Calculation of Scottish Public Transport Accessibility Indicators

Report on Index Calculation

3 August 2006

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1.0 Introduction

1.1 As part of the calculation of the Scottish Index of Multiple Deprivation Accessibility Domain it has been identified as desirable that public transport accessibility should be assessed in addition to drive times. This report describes the approach to calculating the indicators.

Approach to the Project

1.2 The work was undertaken in three stages:

- Agree methodology with Scottish Executive
- Source data and calculate public transport/walking travel times (i.e. travel for someone able bodied without a car) between census output areas (COAs) and selected services.
- Review and map results and refine as required.

The indicators

1.3 As part of the SIMD, accessibility indicators are being calculated for drive times to:

- *Primary Schools - Target population:* primary school pupils (available from the pupil census) *Location data:* PointX quality assured using SEED information.
- *Secondary Schools - Target population:* secondary school pupils (available from the pupil census) *Location data:* PointX quality assured using SEED information.
- *Petrol stations*
- *GPs - Target population:* total population. *Location data:* PointX quality assured using NHS ISD information.
- Post Offices - Target population: total population - *Location data:* PointX.
- Retail centres - Target population and source: total population *Location data:* CACI.

1.4 The indicators are required at neighbourhood statistics data zone level. They are calculated on a continuous scale of accessibility based on the travel time by walking and or public transport (including ferries) from the population weighted centroid of the COA to the point location of destinations. The drive time and public travel time approaches seek to follow similar approaches but public transport access is of limited relevance to petrol stations. Also access to primary and secondary schools depends largely on bespoke bus services for which there is no national data.

1.5 The public transport and walk measures have therefore been calculated for GPs, Post Offices, and retail centres.

2.0 Data Sources and Assumptions

Transport data

2.1 The network being used in the analysis comprises:

- Public transport (PT) networks as defined from the electronic data maintained on scheduled services, which is also used to publish public timetables and support Traveline Scotland. This includes ferry services.
- The Integrated Transport network (ITN) layer of Ordnance Survey MasterMap network data to identify walk links to and between PT services. Within these networks walking trips will be made unless a faster journey can be made by public transport.

2.2 Although the quality of public transport data has improved rapidly in recent years in Scotland, there are still some problems with it. For some of the country only timing points on bus routes are geo-coded so this limits the accuracy with which journey times can be calculated. The data also excludes demand responsive transport services (DRT) services, schools services and works services, unless these are registered as public bus services.

Data sourcing and cleaning

2.3 The Scottish Executive has the rights to use Traveline data since they have been a major funder of the Traveline Scotland. Data from a May 2006 extract of Traveline data were therefore extracted and used.

2.4 Logical checks were undertaken on the data to ensure that:

- Speeds of journeys are sensible for the distances covered (e.g. that there are no 150mph bus services).
- Locations of bus stops are sufficient to represent network coverage across the country. Data was available for all timing points in Scotland but in some areas timing points are a considerable distance apart so significant interpolation is required.

2.5 Services were included which had an origin or destination in Scotland to ensure that cross border trips could be modelled.

Calculation of journey times

2.6 The calculation of minimum time paths assumes that:

- Walking times do not include delays crossing roads, or environmental factors such as perceptions of safety. The availability of a route relies solely on the existence of an ITN link.
- Route planning allows for walk journeys between stops – allowing both interchange between clusters of stops, and short walk trips from one poorly served stop to a nearby stop with a more suitable service.

- Time windows were specified for arrival time and acceptance of early arrival as shown in Table 2.2.
- At interchanges the wait times between the scheduled arrival of one service and the schedule departure of the next are added to the in vehicle/walking journey time. However, when accessing the bus stop/rail station from home it is assumed that travellers do not wait and arrive just in time for the service. The exception to this is ferry services where an interchange penalty of 20 minutes will be added for all ferries. This is an overestimate for the most heavily used ferries such as Gourock to Hunter's Quay and an underestimate for longer distance ferries such as Ullapool to Stornoway. However the penalty recognises a broad average that for many ferries it is necessary to book in well in advance of sailing time and that passengers without a car do not need to arrive as early as passengers with a car.
- The maximum walking distance between bus stops for interchange purposes is 500 metres. There is no maximum walk access time or distance from the origin location.
- There is no limit on the wait time at interchanges but the overall maximum journey time is set at three hours and this includes interchange time.
- Walk access from within the COA to each possible bus stop/rail station/destination is averaged from the population weighted centroid of the COA.

2.7 Table 2.1 summarises networks in the modelling based on the core requirements for the work.

Table 2.1 – Networks and Parameters

Network	Data	Parameters
Public transport	Public transport network defined from national Traveline data. Includes: registered bus and coach services in addition to rail, ferry and light rail services	A journey is deemed to be available if it can be made within the designated time windows specified in Table 2.2.
Walk network and links	Walking network based on OS ITN MasterMap data.	Walk speeds are 4.8km/hr
Interchange	Interchange between public transport and walk	Interchange and wait penalties are based on the actual scheduled clock arrival times of connecting public transport services for the relevant journey.

2.8 Public transport network coverage varies by time of day and day of the week. In particular, in rural areas and for trips that are not constrained to a particular time of day (e.g. for shopping), there is a need to consider multiple times of day.

2.9 It is not efficient to model every time of day and day of the week but a

representative range of trip times is needed to ensure that results provide a robust indication of typical travel times relevant to the trip purpose being considered.

2.10 Tuesday is considered to be the most representative weekday. Wednesdays still have some legacy of half day closing bus service changes, Mondays and Fridays have services associated with the end and start of the weekend and Thursday has late closing.

2.11 Table 2.2 shows the journey times modelled. These seek to maximise the accuracy by trip purpose within the limited budget.

Table 2.2 - Times of Day

Purpose	Proposed times of day
Access to/from post offices	Analysis for Tuesday with arrival by the stated time and early arrival of up to an hour permitted. • Outbound times of day: 09:00, 11:00, 15:00. • Inbound times of day: 12:00, 17:00.
Access to/from general practitioners	Analysis for Tuesday with arrival by the stated time and early arrival of up to an hour permitted. • Outbound times of day: 09:00, 11:00, 15:00. • Inbound times of day: 12:00, 17:00.
Access to/from retail centres	Analysis for Tuesday with arrival by the stated time and early arrival of up to an hour permitted. • Outbound times of day: 09:00, 11:00, 15:00. • Inbound times of day: 12:00, 17:00.

Origin and Destination Data

2.12 In addition to the transport network data, the indicators used data on the locations of destinations and the target catchment population group as summarised in Table 3.1.

Table 2.3 – Origin and Destination Data

Destination Definition	Origin Definition
Medical GP practices as of May 2006 from Point X data quality assured using NHS ISD data.	Total population from 2001 census
Post offices from Point X data as of May 2006.	Total population from 2001 census
Retail centres developed from Point X retail location data and modified by SEGIS using CACI data.	Total population from 2001 census

2.13 The presence of each destination was identified as a point location. For larger shopping centres, the retail data set included multiple point locations at the boundaries of the centre based on analysis by SEGIS.

2.14 None of the destination data was scaled (e.g. the number of GPs at the site or the number of pupils at the school).

2.15 Some destinations were included in England to ensure that accessibility for people living near the border and reliant on services across the border would be represented correctly.

3.0 Indicator Specification

3.1 The aim was that the approaches to drive times and public transport/walk times should be similar. The major differences between drive times and public transport/walk times are that:

- The drive times do not include actual travel times by time of day. In contrast the public transport times are based on actual schedules. It is suggested in the drive time methodology paper that: "There is currently no way of modelling for a reduced or lower than average speed at morning and evening peak periods". The development of the new database to undertake the public transport analysis means that this is no longer the case. The database can easily be linked with the national ITIS data[1], which describes actual speeds by time of day on each major road link.
- Related to the above is the way that ferry services are considered. In the drive time analysis, average speeds are used rather than scheduled ferry journey times. Also advance arrival at ferries for foot passengers is generally less that for car users due to loading requirements. Therefore an advance arrival time of 20 minutes has been added for the public transport passengers instead of the 30 minute penalty used for drive times.

3.2 If the drive and public transport approaches are to mirror each other more closely then one possibility would be necessary to develop the drive time analysis towards a schedule based approach.

3.3 Indicator calculation was undertaken separately for each trip purpose as follows:

- For each of the time periods relevant to each trip purpose, the travel time was calculated from each COA to the nearest available destination of the specified category.
- These COA results were then reviewed against the walk time values which had been derived in ARCVIEW by SEGIS. Where walk times were lower than the calculated values from the above the ARCVIEW results were used.
- The median travel time from these results by time period were calculated and values 50% more than this value were removed from the analysis. The mean of the retained travel times for each of the remaining time periods was then calculated for each COA.
- Of the 42,000 COA this process resulted in a number of COA with no travel times allocated. This could be either data problems or indicate the absence of bus services to the location. For the GP analysis there were 2100 missing COA, 1400 for the Post Offices and 6229 for the retail centres. To derive travel times for these

[1] This data set is derived by mining data on the speeds of mobile phone movements through networks.

values the drive times were factored by 2.5. This is a broad average value of the ratio of public transport travel times to drive times based loosely on accessibility analysis in Scotland (e.g. Scottish Executive 1999 – Accessibility Measuring Techniques and their Application, Scottish Executive 2001 – Rural Accessibility, DHC 2003 – Analysis of Travel Behaviour Using Scottish Household Survey Data in Strathclyde). COA derived travel times were identified in the data by "DRIVE".

- The COA based values were then aggregated up to data zone level by weighting them by the population in each COA and dividing by the total population of the datazone as shown in equation 1 below. The resulting indicators "V" for any data zone level are reported for each of the five trip purpose/destination types.

$$V_i = \frac{V_i \times P_i + V_j \times P_j + V_k \times P_k}{P_i + P_j + P_k} \qquad (1)$$

- The resulting datazone values were allocated a quality score based on their derivation as follows: 100% - all COA based times within the datazone based on actual measured journey times, 0% - All COA based times in the datazone calculated using estimated and interpolated travel times. Intermediate percentages are calculated based on the percentage of COA used in the datazone calculation using actual values.
- All datazone values were mapped using GIS and inspected to confirm that the measured values reflect the spatial distribution of the relevant destination type. Some sample maps are shown in Figures 3.1. to 3.3. The same scale is used throughout with five time bands as shown in the legend.
- The public transport times were compared with road network drive times to ensure that differences can be explained by the coverage and timetables of public transport networks. There were no PT journey times lower than the drive times but some journey times by PT were very much longer than the drive times. This is not uncommon. A five minute drive in a peri-urban 60mph area can easily take ten times this or more to travel by indirect public transport routes or by walking. It is often the case that a different destination further away will prove to be the "nearest" by public transport particularly around cities where public transport tends to take radial routes into the city centre. In locations without public transport coverage some very long walk times can be needed to reach the nearest bus stop or services.

Figure 3.1 – Travel Times to GPs in Aberdeen

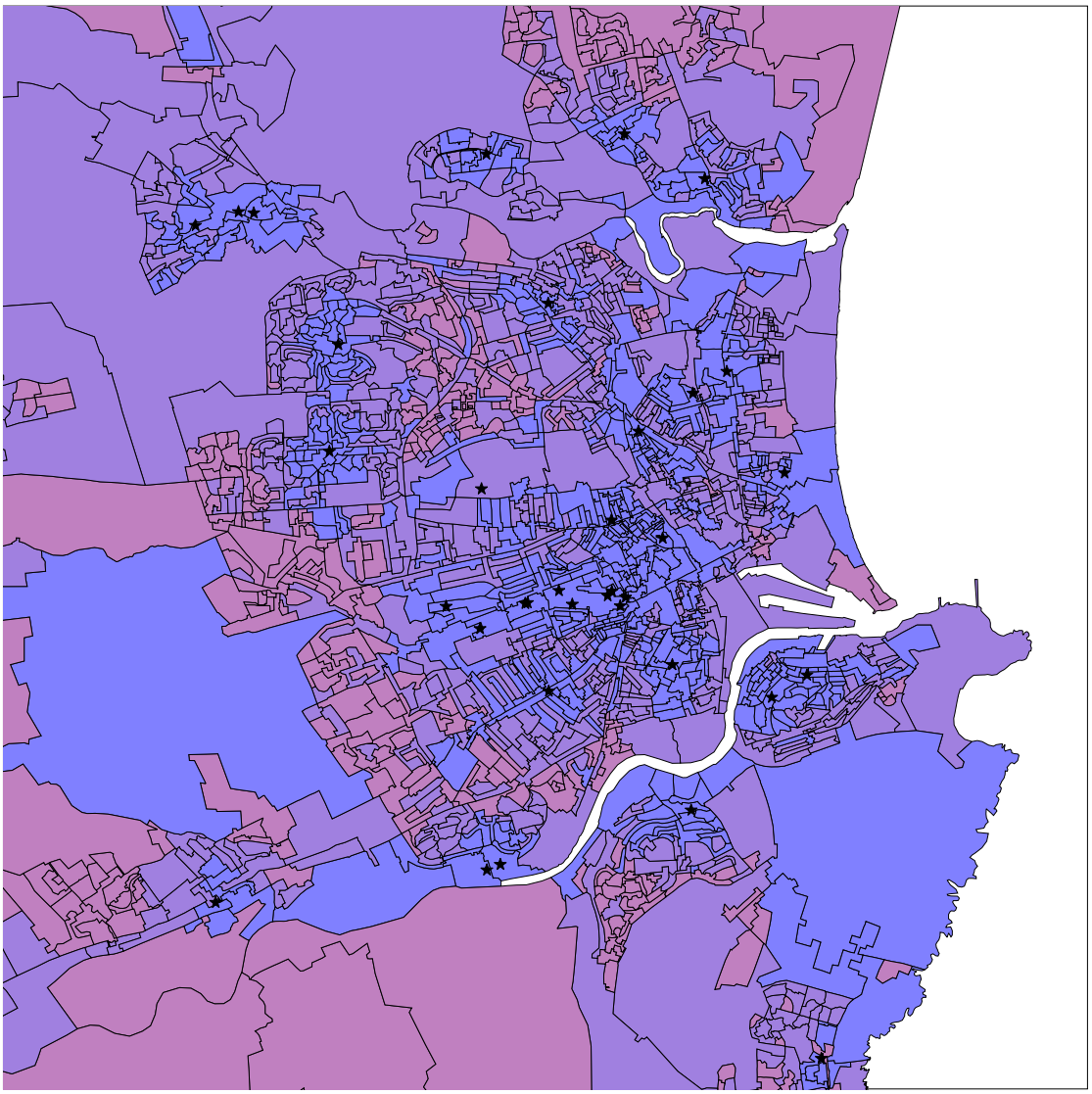

Figure 3.2 – Travel Times to GPs in Clyde Estuary

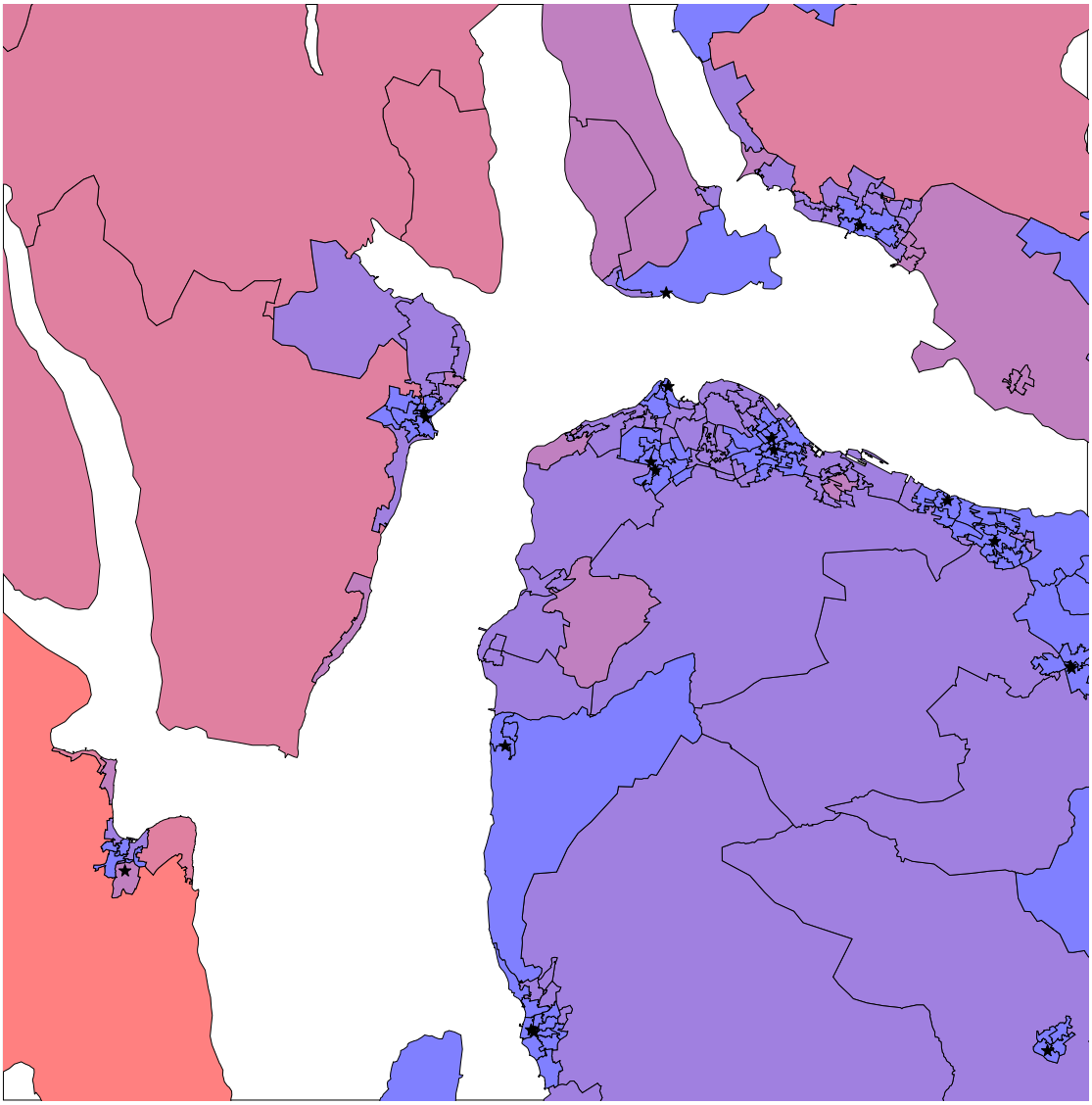

Figure 3.3 – Travel Times to Retail Centres in Glasgow