THE IMPACT OF THE CHANGING INFORMATION ENVIRONMENT
ON TRANSPORTATION AND PLANNING

By: Donncha O'Cinneide
Senior Visiting Fellow
Center for Metropolitan Planning and Research
The Johns Hopkins University
Baltimore, Maryland 21218

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INTRODUCTION

Urban development plans today are usually based on solving existing social, land use and transportation problems rather than anticipating the urban forms best suited to our future needs. This occurs because planners normally use trend type projections (frequently in the form of complex pseudo-behavioral models) to quantify the future magnitude of their present problems. Radical societal changes are not predicted by these models since such changes are often not significantly present in the data used to build and 'calibrate' these models. In recent years largely unforeseen trends in urban development include declining city populations, increasing blue-collar unemployment, rapid suburban development and the growth of exurban or rural areas.

Many of these radical changes in living patterns resulted from the growth of automobile usage and from low energy costs. However, futurists are now predicting that both urban and rural living, working and interaction patterns will change drastically over the next twenty to fifty years as a result of the impact of energy shortages and increased energy costs.

To resolve both our present transportation problems and to plan our future transportation systems a basic understanding of the particular needs and demands of man as a transport user is required. However, little information is available in this area although a vast amount of general information has been collected on urban travel patterns and volumes (mainly as a result of urban transportation planning studies). Transpor-
tation is one sub-system of a larger urban system consisting of elements such as land-use, business, etc. The linkages or relationships between transportation and these other sub-systems must be understood for orderly planning of the urban and ex-urban environment. To date the planning of these areas has generally consisted of planning each element or sub-system in isolation. However, the perturbation of one component in one sub-system can grossly affect components in other sub-systems. The need for a systems approach for resolving urban problems has been convincingly argued by Kolbuszowski (1) and others.

A further variable relevant to the future of urban areas is the new 'information environment' which is being created by the complementary rapid growth in electronic data processing and telecommunications. The predicted vast increase in communications of all types has obvious implications for transportation and urban planning but little information is available on the existing linkage between transportation and telecommunications.

The effects of the new information environment are expected to be as radical as those introduced by the development of the internal combustion engine. Failure to plan for these changes would be comparable in importance to the failure to anticipate the explosive growth in car ownership earlier in this century. However, existing city plans do not anticipate the expected radical changes in living and working patterns. Experts agree on the magnitude of the coming impact but there is disagreement on the impact of the new technologies on specific sectors of the economy such as transportation.
This work briefly summarizes the implications of the changing information environment for society and then examines the available evidence on the relationship between transportation and telecommunications from a number of countries. The expected impacts of the new electronic technologies on planning and transportation are next considered. These impacts are likely to differ between countries depending on the existing land use and transportation systems. Probable differences between the United States, the United Kingdom and the Republic of Ireland are identified.
THE GENERAL RELATIONSHIP BETWEEN TRANSPORTATION AND TELECOMMUNICATIONS

Both transportation and telecommunications are the result of the same underlying commercial and social connections. The role of transportation encompasses the transfer of people, goods and information while the sole function of telecommunications is the transfer of information. Thus the function which both transportation and telecommunications have in common is the transfer of information. The general relationship between human trips and artificial media with information flow suggested by Kolbuszewski (1) is shown on Figure 1.

FIGURE 1

Relationship Between Human Trip and Artificial Media with Social Flow of Information

SOCIAL FLOW

NON-INFORMATION FLOW
(Energy, Commodity)

INFORMATION FLOW

HUMAN TRIP

ARTIFICIAL MEDIA
(non-trip)

MAIL
MESSENGER

TELECOMMUNICATION
TELEPHONE
TELEGRAM
TELETYPE
TELEVISION (GRAPHIC DISPLAY)
TELE-PRINT
(FACSIMILE)
THE CHANGING INFORMATION ENVIRONMENT

A radically new information environment is being created by the convergence and interlinkage of information technology and telecommunications. This new information environment has profound implications for society (e.g. automatic control of production and resources, electronic surveillance, etc.) and has been viewed as more disruptive than any previous technological impact. The developments in computer and telecommunications technologies which are creating this changing information environment are outlined in the following pages. Possible changes in the different sectors of society (politics, business, etc.) are then briefly considered with emphasis on communications aspects. Finally the implications for transport of the new information environment are examined in more detail.

Developments in Computer Technology

The rapid development of computer technology especially over the last twenty years has been analysed in detail elsewhere (2). The growth of this technology has been much faster than in any other technological area. Thus the developments of new systems have been in generation terms (embodying radically new jumps in capability) rather than the incremental growth which is the norm in other technological areas. Computers are becoming smaller, faster and cheaper and these trends are expected to continue in future. To these quantitative trends within computer technology may be added comparable qualitative
changes in computer programming i.e. in software. These changes are not only in the development of new programming languages and new programmes but in the ancillary range of operating instructions, in more sophisticated systems analysis in general, and, importantly, in the development of automatic programming.

A further qualitative impact of computers in in their rapid extension through many different areas of human activity from the individual, community or local business levels to national and international levels.

The increase in the growth and interlinkage of large computer networks and their control capacities will cause significant changes as society begins to rely more and more on cybernetic control systems for many routine production, service and maintenance functions.

**Developments in Telecommunications**

Telecommunications technology has changed dramatically during the past twenty years due to rapid developments in electronics and optics. These changes and the probable future developments have been outlined by various authorities (3). However, unlike computer technology, many of the new developments in telecommunications have not been brought into widespread use due to the high costs involved in modifying the existing telecommunications network. Telecommunication media in widespread use today include telephone, telex, telegraph, television and radio, while more advanced media such as videophone (picture phone), facsimile
transmission, viewdata, etc., although technologically feasible are not yet in widespread use. The current status of these services is reviewed later.

The telephone system is expected to form the main telecommunications distribution system in future due to limitations of channel sizes in air based media and is therefore of particular interest here. Digital transmission, in which speech is sent by a series of impulses in the form of a code, is expected to replace the present analogue transmission of speech in future. This pulse technique is suitable for the combined transmission of all types of telecommunication signals including television, videophone, data and facsimile.

The telephone system consists of pairs of thin insulated copper wires joining each telephone to the local exchange. Each exchange is then connected to other exchanges by hierarchical and/or network systems consisting of various combinations of co-axial cables and microwave radio (both direct overland and via communications satellites). The capacity of these main telecommunications 'highways' has been increasing in order of magnitude terms (like computer capacity) over the past twenty years. Recent new developments using helical waveguides and laser transmission along optic fibres (embodying further radical jumps in channel capacity) are now being operated by telecommunication operators in a number of countries. Telephone exchanges are in the process of being changed from electro-mechanical to electronic operation in most countries. Extensive use is also being made of computer technology to improve exchange performance.
The main limitation to the introduction of new telecommunication services is the local telephone network. Although the replacement of analogue signals by a series of binary pulses (pulse code modulation) can increase the capacity of wire pairs significantly, the additional capacity is not sufficiently great to permit the introduction of many of the new telecommunication services. It appears at present that the provision of these services requires a completely new local network using coaxial cables rather than wire pairs. The rapid extension of cable television services (which use coaxial cables) in many countries is seen as a relatively cheap method of upgrading the existing local telecommunications network. Existing TV coaxial cable systems provide 300 times the potentiality of copper pair but at present do not have sufficient bandwidth for new telecommunication services such as the videophone.

The rate at which new developments in telecommunications are brought into widespread use in a particular country will depend on several factors including the general state of the economy, the demand for new facilities and the costs involved.

As a consequence of the developments in telecommunications costs have been reducing annually though at a much lower rate than computer costs. Thus for a given level of performance Murray Laver (4) states that the cost of computer equipment has been falling at about 50% per annum whereas the corresponding rate for telecommunications has been nearer 2%. Since the development of telecommunications networks involves
high labour costs it appears probable that radical reductions in costs are unlikely in the future. On the other hand transportation costs are predicted to increase rapidly in future.

The Present Status of Telecommunication Services

The current status of those advanced telecommunication devices which are likely to have a significant impact on transportation are briefly reviewed in the following pages. More extensive reviews are available elsewhere (5,6).

(i) Cable television: The penetration of cable television in U.S. homes is growing rapidly because of the availability of communications satellites. More than 4100 separate cable television systems are in operation at present and over 22 percent of the TV owning households subscribe to cable television. As major corporations enter the field it is expected that the penetration rate will double in the next few years. All cable systems installed since 1972 in the U.S. are required by law to have two-way communications capabilities. Although not yet in widespread use the two-way capability enables a number of services to be provided which can substitute for travel (e.g. catalogue shopping, utility meter reading, etc.).

A number of experimental interactive cable television systems are in existence, e.g. QUBE in Columbus, Ohio and the Tama New Town system in Japan. There have also been a limited number of experimental field trials in areas such as education and remote shopping.
Cable television services are available to a much smaller extent in countries other than the United States. These services are mainly provided to improve reception rather than to provide a large number of additional channels and services as in the U.S.

(ii) Interactive air based television:

Ceefax/Oracle: These United Kingdom systems transmit pages of alphanumerical information through the air to modified TV sets. Home viewers can select the information required. Both the BBC and the IBA provide similar systems covering most of the U.K. A system of the same type (Antiope) is operational in France. Using a telephone as the return path would permit remote ordering for goods and services.

Prestel (Viewdata): This is a telephone based service available from the U.K. Post Office. Customers can select information from data banks for display on TV type terminals. The service provided is far more extensive than that provided by the Ceefax/Oracle systems, because by dialing different telephone numbers, different data banks can be contacted. Remote use of computers is also possible with this system.

The above U.K. systems have not been in commercial operation for long and there is no information available about their effects on travel.

Direct satellite to home TV systems: The Communications Satellite Corporation (COMSAT) has announced plans for a satellite-to-home system which would initially broadcast three channels of subscription programming to residents of the U.S. eastern time zone. It is estimated that it would take three to four years to inaugurate service following approval by the Federal
Communications Commission. This system would be particularly applicable to areas without access to high-capacity cable TV systems. Tests of similar systems are being carried out in Japan and Canada. A teletext service similar to that provided by Ceefax/Oracle systems in the U.K. can be provided by direct satellite systems.

Educational TV: Special university level educational services are being provided via normal TV channels in many countries (e.g. the U.K. Open University). Interactive services are not yet in regular operation.

(iii) Facsimile: This permits copies of documents and sometimes transparencies to be transmitted over telephone lines. A4 size pages can now be transmitted in 30 seconds although most commercially available devices take longer. Several terminal types are available and their use is growing rapidly (at a rate of 20-25 percent per annum in the U.S.). However the terminals produced by different manufacturers are not compatible. Also, the quality of documents transmitted is inferior to Xerox. To obtain Xerox type reproduction requires a broadband carrier system at present. The quality of facsimile transmission is reduced where electro-mechanical exchanges are still in operation.

(iv) Radiopaging: This is a pocket sized alarm or message system functioning within a wide service area. It is available in many countries.

(v) Mobile telephones: These are commercially available in a number of developed countries. The user charge is very high due to overcrowding of the air waves but the development of short wave antennae ("cellular" system) may soon overcome this problem.
(vi) **New telephone services:** A number of enhanced telephone services which could reduce travel are available in the U.S. at present. An example is the patented "transaction telephone" which permits limited financial transactions to be carried out remotely. Touch-tone telephones which are more expensive than dial telephones (partly due to increased maintenance costs) are required for these services.

(vii) **Video-telephone:** This has not been a commercial success in the U.S. and is no longer commercially available. Transmission over wire pair telephone lines has not proved satisfactory for the American Telephone and Telegraph Companies (AT&T) "Picturephone" system.

(viii) **Teleconferencing:** Conference call telephone services are offered in many countries but are not generally considered satisfactory as a substitute for travel. More sophisticated teleconference networks are operational in a number of countries and their use has been extensively studied. These systems require specially equipped rooms for successful use and usually include graphics and facsimile transmission capability. Teleconferencing can be divided into audio and video systems. Audio systems may or may not have some means of identifying individual speakers and may have electronic blackboards in addition to facsimile transmission. Several private and governmental teleconferencing networks are currently operational in the U.S. Both the U.K. Civil Service and the U.S. General Services Administration (Federal Government) operate networks connecting eleven meetings rooms in eleven different cities. Audio teleconferencing seems particularly suitable for instructional communications in business, government and education.
Video teleconferencing is considerably more expensive than audio and requires far more costly studios, consequently it is not widely used. In the U.S. a service available to the public is provided by AT&T between conference centers in twelve cities (Picturephone Meeting Service) and a broadly similar service (Confravision) is provided by the U.K. Post Office between five U.K. cities with connections also to two cities in Sweden and two in the Netherlands. These systems are monochromatic at present. Noll found that video conferencing is used primarily for committee type coordination and information exchange activities (7).

To date the use of teleconferencing has not been heavy and is still in experimental operation. However it is understood that the AT&T Company are likely to extend their publically available video teleconferencing facilities and to aggressively market both their audio and video systems. The provision of colour transmission appears likely in future video systems.

(ix) **Computer conferencing:** A number of experimental systems are in operation in the U.S. (e.g. Institute for the Future's Planet system) however these systems are not seen as significant alternative media for travel substitution.

(x) **Data transmission:** Many countries provide special data transmission services or alternatively private wires can be used. The provision of digital networks are under active consideration in many countries.
The Convergence of Information and Telecommunication Technologies

The developments in computer and in telecommunication technologies previously outlined represent major technical advances. However, a totally new information environment is being created by the convergent interaction of both these technologies. This convergence of computer and telecommunication technologies also permits the rapid growth and diffusion of many extended cybernetic systems (e.g. the automatic control of production, inventory and distribution in industry). The major impacts of the radically new information environment are expected to be felt in developed countries within the next twenty years. The possible range of these impacts on different sectors of society are discussed in the following section.

Effects of the Changing Information Environment on Society

Information and knowledge are the basic resources upon which human survival depends since all other resources depend on them for their development. Possible changes resulting from the new information environment would include a revaluation and reperception of our resource range. However the central significance of these changes lies in the profound consequences for the structure of society itself and for its institutions and values (8, 9, 10). Competition for the allocation of scarce resources is the motivating force of our social institutions. The increased dependence upon information as a major resource could move society to post-industrial forms whose institutions, government and value systems are still open to conjecture. A post-industrial society is seen as being
organised around information as contrasted to an industrial society organised primarily around energy.

Since information/knowledge is seen as the central resource of the post-industrial society towards which we are moving, the new information environment may tend to create new forms of power (based on the access to vital knowledge and information) which will be vastly different to the older forms based on physical control over fixed material assets.

Table 1 indicates some of the major characteristics of this new technology.

TABLE 1

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<td>Exponential increase in the volume of information flow.</td>
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<td>Time and distance no longer constraining upon communications.</td>
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<td>Global shrinkage.</td>
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<td>Decrease in &quot;time cushion&quot; between sociotechnical changes, their impact and consequences.</td>
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<td>Increase in dependence upon information and communications services.</td>
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<td>Growth of complexly linked systems subtending basic societal services.</td>
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<td>Increased interdependence of previously autonomous institutions and services due to feedback required for common information.</td>
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<td>Abrupt changes in perception of sociophysical environment.</td>
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<td>Radical conceptual changes induced by increased information and communications.</td>
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(a) **The individual:**

Impacts of the information environment on the individual range from suggestions of increased surveillance and monitoring of personal data "in the social interest" to permitting increased personal growth and development as a result of more flexible and equable access to available knowledge. Social problems may be caused by the division of society into information "haves" and "have nots". A full discussion of these possible impacts are outside the scope of this work.

(b) **Education:**

The level and quality of education largely determines the prosperity of a nation or even the survival of human society. In the developing complexity of our present world, lack of education is a form of disenfranchisement. It is also a world which is being transformed by scientific and technological agencies which demand a high degree of specialised knowledge for their continued functioning and development.

Some specific changes in the educational process resulting from changes in the information environment include (8):

1. Widening of the age range of participants in formal education due to the need for retraining and re-education as knowledge increases rapidly in various fields. This is also a result of the redistribution of work and leisure as employment patterns shift in society.

2. Diffusion of the educational process to include 'real life' experience and extramural attainment; the blurring of boundaries between educational and other institutions (e.g., education and work).
3. A major shift in emphasis from learning what is known to learning the means of attaining the necessary knowledge.

(c) Culture:
The cultural changes introduced by the new information society may be among the major changes in our future. Already multi-channel television with international broadcasting of entertainment, advertising, etc., has lead to more commonly shared cultural experiences. Paradoxically the main development may be in the increased diversity and fragmentation of cultural patterns resulting from the increase in options and choices open to each individual.

(d) Business and management:
Many dilemmas in the management of business and other institutions in our societies results from the radical transformations in the last fifty to a hundred years. As a consequence, the models of many of our institutions and their stated goals and objectives are not in accord with changes which have already occurred in society. For example services in mass transportation are failing or requiring massive injections of public funds for their maintenance. Other operations are changing under pressure from consumer groups as consumers become better informed.

In the post-industrial society of the future it has been suggested (8) that "production industry" will begin to decline as the major motive force and wealth generating sector. Though technically innovative it is no longer socially innovative and no longer plays a prime role in
shaping the values and goals of society. The so-called post industrial society emerges when industrial productivity can be sustained and increased with fewer productive workers. The majority of the labour force moves into the service sector - into managerial and administrative functions, into the knowledge industry of research and development, finance, education, welfare and recreation. Work roles become more diversified and less directly tied to economic productivity. The proportion of the work force in the service sector is used to indicate whether a country has entered the post-industrial phase. Less than 25 percent of the work force in the United States is now engaged in primary production and only about 5 percent in agriculture. This is seen as clear evidence that the U.S. has entered the post-industrial phase. Corresponding values for the Republic of Ireland are 19 percent in industry and 31 percent engaged in agriculture, indicating that Ireland is entering the post-industrial phase. The transition to post-industrial forms will entail a redefinition of roles and values within society. For example the socially useful deployment of human resources may no longer be accommodated within the conventional job market.

Several general trends are discerned by McHale (8):

(i) changes in the hierarchic nature of management,

(ii) a trend towards increased social awareness,

(iii) a trend towards the convergence of public and private organisations.
Many of the essential services in society - education, telecommunications, transportation, information, health services, housing - have developed beyond the economic provision possible by private enterprise. They are increasingly provided by the government or heavily subsidised by public funds. Changes in the concept of profitability may be necessary in order to create the new social services demanded by society in future.

(e) Politics:

In an information dependent society, power tends to be associated with knowledge and information. Due to the swift diffusion of information, the "time-cusion" between the perception of problems and the entry into public dialogue has dramatically decreased. Also as information systems become larger they become less confidential. These two factors suggest that political processes may become more open in future unless the news media is controlled by a particular group or ideology. A further consequence of the new information society could be the emergence of issue oriented politics leading to a less cohesive form of government.

McHale (8) stresses the need for better social indicators to provide early warning systems which would allow the long range planning now considered essential for society. Potentially the new information and telecommunications technologies could greatly assist this need by the extensive use of computer simulation. However such simulation is of limited value until the relationships between the different sub-systems of our society are better understood. The need for real time systems which would provide up to date statistics is also stressed.
Implications for Transportation

Obviously the changing information environment will have profound implications for transportation and transportation planning. There will be an increase in the use of computer simulation for investigating changes in transportation system parameters. Proposed traffic system changes (e.g. in one-way networks) are being simulated before implementation in many cities today. Also the new information systems would permit more direct citizen participation in planning decisions. At the local community level such increased participation could be greatly enhanced by interactive cable television systems.

One specific result of the electronic linkage of individuals, households and communities has been the concept of the "wired city" (there are already many professionals such as doctors "wired" to their workplaces with a pocket signalling device or a mobile telephone). This concept could provide an information capability which could displace many of the temporal and distance constraints which have led to specific growth patterns in urban and suburban communities. Many of these patterns (to work, shop, entertainment, etc.) are already, in theory, obsolete since telecommunications can be substituted for various routine purposes. "More significantly, patterns of transport will change as people and industries (particularly 'knowledge' industries) are freed by the availability of electronic information to determine their home and office location by other requirements than face-to-face interchange of information. If the 'home office' does in fact become widespread, there would be significant modifications to the radial patterns of a large city" (11) (however, a number of recent studies have stressed the importance placed
on face-to-face meetings by business executives). The increased computerisation of routine tasks in production, inventory and distribution control will enable more businesses to locate themselves more flexibly without loss of service quality to customers.

A large scale research effort has been made in Japan (The Plan for the Information Society: A National Goal Towards Year 2000) which recommends that the Japanese government prepare an integrated plan for the development of an information society within the next twenty years. This plan which may be the forerunner of other similar national plans, notes that commercial development of the new information environment may delay its extension to human services such as education and medicine.
A REVIEW OF TRANSPORTATION/TELECOMMUNICATION STUDIES

General Comments

Studies during the last ten years into the relationship between transportation and telecommunications have focussed on the substitution of travel by new forms of telecommunications. Many of these studies have resulted from the escalation of energy costs since 1973. However, the travel saving opportunities of advanced telecommunication had attracted the attention of researchers since the early 1960's. Tyler (12) has reviewed this early literature. More recent studies have been reviewed by a number of authors primarily in order to quantify potential energy savings (13, 14, 15).

Most of the literature on transportation/telecommunications interactions has been largely conjectural and little consensus of opinion has emerged. This, to a large extent, is because of the relatively few controlled field studies which have been undertaken using new media. Until such telecommunications are more widely available it is unlikely that more confident predictions can be made. As a result of the recent partial deregulation of telecommunications in the U.S., the major producers of new telecommunications media and services are not releasing information on studies undertaken. Previously the AT&T Company, the major supplier of U.S. telecommunications published articles on new media use. However, with the convergence of telecommunications and computer technologies neither AT&T nor its competitors (from the computer industry) have reported on the use of new telecommunications media.
The substitution (or diversion) of transportation for telecommunications has been the theme for most studies to date. Extensive psychological and experimental studies carried out by the U.K. Communications Study Group have indicated that both audio and video teleconferencing can substitute effectively for certain types of business meetings (16). It has even been shown that bargaining is more effective by audio teleconference under certain circumstances (17). It is not clear, however, what combination of circumstances will cause people to substitute telecommunications for transportation.

New telecommunications media are likely to generate additional travel (or longer trip lengths) for some trip purposes. However it has been generally concluded by researchers that there will be a net substitution of telecommunications for travel (12). As yet there is little or no hard evidence to substantiate this conclusion. Furthermore as people become more involved with information processing there should be a large increase in communications of all types. Even if substantial diversion of travel occurs, it is suggested that the total volume of travel is unlikely to be reduced to any large extent. However radical changes in travel patterns are likely to occur particularly due to changes in business locations and to an increasing amount of remote work (at home or in neighbourhood work centers).
Typeology of Studies

Tyler (15) has suggested that transportation/telecommunications studies be divided as follows:

(i) The use of intuitive judgement: This methodology involves the use of travel statistics. The number of trips for each trip purpose and the magnitude of the resulting travel is ascertained. Intuitive estimates are then made of the proportion of each trip category which appears amenable to diversion by telecommunications.

This type of study is useful for order of magnitude estimates of the potential substitution of existing travel. However, the use of aggregate statistics is questioned since travel behaviour varies widely between individuals.

(ii) Surveys with hypothetical choices: A particular category of traveller (e.g. interurban business traveller) is identified and surveyed. Respondents are presented with a range of hypothetical telecommunications options and asked whether they would substitute telecommunications for the specific trip they are undertaking. An example is the well known Bell Canada study (18).

This type of study appears more realistic than type (i) since it involves the subjective response of travellers on specific trips. However since the telecommunications options being presented are not currently available and respondents are not familiar with their use, it is difficult to assess the reliability of the results.

(iii) Field trials:

The use of operational or experimental telecommunications systems
is measured. Users are questioned on their preferences, types of communication activity, frequency of use, etc. Studies of this type undertaken to date include the NASA Teleconferencing Pilot Project (19), the AT&T's Picturephone Meeting Service (20) and the U.K. Confravision trials (21).

The results of this type of study provide the most useful information available on the future use of new telecommunications. However the studies undertaken to date have been very limited in extent.

(iv) Model building using survey data: This involves using survey statistics to build behavioural demand models which would estimate the proportion of trips diverted and generated by telecommunications. Significant work has been done on investigating the behavioural relationship involved (mainly by the U.K. Communications Study Group) and a model of this type, for travel to business meetings, has been built and calibrated using U.K. data (12). However, the validity of this model has yet to be demonstrated and it is unable to simulate travel generation effects. The difficulty and cost of obtaining reliable calibration data for models of other trip purposes restricts the use of such models at present.

Because of the limited number of advanced telecommunications systems in operation, it is suggested that surveys which would combine intuitive judgement (i) and hypothetical choices (ii) would provide more realistic information on likely future telecommunications/travel behaviour. Thus, given the detailed trip purpose by the survey respondent, researchers could estimate (using the limited evidence from field trials (iii))
whether that trip could be adequately substituted. This would indicate the potential substitutability (upper bound) of that trip type, while it is suggested that the respondent’s hypothetical choice would tend to indicate the lower bound of substitution.

**A Review of Field Studies**

For transportation planning purposes trips are commonly divided into the following categories:

a. **Interurban passenger**  
   (i) Business  
   (ii) Other

b. **Urban passenger**  
   (i) Commuting  
   (ii) Shopping  
   (iii) Educational  
   (iv) Social and recreational  
   (v) Personal business  
   (vi) Business (in course of work)

c. **Freight movement**

To examine the impact of new telecommunications media on transportation the above categories are used because there is some evidence that travel substitution by telecommunications varies with trip length. However it is not always easy to distinguish between urban and interurban trips in large metropolitan areas. The principal results of the major field studies reported in the literature are summarised in the following pages.
Interurban passenger travel

The business sector of the economy is likely to be the first to benefit from new telecommunications media and a number of studies into the potential effects of such media on interurban business travel have been undertaken. No field studies on other interurban trip categories have been found in the literature.

In 1973 the Business Planning Group of Bell Canada (18) questioned automobile, train and plane business travellers on four major intercity corridors in Canada. Survey respondents were asked whether they would have taken their current trip had a number of alternative telecommunications media been available. The principal result was that "approximately 20 percent of the business travellers sampled would not have taken their current trip had an acceptable communications alternative been available" (18). Information on each traveller was also obtained in order to determine whether "substituters" could be differentiated from "non-substituters". However the study concluded that "substituters could not be systematically differentiated from non-substituters by any of the variables measured in the study" (18).

A second major study was that carried out under the auspices of the European Telecommunications Administrations (CEPT). Data on business meetings and travel costs were collected in eight European countries (22). A behavioral demand model developed by the U.K. Post Office and others was used to estimate the proportion of those trips which would be substituted by audio and video teleconferencing (23). Based on U.K. data Tyler (12) reported that, for estimated 1985 costs, 35 percent of trips
to business meetings would be substituted by an audio teleconferencing system and that an additional 1 percent would be substituted by a video system. For the year 2000 it was estimated that 37 percent of the existing trips would be substituted by an audio system and an additional 3 percent by video. The upper bound of travel diversion likely in future was predicted as 41 percent audio and a further 9 percent video.

The results of the U.K. Post Office/CEPT study for travel to business meetings cannot be directly compared with the Bell Canada study (18) since the latter involved all types of business travel. Tyler estimated that a 36 percent reduction in travel to business meetings in the U.K. was equivalent to a 10 to 15 percent reduction in all business travel (12). Assuming the same proportion of meeting/non-meeting business travel for the upper bound travel diversion predicted by the CEPT study would indicate that 17-20 percent of all business travel would be substituted. This proportion is similar to that estimated in the Bell Canada study.

A number of earlier major studies into the substitutability of interurban business travel were carried out by the U.K. Communications Study Group (16). Since the CEPT model was partly developed by this group it is assumed to supersede that work. However it is interesting to note that the "1975 best estimate" for substitutability of existing business meetings was 43 percent by audio media and a further 7 percent by video (16).
Urban passenger travel

The substitution of urban passenger travel involves greater changes in established work and living practices than the substitution of inter-urban travel.

(i) Commuting: Developments in telecommunications could influence the location of office employment and also journeys to work by permitting employees to work all or part of the time at home or at neighborhood work centers (24). Since commuting accounts for a high proportion of all auto vehicle kilometres worldwide (about 34 percent in the U.S. (25)), a number of studies have investigated the direct diversion of existing work trips to telecommunications. However most of these studies have been carried out at the aggregate level and have been estimates of substitutability rather than estimates of the likely level of substitution. All studies reviewed are the "intuitive judgement" type.

In a case study of the San Francisco Bay Area, Jones (26) divided jobs into substitutable and non-substitutable categories. Then travel data was used to determine the proportion of jobs which could be performed at home or at remote work locations. To obtain better estimates of likely substitution, many routine clerical jobs were not considered substitutable as they did not justify the extra telecommunications costs incurred by working at home. The major conclusion was that 22 percent of commuter travel in the Bay Area during the morning rush hour could be substituted by telecommunications. For trips terminating in the city of San Francisco the equivalent value was 31 percent and for trips terminating in San Francisco's central business district, 47 percent substitutable (26).
Tyler quotes similar work by Teruaki Ohara in Japan which "implies a broadly similar result" for overall substitution of home-work travel (12).

The proportion of U.K. jobs which might be home based was estimated by Glover (27) to vary from 20 percent (1971) to 26 percent (1991). Using Glover's employment criteria, Tyler estimated that 35 to 40 percent of journeys to work in Central London were "of kinds that might ultimately be substituted by telecommunication," assuming no change in employment patterns (12). These U.K. results are also very similar to those obtained for San Francisco (26) which implies that the potential for remote working is similar in developed countries.

(ii) Shopping trips: In theory new telecommunications could substitute for all shopping trips provided that home delivery systems are available. Two-way information and finance transfers between home and shop terminals would eliminate the need for the shopper to attend in person. Mitchel suggested that 50 percent of all shopping trips were potentially substitutable (28) but this estimate does not appear to have been based on a specific field trial. However home delivery has almost disappeared from most countries except for larger household items. Also research has shown that shopping is enjoyed as a special occasion by many people (in particular non-workers) and individuals have expressed strong preference for the personal selection of goods (29). However a significant proportion of survey respondents indicated that they would like to eliminate routine purchases such as grocery shopping (29). A review of home shopping possibilities has been completed by Edwards (30). No substantive field studies appear to have been undertaken on the effects of new telecommunications media on shopping trips.
(iii) **Educational trips:** The impact of new telecommunications media on education has been widely studied (31, 32, 33) but little information is available on the implications for educational related travel. Theoretically all educational trips apart from those involving specialised equipment could be diverted to telecommunications. An earlier intuitive judgement type study estimated that 25 percent of "education-civic" trips were potentially substitutable (28). However school trip patterns will probably remain unchanged because of the need for specialised supervision and social interaction. As a consequence of the new information environment, a far greater proportion of the future adult population will be involved in education. The opportunities offered by advanced telecommunications are likely to be used to supplement the existing educational system by permitting more extensive and new part time adult educational services.

Grey (34) quotes attitudinal surveys on the use of a remote instructional television system as evidence of the effectiveness of telecommunications to substitute for travel. However if such remote facilities were not available it is not clear that the students involved would have undertaken their courses. Tyler suggests that new telecommunications will probably increase travel but to a limited extent (12).

(iv) **Social and recreational trips:** Videophone services could, in theory, substitute for many visits to friends and relatives. However, as for the telephone (35), the videophone could instead result in increased travel since regular personal contact could be maintained with a larger circle of friends. Similarly better information on leisure opportunities provided by new media seem likely to lead towards increased travel. No field
studies into the implications of new telecommunications for recreational travel appear in the literature although there have been many speculative studies into the social impact of telecommunications. Mitchel estimated that only 5 percent of existing socio-recreational trips were potentially substitutable (28). New cable television/satellite services could substitute for some recreational trips in an era of increasing travel costs and energy shortages since research has shown that recreational trips are likely to be restricted before other trip types (36).

(v) **Personal business trips:** Personal or family business trips include visits to health care centres, banks, insurance companies, etc. It has been suggested that such trips offer great potential for substitution (24). Some limited field studies carried out in Ireland have indicated that people would like to eliminate many of these trips (36). The promotion of electronic fund transfer by banks in many countries should divert some personal business travel. A number of studies have investigated the use of advanced telecommunications in promoting health care (37, 38) but little information is available on transportation implications. On average it seems that there would be a small net increase in travel because of the extended health services possible.

(vi) **Urban business travel:** Business travel comprises only a small proportion of urban travel (5-10%) but it is usually concentrated in congested downtown areas. As previously noted new telecommunications media are being introduced first to the business sector of the economy, and many studies have investigated the possible implications for business travel. Most of these studies do not distinguish between urban and
interurban travel in published reports. However a study in Ireland (39) has indicated that trip length is an important determinant of potential travel substitutability. About 30% of all business trips in Cork, Ireland were considered to be substitutable by audio telecommunications compared with only a negligible proportion of interurban trips. Surveys by the U.K. Communications Study Group (22) have also indicated that the potential travel substitution is noticeably lower for meetings which are over typical inter-city distances. However most of the published work of this group does not appear to include distance as an important substitution parameter and the Communication Study Group's type allocation estimates of trip substitutability seem to refer to both urban and interurban travel (16). However the LRS/CEPT model (described previously in the section of this report on interurban travel) includes the effect of distance as a travel cost.

Studies on urban business travel in the U.S. exhibit a wide variation in substitutability estimates. A Pittsburgh study suggested that approximately 73% of all business contacts could be substituted by telecommunications provided effective systems "are made available at prices participants are willing to pay" (40). Another study gathered evidence to suggest that telecommunications could substitute for 20 to 60 percent of local business travel (41).

**Overall substitution of urban travel:** A number of general studies have attempted to estimated the potential substitution of urban travel by telecommunications (14, 42, 43). Typically these studies divided urban
travel by trip purpose and then "estimated" the proportion of "substitution" trips. The usefulness of these studies is limited by the arbitrariness of the values chosen. Values of urban travel substitutability obtained varied from 11 to 22 percent of trips and from 14 to 22 percent of urban vehicle-kilometres. The most recent study appears to be that of Lathy who estimated a 16 percent substitutability of urban vehicle kilometres (14). However it is obvious from this review that little hard evidence is available on the substitution potential of most trip purpose categories and additional field studies are required before much credence can be placed on overall estimates of urban travel substitution.

**Freight movement**

The potential use of advanced telecommunications media to improve the efficiency of freight systems has been extensively studied (44, 45) and is not considered in this report. Otherwise few quantitative estimates of the impact of advanced telecommunications on freight movement have been reported either for urban or interurban areas. Surveys have shown that the intensity of business contacts fall off rapidly with distance (22, 39). Tyler has suggested that advanced telecommunications could reduce the "friction of distance" for business communications thus widening market areas with consequent increases in absolute freight quantities (12). One of the most significant effects may be the transmission of newspapers, mail, computer data, etc., directly to remote terminals. U.S. studies into potential mail substitution have resulted in a wide range of overall diversion estimates (13-60%) indicating that
the relationship involved is not precisely understood. One recent U.S. survey concluded that "some 30 percent or more of first class mail can be handled by some form of electronic fund transfer technique" (46).

**Summary of field study results**

Table 2 summarises the available trip substitution estimates which are based on field evidence. It is clear that for most trip purposes no firm evidence is available and even for those trip purposes which have been studied the evidence is limited. Comparisons of studies carried out in different countries show surprisingly little variation in the results obtained.
TABLE 2

Summary of Trip Substitution Estimates

<table>
<thead>
<tr>
<th>Trip purpose</th>
<th>Substitutability estimate</th>
<th>Substitution estimate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interurban business travel</td>
<td>17-20% U.K. 20% Canada (18)</td>
<td>10-15% U.K. (12)</td>
</tr>
<tr>
<td>Interurban leisure travel</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Urban commuting</td>
<td>22% U.S. (26)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>20-26% U.K. (27)</td>
<td>-</td>
</tr>
<tr>
<td>CBD only:</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>47% U.S. (26)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>35-40% U.K. (12)</td>
<td>-</td>
</tr>
<tr>
<td>shopping</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>educational</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>socio/recreational</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>personal business</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>business</td>
<td>73% U.S. (40)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>20-60% U.S. (41)</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>30% Ireland (39)</td>
<td>-</td>
</tr>
<tr>
<td>Freight movement</td>
<td>13-60% total U.S. mail volume ( )</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>30% U.S. First Class Mail (46)</td>
<td>-</td>
</tr>
</tbody>
</table>
Unresolved Issues: More or Less Travel?

Developments in telecommunications can affect both transportation supply and demand in a variety of ways. The use of telecommunications to improve the supply of transportation (more efficient management of assets, increased route capacity, etc.) has been extensively studied and is relatively well understood (44, 45, 47). Consequently it is not considered in this report. However the likely effects of telecommunications on transportation demand are not at all clear. In the absence of hard evidence expert opinion varies widely; from those who expect substantial reductions in travel demand (48) to those who expect that new telecommunications will result in additional travel (49). Better telecommunications facilities contacts with a greater number of people and also at greater distances. This would lead to an increase in travel unless a substantial amount of travel substitution also occurs or alternatively could alter existing travel patterns substantially.

Tyler distinguishes three kinds of effects - the diversion of communication flows (often termed substitution), the generation of stimulation of demand and the modification of demand for transportation. The studies reviewed in this report almost all concern the diversion of existing travel. No firm conclusions on the probable future amount of diversion can be reached until extensive tests between competing communications media are carried out. Very little substantive evidence is available on generated travel although Tyler quotes some anecdotal accounts from field trials in health care suggesting large effects (12). Lathey states that two U.S. teleconference systems (NASA and DOW) resulted in reduced
amounts of business travel per employee (14). However a more recent report on one of these systems concluded that the employees involved did not reduce their overall travel budget expenditure; instead the money saved on teleconference diverted meetings had been redirected towards other travel (50). This tends to support time budget concepts, viz. that a constant amount of time per day is allocated to travel by each individual (the use of travel time budgets is examined in Appendix A). Tyler argues that "a business communicator is unlikely to spend all the time he gains by substituting telecommunications for travel, in additional communication - let alone spend all of it in the mode of communication whose relative attractiveness has been reduced by telecommunications" (12). Consequently he suggests that in general travel generation effects will be small and this view is supported by Harkness (51) although the latter points out that this may not be true for all classes of trips. However no real evidence is available to either confirm or deny these generation predictions and it is equally valid to argue that the expected increase in communications of all types resulting from the new information environment will result in substantial travel increases.

Finally, it is generally agreed that new telecommunications devices will permit modifications of travel patterns and applications which are not evident at present and these may ultimately have for greater impact on transportation than diversion or generation effects.
THE IMPACT OF TELECOMMUNICATIONS ON TRANSPORTATION AND PLANNING

The consequences of changes in the relationship between transportation and telecommunications have been comprehensively assessed in a major study carried out at Stanford Research Institute (SRI) by Harkness et al. (51). The stated objective of this study was "to comprehensively identify and assess the physical, economic, social, environmental and quality-of-life consequences that may result from a shift in the interactions between telecommunications and transportation." No comparable analysis has been carried out elsewhere although a number of less extensive investigations have been undertaken (53).

To assess the impact of new telecommunications media on society the Stanford Research Institute (SRI) study postulated a range of plausible future scenarios induced by predicted transportation/telecommunications interactions (51). The consequences of these scenarios were then investigated. Three interurban scenarios were developed, one assuming 20 percent substitution of all interurban business trips by teleconferencing and the second arbitrarily assuming an equal increase in business travel. These two scenarios were compared with a third based on the projected industry forecasts of air travel growth to the year 2000. The SRI study concentrated on comparisons between the first and third scenarios - little substantive work was done on the second since its occurrence was considered unlikely by those involved in the study. Four urban scenarios were developed, two dealing with office relocation from central business districts to the suburbs - (i) decentralization to a few satellite centers and (ii) random decentralization.
It was also assumed that audio and video teleconferencing would replace about 20 percent of local business trips that today would require travel. The other two urban scenarios were more radical in concept. One assumed that a substantial proportion of office workers would work at home 95 percent of the time and the other assumed they would work in neighbourhood work centers. The development of the above scenarios was based on a large number of detailed background reports.

From the review of the transportation/telecommunications studies earlier in this work, it appears that the substitution values and scenarios chosen for the SRI study are realistic. Also it appears that the use of new telecommunications in different countries is quite similar. Consequently the SRI conclusions may be broadly applicable elsewhere.

The principal conclusions of the SRI study and other evidence on the impacts of telecommunications on transportation and planning are next considered. The likely implications for the U.K. and the Republic of Ireland are then briefly discussed.

**Transportation System Impacts**

The SRI study concluded that 20 percent substitution of interurban business travel by telecommunications would seriously affect the viability of existing U.S. intercity airline travel. The need for V/STOL and SST aircraft would also be reduced since they cater primarily for business people and others whose time is considered valuable or who must meet quickly in crisis situations. The necessity for airport expansions would be reduced in some cases. Domestic air services in the U.K. and Ireland
should also be affected by new telecommunications but, due to the shorter
distances involved, the airlines are not as heavily dependent on domestic
business travel. The viability of European services from both countries
should be seriously affected if a similar proportion of international
travel is substituted. However limited evidence suggests that international
travel is less likely to be substituted by telecommunications (39).

The viability of interurban train services in the U.K. and Ireland
would probably be seriously affected by telecommunications substitution -
especially the high speed services being developed in the U.K. However
where wideband (video) telecommunications are used as a substitute for
rail travel, the projected cost savings per traveller may not always be
 favourable to telecommunications (53).

Large scale replacement of commuting trips to central business
districts would result from each of the four urban scenarios developed
in the SRI study. This is predicted to have a devastating impact on
the financial viability of existing U.S. rapid transit systems (typically
40-80% U.S. rapid transit trips are CBD oriented (51)). It is also
suggested that considerable savings could be made in projected urban
transportation investments (both rail and freeway) by the elimination of
CBD growth.

These conclusions appear generally applicable to the U.K. and Ireland.
Rapid transit systems in the U.K. are probably not as dependent as U.S.
systems on commuter trips to the CBD but existing decentralization trends
are rapidly changing this situation. Suburban rail services in Ireland
are almost entirely dependent on CBD commuter trips and would be seriously affected. Urban bus services in older U.S. cities as well as in Ireland and the U.K. would lose a considerable amount of revenue. In European cities where traffic restraint is practised as an alternative to the construction of urban freeways, telecommunications may be chosen as preferable to mass transit.

Work decentralization induced by telecommunications would also reduce existing urban traffic congestion and its attendant environmental problems. Traffic accident rates should also be reduced.

The economic justification of public investment in transportation facilities depends heavily on the value attributed to savings in journey time. The highest values of time are ascribed to business trips and to a lesser extent journeys to work by high income groups. Tyler has pointed out that the replacement of some of these trips by telecommunications could have a much greater impact on the economic viability of new transportation investment than the overall figures for trip substitution would suggest (12).

**Energy Implications**

The predominant interurban and urban modes of transportation are very heavy users of energy and the use of telecommunications to substitute for travel normally involves substantial energy savings. Substitution for urban commuting has been estimated by Nilles to reduce energy consumption by a factor of 25.6 when the private auto is used and between 2.4 and 12.1 for public transport depending on the load factor (54).
These figures broadly agree with U.K. estimates (53). A French study showed that a doubling of all energy costs would increase telecommunications costs by only 1.9 percent compared with an increase of 12.7 percent for transportation (47).

Significant energy savings have also been found for intercity business travel substitution (41, 53, 55) although the quantity saved is dependent on the type of telecommunications system, the alternative mode of travel and the contact time involved. However most studies have indicated that the substitution of urban commuter travel by telecommunications offers much larger potential savings than intercity travel substitution.

No studies have yet been completed on the energy costs involved in setting up new telecommunications systems. However it is generally agreed that the available evidence strongly favours the telecommunications alternative to travel.

A number of U.S. studies have attempted to quantify the energy saved by substituting telecommunications for travel (13, 14, 15, 6). Estimates ranged from 1 to 7 percent of total U.S. petroleum demand for urban areas depending on the substitution level assumed. For interurban travel, Harkness has estimated that a reduction of total business air travel by 20 percent would save 0.3 percent U.S. petroleum demand (56). Substituting 20 percent of all business travel by auto would save a further 0.5 percent. The energy saving potential of new telecommunications has been shown by Harkness to be of the same order of magnitude as other energy conservation concepts (e.g. van pool programmes, improved building thermal standards, etc. (56)).
However the predicted energy savings by substituting telecommunications for travel may not be fully achieved since different travel trips may replace the substituted trip. It is also not clear from the available research evidence whether decentralization of homes and jobs leads to more or less travel. Harkness suggests that it may be necessary to change travel budgets and travel authorization procedures if a reduction in total business travel is desired. Similar policy measures may be required for private travel to encourage net travel substitution. However substantial energy savings should be achievable in all countries where telecommunications can substitute for travel.

**Decentralization**

It has been generally assumed that new telecommunications will assist decentralization of both homes and jobs. However telecommunications also permits the concentration of certain jobs, e.g. the headquarters of companies can congregate in downtown areas remote from their production facilities. Other factors such as energy costs, land cost and availability, planning controls, etc., are probably of greater importance than telecommunications in determining future urban form. U.K. research by Goddard suggests that telecommunications development may accelerate job dispersal within metropolitan regions but does not appear as significant for longer distance moves (57). The SRI study postulated that improvements in telecommunications would reduce the needs for office organisations to cluster in central business districts and would result in their relocation to the suburbs (which is consistent with the U.K. evidence). However the
Decentralization of office jobs is likely to be significantly less in the U.K. and Ireland than in the U.S. because of more restrictive planning controls in these countries.

Social Issues

The reduction in local tax revenue as a result of decentralization is of particular importance to U.S. inner city administrations. This is also relevant to the U.K. and Ireland but to a less significant extent. The decentralization of CBD office jobs would also increase social problems in inner city areas. There are a number of other social issues raised by the widespread use of new telecommunications (24, 27). These include the problem of equity raised by differing degrees of access to new telecommunications technologies for different social groups. Substantial reductions in transportation employment would also result from widespread travel substitution. These are disturbing long term problems which must be considered as part of the overall impact of new telecommunications on society.
CONCLUSIONS

Many of the issues raised in this report are necessarily tentative because the full impacts of developments in telecommunications are still unclear. The key question of the media split between different communications modes remains unresolved. Detailed econometric studies of data on past flows of telephone calls and letters undertaken by the U.K. post office failed to find any evidence that changes in the availability or price of one service affected the other (12). Similarly a detailed re-examination of the field data collected for an Irish study (39) by the author has clearly indicated that telephone calls and face-to-face meetings are, on aggregate, used for quite different purposes and very little diversion of existing travel to telephone appeared possible. This result substantiates the result of an earlier U.K. study, that only 3 percent of recorded meetings were considered substitutable by telecommunications (58). Extensive modal split modelling studies have also indicated that specific travel trips are largely captive to certain modes and that the price elasticity is small. This raises the question of whether new telecommunications devices will substitute for a range of travel purposes or alternatively only for specific trip types. It appears from teleconferencing field tests that only certain types of business meetings are suitable for teleconferencing viz. regularly scheduled information meetings (7).
However the potential impacts of new telecommunications on society in general and on transportation and planning in particular are of such magnitude that continuing research in this area is required if radical future problems are to be avoided.
REFERENCES


48.

49.


APPENDIX A

Travel-Time Budgets and the Future Use of Telecommunications

Empirical research has shown that individual travellers and households spend a fairly constant amount of time (or time and money) on travel (1A, 2A). This daily constraint on travel, known as a travel time budget, has been shown to be reasonably constant at aggregate level, regardless of city size, and stable over time. Travel time budgets per traveller have been found to vary from 1.0 to 1.5 hours per day (3A). Zahavi has suggested that expenditures on travel by households is a relatively stable proportion of total household expenditure at all income levels; 15-17% for car owning households and less than half this value for non-car owning households (4A). However invariant expenditure of either time or money on travel is inconsistent with rational economic behaviour and with conventional transportation modelling. A theoretical analysis by Tanner concluded that generalised expenditure on travel might be invariant (5A). Data from the U.K. National Travel Survey was used to indicate that generalised expenditure is much the same in urban as in rural areas, despite the wide variation in modes available and distances to destinations (5A).

Goodwin using London Transport study data (1971-72) empirically tested the stability of individual travel time budgets by examining variations for different traveller characteristics such as income and
car ownership (2A). He concluded that the evidence was inconclusive but his work also supports the concept of some upper bound on travel time. Goodwin also suggested that the total time allotted to travel is likely to increase as the barriers to travel are removed but subject to a saturation level. However it appears unlikely that the existing barriers to travel will be eased due to the predicted energy cost increases.

A study was recently completed in Baltimore into the stability of travel time and money budgets at disaggregate level using a random 966 household day-long trip diary (6A). At aggregate level the proportion of gross household income spent on travel (15.45%) correlated very well with Zahavi's results. However the proportion spent varied significantly with income (from 22% for the lowest income group to 11% for the highest). Thus Zahavi's hypothesis of a constant allocation of income (15%) on travel (irrespective of household income) was rejected at the disaggregate level. Analysis of the Baltimore data at aggregate level gave an average daily travel time per traveller of 1.28 hours and this value showed insignificant variation across various sizes of households (in terms of number of travellers). This result conforms with Zahavi's findings of a relatively constant travel time per traveller (4A). The Baltimore data showed some variance within the population of each stratified group (race; income; location; vehicle availability) but generally the absolute size of the variance was small (5 to 7 minutes) and could have resulted from data inaccuracies. The
difference between the average daily travel time for travellers from zero and two car households was only 5.4 minutes while the same difference was found between outer city and downtown residents (those living outside the city of Baltimore recorded travel times midway between these locations).

Thus it appears that the concept of a constant daily travel time per traveller has some merit especially when applied in aggregate for urban areas. However the range in values between different cities (1 to 1.5 hours) recorded by Zahavi (4A) suggests that caution is required in transferring this concept between cities.

The concept of a daily travel time constraint appears subjectively valid and the evidence to date suggests that, on aggregate, it remains stable over time. This uniformity of travel budgets suggests that, if advanced telecommunications reduced commuting, non-work travel would increase correspondingly to maintain the same travel budget. The results of many transportating studies indicate that the length and number of journeys undertaken by each traveller are increasing over time. Unless the future rate of transportation system improvements continues at past rates (which appears unlikely because of predicted energy costs and financial constraints) it is suggested that daily time budget constraints will reinforce the use of advanced telecommunications media as a substitute for travel.
Appendix A References


5A) Tanner, J. C. "Expenditure of Time and Money on Travel," Transport and Road Research Laboratory, Supplementary Report, SR 466, Crowthorne, Berkshire, 1979.

6A) Makofski, R. et al., Draft report on the stability of travel budgets at disaggregate level, Metro Center, Johns Hopkins University, Baltimore, Maryland, 1980.
APPENDIX B

The Incorporation of Telecommunications into the Transportation Planning Process

New telecommunications media will have a major influence on future transportation and land use requirements. Thus it appears logical that telecommunications should form part of the comprehensive land use/transportation planning process. The inclusion of telecommunications could result in deferring or foregoing some transportation system improvements (which might result in a net savings of energy). However it is not clear how best to incorporate telecommunications in the planning process. It could be included in the modal split stage as an alternative "transportation" mode using realistically calibrated models for each trip purpose. However this would ignore the effects of new telecommunications on trip generation and urban form.

As previously indicated, transportation and telecommunications are probably not alternatives for more than a small proportion of total communications; each appears primarily to serve a different communication need. Consequently it is suggested that telecommunications should be considered as part of the trip generation stage of the planning process. Thus models could be developed to generate telecommunications and transportation "trip" rates separately. The communication rates generated could then be examined for time budget restraints and the likely number of captive communications by transport and telecommunications identified. Separate distribution, modal split and assignment models should be developed to give total assigned flows to the transportation and
telecommunications networks. Since the new telecommunications models will be partly speculative initially, sensitivity analysis must be incorporated in the process. It is suggested that new telecommunications media trip rates should be varied by $\pm 5\%$ for business and commuter trips and by $\pm 10\%$ for other trip types.