TRAFFIC ANALYSIS TOWARDS 2000

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ABSTRACT

This paper examines some of the factors considered likely to have a significant affect upon traffic generation and urban travel patterns in the years ahead. The factors are considered under 3 headings - demographic and lifestyle, economic and technological. Although no definitive conclusions can be drawn about likely future traffic demand, it is noted that the effect of most of the factors discussed is to lead to an increase in traffic generation, while all factors point to a change in the patterns of travel. It is concluded that those with a responsibility for traffic policy and planning should take cognizance of the influence of factors such as those discussed in this paper.

The paper is based upon a review of traffic analysis directions and capabilities undertaken for the Road traffic Authority of Victoria.

INTRODUCTION

Traffic analysis is concerned with the interaction between traffic and the facilities which are provided to accommodate travel demands. The road traffic system is complex, particularly where its interface with the wider socio-economic system is concerned. Traffic analysis must recognise this complexity.

Three separate dimensions of traffic analysis may be considered (Fig 1). First, the specific physical elements of the road traffic system must be defined. This may include analysis of:

networks
links
intersections, and
parking facilities.

Second, the scale of the analysis must be decided . Scale boundaries are somewhat arbitrary, but it may be helpful to distinguish between analyses at the following planning levels:

site planning
district center planning
local area planning
regional planning

Finally, it is necessary to have regard to the people who will or may be affected by the proposal under analysis. Four key groups (which are not mutually exclusive) are:

motor vehicle users
public transport users
non-motorised users
residents and land owners (non-users).

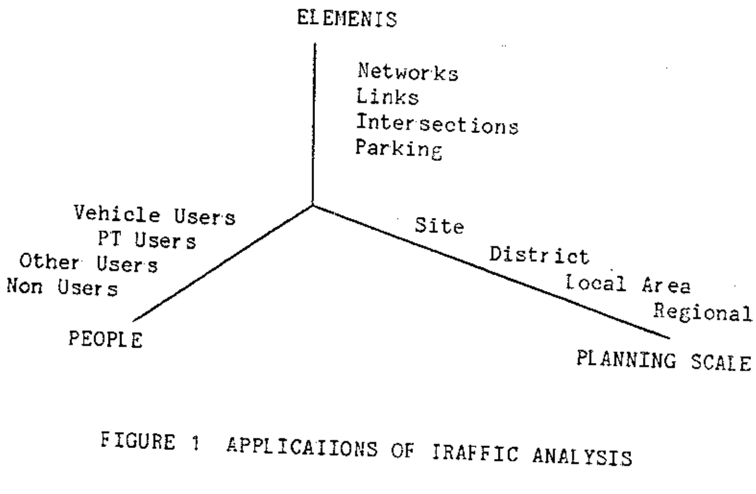

FIGURE 1 APPLICATIONS OF TRAFFIC ANALYSIS

A vital component of traffic analysis, within any of the above (4x4x4=) 64 possible combinations of the above factors, is traffic generation. Traffic generation may be defined as the number of traffic units (e.g. vehicles, pedestrians, etc) generated by a given activity in a specified time period. Estimation of the traffic generation characteristics of a particular proposal is a necessary part of the planning and design process, even though present techniques for performing such analyses are rudimentary and have significant conceptual and practical limitations (Barnard and Brindle , 1985).

The purpose of this paper is not to contribute towards the specifics of traffic generation analysis, but rather to attempt to take a broader, longer term view of the nature of traffic generation, and of the factors likely to influence it in the future (Ogden and Taylor, 1985). As mentioned, the road traffic system is complex, and the interplay of the various forces within it will determine the levels and nature of future traffic demand. It is important however to attempt to understand the strength of those forces and to try and anticipate the likely range of future outcomes, as these may have significant impact upon the appropriateness of present decisions. Recent publications of the Australian Road Research Board (Anon 1985a; Metcalf 1985) have been predicated on a similar basis.

FUTURES ANALYSIS

Future conditions may be regarded as the sum of two components - the projection of trends which are now evident, and the introduction of new factors which are not now evident.

The former is usually relatively straight-forward, at least in terms of getting the sign right (i.e., to estimate whether a particular trend will continue its upward or downward path). What is required is an informed judgement about the underlying causes of such trends, and an assessment of whether they are likely to remain stable. However, there can be no guarantee about the correctness of such forecasts; the real world is a highly complex system, and there is often a high degree of interaction between the component elements of the system - resulting in the well-known "Forrester's Law", that in a complex system the result of any action is always counter-intuitive!

The latter is more difficult, but probably more important when assessed on an historical basis. As Lay (1979) has put it, "the key to predicting change is therefore the prediction of ... discontinuities. It is no easy task." Similarly, Garrison (1984) distinguishes between incremental and non-incremental change in transport systems. Jones (1982) goes so far as to call the period which we are now entering as "the age of discontinuity".

The approach taken here will be based upon this distinction between trends and discontinuities. That is, it will consider present trends and examine whether they seem likely to continue, and then consider whether there are any possible "discontinuities" on the horizon which may cause those trends to alter.

The factors affecting future demand for urban road travel will be discussed under 3 headings, as follows:

- demographic and lifestyle
- economic
- technological

There are obviously some important interactions and overlaps between these 3 factors, but for the purposes of this discussion, it is helpful to structure the analysis in this way.

DEMOGRAPHIC AND LIFESTYLE FACTORS

People make trips, and thus in looking at future transport demand, it is necessary to begin by examining the structure of the population, and the effects of changes in such structure as they may affect travel.

Although Australia's urban areas are growing, the rate of growth is less than that which applied in the 1960's and early 1970's. If these trends were to continue, it might be expected that future travel would behave similarly - i.e. a declining rate of increase in travel, all else being equal. However, this would be a simplistic assumption, because it is necessary to examine also the structure of the population.

An examination of the age profile of Melbourne's population shows that in 1981, 24% of the population was under 15 years of age, and 33% under 20 years (ABS, 1983). As these young people grow to the age where they are eligible for a driver's licence it is certain that most will want to become car drivers and car owners. There is thus a substantial proportion of the population which is not yet self-mobile, but which will wish to become so in the years ahead. This factor alone will tend to keep car usage increasing for many years, even if total population growth rates tend to fall.

The next age group may be considered as being in the family stage of their life cycle. 17% of Melbourne's 1981 population was in the 20-29 year age bracket, and as shown above a further 33% was younger than that. Thus currently half of the population is in, or has yet to reach, the family-forming stage. Moves towards smaller families and households (e.g. single parent households) notwithstanding, this segment of the population will tend to generate more trips.

The 30-39 year age group comprised 15% of the 1981 population, and included the post World War II baby boom. (This group comprised only 12.5% of the 1971 population.) This cohort will move during the 1980's and 1990's into younger middle age, with corresponding increases in disposable income; costs of establishing a family home are behind them, retirement is still some years away, and unemployment falls more heavily on younger and older groups. Many wives return to the workforce in this age group. These factors will likely tend to produce an increase in car ownership and car usage amongst this cohort.

In 1978, Hensher (1978) commented that people who were then approaching or entering retirement had grown up with the motor car, had access to a car over most of their life, and would be expected to continue to use a motor car if they were fit to do so. Since hitherto this group had been included amongst the public transport captives, Hensher suggested that this change was likely to have a noticeable affect upon urban travel characteristics. No data are available to check the accuracy of Hensher's prediction, but it seems reasonable, especially now, with an increasing proportion of elderly women with driver's licences (as compared with the 1970's and earlier). If this is so, the 13% of Melbourne's population which exceeds 60 years of age may well have a higher car trip generation rate than previous members of this age group.

Demographic influences are also affecting the spatial distribution of trips. While for most families, a suburban single-family detached house is considered the ideal, especially at the family-forming stage of the life cycle, there is a noticeable trend for young, affluent, often childless couples to move into the older inner city areas of Melbourne. This trend has pushed up house prices in these areas, but has caused population to decline (ABS, 1984, p7).

There are important transport implications here. Firstly, the population groups which are displaced (typically, migrant families with higher household occupancies) are moving to outer suburban areas. The effect is to move them from a location with good public transport to one where they are in many cases obliged to purchase a car (Kinnear and Ogden, 1978). Secondly, the groups which displace them, because of their smaller family size and higher income, tend not to use public transport as much (except for the journey to work). To the extent that these influences apply, the effect is to cause a growth in car travel at the urban fringe, and a possible decline in public transport travel in the inner areas. Thirdly, the increasing affluence of inner-suburban dwellers (both old and new) is creating quite severe car parking problems in areas where there is often little or no provision for off-street parking.

These trends must however be seen in perspective; the predominant population growth is still very much in the outer areas (Taylor and Newton, 1985). Moreover, it seems likely to remain so, for reasons of lifestyle. For example, Wigan (1981) suggested that "lifestyle choices will continue to be largely a matter of choice rather than constraint .... it would seem probable that we shall see growth in the range of activities offerred in suburban centers. The central area cannot accommodate all demands for proximity to a range of activities." In a later publication, Wigan (1983) has related travel to such lifestyle factors as vehicle access, travel participation, travel time participation, activity rates and on-road time exposure.

Dickie (1985, p182) has reached a similar conclusion regarding future urban lifestyles. He suggests that the increasing availability and variety of information, together with the lessening demands of work upon time, will lead to "a world much more attuned to self-gratification, sensualism and sensationalism." He foresees the development of 'erotic zones', "since the information will be of the 'touch, feel, smell, hear, see' type." Consequences of this so far as transport is concerned would include further social isolation, increased suburbanisation, development of security-protected housing areas, and an increase in both urban and ex-urban travel.

Ihus, so far as demographic influences are concerned, it seems that although there are some tendencies to the contrary, the much more likely overall result will be that the demand for car travel will continue to increase. No significant discontinuities are expected; indeed the nature of demographic change is such that dramatic variations over a relatively short period (say, a decade) are extremely unlikely because of the inherent stability in the population structure.

ECONOMIC INFLUENCES

As mentioned earlier, there is a relationship between each of the influences which we are here considering. Nowhere is this truer than in the case of economic influences; to a greater or lesser extent, all of the other influences are affected by, or revealed through, economic factors. Nevertheless, it is useful in discussion to isolate the other influences and consider them on their own merits, and to consider those economic influences which remain as separate factors in their own right. For present purposes, the economic influences may be considered under three headings, namely structural economic change, the national economy, and energy.

Structural Economic Change

Using ABS employment classifications , over half of Australia's workforce is employed in three areas - wholesale and retail trade (20%), manufacturing (17%) and community services (17%) (ABS, 1985). From a transport perspective, two questions are relevant. Firstly, what changes may occur in this employment pattern, and secondly, how might such changes affect urban travel patterns?

Ihat change will and must occur is inevitable (Jones, 1982). Ihere will however be resistance to the introduction of new industries, and the scaling down of employment prospects in existing, well-entrenched industries. As the BTE (1984b, p16) has recently noted, "from a social and political point of view .... the function of labor is not only to 'get the job done' but also to serve an income distribution mechanism and as an end in itself, giving purpose to the lives of individuals and communities. It is not surprising, therefore, that proposals for technological change with the potential to displace labor should encounter a strong social reaction and that the rate of introduction of such changes will inevitably be lower than might be desirable from a purely economic point of view."

Ihe overall direction of future employment growth is generally regarded as favoring quaternary and quinary industries, at the expense of secondary industry (i.e. manufacturing). For example, Meier (1985, p118) suggests that future cities will have only 10% of their workforce engaged in manufacturing, and "of those workers many will spend their time overseeing instruments". Employment in manufacturing industry peaked in Australia in the 1960's, and has declined as a proportion of the workforce since. Manufacturing industry thus seems destined to follow agriculture, which employed 50% of the workforce a century ago and about 6% now (Jones, 1982, p2).

The tertiary sector (tangible economic services), the quaternary sector (information processing) and the quinary sector (based on domestic and quasi-domestic servicing and/or making) together represent the service sector (Jones, 1982, p51), which already accounts for over nearly two-thirds of jobs. In his important book on technology and the future of work, Jones (1982, Chapter 2) considers that future job creation will occur in such service activities as retailing, personal services, education, home-based industries, leisure and tourism, skilled craftwork, and welfare services. Perhaps more significantly however, Jones argues that the nature of work itself must change: "new types of employment will be generated which are complementary to and not dependent on technological forms. They will be aimed at satisfying individual needs - deliberately intended to be labor/time-absorbing - and work itself will be part of the output of production, as in craftwork, gardening, research, sport, leisure, hobby and do-it-yourself activities." (Jones, 1982, p7)

So far as the immediate future is concerned, noted business forecaster Mr Phil Ruthven was recently quoted (Anon, 1985b) in the following terms:

"Small business opportunities in Australia will lie increasingly in the service sector rather than the goods industries ....

In manufacturing, there are great opportunities in the so-called cottage manufacturing or franchising area (for example) hot bread kitchens .... icecream parlors, water bed manufacture, and the wide area of high-tech including computer software and robotics ....

In construction ... the preconstruction and renovation of homes will be rapid growth areas ...

In retailing .... franchising (is seen) as the only way to set up a profitable small business ....

Very good prospects in finance are in contract accounting ..."

Ruthven was also quoted as saying that employment growth was expected to arise mainly from work sharing, new industries, new export markets, immigration and government spending.

Ruthven also pointed out that reduction of individual working hours in the past 50 years had created about 80% of all new jobs, and this factor was expected to continue to be the major job creator. This is supported by recently published data for Sydney (Bell, 1985, p201) which has shown that full-time employment in Sydney increased by only 1% over the decade 1971-

1981, but that part-time employment (defined as being less than 35 hours per week) increased by 132%, and now represents over 13% of employment.

The urban transport implications of these forecasts are interesting. The jobs traditionally located in the city center are not considered likely to grow as rapidly as more decentralised jobs. Work trips to the CBD are longer than average and have a much greater probability of being accommodated on public transport. Thus, this trend implies a reduction in overall average trip lengths, and little increase in centrally-oriented public transport trips.

The largest increase in jobs is expected to occur in sectors where the location of jobs is closely related to the location of households (e.g. schools, personal services, local government, and home-based work itself). This has several important implications for transport.

Firstly, it may be that such jobs are mainly filled by local people. To the extent that this is so, the length of the journey to work could fall considerably, and thus have a significant effect on work travel demand. For example, Manning (1978) noted that if the proportion of Sydney workers working within three kilometers of home was to double, the total work person-kilometers of travel would be halved.

Secondly, such trends are likely to have important effects upon conventional public transport services. These have very limited potential to serve short suburban trips. The modes likely to benefit from these changes would thus be the private car, walking and cycling, and possibly para-transit services such as taxis, demand responsive buses, jitneys, etc (BTE, 1980).

Thirdly, many service jobs and part time jobs are not fixed in time. In Melbourne in 1978-79, for example, 68% of employed persons reported that their working hours were fixed, 6% worked flexi-time, 6% were shift-workers, and the remaining 20% worked variable hours (Ministry of Transport, 1981, p463). These changing worktime characteristics are probably a result of a number of factors, including the state of the economy, the desire for part-time rather than full-time work, new lifestyles and desires, a dilution of the work ethic, etc. From a transport viewpoint, these trends may have the important effect of reducing the peakedness of travel. In practice, this is more likely to mean a growth in off-peak travel than a reduction in peak travel, but the effect will be to blur the difference between peak and off-peak characteristics.

Fourthly, as a special case of the previous point, reductions in working hours may be reflected in fewer days worked; already nearly 8% of employment in Australia is based upon less than 10 days work per fortnight (ABS, 1985). The immediate effect of this is to reduce work travel, maybe mainly in the peak hours. However, a secondary effect could be to increase off-peak travel for a range of non-work purposes, including recreational travel, personal business, shopping, etc. The opportunity for securing a second job as a result of reduced working hours in the "first" job should not be overlooked; the transport implications of this are also similar to those described above if it is assumed that such jobs are mainly in the service sector.

In summary, the main effects of structural economic change on urban travel, at least over the next few years, are expected to be a reduction in average work trip length, an increase in local travel, a reduction in the peakedness of travel, an increase in the number and proportion of non-work trips, and a change in emphasis for public transport from long distance radial journeys to a more local orientation. Although technological advances (especially in telecommunications - see below) may lead to some significant changes in the work habits of particular sections of the community, the effects of this on transport will likely be to accelerate these trends. In the longer term (say, towards the end of the century), the sorts of fundamental changes in work attitudes and needs advocated by Jones (see above) may well be taking hold. This would constitute a significant discontinuity, which will likely produce important changes in urban travel characteristics. However, the direction of these changes would appear to be the same as those which are now becoming evident, as summarised at the beginning of this paragraph.

The above discussion has been in terms of overall travel demand, not traffic generation. It is important to note that almost almost none of the aforementioned effects will tend to decrease traffic generation. That is, travel demand in terms of person-hours, vehicle-kilometers, etc (both of which relate to the need for arterial road space and public transport service) may be reduced, or spread more evenly throughout the day, but the actual number of trips is likely to increase. For example, CBD public transport work trips may be replaced by non-CBD car work trips; work trips on the occasional day off may be replaced by recreational or other trips; part-time workers may make more than one journey to work in a day; itinerant workers may move between job locations several times in the course of a day; and shorter work trips will simply create an opportunity to spend time travelling for other purposes (in terms of the observed tendency of persons to spend a relatively constant amount of time travelling - e.g. OECD, 1978, p72; Wigan, 1981).

The National Economy

The second economic factor affecting the future level of urban travel demand is the growth in the economy. The stronger the economy, the greater the amount of wealth, and the greater the demand for travel, all else being equal.

This has been examined recently by the BIE (1984a, 1985). Models were developed for several travel markets, based upon two "scenarios" of economic growth. These scenarios consider changes in real GDP, population, and indices of production in Australia, USA, EEC, and ASEAN countries, changes in Australia's exchange rate, levels of imports and exports, migration, air fares and sea freight rates, real fuel prices, and real prices of Australia's exports. The "high" growth scenario made favorable assumptions about the values of these explanatory variables, while the "low" growth scenario was based on less favorable assumptions. The models were based on ordinary least squares regression using historical data.

Parenthetically, it is worth noting that this approach is not capable of capturing the "discontinuities" discussed in the introduction to this section. In other words, the forecasts here can only be valid if there are no new factors entered into the picture.

Two models were developed for car travel, one for the numbers of cars on the register and one for the total vehicle-kilometres travelled. These were expressed in terms of elasticities, i.e. the percentage change in the travel demand variable as a result of a 1% change in the independent variable. The elasticities for each (with t-statistics in brackets) for Victoria were as follows:

Cars on Register:

Purchase Price	-0.48	(-2.44)
Income	1.02	(7.80)
Operating Cost	-0.27	(-1.31)

Total Vehicle Kilometres:

Number of cars	0.80	(24.72)

Both models explained a high proportion of the variance, returning an R-squared value of 0.99 in each case.

In discussing these results, the report noted that "growth in passenger car travel is expected to be higher in urban than in rural areas. This suggests that investment in roads may need to be concentrated more in urban areas. It also has implications for urban traffic management and control, and modal integration in metropolitan centers. Increased demand for urban road space could also increase the pressure for a system of pricing or restricted access for vehicle operation in large cities."

Thus, if we assume that there are no discontinuities in Australia's wealth relative to the rest of the world, and that the world economy (and thus our economy) continues to grow, the clear implication is that motorisation and the use of motor vehicles will continue to grow as well. The effects of such growth will be felt most keenly in the cities.

Energy

The prices of petrol and automotive distillate have risen by about 70% in constant price terms since 1973 (BTE, 1984b, p12). The impetus for this change was the policy of OPEC (Organisation of Petroleum Exporting Countries) to dramatically increase the world price of crude oil in 1973 and again in 1979. However, in Australia, the main reason for the change was the decision of successive Federal governments to price Australian crude oil at world parity prices.

A change of this order is sufficiently large to be noticeable, and the time frame (more than a decade) is long enough for consequent responses to be introduced. These responses have been of three main types - conservation, an increase in vehicle fleet fuel economy and alternative fuels (BTE, 1984b, p12).

Conservation. Conservation involves the curtailment of low-value uses, greater attention to the avoidance of waste, and seeking more efficient modes of operation. There may be considerable scope for additional conservation measures in the future in organisations with large vehicle fleets through "communication, information technology and computer-based management systems" (BTE, 1984b). For the private motorist, such changes would come about not from individual effort, but through greater control of traffic flow in such forms as SCAIS/SCRAM-type signal linking and (later) communication from the traffic system to individual drivers about optimum routes, etc (see below).

Fleet Economy. There have been significant improvements in vehicle fuel efficiency, including lighter vehicles, larger engines (in commercial vehicles), improved engine design, improved aerodynamics, etc. Some of these developments are now reflected in new vehicles entering the fleet, though obviously their effect on overall fleet fuel efficiency depends upon the rate at which new vehicles replace old ones. However, it seems very likely that the average level of fuel economy per vehicle will improve in the years ahead.

Alternative Energy Sources. The potential for this response is more limited. The tremendous advantages of liquid fuels for as an energy source for road vehicles virtually precludes any other source for the foreseeable future. In the past decade, LPG has made a modest impact (particularly amongst fleet owners such as taxi operators), while diesel engines are now almost universal for commercial vehicles. In the future, a significant potential is seen for LPG; the Department of Resources and Energy (1983) has projected LPG to account for 30% of road energy use by 1992, compared with 6% in the early 1980's.

Overall, the BTE expects passenger cars in 1990 "to continue their trend to look more and more alike, bowing to the necessities of low-drag design. Fuel consumption will probably have fallen to 4-6 litres/100 km for the standard 4-5 seat petrol engined sedan. Turbo-charging for fuel economy rather than performance will be common."

It is obvious that projections such as this imply no major new "shocks". This may well be valid, but it is perhaps necessary to suggest that energy remains one of the prime candidates for a major "discontinuity" of the sort mentioned in the introduction to this Section.

For the purposes of this paper, the relevant issue concerning energy is the effect of any future energy scenario on urban travel patterns and vehicle purchase. The evidence of the effects of energy price increases over the last decade seems to suggest that the latter is affected more than the former. That is people tend to purchase smaller cars and to use them more (Wigan, 1981).

If this continues to be the case, then it seems likely that energy price rises in the future will have little direct effect upon urban travel demand. Public transport will not benefit, there will be more small and/or energy efficient cars being purchased, and these will be increasingly found on urban roads.

As with other factors, the significant word in the preceding paragraph is "if". That is, the scenario proposed is based upon there being no major discontinuities in either energy price or supply. Australia's crude oil price is tied to world prices, as mentioned above, and so long as this nexus is retained our prices will fluctuate in accordance with world prices. At present, the expectation is that these will not increase any more rapidly than inflation (and may even fall). However, the 1970's indicated how sudden and unexpected oil price changes could be, and there can be no certainty that similar shocks will not occur. This area therefore must be regarded as one where a major discontinuity is possible, even if not likely.

TECHNOLOGY

In general, there are four sets of constraints which must be satisfied before a technological innovation can achieve widespread application (Ogden, 1973):

- it must be technically possible,
- it must satisfy a demand which the current technology does not adequately satisfy
- that demand must be socially, economically and politically acceptable
- in the long term, the innovation may be revolutionary, but in the short term it is more likely to result from incremental development of existing technology.

This paper is concerned with both incremental change of technology, and also more fundamental technological change, because there is an emerging school of thought that conditions are becoming ripe for major non-incremental change in the transport sector. For example, Garrison (1984) suggests that "in the past, non-incremental changes have occurred as the needs for them became overwhelmingly strong and/or as technological imperatives drove them. Both forces are present today in the merging of telecommunications, information systems, and computer capabilities. Technological imperatives are driving change, and increases in service sector or post industrial activities are pulling change."

Similar sentiments have been expressed by Ward (1984), who went on to discuss several possibilities for major, non-incremental change in, or affecting, transport in the years ahead. These included highway-rail intermodal freight systems, high speed passenger rail systems, road system traffic control, automated vehicle highways, pedestrian mobility systems and new kinds of cities, urban-regional high-speed ground transport, and the "skyhook".

This Section briefly examine a number of possible technological developments, of both an incremental and a non-incremental nature, and discusses their possible effects upon urban transport. The developments to be considered are:

information and communications technology
road traffic systems control technologies
road pricing technology
road vehicle developments.

Information and Communications Technology

A wide range of developments in communications are being developed and are beginning to be introduced. These include such developments as telephones, television (including cable television, satellite transmissions,etc), data transmission, tele-conferencing, electronic mail, videotext, teleshopping, teletext, facsimile transmission, etc. (Meier, 1985; Telecom, 1985; Wigan, 1985a). When allied to developments in computer technology, especially microcomputers which are both cheap and easily accessed, the potential for a "discontinuity" in our ability to communicate is immense. Indeed, Macrae (1984, p87) has described telecommunications as the third great transport revolution (after railways and the automobile) to transform society, with telecommunications attached to the computer being the most far-reaching because "once the infrastructure is installed, the cost of use does not depend greatly on distance."

The following paragraphs consider the effects of communications and information technology upon urban transport in 3 areas, viz urban form, trip rates, and commercial travel.

Urban Form. Cities exist basically to permit interactions to occur between people. It would seem to follow therefore that a fundamental change in the means and ability to communicate would have an effect upon the form and structure of cities. However, even if we accept that recent advances in information and communications technology represent a significant "discontinuity" it does not necessarily follow that there would be an immediate change in urban structure. In fact, the likelihood is that urban form would be very slow to respond to such changes. In large part, this is because physical change within cities can normally only occur over time periods measured in decades. As Newton and Taylor (1985) have put it, "while the impact of new technology on individuals may be revolutionary (rapid changes over short periods of time affecting significant segments of the population), its impact on large organisations and social systems (including cities) is more likely to be evolutionary. Complex systems tend to be more resistant to change."

In the longer term (but with directions for change beginning to become evident in the quite short term) it is possible that information and communications technology could have quite profound effects upon urban structure. Transport (which is a particular form of communication) has always had a major influence on urban form and structure (OECD, 1977, p11ff). Melbourne's form of development, for example, was until the 1960's almost wholly related to the rail and tram developments of the 1880's, and is still influenced to a notable degree by them, a century later. What then is likely to be the influence of new developments in information and communication technology upon urban form?

The answer is that it is an open question. Commentators seem to agree that these technologies could support almost any urban form. For example, Newton and Taylor (1985) conclude that "information and telecommunication technology force neither centralisation nor decentralisation per se". Wigan (1981, p18) has posed the question "will the opportunities for weaker physical links between place of work and homework tend to encourage suburban activity centers or to consolidate the central controls which have classically been the province of the central city head office?" Bly (1985, p139) however concludes that since information and communication technologies are essentially neutral in their effect upon urban form, past trends towards "dispersion and a relative decline in the activity of major city centers" will continue because the influence of the motor car will continue, i.e. it will not be affected one way or the other by these new technologies.

Probably the main factor affecting the emergence of home-based work is its acceptance by the workers involved. Wigan (1985a, p152) noted that in Britain, there was a resistance to such activity because of the increased control of worker's output, and a reduction in "personal interaction due to lack of the office social contact framework." He also noted that firms engaged in such activity were now saving substantial sums in office overheads. Commenting on this, Wigan noted that "if the home workers fail to obtain some part of the cost reduction gains that their employers are now enjoying, then the impetus for changes in location of such business activities will build up swiftly. If on the other hand the home workers extract a price for their more cost-effective performance, such changes would be unlikely to gain much momentum over the next few years. A substantial shift to home-working is perhaps the most significant trend to watch for in a land use or urban form framework". Thus Wigan (p159) concluded that the influences of these technologies on urban form "will be critically dependent on the social reactions to the changes in overhead costs and productivity of home workers".

A further point to note which is relevant to this paper is that improved information systems enable planning authorities to monitor the urban system more closely. Wigan (1985a, p150) argued that "the increased ability to monitor both detailed land parcels and the activities taking place on each parcel will considerably improve the ability of regional authorities to determine what is actually happening on the ground - but politics rather than technical capabilities are likely to continue to determine the land use influences actually emergent from such systems for monitoring and control".

Thus in summary, information and telecommunications technology seems capable of freeing urban form from the close dependence on transport links which has existed in the past, but that it is essentially neutral as to its actual effect upon urban form. It may thus be considered as a continuation of a trend towards loosening the nexus between land use and "communication" (broadly defined) which saw firstly mass transport enabling cities to expand peripherally but needing to retain a strong urban core, and secondly the motor car freeing cities from such central dependency. Future urban form would thus seem to be capable of being moulded, with fewer constraints, by political and market forces.

Trip Rates. A second potential effect of information and communication technology on urban travel lies in the possibilities for trip substitution, or as Kneebone and Howie (1984, p51) put it, "the opportunity to substitute electronic communication for person-to-person contact thereby reducing the demand for person trips".

This argument is usually centered upon the journey to work, because, as Wigan (1985a, p151) has put it, these trips "are the most energy intensive .... and the increasing emphasis on service industries and on information-oriented products leads to the conclusion that these types of journey are the most likely to be reduced (or at least affected)." Kneebone and Howie (1984, p51) similarly suggest that "it seems reasonable to envisage employees electing to work for part of the week at home and travelling to a central work place less frequently than at present."

Two questions must be asked about such scenarios. First, even if such practices become possible, will they apply to a significant proportion of the working population? And second, might it not be the case that access to information and communication links will stimulate, rather than replace, the demand for travel?

Surprisingly little information is available (at least in published form) about either of these factors. However, a priori reasoning would suggest that only a very small proportion of the working population (with work being conventionally defined) would be in a position to take advantage of such arrangements on a regular basis. Apart from some clerical workers (see above), the most likely candidates would seem to be senior executives, professionals, academics etc. However, each of these have other administrative or executive duties to perform which usually require their physical presence with fellow-workmates, clients, students, superiors, etc. The only references found which cited actual cases of home-based workers with an electronic link to the "office" were workers of this type (Wigan, 1985a; Howie, 1985). Thus, it is concluded that in the short term at least, only a small minority of the workforce will be likely to take advantage of communication advances to the extent that home-work becomes feasible. However, this cannot be a firm prediction, and it is recommended that this area should be monitored.

As to trip substitution, there is also surprisingly little evidence or hard data from other sources as to the extent to which telecommunications affects the demand to travel, or acts as a substitute for it. However, Wigan (1984, p107) notes that "information technology would therefore be as likely to increase the range of inviting opportunities for people to leave the home base (by providing information access about the opportunities) as it would augment any tendency to replace travel...." Dickie (1985, p183) reached a similar conclusion: "there will be little tradeoff between communication and transportation, but rather increases in both".

There is little evidence yet available to shed light on the trip substitution - trip stimulation argument. Miyakawa (1985) has reported on a Japanese study which concluded that "for visits which emphasised a high degree of face-to-face communication, the rate of substitution was low. However, for discussions it was found that the TV conference - TV telephone could substitute for 4 out of 10 such meetings. It was noted however that this result was based on expectation, not use. Similarly, we understand that Australian Telecom has data to show that most long-distance telephone calls are made by people who also make long distance trips, and that most ISD calls are made by people who have just made (or are about to make) an overseas trip.

These results would tend to support the argument that travel and communications are mutual stimulants, rather than substitutes. If the same result applies at the urban level, it follows that the effect of improved information and communication technology would be to stimulate an increase in travel. Whether this would result in an increase in congestion would depend upon the time of day of the travel, and the traffic-system responses to traffic growth (see below). In particular, one of the technological responses which will be mentioned below is the potential for the traffic systems operating authority to both provide more information about traffic conditions and routes, and also to charge for the use of roadspace on a cost-related basis.

Commercial Travel. Finally, mention should briefly be made of the potential which computer software, together with communications hardware, provides for optimising commercial transport activities, especially freight (Voorhees, Coppett and Kelley, 1984; Ledford and Sugrue, 1985). It is not difficult to envisage a computer optimising pick-up and delivery schedules, and even routes, for trucks which are on the roads, in real time. All else being equal, the minimum path route for a truck would cause the least vehicle-kilometers of travel demand on the road system, and would thus benefit all road users and the traffic authority.

Road Traffic System Control Technologies

Most of the aforementioned information, communication , and computer developments referred to the demand side of the traffic system. However, these same developments have potential application on the supply, or system control, side.

Developments in electronic vehicle identification (EVI) (Kneebone and Howie, 1984; Daley, 1984; BIE 1984b; Wigan, 1985; Bly, 1985; Luk and Besley, 1985; Bosserhoff and Swiderski, 1984; Jeffery and Russam, 1984) revolve around the ability to identify individual vehicles, by fitting all vehicles with an on-board "electronic number plate" and having a comprehensive set of roadside (or under-road) vehicle detector stations. Such a system would permit:

- dynamic route guidance to travellers through in-vehicle (or roadside) information systems. Information to be made available might include optimum route advice (either minimum travel time or optimum system loading), points of severe congestion, etc.

- speed guidance, related to energy or travel time optimisation, or speed to ensure that the next set of signals can be taken on the green phase

- electronic surveys of origin-destination patterns, travel times, trip length, vehicle usage, time of travel, etc for traffic planning and evaluation purposes

- traffic incident detection (e.g. vehicle breakdowns)

- signal priority to selected vehicles, such as public transport and emergency vehicles

- real time monitoring, evaluation and control of traffic system performance

- electronic citation issuance for speeding, etc

- electronic detection of stolen vehicles

- electronic pricing of road use and parking (see below)

Once again, this is not the place to describe such systems in detail. Suffice it to say that all of the above possibilities are within range of current technology. The major constraints are more related to social and political factors (e.g. the argument that such detection is an infringement of civil liberties), and administrative feasibility. However, it is interesting to note the equanimity with which Melbourne motorists have accepted red light cameras at intersections, and it may be that the social reaction to electronic detection may not be as great as expected; these cameras may be the social and functional forerunners of a more comprehensive system of electronic vehicle identification.

For the purposes of this paper, the relevant consideration is the effect which EVI may have upon urban traffic. As these systems would be within the control of the traffic authority, they provide a means of further refining the degree of external control of individual vehicles, and as such can be seen as part of a logical progression. Ihat is, the philosophy and practice of traffic control has witnessed a steady increase in external control through initially no control, then vehicle priority laws (e.g. give way to the right), then signs, then fixed time signals, then vehicle-actuated systems, to the current phase of dynamic signal systems. Automatic vehicle identification and control could be regarded as a logical next step in this sequence.

The effects on traffic will likely be fourfold. First, it enables a real-time feedback to the potential traveller about the conditions on the road system. Thus "with the advent of videotext systems and widespread use of home terminals it should be relatively simple to provide real time information in the home on traffic conditions. Hence, anyone planning a trip can first check whether to make the trip or delay it or if sufficiently urgent, which route to follow to minimise travel time." (Kneebone and Howie, 1984, p 52). To the extent that such strategies are possible, and that motorists make use of them, this would mean an increase in off-peak trips, and possibly a more uniform level of traffic congestion across broad areas of the city. It would not <u>necessarily</u> lead to a reduction of either total travel or peak hour travel.

Second, the improved information about individual vehicle paths should make possible the development of signal control software to improve system performance, in such terms as throughput, travel time, energy use, etc. This would enable a continuing process of "fine-tuning" of system capacity (or some other objective), although with diminishing returns as system capacity is approached.

Third, this same information should be able to be put to good use in a planning context, enabling better decisions to be made about investment in new roadspace or new system control equipment. To the extent that decisions actually were based upon such information, they should be better decisions, and thus enable best use to be made of the resources available for road system control and investment.

Finally, it provides the basis of a system of road pricing, which is discussed below.

In summary, the advantage which is taken of the possibilities made available by EVI technology is largely up to the traffic authority - given that societal pressures do not prevent the introduction of such technology in the first place. The potential benefits to the authority and to the road user are however quite significant.

<u>Road Pricing Technology</u>

As previously mentioned, road pricing is a particular application of a system of EVI. Economic theory indicates that optimum resource allocation is achieved when prices are set equal to marginal costs. In the road transport field, this means that vehicles would be charged for the use of the road according to the actual costs which they imposed, which would of course vary with time of day, location, etc - i.e. it would relate to congestion. These charges would be an infinitely finer instrument than present standing charges (registration, etc), user charges (e.g. fuel taxes) or parking fees. (Button and Pearman, 1983)

The use of EVI makes such real-time road pricing possible (Wigan, 1978; Bly, 1985, p128; Wigan, 1985a, p145). It is interesting to note that Hong Kong has recently begun large scale testing of such a system (Dawson, 1983; Luk and Besley, 1985; Fong, 1985), although it must also be acknowledged that Hong Kong is a special, and ideal, case, being a "closed" system with a known number of vehicles garaged in a small, well-defined area. However, a real time electronic vehicle identification and pricing system would allow pricing for roads, parking and perhaps insurance (which could be levied in relation to defined measures of exposure) to be assessed automatically, and owners of vehicles billed accordingly.

There is no doubt that such systems are technologically feasible, and almost certainly economically justified (Wigan, 1985a, p145), particularly if they were introduced as part of a wider scheme for using the benefits made available by electronic vehicle identification (see above). As before however, the main obstacle would appear to be social and political acceptance (BTE, 1984b, p38).

Nevertheless, <u>if</u> it was to be introduced, electronic road pricing would represent a significant "discontinuity", with possibly quite substantial affects upon urban road traffic. On the demand side, because road prices would be perceived by potential travellers, they would affect decisions about mode, route, and (importantly) time of travel. For these reasons, a rearrangement of travel patterns could be expected (especially if, as seems likely, trends to less rigid working hours continue - see above). The vehicles which remained on the roads at congested hours would be those whose owners or drivers valued travel at that time sufficiently highly to pay the premium price. This would likely include commercial vehicles, since costs could probably be passed on in many cases.

On the supply side, the revenue collected from road users would enable the supply and operation of road space to be treated the same as any other (public sector) market commodity, such as gas, electricity or telephone. That is, users would provide revenue for the relevant authority (although subsidies would still be possible if thought politically necessary for equity or economic reasons) sufficient to enable a system to be provided and sustained to the extent that users were prepared to pay for it. Such charges could largely replace existing, cruder, charging mechanisms, although the total revenue collected would not necessarily be any different. This would represent a fundamental breakthrough in terms of rationality of decisions about provision, operation and funding of road systems.

Road Vehicle Developments

Finally, possible developments in the nature of the road traffic system should be mentioned briefly. Although as noted above, authorities such as the BTE (1984b, p39) do not anticipate a "discontinuity" in vehicle technology, there is a school of thought that a non-incremental change in the road-vehicle system is possible.

For example, Garrison (1984) argues that there is a limit to the extent to which incremental change can overcome the problems inherent in the existing automobile-highway system (capital shortfalls, environmental concerns, energy prices, "saturation" of accessibility, etc). He suggests that a possible "transformation" of the system would be to specialise. He thus goes on to suggest that the most likely initial specialisation would be the development and introduction of small, lightweight, two-person urban cars, with a part of the highway system dedicated to their use. (It is noted that there are trends towards increasing vehicle specialisation, e.g. truck design; recreational vehicles; one, two and three box passenger cars, etc).

If such a system was to be introduced, its effects on the urban traffic system could be considerable. The eventual introduction and completion of a formal "specialised" system must be a long way off however, and the more important issues concern interim arrangements before the system was introduced. The difficulty is that it would be quite easy to produce the vehicles, but because they would be incompatible with existing road vehicles in many respects, their introduction into a mixed traffic stream would pose problems. The parallels with mopeds are obvious. The likely institutional response would be to ban the use of such vehicles (or surround them with such regulations as to effectively ban them), but this would be to deny potential users the benefits which might accrue from their use.

Even if such discontinuous changes do not occur, progressive development of conventional vehicles will continue. Wigan (1985b) has indicated that 12-20% of the value of US cars in the 1990's will be in electronics. This will mainly be found in the areas of vehicle control, powertrain control, safety and convenience, audio systems, and (increasingly) driver information systems (Ohtake and Mizutani, 1985).

CONCLUSION

Future demand for travel will depend on the relative weights of the various factors discussed in this paper, together, no doubt, with others not mentioned. It is not possible, nor is it useful, to postulate a single likely outcome. However it is significant that most of the factors discussed point to an increase in traffic generation: all factors point to a change in the patterns of travel. What is more immediately important, and is the reason for this paper, is that those with a responsibility for developing plans, policies, or programs for future traffic management and control be aware of the potential for significant changes in the nature and patterns of travel, and accept a responsibility to monitor such changes and adapt to them.

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