
Published paper

Kirby H.R. (1988) *Report on the Workshop held at the University of Leeds on 6 November organised on behalf of the Transport Sub-Committee of the Environment Committee of the Science and Engineering Research Council.* Institute of Transport Studies, University of Leeds. Working Paper 258

Working Paper 258

January 1988

SERC WORKSHOP ON EXPERT SYSTEMS IN TRANSPORT

Report on the workshop held at the University of Leeds on 6 November organised on behalf of the Transport Sub-Committee of the Environment Committee of the Science and Engineering Research Council

H R Kirby

This workshop was sponsored by the Science and Engineering Research Council

SERC WORKSHOP ON EXPERT SYSTEMS IN TRANSPORT

Provisional Report on the Workshop
held at
The University of Leeds on 6th November 1986
organised on behalf of the
Transport Sub-Committee, Environment Committee
Science and Engineering Research Council

Part A: WORKSHOP OVERVIEW AND CONCLUSIONS

A.1 BACKGROUND

The meeting was the second in a series of three, called to review the prospects for future development of the Special Programme in the Application of Information Technology to Transport set up by the Transport Sub-committee of the Science and Engineering Research Council (SERC). The other seminars were: at University College London on Traffic Engineering Applications, held in July 1986; and at the University of Newcastle upon Tyne, on Public Transport Information Systems, held in December 1986.

A.2 OBJECTIVES

The objectives of the workshop were to

(i) review current perceptions of and future prospects for the role of expert systems in transport; and

(ii) provide such feed-back to the SERC Transport Sub-committee as would assist it in forming a view about future work in this area.

A.3 PROCEEDINGS

The workshop was somewhat different from the other two seminars in the series, because its focus was on the uses of a class of specialist computational tools rather than on the end-problems themselves (which is why it was called a workshop rather than a seminar). The emphasis in the workshop was on 'what' transport problems might be addressed with such tools, rather than on 'how'. A basic awareness of expert system terminology and the software tools available for it was taken for granted, though in an introductory session, the nature of the new SERC AI Software Facility was explained. This is described in Part B.

Speakers were allowed 10 minutes to both explain what problem they were addressing and why an expert systems appproach was taken. The structure of the workshop was based on themes identified in the Leeds University review of the potential for transport applications. (Ref 1; distributed to delegates in advance.) Discussions took place after all the papers in a given theme had been presented, and included consideration of some of the other issues raised in Reference 1.

Summaries of the presentations and discussions are in Part C; conclusions reached by the meeting are in Part A.5.

The workshop concentrated on the expert system theme; whilst it did not explicitly include other themes from the field of artificial intelligence, such as vision systems, this does not mean to imply that such aspects are not of interest to the transport community. Indeed, in one paper (given by Jeffery), a Natural Language component is an intrinsic part of the system he describes.

A.4 PARTICIPANTS

Because of the workshop's more specialist orientation, participants were invited for their known interest in expert systems applications, rather than for their transport interests. Twenty-five delegates attended (plus nine from the host university); these are listed in Part D, together with others who have expressed an interest in receiving this report.

A.5 CONCLUSIONS

In the concluding session of the workshop, a senior local authority delegate, who had not previously encountered expert systems, expressed the view that, from the evidence presented, there were potentially many areas of highways and transport engineering and planning which could potentially benefit from the application of expert systems.

Most present would endorse that view - as one might expect, given their existing commitment to the subject. We did not devise a 'shopping list' of new ideas for transport applications of expert systems; that was not the object of the exercise, and in any case it must be doubted whether people would share their best ideas when they are still at a formative stage. The summaries of the presentations given in Section C show the range of applications being tried out now. To supplement these with a wider picture, I enclose in Appendix 1 a list of some other recent UK and American literature on transport applications of expert systems.

Inevitably, with a new and contentious subject, criticisms and reservations were expressed during the course of the workshop, for a number of reasons. The following concerns were expressed by various individuals, but were not necessarily widely supported by the meeting.

- o Oversell of the value of the technique, through 'media hype'.
- o Inadequate or wrong descriptions of what expert systems could do.
- o The potentially misleading effect of the term 'expert'; in that it might lend a degree of credibility and authenticity to a piece of software that was quite unjustified.
- o The risk that, in a fast developing field, by the time an expert system was developed, it would be out of date; but because it could be promulgated widely and cheaply, it would lead to 'dated' rather than current expertise being applied.
- o The possible confusion through different 'expert systems' on a

given topic giving different advice (perhaps through being based on the views of different experts).

o The social implications of any expert systems that might seem to threaten the jobs of the experts or reduce the role of the human in decision-making.

(The following paragraph contains my own reflections on these issues rather than a summary of delegates comments.)

Similar concerns are of course shared in other areas of application of expert systems. That they surface so strongly is no doubt a result of the speed with which the Alvey and related initiatives impelled the community to develop an interest in artificial intelligence and its application, after years of comparative neglect in the UK. There has not yet been the time to experiment widely, to learn, absorb and digest. The application of artificial intelligence techniques - indeed, the techniques themselves - is still a fledgling subject. So much so, that there is as much a danger of under-rating expert system technology as over-rating it: there are for example those who think that something can be called an expert system just because some expert has been consulted in the course of developing a program! Indeed, few of the participants in the workshop would claim to have had the experience of developing an expert system in depth. Because of that, we are scarcely in a position where we can pass considered judgment on the techniques, or with confidence assert what might be the role of expert systems in transport over the next few years. Some of the concerns will doubtless be answered as the subject matures. For example, just as one has now a choice of books with given experts' views, published only after a refereeing process, so one will in due course have a choice of expert systems with different experts' views - perhaps also subject to referees crtiques!

Nevertheless, one can with confidence assert that the task of assessing and applying expert system technology should go on. Already, under the PROMETHEUS and DRIVE programs, some major inititaives in the application of Artificial Intelligence to transport problems are being undertaken in the EEC context: reference was made to this work in the concluding discussion, and a synopsis of these programs is included at Appendix 2. In both the United States and Canada, the scope for applying expert systems in transport has been taken much more seriously and more widely than it has so far in the UK. Most of us shared the view that, in the fullness of time, transport analysts and indeed practitioners should become as much aware of what expert systems technology can do as they are of other branches of computing technology; the technology should become as much part of the tool-kit as technology coming from the disciplines of operational research and statistics are part of the tool-kit now, whether explicitly or not. But, because of the long lead times in training and development, that time is not yet. So it was that the workshop reached three main conclusions, and commend these to the Transport Sub-Committee:

(a) that, to facilitate in-depth insight into what was involved in developing an expert system, a conference should be convened with papers on how certain expert systems in transport were developed;

(b) that the SERC continues to promote the development and awareness of transport applications of expert systems, and support appropriate training, by such initiatives as the Special Programme in IT;

(c) that this further support be for no more than a further 3 years, with the explicit aim of reaching a situation where (i) working expert systems in transport of a non-trivial kind are demonstable; (ii) the level of awareness and education in these tools and their applicability is widespread.

A corrollary of (a) and (b) is naturally to ask whether the SERC might support such a conference, particularly in respect of the possibility of inviting delegates from overseas.

For the conference at (a), the meeting set up an organising committee, consisting of: Dr Margaret Bell (Durham University); Howard Kirby (Leeds University, Institute for Transport Studies); Raymond Kwan (Leeds University, Department of Computer Studies); Dr Alan Pearman (Leeds University, School of Economic Studies).

With respect to the end goal indicated at (c), it is perhaps worth remarking (again, as a personal comment) that serious expert systems, of the kind that would be useful in transport, are difficult and time-consuming. One should not expect there to be many working systems in that time-scale unless there is a proliferation of effort and a determination to succeed. That might entail encouraging new partnerships, between computing and psychology and transport departments, between different universities, between universities and industry. There are high risks. There are also, potentially, high gains.

Part B: SOFTWARE TOOLS

B.1 GENERAL

It was not the intention in this workshop to review software tools or to dwell on details of how particular techniques were implemented. For those with little previous knowledge of the subject, a copy of Wheatley's introduction to expert systems was available (Ref 2). The Appendix to Reference 1 notes some limitations of expert system shells, and that paper contains an Appendix with notes on introductory sources.

B.2 AI SOFTWARE FOR CIVIL ENGINEERING, BUILDING, TRANSPORT AND MARINE TECHNOLOGY

Geoffrey Eastwood (SERC) described the Environment Committee's concern to encourage multi-disciplinay projects across the range of its interests. This particularly applied to projects that used advanced information technology, where applications in one field would often be paralleled in another, and where links with computer science needed to be built. It sought to support projects by providing access to larger facilities than would normally be available to single establishments. The recent establishment of an Artificial Intelligence Software Facility came about because of a concern that prospective users would not find manufacturers demonstrations of a product sufficiently informative to tell them whether it did the job they wanted it to. All too often one might buy a product, only to find out later that it did not really satisfy the requirements. The AI Software Facility was intended to allow people to have access to certain producst for detailed evaluation, typically for a two-month loan period. The facilities have been described in SERC circulars (Ref 3), and are:

1. KEE on a XEROX machine

2. Quintus PROLOG, POPLOG, C-PROLOG, NIP (New Implementation of Prolog) and KYOTO LISP on a SUN

3. SAVOIR, XI, PROLOG II, KES, Golden Common LISP on an IBM PC/AT.

An IBM PC/AT will be available for loan within a year. The software at (3) is licensed for a particular machine, so one has to have that machine with the software.

In discussion, some concern was expressed about the speed with which these tools might be made available.

Part C: PRESENTATIONS

The presentations are grouped by themes identified in Reference 1.

C.1 ENQUIRY SYSTEMS AND INFORMATION PERUSAL

C.1.1 EXPERT SYSTEMS IN THE TRAVEL TRADE / THE TRACE COMMUNITY CLUB

As a result of illness, neither **Bob Ruckwood** nor **Colin Kauntze** (Thomas Cook Group) were able to come to give the planned presentation. The Thomas Cook Group were amongst the pioneers in using expert systems in the travel trade; and Colin and Bob are respectively the TRACE Club's Chairman and Secretary. In their absence, John Wootton (who, with Howard Kirby, had taken a lead role in proposing the Club) outlined briefly the Club's nature and purpose. Community Clubs come under the Alvey Directorate's IKBS Awareness Programme. In this, firms in a given sector of industry are invited to pool resources (which Alvey matches pound for pound) to enable a demonstration IKBS program to be developed in an area of common interest. The target application for the transport/travel club - the development of an enquiry system as an aid for enquiry clerks in answering complex enquiries - arose out of the colaboration between two SERC-aided projects at Leeds, one on the potential for transport applications of expert systems, the other on the requirements for passenger information services. There were thirteen members of the club, and a prototype system had been developed.

C.1.2 EXPERT SYSTEMS IN FREIGHT MANAGEMENT

John Towris (Cranfield) referred to overblown accounts of what expert systems can do, and regretted the amount of 'hype' there is in presentations on the subject. He referred to four problems.

(a) Knowledge elicitation is very time consuming.
(b) The use of Bayesian probabilities can be problematic if one has no updating procedure.
(c) Expert systems are not easy to update.
(d) Some software is painfully slow.

Whether the freight industry would be likely to adopt expert systems was questionable; at present, 57% of freight firms had no access to computers, and 67% no access to software.

In reviewing the question of where expert systems might have a role in the freight industry, he considered there was little scope at the company management level, but far more scope at the distribution management level. He questioned whether there was much scope in route scheduling and planning; algorithmic approaches are useful as far as they go, but for an expert system so much company-specific local management data would be needed.

Mr Towris suggested that expert systems which simply encoded a book of rules were trivial, and undermined the value of the expert system approach: if the book was there, why not use it? In most cases, that would be easier and quicker than using an expert system to look up the rules. However, there might be some value in an automated rule book for occasional problems, like the treatment of hazardous spillage.

C.1.3 SELECTING RELEVANT INFORMATION FOR TRAFFIC BROADCASTS

David Jeffery (TRRL) outlined the 'Traffic Information Collator/Condenser' (TICC) system being developed with **Chris Mellish** (University of Sussex). In its characteristics, the TICC system does not fit neatly into any one of the categories used for the seminar, in that it had elements of an enquiry system; a diagnostic system; and analytical advice system; a control system; and a policy support system. The system is being developed as an Alvey Demonstrator project, and has funds until 1989.(Originally the project was part of the Alvey project on the RACAL Vodafone, but it is now separate from that.) The aims of the system are to:

- monitor messages about road traffic incidents received on the Police Control computer;
- condense the text;
- compare messages;
- produce suitable messages for broadcast;
- decide in which localities the messages should be broadcast.

The project is being developed with the assistance of East Sussex

Police.

The overall design of the system is as follows. (i) An **Input Interface** allows the user to switch between different modes of using the system (viz, inputting new information; reviewing existing information; updating). (ii) A **Natural Language Summariser** allows the user to input information about a traffic incident. It is designed to cope with inputs from multiple sources, and is based on the Loughborough/Leicestershire police system. Whilst a full natural language interface would be desirable, a menu-based system is adequate. It provides help on the form of input required for each field, and has syntax checks. Information from this and from (iii) a **Road/junction Database**, which is based on the Department of Transport's Present Year Network File (PYNF), is then passed to (iv) a **Tactical Inferencer**, which first checks that it knows about any locations mentioned, then decides on what message should be broadcast, the area to be broadcast to, and the number of repeat broadcasts required. These requirements are sent to (v) the **Broadcaster**, which decides which transmitters are needed to reach the required area, and sends the required number of texts to (vi) the **Transmitters**.

In the Traffic Inference sub-system, traffic models are used to estimate the traffic flow past an incident, and how long a blockage might take to disperse. The system runs on a SUN using POPLOG. Input can be in words or figures. Map displays are generated. Most of the systems time is spent on the linguistic analysis of the message, which has three components: message morphology; syntax; semantics.

Mr Jeffrey was interested in methods of deducing rules from examples, and queried whether anyone had experience of EXPERT EDGE.

Further details of this system are in References 4 & 5, copies of which were available to delegates.

C.1.4 ISSUES RAISED IN DISCUSSION

Training was suggested as an appropriate role for an automated rule-book. A debate developed on Mr Towris's view on the role of expert systems in route scheduling and planning; see later for notes on this topic. The question was raised of links between TICC and ARIANNE. John Wootton commented that in three years he had seen only two non-trivial examples of expert systems applications. Factors that limited the usefulness (to us) of existing software were that the nature of the problems to which it was addressed was different; that it was highly knowledge-specific; and that it was released in a premature state of development, and not free from bugs. Often, too, it was not clear from the documentation what precisely these software tools would do.

A key issue in the successful development of an expert system was knowledge acquisition. Knowledge was exepensive to acquire, and techniques for doing so were often hap-hazard. Resistance to providing knowledge could be encountered, because people felt their expertise might be challenged, or their jobs threatened. Because it might be very difficult to obtain the time required from those with deep expertise, one might have to develop systems based on the knowledge of less experienced people who were more willing and able to provide the time; but this could nevertheless be a useful, and provide a basis from which a more experienced person could later suggest refinements.

Flexibility was seen as important in developing an expert system.

An important role for expert systems was seen in providing an aid for less experienced or lay people. An application in marine navigation was instanced as an example of its value.

The name "expert systems" was thought to be misleading, in that overmuch reliance might be placed on the conclusions it came up with; it was important that a human had responsibility for the decisions reached.

C.2 DIAGNOSTIC / PRESCRIPTIVE SYSTEMS

C.2.1 EXPERT SYSTEMS IN ACCIDENT INVESTIGATION AND PREVENTION WORK

Dr Ben Heydecker (University College London, Transport Studies Group) described accident investigation and prevention (AIP) as involving
- (a) identification of sites for investigation
- (b) investigating accidents there
- (c) identifying and applying treatments
- (d) monitoring results.

This is not necessarily done in that order; sometimes one has a treatment and asks what sites to apply it to. AIP work is very cost-effective, showing first year rates of return of over 100 percent. Though there are difficulties in determining the statistical significance of preventative measures: the 'regression to mean' effect means that accident sites chosen for treatment will usually show a reduction in accident rates even if no treatment is applied. Part of the problem is the data source used, which is the STATS19 data.

There are three basic ways of investigating accidents:
- individually
- by site
- by type (cause or treatment).

Possible causal relationships could be investigated by rule-induction techniques. One wants to develop rules that relate causes to effects. A problem however is the nature of accident data: there is only information about positive cases, where accidents happen, as opposed to negative ones, where they do not.

Only certain types of data and rule can be inferred with current inference mechanisms, as shown in the following table:

	TYPE OF RULE	
	Deterministic	Fuzzy
D A T A Consistent	ID3 algorithm eg EXPERT-EASE	Cannot apply
Noisy	BEAGLE	? Open to question

Dr Heydecker likened the approach in the ID3 algorithm to fitting a line through each point in a data set, and the BEAGLE approach to drawing a line of best fit through the points.

C.2.2 AN EXPERT SYSTEM FOR THE EVALUATION OF ROAD CONDITION

Dr Alastair Watson (University of Leeds, Department of Civil Engineering) described the development of a portable expert system designed to overcome some of the limitations of the Pavement Condition Rating (PCR) method. The PCR method, though widely used in the USA, is not well established in the UK. Problems have been that it needs an experienced rating team; it is easy to mis-rate a pavement condition; and there are variations between teams in the ratings achieved. To overcome these problems, an expert system was developed using the SAVOIR shell. It is based on the PCR system, and is designed as a portable system for use by a 2-man rating team in a car. It:

- records all observations
- checks their consistency
- displays appropriate information
- guides the rater
- suggests values and actions to take
- provides help for on-the-job training.

It is the first part of a three-module system, being designed to:

(1) establish existing conditions;
(2) predict pavement performance;
(3) advise on maintenance options.

The reasons for an expert system approach to this were:

(a) ready access to basic knowledge base;
(b) ease of incorporating experience from site trials;
(c) judgement was needed and could be incorporated;
(d) consistency checks;
(e) help system.

SAVOIR was chosen because it had both forward and backward chaining; could interface with Pascal procedures via a trap handler; was technically proven in practice; and was affordable.

C.2.3 ISSUES RAISED IN DISCUSSION

The issue of getting experts to share their knowledge was taken up again. It was suggested that it might not be so much of a problem during the early stages of development of an expert system. Experts are not threatened yet! Providing a Royalty might be one way of ensuring that the provision of their expertise gains a continuing reward. But one overall problem was of course that experts often cannot agree amongst themselves.

C.2.4 APPLYING EXPERT SYSTEMS IN A HIGHWAYS DEPARTMENT

Mr J.L.S. Wilson (Hertfordshire County Council) was unfortunately unable to come to present his paper; but he provided a copy of his notes subsequently (Ref 6), and this summary is based on those notes (which also contain points germane to the discussion reported above).

Mr Wilson argues that expert systems are evolving into two quite distinct types; the enclopaedic type, and the cyclonic type. He shows that the flow-chart of the Hertfordshire Accident System can be likened to the components of an expert system. But as it contains feedback from the review of before-and-after studies to the setting of objectives, it is a model of the cyclonic kind of expert system, in which the system itself uses the results produced from each run to modify its knowledge base at the end of the run, thereby producing a new version ready for the next run. He argues that "it is this learning from experience element which contains the largest element of AI principles. It is no longer sufficient to define AI as being the ability not to detect whether it is a human or a machine on the other side of the screen, but to be convinced that a machine on the other side of the screen is more intelligent at the end of a half-hour conversation than at the start. It is this property of cyclonic expert systems that makes then so exciting... ". (I have quoted this at length, because, as noted in Ref (1), most expert systems are conspicuously lacking in any such ability to learn from their own experience in use.) Mr Wilson remarks that this principle is not difficult to achieve in conventional programs: one can write a command file to run a program, producing results to rewrite and recompile the program from within the command file.

Mr Wilson stresses that the 'Dark site expert system' developed in Hertfordshire CC is only an elementary expert system. It was developed by asking a street lighting engineer how he set about deciding which sites to improve. The rules were straightforward - mainly setting the sources for the data and the criteria to apply - and a program written in BASIC to apply them. In application, the rules are applied to consecutive lengths of road in the county; the length is varied from, say, 300 metres to several kilometres in 100 metre steps, and the results calculated for all sections and all lengths. Sections are ranked according to their economic rate of return. The number of sites to be treated in a given year would of course depend on the budget. The result of developing this program was an increase by a factor of 100 in the economic rate of return being obtained for the sites selected for treatment, compared with a previous computer-assisted manual system.

C.3 DESIGN SYSTEMS

C.3.1 TRAFFIC SIGNAL DESIGN

Mr Frank Montgomery (University of Leeds, Institute for Transport Studies) described the problems facing traffic signal engineers in a developing countries. In Bangkok, for example, there are many isolated traffic signals. With constantly changing traffic conditions, there is a continual need to revise the timings. (Vehicle actuated signals are not an answer for this problem, because the roads get so hot the vehicle detectors are soon defective or broken). Yet there are only six traffic signal engineers in the city (whose size is that of London). Their time is therefore often tied up in the relatively mundane task of devising stages, sequences and timings for the isolated signals, when it would be better spent on other issues. Since computer-assistance is only at present available for the timing aspect of this design process, a great advance would be the incorporation of the elements of judgement that at present go into the stage and sequence selection process. A rule-based approach for this aspect would enable those rules of thumb and procedure that were specific to different countries (or to parts of a country) would enable one program to be developed that could be tailored for use in many different parts of the world. The intention is to develop such an approach on an IBM-compatible micro, probably using PROLOG for the rule-based elements, and interfacing to algorithmic procedures as necessary.

C.3.2 CONTRIBUTION OF EXPERT SYSTEMS TO ROUTEING AND SCHEDULING

Mr John Pollack (Polytechnic of Central London, Transport Studies Group) described some of the problems with conventional packages for routeing and scheduling. They:

- do not allow sufficient description of the problem domain (which can be complex);
- are not very good for interactive use;
- are not suited to on-line use in emergency situations;
- are difficult/costly to modify.

Typically, the problem has to cope with

- stochastic demands (eg for an unforeseen urgent job)
- variable resources, perhaps at short notice (eg a driver off sick, or delays in the network);
- uncertain information (eg road speeds)
- loosely defined and sometimes conflicting objectives and constraints (eg cost minimisation versus customer service)

all of which might be better done using an expert system. The most appropriate role of the expert system might be in updating or modifying an existing solution in the light of changed circumstances, in order to:

- pool expertise
- support non-experts
- provide and improved basis for performance monitoring
- improve acceptability (especially if it justifies its advice).

It could be used for

- crisis management
- 'what-if' planning
- training / improving skills.

C.3.3 ISSUES RAISED IN DISCUSSION

An incremental approach to the development of expert systems was advocated. This could for example take the form of augmenting manuals on design problems with a software version; then developing a smart interactive manual. Distinctions need to be made between the algorithmic aspects of a design problem, and ways of conveying the knowledge on how to use them. Mention was made of an expert system developed in Paris on optimum signal timings. Caution was expressed concerning the provision of analytical advice by means of an expert system; we often do not know the right answers! There should always be a disclaimer.

C.4 ANALYTICAL ADVICE AND INTERPRETATION SYSTEMS

C.4.1 SELINA - AN ADVISORY SYSTEM ON STATISTICAL DESIGN

Mr Al Baines (University of Leeds, Department of Statistics) spoke of the problems caused by the fact that though all statistical packages were written by statisticians for statisticians, they were used by non-experts. Not only were they non-friendly to such a group of users; their use could be dangerous in inexpert hands. Moreover, no package was available that gave advice on statistical design. To rectify this, the Leeds team had adopted an experts system approach with the following features:

- an overview module for initial problem description (equivalent to a dialogue with an expert statistician);
- design modules (for comparative, factorial and response surface designs)
- open tree network of steps.

The user had to:

- supply items of information;
- approve suggested courses of action;
- choose among alternative courses of action.

Help facilities are at four levels: assisted / expert / help / and explain. Check facilities were automatic, embracing logical and arithmetic checks, statistical and validity checks. This contrasts with existing packages, where the user has the option of requesting statistical and validity checks, but does not know what to choose. The statistical checks include tests for outliers.

The package was written in Fortran because of the large amount of number crunching involved. It is expected to be commercially viable by March 1987.

C.4.2 ISSUES RAISED IN DISCUSSION

It was suggested that it would be useful to have an expert system that advised on the choice of transport planning package or method. But the view was expressed that it was dangerous to crystallise out of date and uncertain expertise.

C.5 CONTROL SYSTEMS

5.1 COLLISION AVOIDANCE AT SEA

Dr GP Smeaton (Liverpool Polytechnic, Maritime Studies Department) gave graphic illustrations of the ways in which collisions at sea occurred, in which at times the passing ships seemed to be drawn irresistably to one another! The problem is of course one of interpretating the data as seen by the navigator: what is the other ship doing and where will both ships be after undertaking certain manoeuvres? The problem is that whilst there is good radar positioning information (through ARPA - the Automatic Radar Plotting Aid), it does not suggest what the navigator ought to do. Experienced navigators would not make the errors that less experienced navigators do in this situation. An expert system could assist for the following reasons: collision avoidance rules are imprecise; the rules are based on 2-vessel encounters, and sometimes more complex situations occur; and allowance needs to be made for the fact there is no assurance about what the other ship will do. The system would have to be designed to suggest the action to take to avoid collisions, acting within the rules, but also within the spirit of the legal framework involved. An advisory system is more appropriate than an 'automated bridge'. Eventually systems might be developed for passage planning.

There is a general problem of the risk of mis-interpretation as between the user and supplier of information.

C.6 POLICY SUPPORT SYSTEMS

6.1 EXPERT SYSTEMS AND DECISION SUPPORT UNDER UNCERTAINTY

Dr Alan Pearman (University of Leeds, School of Economic Studies) suggested that there was great scope for expert systems in managerial decision making in transport and decision support. Decision making ranged from the frequent and routine to the infrequent and important, and typically involved a powerful mixture of good analysis, expert judgement, and 'muddling through'. He noted that there was evidence from the psychological literature that even 'experts' are error prone. He suggested that the following might be suitable subjects for expert systems:

- small scale investment decisions in local government (eg project appraisals such as bus lanes versus signal control);
- intermediate decisions, such as those involving COBA

- decisions of major importance where assistance was needed with problem structuring and alternative generation.

These were good fields for expert system applications because of the amount of fuzziness / uncertainty present; the potential for using graphics; and the fact that these were non-critical areas - they did not have to be 100 percent successful to be cost effective.

C.6.2 EXPERT SYSTEMS FOR THE MANAGEMENT OF PUBLIC TRANSPORT SERVICE SUBSIDY AGREEMENTS

Mr David Ling (UMIST) spoke of expert systems interests in the context of a project on the role of computer mapping in public transport co-ordination, which was being undertaken in collaboration with shire Counties and Strathclyde Regional Council. Following the 1985 Transport Act deregulating bus services, there was a need for rapid response to change, but a loss in the experience available to assess the changes in service needed, against a background of many more operators competing for customers.. The legal consequences of the changes imposed more duties on the co-ordinators, such as meeting special needs (for schools, the elderly etc), but with less money available there was a greater need for determing priorities. A more detailed planning role was required by the system of route specific competitive tendering. The public transport co-ordinator had to use spatial and temporal data that was often incomplete or out of date. Problems were multi-faceted, had many secondary effects and fuzzy relationships; trade-offs were needed in reaching a solutions, of which there were a large number.

REFERENCES

1. BONSALL, P.W., KIRBY, H.R. and KWAN, R.S.K. (1986) Applications of expert systems in transport. Working Paper 216, Inst. Transp. Stud., Univ. Leeds, Leeds. All but Appendix now published in: P.W. Bonsall and M. Bell (eds) (1987), Information Technology Applications in Transport, VNU Science Press, pp 353-381.
2. WHEATLEY, M.D. (1984) Expert systems in transport. Part 1: an introduction to expert systems. Working Paper 178, Inst. Transp. Stud., Univ. Leeds, Leeds.
3. SCIENCE AND ENGINEERING RESEARCH COUNCIL, Environment Committee (1986) Artificial intelligence software for civil engineering, building, transport and marine technology. Letter P:BG:140 C2 dated 29th July 1986.
4. MELLISH, C.S. (1985) Traffic information collator / condenser. Task 1 Report, TIC: Issue 3. Univ. Sussex.
5. The current menu-based traffic-information collator. Appendix (to unknown report).
6. WILSON, J.L.S. (1986) A practical application of an expert system in a county highways department. Slides and notes, Accident Data and Analysis Team, Hertfordshire County Council.

Part E: PARTICIPANTS AND OTHERS INTERESTED

E.1 PARTICIPANTS

Mrs C Ashley	Bolton Institute of Higher Education Deane Road BOLTON BL3 5AB Bolton 28851 ext. 3032
Dr Margaret Bell	Senior Research Assistant School of Eng & Applied Science Science Laboratories South Road DURHAM DH1 3LE Durham (0385) 64971
Dr Michael Bell	Transport Engineering Dept of Civil Engineering Univ of Newcastle upon Tyne Cassie Building Claremont Road NEWCASTLE UPON TYNE NE1 7RU 091-232-8511
Ian Black	Cranfield Institute of Technology Centre for Transport Studies CRANFIELD MK43 0AL Beds (0234) 752770
Capt Alan G Bole	Dept of Maritime Studies Liverpool Polytechnic Byron Street LIVERPOOL L3 3AF 051-207-3581
E J Bradford	Lloyds Register of Shipping 71 Fenchurch Street LONDON EC3M 4BS

	01-709-9166
Frans Coenen	Dept of Maritime Studies Liverpool Polytechnic Byron Street LIVERPOOL L3 3AF 051-207-3581
Mike Cowell	Transport Engineering Department of Civil Eng University of Newcastle upon Tyne Cassie Building Claremont Road NEWCASTLE UPON TYNE NE1 7RU 091-232-8511
Geoffrey Eastwood	Science and Engineering Research Council Polaris House North Star Avenue SWINDON SN2 1ET (0793) 26222 Ext 2154
Dr Ben Heydecker	Transport Studies Group University College London 20 Flaxman Terrace LONDON WC1 01-387-7050 Ext 2091
David Jeffery	Highway Traffic Division Transport & Road Research Lab Department of Transport Old Wokingham Road CROWTHORNE Berkshire RG11 6AU Crowthorne 773131
Graham Heywood	Bolton Institute of Higher Education Dean Road BOLTON BL3 5AB

	Bolton 28851 Ext 3032
Neil Hoose	Transport Studies Group University College London 20 Flaxman Terrace LONDON WC1 01-387-7050
Mark Howell	Gaydon Technology Ltd Gaydon Proving Ground Banbury Road Lighthorne WARWICK CV35 0BL (0926) 644461
Nigel Lee	Research Division British Railways Board Railway Technical Centre London Road DERBY DE2 8UP (0332) 42442
Derek Linder	Research Division British Railways Board Railway Technical Centre London Road DERBY DE2 8UP 0332-42442 ext 5377
David Ling	University of Manchester Dept of Civil Eng Institute of Science & Tech Sackville Street MANCHESTER M60 1QD 061-236-3311
Christine Marsden	Science & Engineering Research Council Polaris House North Star Avenue SWINDON

	SN2 1ET (0793) 26222
David Morgan	Transportation Research Group Department of Civil Eng University of Nottingham University Park NOTTINGHAM NG7 2RD (0602) 506101
John Pollack	Transport Studies Group Polytechnic of Central London 35 Marylebone Road LONDON NW1 5LS 01-486-5811
Bob Relph	Highways, Engineering & Technical Services Unit (HETS) Dudley House Albion Street LEEDS LS2 8JX Leeds (0532) 463000
Dr Peter Smeaton	Department of Maritime Studies Liverpool Polytechnic Byron Street LIVERPOOL L3 3AF (051) 207 3581
Mrs Margaret Thiobold	Transport Studies Group University College London 20 Flaxman Terrace LONDON WC1 01-387-7050
John Towriss	Centre for Transport Studies Cranfield Institute of Technology CRANFIELD Beds

MK43 0AL

(0234) 752770

L G Willumsen (Pilo)	Transport Studies Group University College London 20 Flaxman Terrace LONDON WC1 01-387-7050
John Wootton	Wootton Jeffreys & Partners Cemetery Pales Brookwood WOKING GU24 0BL 048-67-80033

University of Leeds	Leeds (0532) 431751
Peter Bonsall	ITS Ext 393
Ferri Ghahri-Saremi	ITS Ext 7213
Howard Kirby	ITS Ext 7024
Frank Montgomery	ITS Ext 273
Dr Al Baines	Statistics Ext 7077
Dr Andrew Cole	Computer Based Learning Ext 7106
Raymond Kwan	Computer Studies Ext 6119
Barbara Smith	Computer Studies Ext 401
Tony Wren	Computer Studies Ext 6112
Alan Pearman	Economic Studies Ext 6517
Dr Alastair Watson	Civil Eng Ext 7419

OTHERS TO BE KEPT INFORMED

David Barnard	Project Manager (AI) British Airways Viscount House (E156) P O Box 10 Heathrow Airport HOUNSLOW Middx TW6 2JA 01-562-4389

Dr Robert Barr	Department of Geography University of Manchester MANCHESTER M13 9PL 061-273 3333
Malcolm Bourne	County Surveyor's Office (Traffic) Kent County Council Springfield Sandling Road MAIDSTONE ME14 2LQ Maidstone 671411 Ext. 3824
David F Feeny	Templeton College (Oxford Centre for Management Studies) Kennington OXFORD OX1 5NY Oxford 735422
Mrs Julie Gadsden	Admiralty Research Establishment AXT3 Portsdown Cosham PORTSMOUTH PO6 4AA Cosham (0705) 379411 ext. 2119
Graham Geary	Senior Research Assistant School of Eng & Applied Science Science Laboratories South Road DURHAM DH1 3LE Durham (0385) 64971
Dennis Gilbert	Imperial College Transport Section Civil Engineering Imperial Institute Road LONDON SW7 2BU 01-589-5111

Dr Frank Hickman	Knowledge Based Systems Centre South Bank Polytechnic 58 Clapham Common North Side LONDON SW4 01-350-1622
Geoffrey Hyman	MVA 115 Shaftesbury Avenue LONDON WC2H 8AD 01-836-9381
Peter Jenkins	Logica Cambridge Ltd 104 Hills Road CAMBRIDGE CB2 1LQ 01-637-9111
Colin Kauntze	Thomas Cook Group P O Box 36 Thorpe Wood PETERBOROUGH PE3 6SB (0733) 502300
Chris Mellish	Cognitive Studies Programme University of Sussex Falmer BRIGHTON BN1 9QN Brighton 606755
Hugh Neffendorf	MVA MVA House Victoria Way WOKING SURREY GU21 1DD (04862) 28051

Peter O'Neill	Department of Transport 2 Marsham Street LONDON SW1P 3EB 01-212-8276
Peter Nutt	Department of Transport Room 4147 St Christopher House Southwark Street LONDON SE1 0TE 01-921-4746
Bob Ruckwood	Thomas Cook Group P O Box 36 Thorpe Wood PETERBOROUGH PE3 6SB (0733) 502300
Dr Steve Willmott	Civil Aviation Authority Chief Scientist's Div CAA House Room K 718 45-59 Kingsway LONDON WC2B 6TE 01-379-7311 Ext 2298
J L S Wilson	Highways Department Hertford County Council Goldings North Road HERTFORD SG14 2PY Hertford 556140

APPENDIX 1: SOME OTHER RECENT PAPERS ON TRANSPORT APPLICATIONS OF EXPERT SYSTEMS, UK AND OVERSEAS

(NB No attempt has been made to make this list comprehensive; my aim here is to simply to note some recent work that UK readers may not have come across, to give some indication of the potential for transport applications of expert systems as seen in other research communities. Other papers are noted in the references supplied in Reference (1) above. Readers are invited to let the author have other references, to help build up a comprehensive bibliography of such applications.)

Reported in UK

GADSDEN, J. (1986) Resource allocation, scheduling and design. Notes for a presentation on knowledge-based planning to the IEE, April 1986. Admiralty Research Station (unpublished)

GADSDEN, J.A. and LAKIN, W.L. (1986) FlyPAST: An intelligent system for naval resource allocation. Presented at 9th MIT/ONR Workshop on C3 Systems, 2-5 June 1986, Monterey, California.

MILNE, P.H. (1986) An expert system for road curve design and setting-out. Paper presented to 1st International Conference on the Applications of Artificial Intelligence to Engineering Problems, held at University of Southampton, April 1986.

PEARSE, P. and RESENBAUM, M. (1986) The evaluation of proposed road corridors by the use of expert systems. Paper presented to 1st International Conference on the Applications of Artificial Intelligence to Engineering Problems, held at University of Southampton, April 1986.

NIELSEN, N.R. and GADSEN, J.A. (1987) Knowledge-based scheduling in FlyPAST. Paper submitted to 3rd IEEE Conf., AI A0plications, Orlando, Florida, Feb 1987. Paper presented to 1st International Conference on the Applications of Artificial Intelligence to Engineering Problems, held at University of Southampton, April 1986.

Reported in USA

BRYSON Jr, D. A. and STONE, J. R. (1987) The intersection advisor: an expert system for inter-section design. Paper presented at 66th Annual Meeting, Transportation Research Board, held in Washington D. C., U.S.A, January 1987. (Authors from North Carolina Sate University).

CHIN-PING CHANG, E. (1987) Select traffic analysis software using expert systems. Paper presented at 66th Annual Meeting, Transportation Research Board, held in Washington D. C., U.S.A, January 1987. (Author from Texas A & M University Systems.

CHIN-PING CHANG, E. (1987) Expert systems application in left-turn signal treatment. Paper presented at 66th Annual Meeting, Transportation Research Board, held in Washington D. C., U.S.A, January 1987. (Author from Texas A & M University Systems).

FLANAGAN, P. R. and HALBACH, D. (1987) Expert systems as a part of pavement management. Paper presented at 66th Annual Meeting, Transportation Research Board, held in Washington D. C., U.S.A, January 1987. (Authors from ARE, Inc.)

HAJEK, J. J., CHONG, G. J., PHANG, W. A. and HAAS, R. C. G. (1987) Can knowledge-based expert systems technology benefit pavement maintenance? Paper presented at 66th Annual Meeting, Transportation Research Board, held in Washington D. C., U.S.A, January 1987. (Authors from Ontario Ministry of Transportation and Communications (JJH, GJC and WAP) and University of Waterloo (RCGH)).

HENDRICKSON, C., ZOZOYA-GORSTIZA, C. and McNEIL, S. (1987) Network representations of performance analysis for intersections. Paper presented at 66th Annual Meeting, Transportation Research Board, held in Washington D. C., U.S.A, January 1987. (Authors from Carnegie-Mellon University (CH and CZ-G) and Massachusetts Institute of Technology (SMcN)).

McNEIL, S. and FINN, A. M. (1987) An expert system to cost feasible bridge-painting strategies. Paper presented at 66th Annual Meeting, Transportation Research Board, held in Washington D. C., U.S.A, January 1987. (Authors from Massachusetts Institute of Technology).

RITCHIE, S. G. (1987) A knowledge-based approach to pavement overlay design. Paper presented at 66th Annual Meeting, Transportation Research Board, held in Washington D. C., U.S.A, January 1987. (Author from University of California).

TUNG, S-I. and SCHNEIDER, J. B. (1987) Designing optimal transportation networks: an expert systems approach. Paper presented at 66th Annual Meeting, Transportation Research Board, held in Washington D. C., U.S.A, January 1987. (Authors from University of Washington).

WALKER, W., LEWIS, R. T. and JOHNSON, W. F., (1987) Applications of expert systems to transportation: a strategy for safety and productivity gains. Paper presented at 66th Annual Meeting, Transportation Research Board, held in Washington D. C., U.S.A, January 1987. (Authors from Transport Canada).

WELCH, J.G. and BISWAS, M. (1986) Application of expert systems in the design of bridges. Paper presented at 65th Annual Meeting, Transportation Research Board, held in Washington D. C., U.S.A, January 1987. (Authors from Duke University).

YEH, C-I., SCHNEIDER, J. B., NIHAN, N. L. and RITCHIE, S. G. (1987) Knowledge-based expert systems in transportation planning and engineering: an initial assessment. Paper presented at 66th Annual Meeting, Transportation Research Board, held in Washington D. C., U.S.A, January 1987. (Authors from University of Washington (CIY, JBS and NLN) and University of California (SGR)).