

HOW TO DESIGN A MORE SUSTAINABLE AND FAIRER BUILT ENVIRONMENT: TRANSPORT AND COMMUNICATIONS

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Executive Summary

Transport and information and communications technologies (ICT) and the city are closely and inextricably linked. These elements must be designed to work together, in mutually reinforcing ways, so that the economic, environmental and social vitality of the city is maintained and enhanced. Transport must no longer adversely dominate city design, but instead play an important, supporting role in improving the quality of life in the city.

The hugely complex set of interdependencies in the transport, ICT and urban planning field is not well understood - and has been under-researched - yet plays a critical role in the design of the sustainable city. There are considerable uncertainties in terms of strengths of relationships and directions of causation.

The design of cities, strategically and locally, is important in terms of the travel behaviour it enables. The polarities of the options are in car dependent, low density urban sprawl, or public transport orientated urban development, with higher density development provided at public transport nodes. Much of current urban life lies somewhere in between - as hybrid development forms - there are few examples of 'pure' walking or cycling, public transport or car cities or towns. The future emphasis will be in exploiting the potential for increased usage of public transport, cycling and walking and low carbon vehicles. This requires an increased localisation of activity and mobility patterns, whilst still maintaining internationalised accessibility. Urban spatial structure - including population size, density, job-housing balance, mixed land use, the location of development, accessibility and local neighbourhood design - can also be used to help in the design of the sustainable city. Urban form should be targeted at improving the quality of life in our cities and towns and in enabling a sustainable transport future.

ICT developments can act as a key catalyst in helping to achieve the sustainable city. They provide the means to address the new complexity, flexibility and opportunity in our future urban areas. Complex behavioural changes mean that certain activities can be undertaken with less or even no travel, although face-to-face communication will remain important as new opportunities for information exchange open up. The means of work, commuting, personal business, information gathering, shopping, leisure and entertainment are changing in a myriad of ways. Improved accessibility rather than mobility will be critical. Spatially, further urban concentration will occur at the international level, with world and core cities becoming increasingly important. Airports and public transport nodes will be the focus of growth, acting as technopoles of development. Urban deconcentration and dispersal will also occur, with some remote communities becoming more viable as electronic accessibility becomes increasingly viable. Cities need to provide the means for all people to benefit from these new opportunities - so they become more inclusive rather than exclusive.

The future intelligent infrastructure system must be based upon a robust understanding of the way transport, ICT and the city inter-relate, and the emphasis for future development and investment must be in supporting the sustainable and fair city. Inclusiveness, communication, participation and ownership will be critical to successful change.

1. Introduction

Sustainable urban development will be focussed on the city as this is where most people live and are projected to remain and where most economic activity will take place – in the UK, for example, some 80% of the population live in urban areas. It is important that the city is seen to be attractive in terms of its built environment as well as the opportunities that it provides in terms of its jobs, housing, open space, education, amenities and recreational facilities. It must also be seen to provide a safe and secure environment for individuals and families, and for people of all ages and ethnic groups. This is the sustainable city where the economic rationale for prosperity is matched by an equal concern over the inclusivity and fairness of the city and the quality of the environment, including the buildings and spaces that make up the city. Such aspirations are often found at the beginning of many strategy statements for city development, but actions that are consistent with these high level aims are often difficult to devise and, critically, difficult to implement (Banister, 2005).

Transport is an essential part of any city and it should be seen as an integral part of the more sustainable and fairer built environment, not separate from it, or working against it. Our central argument within this review is that transport provision must no longer adversely dominate city design, but instead play an important, supporting role in improving the quality of life in the city. Hence our future transport system can still act as the 'maker and breaker' of cities; but it must work to facilitate an improved quality of city life. We must move away from the traditional view of highway provision, which often leads to urban sprawl and facilitates car dependent lifestyles; where congestion, severance and air quality problems are all too evident, and where highways and parking provision take up a hugely inefficient proportion of land in urban areas.

This review considers urban spatial structure and travel, and information and communications technologies (ICT) and travel and urban form. Their respective likely future development trajectories are considered within the context of the sustainable city. The close linkages and inter-relationships between these three elements - the city, ICT and transport - are emphasised throughout. It is argued that these three elements must work together, in mutually reinforcing ways, so that the economic vitality of the city is maintained and enhanced, whilst at the same time addressing the equally important equity and environmental concerns that together generate the sustainable city.

This review therefore covers two key areas of literature as outlined below:

- Cities, urban form and transport
- ICT's contribution to accessibility in the sustainable city

The initial part of the review addresses issues relating to the design of cities, including the links between urban form and travel. Here it is argued that the structure of cities (strategically and locally) is influential in determining the main characteristics of travel – the numbers of trips made, journey lengths, modes of travel used, and the resulting energy consumption and emissions. It is recognised that there are strong social and economic factors (e.g. income, car ownership, family size and structure and employment) that also influence travel. Critically, in terms of sustainable development, it is the physical environment that is within the scope of intervention and under the control of urban planners and developers. The decisions made concerning the location of new development (including housing and employment) are a key determining factor towards future changes in travel behaviour. This is central to the current debate in the UK on sustainable communities, however is one that is not well understood and is hence being underplayed. We need to design our urban form to enable sustainable transport, and design sustainable transport to enable quality in city design.

The second part of the review examines related issues concerning ICT and transport, and how new developments in ICT can also contribute to improved accessibility and a more sustainable and fairer built environment. In much of the discussion, the key concern is in matching up the empirical evidence (wherever available) with actual trends on the ground, and to generate policy options that may take us forward towards the sustainable city.

The review concludes with a synthesis of the discussion and suggestions for future research, and considers how the Foresight Project on Intelligent Infrastructure Systems (IIS) can contribute to the sustainable and fair city in terms of spatial structure, ICT and travel.

2 Cities, Urban Form and Transport

2.1 The Debate

There has been a healthy debate in the literature about the relationships (if any) between urban form and transport. Some have argued for the compact city or polycentricity, whilst others have suggested that continued dispersal will lead to a natural 'co-location' of residential and employment locations (Breheny, 2001). There is certainly a continuous and dynamic process going on, which results in centralisation and decentralisation, as people and jobs are located in response to each other and other factors. In all cases (ironically) the aims are much the same, namely to reduce average journey distances, trip frequencies, traffic volumes, energy consumption and/or transport emissions (Banister, 2005).

The compact or polycentric city achieves this through higher densities and the dispersed city through locating work near to where people live. The crucial difference between the options is that the compact city is amenable to the provision of public transport, and walking and cycling, whilst the dispersed city is more likely to depend on the car as travel patterns are more diverse. In terms of sustainability, the compact city has more to offer if public transport is well used, and it also provides opportunities for those without access to the car. Underlying this debate on compactness and travel is the premise that higher densities make the best use of available land (often a scarce resource), reduces travel distances, and provides a greater intensity and diversity of activities – this is at the heart of the urban renaissance movement in the UK (Urban Task Force, 1999).

Although such a polarisation of the debate is interesting, the reality is far more complex. Much of the available empirical analysis has tended to be rather simplistic in its approach, with the data being open to several interpretations, and causality is usually unproven (Crane, 2000). The complexity, in the physical sense of the built environment, revolves around at least four separate themes - population size, density, jobs-housing balance and mix of use, and location - all of which are under the control (to a greater or lesser extent) of urban planners. Table 1 provides a summary of the research field, showing many contradictory findings. These urban form variables must be related to wider socio-economic variables that also influence travel, but are not emphasised in this review (see sister DTI Foresight Science Reviews by Axhausen and Goodwin for more detail).

Table 1: Summary of Research Findings

Urban Form Variables	
1. Settlement Size	
<ul style="list-style-type: none"> ▪ No correlation between urban population size and modal choice in the US (Gordon et al., 1989a and b). ▪ The largest settlements (>250,000 population) display lower travel distances and less by car (ECOTEC, 1993). ▪ The most energy efficient settlement in terms of transport is one with a resident population size of 25-100k or 250k plus (Banister, 1997). 	
2. Density	
<ul style="list-style-type: none"> ▪ Increasing densities reduces energy consumption by transport (Newman and Kenworthy, 1989). ▪ There is no clear relationship between the proportion of car trips and population density in the US (Gordon et al., 1989a and b, 1991). ▪ As densities increase, modal split moves towards greater use of rail and bus (Banister et al., 1997). ▪ Compact cities may not necessarily be the answer to reducing energy consumption, due to 	

<p>effects of congestion, also decentralisation may reduce trip length (Breheny, 1997, 2001: Gordon and Richardson, 1997).</p> <ul style="list-style-type: none"> ▪ Decentralised concentration is the most efficient urban form in reducing car travel (Jenks et al., 1996). ▪ Density is the most important physical variable in determining transport energy consumption (Banister et al., 1997). ▪ Higher densities may provide a necessary, but not sufficient condition for less travel (Owens, 1986). ▪ As people move from big dense cities to small less dense towns they travel more by car, but the distances may be shorter (Hall, 1998).
<p>3. Jobs-Housing Balance and Mixed Use Development</p>
<ul style="list-style-type: none"> ▪ Communities are balanced where the ratio of jobs to housing units lies in the range of 0.75 to 1.5 (Breheny, 1995). ▪ Local facility provision does not determine modal choice, personal and household characteristics are the determinants (Farthing et al., 1997). ▪ Diversity of services and facilities in close proximity reduces distance travelled, alters modal split and people are prepared to travel further for higher order services and facilities (Banister, 1996).
<p>4. Location, Accessibility and Neighbourhood Design</p>
<ul style="list-style-type: none"> ▪ Location of new housing development outside existing urban areas, or close to the strategic transport network, or as free-standing development increases travel and influences mode split, and can lead to "stretch" commuting (Headicar and Curtis, 1998). ▪ Location is an important determinant of energy consumption and car dependency (Banister et al., 1997). ▪ Development close to existing urban areas reduces self-containment and access to non-car owners (Headicar, 1996). ▪ Urban design quality: some anecdotal evidence in the US showing the differential impact of new urbanism versus cul-de-sac route networks on travel behaviour. Some initial evidence in the UK (Marshall, 2001).
<p>Wider Socio-Economic Characteristics.</p>
<ul style="list-style-type: none"> ▪ Increased household size, income and car ownership are associated with increased trip frequency (Hanson, 1982). ▪ Car ownership is associated with increased travel distance, proportion of car journeys and transport energy consumption (Naess, and Sandberg, 1996). ▪ Dual-income households: the choice of new housing location is influenced by the location of two workplaces. The extent of "excess travel" and the reasons behind this phenomenon are not well researched. Travel time is more important than travel distance, and the role of the travel factor in the choice of a new home location seems to be important (Ma and Banister, 2006) ▪ Attitude: some research in California, US as to the impact on travel behaviour, which suggests it may be a more important factor than land use and other socio-economic variables. Early research available from Surrey, UK (Hickman, 2005).

(Based on Banister, 2005)

Much of the existing empirical evidence is thus limited. Simple bivariate relationships (such as density and travel) are most often analysed, few research studies consider the wide range of likely urban form and socio-economic influences on travel, and nearly all are based on cross-sectional data, showing just one 'snapshot' of results in time. Further research should hence include wide ranging, detailed longitudinal analysis that allows the dynamic processes to be explored (and not only the net effects) by following decision processes over time. It should also be noted that in the 21st century there are 'no' compact cities and 'no' dispersed cities, as cities are hybrids of these forms, and are dynamic and constantly changing. Below we briefly consider the literature in more detail, structured around our four broad themes.

2.2 Settlement Size

Settlement size affects the range of jobs and services that can be supported and influences the quality of public transport that can be provided, and the length of trips. Diseconomies of scale may occur with the larger settlements (e.g. London, Birmingham and the larger conglomerations) where travel distances again increase, as labour market areas function regionally, and as specialisation in terms of certain jobs require particular skills which are often scarce, and hence may be remotely located (Owens, 1985; ECOTEC, 1993).

- Empirical evidence from the National Travel Survey (NTS) suggests a clear correlation between increasing settlement size and decreasing travel distance (for all purposes). The average journey distance by car (and other modes) is lowest in conurbations and highest in rural areas, even if the variations in travel by car ownership (a proxy for income) are controlled for. Transport related energy consumption (one measure of sustainable transport) is one third lower than average in the metropolitan areas (excluding London) and more than one third higher than average in the smallest settlements (Banister, 1997).
- Analysis of the changing patterns of commuting distance in the three largest cities in the UK shows how over time (1971-1981) different patterns have developed. In London, commuting distance increases linearly from the centre as there is a strong pull from the central city. But in Birmingham there is a threshold at 7km after which the commuting distance plateaus, and at 9km from the city centre it falls as work places become more dispersed. In Manchester, the threshold is 5km from the centre, but it remains constant over space. Changes in thresholds depend both on patterns of location, access to transport, and the increasing complexity and diversity of the job market that has to accommodate multi worker households, shift workers and part time workers (Spence and Frost, 1995). The most recent changes now being brought about through opportunities provided by new ICT technologies for distance working and telecommuting also need to be considered (Banister and Stead, 2004).
- At the more local level, some empirical evidence suggests that there is a link between travel patterns in new housing developments and the urban centre for the work journey, but not for other journey purposes. The conclusions (from a study of six new housing developments around Oxford) were that income differences between the new housing locations were not the primary source of variations in work related car travel, but that location was also a key determinant. This important conclusion means that local planning authorities can exert a major influence on the amounts of car based travel through their policies on the location of new housing developments (Curtis, 1995).
- Other evidence from major cities also points towards a linear relationship between distance from home to the centre and transport energy consumption (i.e. in London and Paris), and more recently in Perth (Australia). In London and Paris it was found that residents living at a distance of 15km from the centre consumed more than twice the transport energy consumed by those living at 5km from the centre (Mogridge, 1985). The figures for Perth were less dramatic as those living 15km from the centre consumed only 20% more transport energy than those living 5km from the centre (Newman and Kenworthy, 1988).

The general conclusion reached here is that the larger metropolitan settlements are associated with low travel distance and transport energy consumption. In many studies, increasing distance from home to the urban centre is associated with increasing travel distance, an increasing proportion of car journeys and increasing transport energy consumption. The only exception is trip frequency, which does not appear to vary significantly according to the distance between home and the urban centre. The evidence is however mixed, particularly when considering differing urban forms from the US: evidence from the ten largest urban areas in the US, for example, shows no easily identifiable relationship between urban population size and modal choice (Gordon et al., 1989a and b, 1991).

The literature on population size and travel behaviour is hence not fully developed, and there is much scope for further research, particularly in view of the current development growth agenda and discussion on Sustainable Communities¹ (ODPM, 2003). A further piece in the jigsaw is the growth in long distance journeys, particularly for commuting, which seems to be on the increase. Most trips do not use much energy as they are locally based, and perhaps carried out on public transport or by walk and cycle. From a limited small-scale household survey, it is estimated that 84% of car trips used less than the average amount of energy per trip (15.1 MJ per trip). About 24% of motorised trips use 78% of the total energy (Banister et al., 1997). Such evidence again suggests that sustainable transport strategies ought to be placed within the wider regional context, to be based on journey to work and city-region areas, and to be closely integrated with the wider growth agenda.

2.3 *Density*

Development density is measured in terms of population, residential and employment density. The argument here is that higher population densities should widen the range of opportunities for the development of local contact networks, and that activities can be undertaken without using motorised travel (ECOTEC, 1993). Higher population densities can widen the range of local services and facilities that are provided, thus reducing the need to travel long distances. By developing public transport orientated development - where pyramids of development density are orientated around public transport nodes - public transport patronage can be supported, urban form becomes less car dependent, urban sprawl is confined, and there is a greater opportunity to cycle and walk (Crane, 1996). These are all essential ingredients of the sustainable and fair city in transport terms.

- Although it is difficult to take full account of short walk trips, as the data sources are sparse, it does seem that about 1,000 trips are made on average per person per year. Lower densities (1-5 persons per ha) result in a slightly higher number of trips (+6%), and higher densities (over 50 persons per ha) have slightly lower numbers of trips (-7%). But it is probably in the higher density areas that there may be under recording of short trips, particularly if they form part of a trip tour (or trip chain). These types of activities are common in urban areas where services and facilities are located in close proximity to each other (Banister, 1997).
- With increasing population density, the proportion of trips by car decreases, whilst the proportion of trips by public transport and walk both increase. Car trips account for 72% of journeys in low density areas (less than 1 person per hectare) but only 51% of trips in high density areas (more than 50 persons per hectare). There is a fourfold difference in public transport trips and almost a twofold difference in walk trips between very low density areas and very high density areas (NTS data). There are many other variables apart from density that influence these figures, but the pattern still exists if socio-economic variables are controlled for (ECOTEC, 1993).
- The links between residential density and travel are less distinct, except at the metropolitan scale (Ewing, 1997). For small scale cities, as size and density decreases the links become weaker. This weakening relationship has been linked to the decentralisation process and the decline in household size over time with more housing units for the same population. There would need to be substantial increases in population density to make any real differences, as the counter factors of smaller households would diminish the effectiveness of density increases (Breheny, 2001).
- A controversial but widely cited study of energy use in cities around the world found that population density, job density and city centre dominance control petroleum use (Newman and Kenworthy, 1989 and 1999). For example, there is a strong increase

¹ The Sustainable Communities Plan is seeking to deliver a much increased supply of new housing in London and the South East by 2016. In four growth areas - the Thames Gateway, Ashford, Milton Keynes/South Midlands and London-Stansted-Cambridge-Peterborough - an additional 200,000 homes are planned above levels in current regional planning guidance. Complementary strategies are planned for the Midlands and the North, including the 'Northern Way' and various Housing Renewal Pathfinder strategies, the latter of which are focused on developing the most deprived communities in the UK. The success of these growth plans is critically reliant on transport (and other) infrastructure investments.

in petroleum consumption when population density falls below 29 persons per hectare, and the conclusion is drawn that cities need to develop with strong centres and intensively-used suburbs. The analysis has been criticised for the quality of data used, the type of methods employed, and the interpretation of the output, particularly on the causality inferred. Although the original research used data for 1980, it has been updated to 1990, where the patterns were found to be even more pronounced. In all cities, it seems that there has been an increase in the use of the car over the decade as measured by vehicle kilometres of travel per person. There has also been an increase in the use of public transport, but only in certain cities (e.g. Zurich and Singapore), and even here the increase has been modest. It is not clear whether this increase in public transport use has come from car users or from existing users of public transport or from walking and cycling. Even in cities where public transport investment has been substantial and where reductions in the use of the car might be expected, this has not taken place. Action has to be more comprehensive than merely the promotion of public transport.

- Evidence from the US suggests that there is no clear relationship between the proportion of car trips for work journeys and population density (Gordon et al., 1989a and b). The market economist perception is that 'co-location' of firms and households can reduce journey times, and decentralisation can reduce city centre congestion. A comparison of auto commuting trip times from the 1985 American Housing Survey with data from the 1980 Census for the 20 largest metropolitan areas in the US suggests that average trip times either fell by a statistically significant amount or remained the same. The explanation in the US has been that it is simply the market operating spontaneously through the relocation of firms and households, which helps achieve the balance of keeping commuting times within tolerable limits, even though commuting distances may have increased substantially. This alternative view may be explained by the definition of population density in terms of workplace locations rather than conventional residential location, and also that much of the research is based on studies of suburban sprawl in California – a very different urban form to that found in the UK.

There is therefore a substantial body of research that on balance demonstrates a link between population density and many measures of travel patterns - mode, distance, and travel time. The only exception is that there is little variation in journey frequency by population density (Richardson and Gordon, 2001). Conversely, there has been little recent research concerning the relationships between employment density and travel patterns. The recent debate includes considerations of the new urbanism and urban renaissance, where the concern is not over density alone, but over the quality and design of the urban environment as a whole (Handy, 2002). Within the wider urban environment, density has an important role to play, but this role is enhanced when combined with other factors such as mixed uses, safe and secure places, community, open space, green space, and quality of development.

Again the research field can and should be further developed, with detailed empirical analysis for example focused on alternative development forms, the role of density, potential synergies with population size and other variables, longitudinal change, adaptive change, the potential adverse impacts of sprawl; and wider factors such as attitudinal reasons for co-location of homes and workplaces, and the impact of recent ICT developments (for example, in terms of whether telecommuting for two or three days a week actually reduces overall travel to work distance, or whether it allows people to locate even further away from their workplaces).

2.4 Jobs-Housing Balance and Mixed-Use Development

Jobs-housing balance and the mixing of land uses are also perceived to affect the physical separation of activities and hence travel demand, particularly in recent times through the outsourcing of less specialised employment (Owens, 1986). This is commonly measured using job ratio - this is the ratio of jobs in the area to workers resident in that area. The evidence here, much of which is US-based, is variable, as even if there is a balance between workers and jobs, there is no guarantee that local workers will take local jobs. A balanced community is viewed as having a ratio of jobs to housing units within the range of 0.75 to 1.5.

More generally, mixed-use developments should help reinforce denser neighbourhoods through the provision of more small shops and other facilities, but again availability does not necessarily mean greater use. In terms of fairness, this issue is important as it may be those without access to a car that make most use of local jobs and facilities.

- Evidence from the US finds a weak relationship between job ratio and travel (Ewing, 1997). For example, in a national investigation of the effect of the various land use characteristics, including the balance of homes and jobs, on trip generation, it was found that there is no statistically significant relationship between the balance of homes and jobs and journey frequency. More locally, in a study of commuting patterns in the San Francisco Bay Area, only a weak negative relationship between job ratio and the proportion of journeys undertaken by foot and cycle was found, and where there were many more jobs than houses, the proportion of journeys by foot or cycle falls. Policy could balance housing and jobs so that walking and cycling are encouraged.
- A further study in the Los Angeles region questioned the importance of job ratio on travel patterns and presented the results of a commuting study to show that job ratio has a statistically significant, but relatively small, influence on commuting time (Giuliano and Small, 1993). The conclusion reached was that attempts to alter the metropolitan structure of land use are likely to have small impacts on commuting patterns, even if jobs and housing became more balanced.
- In the UK, jobs and housing balance has gained less attention, with the exception of research based upon the New Towns. These settlements were originally designed to be self-contained and balanced (Breheny, 1995). The evidence shows that Mark I New Towns retained their self-containment over the 1960s, although this declined in the 1970s and 1980s. Compared to other settlements, the New Towns performed well in self-containment terms. The newer generation of New Towns have also showed relatively good levels of self-containment.

The provision of local facilities and services is also perceived in the literature as helping in reducing the need to travel long distances and to increase the probability of journeys being made by non-motorised modes.

- The limited evidence suggests that the provision of local facilities in new residential developments reduces average trip distances but does not significantly affect the proportion of journeys by foot. Proximity to neighbourhood facilities is positively associated with average distance, after taking into account the effects of various socio-economic differences of the areas studied (Farthing et al., 1997). It has also been shown that the provision of local facilities is associated with increased use in terms of journey frequency, although the effect of increasing journey frequency is not as strong as the effect of reducing trip length.
- A limited amount of empirical research on threshold analysis has tried to quantify within the UK the levels of population required to support different local facilities (see Table 2).

Table 2: Threshold Analysis of Services and Facilities against Population

Service or Facility	Farthing, Winters and Coombes, 1997	Williams, 2001
Primary School	2,500 – 4,000	2,000
Doctor	2,500 – 3,000	-
Corner Shop	2,000 – 5,000	4,000
Public House	5,000 – 7,000	1,100
Group of shops	5,000 – 10,000	-
Post Office	5,000 – 10,000	-
Clinic	-	8,000
Bank	-	18,000
Supermarket	-	10,000

2.5 *Location, Accessibility and Neighbourhood Design*

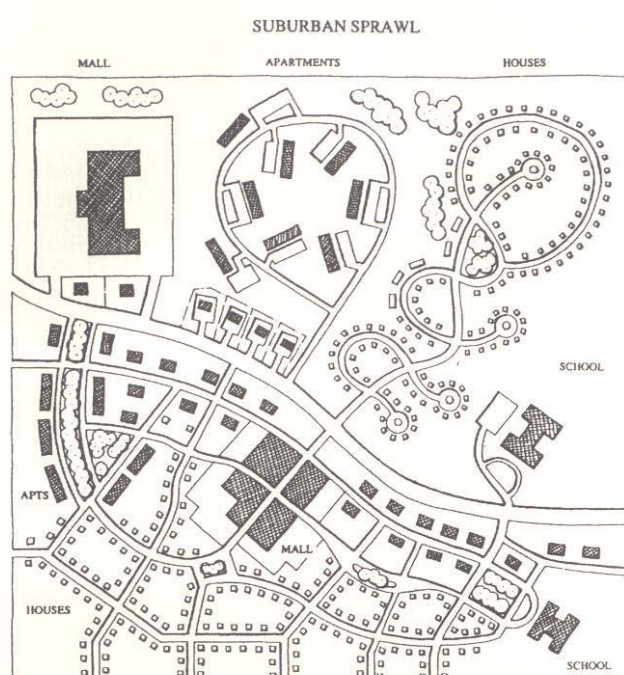
The proximity to transport networks - highway, public transport and walking and cycling - also influences travel patterns, and consequently transport energy consumption. Better access to major transport networks, particularly road and rail networks, increases travel speeds and extends the distance which can be covered in a fixed time. So major transport networks are a powerful influence on the dispersal of development, but local neighbourhood design may also have an impact, for example in improving pedestrian and cycle permeability, and in helping to concentrate development (Hickman, 2005).

- Short distances from home to the highway network, particularly free-flowing strategic routes, appear to increase travel distances (through increased speeds) and can contribute to a high proportion of long distance "stretch" commutes (Calthorpe, 1993). Routes in the south east of the UK, such as the M25, M40 and M3, are a powerful influence on the dispersal of development (Hickman and Banister, 2005).
- Distance from home to the nearest bus stop and railway station affects the modal share. The proportion of car journeys increases and the proportion of non-motorised journeys decreases with increasing distance from the nearest bus stop. US research shows how the proportion of rail journeys decreases with increasing distance from the railway station. Residents living within 150m of a railway station in California typically use rail for approximately 30% of all journeys (Cervero, 1994), but those living at a distance of around 900m from the nearest railway station are only likely to make about 15% of journeys by rail. Similar findings are available from Surrey, UK (Hickman, 2005).
- Evidence in London provides an indication of the distances that people are prepared to walk to Underground stations. Although individuals obviously differ, the aggregate story is that 'acceptable' distances range from about 800m for residential properties to about 500m for commercial properties. However we have to be careful with the use of such broad thresholds (Banister et al., 2004).
- It is important to understand that individuals are, whether pedestrians, cyclists, public transport users and/or car drivers, very different in terms of their personal characteristics. Gender and (dis)ability differences in particular are often overlooked. Traditionally transport policy has been heavily geared towards the male, car-based commuter without any understanding of the needs of other members of society. To make greater use of public transport requires both the distances to the facility to be within walking distance (or reasonable cycle and ride distance or park and ride distance), and the quality of the service provided to be acceptable. There should be a clear recognition of all types of social diversity and a resistance to generalisation (Social Exclusion Unit, 2002).
- In the Netherlands, the ABC location policy sets the conditions as to where businesses can locate in order to control mobility. The mobility characteristics of the business have to match the accessibility characteristics of the area where it wishes to locate. There have been difficulties with the implementation of the policy. Businesses for example complain about the lack of 'A' locations which are accessible by public transport and are reserved for people-intensive uses such as offices. As a consequence, development sites are often categorised as 'B' type to maximise opportunities for development and for reducing the mobility constraints (Priemus and Maat, 1998).
- Local design issues provide a classic example of the dilemmas that need to be addressed to reconcile transport concerns with those of sustainable urban development. There seem to be substantial benefits in terms of land use from switching away from grid transport networks in cities to loops and cul-de-sacs, as the amount of usable land increases from 64% with a grid system to 76% in a cul-de-sac system (Grammenos and Tasker Brown, 2000). This possibility is attractive from the developers' perspective. From the transport planning perspective, it also reduces the problems of 'rat runs' or shortcuts through residential areas and it succeeds in reducing traffic speeds through design. But there are disadvantages, as a traditional

grid network provides greater accessibility, a wider choice of routes and better potential for public transport. A grid network is estimated to reduce motorised traffic and increase walking and cycling usage when compared to cul-de-sac networks, using both US and UK-based research (Boarnet and Crane, 1999). The new urbanism movement in the US and much of good urban design practice in the UK now encourage traditional grid street networks (Marshall, 2005). Figure 1 provides the classic comparison between suburban sprawl and traditional neighbourhood development.

The dilemma is the reconciliation of the needs of the pedestrian for short, direct routes, including access to public transport, and the needs of the car driver, which are also for short direct routes. The difference is one of scale and speed, with the pedestrian wanting a memorable experience, pleasure (sociability and walkability), but also safety, perhaps with separation from cars. The car driver, in general, also wants separation from pedestrians, but is more interested in ease of navigation around towns (including issues such as legibility and signposting), low levels of congestion and availability of parking (Marshall, 2005). At times, it is where these two sets of different requirements coincide that accidents take place, as best illustrated at road junctions where pedestrians may want to cross and car drivers may want to turn (Berman, 1996). Table 3 provides a list of eleven aspects of neo-traditional development that are important considerations in the determination of behavioural change and in determining the quality of the environment. Such understanding is important for both sustainability at the local level, and to ensure that neighbourhood living is inclusive.

Figure 1: Suburban Sprawl Versus Traditional Development



(Source: Duany and Plater-Zyberk, 1992)

Table 3: Determinants of Local Quality

1. Mixed use core within walking distance for residents.
2. Local employment and civic centres.
3. A range of housing types for different income levels.
4. Higher housing densities and smaller lots than those found in suburbs.
5. District architecture based on the local vernacular.
6. Creation of a sense of community.
7. Creation of a sense of tradition.

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| <ol style="list-style-type: none">8. Common open spaces.9. Streets that are social spaces as well as a transport facility.10. Narrow streets with side walks and alleys running behind homes.11. Grid street patterns that provide multiple paths for drivers and pedestrians. |
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(Source: Berman, 1996)

There is a need for a real shift in the way streets and urban spaces are imagined and designed. Walking, cycling and public transport become the prime focus of design efforts, with the needs of the car relegated as appropriate. There is much useful experience to draw on here, particularly from countries in the rest of Europe, such as Germany and the Netherlands. Innovative solutions are on offer, where the usual 'taken for granted' assumptions are removed, with reduced needs for signage, and different emphases placed on shared space and pedestrian-car interactions, often with dramatically successful and popular results (Southworth and Ben-Joseph, 1997). Friesland in the Netherlands provides an interesting example. Such experiments can offer UK policy makers very useful lessons and best practice models (Marshall, 2005).

Parking provision also affects local accessibility. In the short term, parking policies have a direct impact on modal choice, whilst in the longer term location policies have a continuing effect on transport demand, in terms of the numbers of trips, mode choice and trip lengths. Trip frequency and modal choice are both influenced by parking availability. As the availability of residential car parking increases, the average number of trips per person decreases (Kitamura et al., 1997). It is suggested that residents with more parking spaces make fewer, longer car based journeys, whilst residents with fewer parking spaces make more journeys but these tend to be short and less car-based. But as with much of the empirical evidence, the issue of causality is not proven.

- Maximum parking standards have been set rather than minimum levels so that there is no basis for commuted payments for on-site parking provision, but such payments can still be sought for park and ride or on-street parking controls. The maximum levels for food retailing are now one space per 14m² (above a threshold of 1000m²), and one space per 20m² for non food retail above the same threshold. For B1 uses (including offices) the standard is one space per 30m² (above a threshold of 1500m²) and 1.5 spaces per dwelling for residential parking. Work Place Parking Levies (WPPL) are being considered by some local authorities (e.g. Nottingham) as a means to raise revenues for public transport investment (e.g. trams), but they are also being resisted by business who see WPPL as a tax that is not related to congestion (Banister, 2002).
- Car parking is enormously important to local authorities as it is a major source of revenue and as it determines the attractiveness (for some) of the town centre. There does not seem to have been a definitive study that demonstrates whether or not a strong parking policy applied over a period of time with appropriate accompanying measures (e.g. on public transport priority) enhances the economy and environment of the town centre or reduces it. There are arguments in both directions.

Complementary measures are also important. Complementary is defined in a broad sense to include individual measures that reinforce existing measures and those that are used in combination and involve actions in both transport and planning. In addition to traditional packages of measures in the transport sector (e.g. pedestrian and cycling priorities; traffic management and demand management; public transport priority and park and ride), there is a range of alternatives to promote sustainable development through complementary actions:

- Company transport plans (some local authorities and businesses have been in the lead in introducing these as part of their sustainable urban development strategy).
- Travel awareness campaigns and provision of quality information.
- School travel provision and accessibility to other facilities (e.g. hospitals and day care centres), particularly for those with no car available.

- Corporate policies which have an effect on travel decisions - just in time deliveries and the length of freight supply chains, specialisation with high consequent levels of transport intensity, rationalisation and closure of local facilities with increased travel distances, and company relocation policies from central to peripheral locations.

Park and ride is an interesting example of a transport and planning solution to a city centre problem, namely congestion and a deterioration of environmental quality. On its own, it may have limited value, but this value is greatly enhanced if it is seen as part of a traffic reduction strategy to limit car parking and give priority to public transport in the town centre (Banister, 2005).

2.6 *Conclusions: Moving the Debate Forward*

Underlying much of this debate and the empirical evidence is a lack of detailed analysis. Much of the thinking has been constrained by convention, with protagonists either being seen to favour intervention through planning and other controls, or technological fixes, or much greater freedom for the market to operate. As usual, the reality is more complex and requires a combination of approaches, not just one based on an over simplification of trends on the ground. The approaches used may be synergistic or may not be compatible and lead to counter-intuitive results. Effective policy packaging is thus critical. The literature on urban planning and sustainability also needs to be considered alongside wider fields - such as that covering traffic demand management, "soft factors", city competitiveness, urban design, social inclusion, etc. - if progress towards the sustainable city is to be achieved.

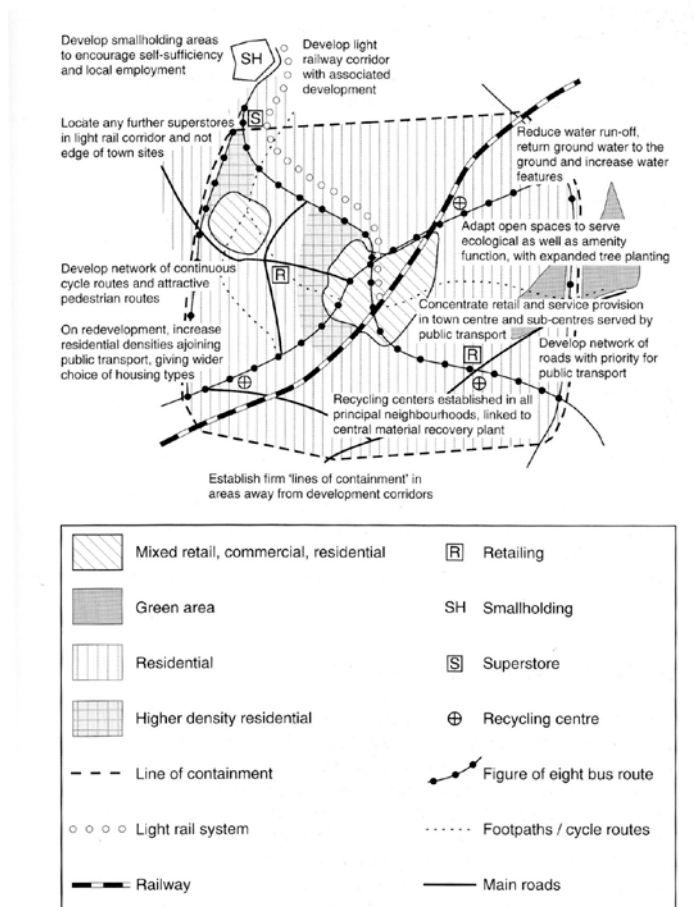
Different researchers have examined the issue of energy use in transport at a variety of levels. Some favour regional and city-wide approaches, others more detailed studies which examine commuting movements and patterns of suburbanisation. It should however be remembered that commuting only accounts for about 20% of all trips and that the growth in travel demand is now taking place in the non work-based activities, in particular for social, shopping and recreational purposes.

The debate is important to current development aspirations in the UK, particularly in terms of the development of Sustainable Communities (ODPM, 2003). Decisions affecting cities take place at all levels. At the national level, planning policies can influence the location of new development in relation to existing towns, cities and other infrastructure. Regional and city wide policies can influence the size and shape of new development and the type of land use: whether it is used for housing, commercial and industrial purposes, or a combination of these in a mixed use development, where clustering and concentration may take place. At the local and neighbourhood levels, planning policies can be used to influence the density and layout of development, together with accommodating local concerns over the quality of design and the local environment (Figure 2).

A critical point is that the design of the sustainable city needs to be influenced by the global environmental agenda: transport investment, for example, needs to be working towards the goal of reduced carbon dioxide emissions in transport. A lower carbon future needs to be placed at the heart of decision making.

There are many factors that affect decisions on location and behaviour, and in the most extensive UK study, it was concluded that socio-economic factors are more important than land-use factors, explaining more than 50% of the variation in the amount of travel by wards (there are some 8,400 wards in England). The most important socio-economic factors are car ownership, socio-economic group and employment. Land-use characteristics explain up to a third of the variation in trip making (Table 1). There may also be two way and three way interactions between these elements. Land-use characteristics such as mixed-use developments, settlement size and the provision of local facilities also have a role to play in promoting sustainable development (Stead, 2001; Hickman 2005). Further detailed empirical analysis is however required to ensure that our sustainable communities of the future are developed to reflect best practice in the integrated land use and transport field.

Figure 2: Sustainable Development



(Source: Breheny and Rookwood, 1993)

The US evidence also concludes that the built environment is more important than socio-economic factors in predicting trip lengths, but that socio-economic characteristics are more important in predicting trip frequencies and modal choice. When looking at vehicle distance travelled (a combination of trip lengths, frequencies and modes), the built environment again comes out as being the key determinant. Land use strategies have the potential to reduce vehicle travel by bringing activities closer to the home location and thereby reduce the length of trips. Even though there may be decreases in trip lengths, there may also be a tendency to increase frequency of trips, thereby reducing the net effects. A third possibility is the preferences and attitudes of people: these factors may be more important than both the built environment and socio-economic factors in predicting travel behaviour (Hanson, 1982). There is little research covering these issues in the UK.

The characteristics of the built environment may also not always determine individuals' travel patterns, but individuals will choose to live in particular locations because they want to adopt a particular lifestyle – a type of reverse causality. There is some evidence of this in Europe, where people are beginning to choose where to live on the basis of the lifestyle they want, which in turn is partly dependent on their travel patterns and mode preferences, for example in car-free communities. Again these arguments provide a rich background against which to examine the impact that transport has had on the built environment and the way in which our cities are becoming either more or less sustainable.

Despite the empirical difficulties and the lack of robust research evidence, it is possible to come to some conclusions. In terms of the particular influences that transport has on land use and urban form, there are clear influences on trip length, speed and mode choice. There

is less impact on the frequency of travel. Conversely, development patterns and form may influence travel behaviour. Higher density development is more likely to be clustered around a public transport network; highway networks enable commercial strip 'edge city' development and low density, urban sprawl. There are six further conclusions in terms of moving towards a more sustainable and fairer built environment (Hickman and Banister, 2005).

1. The location of new development, particularly housing, should be of a substantial size and located near to or within existing settlements so that the total population is at least 25,000 and probably nearer to 50,000. The provision of local facilities and services should be phased so as to encourage the development of local travel patterns.
2. Average journey lengths by car are relatively constant (around 12km) at densities over 15 persons per hectare, but at lower densities car journey lengths increase by up to 35%. Similarly, as density increases, the number of trips by car decreases from 72% of all journeys to 51%. Car use in the high density locations is half that in the lowest density locations.
3. As settlement size increases, the trips become shorter and the proportion of trips by public transport increases. Diseconomies of size appear for the largest conurbations as trip lengths increase to accommodate the complex structures of these cities.
4. Mixed use developments should reduce trip lengths and car dependence. Although research here is limited and concentrates on the work journey, there is considerable potential for enhancing the proximity of housing to all types of facilities and services.
5. Development should be located near to public transport interchanges and corridors so that high levels of accessibility for all can be provided. But this may also encourage long distance public transport commuting. Free flowing strategic highway networks are likely to encourage the dispersal and sprawl of development and stretch commuting.
6. The availability of parking is a key determinant of whether a car is used or not and further research is required to determine appropriate standards linked to accessibility levels.

An important issue for the design of the sustainable city is an understanding of the impact of transport measures on the broader economy, city competitiveness and quality of life indicators. At the moment, under investment in the transport sector, particularly for public transport, walking and cycling, is *constraining* the level - and, critically, the quality - of development. It is sometimes suggested that restrictions (e.g. parking or pricing regimes) may disadvantage traders within the city and result in falling turnover, rental levels and lead to city centre decline. The logic of this argument is clear, but little is known about the short or longer-term impacts of transport measures on city vitality and viability, and counter arguments about increases in quality and turnover are likely to be equally, if not more valid.

The basic argument being presented here is that the role integrated urban and transport planning can and should play in avoiding the need to travel and in achieving the sustainable city has been underestimated. To reduce levels of car dependence and trip lengths, planning decisions must have an instrumental role through establishing and implementing clear development principles based on sustainability. Although urban planning and transport are only two of the major elements in sustainability, urban planners can take positive action in both fields. A related point is that if transport capacity is freed up, latent demand may take up the new space. Some mechanism(s) of providing a 'lock in' of benefits is required, including such measures as the reallocation of road space (Williams, et al., 2000; Williams, 2005).

A further critical issue is that the future IIS must give walking and cycling much more emphasis. In recent years they have been given little coverage in transport policy. They are often perceived as the "infill" between the overwhelmingly dominant treatment of car use (and

even public transport use). We should be wary of what might be called "major-project fetishism" - small scale investment can and should make a major contribution to transport strategies. A prime challenge for future UK transport, urban planning and health policy is to give active mobility much more emphasis. It needs to be central to investment patterns. This requires a real shift in attitude, with strategies focused on active mobility systems and networks, and walking and cycling as prime means of travel, being well integrated with other modes.

Finally, there are a series of more strategic issues that must be addressed if sustainable land use and transport is to be achieved nationally and regionally. Cities are changing from centres of work to centres that have a much wider role, including functions of leisure, education, government and retirement. Patterns of dispersal and decentralisation are important, as are the possibilities for recentralisation, with densification and new forms of urban living. It is here that issues relating to urban design, in terms of innovation and quality need to be considered as part of the sustainable and inclusive city. Cities are no longer just the centres of wealth creation, but need to address concerns over the quality of the environment, including equity issues, access to open space, low crime rates, safe and secure living, clean air, affordable housing and access to services and facilities. All these topics should be the focus of a renewed interest in the development of the sustainable and fair city.

3. Information, Communications and Technology's (ICT) Contribution to Accessibility in the Sustainable City

3.1 The Debate

High expectations are now being expressed over the potential impact of ICT² developments on the sustainable city, particularly in terms of reducing the growth in demand for travel, changing requirements for transport networks and generally improving the quality of peoples' lives. The potential impacts of ICT are seen in the literature as exerting an influence on the demand for transport and mobility, in terms of volume, and the spatial and temporal distribution (Banister and Stead, 2004). ICT provides a 'missing link' to the sustainable city as more activities can be undertaken without travel or through sequencing activities through ICT to reduce travel. This is a complex, fast-emerging and vitally important area. There are many opportunities to reduce the travel component for existing activities, including shopping, personal business, meetings, information exchange, ticketing and marketing etc. Changing travel patterns are not a matter of simple substitution effects, but much more complex adaptations that at times might lead to additional travel. Cities provide the main focus within which the balance between remote activity and face-to-face contact can be assessed, including the potential for time shifting of activities or even location shifting, and the use of technology to save time whilst travelling (e.g. multi-tasking).

Technological change is thus likely to fundamentally influence the location of economic development, and the function and form of cities (Hall, 1988). Convergence of computing and communications will allow a user-friendly interface for many transactions, for information, and for business and social activities. Equally, information and technology may cause social divergence as knowledge to use new systems is not universal, costs of access to high-quality broadband communications systems will initially be expensive, and control of these systems may reside in the hands of a few multinational companies (Lyons, 2002). In spatial terms, power may be concentrated in existing centres of information exchange at accessible points on the network; or in the few world cities where rapid innovation and high-level service competition can take place. Second-order cities and those in peripheral locations may continue to be centres of low demand and low innovation.

Similar developments can be seen in transport where key centres in the UK are likely to be located on the high speed rail network and at international airports, particularly at interchanges between road and rail, and between road, rail and air. The international nodal

² Information and communications technology includes the Internet, electronic data interchange, email, personal computer based fax, and automatic telephone entry (e.g. voicemail).

points will be located where the global airlines have their hub operations, and where good quality transport links are available to the local and national centres of population and activity - the "technopoles". Increasingly, these nodal points will also be centres of the international information networks – the "logistics platforms".

Some of these and other main themes found in the literature are summarised below in Table 4. The interplay of ICT developments and transport is a complex relationship to understand, and perhaps the only common agreement is that a radical transformation process lies ahead for society. We have structured our thoughts, and the literature, into the key categories of societal change, globalisation and localisation, and impacts on the sustainable city.

3.2 *Societal Change, Globalisation and Localisation*

As history has demonstrated with respect to the industrial revolution, the technological revolution is likely to promote concentration, but this time at an international rather than national level. Traditional arguments based on scale economies and decreasing returns to scale are being replaced by new debates on increasing returns to scale (Krugman, 1994). In addition to the economic factors of production, two new dimensions have entered the theoretical debates. Human capital in terms of the skills and learning capacity of the workforce, and the role that innovation can have in production both suggest that the most dynamic locations will be created where these three positive factors coincide (i.e. economic, human capital and innovation). It seems that the demand for transport will increase in scale, in range and in quality as these changes take place. Much of this revolution has been predicated on globalisation of the economy, the move towards market economics and the dismantling of trade barriers. It is also dependent on maintaining the capacity and quality of the ICT networks and crucially upon the availability of "cheap" and reliable transport.

With the breaking down of trade and technological barriers, the differences between the rich and poor nations may be reduced, as nationally based activities are outsourced to cheaper locations around the world, and as migration takes place between countries. There is even some evidence (e.g. in the US) of developed countries considering protectionism by restricting the out sourcing of employment to low wage economies. Although this new entrepreneurship is taking place in some countries, it may again act as a barrier to those countries that are not technologically rich. Financial wealth may be important, but technological knowledge and the ability to innovate are equally important. At the individual level, the increased polarisation, between those who are financially secure and technologically rich, and those that are not, may lead to political and social instability. This trend is already taking place through the job market, as this becomes more demanding in terms of skills requirements and less protective of its workforce, and as work itself becomes increasingly casualised.

Technology in a variety of forms has been a central concern in much of the debate over solutions to transport problems (Banister, 2005; Mokhtarian, 2003). Three basic arguments have been used to categorise the possible impacts of ICT on transport:

- Stimulation of more travel as new opportunities become available.
- Substitution for travel as activities can now be carried out remotely rather than by travel.
- Modification of travel, as the two elements combine, to change the ways in which activities are carried out.

This rather simplistic conceptualisation has been widely criticised in the literature, as it does not attempt to understand how technology develops and shapes society, and how wider impacts, such as globalisation, may have an impact (HOP Associates, 2002). The resulting changes are thus more complex, far less obvious and much more subtle. Realisation of changed behaviour depends on the quality of the technology (including its reliability), its ease of use and its cost. Even if there are reductions in one set of transport related activities (e.g. the journey to work), there may be compensating increases elsewhere as the car is now

Table 4: Summary of Research Findings

ICT-Influenced Change
<p>1. Societal Change, Globalisation and Localisation</p> <ul style="list-style-type: none"> Instant global communications and an interconnected world economy may make place less important and potentially lead to the end of cities. <i>"The historical emergence of the space of flows supersedes the meaning of the space of places"</i>. ICTs are supporting a very complex and subtle remediation of the relationships between individuals, urban places and physical mobilities. Places are continually remade through increasingly complex combinations of continuous electronic and physical interchange and connection. Distance becomes a less important driver for the location of employment and residential location choices - activities can now be undertaken remotely using the internet and new ICT. Businesses can suburbanise without compromising their access to sources of labour and materials. Agglomeration and face-to-face contact remains critical. Significant locations, notably the world cities, continue to drive economic activity. Global cities, where banks, corporate headquarters and high-level service industries are located, have emerged as strategic places in the world economy. Technology-based cities and technopoles represent a new industrial space; they are tied to a global informational society and are fundamentally different to anything that has come before. These are likely to be linked with transport accessible locations, such as airports and major rail termini. A two-tier economy may develop, with a widening gulf between the educated elite and the ghettoised, socially excluded, disenfranchised, e-divided, marginalised urban population. Continuous production is possible throughout 24 hours as knowledge based work is transferred electronically from one location to another. E-universities will increase in importance for knowledge development and transfer, and for education and research – as the basis for improved investment in human capital.
<p>2. Impacts on the Sustainable City</p> <ul style="list-style-type: none"> The traditional perception of the impact of ICT on travel has been highly optimistic, with much potential considered likely for trip numbers and trip length reduction. More recent approaches stress that more complex relationships are evident: "subtle" interrelationships are evident between societal, technological and travel trends. ICT can work in a number of ways: it may stimulate more travel as new opportunities become available, substitute for travel as activities are carried out remotely and electronically, and modify travel as these two trends combine. Transport ICT developments and infrastructure investment act as a complement to other more important underlying conditions in the city, such as macro and micro economic trends. Transport ICT investment is a necessary, but not sufficient condition for the development of the sustainable city. ICT provides a huge opportunity for "seamless" travel, with easy integration and transfer between different modes: services, information, timetables and ticketing can be radically improved, using realtime information and a multitude of applications in reaching the consumer (mobile technologies, etc.). Private transport planning, using realtime route guidance, may lead to savings in congestion and travel time, but may lead to increased journey distance. Hybrid vehicle technology can reduce the environmental impacts of travel, and combined with behavioural change, will lead to a new sustainable transport future. Cities will become the centres of high-order activity, with localised centres linked to globalised activity. Road pricing, user charging and infrastructure capacity measures can use vehicle position and recognition technology and help reduce travel distance, occupancy and mode shift. Additional traffic will not be induced as the benefits are "locked in". High-level freight operation decisions to centralise warehousing and distribution networks, source products from distant suppliers, and move to just-in-time operations often increase total vehicle kilometres. The development of hub-satellite systems, where freight (e.g. parcels and pallet loads) is assembled at local satellite depots and sorted at a centralised hub, then distributed via other satellite depots to their final destinations, generates more tonne km of freight movement, though offers the advantage of improving utilisation and loading levels and may lead to the reduction of aggregate traffic levels – logistics platforms.

available during the day for other uses (e.g. for shopping and social activities) or for other users. The net effects of change may conceal quite large variations in individual behaviour (Lyons, 2002).

3.3 *Impacts on the Sustainable City*

Cities are thus simultaneously concentrating and dispersing as behaviour becomes ever more complex within the new society. ICT innovation, like transport, is one (important) factor in facilitating this process. The net effect may be that fewer journeys to work take place each week, but these journeys may be much longer and total distance may increase. This is an example of simultaneous substitution and stimulation (Mokhtarian, 2003). The actual impacts are varied and complex, as they relate to both global and local trends. They require an understanding of the context within which change can be placed (Table 5). The general trend towards globalisation means that more and longer distance accessibility (and sometimes travel) is required for goods, services and meetings. Changes in the nature of work (from manufacturing to service and information), and the labour force (more females and part-time labour) may act to reduce travel frequency, but again encourage longer distances and some substitution effects. The traditional arguments for centralisation of production have been replaced by more flexible location patterns, some where labour is cheap, and others where agglomeration and short supply chains are important. Again, the implications for travel are varied with some increases in distance, some remote working, but also the continued need for face-to-face contact. Such changes have been reinforced by the 24-hour economy where activity is continuous within countries (through shift working), but also on a global scale, where markets are open all the time in the key financial centres (Geels and Smit, 2000). Global commerce requires servicing and support at all times, and this in turn has implications for transport modes and supply chains. The changed emphasis is for improved accessibility to information and exchange rather than improved mobility.

Table 5: *Global and Local Trends and Travel Behaviour*

Trend	Role of ICT	Impacts on Transport
Global Markets	Improves communication, assists global marketing	More long distance transport for goods and services, and also for business meetings, unless the business meeting is held electronically
Changes in nature of work – manufacturing to service and information. Greater female participation	Higher levels of skills and access to ICT at work, home and local centres	Reductions in travel frequency, but possibly longer distances and some substitution
Flexibility of the labour market	Technology for flexible and remote working	Reduction in travel frequency, but perhaps longer distance travel (when individuals move further from work) and also substitution of work travel with other travel (with time saved by not travelling to work)
Footloose industry	Technology for industries to be located far from clients	Increases travel distance for business client journeys, unless done through telecommunications
24-hour economy	Improves ability to carry out transactions automatically and in real time	Reduces the need to travel for many transactions, but requires more people to work outside 'regular' work hours – implications for transport modes

(Source: Banister and Stead, 2004)

It is against this background that the effects of ICT on transport must be placed. It is not a matter of simple bivariate cause and effect, but part of a much richer background of change that creates different responses under different conditions. Much of the development of ICT has been paralleled by substantial increases in travel as levels of affluence have increased, as trade barriers have been dismantled, and as leisure time has increased. As the costs of

travel have been maintained at low levels, the opportunities for travel have increased substantially (Handy and Mohktarian, 1996).

During the 1990s, there was huge optimism about technological futures and expectations of high take-up and acceptance rates of the new dot.com future. Though this dimmed with the burst of the 'bubble', technological change is still enormously influential. There is a distinction to be made in terms of the impacts *in* transport, namely in influencing the operation of transport systems, providing in-vehicle monitoring and control systems, and information to users of all transport systems. This role may be more important than that *on* transport, namely the influence on travel behaviour.

Society is only just beginning to understand the tremendous potential that ICT has to offer. Much of the evidence cited in the literature is based on current best knowledge, and here there is another clear distinction: between the techno-optimists and the techno-pessimists. The optimists anticipate rapid take-up of the new technologies in every aspect of travel, in producing, living and working, and that access will be available to all at a low (or even zero) cost. The pessimists suggest a much more cautious take up, with only limited interest in using the new technology, and a strong social division between those that have the knowledge and the resources to take full advantage of it and those that do not.

Current thinking has moved away from simple cause and effect type relationships towards co-existence and complementarity between the old and new technologies (Banister and Stead, 2004). Traditional logic viewed teleconferencing, for example, as a substitute for business travel, based on the assumption of a fixed number of social contacts, not the probability that such contacts would occur more frequently. There are various perceived advantages to telecommuting: workers, faced with increasing household responsibilities, see it as a way to reduce travel time, reduce stress, focus on particular pieces of work, and/or increase their free time. Employers [at times] see telecommuting as a way to reduce office space costs, and as a new kind of benefit they can provide to employees. Transport planners see telecommuting as a promising way to reduce traffic volumes, increasing congestion, energy use and emissions, and declining local air quality. Local communities see telecommuting as a potential economic development strategy.

Examples of changing behaviour are increasing in number. In Surrey, for example, the Epsom telecentre has been well used by local authority employees and acts as a substitute to travelling to the main employment centre, County Hall, in Kingston. Surveys have shown that use of the telecentre has led to a 13% reduction in commuting distance³. But the wider impacts on cities are unclear, at least in the short term.

Many of the larger computing and telecommunications firms are supporting these new working trends; they of course have a vested interest: telecommuting could be a promising new market. British Telecom, Hewlett Packard, IBM etc. are all at the forefront of flexible working. "Hotelling" is, for example, becoming popular with workers who are frequently out of the office, e.g. sales representatives and consultants. Employees are assigned a "hot desk" on an as-needed basis; workers can pre-book a space, hence the analogy to hotels. Local authorities have followed the trend, Ashford Borough Council, for example, run on a hot desk basis, where employees don't have a permanent desk, and must pre-book space as and when required. The wider impacts on office markets are as yet unclear.

Internet shopping provides a good example of the new complementarity and a break with the conventional approach that treats shopping solely as a functional activity. Whilst certain goods can be purchased via the Internet from home, there are still various fresh goods that

³ Note that SCC have recently moved their headquarters from Kingston and replaced County Hall with area offices throughout Surrey. Employees are able to use their nearest area office and log in to the County Council computer network remotely; each local office has been designed to have temporary touch-down and hot-desking facilities for casual use by staff. Hence flexible working has been 'mainstreamed'.

need to be seen before purchase. Other aspects of shopping include its social function as a place to meet people and to satisfy the need to get out of the home. There is empirical evidence of this where visiting shopping centres has a social as well as functional rationale (Putman, 2000). There is also an important temporal dimension, as new patterns of activities take time to establish themselves. Apart from problems with systems being established, for example whether Internet shopping is done through the local supermarket outlet or through the regional distribution centre, there is the user interface and the delivery window problem, and the acceptance of the basic concept.

Cities will change as centres of production to centres of consumption, as much of the manufacturing traditionally associated with cities is outsourced overseas. Cities will remain as centres of finance and the service sector, providing important roles for government, education, health and leisure (including shopping). They will operate for 24 hours and be international in their networking – these are the hubs. This means that to maintain and enhance their competitive position, they need to invest in a high quality infrastructure – transport, water, electricity, other utilities and telecommunications (including broadband). The economic arguments for agglomeration will still be strong, with perhaps greater emphasis being placed on clusters of innovation where specialisation takes place because of key local inputs, such as research laboratories and university research centres. The international networks need to be both physical and virtual.

Critically, not all cities will be the same. The emergence of the globally integrated economy, including the growth of multinational corporations, is heavily dependent on the development of ICTs. They help bypass time differences, reduce the effect of distance and mean the spatial separation of offices and people can, to a certain extent, be overcome. Technologies such as email, voicemail, fax and teleconferencing have been instrumental in these changes.

A further related trend is towards offshore working, where UK companies move part of their business - usually 'back office' activities - to locations either in peripheral areas in the UK where labour is cheaper, or further afield in southern Europe, eastern Europe or places such as India or south east Asia. Norwich Union, for example, run their call centre from India. Telecommunications are usually the facilitator: *"the increasing capacity, speed and reliability of worldwide communications networks broaden the possibilities for production jobs to shift offshore, take advantage of Third World labour, and still tie into capital and labour markets"*.

Lower skill data entry has most frequently moved abroad, but increasingly higher order employment is being moved, e.g. Tesco's computer support system is run from India, Halcrow's computer aided design lab is run from Dubai. Many software development companies have been located in Mumbai and Bangalore, India.

The space available for travel within the city will be much as it is today, but with dynamic use patterns in that extra capacity is provided at certain times of the day, whilst at others the street becomes a market or a play area where no traffic is allowed. Flexible use by time of day and day of week will be a feature of shopping areas and residential areas, but even in commercial areas the value of peace and quiet will be overriding. The vehicles using the streets will be silent with zero or low emissions, using the electric parts of the hybrid technology (Banister and Hickman, 2005). Hydrogen fuel cells may also be available, most likely in the mainstream post-2030, and initially restricted to the taxi, bus and delivery vehicle sectors. For many living in the city, it will not be necessary to own a car, as services and facilities will be provided locally or through the Internet, so there will be less need to travel. Deliveries will be made to the door or local collection points. Others will choose to share a car or have joint ownership arrangements. The growth areas for travel will be leisure (including long distance travel) and social/networking.

Low speeds in leisure, residential and shopping areas will dominate (20 and 30 km/hr), so safety will be substantially improved, and access will be limited to many areas by time of day. Low speed, safe vehicles mean that the age for driving could be reduced (maybe to 13 years of age) and the elderly will drive more frequently (to 85 years and over). There would be no

pollution from vehicles in the city, although the hybrid, fuel cell and electric technologies may still use some non renewable energy sources. The priority will be given to those vehicles using renewable sources of energy, generated locally from biomass and waste from the city, thus reducing ecological footprints to a more sustainable size. These changes will all have been embedded as part of the vision for the sustainable city, as the global convergence and contraction agreement is implemented to reduce CO₂ emissions by at least 60% (by 2050).

Cities will return to being multiuse and reintegrate. The separation and fragmentation caused by incompatible land uses and the car will be reversed, as they again become centres of high quality activity built around localised centres linked to the global networks. The main difference (apart from the high quality environment) may be the privatisation of the ownership of space, as cities will be in competition for global dominance. The public realm model typical of the 20th century will be replaced by the liberalised city based on the new technology.

At the global level, some cities will be leaders in the 'new' liberalised regime with private spaces that are of a high quality and affluent – these will include the city centres, spaces for retail and leisure (including resort complexes), and residential locations. It is here that wealth will be created and consumed, and these locations will be well connected locally and globally. Elsewhere, there will be marginalised spaces where poverty may exist in unwired locations with little or no investment in the infrastructure, sometimes called the fragmented city or the city of the permanent underclass. The challenge here is to integrate the poor as the rich depend upon them to make the cities work. Even though there can be substantial substitution of capital for labour in the form of automation and technology, there will still be many low quality jobs needed to make the city work – there is a mutual dependence between the rich and the poor. The ideal is to aim for convergence so that there are fewer poor and the city can then operate optimally. This is the path to the sustainable and fair city, and it requires a redressing of the notions of private and public space, so that all citizens can benefit fully from the opportunities and wealth that the new technology offers.

3.4 Conclusions: ICT and the Future Built Environment

Cities are changing, not only in terms of their functions, but also their form. The physical urban fabric is replaced at a rate of 1-2% per annum, and so by 2050 we would expect about half of the city to change in some way from today (Banister, 2005). This doesn't mean radical change as many buildings are refurbished and others have their uses changed. In addition there is an increasing pressure on both redevelopment of existing space in cities and expansion to new areas as the demand for housing rises, as a result of demographic changes. The largest unknown here is the extent of migration both into and out of the UK, with the further globalisation of the economy and the extension of the EU, where there is complete freedom of mobility between labour markets.

It is important to accept that cities must be central to the sustainable and fairer future. Although technology may seem to offer an opportunity for greater dispersal and less need for contact, it is highly unlikely that the need for increased face-to-face contact will disappear. Also the ability to take full advantage of the available technology is likely to be highly selective, at least initially. Barriers to diffusion of innovation have in the past been mainly limited by income. Technological innovation presents cost barriers, but also significant skills and knowledge barriers. And there is even evidence of negative reactions against particular technologies being used in public places (e.g. closed circuit television surveillance). The behavioural response to innovation is also poorly understood, both in terms of how the technology is used, but also in terms of the real changes that are actually made to behaviour – the stimulation, substitution and modification arguments. Behavioural change is far more complex than normally presented. It is this variety in the nature, scale and diversity that makes it important to look at individual change over time rather than average net change.

The use of ICT developments provides huge new opportunities for the design of the sustainable city. A number of issues are, however, still to be resolved:

1. *Necessity to take an intermodal perspective on transport* – there seems to be considerable potential within cities to exploit the potential of intermodal transport by means of ICT use. For instance, there is scope to reduce short distance travel by air through the linking of the air and rail networks, as has been achieved at Charles de Gaulle and Frankfurt airports. Through innovative hubbing solutions facilitated by ICT, it is possible to optimise the use of air space and rail systems. This applies both to passenger travel and high value freight movements, but it is important that the potential role of ICT is not over emphasised, as the basic driving force for change would be the economics of integration.

2. *Impact of technology and flexibility* – ICT provides tremendous opportunities and choice to carry out the full range of desired activities in a variety of ways. It also provides firms with important new challenges with respect to their production processes and employees with new choices in terms of working practices. The knowledge base is extended and this may result in more travel, but more important is the transfer of power from the producer to the customer. Users are increasingly controlling their own lives and what they want (at a price), and so the production processes have to react to those new requirements. This flexibility in turn requires the extensive use of ICT throughout the supply chain, but we are far from understanding the multitude of consequences this is likely to have, or the collective impact on transport demand.

3. *Sustainable supply chains* – there is an increasing awareness world wide of the transport costs entailed in providing goods to the final user. One of the main growth sectors in air travel has been the freight sector where high value goods are carried long distances to give year round availability. If transport activities pay for their full environmental costs, transport costs would be a more decisive factor and the need to optimise them would arise. The internalisation of external costs can thus turn into one of the key drivers of ICT use in transport. This is because of its efficiency enhancing potential along the supply chain, where sustainability can be combined with efficiency.

4. *ICT and quality of life* – ICT has the potential to increase accessibility and quality of life for users and there may be some substitution of additional trips by its use. More optimistically, this might also lead to some individuals living without the car, and this in turn might lead to car free lifestyles. It could also increase the potential for car clubs, as these cater for those who desire the occasional use of the car. Virtual mobility has substituted for the increases in physical mobility, so that more sensitive time use studies, with an assessment of change over time, are necessary to establish the nature and scale of the trade offs.

We therefore need to understand that fluid, non-deterministic, and often counter-intuitive relationships are at play. Ambivalence is often a key factor in our knowledge of the ICT-transport relationship. For example, ICTs underpin cheap airline growth and just-in-time logistics flows, but there is little understanding of connections and causality; increased use of e-commerce and e-retailing has uncertain impacts on the road network and local traffic; ICTs can add to the relative attractiveness of the car, as more and more services and facilities are bundled onto the basic model; and ICTs might offer the potential to convert 'dead time' stuck in traffic into useful time.

Any research work aiming to underpin these key questions and opportunities needs to be based on a sound empirical basis. The analysis of available literature and evidence has shown that much of the analysis on the interdependencies between new types of ICT applications and the implications they have for transport is still in its infancy. Even where there is better information (e.g. in distance working and e-commerce), most studies concentrate on the direct impacts on trip frequency and distance, whereas second-order effects are rarely taken into account. There is a clear need for further empirical research work, broken down by the distinct ICT applications, and their sub-dimensions. New perspectives are required on the nature of accessibility as the physical and social constraints normally used are matched by virtual constraints. This needs in turn to be reflected in transport analysis that replaces the notion of a single activity (travel) being carried out at a particular point of time with a more flexible notion of virtual travel and of multitasking when travelling. Travel behaviour now continuously changes over time.

4. Future Directions: IIS and the Sustainable and Fair City

The future IIS must be based upon a robust understanding of the way transport, ICT and the city inter-relate, and the emphasis for future IIS development and investment must be in supporting the sustainable and fair city.

Technology offers great opportunities and its impact on the city is likely to be as fundamental as the previous agricultural and industrial revolutions were in the 18th and 19th Centuries. The real difference is that all types of activities will be able to take place within close proximity of each other as there are no “conflicting uses”, so people can live where they work. Conversely, for the first time distance may be less important as technology permits remote working and networking. So there are forces operating in both directions, for centralisation and dispersal. Yet if society is to move towards sustainable development, then policy must look at ways of reducing travel and trip lengths, and in ensuring that all energy used is “clean”. The city of the future can and must achieve both these objectives of minimising trip lengths and maintaining high environmental quality.

As we have noted, the fabric of the city changes slowly, and so the potential is there to build in sustainable designs with local jobs, services and facilities, as well as local combined heat and power schemes that run on waste, biomass and other renewable energy sources – the supply chains are considerably reduced. The ecological footprint of the city can be substantially reduced. In a future era of carbon trading, this means that there will be substantial financial and economic benefits for the ecological city. Urban spatial structure and technology have key instrumental roles in achieving this objective.

Cities will also retain their individuality, partly as a result of their own histories and cultural diversity, but also in light of their new development paths. There is no single solution to the sustainable and fair city, there are multiple pathways, and differences should and will exist between them. Transport policy and investment needs to reflect the myriad of differences in society, and not be simply focused on the “traditional” cohorts such as the male car commuter. One of the strengths of the city is its diversity, and this needs to be encouraged through the greater involvement and participation of all groups with the decision making process so that outcomes reflect their interests. In the 21st Century, there needs to be investment and quality in design so that urban spaces match up to the high expectations of the population for city living. Many of these possibilities have been highlighted in this review.

Future empirical research should move towards developing an understanding of how alternative images of the future, incorporating different urban spatial structures and ICT developments can contribute to that city future. That research must be embedded within a clear vision of the sustainable city that embraces prosperity (economic), a high quality of urban environment, and inclusivity (social) as its main constructs. It is only through balancing the economic factors with the new environmental imperatives and the importance of building on the diversity of the social structure that the role of great cities will be maintained and enhanced. Within that vision, transport has a crucial role to play and in turn IIS has the potential to deliver a cleaner and fairer transport system. But there is also a danger that it may deliver more travel with greater inequality between those that can take advantage of the new technology and those that cannot.

Two key elements need to be highlighted. Firstly, the city depends on a range of skills and knowledge bases for its existence, and its real strength is embedded in its diversity. The technological city demonstrates this diversity, and the possibilities for extreme wealth and poverty to coexist. But to flourish, there is a need for an even greater range of skills. The knowledge base needs investment so that the skills levels of all city dwellers can be improved. Otherwise a possible polarisation may lead to increased inequity, social unrest and a growth in those elements that make the city unattractive. The basic need is to raise the level of the human capital so that all residents can benefit from the new wealth and improved quality of life in the city.

Secondly, and partly related are the issues of empowerment and effective implementation. We need to carefully consider how we communicate the benefits that can be gained from sustainable living and the high technology society to all residents in the city. Individuals need to be given ownership and responsibility for the quality of their local environment – they need to accept the arguments for the sustainable city and their contribution to it, and they need to appreciate the benefits that can accrue to them individually and to society as a whole. Too often, good ideas do not translate into good practice. We should focus on developing the means by which often difficult decisions can be made in order to relate more closely to the priorities of individuals. Technology provides one valuable means by which this problem can be overcome, yet there are still many barriers to effective implementation. Actual outcomes are often very different to expectations.

The future development of spatial structure and technology thus provide part of the picture in achieving the sustainable and fairer city. And to a large extent the possibilities are well known. The main barriers would seem to be to make progress inclusive, so that social and welfare objectives match economic and global environmental objectives – this suggests heavy investment in the knowledge infrastructure. There is therefore the need to communicate fully with all people to raise awareness, to involve them in the process of change, and to give them ownership so that they buy into the sustainable and fairer city. As with the previous agricultural and industrial revolutions, it is not the hardware that creates the problems and solutions, but the software, and in the context of technology and the city, this means the people.

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