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ANALYSING AND MODELLING THE INFLUENCE OF ROADSIDE VARIABLE MESSAGE DISPLAYS ON DRIVERS' ROUTE CHOICE

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Abstract

The VLADIMIR route-choice simulator was used to collect data in Denmark and Scotland on drivers' route-choice responses to roadside VMS messages. The results of this study are presented. Logit models of drivers' exit choice decisions are specified and calibrated revealing the importance of network structure and pre-VMS behaviour.

INTRODUCTION

The use of variable message signs

Roadside variable message displays have been installed in many countries as a means of communicating with drivers. The simplest signs use rotating flaps or prisms to display text or pictogram messages from a small predetermined set, whereas dot matrix displays can show an almost infinite range of simple pictograms or short text messages. These displays can be used for various purposes connected with traffic system management but the main applications are; safety warnings (eg hazards ahead, speed restrictions); parking guidance and information (eg space available at specified locations); capacity variation (eg instruction on use of a shared lane); and flow diversion (eg in response to incidents). We are concerned here only with their use for flow diversion.

An attempt to divert all or part of a stream of traffic from one route to another will normally be in response to a decrease in capacity in one part of the network due to a scheduled or otherwise predictable disruption (such as roadworks or emergency repairs) or an unscheduled incident (such as an accident). Sometimes, however, it will be due to a temporary, albeit perhaps periodic, increase in demand in part of the network (eg traffic leaving a sporting event). In either case the network managers will wish to improve the match between the traffic flow and the road capacity available.

Information on user response

The selection of a particular message to display in a particular set of circumstances is usually made in conformity with an agreed strategy. This strategy may be triggered 'automatically' in response to the value of system state variables (eg capacity reduction or flows on key links) or may require manual intervention. Considerable research is currently underway to explore the relative merits of 'automatic', 'manual' and 'expert system' approaches to strategy selection (see for example Papageorgiou et al. 1994).

Whatever method of selection is used, the success of the strategy will depend crucially on the reaction of drivers to the messages displayed. VMS has been in use to promote route diversion for many years and field studies at specific locations have shown that the messages can cause a proportion of the traffic to divert (with evidence in the range 5% to 80%). However, unless this is backed up by knowledge of the intended destinations of the traffic exposed to the message, it is not possible to interpret this evidence in a way that enables predictions to be made of its likely effectiveness at another site. It is clearly important to know for what proportion of the traffic the message is relevant and, for those drivers for whom it is relevant, how significant a diversion the message implies.

A number of studies are now attempting to overcome this deficiency in the data by conducting interviews, or issuing questionnaires, downstream of the message site (see for example, Durand-Raucher et al. 1993, and Kawashima 1991). These studies will provide very valuable information but their results will obviously be restricted to those messages which are shown at the sites in question during the survey period. Given an understandable reluctance of network managers to display messages relating to fictitious events, this restriction will (unless there is serendipitous coincidence of events) effectively rule out those messages which relate to serious unscheduled incidents.

As a solution to this problem we have developed a variant of the VLADIMIR route choice simulator (Bonsall et al. 1994) to gather information on drivers' responses to a wide range of messages in such a way as to yield transferable information.

VLADIMIR is a PC-based route choice simulator which can be made to represent any specified network. Subjects are presented with a series of screens showing a driver's-eye-view of the road ahead and of their dashboard (see Figure 1). They are required to 'drive' to a specified destination selecting their route as they go by choosing the desired exit at each junction encountered along the way. The road views shown to them are digitised photographs of the actual views (including signposts and VMS sites) they would see if they were really driving along the chosen route.

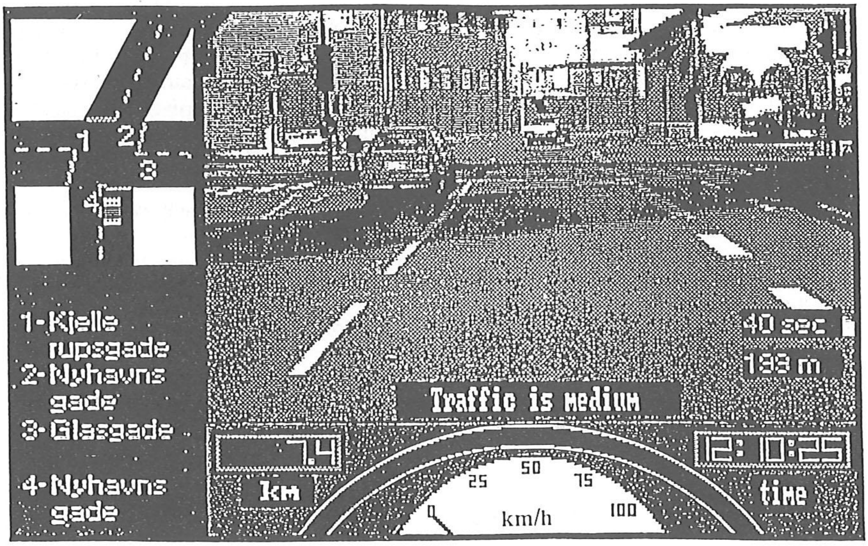

Figure 1 Example of VLADIMIR Screen (note that original is in colour)

The time taken by subjects to reach their destination will depend on the route taken and the conditions encountered en-route. They are made aware of current traffic conditions by annotations on the road view (eg heavy traffic) and by the fact that their rate of progress will be affected; if they select a slow route the experiment will take longer (in direct proportion to the journey time), the tone of their car engine will descend a few notes and their dashboard speedometer will give a lower reading. In a similar vein, their progress will be slowed if they select difficult or time consuming manoeuvres at junctions.

A VLADIMIR experiment involves asking subjects to 'drive' to a series of destinations, sometimes under great time pressure and sometimes to no particular deadline. The software records subject details together with their routes and their own explanation, after the event, of their decisions. A particular experiment may be designed to study the effect of varying the conditions they meet en route or of supplying them with various forms of guidance or information at the roadside (through their "windscreen") or in their vehicle (on the "dashboard" or via its "radio").

The reliability of data from route choice simulators

VLADIMIR is one of several route-choice simulators developed over the past few years (see for example Bonsall and Parry 1990, Ayland and Bright 1991, Adler et al. 1992; Allen et al. 1992 and Koutsopoulos et al. 1994). Most of these simulators have been designed with the particular aim of exploring the impact on driver route choice of in-vehicle guidance and information because of the obvious difficulties involved in gathering data on this by other means. Results from experiments using these simulators have been widely reported but there has been a concern in some quarters that the subject samples have not always been adequate or representative and, more fundamentally, that there is little reason to believe that the data from such simulators is indicative of 'real' route choices. In anticipation of these criticisms, work has been conducted in Leeds to determine the essential features of a successful route choice simulator and to compare the behaviour of simulator subjects with that of 'real' drivers. Conclusions from this work have been discussed elsewhere (Bonsall et al. 1994) but may be summarised here for convenience.

Briefly, it was concluded that the results obtained from simulators could be profoundly influenced by 'details' of the simulator design. A simulator needed, ideally to be *portable* (so that it could be transported to a range of locations where a representative sample of subjects might be recruited), to have a clear *distinction between the sources of different types of information* provided to the driver (fundamentally, a distinction between information that might be observed through the windscreen or via on-board gauges, and that which originates from a specific information system—such as VMS, radio or in-vehicle guidance), to provide *feedback* to the subject on how slow, lengthy, frustrating or tortuous his journey might be, to represent the *relative ease of different types of manoeuvre*, to include landmarks and other visual clues used in navigation and to *ask the subjects for their assessment* of the realism of the exercise. A controlled experiment was conducted in which 120 drivers were split into two groups, some to make journeys in a version of VLADIMIR designed to have the features listed above, and some to report how they would make the same journeys in real life. The results showed that, provided that the features were present, a very good match could be achieved between the routes chosen by simulator subjects and by real life drivers.

COLLECTION AND ANALYSIS OF DATA ON DRIVERS' RESPONSE TO VMS MESSAGES

The surveys

QUO VADIS is a European Union (EU) funded DRIVE project concerned with the design and evaluation of strategies for the management of traffic by means of variable message signs. The work was based on two networks; one urban (the town of Aalborg in Denmark) and one interurban (the FEDICS network in central Scotland). As part of this project it was necessary to determine the likely impact on drivers' route choice of a range of VMS messages.

These included text-only and text-plus-pictogram messages each of which contained one or more of the following items of information:

- location of an incident on the network
- nature of the incident (eg roadworks, accident, queues)
- warning of delay (at location specified or implied)
- estimate of delay (at location specified or implied)
- recommended route to specified or implied destination

In order to test these messages, a visual mock up was made of each one and a version of VLADIMIR was developed to include a carefully selected set of these messages as part of the drivers' through-the-windscreen view at appropriate locations in the Aalborg or FEDICS networks. Figure 2 provides an example of two of the signs tested in this way.

The decision to use VLADIMIR rather than a full field trial was based on the fact that indicative results could be produced by VLADIMIR more quickly and at a fraction of the cost of a field trial and that, with appropriate experimental design, the results would be transferable.

The QUO VADIS VLADIMIR sessions were structured to include four journeys in the Aalborg or FEDICS network. Each subject was asked to 'drive' to the first destination once without any VMS messages being shown and again (a year later) with VMS messages being shown at the appropriate places but with network conditions met prior to the VMS sign being otherwise identical. Most of the messages were 'correct' (in that they included a correct description of an actual event in the then current network and/or gave sound recommendations as to the best route) but, unbeknown to the subjects, some contained deliberately misleading advice. In subsequent journeys the subjects were 'interrupted' at a key junction and were asked what exit they would have selected if they had seen each of a randomly ordered set of different VMS messages just prior to that junction.

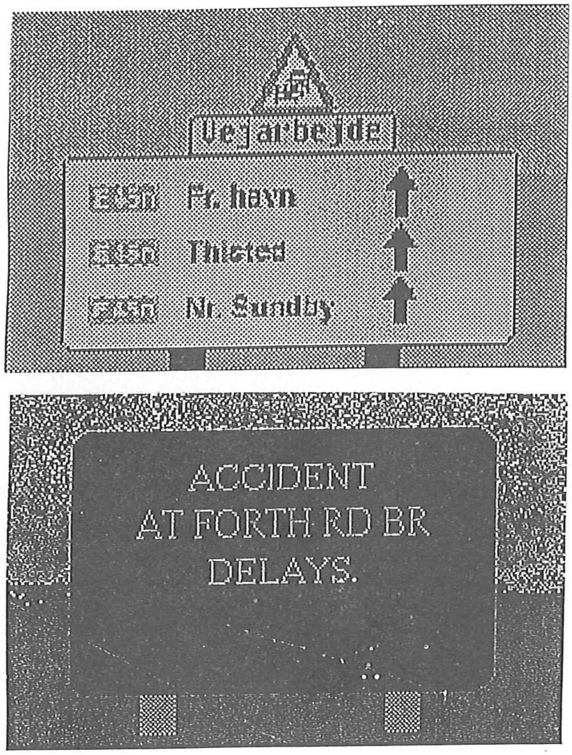

Figure 2 **Examples of VMS messages tested on the QUO VADIS project**

The 457 subjects (284 in Denmark and 173 in the UK) recruited to participate in the QUO VADIS VLADIMIR survey were broadly representative, in terms of age, sex and network knowledge, of the driving population in the Aalborg and the FEDICS networks. The 457 interviews, which were conducted primarily at the subjects' workplaces but also at sites such as shopping centres, yielded over 20,000 data points of which about 5,000 related to interrupt journeys. Fuller details of the surveys, and of the preliminary analysis can be found in QUO VADIS (1994).

Preliminary analysis of data from the Aalborg and FEDICS interrupt journeys

Tabulation and graphical display of the data from the Aalborg and FEDICS experiments immediately allowed a number of conclusions to be drawn about the effectiveness of VMS messages under test. The results are detailed elsewhere (QUO VADIS Consortium, 1994 and Bonsall 1994) but Table 1 and Figure 3 are included here for illustrative purposes. Table 1 summarises the effectiveness (in the context of standardised implied diversions) of some of the message tested in the Aalborg and FEDICS experiments. The data suggest that the information contained in a message gives it a certain inherent effectiveness and that the response of a given individual will vary depending on the relative travel times to their destination via the existing and best alternative routes, and their level of network knowledge. Preliminary analyses led us to draw a number of conclusions which can usefully be summarised here. They were that:

- Some of the trialed messages were quite ineffective and some had the opposite effect to that which had been intended due to their inherent ambiguities (a finding which might have caused some embarrassment if it had come via a field trial);
- Some of the more expensive message formats (involving coloured pictogram displays) were not noticeably more effective than their cheaper counterparts (again, this is a finding which might have been somewhat embarrassing if it had required a full scale field trial);
- The effectiveness of an individual message (measured in terms of its ability to persuade drivers to divert from their previously favoured route) is a function of:

  - site factors such as;
    - the extra travel time that would be incurred by using the implied diversion route in normal traffic conditions
    - the existence of other potential diversion points further downstream
  - the message content; eg.
    - whether a delay is mentioned and if so how much?
    - whether the cause of the incident is mentioned, and if so what is it?
    - whether a diversion is recommended and if so whether it is allied to specific destination(s) or to a general destination area; and
  - the characteristics of the population exposed to the message, most notably how familiar they are with the network and, by implication, with the locations mentioned in messages.

Some more specific findings were that:

- a message which includes mention of roadworks will, other things being equal, have less impact than one which mentions an accident;
- the more detail that is given the more persuasive the message will be ('location + nature-of-problem + resulting-delay 'is more effective than' location + delay' or 'location + nature-of-problem');
- the greater the quoted delay the more effective will be the message;
- some messages have more effect on drivers who are very familiar with the network whereas others have most effect on drivers who are unfamiliar with the network.

Figure 3 is a schematic representation of the relationship we found between a message's effectiveness and the extent of diversion implied by it.

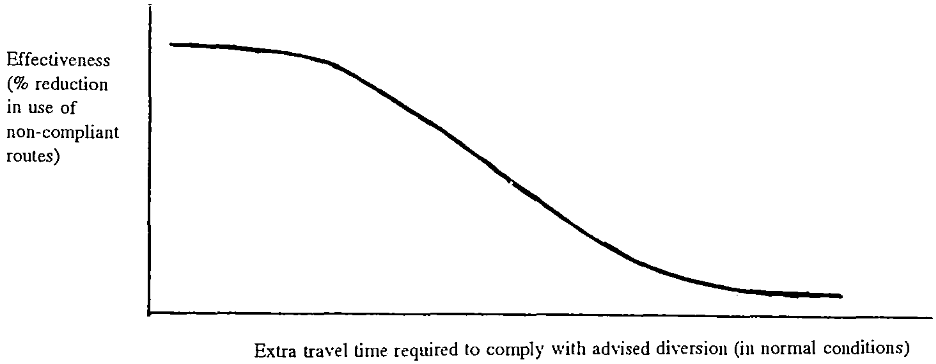

Figure 3 Schematic relationship found between effectiveness of messages and the extent of implied diversion

Table 1 Effectiveness of various VMS messages (for 'standard' journeys)

a) Danish signs	effectiveness (%)
10 minute delay at specified location, no cause given	37
15 minute delay at specified location, no cause given	60
20 minute delay at specified location, no cause given	91
Recommended route indicated to specified destination	32
5-minute delay due to "queue" at specified location	20
10 minute delay due to "queue" at specified location	42
20 minute delay due to "queue" at specified location	90
Recommended route indicated to specified destinations (due to queues at unspecified location)	37
Recommended route indicated to specified destinations (due to queues at specified location)	65
15 minute delay ahead due to roadworks at unspecified location	38
20 minute delay ahead due to roadworks at unspecified location	88
Recommended route indicated to specified destination (due to roadworks at unspecified location)	20
b) Scottish signs	
Accident at (specified location) leave at next exit	85
Accident at (specified bridge) (other advice)	80
Accident at (other specified location) (other advice)	55
Accident at (specified bridge) or within next few miles	55
Accident at (other specified location)	38
Accident at (specified location) delays/queues	50
Roadworks at (specified location) delays/queues	35
Accident/roadworks at FRB, delays possible/likely	41
Accident/roadworks at (other specified site) delays possible/likely	9
Accident/roadworks at (specified location) 15 minute delays	14
Accident/roadworks at (specified location) 30 minute delays	53
Accident/roadworks at (specified location) 45 minute delays	76
Accident/roadworks at (specified location) 1 hr delays	67
Accident/roadworks at (specified location) long delays	58
Long delay at FRB (advice)	85
Long delay at (other specified location) (advice)	70
1 hour delay at FRB (advice)	85
1 hour delay at (other specified location) (advice)	65
45 minute delay at FRB (advice)	85
30 minute delay at FEB (advice)	57
15 minute delay at FRB (advice)	25
Delays/queues at FRB (advice)	60
Delays at (other specified location) (advice)	55
Delays likely/possible at FRB (advice)	52

Notes: (1) These results are derived by simple tabulation and plotting. No correction has been made for potential bias in the sample of people exposed to each message.

(2) Effectiveness is here defined as the net percentage reduction in use of the route(s) which the message was intended to affect.

(3) The standard journey for the Danish signs assumed a 10 km distance (approx 15 mins journey time) with the diversion route taking 3 minutes longer. The 'standard journey' for the Scottish signs assumed a 60 km distance (approx 75 mins journey time) with the diversion route taking 20 minutes longer.

FRB = Forth Road Bridge

Source: Bonsall (1994)

MODELLING

Model specification

There are of course many ways of modelling route choice. Much effort in recent years has been concerned with representing some form of equilibrium between network performance and individual drivers' choices and while 'conventional' approaches to solving the stochastic-dynamic user equilibrium problem may yet have much to offer, there is now increasing interest in issues such as the day-to-day dynamics of network learning and the evolution of behaviour over time (see for example Mahmassani and Jayakrishnan, 1991; Ben Akiva et al. 1991; Vaughn et al. 1993; and Watling 1994).

The immediate requirement in the QUO VADIS project was for a model which would be able to show how route choice decisions at a particular point (junction) in the network, on a particular day might be influenced by VMS messages upstream of that site. An obvious framework for this problem is the discrete choice logit model given in equation (1).

$$P_i = \frac{\exp(U_i)}{\sum_{k=1,n} \exp(U_k)} \qquad (1)$$

where P_i = proportion of drivers choosing exit i from the current junction

U_i = utility of choosing exit i (see below)

n = number of exits available at the junction, and

$$U_i = \alpha 1\ v1_i + \alpha 2\ v2_i + \ldots \alpha n\ vn_i + \beta 1 w1 + \beta 2 w2 + \ldots \beta n wn$$

where $v1_i$—vn_i are attributes of exit i

$w1$—wn are characteristics of the decision maker and the choice context

$\alpha 1$—αn and $\beta 1$—βn are calibrated coefficients

Table 2 lists the exit specific attributes v. Note that the list includes conventional variables, such as travel time to destination via this exit, and others which are attributed to the exit by the VMS message. Note also there is no constant term in the normally accepted sense of the phrase, but that attribute $v3$ will encapsulate any different response to the 'main' exit, while attribute $v13$ should pick up any habitual preference for one exit over another. The interpretation of $v13$ will be further addressed below. The inclusion of such a wide range of generic attributes will hopefully allow a model to emerge which is transferable between different junctions in a network, and indeed between different networks.

Table 3 lists the characteristics w of the decision makers and the choice contexts. Characteristics $w10$, $w11$ and $w12$ relate to the choice context but can be transformed into exit-specific attributes if multiplied by $v1$ or $v2$ (time or distance to destination via specified exit). The rationale being that the exposure to queues, roadworks or 'motorwayness' would be proportional to journey time or distance. Of the two possibilities, multiplication by distance produced the better result and was therefore adopted.

Table 2 Exit specific attributes used in the models

v1	Minimum travel time to destination via this exit in normal traffic conditions [min]
v2	Minimum travel distance to destination via this exit [km]
v3	Whether this exit represents the natural 'continuation' of the entry arm [Y/N] (this variable was included following previous field research on driver route choice—see Gotts and Bonsall, 1992—which had shown that, in the absence of indications to the contrary, drivers tended to select the natural continuation arm more frequently than any other -note however that some approach arms, have no 'natural continuation'; eg the 'leg' of a T junction has no natural continuation).
v4	Whether the VMS sign specifically recommended this exit as a route to the subjects' destination [Y/N]
v5	Whether the VMS sign specifically recommended this exit as a route to destination(s) close to, or incorporating the subjects own destination [Y/N]
v6	Whether the VMS sign indicated that this exit would lead to a site with queues (unquantified) [Y/N]
v7	Whether the VMS sign indicated that this exit would lead to a site with current roadworks [Y/N] this exit
v8	The extent of any delay due to queuing indicated by the VMS sign as likely to be encountered at sites reached via this exit [min]
v9	The extent of any delay due to roadworks indicated by the VMS sign as likely to be encountered at sites reached via this exit [min]
v10	The extent of any delay (not attributed to any cause) indicated by the VMS sign as likely to be met via this exit [min]
v11	Whether the VMS sign indicated queues ahead without clearly indicating which exit they would be associated with [Y/N]
v12	Whether the VMS sign indicated roadworks ahead without clearly indicating which exit they would be associated with [Y/N]
v13	Whether this exit would have been (was) chosen by the driver in the absence of VMS advice [Y/N]

Table 3 Characteristics of the decision makers and the choice context

w1	The subjects' age [18-29/30-49/50+]
w2	The subjects' gender [M/F]
w3	The subjects' own asesement of their familiarity with the network [unfamiliar/quite familiar/very familiar]
w4	The subjects' own assessment of their sense of direction [poor-average/good/very good]
w5	The subjects' own assessment of their prior attitude to VMS [no experience/impression of poor reliability/impression of reliability]
w6	The subjects' own assessment of their reaction to signposts recommending an unexpected route in an unfamiliar area [ignore them/check map and follow cautiously/follow happily]
w7	The subjects' own assessment of their reaction to meeting a jam in an unfamiliar area [put up with
w8	it/seek diversion]
	The quality of VMS advice received by this subject earlier in the VLADIMIR experiment [matched
w9	conditions/did not match conditions]
w10	Whether the journey is being made under considerable time pressure [Y/N]
w11	Whether the decision maker is on a motorway [Y/N]
	Whether the VMS sign indicated queues ahead without clearly indicating with which exit they
w12	would be associated [Y/N]
	Whether the VMS sign indicated roadworks ahead without clearly indicating with which exit they would be associated [Y/N]

Two different model structures were explored. The first sought to predict choice of exit from the current junction in the presence of VMS as a function of exit attributes, VMS information and driver characteristics. The second, drawing part of its inspiration from the notion that behaviour evolves gradually in response to stimuli rather than being periodically reformulated ab initio, sought also to use each individual's without-VMS exit choice (*v13*) as an input to their with-VMS choice. This second model obviously requires information on prior behaviour. Such information is available from VLADIMIR but, unless it is also available in the forecasting context, there would be little point in specifying such a model. However, there are some circumstances, eg in the context of a network control system with on-line monitoring of exit flows, when the current without-VMS choices would be known and it is with this in mind that we have explored the performance of this second type of model.

The analysis that follows is based on a small part of the QUO VADIS database; it relates to exit choices made by the 284 subjects who made journeys in the Aalborg version of VLADIMIR but includes only those choices made at the two junctions where the widest range of different VMS messages were shown and excludes data from those subjects (approximately 6% of the total) who, in response to specific questions, indicated that they had treated the VLADIMIR exercise as a game or who thought that the route choices they had made in VLADIMIR would be quite different from those they would have made in real life. The resulting database has 2808 observations.

A wide range of alternative model specifications were tested using these variables in the ALOGIT package and a full report of these, together with an account of our investigation of correlations between the variables can be found elsewhere (Merrall 1994). The following section summarises the results of the most successful models.

Coefficient values

Table 4 presents a number of models. Models A, B and C represent respectively our most successful models of exit-choice-without-VMS, of exit-choice-with-VMS (without benefit of knowing the without-VMS choice) and of exit-choice-with-VMS (knowing exit choice without VMS). Model B2 is an alternative specification of model B which, since it has the same parameters as model C, can more readily be compared with it.

Table 4 Logit models of exit choice

Exit attribute variables		Models							
		A (without VMS)		B (with VMS, not prior knowledge		B2 (with VMS, no prior knowledge		C (with VMS knowing withoutVMS)	
		Coef	T	Coef	T	Coef	T	Coef	T
v1	Journey time(min)	-0.891	-29.6	-0.317	-14.0	-0.322	-14.1	-0.052	-1.9
v2	Journey distance (km)			-0.146	-8.2	-0.168	-7.2	-0.174	-6.9
v3	Natural continuation (Y/N)	0.502	11.6	0.227	5.1	0.129	2.1	0.149	2.3
v4	Specific advice? (Y/N)			0.982	6.3	1.004	6.4	1.075	6.8
v5	General advice? (Y/N)			0.613	6.2	0.629	6.3	0.761	7.1
v6	Unqualified queue (Y/N)			-1.187	-4.5	-1.145	-4.3	-1.328	-4.8
v8	Delay due to queues (min)			-0.132	-11.9	-0.131	-11.8	-0.145	-12.7
v10	Unexplained delay (min)			-0.082	-12.0	0.080	-11.8	-0.091	-12.6
w11xv2	Unalocated queues (km)			-0.267	-3.5	-0.295	-3.6	-0.369	-4.1
w12xv2	Unlocated roadworks (km)					-0.082	-1.6	-0.128	-2.2
w13xv2	Motorway site (km)					0.156	2.4	-0.119	-1.6
v13	Exit chosen without VMS?(Y/N)							1.099	18.5
p^2		0.379		0.210		0.211		0.275	
sample size		401		2808		2808		2808	

Note: See Tables 2 and 3 for more precise definition of variables.

Source: Merrall (1994)

Examination of the ρ^2 results shows that the prediction of route choice in the presence of VMS is less easy than doing so when there is no VMS (Model A has the highest ρ^2) and that predicting route choice in the presence of VMS is easier if one has data on the drivers' choice without VMS (C's ρ^2 is higher than B's).

Starting with our simplest and most successful model (A), we note that the prediction of exit choice in the absence of VMS is achieved with only two variables; journey times (*v1*) and natural-continuation (*v3*). Experimentation with a wider range of variables including trip distance showed that these were insignificant at the 5% level and/or had small and counter initiative coefficients whose inclusion had little impact on ρ^2.

The coefficients of model B suggest that prediction of exit choice in the presence of VMS is still strongly influenced by journey time and natural-continuation but that a number of variables relating to the context of the VMS message have a significant impact. We note that a specific recommendation (*v4*) is more influential than a general one (*v5*) and that mention of delays is more persuasive if a cause is given (compare *v8* with *v10*). Note also that if delays are mentioned but not quantified, a delay of about 9 minutes seems to be imagined (compare variables *v6* and *v8*). It is interesting to note that journey distance has an effect additional to that of journey time (both *v2* and *v1* are significant and negative) and that this effect is particularly marked if the VMS signs have indicated queues at an unspecified location (*w11*x*v2* is significant and negative).

Model C shows what might be achieved if the without-VMS choices of drivers were already known. Clearly the without-VMS-choice variable (*v13*) is very important but we note that this is in part balanced by a reduced value and significance for the journey time and natural-continuation variables (*v1* and *v3*). It is interesting to note that journey time and natural-continuation have an influence in model C over and above that which will have been carried forward from the without-VMS choice, and that this influence is still in the intuitive direction (negative for travel time, positive for natural-continuation). This suggests that these variables act to 'temper' the effects of VMS advice.

Model B2 is presented in Table 4 in order to allow a direct comparison with model C. It can be seen that inclusion of the without-VMS-choice variable in model C is balanced by reduced influence for the journey time variable (*v2*) and with increased influence for the message content variables (*v4, v5, v6, v8, v10, w11*x*v2* and *w12*x*v2*).

All the above models were calibrated using observations from all our subjects (except those who volunteered that their data was unreliable). It is interesting now to consider the effect of building separate models for different types of driver. Preliminary regression analysis showed that 'directional sense', 'network familiarity' and 'perception of VMS reliability' each appeared to have a significant influence on exit choice (in the presence of VMS) and that the subjects' age also had some influence. The consequences of constructing separate logit models for each type of respondent thus defined were explored.

When separate logit models of exit-choice-with-VMS were built for subjects claiming different levels of familiarity with the network, we noted that data for the 'unfamiliar' group produced a less satisfactory model (ρ^2 0.258 compared to 0.290 and 0.281 for the 'quite familiar' and 'very familiar' groups respectively) and that the 'very familiar' group produced the most significant parameters for journey-time, journey-distance, natural-continuation and same-choice-as-was-made-without-VMS. These results perhaps suggest that increased familiarity brings greater rationality and consistency in choices.

Table 5 contains results for two models built with the same subset of variables (those which were significant for all familiarity level groups). These models omit variables which are important in explaining familiar drivers' choices and so show a reduced ρ^2 but they do permit comparison of parameter values for the different familiarity groups. We note that compared to the other groups, the unfamiliar group is more influenced by VMS guidance to their *specific* destination but less influenced by VMS guidance to their *general* destination. (This no doubt reflects their greater reliance on guidance but perhaps a difficulty in recognising a description of their general destination). We also note that unfamiliar drivers are more swayed than others by signs mentioning delays and that they take less heed of extra distance incurred (this may reflect a lack of realisation that they were being so diverted or may reflect a readiness to take 'simpler', but longer, bypass routes in preference to the confusion of the city centre). Clearly, disaggregation on the basis of familiarity appears to be quite important.

Table 5 Comparison of coefficients for different familiarity groups

Exit attribute variables	Model					
	unfamiliar subjects		quite familiar subjects		very familiar subjects	
	coefficient	T	coefficient	T	coefficient	T
v2 Journey distance (km)	-0.184	-4.6	-0.324	-7.1	-0.264	-11.9
v4 Specific advice? (Y/N)	1.879	3.4	0.728	2.1	1.282	7.0
v5 General advice? (Y/N)	0.777	3.2	1.278	5.5	0.925	7.1
v8 Delay due to queues (min)	-0.180	-4.4	-0.104	-4.7	-0.148	-10.5
v10 Unexplained delay (min)	-0.127	-6.0	-0.074	-4.8	-0.082	-9.7
v13 Exit chosen without VMS? (Y/N)	1.041	8.3	1.218	11.7	1.166	20.5
sample size	402		570		1836	
ρ^2 (see note)	0.269		0.281		0.263	

Note: these models were specified with a common list of parameters to permit comparison—they do not represent the best model for any one of the three groups.

Source: Merrall (1994)

When separate models were constructed for groups claiming each of three different levels of directional sense (in answer to the question "How good is your sense of direction?—poor or average/good/very good"), it was noted that the best models for all three groups have similar ρ^2 values but that, when models were constructed using the subset of variables which had been significant in all three individual models, there were some interesting differences between the parameter values; it was noted for example that sensitivity to delays due to queues, and to direction advice, seems to increase with directional sense. It is not clear that this latter difference is intuitively reasonable. On balance we do not see any great value in this disaggregation of the population.

Separate models were constructed for groups who, in answer to a specific question, claimed to have had generally negative, generally positive or generally natural/non-existent prior experience of VMS reliability. The resulting models were not markedly different from one another and showed only a weak relationship between prior experience and likelihood of being influenced by guidance. Again we do not see any great value in this disaggregation of the population.

Experimentation with separate models for subjects of differing age and gender similarly showed no clear pattern, although there was some evidence that sensitivity to journey time increased with age and that compliance with queue/delay advice decreases with age. One should not reject the notion that disaggregation by these variables might be significant but they were not clearly supported by this dataset.

CONCLUSIONS AND IMPLICATIONS

The use of VLADIMIR in the QUO VADIS project has demonstrated the value of route choice simulators as a source of data on driver response to VMS messages. The technique was able to produce information on driver response to a wider range of messages in a wider range of situations than would have been possible by field observation.

The usefulness of a route choice simulator as a pre-implementation testbed for potential messages has been demonstrated; our tests were able to identify several messages whose impact was marginal or negative and to identify unnecessarily expensive message specifications.

Naive tabulation of the data derived from our Scottish and Danish QUO VADIS VLADIMIR dataset has suggested that the effectiveness of a given VMS message in changing drivers route choice will be a function of the magnitude of the implied diversion, the nature and specificity of the message and the characteristics of the driving population—most notably their familiarity with the network.

Logit analyses of junction exit choice decisions just downstream of VMS sites in the Danish dataset have helped to quantify these effects and have shown the particular importance of the extent and attribution of any delay and the specificity of any diversion advice.

The different response to VMS by people with different levels of network knowledge has similarly been emphasised and quantified. We note that, compared to their fellows, familiar drivers are the most likely to achieve optimal routes (in terms of time and distance), that they are less swayed by VMS messages indicating unattributed delays but that they take more notice of route recommendations that mention 'general' destinations. We interpret this as reflecting the fact that higher levels of familiarity equip drivers to make best use of the guidance and information provided by VMS because they can better appreciate its implications and act accordingly.

The fact that different messages can have very different effects and that a given message can have very different effects in different circumstances makes prediction of the impact of messages more difficult but also potentially very rewarding. If the effectiveness of a given message can be predicted reliably then the traffic system manager can begin to use VMS messages for sophisticated fine-tuning of network flows.

Unfortunately our logit analyses have suggested that accurate prediction of route choice is more difficult when VMS is in operation than when it is not. We have suggested that a good without-VMS model of exit choice can simply be based on journey time minimisation and route-continuation. The inclusion of journey time in this model reflects conventional wisdom and supports the widespread use of journey time as the prime determinant of route choice in assignment models. The significance of the route-continuation variable is perhaps more interesting since it is usually overlooked in such models.

Although we have seen that the prediction of exit choice is complicated by the presence of VMS messages, our analyses have shown that good predictions can be made if the without-VMS choice is known. This suggests that individual route choice is influenced by factors which have not been captured by our models and that these factors retain an influence whether or not VMS is present. The practical consequence of this is that the best predictions of with-VMS routings are likely to come from models which can be 'primed' with data on without-VMS routeings. This concept fits well with a control-theory approach to the use of VMS -with interventions being prescribed as a result of model prediction of the likely net effect on known current routeings of each of a set of possible messages. This approach presupposes effective on-line monitoring of the current system state, most notably of link flows and O-D patterns. In this context we should note that our work has shown how, at a disaggregate level, without-VMS route choices can help predict with-VMS route choices, but if, as one would expect, the same holds true at an aggregate level, the data requirements for effective system control can be considerably simplified.

The analysis presented in this paper represents a small part of what may be done with our VLADIMIR databases. Future papers will use data currently being collected on the effect on route choice of other forms of roadside and in-vehicle guidance and will revisit the modelling of route choice in the absence of such guidance. Particular themes will be the inclusion of a wider range of possible explanatory variables (along the lines of our natural-continuation variable), the transferability of coefficients between sites, the different behaviour of different types of driver and the use of previous experience as a major determinant of future behaviour.

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