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INFORMATION TECHNOLOGY AND TRANSPORT: WHAT RESEARCH NEEDS TO BE STARTED NOW?

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ABSTRACT

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The ten week period from 9th October to 19th December 1982 was spent as Visiting Fellow at Leeds University at the Institute for Transport Studies, to examine the opportunities for research into the effects of information technology on transport and the interactions between them. This Fellowship was sponsored by the Science and Engineering Research Council (UK) and the Australian Road Research Board with additional support from Oxford Sytematics (Australia).

This report reviews the scope for research in this area, with particular emphasis on identifying workable project directions in the Institute for Transport Studies (ITS). Appropriate contacts and related work are given. Topics covered include data acquisition systems (including the potential for hand-held data capture devices, and the use of aural, visual and micro-wave wavelengths in capturing data); data processing and communications policy appropriate to the Institute's requirements; the role of knowledge-based systems; and the analysis of the relation between communications and transport activities in respect of time-use and expenditure patterns.

A number of the research proposals raised and put to ITS staff during the period are summarised in an Annex to this report (ITS Technical Note TN 126). The summaries and texts of a series of seminars given during November-December 1982 at ITS are covered in a companion document (ITS Working Paper WP169).

KEYWORDS: TRANSPORT/ COMMUNICATIONS/ DATA ACQUISITION/ DATA BASE/ ELECTRONIC CONFERENCING/ VIEWDATA/ DIGITAL NETWORKS/UK/ AUSTRALIA/ ELECTRONIC PUBLISHING/ PRESTEL/ TIME USE/ FAMILY EXPENDITURE/ INSTRUMENTATION/ NETWORKS/

INFORMATION TECHNOLOGY AND TRANSPORT: WHAT RESEARCH NEEDS TO BE STARTED NOW ?

1. INTRODUCTION

A proposal was put to the UK Science and Engineering Research Council in mid-1982 for the author to come to Leeds for three months of the academic year 1982-3. The objectives were to accelerate and advance the work at the University's Institute for Transport Studies (ITS) in identifying and initiating necessary research in the overlapping areas of transport and information technology.

This proposal was accepted, and the ten week period from 9th October to 19th December 1982 was spent as Visiting Fellow at Leeds University at the Institute for Transport Studies, to examine the research opportunities for transport and information technology interactions and influences. The results of these initiatives and the minor amendments to the texts of December 1982 were pursued in the last weeks of June 1983 on a return visit to Leeds.

This Fellowship was sponsored by the UK Science and Engineering Research Council (SERC) with the Australian Road Research Board (ARRB), and additional support was provided by Oxford Systematics (Australia). It became the third project undertaken by ITS on the impact of communications technology on transport (see Section 1.1).

The initial period of the Fellowship was spent on obtaining an understanding of the nature of the changes in Information Technology which will or are already beginning to change the way in which activities are served by transport and by telecommunications.

The convergent fields of computer communication, telecommunications, publishing, information retrieval, working patterns and transport movements are changing so swiftly that to obtain even a partial picture of the active initiatives in the UK proved to be a demanding task for the time available.

Now that the real costs of telecommunications are becoming more competitive with those of transport, there will be an increasing need to extend the range of skills and experience of transport researchers into the telecommunications area. To assist in this process, a series of five seminars were given whilst at Leeds during November/December 1983. A companion document (WP169, Wigan 1983h) summarises - and in some cases extends - the text of these seminars.

The present document (WP172) provides initial views on workable project directions in which ITS could move, and gives some contacts and references. The projects were specifically designed to build on the extant expertise and experience of the

Institute, rather than to be a general view of research priorities in the area of interaction of transport with information technology or telecommunications. The project selections discussed were thus designed to address both the needs in the area and to enhance the knowledge, data and experience base available to the Institute. An Annex (TN126, Wigan 1983i) suggests specifications for some of the research opportunities identified.

The present report is a summary of a learning process over the ten weeks to December 1982 (of the twelve week total period involved). Some minor changes, additions and amendments have been made to both documents while at Leeds during the last two weeks of the Fellowship (in June 1983). By this date a considerable number of the proposed initiatives had been set under way.

The perspective achieved during this concentrated period of attention to IT issues and transport has led to several papers, reports and other contributions during the period January-June 1983, when the author had returned to duty at the ARRB in Australia. These included the following items, largely reliant on the subject matter covered during the Fellowship.

1) A chapter for the published summary of the two-year IIASA program on Regional Information Systems (Wigan, 1983a).

2) A paper for the World Conference on Transport Research (Wigan, 1983b).

3) A panel address on the impact of computer technology on the engineering profession at the National Conference of the Australian Institution of Engineers. (Wigan, 1983c), which is now likely to appear in the transactions of both the Australian and the New Zealand Institutions. It is under review for the former, and has already been requested for the latter.

4) A direct transcript of the seminar on electronic mail and computer conferencing was produced at Leeds subsequent to the departure of the author, and has gained wide circulation amongst members of the UK Universities Transport Studies Group. (Wigan, 1982b, 1983d).

5) A paper for the CIB79 Working Group International Meeting in Waterloo in July 1983. (Wigan, 1983e).

6) An illustrative analysis of the interconnections between various aspects of a research organisation affected by information technology changes, and the areas of potential productivity gain. This is given in full in the associated Working Paper (WP169, Wigan 1983h).

7) A seminar on Electronic Publishing to the Central Editorial Group of CSIRO (which publishes 14 Journals as one aspect of its activities): a subsequent request was received to act as a keynote speaker at December 1983 National Libraries and Automation Conference in Melbourne, Australia.

1.1 RELATED WORK AT THE INSTITUTE FOR TRANSPORT STUDIES

The first ITS work in the area was a project by R. Allport and K.M. Gwilliam (1981-2) as a contribution to the EEC FAST program, in which a number of transport impact areas were identified as needing attention. In October 1983, a couple of weeks after the start of this Fellowship, ITS initated work on its second contract in this area. The contractor is the British Telecom Research Laboratories (BTRL), and the objective of the project is to monitor the impacts of Video Conferencing, with specific reference to the compressed band-width video-conferencing system developed by R16 Divison of BTRL. This project is being carried out by P.W. Bonsall and D.J. Bennison.

Since the Fellowship commenced, the Institute has sought and been allocated a research post on the Application of Artificial Intelligence Techniques in Transport. External operational and funding bodies have also invited ITS to make proposals for work on other aspects of IT and Transport/Communications. It is thought that such developments were assisted by the discussion, seminars and initiatives proposed in late 1982 and by the initial draft of this document (Wigan, 1983f).

It would therefore appear that the initiative was well timed, and has been effective and productive for both the UK and the Australian sponsors.

2. MARKET SEGMENTS

The information technology changes which are of greatest significance to transport can be treated in several ways. It is useful to give a classification scheme, and then make some tentative rough and ready judgements as to how best to proceed.

The major areas are:

1) Data acquisition
2) Data communication
3) Location substitution
4) Activity substitution
5) Expenditure changes
6) Time use changes

To which should be added the issues of workforce participation rates (especially for female workers), lifestyle alterations, and impacts on privacy and behaviour. Changes in

business content, practice and ethical behaviour might also arise, given the increased effectiveness of information access, and the ability to correlate and selectively apply information. A further major issue is that of information economics, and the associated costs, benefits, impacts, distributional effects, efficiency and quality measures of information flow.

As an overall point, it is clear that present data sources have not been adequately exploited as yet. Also, the expertise developed in transport as a discipline could be put to good use in monitoring studies of time use, location and activity choice behaviour.

3. DATA ACQUISITION

Under the heading of data acquisition there are two major factors to be considered: increased productivity of the research workers, and new methods and devices for data acquisition which will require research, and the application of new IT capabilities in transport contexts as intrinsic components of new monitoring and control systems.

Modular instrumentation systems for travel time, road roughness, and fuel consumption etc have been proven in the field and are now available as production versions. They could be employed to improve the productivity of data collection and processing in ITS. They could also be used far more effectively in an applied manner as part of the regular maintainence, monitoring, and operational organisation of many transport authorities, for such applications as:

- travel time and fuel consumption systems for congestion monitoring;
- road roughness measurement at speed for road maintainance studies.

Within Universities many other Departments, and specifically Departments of Electronic Engineering, have similar needs, and an active interest in subsequent complementary special-purpose board development exercises for further applications.

For field data capture, the use of transducers and of hand-held devices with keyboard data entry are the most obvious means by which information technology can be most directly and readily applied to transport and traffic data acquisition. The less-developed areas of data acquisition are visual and aural. The Department of Electrical and Electronic Engineering at Leeds has an interest in such areas, but these are well supported by other disciplines in an applied manner, and unless specific image reduction and encoding applications were in prospect, this would probably not be an entirely appropriate or productive route to follow at the ITS unless staff with a recent physical science or electrical engineering experience were to be brought in. If this were to be done, the technical support required would

be cumulatively significant, and so in these areas it is probable that ITS should in general not take the lead role, but actively participate in cooperative inter-departmental initiatives.

After reviewing, in 3.1, the scope for direct data capture in the field, using transducers and key-board entry devices, data-capture will be reviewed in the remaining sections in order of decreasing wavelengths of the media concerned.

3.1 FIELD DATA CAPTURE

One of the key areas for exploiting IT is in carrying intelligence into the field in computer aided forms. There are numerous areas in traffic and transport research where data must be gathered in a tailored manner, and then subsequently transcribed into machine-readable format. This need is quite separate from the data acquisition requirements so readily covered by systematically field tested modular microprocessor controlled data logging systems suitable for limited production runs, as exemplified by the ARRB AMBDAS family of production systems developed originally for research projects (eg Richards (1980), de Vos (1982 a,b)).

Such systems as AMBDAS (developeed by the Australian Road Research Board) and similar commercial products marketed by Golden River provide an effective gain in productivity and in the accuracy of acquisition of physical data (such as road alignment and geometry, driver responses, fuel consumption and dynamic axle and wheel loadings). However, for transport survey applications, an ideal specification of a point of application support tool would be somewhat different.

An ideal device for these tasks is a portable computer with a full keyboard and good data entry facilities, battery supported (or bubble) memory , backup storage facilities on the machine, and with some form of written or printed log of the information, with comments where required. Clearly a clock/date stamp is necessary, and it would be desirable to have a ready means of transferring the data so obtained without special ancilliary equipment (E.g. the MFE digital cassette readers used at ARRB for AMBDAS cassette data transfer to mainframes (de Vos, 1982b)).

This functional requirement was identified by the author prior to the UK launch of the Epson HX-20 handheld computer during the term of this Fellowship. It may be confidentally expected that this functional requirement will be addressed by an increasing number of manufacturers, Epson being only the first. The HX-20 is based on the instruction set of the Hitachi 6301 processor. This is implemeted in CMOS and has the same instruction set as the Motorola 6801. This system meets all of the above requirements, and has one or two extra features further confirming its suitability for field data acquisition. As an indication of the author's confidence in

this functional device, personal funds were used to acquire an HX20 in October 1982, and test out the potential capabilities inherent in the specifications.

Since then, Epson have released a graphics-oriented "base" machine (QX-20) with explicit provision for direct downloading of data from the HX-20 and with networking support for the HX-20 itself. This product appeared in June 1983, and quickly gained wide endorsement.

Consequently, the specifications for a field transport survey support device have all been met, and it is recommended that HX-20s (or their equivalents when action is financially possible) be obtained and used for field data capture within the ITS. Given that adequate knowledge is gained over time, by using the training facilities of the University of Leeds Microsystems Unit, the ROM (Read Only Memory) customisation features can be used to make the entire system appear to be a self-prompting single purpose device to the field user. The necessary cross-assemblers for the 6800 series microprocessors are already available on the MSU PDP 11/44 UNIX system on the Leeds TAC (Terminal Access Controller) system which links together most of the major computing resources of the University.

The key features of confirmed value in the Epson HX-20 include:

(1) 50 hour life of programs in memory between trickle charges of the built-in NiCad battery.

(2) Upper and lower case display of a windowed screen

(3) Room for a 2764 (8kb) ROM to be added inside the casing as customised by the user: a further ROM Pack can be added in place of the microcassette.

(4) High speed terminal data transfer at 4800 baud WITHOUT handshaking, for all 7 and 8 bit ,stop bit and parity variations without data loss(provided that the recent (mid-1983) System ROMs are used.

Some of the obvious applications might include registration data capture with a time stamp, cordon surveys, parking accumulation data, some interview data collection and survey control procedures.

In-car applications also appear to be promising, as the HX-20 has been operated effectively in moving cars and in heavy traffic where substantial electronic interference is rife. A major automotive ignition firms are currently assessing the use of modified HX-20's for their own data acquisition needs in the field.

This market will not remain (and, as of mid 1983, has not

remained) empty for long: the National PanaSonic "Quasar" hand held computer has already been on the market for some time, and is available as a briefcase model with acoustic coupler, colour printer, and TV adaptors... all with battery backup if required. However, the HHC itself is patterned more on a calculator keyboard than the full typewriter keyboard offerred by Epson. Other systems, such as the Tandy 799 US $ system with a built in (US) Modem, and the even smaller Sharp 1500 series of systems have already appeared by mid 1983.

Field Data Capture	Data Transcription to magnetic Media	Data Checking and Verification
1) MANUAL Written	Manual Second manual entry	Manual check of entry errors
2) ELECTRONIC CC Manual notes Machine readable	Done at data collection time: may need second transfer Medium->Medium	Prompted data entry, some autocorrection

FIGURE 1: INFORMATION TECHNOLOGY IN MANUAL DATA COLLECTION

Hewlett-Packard have also launched the first in their own series of hand held computers, with the impressive HP 75. This machine has been aimed at a different market again, and it is clear by comparison how Epson have specifically aimed their product at data acquisition and communications usage.

The recommendations at this stage are :

REC. 1) To acquire a instrumentation system designed for field data acquisition of data types requiring transducers, of proven reliability , as long as it is:

a) Modular
b) Expandable
c) Supported
d) FULLY DOCUMENTED for maintainence and extension

If ALL of these conditions cannot be met, it is unlikely that any such data acquisition system will be manpower-cost effective for ITS to obtain, set up, use, maintain and have extended. There is a reasonable possibility that the ARRB AMBDAS systems may be able to fulfil the full range of the immediate requirements within the support capabilities of the staff to hand in collaborating Departments.

The major problem with many such systems is likely to be requirement d), in view of the commercial aspects of these fully developed sets of equipment. Joint commercial development of additional modules in whatever system is obtained would of course overcome this potential problem, but is likely to be the province of the Electrical and Electronic Engineering Department in most cases, although much of the software for use of the data so collected would be expected to come from the ITS. It is of interest to note that the Australian UNISON MC68000 based system is predicated on such a philosophy of joint development of hardware and sofware on the UNISON bus (based on EuroCard modules, and thus suitable for in vehicle usage).

REC. 2) To acquire one or more HX-20 Epson portable systems for applied use in the field. In view of the need for tailored software, and at a later stage Hitachi 6301 assembler Code development, this should be done in collaboration with the Microprocessor Support Unit when a ROM development stage is reached. A suitable CP/M cross-assembler for the 6801 is now available for Z80/8080 microcomputers. This is based on the public domain 6800 Cross Assembler in the BDS-C user group library (Colley, 1980). This has now been cleared of errors, and enhanced to cover RCA 1802 and M6801 processors by H. Schultes (1982). It has been available from either H.Schultes or the author in Melbourne since early 1983.

There are many other applications for this class of device, and as it has already proved possible to demonstrate high speed data transfer to the APPLE (by using the Epson as a smart terminal), it should be noted that the ITS must also firm up a policy for its own internal data and text processing to follow through the issues raised above.

REC. 3) Different means of data acquisition are also worth following up, but probably after the lead of another Department. Data acquisition by image processing and voice recognition are no longer impractical, but are still substantially in the research domain. Image data capture is proceeding in many areas very much as an applied rather than a research task, and the aspect worth most specific attention from the ITS is in the application of surveillance technology. Image processing techniques now allow the use even of the APPLE for useful tasks (Masuoka, 1982) from LandSat images, and the techniques developed in a number of fields, including radar (Okkes and Schotter, 1982) can now be applied rather than have to developed prior to use in transport research applications.

The potential for aural, visual and micro-wave data capture will be reviewed in the remaining sections.

3.2 AURAL DATA CAPTURE

Aural applications of IT in data capture take on two distinct aspects. The first requires the use of speech recognition techniques: the capture of data by speaking to a device which recognises the verbal information; the second reguires the use of speech synthesis to issue generated information or commands on the basis of data acquired by a range of sensors or sources.

Succesful aural data capture area is extremely difficult. Speech recognition is still at an early state of development, but Logica have developed a system under contract to the Government's Joint Speech Research Unit (JSRU), which offers a sound opportunity for research into the efficacy of this means of data capture in the field, as field tape recordings may subsequently be analysed in the Laboratory. Texas Instruments have very recently announced a 32 bit bipolar co-processor specifically for audio signal processing in conjunction with their new Pegasus Personal Computer, based on the Intel 8088 central processor.

The Logica machine is in principle a very high speed filtering and computation system; the early prospects for a hand held field device are at this stage dim. The question worth addressing is the effectiveness of CAPTURING data by voice, with subsequent analysis in the laboratory. The problems of background noise, multiple voices being recognised for a standard set of words etc are all research questions in which ITS and the Department of Linguistics and Phonetics at Leeds University have a complementary interest.

Thus:

REC. 4) Set up field recordings and subsequent laboratory experiments on speech recognition and retrieval using the Logica and other systems as research tools. This should if possible be done in close co-operation with speech research specialists.

The Institute for Transport Studies initiated a suitable research proposal to SERC for such an evaluation; this was awarded in mid-1983.

3.3 VISUAL DATA ACQUISITION

Visual data acquisition at present demands substantial manpower. Assistance in the data capture tasks and even more for data transcription would be a major advance. It would also enable a wider range of measures to be brought into play for both the monitoring and the control of the operation and use of transport systems and fixed facilities. Portable systems would clearly be of substantial practical value to operators in the field.

Such assistance might be obtainable from the fields of astronomy and surveillance. For example, a compact (11lb all up) 3.5" Matsukov field telescope with Barlow lenses, to match resolution to 625 line video separation (giving about 8000mm focal length for a standard Questar 3.5", for example), provides the capability of reading and recording on video tape registration numbers at 2km.

This sort of device is regularly attached to remote controls, and would appear to provide an ideal means of data acquisition for visual recording situations where close contact is either difficult or undesirable.

The Questar (in both 3.5" and 7" models) is effectively a standard for surveillance work, due to their extremely high quality optics and their portability and robustness. The UK Questar telescope importer (Dr Lancaster, Harpenden) is also a surveillance video specialist, and makes regular use of the combination of a small telescope and video surveillance equipment.

The UK Home Office, in the Police Scientific Branch, have also reached a near-practical level for registration number recognition from continuous video camera imagery linked to an online computer containing stolen car registration numbers. Such combinations of technologies would therefore appear to be timely for research applications.

The author is producing a specific research program for the progressive development and application of the combination of telescope, image intensifier, loop or optical presence detectors, line detectors and CCD cameras, frame grabbers and temporal noise filters for vehicle detection and identification purposes. The use of an Arlunya temporal image noise reduction device also offers the simultaneous opportunity to adopt line detectors for the scanning process. This report will be available to SERC, but is being completed at ARRB as a possible research proposal for that organisation to consider, as much of the necessary equipment and the links with image processing chip development at the CSIRO Division of Manufacturing Technology make this an appropriate project to pursue. The special needs of Australian authorities for an effective means of identifying vehicles in conjunction with their axle loadings, and on roads with little traffic, make this an excellent project for that country. The technique has a similarly desirable, but different, pattern of applications in the UK, and should also be pursued at the ITS. International collaboration would clearly be assured. Another key item required for this line of work is the use of either frame grabber techniques or direct image acquisition using either linear arrays or Charge Coupled Device Video cameras. These cameras capture the video image in a directly encoded digitised format, and thus are ideal for data acquisition. The costs of CCD camers of adequate resolution are now dropping very swiftly, and they have become a practical and cost

effective alternative for many purposes at present and projected 1983 prices. The use of ordinary video tape systems in conjuction with subsequent computer aided encoding of the data to be captured has been used by many workers, including Troutbeck's work on vehicle overtaking behaviour at the ARRB and the commercial UK Wootton-Jefferys VISTA system (Wootton and Potter, 1981) based on APPLE or DEC PDP11/V03 computers.

The more promising line of work for further investigation is exemplified by that at the University of Louvain (Theuwissen, Vits and Vermeiren, 1980a,b), who have used CCD cameras with 72 x 128 point arrays in a pilot study aimed at traffic flow monitoring. The full resolution capacity of a domestic TV camera is now effectively available in CCD technology, and with the experience of the Louvain group to draw upon, can confidently be recommended as a further ITS proposal. Louvain themselves have gone further, to a slightly higher matrix density, and arenow mounting a commercial production agreement using the special purpose chips that they have designed. Full details of this work are therefore unavailable. Sheffield University have made some initial progress on the direct interfacing of CCD devices to video recording of frames for other traffic purposes, but the addition of image processing and shape recognition techniques with image intensification and temporal filtering has been part of their program. The development of suitable image processing software is an active concern in the Electrical and Electronic Engineering Department at Leeds, and they should form a part of any project set up at the ITS or at Leeds.

Thus:

REC. 5) Development of CCD or Video Camera based remote data acquisition equipment, and research and development to produce traffic monitoring, sampling, and other image processing techniques for research and field applications in traffic, transport and behaviour observation.

3.4 MICROWAVE DATA ACQUISITION

Moving up the frequency spectrum from the short wavelengths of light to microwave frequencies, microwave scanners now provide quite phenomenally effective target processing and identification capabilities in the military field, and low cost intelligent microwave scanners should now be applied more efficiently to traffic detection and identification.

In the mundane task of vehicle counting and identification, road loops are still not entirely satisfactory, and even then require works on the road for the most temporary site. The pneumatic tube counters are prone to vandalism,errors,and abuse and have but a mixed history of collecting reliable data where

year to year records are not available for corrections to be made. Vehicle identification and axle counting are both increasingly important, as is the requirement for axle LOAD recording.

In the area of temporary traffic counting and detection, there is certainly room for a non contact, non inductive system: microwave scanners may well provide an alternative route to this end.

Thus:

REC. 6) Specify the range and capability envelopes of vehicle detection and identification systems, and initiate work to assess microwave scanning in this role.

REC. 7) Specify the range and capability envelopes of dynamic vehicle axle load detectors, and draw up an economic (application) system for most effective combination of axle load detection, vehicle identification, road / load taxation and enforcement.

3.5 THE ROLE OF 'IT' IN TRAINING AND EDUCATION

The application of straightforward video records in conjunction with fully equipped simulation of noise vibration and angular movement has long been used for aircraft pilot training, and has occasionally been proposed as the basis of improved car driver training. The rapid advances in communications and data processing technology have brought with them a considerably reduced level of cost for such systems, and the application of these techniques to human factors research in transport traffic and safety is now practical. Simple efforts in this direction have been reported by Van der Horst (1980), for example, who used only video tapes and a large screen for conflict manouevre data collection. Considerably better quality results can now be obtained economically, and the use of powerful graphics and data processing equipment now permits automatic data gathering and responsive "experiments" to be carried out, with tests of control strategies.

This line of work has considerable potential for computer aided education, and, in conjunction with interactive videodiscs and transducers, permits immediate self training transfer of findings to the field. It is well understood that expert educational input will be necessary to make such a philosophy ultimately effective for a broad range of target audiences, but for the expensive staff so often involved this extra overhead might well be profitably delayed to a later stage.

Such work should also be done in conjunction with library and information experts, as the selective use of the mass information available in fast access visual format on a random access videodisc is far larger than most people have

immediately to hand. Strategies for making this 80,0000 frame $25 consumer product (the disc) a truly effective means of interactive information access rather than a simple reference list of filmclips, stills and text frames will be of considerable value.

This convergence of technologies is now raising the questions of the role and use of libraries. Libraries of DATA (as distinct from data banks or information utilities per se) are now becoming important. The SSRC Data Archive at Essex University being one example, but the issues discussed further in Section 5 of the complementary paper (Wigan 1983d), raise the questions of document delivery in terms indistinguishable from the locational impacts on business operations of greater IT adoption. The County Surveyors Trip Data Bank is one of the holdings of the Data Archive, and the Regional Highway Traffic Model Data Bank covers over 40,000 households over the country, and the production of effective software to make efficient applied use of the increasing access to mass data of this type has still not been faced. It should be.

Information retrieval and Library people would therefore be profitably involved in some aspects of data acquisition and storage developments. It is significant that the British Library is already taking a lead with the BLEND computer conferencing and electronic publishing project at Loughborough and Birmingham Universities - another area of demonstrable overlap of service and application interests in IT in a scientific, productivity, and information transfer role.

One of the areas of overlap is in the direct capture of written and printed information onto magnetic media. The KDEM Kurzwiel equipment available to the Universities at Oxford University Computing Centre is able to handle much of this, and work to reduce written manuals of operation (as one example) of transport vehicles to a magnetic medium, ands the subsequent development of software to link sensor data to give selective aural warnings or advice to the driver of the vehicle is a simplistic illustration of the conjunction between the different types of skills and disciplines now convergent in application through IT technology. The costs of such data capture devices are dropping very quickly, and products to transfer up to five mixed fonts at a time to floppy discs are already being offerred at about $12,500 US.

3.6 HUMAN FACTORS ASPECTS

Clearly, in order to apply information technology to extend the range and effectiveness of the information reaching a driver, the greatest effort should be directed to working out the best way of presenting information to the driver, rather than to the hardware itself (though these two lines of work cannot be done in isolation from each other). The research evidence is that the driving task is a heavy one, and that extra information on a

supplementary channel (eg audio) can be of effective value if it complements the signals being sought. If the visual and aural channels are presented with orthogonal information types there is little evidence of positive effect (Dougherty, Jones and Engel, 1971).

A specific example is the use of an audio assistance when searching for parking. If that task is being undertaken, then audio channel information about parking access, limits, locations and costs will be of value and reduce the overall task load. If this information is offerred when trying to get out of a city centre to an exit freeway it would be of no value, and may even be deleterious.

There is a great deal of Human Factors work in traffic, transport and traveller behaviour to be done in this area, and Ergonomics and Psychology are the two major complementary skills already involved in these types of transport research and application. The work required could properly be considered more an application of Aural data acquisition and processing.

The human factors aspects of a number of IT hardware potential applications in vehicles needs urgent study. Some such systems include applying radar and microwave collision detectors, direction assistance schemes, talking road signs, fuel efficiency rates when driving and other tasks which can now be realistically carried out by the vehicle, but which still need a traffic human factors treatment to make them a really valuable addition to the safety and effectiveness of the vehicle/driver system. The area of multiple sensory inputs, covered by Dougherty et al in such a practical manner, has not received much attention for some years, and it is clear that transport and traffic priorities coincide with the Alvey Report (1982) recommendations for more attention to the man-machine interface.

Much of the previous work in this aspect of human factors research was of an abstract and restricted nature (Loveless, Brebner, and Hamilton, 1970), and led to pessimistic assumptions about the prospective utility of such systems. The Dougherty et al results are both more practical in experimental terms and far more positive in terms of the results. It is now evidently time to build equipment using modern IT technology and pay specific attention to this special area of human factors work. It is significant that Loveless et al were unable to draw more than a single useable reference from their extensive review of the literature as of 1970. Loveless et al also highlighted the confused findings of red/green sensitivity changes induced by an auditory signal. This aspect is independently worthy of some further pursuit from a traffic standpoint.

An example of an important area of application is route advice. Information on this could come from cellular radio, from the present system of self appointed CB radio traffic information

co-ordinators, from instrumentation on the dashboard, or from speech synthesis, to name but a few of the options. The demand for some such system has already been made apparent by the use made of CB Radio. To make this extra channel of information to the driver really effective will require careful work at the instrument, display, task handling, and system performance and tariff aspects. Use of cellular or mobile radio raises additional problems, since the human desire for communications means that drivers may use this for person-to-person communication, in a way that might interfere with the driving task or with the assimilation of information useful to the driver.

One of the major side effects of IT and the traveller is the practicality of 100% behaviour and location monitoring and selective retrieval. The private vehicle equivalent of the truck TacoGraph is but the first sign of this privacy and social issue. The implications of a detector based road pricing, route advice, or even a selective talking roadsign system are that it will now be possible and economic to filter for road offences, location etc. This change in the enforcement/ violation balance will require extremely careful handling, even when the human factors aspects of its integration into the vehicle/driver/road (or track) system are overcome.

There are numerous issues where a greater interaction between ITS and psychology/ergonomics/human factors interests would benefit both parties in their researches into the problems and issues that arise when applying IT in transport and safety. The effective links between such areas of expertise at the ARRB would suggest that setting up such working teams as this should be a priority goal.

4. INTERNAL ITS DATA PROCESSING COMMUNICATIONS AND COMPUTING POLICY

The peculiar requirement of IT is that, to use it effectively, one must have a complete pipeline between the different types of information and its storage. This ranges from the need to be on a telephone to use a Modem, to be on a Packet Switch Data Network to communicate between services using Bell and CCITT Modem tone standards, and to have data captured on magnetic media if word processing and data reduction and presentation is to be done economically.

The internal computer and data processing policy at ITS is therefore an essential part of the gearing up for better use of IT. The present limitation to a single common access point to the Amdahl V7, the PRIME 750 (on which the Packet Switching Node resides), the Microsystems Support Unit PDP 11/44 UNIX system (which contains all of the software development tools), and the Systime (a VAX 11/780 in functional terms) is already under pressure from the Amdahl usage- and the computing demands of PSS and Microsystems development usage are beginning to arise. The introduction of increasing numbers of UNIX

based systems of micros and workstations around the University is assured, due to the Three Rivers/ICL Perq adoption by SERC, and will add the Systime access demands to this conflicting list.

The use of smart terminals for off-line text, program and data input and correction will help to reduce this pressure (and the APPLEs in house may be used for this task). The Institute is quite markedly under-equipped with screens to word processing/computing facilities of all kinds, but much of these needs could be met by microsystems of various types. There are numerous competitors for local area networks suitable for the ITS, but the most pragmatic and likely towork reliably in the ITS environment is the CLEARWAY system, which links devices and computers through a simple RS232 plus coaxial cable coupling at remarkably high data rates, with inexpensive devices at each station.

The rapid emergence of networking software and conventions mean that the detailed choice of hardware is less important than a software compatibility with network support software, as long as the systems in use have committed forward support for (or are likely to get it anyway from third parties) EtherNet, OmniNet, ARCNet, or Cambridge Ring software and ports. The SofTech MicroSystems P-System Operating System (known as "UCSD") has made such a software commitment (essentially for OmniNet it is understood), and therefore will probably enable APPLE, IBM PC, Tandy, Sage etc systems all to be hooked together under this operating system at a later stage. UCSD IV should therefore be considered for adoption. Native code gerators for Z80, 8086 and 68000 all exist to accellerate the p-code on each target machine as it is added. If a CP/M 8-bit environment is preferred then a TurboDos networking system should be appraised.

The Three Rivers/ICL Perq workstation has a great deal of potential as a single user workstation for program development (especially where graphics or animation are involved), and also has local area networking capabilities. It is however neither portable nor transportable, and must be regarded as a fixed resource. It is also rather expensive, but it would clearly be sensible to ensure that any proposals made to SERC covering graphics applications include a case for a Perq in support, given that it is now the SERC "Standard", has Fortran available, and is committed to SERC support for both UNIX and local and at least one local area network (EtherNet).

However the internal ITS policy proceeds, access to Prestel is likely to become of practical importance. As the Micronet 800 system was, at the time of writing, about to come into play (with a January 1983 launch date), the £49 Prestel modem / RS232 connector adaptors being made available will enhance the usefulness of the Institute's existing APPLEs.

It should be noted that Prestel (V21: 1200/75 half-duplex communications) links can be made into PSS to

enable communications with any other systems also connected to PSS, so the fact that this first cheap and available modem is limited to Prestel standards is not nearly as restrictive as it might seem to be at first sight.

The wide availability of 300/300, 1200/1200, 1200/75 baud access ports to PSS systems (with the future BT-committed addition of Telex input and output) will steadily enhance the utility of Prestel adaptors to minimal systems such as the Sinclairs and the ORIC. Both the UK PSS/IPSS system and the Australian OTC MIDAS services now offer all of these modes of access, and the AUSTPAC national packet switching network states that it will support at least this range of modes when it makes private access possible later in 1983, when launch delays have been overcome and business markets serviced with the present restricted service.

Computer-aided communications developments in the area of electronic mail and computer conferencing are likely to take a considerable leap forward as a result. The electronic mail aspect of Micronet (and of course Prestel) is the area in which the supressed demand for communications and data interchange may first have widespread outlet. With nearly a million personal computers in the market place this market is likely to be far more responsive than the "cold" Prestel residential market as developed to date.

The Institute's computer and text processing equipment should therefore be acquired with an eye to text processing, local communications, remote communications, ViewData interactions, PSS connections and thus be suitable for direct use and involvement in the new communications services now coming into mass financial reach of the near-million personal computers in place in the UK to date. The increasing use of remote data services such as SDC ORBIT, Lockheed DIALOG and DIALTECH access to the ESA-IRS QUEST system (the latter containing the IRRD data base) will also place an increasing premium on direct external line or PSS access from a smart terminal with local data storage and printing abilities. Nevertheless, the primary task is to DO a task: if the software and hardware combination is appropriate, OTHER tasks that it MIGHT do should be given much shorter shrift. The real costs in small systems lie in the software, and in the learning curve for the operating systems and compilers in use on them.

This means that a viable policy for ITS is to adopt - say - the UCSD operating system environment, and worry little about the machines on which it is hosted. SofTech MicroSystems have undertaken to deliver both local area networking for the P-system during 1983, and to make the p-system available on mainframes to permit microsoftware to be transported over the full range of computer power. At Leeds the Systime 780 will probably be running the available VAX implementation of UCSD before long, and so access would not be limited to small systems. It would however increase the

pressures on the single TAC multipurpose port presently available in the ITS buildings.

At other sites, the Open University is negotiating to make multiuser UCSD p-system operative on their DEC 20 network for OU remote teaching purposes.

Reference should also be made to the section in the companion Working paper (WP169, Wigan, 1983h) to the other lines of productivity enhancements made possible by IT developments. (Wigan, 1983).

4.1 KNOWLEDGE-BASED SYSTEMS APPLICATIONS IN TRANSPORT AND TRAFFIC

One of the key elements in the accumulating web of IT advances is the development and application of inference engines and logic based programming. These abstract concepts have become a reality, and substantial work can be done even on the smallest of machines. McCabe's MicroPROLOG (1981) is such a system, which runs under CP/M on computers as small as an APPLE][.

The two underlying streams of capabilities are :

(a) Expert systems in the sense of user friendly, rule based systems for harnessing inference and probabalistic information to applied user ends, and

(b) The intimate relationship between relational data bases and logic and rule based programming approaches (See LLoyd, 1982 for a typical discussion).

For targets (a), even the smallest systems are already proving to be sound workhorses for small applications. British Telecom are using MicroPROLOG (Probert, 1981) to develop a front end to their large scale strategic business planning system for BT. Many users have made use of MicroExpert (Cox and Broughton 1982) for query/answer assistance projects, where a Bayesian model is most appropriate. Micro Expert is based firmly on the large scale PROSPECTOR geological Expert system in its philosophy and antecedents, and can operate quite substantial pieces of the PROSPECTOR system. Perhaps the best references to MicroExpert and the necessary problem structuring for its use are two reports on PROSPECTOR by Duda, Gashnig and Hart (1979), and Gashnig (1982). MicroExpert is available under UCSD, while MicroPROLOG at present operates only under CP/M.

The PROLOG products of Expert Systems Ltd (1982,1983) are also available in essentially the same form on CP/M and large mainframe systems. There a large (and growing) number PROLOG systems becoming available. Some are written in C, notably CPROLOG, and others can be brought into a UNIX environment in other ways. HORNE, from the University of Rochester, for example,

is built from Franz Lisp, which in turn is written in C. Such systems as this allow predicates to be Lisp expressions, and thus extend the power considerably.

LOGLISP has a similar effect, while POPLOG at the University of Sussex is also to be aimed at a UNIX environment, and provides a combination of POP and PROLOG. However, the UNSW and other Unix PROLOG systems are entirely appropriate hosts for work in which rule discovery and deduction, and specially tailored systems are to be developed. This would clearly indicate that a PERQ running UNIX would be a necessary concomitant for any substantial developments, not least because of the widespread concentration on UNIX and PERQ for the fundamental IKBS work under the Alvey programmes on which such applied projects should build. While large scale systems can be produced, even at the present state of knowledge, the small scale limited application packages typified by MicroProlog and MicroExpert are perfectly adequate for certain applications. One such application previously proposed by Wigan (1981c) is the use of a Bayesian system for cost/benefit assessments of location-specific accident reduction treatments. This would provide both a useful learning basis and a thoroughly practical application result on the smallest system, and it is recommended that this project be undertaken in this spirit.

Thus:

REC. 8) Rule based systems can clearly now be applied directly to transport, planning advice, user instruction, specialised training, customer information, data deduction and accident and transport analysis in a particularly portable manner (in that the product is a tool for teaching others what has been leaned). Consequently active collaboration with computer based learning specialists is highly desirable. The effort should be placed in two areas. First, on knowledge base definition and structuring into rule based systems (where a psychologist would be useful), and secondly on developing understanding and sophistication in the more advanced tools beyond the simpler rule based systems (MicroExpert etc), so that data rule deduction, database retrieval from transport data sources, and more closely tailored fuzzy logic and Bayesian inference systems can all be applied as the skill level increases.

This philosophy of approach is closely in accord with the recent Alvey (1982) Report on Advanced Information Technology, and such applied projects of multidisciplinary nature are essential if these new tools are to come into wide and effective use.

5. BASIC INFORMATION FROM TRANSPORT ANALYSIS REQUIRING EARLY ATTENTION

The hardware aspects of the IT profile are essentially a list of new capabilities, and sometimes old ones with an affordable price tag. There are a number of issues in IT which should be addressed using "classical" transport data sources as a very early stage in the research program.

The Family Expenditure, Household Interview and Time Use/Activity data sets in use for transport analysis are of special importance here. There are a number of clear cut analyses which should be undertaken on these and similar data sources, with a view to obtaining a sound perspective on the areas of sensitivity and the scales of impact on specific household types before undertaking special new surveys of this type tailored for the slightly broader objectives of IT impact asessments.

It should also be noted that these impacts will also arise on the business operations front, and by analogy with the household vehicle / freight movement situation in transportation analyses, where the residential base for data collection has received a disproportionate amount of attention as compared to the residential and household bases for analysis of behaviour, the business time impacts and freight/personal movement patterns are crucial.

The documentation and verification costs are a major component in freight transport, and the impact on information movement itself - as a commodity - is an important transport question in its own right.

One of the key needs identified in this work is the need for a specific analysis of information economics as an integrated applied discipline. The relative economics of transport v communication tranfer by other means is simply one case of the more general problem of pricing and market segmentation for information access, quality, timing and availability. Information (as distinct from data) is now available swiftly by several means - at a price - and in large and compact volumes for re-use. The economic and behavioural analysis of these trade-offs in perception, use, response and the interactions with tariff setting and security and confidentiality need to be treated in a more unified manner.

Some clues may arise from studying the behaviour of successful business operatins in this regard, and especially the changes in organisational structure that follow. However there are many tasks which can be addressed simply by proper use of existing under-utilised data sources already available to transport analysts.

Some of the three major underexploited UK data sources include:

(1) The Family Expenditure Survey (Annual from 1963)

(2) The General Household Survey (1971-80)

(3) The BBC Time Use Surveys (1963,1975,1984-projected)

Family Expenditure Surveys have been put to effective use by a number of transport workers, including Wigan (1981), Morris and Wigan (1979), and Lane and Morris (1983) in Australia and by Goodwin, Potter, Mogridge and others in the UK.

These surveys include details of postal and telephone expenditures in addition to details of leisure, work and other forms of expenditure for an entire family. The analysis of the communications and leisure expenditures by lifecycle stage of the household, by transport provision and expenditures, and by socieconomic group is a worthwhile initial step to ensure that a properly analysed time series of these factors has been set up and understood prior to the monitoring of changes expected as IT spreads. The application of transport analysis methods to leisure, tourism and recreational behaviour is now becoming a matter for early attention, and the FES can also be useful for this purpose.

The years for which the FES is now available through the Social Science Data Archive are 1961-3,1967-80. Two of the four quarters of 1964 are lost irretrievably, while 1964 and 1965 require scarce validation effort within the Department of Employment, and this is unlikely to become available given the priority accorded this task within DEP. To obtain access to this information it is necessary to submit a proposal to the Department of Employment and Productivity, with a specification of the forms of analyses to be undertaken. The results of analyses completed must be submitted to the DEP prior to any public use being made of them.

These conditions are similar to those normally laid down for the use of the Matrix generator tapes released by the Australian Bureau of Statistics, and offer a realistic balance between user confidentiality, statistical reliability and the needs of research investigators.

A second survey series is offerred by the General Household Survey (GHS). This is a very large survey carried out on a rolling annual basis. The GHS covers a very wide range of topics and is of special interest as it covers telephone holdings and rentals, the length of time telephones have been installed, the ownership of motor vehicles, the ownership and the use of the TV, and extensive income and household data.

This survey is carried out at yearly intervals, and the tapes for 1971, (some variables from 1972), and all of the years from 1973 to 1980 inclusive are held by the SSDA (Social

Science Data Archive) at Essex University.

Access to the GHS data is under similar conditions to those applied to the Family Expenditure Survey by the DEP. In this case of the GHS, the application for approval must be made via the Archive to the Office of Population Census and Surveys (OPCS). This data set provides a solid basis for setting down a numerate framework for assessing the household penetration of telephones (the primary IT access medium) and of TV sets (the other access medium, for TeleText, and the device in contention for Video Tape and home computer and Video game applications in the home) as a function of time.

Access to telephones is a rather different question, and one which - as for vehicle ownership and use - must await details of the activity and usage patterns within the household. Survey data of this kind must now be specifically obtained.

Both of the FES and the GHS surveys also provide geographically specific data, and the basis for ongoing monitoring as both are continuing surveys. The GHS in particular may offer the opportunity of adding questions for IT impact monitoring on a sample basis, as was done for Long Distance travel on several occasions in the 1970's. The GHS is extremely large, and significant efforts are needed to create SPSS compatible format files, and to analyse this hierachical file structure using the dated - but heavily used - statistical systems such as SPSS, requires notable effort.

The work of the Surrey University team (Gilbert, Arber and Dale (1982a)) in producing a set of SPSS-compatible files and a program (CROSSLINKER, Gilbert, Arber and Dale (1982b)) to make treatment of the GHS file structures more manageable under such statistical systems, would suggest that consultation with Surrey would be effective in reducing the manpower required to work with the GHS.

It must be recognised that the levels of expenditure on postage, telephones and cable rentals are small in comparison with the overall household budget....but they are NOT small when compared to transport expenditure components.

Perhaps the most crucial aspect is the assessment of the ranges of access to telephones by different groups. At this early stage in IT infrastructure development the telephone line is a crucial measure of comparative advantage and of simple accessible market segments. These can be deduced from the GHS as it stands.

British Telecom (1983) have carried out (through NOP) a telephone usage survey, which would provide an essential datum to assess the (changing) utility of access to telephone lines. A coding frame and survey form for this survey has been supplied by The Long Range Planning Division of BT. Access to the results and the data collected is not anticipated to be made

public.

As a Transport Institute, the first task on the IT agenda should be the examination of individual and household data sources such as these, as they provide a sound basis for futher work to proceed on a numerate grounding and also are sufficiently similar to previous transport work that the present inventory of skills at the ITS can make an immediate and effective impact.

The use of time, and in particular the use made of the large amounts of time spect on watching television or listening to radio, in addition to the travel times associated with different forms of activity have all been the subject of large scale time use surveys by the British Broadcasting Corporation E.g. (BBC, 1978).

The data tapes for the 1974-5 BBC Time use survey are to be held by the Data Archive, but at present are available from the Sussex University (Dr J Gershuny, Science Policy Research Unit 0273-686 758). Dr Gershuny is completing a major series of analyses of changes in time usage and in labor force participation and recreational time use over the period from 1935 to 1975.

Using a variety of sources, the SPRU has resurrected the 1935 time use survey carried out by the BBC as part of this program. These sanitised tapes could be made available to ITS during 1983, when the work on the books in progress has been completed at Sussex (Gershuny 1982a,b,forthcoming), Gershuny and Thomas (1981), Gershuny and Miles (1982, forthcoming).

It is clear that analyses of these data sources should precede any new data collection, but for the effective monitoring of IT impacts the tools of time use, activity and transport surveys are of immediate application. The availability of sophisticated data reduction and analysis tools for choice behaviour analysis has been a reality in transport analysis for many years (Wigan, (1977), Crittle and Johnson (1980)), and the lessons learned from location, mode, and behaviour choice analysis at a disaggregate level should be the key design guide criteria for such monitoring exercises.

The high efficiency of disaggregate models makes the sample size required for productive monitoring sufficiently small to match even the smaller trials, such as the Milton Keynes wired city trials. The really detailed activity studies (exemplified by the ARRB Adeleide data set (Barnard, 1981)), are essential if behavioural analyses are to carried through with a commercially - applicable level of effectiveness. The joint analysis of detination and mode choice for shopping journeys already completed on the Adelaide data base demonstrates the potential utility of this approach (Barnard, 1983).

There is a clear case for developing the same level of

understanding and mensuration for accessibility to telecommunications and data access as has had to be developed to make the political problems of transport provision manageable.

It is also clearly worth while applying transport choice and behavioural analyses to telecommunications and IT markets per se. Hensher (1979) has applied such methods in a restricted manner, and has shown the practicality of the approach.

Thus:

REC. 9) Design of a monitoring survey technique employing time use, activity analysis, transport survey and disaggregated behavioural choice analysis experience should be undertaken in advance of the completion of the major survey reduction and monitoring tasks already specified.

REC.10) Design and execution of a survey of telephone access and use with a view to applying transport concepts of accessibility (Dumble, Morris and Wigan, 1979) and individual choice model techniques to specific markets.

The structure of time use and constraints on individuals in their transport behaviour has proved to be an effective line of approach in transport analysis. Once again, Information Technology is forcing a further conjunction of different interest areas... in this case that of Management Studies, as the same techniques applied to the operation of a business (and the people within it) become crucial when the rapid and fundamental changes in information access and use caused by IT introduction is under study.

Perhaps the most clear cut initial observation is that the brunt of almost all of this change will be bourne by middle managers, who therefore may reasonably be expected to be resistant to IT innovations. This too requires special attention, as this group already has much of the freedom of action to take full advantage of information: it is the popularisation of such access (and maybe even such freedoms?) which will cause problems for these and similar groups. It is also the case that this group is more than usually fitted by education to make effective use of IT - if won over. Sociological and observational studies of these aspects of innovation are clearly indicated, and as it is this group which makes most of the discretionary journeys in a firm, the transport interest is clear.

While it might better fit in Section 7 of this report, on Electronic Mail and Computer Conferencing, the development of SERCNET as a tool for improving the effectiveness of interaction between geographically isolated workers is an opportunity which should not be missed. A before study of the telephone, travel, and computer aided communications of the groups with access now to SERCNET - and the groups which will in future also have access

- will provide an invaluable baseline for assessing the price/quality/travel-communications tradeoffs in an area where the output of the individuals themselves both (before and afterwards)may be more readily measured that in most of the alternatives yet available. The links with both the EEC ESPRIT and ARTEMIS initiatives, and the joint European publishers ADONIS initiative (see the companion volume and Norman, 1981 for futher details) are also possible lines to pursue.

6. PRESTEL AS A USER MARKET OF TRANSPORT SIGNIFICANCE

There are increasing numbers of experimental installations of specialised public and private ViewData services systems. Several of these are of special and immediate importance to transport interests. These include :

(a) Gateshead : a Teleshopping trial being studied by Newcastle University, sponsored by Tesco.

(b) Nottingham : HomeBank, combining the Nottingham Building Society and the Bank of Scotland.

(c) Birmingham: CLUB 403, a PRESTEL/DTI experiment in Hull to bring shopping and other services into many of the homes in Solihull and Sutton Colfield (by July 1983 this had already an IT become a monitoring initiative of ITS)

(d) National: OPTEL - the Open University's own multiuser ViewData system, compatible with Prestel (Bacsich, 1981a,b,c,1982).

(e) National: CYCLOPS - the Open University's Prestel compatible remote tutoring system.

The latter pair of services (d,e) has now been complemented by an Electronic Mail service also on the OU DEC 20, and this overall package is under discussion with OU for monitoring and assessment for the education servicing aspects and the business operations of the OU itself through these nation wide media systems of OU leased line networks and the IPSS/PSS gateways now being installed.

(f) National : MICRONET 800 is an initiative by East Midlands Allied Press, ECC Publications, Prism Microproducts and BT, intended to bring cheap Prestel communications to personal computer users. (This contact also led to active involvement by ITS although the full contract for all of the monitoring was in the end let to another body with previous IT survey panel experience : however further opportunities are expected in the next stage of MICRONET development.

(g) Milton Keynes: The well publicised local networking system

in Milton Keynes where the public transport responsibilities of the Development Corporation comprise a clear case for some survey and assessment work. The EoSys Consulting Group has some work in hand on other aspects of the MKDC program in IT.

Clearly not all of these systems could reasonably be followed up, and it is important to keep a balanced view of the market in mind. The overall impact of Prestel has been very much less (to date) than that of TeleText of the CEEFAX and ORACLE variety, which have swiftly gained a user base of over 300,000 receivers and a real advertising and user base.

The marketing and high prices of the telecommunications costs for Prestel services have to date severely limited public Prestel's success (see Mayes, 1982), and only around 500 sets were thought to be completely "home" installed for "home" use by mid 1982.

This was sufficiently low that at least one service (UniTel, the news service for local papers etc provided by Universal News) came about 40th in the Prestel league in terms of pages access per month . UNS has no present interest in the use made of the UniTel pages by private parties, and does not expect them to be very important. This demonstrates that even quite small business market sectors can become viable operations, and in passing, that few such operations had made much headway by mid 1982.

At the outset of the study (in Oct 1982, before the announcement of MicroNet) a major area of neglect by Prestel was the personal computer market, where the installed base of machines from ZX81 upwards was already well over 500,000 and rising very swiftly. MicroNet 800 has since been introduced, and is designed to bring even the smallest Sinclair ZX systems into direct use on Prestel, with services designed to develop to a coverage similar to the SOURCE (see Wigan, 1982b; also Wigan, 1983d Section 5 / 1983h Section 4 on computer communication systems).

This is clearly the best prospect for monitoring, and market response work should be initiated forthwith. The Institute has now established relationships with MicroNet, and have responded to a request for a proposal to carry out the full monitoring survey. Whilst not successful with that proposal, the Institute intends to continue research related to Club 403 and MicroNet.

The take-up of MicroNet has been substantial, with over 17,000 connections made in the first few months. The basic evidence which pinpointed this previously overlooked market for Prestel is fully specified in Wigan (1983e), and rests on the income levels at which communications and transport expenditures are about equal. The UK Family Expenditure Survey (FES) for 1981

showed that if an IT product within the expenditure capacity of the average income household was made available, it had a large potential. This deduction appears to be being fulfilled, although the leisure/hobby expenditures should really have also been included in the analysis referred to.

The overall public ViewData market is still rather weak - although the private ViewData system market is very much more active.

The next moves of the Radio Rentals subsidiary of Thorn will probably determine the Prestel home and small business market, as they are the market leaders in rental, and well committed to ViewData service developments. This group should be approached at an early date.

A 1982 Finnish report underlines this position in the international marketplace for public ViewData systems (Technical Research Centre of Finland, 1982) in the following format:

TABLE 1 : PUBLIC VIEWDATA SYSTEMS AROUND THE WORLD

Country	System Name	Date in Service	Terminals Installed	Technology Source	Standard Adopted
Austria	BildShirmText	1981	300	UK	Prestel
Brazil	<-on order->	-	-	France	Antiope
Canada	Telidon Ida	1980	100	Canada	Alpha-Geom
	" Vista	1981	500	"	"
	" Mercury	1981	45	"	"
Denmark	TelData	1982	<300>	Denmark	Prestel
Finland	TelSet	1978	200	Finland	Prestel
France	TeleTel	1981	2500	France	Antiope
	Elec.Drctry	1981	1000	"	"
Holland	ViditTel	1980	3500	UK	Prestel
Hong Kong	Viewdata	1980	50	"	"
Japan	Captain	1979	4000	Japan	-
Italy	Videotel	1982	-	UK	Prestel
Norway	TeleData	1979	50	Sweden	"
S.Africa	BelTel	1982	300	UK	"
Spain	InselTel	1982	<200>	Spain	Antiope
Sweden	DataView	1979	50	Sweden	Prestel
Switzerland	Videotex	1979	200	UK	"
	"	1983	<2000>	Germany	CEPT
U.K.	Prestel	1979	11000	UK	Prestel
Venezuela	-	1981	30	Canada	Alpha-Geom
Germany	BildShirmText	1980	6000	UK	Prestel
	"	1983	-	-	CEPT

< > = Planned: - = Not Yet known. All data from early 1982 (see the report quoted above)

7. COMPUTER CONFERENCING AND ELECTRONIC MAIL AS SPECIFIC TARGETS

The segments of the professional community most involved in the conference and seminar market tend to be those in a position to work using remote meeting tools such as computer conferencing, and also are those who make heavy use of telephones....and lose significant amounts of time in trying to locate a time slot when both parties can make synchronous contact.

This area is precisely the one where asynchronous computer conferencing or electronic mail has a real role to play, and real returns in terms of time and response in the short term. The area of the problems of making synchronous contact through the telephone has attracted attention by the New Jersey / Orange group (Hiltz 1982, Hiltz and Turoff 1981).

This market is also the one most vulnerable to travel substitution for a specific number of the many tasks that travel serves for such people.

The airline users in this group are a specific target, and the airlines and the professional conference organisation industries now need to work with the tourism offices on routes heavily used by the conference trade, to determine what are the major factors now coming into play on travel choice in this field.

Potentially, major developments in electronic mail facilities will arise with the development of the SERCNET service (becoming the Joint Academic Network, JANET) and the initiation of a communications network following the Alvey Report (in December 1983). The latter is intended in the first instance to link up the various parties in the Artificial Intelligence (AI), IKBS and VLSI communities emphasised in the Alvey initiatives. Considerable weight is placed on improving the communication between these communities by this means, as the individuals and organisations involved are widely scattered and need a focus which is cheaper and more immediate than travel between them could provide.

These are precisely the same objectives as the GILT (Sztajnkrycer and Karmouch, 1982: Palme, 1982f) and other projects in Europe, aimed at linking different message and conferencing systems together (see also Wigan, 1983a).

The recently endorsed EEC ESPRIT program also contains similar recommendations at European level; this is a sensible follow up to the earlier EuroNet initiative of the EEC which accelerated the creation of the EEC-wide packet switched network linkages on which a personal networked communication system can now be overlaid.

It is worth noting that the major source of AI communications in the USA does not appear to be the published

literature, but the Unix and ARPA networks on which almost every US University VAX appears to sit. Kent University is the node for this Unix net in the UK, and is the designated SERCNET GateWay for overseas links in the present SERCNET plans. (See Daly, 1982 for technical details).

Unfortunately there is no known overall study available of the nature and effectiveness of the uses made of this means of direct communication by the US AI community, nor is it known how the present use of inter-university and packet switched networks already operative in the UK for communications and for data/program transfers spilt up the usage of their line capacity. Now that SERC has committed itself to a major task in extending and administratively further integrating SERCNET, and with the Alvey proposal for enhanced communications, it should be a matter of priority to carry out AT LEAST a before survey of communications frequencies, travel frequencies, and interchange contents between at least the major target communities involved.

The ITS is very well placed to undertake such work, and the subsequent monitoring of the travel, communication frequency, and influence/content nets that develop from SERCNET as it begins to operate on an integrated basis. The value to the network coordinator of such a before survey would be in providing a sound basis for assessing the network traffics and capacities required, and with the use of time budget and choice set analysis work, a useful basis for predicting network utilisation and demand increase level could reasonably be expected.

The current basis for SERCNET service expectations pivots on messaging and mail: as the experience of most electronic mail providers has shown, structured computer aided conferencing facilities very soon become desirable, if not essential. The nature of such services could reasonably be expected to alter that nature of the travel and interchanges between participants, once the necessary mechanisms had been set up.

There is a already substantial evidence of productivity gains by network system use by professional on-line commmunities (eg Hiltz, 1982), and of effective distributed project management through this type of communication system (eg Vallee and Gibbs, 1976).

Thus:

REC.11) A "before" study should be undertaken of travel and communications patterns between present and prospective SERCNET nodes, and the characteristic of these traffics and interchanges. The nature of the data and communications patterns in these traffics should be monitored, and choice set and activity survey methods used to build forecasting models of the changes and stable patterns of use and their determinants, making effective use of disaggregate individual choice model techniques for mode/destination choice for physical and

electronic communications.

The Universities Transport Studies Group in the UK has already considered the possibility of a network for interchange, communication and electronic pre-publication purposes on the basis of Kirby's presentation of Wigan's (1982b) paper at their 1983 Annual Conference. The mounting of an excellent Electronic mail service on the Open University DEC 20 network, under the guidance of Dr P. Bacsich, has provided a beta-test service to the members of the UCSD P-System Users Group in the UK (a group to which ITS, ARRB, Dr Bacsich and the author all belong). It has been mooted that this service should be offered to a wider community, as well as to the OU members and students across the UK. Conferencing capabilities are also being reviewed, and the provision of multiuser UCSD p-system software on the DEC 20 in conjunction with the OPTEL ViewData system hosted on the same machine is likely to shortly provide a very powerful base for educational interchange at a highly sophisticated level. The connection of the OU system to the BT IPSS/PSS packet switched services, and the enthusiastic takeup of MicroNet 800 with its 50 pound approved modems for Sinclair Spectrums, BBC micros, APPLEs and the like has vastly expanded the likely user base. The CYCLOPS remote teaching system is also compatible with OPTEL and the other services (Read, 1981). CYCLOPS in particular is under active review elsewhere, notably in the South Australian Department of Education in Adelaide.

Consequently it would be desirable to involve the OU in an operational use of networking services between the Universities Transport Studies groups, and in active assessment of the impacts of the package of services available as they become available to a wider public. This would be particularly important if the proposals to link into SERCNET were not to be accepted: this being independent of the proposal to assess SERCNET impacts on the academic community.

REC.12) National: Use of OU Mail/OPTEL systems and assessment of impacts, with electronic publishing investigations. This should be done in collaboration with Shackel (1982) and his work for the National Library using a modified version of the *InfoMedia* "Notebook" software. The TRRL should also form part of this network, as a means of testing the utility, cost and effectiveness of external technical project monitoring (and perhaps enhanced participative contribution), in view of the technical project overview functions for DTp now the responsibility of the TRRL. Similar monitoring and telephone/ travel/ contact rate measures should be undertaken before and after the linkup, exactly as proposed for the Alvey community. This aspect would be eased by the coverage of TRRL staff involved in project review being located in one place, sophisticated in survey and management methods, and used to an active role in projects with which they become involved. The availability of IRRD data base

searching online from TRRL is another added-value service which could reasonably be offerred through this net, or via SERCNET if the emergent policy towards non-SERC funded bodies permits their connection to it.

IIASA has undertaken extensive work on computer networking and the communication systems which become possible when such networks are available. This work has covered the specification and use of gateway systems to X25 and dedicated line networks linking East and West (Sebestyen, 1981: Maurer and Sebestyen, 1981: Maurer, Sebestyen and Rauch, 1981a,b).

The network linkages themselves are described from the computer network aspect by Labadi (1981), and Labadi and Sebestyen (1981).

The use of C-Shell programming to produce a computer conferencing and report development and reviewing system under the UNIX operating on the IIASA PDP 11/44 is described in detail by Pearson and Kulp (1981). The manual for the TELECTR system used by the IIASA associates on both sides of the Atlantic (and to which successful connections have been made from Australia) is available as Lathrop and Pearson (1981). IIASA operate this system on an open basis to participant nations, and have practical experience of its use as a travel substitute or supplement.

At a computing and implementation level there is much to be gained from examining the low-cost technique used to create TELECTR. The system is constructed as a set of UNIX files as an extended shell, and took less than two weeks to come into initial trial operation. The advantages of this technique are :

(a) It makes adaption and modification of the system very easy and fast.

(b) All of the UNIX tools are available to the users while using TELECTR, and indeed the message editor is simply the standard UNIX line editor.

(c) Portability is no great problem for this approach, although the code would require rewriting for other shells, and the full system could be readily - and profitably - be ported to small UNIX systems such as the WICAT, FORTUNE etc.

The implementation of the EIES system (now seriously being assessed by a French group based on the Ministry of Employment in Paris) would require a Perkin Elmer system, as the implementation of EIES requires the intermediate MACRO code produced by the PE Fortran compiler to be filtered and modified.

While this is not on the central theme of this report, it would be well worth while SERC producing a local and improved portable version of TELECTR for propagation around the Alvey and

other research communities. In Australia the demand for such facilities from individual groups (for example, the Microbiologists) in becoming insistent, and microcomputer based bulletin boards are not a fully satisfactory solution. CSIRO is producing a mail system for the CSIRO internal network, hosted on the central servicing computers in Canberra.

This may not be as effective as either a wider access and use of '.uucp' (the Unix-Unix Communications Protocol) on the many VAXs, or the provision of a TELECTR-style of conferencing system compatible with both small and larger hosts. The danger of the small host option is that the AustPac service is well behind schedule for public access, and a closed network host may remain the more appropriate for some time. Similar points (toghether with the packet charging rates now ruling in the UK) would suggest that SERC used an extended closed network with gateways rather than IPSS/PSS. This appears to be likely.

In either case the identification of groups needing such linkages is an issue in its own right, and worth attention by communication and transport analysts - and certainly by communications network service planners in both countries.

Although not central to the main theme of this paper, the role of information systems for both the individual researcher and the organisation is an important issue. The latter was particularly relevant at Leeds at the time, since computerised printing/typesetting options were then under review. An illustrative note of the manner in which this aspect of IT fits into the IT / knowledge worker / applications framework is given in Wigan (1983j) (also as Chapters 6 and 7 of the companion summary report, WP169, Wigan 1983h). It is clear that a specialist in this aspect of IT should be sought at Leeds, although not in the Institute.

8. FURTHER POSSIBILITIES FOR STUDYING THE IMPACTS OF INFORMATION TECHNOLOGY

The numbered project proposals detailed in the previous sections are simply indicative of the types of work which could reasonably be undertaken by the ITS as it now stands, and - if undertaken - would build up the basis and breadth of the expertise of the staff while contributing substantially to the understanding and quantification of the growing mutual impacts of transport and telecommunications. A few of these research ideas are spelt out in detailed form in an Annex to this report (ITS Technical Note 126: Wigan 1983i). In part 8.1 of this section we comment on three projects identified there, that elaborate on the discussion in Section 5 of this report. In the remaining parts, we comment on a number of other, related, possibilities. These additional items are far from comprehensive, and are simply a selection of the more obviously appropriate fields where attention may be turned within a transport and communications group, to enable the development of a broad and soundly based programme of research.

8.1 THE IMPACTS ON PERSONAL LIFE-STYLES

Following the discussion in Section 5, the Annex (TN126), proposes three investigations for obtaining insights into personal life-styles and expenditures from analyses of already available mass data. These should be seen as a capital investment in fundamental information, and used to underpin more specific investigations. The analyses should be executed as part of a research programme covering transport, communications, accessibility and market segmentation aspects. This would provide a solid country-wide basis for generalising and assessing the outcome of future studies. For these projects, time series data is available for:

(a) the Family Expenditure Survey series;
(b) the General Household Survey series;
(c) the BBC Time use survey series.

The first two should be investigated immediately, and some of the simple first-cut findings from the aggregated published data are given in Wigan (1983e), which is reproduced as part of the accompanying report. Work on the BBC time use datasets should be delayed until Dr Gershuny is able to release to the ITS team the three fully validated survey data tapes he has created as part of his work on employment issues. The 1983-4 Time Use survey is now in progress, and the results of this will contain data on the impacts of Video games, Video Records, Video tapes, home computer, Prestel, TeleText and other competing uses of the TeleVision and time now becoming significant. It is therefore appropriate to delay the initiation of that project, perhaps until the 1983-4 data is due to become available.

These investigations could compare lifestyle changes, home working and workforce participation rates with similar findings from those of previous decades.

8.2 THE IMPACTS ON BUSINESS TIME USE

The value of time is a key transport evaluation issue, and the marginal utility of the new methods of conducting business can confidentally be expected to enhance the value of small units of time saved (due to the greater opportunities to make use of it by telecommunications or by means of in-situ text-recording).

Business time use is an issue in its own right, and deserves specific attention. The factors involved include location of both activities and business operations: interchanges between suppliers, customers, support, and business services themselves: proximity influences, and the possible abrogation of the normal exponential decline in interchanges with distance, the range of business catchment of customers and the reciprocal effects of size of area included in customer choice sets. This latter issue is a key datum for teleshopping assessments ; and is peculiarly

well suited to present ITS skills, as the choice set and joint mode/destination choice issues have recently proved to be amenable to disaggregate individual choice model techniques.

Thus:

REC.13) ITS should propose studies of customer and business choice set behaviour, and of catchment definition, for areas where teleshopping is being tried out. The techniques developed for transport analysis should be used as a basis for market size assessment and the analysis of consumer response, and possibly for prediction.

8.3 THE IMPACTS ON INVESTMENT AND LOCATION DECISIONS

The factors controlling catchment and servicing costs can sometimes control investment and location decisions. It is still not clear if business location and service decisions drag household locations after them, or if they follow them. Teleshopping, telebanking, and the time patterns and frequencies of involvement in these activities can readily be extracted from transport household survey data sources (see Wigan, 1983e). The more general effects of developing residential applications of telecommunications services were covered from a communications perspective by Short (1978), but, not having been covered from a transport/activity viewpoint, a substantial fraction of the issues of concern for movement and location planning were omitted. The overall document (Smith, 1978) is still a reasonable introduction to this area, though as time proceeds an increasing number of errors of omission may be found.

Decentralisation costs are now declining, and major firms are leaving central city locations for more pleasant environs. Given the inevitability of some loss of staff when a re-location occurs, the choice of such destinations is influenced to a degree by the inclinations of the senior executives and workers which the companies wish to retain. This would suggest that the greater freedom from physical location limitations may exacerbate the employment location problems of those cities with less pleasant environs. This may be worth pursuing as a transport/planning issue in its own right.

The shifts in office location and real estate which might arise as IT changes the manner of executing work are probably best dealt with as secondary effects rather than at the initial stage. Certainly the influence of IT factors has been noted by major real estate and property firms already.

8.4 THE IMPACTS ON EDUCATION

Education is a major market for almost all IT services. This could be expanded considerably beyond the few points raised in

these pages, and many examples of satellite applications to remote areas, such as to the Pacific Islands and outback Australian areas, could be listed (See Semahu, 1982, for example). The issue of greater practical interest from a transport stance is that of handicapped and ESN education, where IT aids are having a major and positive impact on both the quality and the location of provision of special education and remedial aid. Welfare and social services transport movements are substantial, and this small but specific sector may be worth at least an outline assessment at an early stage.

8.5 THE IMPACTS ON CONFERENCE AND CONVENTION ORGANISATION

One of the larger of the new service businesses is that of Convention and Conference organisation. These are now a major business, with substantial impact on the travel market. This business is already making siognificant use of computer aided conferencing and mail systems. It would be worthwhile using this segment of the overall telecommunications market to assess the cost effectiveness of these aids in both business and travel terms. The activities of these organisations are also worthy of specific attention in their own right, because of their influence on travel patterns, locations and frequencies.

The airlines are strongly associated with the conference market, and are well aware of the impacts of improved communications on their most profitable market segment - that of business travel. A fairly small but carefully structured survey of choice sets and revealed preference for this market would be a useful piece of work. Ideally, longer haul destinations would be covered at a higher sampling rate, and an airline with a high proportion of long haul flights (such as Pan Am, or Qantas) would be the most suitable for such a pilot study.

8.6 THE IMPACTS ON THE ENTERTAINMENTS INDUSTRY

The impacts of the entertainment industry are extremely interesting. As leisure (voluntary and enforced) increases, the influence of mass spectacles such as football matches, of bulk entertainment such as cinema, and of non-participative events such as horse and greyhound racing (essentially betting vehicles) on the location and travel behaviour of the population can certainly be expected to change. This has a number of effects on transport and traffic generation, both at home and at sporting venues. Planning for recreation is a rapidly growing industry, and induces many non-home based trips---the bane of transport forecasting to many analysts. Recreational travel as a whole is severely under-researched in any very systematic manner, and so the influences of IT on recreational and sports participation behaviour and location are likely to start from a fairly weak base. This is not a reason for ignoring this aspect of the changing nature of non-work travel and activities. Some suggestions as to how these effects might be approached from the

transport and participation frequency aspects are given by Wigan (1981a).

8.7 THE DEMAND FOR 'IT' PRODUCTS

The use of transport demand analysis and choice models in the forecasting of the demand for IT equipment, and market analysis of this volatile market segment, would be a suitable area of application of Institute skills, but not essentially an issue of either transport or communication interest - more of commercial concern. Some applications to analyse choices and determine market segments could however help to establish a firmer basis for subsequent work on a more central theme with appropriate organisations and firms.

9. SUMMARY

This review of the way in which research issues in information technology, communications and transport come together, has been undertaken to help promote suitable changes in emphasis in transport research. This should help ensure that the productivity benefits of IT are reaped in the course of the research, and to ensure that relevant and timely projects are undertaken. In this way, the relevance and usefulness which has long been the hallmark of much of the work on transport and traffic planning will be effectively maintained as the scope of that work widens.

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