

# **Measuring Accessibility as Experienced by Different Socially Disadvantaged Groups**

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## **Accessibility Analysis Literature Review**

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## **1.0 Introduction**

1.1 This report is an input to a major EPSRC project looking at how to develop measures of accessibility that are sensitive to the needs of different disadvantaged groups. The project aims to:

- Identify the particular travel/activity needs of specific disadvantaged groups and the barriers they face
- Translate these varying needs into sets of parameters and relationships that can be incorporated within existing accessibility models and tools.
- Make the proposed modifications to two existing accessibility tools
- Apply and validate these tools

1.2 This report links to the second of these aims, by reviewing the available literature and knowledge on the concept and parameters of accessibility, including:

- Definitions of accessibility
- Parameters in the measurement of accessibility
- Different analysis approaches
- Types of indicator

It concludes by identifying issues to be explored further in this project.

1.3 Note that, in the UK, the term 'accessibility' is used in two different contexts: (i) to describe the detailed design characteristics of transport systems that enable or inhibit their use by people with physical and mental impairments, and (ii) at a more general and macro level, to describe the ease of reaching opportunities or the ease of being reached. It is in this latter sense that we are addressing accessibility issues in this review, which includes reference to the former as one type of barrier to be overcome.

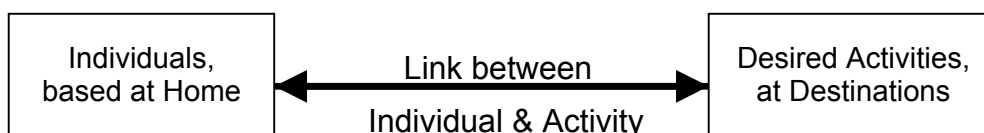
## 2.0 Definitions of Accessibility

- 2.1 Accessibility is a broad and flexible concept. Breadth and flexibility are its main strengths, but are also the main reason why accessibility can be perceived as confusing and complex; Gould (1969) has described accessibility as a 'slippery' concept.
- 2.2 Definitions of accessibility can be approached in several ways, and this chapter discusses these in terms of:
- Basic concepts - what is accessibility? How does it relate to mobility?
  - How can it be defined and measured?
  - How is it applied within Accessibility Planning?
  - What do we mean by accessibility needs?

### ***What is accessibility?***

- 2.3 Accessibility is an attribute of people (and goods) rather than transport modes or service provision, and describes integrated systems from a user viewpoint.
- 2.4 There are three primary components that make up accessibility, as shown in Figure 2.1.

**Figure 2.1: Primary Components of Accessibility**



- 2.5 Groups of individuals have a range of activity needs, which can be met through facilities provided at various destinations, with transport and communications providing the links between 'demand' and 'supply'.
- 2.6 DHC (2000) characterises the understanding of accessibility in terms of three questions: "who"/"where", "what" and "how":
- Who or where is being considered – accessibility is an attribute of people or places.
  - What are the opportunities being reached - the land uses, activity supply points or resources (including people) that allow people or places to satisfy their needs.
  - How: the factors that separate the people and places from the supply points – these can be distance, time, cost, information and other factors that act as deterrents or barriers to access.

- 2.7 Accessibility can be examined primarily from two viewpoints: that of the individual (origin), and that of the service provider (destination).
- 2.8 When considering people, accessibility is about “the ease with which any individual or group of people can reach an opportunity or defined set of opportunities”; this is often referred to as origin accessibility. When considering service providers, accessibility is “the ease with which a given destination can be reached from an origin or set of origins” (Simmonds *et al* 1998); this is usually referred to as destination accessibility, catchment accessibility or facility accessibility.
- 2.9 All definitions of accessibility include some reference to “who/where”, “what” and “how” components, but considerable confusion has resulted from differences in treatment about what is implicit and what is explicit. Organisations specialising in providing services, such as employment agencies, health services, supermarkets, etc. tend to use very simple proxies (such as distance) for “how”, and concentrate on the facilities available and the population characteristics within the catchment.
- 2.10 In contrast, transport planning has traditionally concentrated in greater depth on the “how”, looking in great detail at movement patterns between homes and destinations, with very little consideration of the “who” and the “what” (DHC 2000). People and opportunities have been considered within the planning of improved transport only to the extent that the characteristics of the people (e.g. physical disability or car ownership) or of the places (e.g. pedestrianised area) affect mobility and the demand for travel.
- 2.11 However, nowadays the “how” component is broader than transport systems, and includes connections that do not involve travel. Telecommunications and technology are increasing the range of “virtual mobility” options available to connect people and opportunities (Kenyon *et al* 2002).

#### Accessibility and mobility

- 2.12 Mobility – the “how” - has been the traditional focus of transport planners and engineers, but in the light of growing social and environmental concerns, this has become increasingly contentious, with many questioning the assumption that the aim of transport policy should be to improve mobility (Cervero 1997), and favouring its replacement with the broader concept of accessibility.
- 2.13 Hansen (1959) characterises mobility as the potential for movement, whilst accessibility is the potential for interaction.
- 2.14 Mobility is measured either in terms of the resources and characteristics of the travellers: car ownership, physical disabilities, etc; or by the behaviour of these travellers: trip rates, vehicle kilometres travelled, vehicle occupancy, passenger kilometres, or speed of travel.

- 2.15 One of the main problems with the concept of mobility, and a major reason why it is difficult to use as a policy objective, is that it is not clear whether the objective is to encourage more or less travel, or whether more or fewer trips is better (Jones 1997). More particularly, despite accessibility being heavily influenced by mobility, improved mobility does not always lead to improved accessibility (Ross 2000).
- 2.16 On the other hand, the concept of ‘mobility’ is also often linked to discussions about individual rights and freedoms and continues to be surrounded by controversy (Janssen 1993). Kenyon *et al* (2002) suggest that mobility also has an important social function and value in its own right – it is not simply a means to an end:

*‘It can be viewed as a social service, facilitating social interaction and participation, whether at the destination or during the journey. Lack of mobility can reduce access to formal and informal social networks, increasing isolation and separation not only from goods and services but from social activities, family and friends’.*

### **How Can Accessibility be Defined and Measured?**

- 2.17 If accessibility is to prove a useful concept in practice, a consistent terminology is needed. There are many definitions of accessibility in the literature, a selection of which are summarised in Table 2.1.
- 2.18 Whilst the basic elements of accessibility are therefore clear from the common themes within these definitions, in line with the preceding discussion, there are also some differences which make a detailed comprehensive definition of accessibility problematical. In particular:
- How to segment the population to reflect abilities and perceptions, given that these are often specific to individuals or small groups.
  - Ensuring a broad enough view of all transport and communications options, which reflects all aspects of modal choice, telecommunications, and quality in terms of speed, cost, prestige, security, comfort and other factors.
  - Clarifying when absolutes can be defined e.g. “ability” and when comparatives are needed e.g. “ease”. Specifically, what is “reasonable”, what is “need”, and how much choice is needed?
- 2.19 To move forward, it is first necessary to provide a framework for measuring accessibility. This broad framework is usefully defined by “ease of reaching or being reached”, and using this, the concept of accessibility becomes more meaningful as an applied method of Accessibility Planning, which “offers a new way to find and solve local problems” (SEU 2003).

**Table 2.1 - Definitions of Accessibility**

Author	Definition	Key factors in accessibility
Litman, 2003a	<p>Accessibility refers to the ability to reach desired goods, services, activities and destinations (together called <i>opportunities</i>). Accessibility depends on mobility, mobility substitutes and opportunities as follows:</p> <ul style="list-style-type: none"> <li>• Mobility - provided by walking, cycling, public transport, car sharing, taxi, cars, and other modes. All else being equal, an increase in the speed, service quality or affordability of a mode will improve access by that mode.</li> <li>• Mobility substitutes - telecommunications and delivery services. These can provide access to some types of goods and activities, particularly those involving information.</li> <li>• Land uses - the geographic distribution of activities and destinations. The dispersion of common destinations increases the amount of mobility needed to access goods, services and activities, reducing accessibility. When real estate experts say "location, location, location" they mean "accessibility, accessibility, accessibility".</li> <li>• Other factors - information availability, affordability, convenience and comfort, security and prestige.</li> </ul>	<p>"All else being equal" – Responses to mobility changes can mean that things are usually not "equal" and often complex behavioural responses need to be considered.</p> <p>The need to consider information, availability, comfort, security, prestige, speed, modes available, telecommunications, land uses and all potential activities emphasises that it is important not to confuse detailed components of accessibility with the definition "the ability to reach goods services, activities and destinations".</p>
David Simmonds Consultancy <i>et al</i> (1998)	A way of measuring the ease with which a particular category of persons can reach a defined set of destinations, from a given origin (origin accessibility), or the ease with which a given destination (destination accessibility) can be reached by a particular set of potential individuals	Different people have different levels of accessibility so definitions relate to a "particular category of persons"
SEU Report, 2003	The ability of people being able to get to key services at reasonable cost, in reasonable time and with reasonable ease.	Key words "ability" and "reasonable" need to be defined.
DfT, 2001	Difficulties with boarding and alighting vehicles, carrying items, confusion over use and staff attitudes.	Physical access to vehicles and transport providers understanding their customers are important.
Geurs <i>et al</i> , 2001	The extent to which the land-use transport system enables (groups of) individuals or goods to reach activities or destinations by means of a (combination of) transport mode(s).	Accessibility is best considered by a combined view of modes.
Ross, 2000	The ease of reaching some destination, and may include real or perceived costs in terms of time or money, distance travelled, level of comfort, availability and reliability of public transport, or any combination of these.	Real and perceived barriers are important.
Gray, 1989	A measure of the relative access of an area or zone to population, employment, opportunities, and community services	Comparative accessibility can be as important as absolute levels.
Handy 2004	The ability to get what you need, ideally with a choice of destinations and using a choice of modes	"Need" and "ideally with a choice" are important concepts

**Accessibility Planning**

2.20 A study by DHC and Transport Studies Group at the University of Westminster (2003) identified several different ways in which accessibility has been used for planning purposes (see Table 2.2).

**Table 2.2 - Uses of Accessibility within Planning**

Access to Opportunities	To consider the effects of changes in the transport system (i.e. covering all modes, interchanges, cost, time, reliability and quality) on people's access to opportunities such as employment, shopping, health services, social support networks, recreation, countryside etc.
Distribution of transport impacts	When defining how transport impacts are distributed across geographical areas, population groups, trip purposes and modes of travel ensuring compatibility with equity objectives. This allows gaps in the public transport network to be identified and the contribution of new services to the overall utility of the network to be evaluated
Travel Options	When defining the travel options available to people including the changing contribution made by commercial public transport services, subsidised services, community transport, rail, walking, cycling and private car travel
Consistency of Transport	For ensuring consistency of transport with other public policy objectives including: land use planning, housing, health, education, local regeneration and regional development
Linkages with Other Public Policies	To make evident the transport implications of other areas of public policy decision making and service delivery, especially the opening, closure and relocation of facilities and in the scheduling of services
Impacts of New Developments	When assessing the impacts of new developments and the needs for development control decisions to improve access to the transport system
Community Planning and Business Travel Planning	As part of community planning, and business travel planning to explain transport changes to communities in terms that they can easily understand such as journey times to shops, or travel time and cost to work

Source: DHC & TSG, 2003

2.21 Turning the concept of accessibility into a practical and robust planning methodology requires that some key decisions are taken, about how to define people and places, how to represent transport and communications, at what level of spatial/geographical detail this should be done, and the ways in which current accessibility performance should be expressed.

People and places

- 2.22 A primary distinction within accessibility planning is about whether the measures that are being used describe people or places. Church and Frost (2000), in reviewing approaches in the UK, described people measures as the 'category approach' and place measures as the 'spatial approach'. This is helpful in explaining the way researchers have approached accessibility issues. The key differences are that:
- The category approach focuses on the travel patterns, attitudes and needs of particular social groups – e.g. women's needs (Turner and Grieco, 2000), people without paid employment (Meadows *et al.*, 1988) older people (Askham and Warnes, 1992).
  - The spatial approach focuses on transport usage characteristics of people in different types of area such as people living in deprived urban areas and rural areas – e.g. Nutley (2003) found that people in rural and sparsely settled districts "do not necessarily make more or fewer trips than people in urban areas, but the distances travelled and times taken are significantly higher"; and Grieco (1994) found that people living on urban housing estates tend to be concentrated in higher density, inner city neighbourhoods which are typically well served by public transport.
- 2.23 There are limitations to both approaches (Church and Frost 2000), since material affluence and activity patterns differ significantly amongst different social groups, and the population within a particular area can be quite heterogeneous, making it is difficult to generalise about transport needs and accessibility preferences. Also, research usually concentrates on one particular problem, e.g. age, and fails to take account of the multi-dimensional factors affecting behaviour.
- 2.24 To take a more comprehensive view, it is necessary to incorporate both approaches, and consider detailed geographical factors, such as the relations between residential location, and where the activities that individuals want to participate in are located, and their options to move between the two.
- 2.25 A systematic typology for measuring accessibility for people and places has been proposed (DHC 2000) that considers the accessibility needs of the people group being considered, the modes of transport and communication available to each group, and the opportunities available at the destination.
- 2.26 Types of person are based on:
- Mobility – car owner/driver, physical and sensory disability.
  - Employment status – unemployed, economically active, job seeker, etc.
  - Age – Retired, adult, children, etc.

- Cultural factors – gender, ethnicity, faith, etc.
  - Responsibilities – carer, lone parent, etc.
- 2.27 Each section of the population has specific needs and desires to be involved in activities. These activities are translated into types of opportunities and defined in terms of the land use supply and the location and timing of a range of local services and facilities, which would allow any individual to satisfy their desire to participate in the activity under consideration (DHC 2003). This includes:
- Employment, Education and Training – Employment locations, job centres, childcare facilities, nurseries, schools, colleges, universities, training centres.
  - Health and Social – GP surgeries, health centres, hospitals, dentists, social security offices, drop-in and day care, centres, youth services, citizens' advice bureaux, legal services, etc.
  - Shopping and Leisure – Shops/shopping centres, cinemas, theatres, sports centres, outdoor activity opportunities, centres for religious activity, pubs, clubs, post offices, financial services, etc.
- 2.28 In looking at real life situations linking people to opportunities, and taking account of preferences of different individuals or groups, a major challenge is to describe consistently the quality and value of each opportunity that can be reached (Halden 2001). Where this is possible, opportunities and population catchments can be weighted according to some form of quality or relevance. For example:
- What choice, if any, the “consumer” can exercise in obtaining the service or reaching the opportunity being considered.
  - Do the accessibility indicators need to recognise and reflect choice, or can the set of opportunities to be reached be constrained.
- 2.29 Some opportunities can be represented simply as either being ‘present’ or ‘absent’ e.g. a post office. However, most types of opportunities need to be sized e.g. to consider the number of jobs in a zone, the capacity of the facility, etc.
- 2.30 It is also important to recognise that there are opportunities which are conventionally counted as a single set, but which in fact are not substitutes for one another at all (e.g. “health facilities” if this includes, for example, both dentists and opticians). Jobs, schools, and other opportunities can often be treated as effective substitutes for one another, if they are disaggregated to consider sub-groups or sub-markets e.g. primary schools. For opportunities that cannot be disaggregated into meaningful groups to reflect the choices available, e.g. access to friends and family, aggregation can be the best approach, considering access to major centres or to the total population.

Transport and communication

- 2.31 Ways of representing the link or separation between people and desired activity locations are also multi-dimensional. The deterrent effect of travel varies according to the trip purpose and people group (Handy 1992). It is clearly desirable that the accessibility measures reflect the perceptions and behaviour of local people for each trip purpose as closely as possible, and Simmonds (1998) suggests defining this in terms of:
- The 'objective' physical, monetary and other measurable characteristics of the journey;
  - The measurable characteristics of the journey in combination with the traveller responses to these characteristics. This is described as the 'behavioural' approach.
  - The measurable characteristics in combination with particular standards. This is described as the 'normative' approach.
- 2.32 Behaviour is site specific and different people behave in different ways. Therefore, calibration of accessibility measures to reflect local preferences presents many problems. The approach adopted by the Department for Transport in England (DfT 2004) has been to take travel time as the most easily quantifiable measure of separation, and calibrate this to observed behaviour using National Travel Survey Data (DfT 2004). DfT has adopted the normative approach in national ward based indicators, by specifying travel time thresholds consistent with cross sectoral policy aims for access to education, healthcare, work and shopping (DfT 2004).
- 2.33 This approach assumes that travel time can adequately act as a proxy for the other important elements of the journey, which is not always the case. Public transport fares are not always proportional to travel time and there are many other factors affecting the security, reliability, and quality of transport, which have an important influence on people's access to various activities.
- 2.34 Due to the complexity of travel behaviour and limitations on data, it is not practical to have a fully specified accessibility tool which takes direct account of all the dimensions of travel behaviour (DfT and TSG 2003). It is, however, practical within the accessibility planning framework to consider systematically all the factors that affect whether a transport option is available or desirable. These are summarised in Table 2.3, under six headings.
- 2.35 In many cases, however, removing one barrier will not improve accessibility until all other barriers are also removed. In a study of factors inhibiting parents of younger children from letting them travel to school by bus or on foot/cycle, Jones and Bradshaw (2000) identified a whole series of successive barriers that needed to be addressed, not all

of which were directly related to transport provision (e.g. provision of secure lockers at school, to store books and equipment over night).

**Table 2.3 – Transport Barriers to Accessibility**

<b>Factor</b>	<b>Barrier</b>
Spatial	Travel time including walk, wait, and in-vehicle in relation to time budget available
	Ability to interchange between all modes within integrated networks
	Availability of a route
Physical	Vehicle designs suitable for users e.g. low floor buses
	Kerb heights
	Topography
Temporal	Transport system and service reliability
	Waiting time/ service frequency
	Scheduling of transport and activities
	System capacity
Financial	Travel cost
	Discounts for traveller groups
Environmental	Street lighting
	Interchange/waiting areas
	Safety/security
Information	Information prior to journey/skill levels of travellers
	Information whilst travelling

- 2.36 The way that these factors interact with other components of accessibility is discussed in more detail in Chapter 3.
- 2.37 In Table 2.3 information is viewed only from the perspective of information available to make a journey. However, increasingly ICT provides substitutes and complements to travel options for access for people to opportunities (Cairns et al 2004, DHC 2005).
- 2.38 The main conclusion of this work is that ICT provides greater flexibilities to people in relation to the timing and need for travel. This reduces the relative importance of spatial, physical and environmental factors relative to information and financial factors. More generally, the research on transport and ICT development emphasises that travel behaviour increasingly needs to be viewed within overall lifestyle choices. This make the consideration of accessibility more important but no easier.

Spatial detail and geographical level

- 2.39 The level and detail of the accessibility analysis needs to be commensurate with the scale of the issue being considered and the detail with which particular problems need to be understood.
- 2.40 When considering the accessibility of places, Litman (2003b) suggests that there are four main geographical levels:

- Very fine-grained scale
- Neighbourhood
- Regional
- Interregional

- 2.41 At the fine-grained level, accessibility is affected by the quality of the pedestrian conditions and the clustering of activities within a site or small district area, where people can walk to the destination without needing to drive. At the neighbourhood level, accessibility is affected by the quality of footpaths, street connectivity, geographic density and mixed-use developments; for example, a more accessible local community will tend to have shops and public services (e.g. schools) within or adjacent to residential areas. Accessibility is affected at the third level by street connectivity, public transport services, geographic density and the spatial mix of developments; a more accessible region will have a network of many roads (rather than just a few major routes) and efficient public transport services that make it convenient to travel within the region by car or public transport. At the interregional level accessibility refers to the quality of main arterial routes, highways, air service, bus and train service, and shipping services.
- 2.42 In practice, these typologies need to be linked to the decisions required at each level: within communities, neighbourhoods, and larger administrative areas. This means that applied accessibility measures need to be closely related to the relevant policies and required decisions.

#### Measuring Current Accessibility Performance

- 2.43 Since accessibility is a function of opportunity and separation/transport deterrence, accessibility measures can be expressed in either the units of the opportunity (e.g. number of jobs accessible to group X) or the units of the transport deterrence (usually time or generalised cost, e.g. average time taken to reach a hospital).
- 2.44 The opportunity units are generally easier to understand where the units have some recognisable meaning, such as number of people or jobs (DHC 2000). Measuring accessibility in terms of generalised cost allows measures for different trip purposes to be combined since the same units are used for all trip purposes. At its more complex level composite utilities have been used in some studies to measure the overall “value” of accessibility (Weibull 1980). However, such sophisticated measures are not very meaningful to local practitioners or population groups when applying accessibility planning in practice.

### **Accessibility Need**

- 2.45 Studies of transport and social inclusion highlight many different accessibility needs (SEU 2003), and various approaches have been taken to measuring need by researchers. These fall into two main categories, as discussed above:
- The normative approach
  - The behavioural approach
- 2.46 The normative approach is generally based on some assessment from a non-transport sector, related to the competitiveness of a location or people group, or based on basic human needs. The behavioural approach seeks to assess the value of these needs as they are expressed through observed behaviour – while recognising that ‘revealed’ behaviour may not always be a good measure of ‘preferred’ behaviour.
- 2.47 The normative approach often defines what are called community or social accessibility measures, and these are common in government policy, e.g. the well established 2-3 mile distance thresholds over which students are offered free school transport<sup>2</sup> (DfT 2002). They usually seek to set standards or targets for improving accessibility e.g. to increase the number of people within 20 minutes walk of a health centre. Although these are often set in the absence of behavioural research (DHC 2000), the most useful measures of community need are based on research about what might be realistic accessibility goals.
- 2.48 The behavioural approach to measuring accessibility need has been approached both from the perspective of utility maximisation and social inclusion.
- 2.49 Niemeier (1994) and Handy and Niemeier (1997) adopted a consumer welfare approach to measuring accessibility, by linking individual travel behaviour with journey-to-work mode and destination choice. The approach joined a multinomial logit model (the transport model) and a compensating variation model derived from econometrics. The aim was to assign a value to accessibility i.e. the monetary “worth” of accessibility for the journey-to-work trip.
- 2.50 Van Wee *et al* (2001) noted that the impacts of accessibility change on social inclusion in this work had been underestimated, since the authors did not take into account competition for jobs within the employment market. The imbalance between jobs and employees in any area was found to be more important than had been thought, once the measures were corrected for competition within employment markets.

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<sup>2</sup> But only if the pupil attends the nearest available school within that local authority area, thereby limiting subsidised access to one destination.

- 2.51 In many cases, it has been more convenient to define need by comparing the accessibility of one location with another. Currie (2003) described this comparative accessibility in terms of the 'Public Transport Needs Gap' within Hobart, Tasmania. The project measured the geographical distribution of transport need in the community, and assessed the distribution and quality of the public transport services provided. In common with similar studies elsewhere (DHC 2001), it was found that the gaps varied by trip purpose.
- 2.52 To ensure that all these various needs are considered within the appraisal process, the Scottish Executive has identified four types of accessibility need (SE 2003):
- **Expressed accessibility** or revealed accessibility need – A need is revealed by observations of travel behaviour. This does not identify gaps in networks (since if there is a gap then people cannot travel and are not observed travelling), but it helps to benchmark social norms - such as how far, on average, different people groups travel for shopping.
  - **Community accessibility**, social accessibility, or potential accessibility need allows standards of accessibility to be defined in absolute terms, based on an assessment of society's expectations of basic needs. Different communities have different needs, and the term "option value" (SRA 2003) is sometimes used to describe the value a community places on accessibility, even when it does not express this through use.
  - **Stated accessibility** need can be different from community or comparative accessibility, and it is important to consider since it affects the implementability of initiatives to improve accessibility and, perhaps more importantly, people's views often reveal needs which have not been identified or measured using these other techniques.
  - **Comparative accessibility** need looks at the distribution of access opportunities or accessibility gaps by people group and location. Comparative need can be assessed using expressed, community or stated measures and in practice common messages from all three approaches define how to close accessibility gaps to tackle social exclusion.
- 2.53 The community accessibility approach has been most widely used in rural areas to define minimum accessibility standards to a small selection of local services which are frequently used by people, such as post offices, health centres, shops, and perhaps more complex opportunities such as leisure facilities, parks, and the countryside (CA 2002). Since comparative needs define where interventions are most required within a study area or funding programme, they have a key role in accessibility audits (DHC and TSG 2003).

- 2.54 Overall, it is not possible to identify every need for every group, since there are potentially many hundreds of combinations of people groups, times of day, trip purposes and travel behaviour preferences which could be relevant to the analysis. Practical definitions of accessibility need to optimise the choice of population sectors, geographical coverage, spatial detail, and trip purposes, to reflect policy issues which are sensitive locally.
- 2.55 This audit and targeted delivery process is at the core of accessibility planning (SEU 2003), which is intended to “offer a new way to find and solve local problems, checking whether people experiencing social exclusion can reach the services they need, and identifying action to take if they can’t”.

### **3.0 Accessibility Parameters**

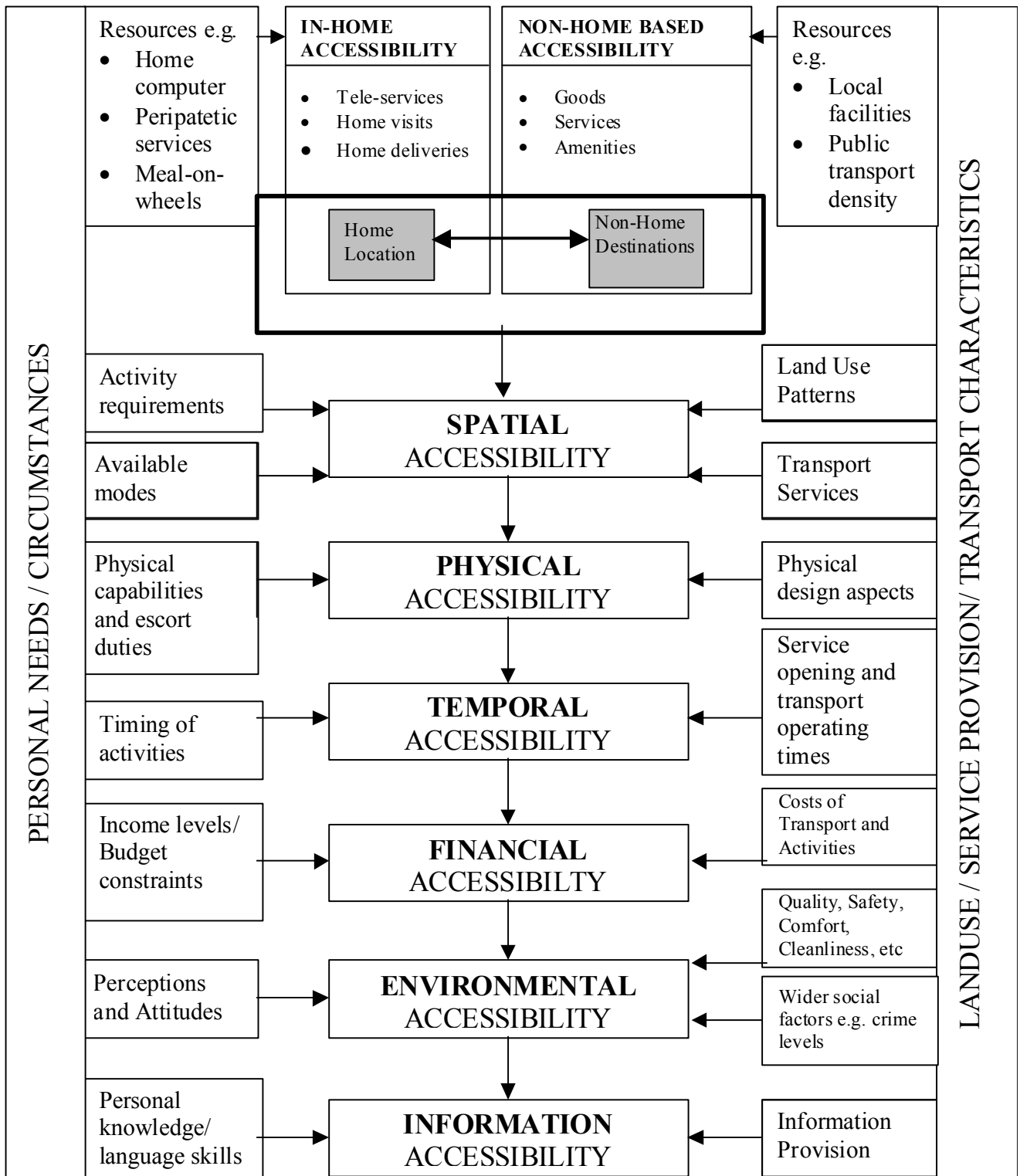
- 3.1 At a practical level it is clear that a systematic approach is needed to overcome all the barriers to accessibility, and the typology in Table 2.3 introduced six principal parameters that defined the ability of the transport system to connect people with opportunities as follows:
- Spatial
  - Temporal
  - Financial
  - Physical
  - Environmental
  - Information
- 3.2 For each of these parameters, the interaction between personal needs and circumstances, and the local infrastructure, land use and transport may result in barriers to accessibility, as shown in Figure 3.1.
- 3.3 At the core of Figure 3.1 is the distinction between in-home accessibility (where services are delivered in the home, physically or electronically) and non-home accessibility, where an individual travels to a destination. Most work on barriers has been carried out for the latter situation, although a number of these barriers may also be relevant to in-home accessibility; for example, timing of service provision, cost, and awareness of the options.
- 3.4 This chapter briefly summarises findings from travel behaviour research about the influence of each of these types of barrier on non-home accessibility, and about issues relating to data needs and availability.

#### ***Accessibility Barriers***

##### Spatial

- 3.5 Spatial barriers relate to the distances involved in accessing required goods and services.
- 3.6 The geography of space and time is changing as people seek to do more in less time. As faster travel options have become available, people have generally travelled further. Some have argued that the policy focus on improving provision for mobility has actively encouraged urban sprawl (Handy 2004), since local destinations have become less attractive relative to longer trips. Within this fast changing economic geography, the stability of travel time budgets is interesting and potentially useful in analysing accessibility (Noble and Potter 1998). If travel time is relatively fixed, then this defines the boundaries of the space within which opportunities can be accessed.

Figure 3.1 – Parameters of Accessibility



- 3.7 Stradling (2002) suggests that around 10,000 miles per year appears to be a pivotal level of car use for English drivers, below which most drivers would like to use their cars more and above which they would like to use their cars less. At an average car speed of about 40mph, 10,000 miles would account for about two thirds of the average one hour a day travel time budget. Handy (2002) notes that, on average, car drivers in the USA spend 56 minutes per day in a car and that this is progressively replacing other forms of travel.
- 3.8 Trip complexity is also growing, with journeys increasingly being composed of trip chains. Rather than simply travelling between home and work, people add in additional stops (to go shopping, visit friends, etc.). Many studies have found that trip chaining is also more common and more complex among car users than public transport users,. If public transport services cannot adapt to these new requirements, then accessibility maximising policies may require the restructuring of travel into simpler types of trip chains (Hensher and Qeyes 2000, Jones 2002a).
- 3.9 Handy (2004) suggests that the policy aim should be to improve accessibility by maximising interaction between people and activities within communities. This is based on some evidence in the US that the type of built environments and travel behaviour are closely related. Where people can access opportunities closer to where they live they do so, and tend to use slower modes.
- 3.10 However, Handy also notes that, although some have suggested that land use planning can be used to influence travel behaviour (Cervero 1989), it is not yet clear whether changing the built environment actually leads to changes in travel behaviour, or simply that people are choosing the type of lifestyle they want. For example, people who want less car dependent lifestyles choose to live in locations where there is good local non-car accessibility, and those who want more car dependent lifestyles operate within much wider boundaries of space and time.
- 3.11 The evidence is, however, unambiguous that market forces acting in isolation will tend lead to a decline in accessibility for many people, since markets operate within narrower boundaries than the broader social and economic needs which characterise sustainable development (Halden 2005).
- 3.12 Within any population group, travel demand and accessibility by any mode are strongly correlated (Ecotec 1993). The ability to reach clearer conclusions about these relationships requires more studies setting transport and accessibility within wider lifestyle choices (Lyons 2004).

### Temporal

- 3.13 Temporal barriers arise in two contexts: (i) when there is a mis-match between the times at which services (including public transport) are available, and people are able or willing to access them, and (ii) when the required travel times exceed some maximum threshold of practicability or acceptability.
- 3.14 Even without changing the spatial geography of an area, accessibility can be significantly improved by scheduling service delivery and transport provision jointly. The Department of Health in England (George and Rubin 2003) highlights that patient non attendance at three trial sites was reduced by between 50% and 85% by the introduction of booked appointments. Although booked appointments involve ownership and capacity building to achieve these benefits, the basic principle is a negotiation on scheduling.
- 3.15 Flexibility within employment packages on factors such as working hours can improve accessibility by allowing people to travel when it is convenient and feasible (DHC 2003). In contrast, inflexibility in school opening and closing times has been identified as a major factor affecting the quality and affordability of school transport in the UK relative to other countries (SEU 2003).
- 3.16 In rural areas, greater flexibility in scheduling for public transport is being achieved through wider deployment of demand responsive transport services (Enoch 2004). Where traditional approaches using fixed route services might not permit a return trip to shops or to the doctor, the demand responsive solutions allow travellers to book the services at times convenient to themselves.

### Financial

- 3.17 In debates about the cost of travel as a factor affecting accessibility, the emphasis is often on affordability (SEU 2003); in the UK, the steady rise in the cost of bus fares relative to declining motoring costs has changed the balance of car to non car accessibility in favour of the former.
- 3.18 Travel costs for some groups are a much more significant barrier than for others. Access to work for low paid employment will only be practical if fares are low enough to make the employment option attractive. As a result, people with low income jobs tend to work much closer to home, with household expenditure surveys showing that people do not generally spend more than 10% of their income from employment on accessing that employment.
- 3.19 Transport costs are the largest expenditure associated with participation in post-16 education. In 1999, the average annual (education-related) transport costs for 16 to 18 year olds was £371 (around £10 per week during term time). Nearly half of 16 to 18 year old students say they find their transport costs hard to meet (Callender 1999).

- 3.20 The main instrument used to reduce the cost of public transport for targeted social groups is concessionary fares; however, these are not always targeted as effectively as they could be, and arbitrary administrative boundaries can limit access to a variety of key destinations that are spatially close to people, but lie outside the administrative boundaries of the area in which they live (Lucas et al 2001). Also, the time restrictions placed on the use of concessionary fares can mean that job seekers and low paid workers are prevented from accessing employment in the early morning, and elderly people cannot afford to pay the full fare that is required to access early morning health appointments.
- 3.21 Overall, however, for most people cost seems to be prioritised less highly than journey time in the case of access to healthcare services. Even amongst deprived people, taxis are often used for health journeys (DHC 2001).
- 3.22 The local spatial availability of services is much more critical in relation to maintaining healthy lifestyles, and a decline in local facilities within walking distance has been associated with a rise in obesity and other health problems. However, the decline in local shopping facilities has also in part been associated with consumer resistance to higher costs at local stores than in big supermarkets (Dowler 2002).
- 3.23 Financial, spatial and temporal barriers are therefore closely related. However, attempts to calculate generalised costs to consider cost and time together within models tend to be limited to using average values of time. These do not generally reflect financial hardship, since values of time for disadvantaged groups are very different from the average values normally used (Metz 2005).
- 3.24 When considering financial barriers to access within accessibility planning, it has been suggested (DHC and UoW 2004) that the best measure is to use comparative accessibility and sensitivity tests, to compare whether there are financial barriers to access by people groups and trip purposes. These tests should consider differences by ticket type, administrative areas, ranges of cost in the absence of cost data, variations by people group, eligibility for tickets and cost sensitivity to single or multiple operator journeys.

### Physical

- 3.25 Physical accessibility barriers are often perceived to be the easiest to understand, and these can be classified in terms of the assistance which people require to make a journey using any particular mode. For example, a wheelchair user may only be able to cross kerbs with assistance from another person, and a blind or deaf person may need aids such as a guide dog or a hearing aid. A useful classification of assistance is provided by Tyler (2002):

- No assistance - people can travel alone without the need for any technical or personal assistance
  - Technical assistance – people can travel alone if they have technical assistance, such as a wheelchair or hearing aid.
  - Localised personal assistance – people can travel alone if they have some personal assistance at specific points e.g. to board a train.
  - Continual personal assistance – people can only travel if they are accompanied by someone throughout the journey.
  - Specialised full assistance – Specialised assistance is needed throughout the journey.
- 3.26 Tyler notes that there are two main ways to close the physical accessibility gap: by making conventional transport more accessible to more people; and by providing separate specialised transport (which may also be necessary where a person has trouble reaching the bus stop or railway station). Here the gap in provision where a new initiative is required is defined by the trips that cannot be made using either conventional or specialised services.
- 3.27 From an accessibility planning perspective, however, it is also important to take into account any physical access restrictions associated with the location of the activity itself; for example, is the building/site wheelchair accessible?
- 3.28 Physical restrictions can also apply to varying degrees to fully mobile people, particularly when carrying heavy shopping, or being accompanied by young children. However, there is a wide spread within the population of acceptable limits, which makes the setting of thresholds difficult. Nevertheless, based on the current user market for buses, surveys show that usage drops off sharply with walk distances to bus stops of more than 300 metres (DoE 1995).
- 3.29 To allow assessments to be made of acceptable walk distances, transport appraisal guidance (SE 2003, WAG 2002) provides indicative thresholds, as shown in Table 3.1. The guidance notes that the distances will be less for older people and those with mobility impairments. Acceptable walking times will be lower where there is no dedicated footway. Walking distances will also be highly dependent on topography and other factors. For cycling thresholds and times, the guidance suggests that distances will be typically two or three times the values for walkers.

**Table 3.1 - Indicative criteria for acceptable walking distance**  
(adapted from WAG 2002 and SE 2003)

<i>Aspect of travel</i>	<i>Time and (Distance)</i>
Walking to facilities	20 mins (1.4 - 1.6 kms walk)
Walking to bus stop (urban)	5 mins (300-500 metres walk)
Walking to bus stop (rural)	10 mins (600-1000 metres walk)
Walking to railway station	10 mins (600-1000 metres walk)

Environmental

- 3.30 Both real and perceived safety, comfort and quality affect accessibility throughout the journey. Waiting for buses in threatening locations is identified as a potential barrier for some people (DETR 2000), but the thresholds at which safety, quality and comfort act as a deterrent for any group of people is not clear from the research (UoW 2004).
- 3.31 Road traffic can act as a significant barrier to people, and where vehicle flows are higher there can be a significant accessibility benefit from providing road crossing facilities, particularly for use by vulnerable road users (DETR 1995). Indicative flows for roads that might comprise an accessibility barrier to pedestrians wishing to cross, or where cycle facilities are needed, are shown in Table 3.2 - although it is noted that these values are highly sensitive to local conditions.

**Table 3.2 – Traffic Barriers to Walking and Cycling**

	<b>Value for significant barrier</b>
<i>Walking</i>	
Significant traffic barrier (traffic flow)	Above 9000 - 12,000 vehicles per day
Slight barrier	2,000 to 9,000 vehicles per day
Quiet road	Below 2,000 vehicles per day
<i>Cycling</i>	
Road considered unsafe (2 lane <3m width)	10,000 vehicles per day
Road considered unsafe (wider road)	20,000 vehicles per day
Road speed considered too fast (2 lane <3m width)	40 mph limit
Road speed considered too fast (wider road)	50 mph limit

- 3.32 Providing support services when travelling, such as catering or business services such as wireless internet and power sockets, can change the travelling environment so significantly that people become much less sensitive to travel time. Research is currently underway to explore these issues (Lyons 2005).

Information

- 3.33 Information can help to reduce many of the uncertainties that can act as barriers to public transport use. Not only is basic information useful, such as greater certainty about journey times and dropping off and

picking up points, but also about the quality of the journey e.g. availability of a seat.

3.34 Concern about where to find public transport services, and that services may be cancelled or not be running on time, have been identified as significant barriers to bus use (Wardman et al 2001).

3.35 Other information factors that affect accessibility include:

- Comfort of waiting areas and vehicles
- Assistance and helpfulness of staff
- Information availability from which to plan journey
- Time spent planning and booking journey
- Availability of information during journey

### **Key Barriers by Person Group**

3.36 With so many potential accessibility barriers, it is nearly always necessary to focus on a few of the most important barriers for any particular person group. Between 1998 and 2000, a series of studies were undertaken on the specific transport concerns of different groups (e.g. DETR 2000; DETR, 2001) which provides a useful guide. These were reviewed (DHC and TSG 2003) and summarised as set out in Table 3.3.

3.37 Most of the studies centred on the transport problems of disadvantaged groups and used predominantly qualitative methodologies. This makes the application of the findings within accessibility analysis more difficult, but the results still help to identify the extent and severity of the problem for different types of people and places. These issues are explored in more detail in Working Paper 1 (Wixey *et al*, 2005).

3.38 New approaches to accessibility planning (e.g. as defined in DfT 2005), aim to ensure that there is a clear and systematic approach for identifying and tackling the barriers that each people group faces, particularly those likely to be most disadvantaged in accessing jobs and key services. To achieve this, partnership in delivery is needed, involving particularly those in the land use planning, health care, education and welfare to work sectors. The approaches recognise that accessibility planning is not just about improving transport, but about ensuring that jobs and services are delivered where and when they are needed.

**Table 3.3 – Priority Transport Concerns by Person Group**

	Children 5-11	Young people 12-18	Job seekers	Black and minority ethnic	Lone parents (women)	Disabled people	Older people	Rural dwellers	Urban dwellers
No car		**	***	***	*			***	*
Cost of motoring		*	*	*	*			**	
No/poor PT		*	***		*	***	**	***	**
PT access difficulties	*				***	***	***		
PT reliability			***			*			**
Personal security	**	***		***	**	***	***		***
Cost of fares		**	**		**	*	*	**	**
Driver attitudes	**	***		***	**	***	***		
Lack of information			**	***					**
Accidents (fear of)	***				***		***	*	***
Pollution/ health concerns	***			*	***				**
Reduced opportunities	***	***	***	***	***	***	***	***	***

3.39 For this systematic audit there are some factors that can usually be quantified:

- travel time;
- cost of travel;
- location of facilities and services;
- method and timing of service delivery;
- some environmental, health and safety factors;

3.40 Other factors which may be at least as important, but where quantification has proved to be more difficult or impossible, include:

- transport reliability
- fear of crime;
- knowledge of available travel and service choices;
- travel horizons.

- 3.41 Although the unquantifiable factors may be at least as important as the quantifiable factors, the remainder of this report concentrates on accessibility analysis indicators that represent the directly quantifiable elements.

***Journey Information Available to Travellers***

- 3.42 By far the most common form of accessibility analysis is carried out by individuals using their local knowledge, paper maps and timetables, or computer based journey planners, to identify what opportunities they can reach.
- 3.43 At the level of the information needs of the individual, a very wide range of detail is now available within the better existing journey planners (Austin Analytics 2001, DHC 2005). Table 3.4 summarises the kinds of information provided in relation to the six main accessibility parameters above. Three ticks indicate major relevance, two ticks include significant relevance and one tick indicates some relevance. The individual can interrogate this type of database, to obtain the precise information that they require.
- 3.44 However, in a planning context, when investigating the current levels of accessibility available to different population groups over a large geographical area, it is not possible to customise the analysis in this way, for each individual. When looking at large numbers of people, trade offs need to be made between the type of information available and the type of information needed. Different accessibility analysis and modelling approaches have approached these trade-offs in different ways, as next discussed in Chapter 4.

**Table 3.4 – Types of Personal Journey Information**

	<b>Spatial</b>	<b>Temporal</b>	<b>Financial</b>	<b>Physical</b>	<b>Environmental</b>	<b>Information</b>
Opportunities and activities at the destination	√√					√
Travel time	√√					√√
Scheduling e.g. target departure or arrival time or both, arrive before, depart after, departure or arrival during a specified period		√√√				√√
Travel cost and fares taking account of travel cards and concessions, fares restricted by quota, season ticket options and time of day restrictions.		√√	√√√			√√
Interchange points by facilities available e.g. shelter, information, staffed/porters, availability of luggage trolleys, CCTV.				√√	√√√	√√
Interchange options e.g. minimum time accepted for interchange, restrict interchange options between modes or operators, restrict the number of interchanges acceptable, availability of guaranteed connections.	√	√		√√√	√	√√
Route choice: minimum time, minimum cost, least amount of walking, include or exclude modes, avoid a location or route via a location, etc.	√√	√√	√√		√	√√
Mode choice, bus, rail, ferry, air, bespoke services (school transport, patient transport)	√		√		√	√√
Day of the week, seasonal variations	√	√√√				√
Real time updates and reliability e.g. congestion, roadworks, delays	√				√	√
Health information e.g. calories used				√√		√
Environmental information e.g. emissions associated with the journey					√√	√
Confidence building information e.g. to confirm the validity of the results with map based presentation, emergency telephone numbers in the event of problems					√√	√√
Type of vehicle e.g. low floor bus, luggage carrying capability				√√		√

## 4.0 Accessibility Analysis Approaches

4.1 This chapter includes:

- A summary of the main categories of models and analysis tools that can provide useful measures of accessibility.
- An overview of the main structural differences between the different categories.
- An indication of where the two local authority accessibility analysis tools, CAPITAL and PTAM (that have been modified as part of this project) fit into this overall classification.

4.2 A primary distinction is made in this chapter between land use/transport **models** and accessibility analysis **tools**. The models seek to identify relationships between (changes in) transport/land use provision and resulting (changes in) travel and activity behaviour; whereas the tools use similar kinds of data on provision to develop measures of accessibility – but do not attempt to relate this to patterns of behaviour.

### ***Land Use/Transport Models***

4.3 The main problem encountered in trying to categorise land use/transport models in relation to accessibility, is that accessibility has traditionally been perceived as a useful but secondary output from a very wide range of models which could all technically be regarded as accessibility models.

4.4 Simmonds *et al* (2001) provide a useful classification of land use/transport models according to the complexity and sophistication of the way in which the transport and land use dimensions are handled (Table 4.1).

4.5 Transport sophistication increases from the simple sequential, four step trip-based models, to more activity based approaches where trip chaining is included. Within these transport models, there is a trade off between the operational detail of the micro-simulation approaches and the range of policy factors to which the models are sensitive.

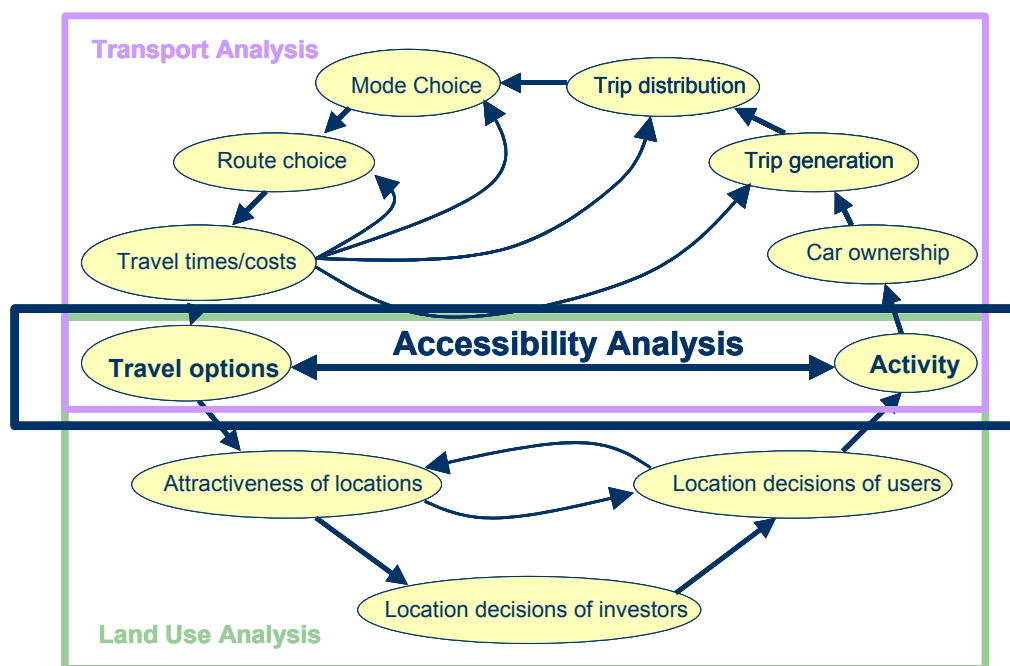
4.6 The land use dimension, at its simplest, involves land use forecasts being provided as exogenous variables, simply as an input to the transport model; but the more complex model structures allow some degree of iteration between the land use and transport components.

**Table 4.1 – Land Use/Transport Model Classification**

		Transport							
		four-step (traditional)			aggregate		micro-simulation		
		standard	enhanced	Complex	tour	activity-travel	tour	activity-travel	
Land use	one-way	factored	Numerous examples of conventional four-stage models based on "planning data" prepared using factored, simple or intermediate methods			APRIL (London) TRAM (Bristol)			
		simple				Boise	San Francisco		
		intermediate		Sacramento	Edmonton				
	Connected	intermediate		many DRAM applications	[Sacramento UPLAN]				
		market-based		Eugene-Springfield UrbanSim		Santiago; GMSPM and Edinburgh DELTA/START	Merseyside New York	Portland Metro	
	Integrated	aggregate economic (spatial IO)		many MEPLAN and TRANUS applications	LASER; Sacramento MEPLAN	TPCM and SWYMMS DELTA/START		Ohio Statewide	
		disaggregate economic (micro-simulation)							Oregon Statewide; [Calgary]

From Hunt 2000 in Simmonds et al 2001

4.7 Figure 4.1 illustrates how accessibility analysis relates to the main stages in land use and transport modelling. The top half of the diagram shows how the various components of travel choice can feed into the measure of separation used in the measurement of accessibility, while the bottom half of the diagram shows how the land use analysis can provide information on activity characteristics to input into the accessibility measure.



**Figure 4.1 – The Classic Stages in Transport/Land Use Modelling, and Their Relevance to Accessibility Analysis**

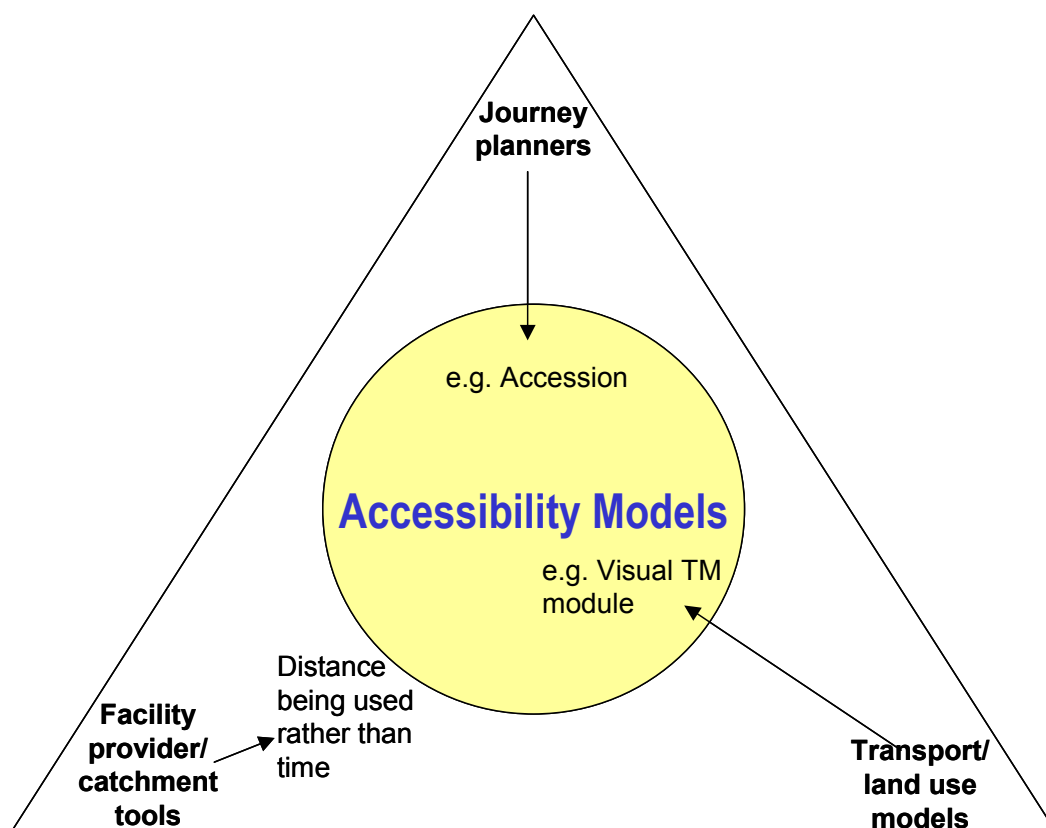
4.8 The key point from this is that even the simplest approaches to land use and transport modelling produce accessibility measures. The more accurate and detailed the land use and transport modelling representation of local conditions, the more accurate and policy relevant are likely to be the resulting accessibility indicators.

4.9 It is impractical to have models that cover everything well, so there are no examples of integrated land use and transport models that include complex trip chains and detailed representation of services and networks. Yet, accessibility analysis needs to consider all of these parameters, so simpler approaches are needed where the components of accessibility are considered separately, without the need to forecast impacts on behaviour.

### **Accessibility Models vs. Journey Planning Tools**

- 4.10 There are two main stages to practical accessibility analysis:
- To calculate in an appropriate way the separation between the zones in a specified zoning system, using a specified set of modes between each of the zones in the analysis.
  - To link this measure of separation with land use and population data to present accessibility indicators.
- 4.11 In chapter 2 it was noted that different professional groups have approached these tasks in different ways. Transport planners have concentrated on how people travel, and other public and private service agencies have concentrated on who is travelling and for what purpose.
- 4.12 Users, meanwhile, have demanded a more comprehensive approach, and have driven a market for journey planners, which provide much more comprehensive information that is customised to specific information for individuals.
- 4.13 These three strands have driven three different modelling/analytical approaches, as shown in Figure 4.2.

**Figure 4.2 – The Range of Accessibility Models and Tools**



- 4.14 The journey planners have provided most detailed data about the characteristics of transport systems, whereas the transport/land use models have traded accuracy about individual journeys to achieve wide geographical coverage. The facility providers (non transport agencies) have tended to use crude proxies for transport provision, such as road mileage or crow flies distances, but have retained more detail about people (customers) and places (services/facilities). However, these latter methods are now improving, with journey times increasingly being used (e.g. Copus 1999 - A New Peripherality Index for the NUTS III Regions of the European Union).
- 4.15 With the continuing development of each approach, there is an increasing convergence of agreement on the sort of accessibility information that they need to provide (e.g. on the appropriate measure of accessibility to work for unemployed people). However, the underlying purposes and bases of the journey planning tool relative to the transport/land use model means that there is an essential difference between the two approaches in the handling of time periods and scheduling.
- 4.16 This can be characterised as follows:
- The need to specify a precise time of day and day of the week is essential for journey planning enquiries, but separate runs of the tools would need to be carried out and averaged across the week to obtain a reliable overall picture of strategic accessibility for planning purposes. In different types of area, the number of runs required to obtain a consistent picture of overall accessibility varies, and further runs may need to be undertaken until convergence is achieved. Since this needs to be managed manually, for a very large number of locations and time periods, this results in such an analysis being extremely time consuming. Alternatively, the analysis could be undertaken for externally selected time periods and location pairs, which could jeopardise the accuracy of the exercise.
  - Transport models typically use service frequencies rather than schedules to describe the provision offered by public transport networks. Although the frequencies are very broad averages, they are estimated by, or for, the model using the public transport timetable for the specified period, which could be a narrow time band or the entire week. Although this is a very much less accurate approach than the schedule based method, it significantly simplifies the analysis process and is likely to be practical in more situations.
- 4.17 If accessibility methods are to be successful in replicating the conditions confronted by people in everyday life, then perhaps the most important aspect will be to ensure that real journeys involving multiple destinations can be analysed. Although, in principle, trip chains could be considered

within the journey planning approach, again this needs to be specified externally to the tool; so, in the short term, the frequency based approach within transport/land use models that can handle tours may offer the most practical approach.

- 4.18 The transport/land use model based approach also potentially allows supply/demand relationships to be included, as part of the accessibility planning process. There could be a danger in urban areas, with just using an accessibility tool, that new services might be planned which were either not viable or which were overwhelmed with demand. However, this is an evolving area where further work is required before successful approaches can be demonstrated (DHC and TSG 2003).

### ***UK Accessibility Planning Tools***

- 4.19 Most of the new breed of accessibility planning tools has originated in the form of simplified journey planning approaches, using Ordnance Survey land use information and public transport timetable data to define networks and services. The tools calculate journey times for people within a zone, for some specified time of arrival or departure, taking account of walk times to cars or public transport services, wait times, and in-vehicle times. The main constraint on most of these tools has been that users have generally been limited to analysis of one origin or one destination at a time (i.e. these tools tend to be point/zone to multiple points/zones).
- 4.20 There are many such accessibility planning tools, with the best known being the MVA model ACCMAP, but Halcrow, Mott Macdonald, Brown and Root and Colin Buchanan and Partners all have products with similar routing capabilities. Most of these tools can link the calculated journey times to GIS packages to allow thematic and contoured maps to be presented. However, the functionality available for editing networks and data and presenting results varies substantially.
- 4.21 The two accessibility planning tools adapted as part of this project (i.e. PTAM and CAPITAL) are of this general type, although they differ in coverage and complexity. Both can provide measures of accessibility to single points or to related sets of points (e.g. hospitals) and are described in more detail in Appendix A of this report.
- 4.22 PTAM, used by METRO, was limited to measuring bus network accessibility, but time periods are built directly from bus timetable data, so these can be readily customised for time of day and day of week. Walk access to bus stops is measured as a simple, straight line distance, and so represented as a circle around each stop.
- 4.23 CAPITAL, developed by Transport for London, currently uses only morning peak period data, but it calculates shortest time routes between two zones using any combination of public transport modes (i.e. walk,

bus, underground, DLR and national rail), and incorporates a detailed walk network to bus stops and railway stations.

- 4.24 Recently, a substantial investment has been made in the ACCMAP package by DfT, to create a new tool called Accession, which has the ability to calculate many more origin and destination combinations and to output a wider range of indicator types.
- 4.25 Some of the main problems with the current products that the DfT investment in Accession has sought to resolve are:
- Although most products can calculate and present travel times from a single destination to many zones, the use of such tools to calculate accessibility for multiple trip purposes to multiple destinations is very time consuming, particularly where destination quality varies and there are a large number of potential destinations.
  - Many include subjective views of need, making their use in accessibility planning problematical, particularly where objective measures are needed; e.g. SONATA (Steer Davies Gleave).
  - Representation of demand responsive services is problematical; and
  - Data importing, validation and network editing has been very time consuming.

#### PTALs

- 4.26 PTALs, or 'Public Transport Accessibility Levels' was developed by the London Borough of Hammersmith and Fulham as an aid to decisions about the suitability of specific sites for redevelopment at different densities, and is now widely used across London.
- 4.27 It differs from the other accessibility models and planning tools described in this review, in that it deals only with accessibility of public transport *at a point* and not between places – it takes no account of where access is provided to, and is thus only useful in areas with dense and comprehensive public transport networks.
- 4.28 Each site is scored on a six-point scale using a set formula, which takes into account: walk time to nearby public transport services, the number of services available, average waiting time and service reliability.

#### ***A Comparison of the Functionality of Transport/Land Use Models and Accessibility Tools***

- 4.29 Using the information categories available from the journey planners, as set out in Table 3.4, Table 4.2 summarises the comparative coverage of the transport/land use models and the accessibility planning tools. The transport model category has been taken to include all demand models, whether transport only or land use and transport (LUTI).

**Table 4.2 – General Capabilities of Models and Tools**

<b>Analysis Capability</b>	<b>Transport/Land Use Models, including LUTI Models</b>	<b>Accessibility Tool e.g. Accession</b>
Opportunities and activities at the destination	No methodological reason why data cannot be included	Increasingly assisted data import facilities for a wide range of data sets.
Travel time	Times between centroids of zones with zone connector times being calculated from the area of the zone.	Times between either points or centroids of zones
Scheduling e.g. target departure or arrival time or both, arrive before, depart after, departure or arrival during a specified period	No	Yes – specified by user
Travel cost and fares taking account of travel cards and concessions, fares restricted by quota, season ticket options and time of day restrictions.	General and broad assumptions rather than actual ticket costs	Possible, but data problems
Interchange points by facilities available e.g. shelter, information, staffed/porters, availability of luggage trolleys, CCTV.	No	Limited
Interchange options e.g. minimum time accepted for interchange, restrict interchange options between modes or operators, restrict the number of interchanges acceptable, availability of guaranteed connections.	Can sometimes be specified.	Can generally be specified
Route choice: minimum time, minimum cost, least amount of walking, include or exclude modes, avoid a location, route via a location or locations, etc.	Route and mode choice usually based on generalised cost so average values of time can reduce accuracy for some groups. However minimum time routing often possible. Limited trip chaining allowed.	Route and mode choice generally minimum time path.
Mode choice, bus, rail, ferry, air, bespoke services (school transport, patient transport)		
Day of the week, seasonal variations	Not explicit unless user seeks information	User specified.
Real time updates and reliability e.g. congestion, roadworks, delays	No	No
Health information e.g. calories used	Occasionally	Occasionally
Environmental information e.g. emissions associated with the journey		
Confidence building information e.g. to confirm the validity of the results with map based presentation, emergency telephone numbers in the event of problems	Yes	Yes
Type of vehicle e.g. low floor bus, luggage carrying capability	No	Limited

4.30 Overall, as can be seen, much of the information available to travellers through journey planners is increasingly being made available through transport/land use models and accessibility planning tools.

## 5.0 Indicators

- 5.1 In this chapter a typology of accessibility indicators is described. There are many hundreds of published indicators of accessibility with different names, source data, uses, and calculation methods (DHC 2000). However, as described in Chapter 2, the units of measurement are either the opportunities being reached or the measure of separation of the means of reaching them, so there are two basic types of indicator based on this classification.
- 5.2 Chapter 2 also noted that, if accessibility policy is intended to improve the “ease of reaching” activities, then the indicators need to mirror this. If, however, accessibility policy can be defined more explicitly in terms of people’s “ability” to reach, or it can be specified what is “reasonable”, then this can allow thresholds to be set for either travel times or target levels of opportunity, or both.
- 5.3 This then gives a basic typology of indicators:
- Opportunity measures
- Type 1 - Catchment/contour
  - Type 2 - Continuous measures
- Time/Cost/Value measures
- Type 3 – Opportunities within space time boundaries
  - Type 4 - Utility based measures
- 5.4 Within each of these there are many levels of detail and choice of parameters which affect how accessibility is then measured.
- 5.5 In Chapter 2 it was suggested that generalised cost or time are not particularly useful concepts when looking at socially excluded people, since the effort involved in calculating a suitable value of time for each group, to allow cost and time to be combined into one measure, is far greater than considering each issue separately.
- 5.6 Most accessibility analysis tools currently therefore use simple travel times, adding up the various components unweighted.
- 5.7 In the remainder of this chapter we briefly review contour measures, then continuous measures of separation, followed by space-time measures and utility-based measures.

### **Type 1 – Contour measures**

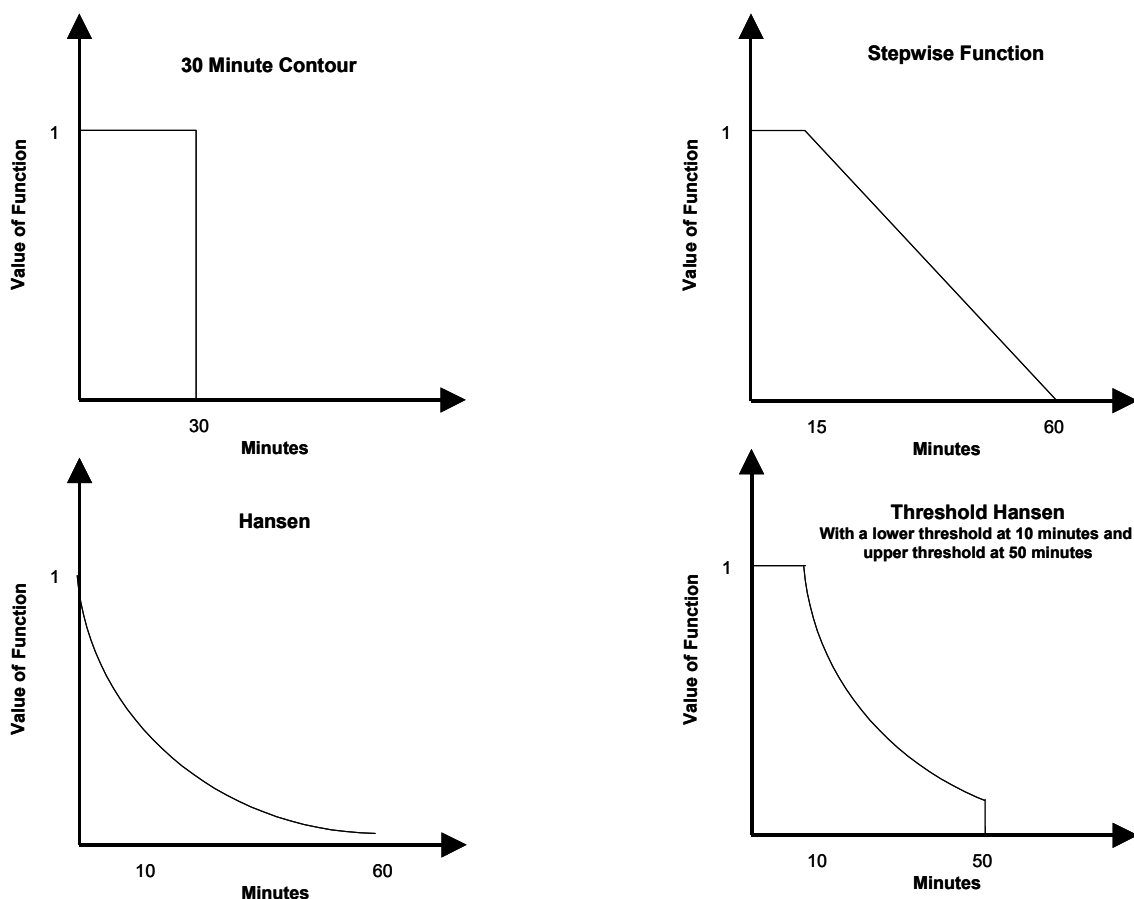
- 5.8 In many cases it is possible to agree travel time thresholds that are consistent with relevant policy objectives, for example, as DfT has done with the national indicators in England. Geurs *et al* (2001) suggest the main advantage of contours is that they present an easily explainable

accessibility measure without implicit assumptions about a person's perception of transport, land use and the interaction of these two. However, Vickerman (1974) and Ben-Akiva & Lerman (1979) note the limitation that they assume that all opportunities (e.g. jobs) within the fixed threshold time are equally desirable, regardless of the time spent travelling to reach them.

- 5.9 There are many situations where continuous measures, which take account of the 'distance' required to reach a facility, are preferable.

**Type 2 - Continuous deterrence measures**

- 5.10 The main advantage of continuous measures is that they can be fitted with reasonable accuracy to the observed behaviour for any group, so they represent more than just a 'social' view of need.
- 5.11 To support accessibility planning in England, the form of the (optional) continuous measures that are used in Accession is a Hansen measure, as shown in Figure 5.1.



**Figure 5.1 – Alternative Deterrence Functions**

- 5.12 The contour threshold function is often perceived to be easier to understand, but cannot generally be fitted to observed behaviour; while the stepwise function can be easily fitted to behaviour, but is harder to present and understand. The threshold Hansen has the best fit with behaviour, but is harder to understand. For this reason, the simple Hansen measure has proved to be the best compromise between calibration and ease of understanding and has been widely applied.
- 5.13 However, in some situations, observed behaviour patterns may not be a good indicator of preferred behaviour, so (as noted in Chapter 2), it will be important to corroborate this generally preferred form of representation against stated accessibility needs.
- 5.14 Another potential limitation of this approach is that behaviour is often more complex than a simple linear or exponential relationship, and to handle this the separation may need to be measured in other ways.

### ***Type 3 - Space-Time Geography***

- 5.15 Space-time measures are calibrated using travel diaries and define accessibility in terms of the opportunities available within defined time windows, taking account of both the time needed to access an opportunity and the minimum time required for participation at the destination.
- 5.16 The results of space-time measures can be displayed as prisms that show the potential areas of opportunities, which can be reached given, predefined time constraints (Geurs *et al*, 2001; Ashiru, 2003). Miller (1991) developed an operational method for implementing network-based space-time prisms using GIS procedures to help evaluate the performance of the transport system.
- 5.17 The first attempt to measure access in terms of space-time prisms was the development of the PESASP method (Lenntorp, 1976), building on Hagerstrand's seminal work (Hagerstrand, 1970); this calculated all possible space-time paths between fixed anchor points in space and time. In a development and simplification of this approach, Dijst and Vidakovic (1997) developed their MAJESTIC tool to look at access of population groups to various activities in Dutch towns.
- 5.18 Miller (1991) developed an operational method for implementing network-based space-time prisms based on GIS, to evaluate the performance of the transport system. While Kwan (1998) estimated three space-time accessibility measures (number of feasible prisms, the weighted sum of opportunities contained in the prisms, and the length of the network arcs), again using GIS and a travel diary data set from 50 households in Columbus, Ohio.

- 5.19 The advantage of using the space-time geographical approach is that personal characteristics can be taken into account, and the information can therefore be analysed on an individual or disaggregate level. It can be argued that a detailed understanding of travel choices of a few people can sometimes provide a better basis for understanding problems and decision making than a less good understanding of accessibility for the whole population.
- 5.20 The main disadvantages are that data are usually not available or sufficient to establish time budget constraints, and because of the large data requirements only small areas can be studied at any one time without very large budgets (Geurs et al 2001).

***Type 4 - Utility based Measures***

- 5.21 Utility-based measures are typically used within economic studies to calculate the 'value' or benefits to the individual or group of improvements in accessibility resulting from, say, a new urban rail line. A combination of both infrastructure-based and utility-based measures is used for urban planning. These measures are used to analyse the benefits that are derived from the land use transport system and the way this overall value might change under different scenarios (Halden 2002).
- 5.22 However, a disadvantage of utility-based accessibility measures is that they are not easily interpreted and require a great deal of explanation and reference to other theories such as behavioural models of destination choice, or consumer surplus models (Handy and Niemeier 1997).
- 5.23 More information about the DfT. National Indicators, and options for using weighted indicators are provided in Appendix B.

## **6.0 Conclusions and Implications**

- 6.1 There is a very extensive international literature on accessibility analysis. For many years, however, much of this was theoretical in nature or confined to local studies. But with the advent of GIS systems, it has become much more practical to develop accessibility planning tools, and many commercial packages are now available.
- 6.2 While such packages differ in their detailed functionality, most share the common conception of accessibility as a measure of the ease with which people and activities can be brought together, due either to the close proximity of the two, or the availability of fast transport systems – or, in some situations, in-home service provision.
- 6.3 The UK is currently leading the way in accessibility planning, by making it a formal requirement of transport and land use planning, as part of the Local Transport Plan process (in England).
- 6.4 While there is a general recognition of the multi-faceted nature of accessibility, for example as set out in Figure 3.1<sup>3</sup>, most of the available tools deal only with a limited sub-set of these parameters – notably spatial and temporal – and largely ignore physical, financial, environmental and information access barriers.
- 6.5 There is also very little reference to differences in the accessibility needs of various population groups, except with regard to differences in the types of activity to which they require access (e.g. education, employment, medical care).
- 6.6 Most tools also pay relatively little attention to the walk access/egress stage of the journey, either using straight line distances, or the OS road centre line database.
- 6.7 Where weighting is applied, it is confined to the measure of separation between people and places (to reflect a preference for locations close at hand), and in the treatment of aggregation. The travel time components of accessibility are all weighted equally – in contrast to the transport/land use models, where different aspects of travel time (i.e. walk, wait and in-vehicle time) are given different weights as part of the generalised cost formulation.
- 6.8 Thus, while the broad principles of accessibility planning are becoming well established, the existing tools are still relatively insensitive to the detailed nature of the accessibility requirements of different population groups.

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<sup>3</sup> Developed as part of an early draft of this EPSRC project review, the figure has been incorporated by DfT in its Guidance on Local Accessibility Planning.

- 6.9 This is partly a function of data availability, and partly one of analytical capability. As indicated in Chapter 4, the most detailed and sensitive measures of accessibility are likely to derive from a journey planner type of tool (recognising that this is also limited in its coverage of several of the accessibility parameters), but this would need to be used in conjunction with a simulation tool that was able to handle a very large number of repeated enquiries, that varied in location, activity type and time of day, and took into account space-time prisms.
- 6.10 Overall, this suggests that there is considerable scope to refine the treatment of accessibility, even within the limitations of existing accessibility planning tools, both through broadening the incorporation of different parameters, and applying these in ways which are more sensitive to the needs and concerns of different population groups.

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## **Appendix A – The Accessibility Tools Adapted in this Project**

### ***PTAM***

METRO's "Public Transport Accessibility Mapper" package is an integrated GIS-based accessibility mapping tool that draws on the following primary data sources:

- METRO public transport databases containing timetables, stops and routes;
- Census statistics, covering a wide range of population characteristics;
- NOMIS data, covering employment location characteristics;
- OS mapping showing various physical features, road networks and administrative boundaries; and
- Facilities databases, covering details of the provision of education, retail, health and leisure services).

The tool is designed to provide an estimate of the accessibility of a location, or set of locations, and can output both origin and destination-based indicators. It has been widely used as a policy tool, for example in developing Urban Bus Challenge schemes, and is used in negotiations with developers over Section 106 planning agreements at particular sites.

The package is able to define location(s) either via on-screen OS mapping, or through user selection from a facilities database. The main stages of an application are as follows:

- First, all bus stops within a defined straight line walking distance of a location, or set of locations, are identified.
- Second, routes serving each of these stops are identified and, from information on service frequencies in a specified time period, bus waiting times are calculated.
- Third, bus journey times from the starting point(s) to bus stops along the identified routes are calculated.
- Fourth, walking catchment areas from the alighting stops along the identified route(s) are estimated.
- Finally, overall journey times and catchment areas are defined and the facilities / populations within them are listed/mapped.

The outputs from the package are of three main types:

1. Available opportunities: i) Location-specific opportunities and ii) Multi-location opportunities;
2. Mapping – using isochrones on an OS background, showing bus stops and relevant facilities;
3. Tables – containing census statistics, employment statistics, and lists of facilities and their attributes.

## **CAPITAL MODEL**

CAPITAL stands for “CalculAtor for Public Transport Accessibility in London”. It is Transport for London’s tool for measuring accessibility to a specific destination/set of destinations, or from a specific origin/set of origins. It takes into account all the main aspects of journey time (i.e. walk access time, waiting time, in-vehicle time and interchange time).

The walk access times to/from locations are calculated using the smallest geographical unit in the Census hierarchy, that of the Enumeration District (ED). There are around 15,000 EDs in Greater London, each containing approximately 200-300 households, or 400-500 people. Each ED is given a defined centroid to/from which access times are calculated; this is the (weighted) centre of population within that zone.

The CAPITAL combines information from Transport for London’s Planning and Development Geographical Information System (PDGIS) and its public transport assignment model (RAILPLAN). PDGIS is used to calculate the walk access times to the public transport network, using the Ordnance Survey Centre Alignment of Roads (OSCAR) database, whilst RAILPLAN is used to calculate the time (actual not generalised/weighted) through the public transport network (i.e. Underground, National Rail, DLR and bus services). All rail stations are modelled within the Greater London area and detail all station entrances. The bus stop locations are based on the Bus Origin and Destination Survey (BODS) definition; these locations do not necessarily correspond to individual bus stops, but tend to represent a pair or group of stops. Overall there are around 12,000 public transport access points within CAPITAL.

The OSCAR network provides a very detailed representation of the road network in Greater London, including all major and minor roads. Distances between the ED and PT Access points, via the OSCAR network, are calculated and are converted to time using an assumed average walk speed of 5kph (which can be globally varied).

RAILPLAN represents stops, links and services together with route attributes such as frequency, which form the network, and uses multi-routing assignment algorithm. A matrix of trips is assigned to the network and a matrix of travel times is produced. The travel times reflect the quickest route from the PT stops/access points to the selected PT stops/destination points.

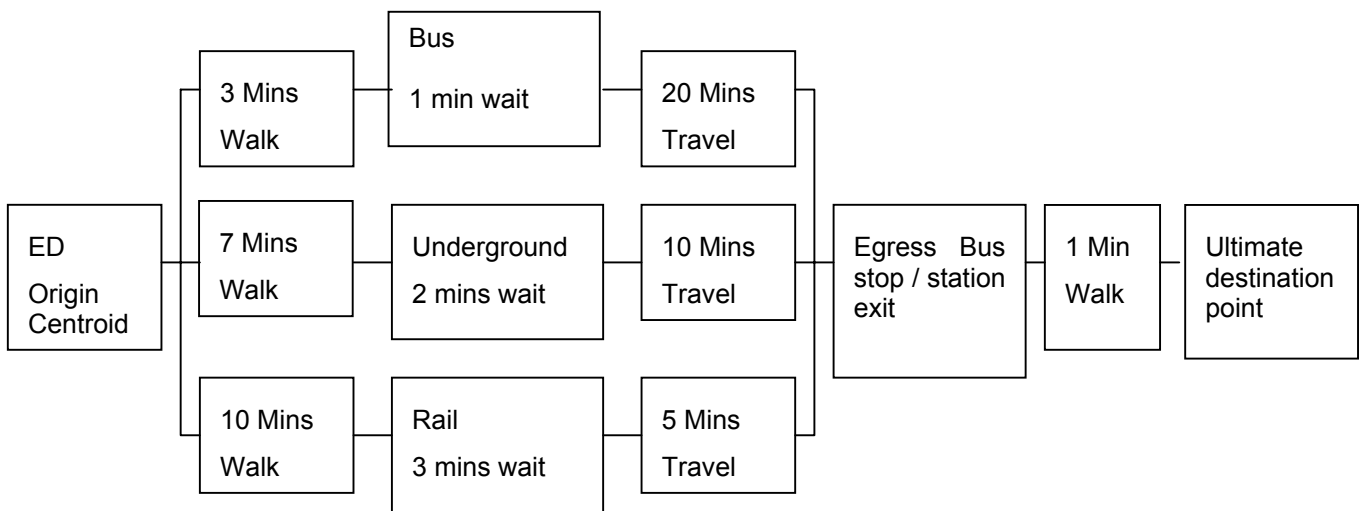
For each trip there will be a number of possible routes available if, as in the majority of cases, there are a number of possible points at which the PT network can be accessed. Within London, the nearest PT access point from the trip origin does not always take people to where they need to go, and for some individuals they may have to walk further to access the relevant PT network. In addition, the nearest point may not necessarily provide the quickest overall

journey time, as factors such as waiting time, in-vehicle time and interchange time will all affect the overall journey time. It is, therefore, necessary to combine the walk access and PT journey times and then take the minimum of total time.

An example of the combined walk/public transport travel time calculation is shown in the figure below<sup>1</sup>.

**Example Calculation**

- Route 1: Bus  $3+1+20+1 = 25$ mins
- Route 2: Underground  $7+2+10+1 = 20$ mins
- Route 3: Rail (minimum overall time)  $10+3+5+1 = 19$ mins



The outputs of CAPITAL runs are usually presented as shaded maps showing isochrones of journey travel times, at ED level, to and from a particular location, or set of locations. Displaying travel time information using GIS mapping software means that a detailed description of the PT network and journey times can be clearly demonstrated and easily understood by non-transport individuals. Alternatively, the output file can be fed into a spreadsheet where other types of analysis can be performed.

## Appendix B – Forms of indicators

### *DfT National Indicators*

The indicators needed for any local accessibility plan have to be defined locally by all partners, but to provide a starting point national indicators have been specified. A good starting point for a local transport authority is to present the impacts of its policies on these national indicators which are defined as follows:

- % of a) pupils of compulsory school age; b) pupils of compulsory school age in receipt of free school meals, within 15 and 30 minutes of a primary school and 20 and 40 minutes of a secondary school, by public transport;
- % of 16-19 year olds within 30 and 60 minutes of a further education establishment by public transport;
- % of a) people of working age; b) people in receipt of Jobseekers' Allowance, within 20 and 40 minutes of work by public transport;
- % of a) households b) households without access to a car, within 30 and 60 minutes of a hospital by public transport;
- % of a) households b) households without access to a car, within 15 and 30 minutes of a GP by public transport; and
- % of a) households; b) households without access to a car, within 15 and 30 minutes of a major centre by public transport.

The DfT guidance notes that the above thresholds in the indicators are for clarity of presentation at a national level, but this makes the indicators more suitable for monitoring changes than for planning interventions.

For detailed planning of interventions at a local level, continuous measures are therefore recommended calculated as a measure of the form:

$$h(A^k, s)_i = \frac{\sum_{j=1}^J A_j^k \times \exp\left(-\lambda^s \cdot \left(\frac{\sum_{l=1}^L (t_{ij}^{ls} + t_{ji}^{ls})}{2L}\right)\right)}{\sum_{j=1}^J A_j^k}$$

Where

$h(A^k, s)_i$	The proportion of relevant facilities or services (e.g. primary schools) $k$ for population in segment $s$ (e.g. primary school children in receipt of free school meals) relative to the origin zone location $i$ . <i>Note that separate calculations can be undertaken for different modes or a single door to door calculation can be used.</i>  Indicator range 0 - 1 inclusive. (0 = Poor accessibility, 1 = Good accessibility)
$A_j^k$	The total number or attractiveness of the opportunities in destination zone $j$ . For example, for access to education this term equals 1 for each primary, secondary or further education establishment. For access to employment this figure equals the number of jobs.
$l$	The time period under consideration, e.g. $l = 1 =$ pre-AM peak hour, $l = 2 =$ AM peak hour, $l = 3 =$ pre-Inter peak hour, $l = 4 =$ Inter peak hour, $l = 5 =$ pre-PM peak hour, $l = 6 =$ PM peak hour. For cycle and walk travel, it is assumed that there is no variation in travel speeds by time of day.
$L$	The total number of time periods under consideration. For public transport $L = 6$ . For cycle only travel $L = 1$ .
$t_{ij}^{ls}$	The total door to door travel time from $i$ to $j$ for persons of segment $s$ during time period $l$ .
$t_{ji}^{ls}$	The total door to door travel time from $j$ to $i$ for persons of segment $s$ during time period $l$ .
$\lambda_m^s$	A positive coefficient which defines the influence of travel time on travel for persons of type $s$ using transport mode $m$ .

The larger the above indicator the more accessible the particular location (tending to unity for very accessible locations). Small values for regions with poor accessibility tend to zero for locations with very poor accessibility.

These indicators are particularly useful for mapping accessibility to identify gaps by trip purpose.

The absolute values of accessibility will differ by trip purpose. However by mapping several trip purposes public transport network coverage becomes apparent and gaps can be identified. Gaps are defined mainly from analysis of relative accessibility between two locations rather than any exogenous threshold.

### **Weighted indicators**

As the focus of accessibility planning is on identifying areas and regions where individuals are experiencing or are at risk of experiencing transport related

social exclusion, the above expression is usefully transformed to place more emphasis on regions with poor accessibility.

$$h'(A^k, s)_i = 1 - h(A^k, s)_i$$

Where

$$h'(A^k, s)_i$$

The corrected proportion of relevant facilities or services  $k$  for population in segment  $s$  relative to the origin zone location  $i$ .

Indicator range 0 - 1 inclusive. (0 = Good accessibility, 1 = Poor accessibility)

Having introduced this transformation, weighting can be applied to the origin based relative-Hansen measure to reflect the population segment resident at the origin location experiencing the particular level of accessibility (e.g. the total primary school age population or the primary school age population in receipt of free school meals). The larger this figure is, the greater is the accessibility problem. The lower this figure is, the less is the problem. This form of indicator can reflect changes over time in the transportation network, changes in the location and numbers of opportunities e.g. schools and hospitals as well as changes the number and distribution of the population segment being considered e.g. all pupils or pupils in receipt of free school meals etc.

The corresponding weighted-Hansen measure takes the following form.

$$w(A^k, R_i^s, s)_i = R_i^s (1 - h(A^k, s)_i)$$

Where

$$w(A^k, R_i^s, s)_i$$

The corrected proportion of relevant facilities or services  $k$  for population in segment  $s$  relative to the origin zone location  $i$  weighted by the total resident population in segment  $s$ .

Indicator range 0 -  $R_i^s$  inclusive.

$$R_i^s$$

The number of residents in segment  $s$  living in zone  $i$  (e.g. the total number of pupils living in zone  $i$  in receipt of free school meals. For access to employment this is the number of people in receipt of Jobseeker's Allowance).

The main problem with the weighted indicators is that they become very complex. Mapping weighted indicators shows a complex mosaic of values. The fact that locations with very different levels of accessibility can have the same indicator can be particularly confusing. For example, some locations will have

good accessibility but a high number of the target population group. Other locations will have lower levels of the target population but poorer accessibility. Both locations however have the same index.

Therefore although these indicators are powerful they are not generally appropriate, at the level of individual locations, for managing progress with accessibility planning, since the meaning of the results is not inherently clear. One way of overcoming this problem is for indicators to be aggregated by ward and displayed non-geographically in a graphical or tabular format.

Although it is always important to ensure that the modelled area is appropriate for the results being required, this is particularly important where weighted indicators are being considered. Large population weightings near boundaries can distort the indicators and result in inaccurate effects. For indicator calculation it is therefore important to model a buffer area of around 60 minutes travel time surrounding the target area of interest.