start of the journey. In such instances, it was assumed that the driver would have looked for an associated "higher-order" place name to help find his or her destination--for example, a name on the list of primary destinations. Hence, if the destination place name was not signed at the origin, an appropriate alternative name was established from the route actually taken by the driver.

As well as recording the routes indicated on the existing signposts, two additional characteristics of the signposted routes were noted. These were the number of intersections on each journey that were without signposts and the number of changes of place names required before the destination was finally reached. The former served as a measure of the completeness of the current signposts, and the latter provided an indication of the complexity of the existing signs.

The results show that there is little difference between the actual and signposted routes; i.e., 86 percent of the journeys in the sample were the same. For the sample, there were an average of 2.6 intersections/trip without signposts and 1.8 place-name changes/trip. The average trip length was 10.8 miles, which means that there was one intersection without signs every 4.2 route miles and one change in place name every 5.9 route miles.

Tables 4 and 5 compare the actual and signposted routes in more detail. The astute reader will, of course, have noted that, in determining the signposted route, the actual route was used as a guide in selecting the place names. The reader may therefore not be surprised that such a high proportion of the signposted routes are the same as the actual routes (Table 4). However, in the case where the destination place name is signposted from the origin--the case of no change of name in Table 4--the driver who uses signposts is bound to follow this name. In this case, more drivers followed a route that was signposted than in any other case (95 percent) and, in percentage terms, they also incurred greater excess cost (13.4 percent).

Table 5 also has important repercussions. It not only suggests that drivers are strongly influenced by direction signs but also questions the assumption made in transportation planning studies for more than 25 years: that drivers follow a minimum-path route.

Table 4. Comparison of actual and signposted routes by number of place-name changes and excess cost of signposted route over minimum-cost route.

No. of Changes of Place Name	No. of Trips in Sample	Actual Routes the Same As Signposted Routes No.	Actual Routes the Same As Signposted Routes Percent	No. of Signposted Routes the Same As Minimum-Cost Routes	Percentage Excess Cost of Signposted Route over Minimum-Cost Route
0	102	97	95	41	13.4
1	135	119	88	99	3.5
2	121	103	85	63	5.6
3	87	74	85	26	8.0
4	34	28	82	5	5.0
5	19	10	53	4	7.9
>6	10	7	70	2	7.1
Total	508	438	86	240	7.1

Table 5. Comparison of actual and idealized routes for a sample of 508 journeys.

Trip Purpose	Number of Journeys in Sample	Percentage of Actual Routes the Same as Signposted Route	Minimum-Cost Route	Minimum-Time Route	Minimum-Distance Route
Journey to work	128	78.9	55.5	60.9	74.2
Leisure	125	84.0	32.0	36.8	41.6
Company business	129	93.0	45.7	50.4	65.1
Commercial vehicle	126	88.9	60.3	65.1	72.2
All	508	86.2	48.4	53.3	63.4

COMPARISON OF EXISTING AND IDEALIZED SIGNS

The SIGNPOST suite of computer programs allows the user to prepare a set of idealized signs that conform to given criteria. Three sets of idealized signs were therefore created that conformed to minimum time, distance, and cost criteria. Our purpose was to look at the difference between such idealized signs and the existing signs. The following is a summary of the findings for the minimum-cost idealized signs.

Of 250 intersections in the Gloucestershire and Avon study area, at 204 intersections (82 percent) there were differences between the signs, and at 46 intersections (18 percent) a comparison was not possible because there were no "existing" signs on any arm of the intersection.

The classification of differences at the 204 intersections was as follows:

Category	Total Changes	Changes per Intersection
Change in place name	1417	6.95
Change in direction	35	0.17
Distance and route change	647	3.17

There is a general pattern of above-average changes for intersections in urban centers, particularly Gloucester, and below-average changes elsewhere in the rural areas. The signs on the A38 between Bristol and Gloucester also exhibited above-average changes. The number of intersections with more than 12 place-name changes are almost all confined to the city of Gloucester.

Although it is difficult to establish a definite pattern, the tendency is for sets of signs at intersections in rural areas, away from the primary road network, to experience a net gain in names and for signs at intersections in urban centers and on the primary road system to suffer a net loss in names. In the existing system, rural signs generally have fewer names on them than signs in urban areas and on primary roads; the idealized system balances out the differences to provide a similar number of names on all signs.

A further method of comparison involved the plotting of place-name trees for various places in the study area. A circle representing the distance limits for each place name was drawn on a network plan, and the signing of that place name was investigated at each intersection within the area. If a place name was signed at an intersection, a line was drawn along the link in the direction indicated. This was done for both the existing and idealized systems and allowed gaps in the existing system to be identified and a comparison to be made visually between the two signing systems. Figure 3 shows the place-name trees for Nailsworth, for which the distance limit was set at 2 miles and the route limit at 5 miles in the SIGNPOST programs.

The overall conclusion is that implementation of an idealized system of signposts may involve changes in most of the signs in the study area. There will be an average of seven place-name changes per intersection, intersections in rural areas will tend to involve fewer changes than average, and intersections in towns and on primary roads will tend to involve more changes than average. In general, the occurrence of above-average changes is coincident with a net loss in place names.

BENEFITS AND COSTS OF INSTALLING AN IDEALIZED SET OF SIGNS

The results obtained from the Gloucestershire and Avon surveys allow a simple cost-benefit appraisal to be made of implementing an idealized system of signs throughout Great Britain. The potential benefits to drivers of following minimum-path routes can be expressed as savings per vehicle mile. The total savings for Great Britain as a whole are then estimated by multiplying the savings per vehicle mile derived from the Gloucestershire and Avon surveys by the total miles traveled in Great Britain.

It seems extremely unlikely that all drivers will be persuaded to follow signposted routes or that the minimum-cost routes are ideal. The maximum savings of £960 million/year must be regarded as unattainable. To make an estimate of the likely savings, it

Figure 3. Place-name trees for the town of Nailsworth.

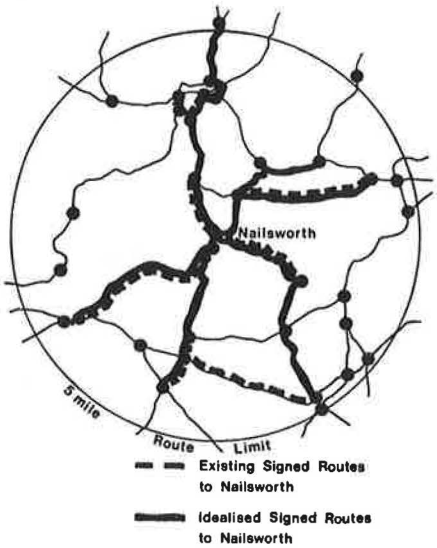


Figure 4. Comparison of potential savings and costs of introducing an idealized system of signs.

	Potential Annual Savings (£ millions)	Required Compliance by Drivers (%)	
	960	100	
	900	96	
Maximum Possible Saving -	780	90	
	700-------------	86	- Observed Compliance
	600	80	
	500	75	
	400	70	
	300	64	
Minimum Likely Saving -	180	58	
Maximum Fuel Savings -	117	55	
	100	54	
	70-------------	52	- Costs of new Signs
Maximum Savings from Accidents -	55	51	
Minimum Fuel Savings -	27	50	
Minimum Savings from Accidents -	12	49	
	7-------------	49	- Req'd Rate of Return

is necessary to make assumptions about the way drivers behave and/or about the routes to be signposted.

If it is assumed that 86 percent of drivers follow the direction signs, which is the percentage observed, then the maximum possible savings are £700 million/year. At the other extreme, the minimum likely savings seem to be £180 million/year. This minimum estimate assumes that minimum-distance routes are signposted and only drivers whose route-choice criteria--perceived or required--are the same as the signposted routes will follow the routes. An independent estimate of the likely savings has been made by Jeffrey and Taylor (8). They suggest that the likely savings are £215 million/year at 1976 prices plus a saving of £15 million/year from a reduction in the number of accidents.

Obviously, other criteria could be used to determine savings. For example, the vehicle mileage associated with the specific use of bypasses could be excluded from calculations, and other policy issues could be considered. From the many assumptions and calculations we have made, we doubt that the savings will be less than £180 million/year and, as will be seen later, any significant error in this figure is not critical in considering the return on any investment.

An estimate can also be made of the cost of modifying the signposts in the Gloucestershire and Avon study area. This estimate is almost £400 000 and requires completely new signs at 46 intersections and modified signs at 204 intersections. Given that the Gloucestershire and Avon study area comprises some 500 miles^2, and assuming that the density of the network, and therefore of signposting, is similar for the whole country, the equivalent cost for improving signs throughout Great Britain is of the order of £70 million. It must be emphasized that this calculation of costs is crude, since it makes other sweeping assumptions about the size of signs and the number of legends to be replaced. However, two important observations can be made:

1. A return of 10 percent/year on an investment in a new road scheme would be considered good. Even if there are substantial errors in the estimates of potential savings and the cost of improving signs, the return is likely to be very much higher than that normally required for an investment of this type. It is even possible that the cost will be covered by the annual saving in fuel alone. The results are summarized in Figure 4.
2. The cost is already being incurred during the normal course of maintaining signs. All that is required is to introduce the systematic procedures offered through the computer program to begin the improvement immediately.

CONCLUSIONS

The work discussed in this paper has suggested the following conclusions:

1. Drivers are not very successful at finding a route that satisfies their criteria for route choice. More than 75 percent of drivers are trying to follow the quickest or shortest route, yet only about 50 percent achieve these stated objectives.
2. More than 86 percent of drivers followed a route that was the same as the logically signposted route. If there is no change of name on the signposts between the origin and destination of the journey, 95 percent of drivers follow the signposted routes.
3. Implementing a set of direction signs that indicate minimum-cost routes would require approximately 7 place-name changes/intersection, 3 distance and route-number changes/intersection, 1 directional change every 6 intersections, and the construction of new signs where no signs currently exist at 18 percent of all intersections.
4. The total waste, in terms of fuel, operating costs, and time, incurred by drivers in Great Britain in using routes that cause them to travel a greater distance than is strictly necessary is estimated to be between £700 million and £960 million/year (1976 prices).

5. It is estimated that, after one accounts for drivers who are unlikely to follow signposted routes, the potential savings in Great Britain are at least £180 million/year and could be £700 million/year if 86 percent of drivers continue to follow the direction signs.

6. The cost of modifying signs throughout Great Britain to conform to the idealized set is estimated to be at most £70 million at 1979 prices (in 1979, £1 = U.S. $2.12). This implies that, even if there are gross errors in the estimates, an investment in improving the accuracy and consistency of direction signs is likely to be one of the most worthwhile transportation investments that can be made at the present time in Great Britain. It should also be noted that the savings in fuel costs or accidents alone can more than justify the investment based on normally accepted rates of return.

QUESTIONS THAT REMAIN

There are obvious and perhaps important deficiencies in the work we have done. We have not studied important questions of policy. For example, the requirement that forces heavy lorries to use a bypass rather than drive through the center of a small town has been ignored in creating the idealized set of minimum-cost signs. Some of these questions will be answered in a new study that is just commencing and that will examine the practical problems associated with installing the idealized signs and the policy issues this raises.

On the other hand, the results that have been obtained are sufficient to raise questions about existing signing practices and policies, not only in Great Britain but also in other countries. We have no doubt that there are substantial savings to be made by improving the accuracy and consistency of information on direction signs. Achieving accuracy and consistency requires a review of existing standards (for example, what names and route numbers should appear on signs and to what extent). It also requires more discipline in determining the content of signs than is obtained from "back-of-the-envelope" designs, a phrase that we have all too frequently heard in discussions.

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The SIGNPOST suite of programs discussed in the paper was developed by Wootton, Jeffreys, and Partners and has been purchased by the Department of Transport for use throughout the United Kingdom.

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Experimental Evaluation of Delineation Treatments for Special-Use Lanes

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Results of a laboratory evaluation of 18 buffer-zone treatments designed to delineate special-use lanes on highways and arterials are reported. A slide presentation using a paired-comparison technique and a questionnaire were administered to 40 drivers to determine whether various delineation designs had any inherent permissive or prohibitive meaning and effect for driver entry into a given lane. The impact of several design parameters on the prohibitiveness and permissiveness of the various designs was evident: Any design that had repeated openings was clearly more permissive than treatments that included a continuous line, the stroke width of lines appeared to be relatively ineffectual, and colored treatments were somewhat more prohibitive than white ones, though by relatively small amounts. Questionnaire data were collected to supplement the paired-comparison data, and a Spearman rank correlation coefficient of $r_s = 0.93$ indicated that the results of the two methods were highly complementary. Several design characteristics, including delineation width, effect of spacing or density of design symbols, and driver perception of where the vehicle can be stopped relative to the delineated special-use lane, require further definition and study.