The Experience of Developing and Providing Driver Route Information Systems

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BACKGROUND

The contents of this paper draw upon the experience of developing several driver route information systems over a period of 10 years. We were first concerned with improving the information given on direction signs and this was quickly followed by the development of systems for providing route information for individual journeys. Subsequently these developed into an autonomous in-vehicle route guidance system as early as 1980 and systems which have allowed automobile clubs to automate the route information services they provide to members.

The future also offers exciting prospects. We are involved in the Autoguide trial in London and look forward to using the two-way communication features of this system for improving traffic control.

DRIVER'S NEEDS AND BEHAVIOUR

Common sense suggests that drivers are influenced by information from a variety of sources in selecting the route they travel. Sources of information such as maps, signs, personal knowledge, experience and hearsay play an important part in selecting the route. The impact that each of these sources of information has on route selection can not be easily quantified, studies [1] and experiments [2] have suggested that there are limitations in maps and road signs that result in excess mileage being driven. The implication being that the information given to drivers influences their choice and behaviour.

Interviews with drivers suggest that a minority, about a quarter, have some difficulty in planning a route. The great majority say that their journeys are repeated. They feel they know the route that is travelled well or that their experience is such that they can overcome any route planning problems that they encounter.

Several studies have asked drivers the criteria they use for selecting a particular route. Table 1, taken from a survey [3] in the United Kingdom, is typical of the results that are obtained. The overwhelming majority, about 70%, of drivers are trying to select the quickest route, with approximately 10% trying to select the shortest distance route and another 10% having no known alternative. Other important criteria are scenic routes for leisure trips and specified routes for commercial vehicles.

Table 1. Reasons given by drivers for choice of route

	Percentage of sample					
Trip purpose	Quickest	Shortest	Scenic	Ani-motorway	Specified	No known alternative
To work	76.0	11.4	0.9	0.1	0.5	10.4
Firm's 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. Drivers' inefficiency in choosing a route

	Percentage of drivers achieving their reason for selecting a route		Percentage excess cost above the minimum that was strictly necessary
Trip purpose	Quickest	Shortest	
To work	50.3%	57.3%	6.5%
Firm's business	50.3%	36.2%	5.0%
Commercial vehicle	49.1%	40.1%	6.0%
Leisure	49.6%	54.0%	8.0%

Table 2, from the same survey, clearly demonstrates the inability of drivers to satisfy their desired criteria. Only 50% of drivers seeking either the quickest or shortest routes succeed in finding the route they desire. The inefficiency introduced by travelling a time longer or a distance greater than desired has been estimated[1] to be between 4 and $6\frac{1}{2}$ percent of total travel costs. A substantial part, around a third, of the inefficiency is thought to be concerned with the "terminal search", the problem of finding the exact location of the destination. Consequently the best driver route information systems need solve the terminal search problem by giving more detail as the destination is approached.

Table 3. Comparison of actual and 'ideal' routes

	Percentage of actual routes the same as		
Trip purpose	Planned route	Min. time route	Min. dist. route
Journey to work	78.9	60.9	74.2
Leisure	84.0	36.8	41.6
Employer's business	93.0	50.4	65.1
Commercial vehicle	88.9	65.1	72.2
All journeys	86.2	53.3	63.4

Further analysis of the survey compared the actual routes driven by drivers with a "planned route" obtained by consulting a map and the direction signs found on the roads. The results in Table 3 show that there is little difference between the actual and planned routes, 86% of routes being the same. Far more of these planned routes are the same as the actual routes than either the minimum time or minimum distance, which puts into question the assumptions made in transport planning studies for more than 25 years that drivers follow a minimum time, distance or cost route.

The quantitative and qualitative evidence suggests that the majority of drivers respond to the information that is given. If the driver can be provided with accurate information on the quickest route to follow the majority of drivers will obey that information. If the route that is given is better than the driver currently follows, the driver will obtain a benefit and the community will benefit from fewer miles being driven implying fewer accidents and less pollution. If information can be obtained in real time, for example on traffic incidents or congestion, then drivers might be advised of new routes to follow to their destination with the consequent reduced travel times and better use of the capacity of the road network.

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COMPONENTS FOR ROUTE INFORMATION SYSTEMS

Route information systems have three major components;

i) The product given to the driver. Products vary from simple maps to sophisticated electronic equipment installed in the vehicle.

ii) The infra-structure needed to create and maintain the currency of the information required by the product. All of the products of which we are aware require a map identifying the roads that can be used. In addition information on road markings, traffic signing, incidents and traffic conditions may also be required. The information is usually coded so that it can be stored on computers and presented to drivers as required. Most of the cost of providing a route information service is spent on creating and maintaining the information.

iii) Communication of the route to the driver. This again can take many forms. With pre-trip route information systems communication might be by post, telephone or similar means, whereas en-route trip information systems can demand a complicated communication infra-structure providing two-way communication between vehicles and central control.

MAPS

Every route information system needs information about the roads that the vehicles can use. Maps are the most common sources of this information for current computerised information services. The information that can be obtained includes class of road, distance between intersections, horizontal profile, places of interest, place and street names. The accuracy of this information depends upon the scale of the map and the time at which it was collected. Some important information, such as travel times, one-way streets and prohibited turns, may not be available from maps and has to be obtained by driving the roads that are to be used.

There are several sources of maps. Atlases and maps published by automobile clubs, state/provincial departments of transport and commercial organisations specifically for route finding usually contain information at three levels, overview, general, and detailed insets of urban or special areas. They also include an index or gazetter of places marked on the maps. For each of these levels the cartographer has made decisions on which roads to include and how to emphasise some routes over others. A driver using the map to plan a route can only use the information given by the cartographer and interpret it in the light of experience gained by using the information.

Topographical maps produced by national mapping agencies (eg. Ordnance Survey in Britain, United States Geological Survey or Canada Map Office) are an alternative source of route information. These maps are not designed specifically for route finding but often provide the best source of detail at the start and end of the trip. The aim of the cartographer in topographical maps is to give an even representation of the area being mapped rather than to highlight particular details of the road system. The disadvantage of using topographical maps for route planning are their size, number (over 500 maps at 1:250000 scale to cover USA), lack of index and their low frequency of updating.

Maps are a static source of route information, they represent the road system at the time of publication, with perhaps a few roads marked as opening in the coming year, and are only updated by purchasing the next edition a year or two later. They require skill and experience by the user to estimate the best route, generally giving little information on journey times. They do have the advantage over other pre-trip route information systems that routes can be generated on demand by the user and that routes can be modified while the trip is underway.

The name of a town or district in a city is usually insufficient to locate the drivers precise destination. A more precise method of locating the destination and of determining where a vehicle is relative to the map is required. Cartographers have solved this problem by two methods, the first a system of cartesian coordinates, as for example the UK's system of grid references, and the second a system of polar coordinates, as for example in the universally used system of longitude and latitude. Whilst these systems provide a means of locating a point on a map or the earths surface, they are not universally understood by drivers and a computerised route information service needs to construct indexes that relate an address to the map referencing system. The addresses can take the form of zip codes, a house number and street name, the intersection of two-named roads or even the distance along a street from a named intersection.

The task of digitising and maintaining accurate map information and the creation and maintenance of the necessary indexes is enourmous. Most of the cost of providing a computerised route information service will be incurred in creating and maintaining all this information. Not surprisingly this is a strong barrier at the present time to the development of computerised services and only large organisations willing to invest considerable sums of money are able to develop systems.

TRADITIONAL SERVICES

The traditional pre-trip route planning product offered by automobile clubs has been a set of preprinted pages bound or stapled together to form a route. They may take the form of text as in the case of the UK Automobile Associations Home Routes Service, or a strip map as in the case of the AAA 'Triptik' service.

Other organisations eg oil companies, car rental companies have also offered pre-trip route information services as a marketing aid to their main product. In each case the product is free or sold to the customer at much below production cost and therefore there is a strong incentive for the producer to reduce costs and possibly to try and restrain demand. This need to restrain costs has lead several automobile clubs to turn their pre-trip route information systems over to a computer based route information system.

From the providers point of view the information imparted by a pre-trip route information system must be robust without obvious error, and sufficient to provide the customer with a good route. Usually the route provided will relate to average traffic conditions as the customer has not specified a date or time for the journey. The route may well be personalised so that if the customer is towing a caravan (trailer) unsuitable roads are avoided or the customer may wish to avoid tolled routes. The route provided may be the quickest or it may be the best by some other criteria. The wide variety of route selection criteria means that the personalised route has to be generated from a database of route information. It is not economic to hold ready compiled routes for all combinations of selection criteria, although some popular touring routes may be precompiled.

Automobile clubs, as one of the longer established providers of route information, have built up manually maintained databases of route information, and, equally importantly, established links with highway authorities to record changes in the road system. They also conduct their own surveys of the road system to continuously check the currency of their information. Over time many automobile clubs have created a database covering their entire area of operation with a uniform quality of information within it.

Newer entrants to the field of route information provision have either restricted themselves geographically, perhaps by only offering a small set of precompiled routes, or have built databases from cartographic sources but have not yet built in the detailed knowledge gained over time by the automobile clubs.

THE UK AUTOMOBILE ASSOCIATIONS COMPUTERISED SERVICE

Until 1984 the AA in Britain used a text based system where each sheet contained text describing a section of route including turning movements (eg take 3rd exit at roundabout). A complete route was built up by a compiler choosing a line of route and listing the sheets to be included, which were then assembled in order. Often the compiler would make typewritten alterations/ additions to the route before dispatch to the member. This labour intensive operation has now been replaced by a computer based system.

The computer generated product is still a description of the route, the source material for which was an expansion of the manual route sheets, but the quality of the product is much improved. The route is produced on small fanfold stationery so that it can be used in a car easily. There are no alterations/deletions apparent to the user, although the system still has facilities to add detailed instructions at the start or end of the route if required and true cumulative distances are incorporated throughout the text. An example of the output from the system is shown in Figure 1.

Apart from labour savings the main benefits to the producer, and to the user, has been the ability to keep the route descriptions up to date by incorporating new roads from the day they are opened. The major problem of stockholding, updating and reordering of route sheets has been eliminated. The software content of the system is approximately one quarter devoted to route production and three quarters devoted to input, updating and checking the database. The system produces about 500,000 routes per year. The AA system runs on a Prime minicomputer. As an indication of performance, a modern PC is capable of calculating and printing a route every minute. In practice the operator and printer are the limiting factors on throughputs and a single workstation has a capacity of about 12 routes per hour.

Figure 1 - Part of AA Prepared Route from Brookwood to Bristol

Miles

		Brookwood (crossroads) Follow signs Bagshot A322
1.7	1.7	Bisley ("Hen & Chickens" public house)
2.7	1.0	West End
3.0	0.3	Junction with A319/B311 At roundabout take 2nd exit
4.7	1.7	Junction with M3 At roundabout take 2nd exit (signposted Bracknell) 1.6 miles farther take left-hand lane & keep forward In 2.2 miles at roundabout take 2nd exit In 0.5 mile at roundabout take 2nd exit
10.0	5.3	Bracknell Follow signs Reading A329
12.8	2.8	Junction with A329(M)/B3408 At roundabout take 2nd exit to join Motorway A329(M)
15.5	2.7	Junction with M4 Branch left (signposted South Wales) to join M4
21.1	5.6	Junction 11 (A33)
		Etc.

An alternative form of pre-trip route planning product is the "Triptik" produced by the AAA and CAA. This again is assembled from preprinted sheets, but the sheets contain strip maps, supplemented by descriptions of major towns, cities and a map giving fuller details of the area highlighted on the strip map. The system is operated from a large number of regional centres, each of which has a number of trained counsellors who assemble the Triptiks and mark routes on maps. This map based system presents a greater level of difficulty when developing a computer based system to replace it. In particular any text based product has to be entirely computer generated and the technology for printing a map based product at speed, at an economic cost, has only recently become available.

IN-VEHICLE NAVIGATION SYSTEMS

In-vehicle navigation systems are a natural extension of the traditional pre-trip planning services. They fall broadly into two groups. Those that are self contained within the vehicle and those that can transmit and receive information from external units.

The most elimentary of the self contained systems are those that undertake map matching. The Etak, Carin, Travel Pilot and Honda systems are typical examples. In these systems a map is displayed to the driver and the location of the vehicle on the map is shown. The benefits from these systems is largely with the destination search problem and their value in relation to their cost is debateable. The value of these systems would be increased if additional information was available on meeting places, hotels and other places of interest, but it should also be remembered that drivers do not rate this additional information as highly as receiving information on traffic conditions. The commercial success of these systems seems likely to depend upon their inclusion as part of existing in-vehicle entertainment systems.

Other self contained systems, for example our own MicroPilot, have the added feature of selecting the route and presenting it to the driver as a set of instructions. The location of the vehicle relative to the map is still required but as an intersection is approached instructions are spoken to the driver and can be presented visually on which way to turn. For example the message "turn right on the A322 towards Guildford" would be typical of the instructions given.

The communication system is the most important feature of the second group of vehicle navigation systems. For greatest benefits this communication system must be two-way so that the vehicle can tell the central control system its location and its required destination and can in turn be updated by the central control system on the route to follow, traffic conditions and other incidents. The type of communication, for example infra red or microwave, is not too important but in Europe systems based on infra red communication are already operating in Berlin, Munich and London.

There are other features of a two-way communication system that have not yet been exploited. One can conceive pricing and control mechanisms that depend upon these systems and electronic signposts that give information on road and traffic conditions ahead. For example a vehicle could receive a message and tell the driver "the bridge 200 metres ahead is frozen over".

AUTOGUIDE

The Siemens Ali-Scout system is now well established and seems likely to become the de facto European vehicle navigation standard. An Anglo-German agreement has established communication protocols and the Ali-Scout system is now being promoted as Autoguide in the United Kingdom and Ulysse in France.

In the Autoguide system a unit in the car gives spoken and visual instructions to the driver on the best route to follow. The unit communicates with roadside beacons using infra-red transmission. A central computer is told the vehicles destination and its current location by the roadside beacons so it can calculate the best route for the vehicle from the prevailing traffic conditions. The driver receives messages on the turns to make, routes to follow and is guided to within 50 metres of the required destination.

The vehicle's location is determined by an odometer and electronic compass. The vehicle receives sufficient map information as it approaches a beacon for it to match its position with the map until it reaches the next beacon.

Autoguide is also capable of operating in autonomous mode independant of any information from beacons. In autonomous mode, the system points, like a compass, in the direction of the destination. This facility helps considerably with the terminal search and allows the system to operate without having coded all the detailed information associated with local roads.

The installation of an Autoguide system in London will become possible when the Government's present transport bill has gained Parliamentary approval. The bill provides the legislation needed to introduce the system and allows the Government to offer a licence to operate a pilot system which, if successful, will be followed by a London wide system. The Government has already invited companies to bid for the licence, and whoever wins, the pilot system can be expected to be operational in 1991 with the installation of the larger system starting a year later. A further licence to operate a system in another part of the country can be expected within the same time scales.

The Pilot system will be used to prove the technology and establish the financial viability and benefits of Autoguide. The Government believes that the system will provide substantial benefits to users and non-users. Delays should be reduced as the system can encourage better use of the road capacity. At the same time, by encouraging the use of main roads, sensitive areas can be protected. The safety of the system is an important matter and this will be watched closely during the Pilot phase.

Initial trials of the Ali-Scout system were carried out in Munich and this led to a full installation of the system covering Berlin. The Autoguide system in London is likely to be followed by similar systems installed in other European cities. Within the next 5 years any driver with an in-vehicle unit can look forward to using his system anywhere in Europe.

FINAL THOUGHTS

We have been involved in traffic forecasting long enough to know that any prediction we make will certainly be wrong in some respect. It is however tantalising to look into the future and speculate on the vehicle navigation systems that may exist in ten years time.

We believe there will still be a need for two types of service. A pre-trip planning service and an en-route service. The pre-trip planning service will be a development of the personal service currently provided by many automobile clubs. These services can be automated and provide drivers, at their home or in their office, with detailed information about their journey and facilities along the route. The product we prefer is one which provides both a map and a written description of the journey.

The second service is the en-route service of which the Ali-Scout system is currently the outstanding example in Europe. These systems can respond to traffic conditions, help drivers avoid incidents and traffic congestion and guide them to their precise destination. The systems are capable of providing firms with information on the location of their fleet of vehicles and of forming part of sophisticated traffic control systems. We expect the Ali-Scout system to become the de facto standard in Europe.

The autonomous in-vehicle systems, represented by Carin and Travel Pilot, look likely to be left out in the cold. But it must be remembered that both are being promoted by large firms who can influence the market. Consequently we expect the emphasis of these systems to change with navigation elements becoming only a small part of a more general information system. In the longer term the autonomous systems are unlikely to remain self contained and will develop communication links. A new European standard for digital cellular radio is expected to come into operation in the mid-1990's. It is not unreasonable to believe that this will become the communication link for en-route navigation systems and that a rationalisation of all the existing systems could take place at around the same time.

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