



Travel and transport analysis for the NHS

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Section I

Introduction to TfL's connectivity tools

At Transport for London (TfL) we maintain a set of computer tools to analyse levels of connectivity throughout London's transport network. These tools examine how easy it is to travel between different places. Over the past few years, we have worked with NHS London to make these tools readily available and adjusted them accordingly to the needs of the NHS to help it understand travel issues associated with health service reconfiguration. The result of this is H-STAT, an umbrella term covering a number of our strategic connectivity models and their application to support the NHS.

The tools are designed primarily to allow the NHS to carry out in-depth analysis at the strategic level before deciding the best location for healthcare provision in terms of the site's connectivity to the local area. The connectivity tools also allow analysis on a consistent basis, which can then be used to prioritise and facilitate more detailed transport network discussions.

The tools described in this guide include:

- PTALs (Public Transport Accessibility Levels) – which indicate relative connectivity to the public transport network for any location in London. The term 'connectivity to the network' indicates that the PTAL measure focuses on the proximity to public transport services, and not on where these services take you to

- CAPITAL – a strategic travel time model for both highway and public transport services in London, which can extract travel time information for any combination of origins and destinations, depending on the user defining their area of interest and the level of detail required

This guide is designed to be read by consultants and clients who expect to use travel time data as part of their analysis. It provides background information on the tools themselves, information on how to request data and some of the issues that may be encountered when using it.

The guide assumes some basic understanding of the concepts and principles used. It is not designed to explain how the analysis should be conducted but instead provides advice on how the tools and their outputs can be used to support service reconfiguration exercises undertaken by the NHS.

Section 2

PTALs

2.1. Overview

The PTALs tool provides a detailed measure of the connectivity of a given location to the public transport network. It takes account of walk access time and service availability and offers an overview of the density of the public transport network across Greater London. No equivalent measure exists for road connectivity.

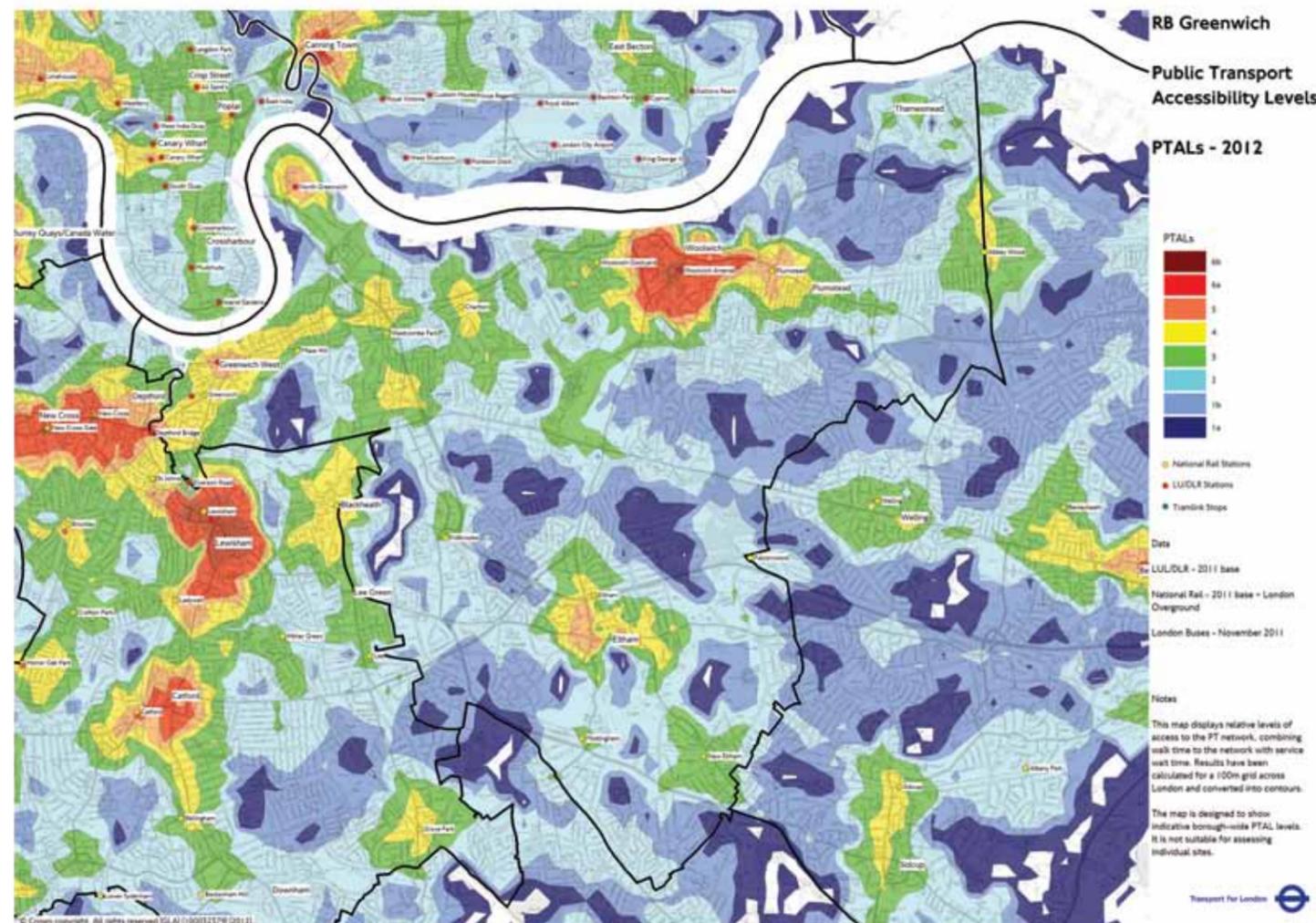
The tool calculates walk times from specified points of interest to all public transport access points, ie bus and tram stops as well as rail and Tube stations within pre-defined maximum walk times. These results are incorporated with a measure of service frequency based on the public transport services available at each access point to give an overall connectivity index score. This index can be assigned to a level ranging from PTAL 1 (poor connectivity) to PTAL 6 (excellent connectivity).

PTALs can be calculated for individual sites using the site entrance as the designated location. For larger sites and campuses, it is recommended to calculate a grid or selection of points because the measure is sensitive to network proximity and changes in connectivity can be shown to occur over relatively short distances.

2.2. Requesting PTAL data

We can provide pre-calculated PTAL values, based on a grid of points at 100 metre intervals for the whole of London. This data includes the X and Y coordinates and can be used in a Geographical Information System (GIS) to associate PTAL values with your selected locations. This data has been further processed into a series of regular grid cells or contours and

Figure 1: Greenwich 2012 PTALs Map



can be used to produce area-based PTAL maps at a London or borough-wide level.

If PTAL values are required for an individual location then an alternative method is to use the PTAL website, www.webptals.org.uk.

This site allows users to navigate to a specific location using a series of search methods. A point can then be selected on the map using the 'PTAL tool' which returns an individual 'PTAL report' for the location.

2.3. Using PTAL data

Individual site PTALs will provide a general indication of the level of connectivity to the public transport network at the location of interest. PTALs are relatively simple calculations because they only measure access to the public transport network, and ignore what happens once a passenger has 'entered' this network. They do not consider aspects of the journey such as the final destination of the journey, vehicle capacity or service quality. For this reason PTALs should not be used to estimate how many people will actually use public transport. Two sites with the same PTAL scores will most likely offer different levels of public transport service. Furthermore, PTALs will not be appropriate for assessing how accessible a location is by ambulance or by private car.

PTALs are still helpful when there is a need to assess a large number of sites and service reconfiguration options, and present this as a simple map. In these situations PTALs can provide an initial indicator of a site's connectivity and proximity to the public transport network, and allow users to select and prioritise locations based on connectivity to transport services.

At a borough level, the tool provides an overview of the variation in connectivity to the public transport network. A borough-wide grid of values can be converted into a series of PTAL contours as demonstrated in Figure 1. A high PTAL (shaded red or orange on the map) will in most cases equate to the availability of a larger number of public transport services. A low PTAL (shaded blue on the map) will equate to lower service provision.

Section 3

CAPITAL

3.1. Overview

CAPITAL is a tool developed by TfL to provide detailed minimum travel times for any combination of origins and destinations primarily in London. The origin points could be a series of postcodes or zones, such as Census Output Areas, while destinations could be a series of hospitals or clinics. Public transport CAPITAL (PT-CAPITAL) calculates travel time using the public transport network, while highway CAPITAL (HW-CAPITAL) calculates travel times through the road network.

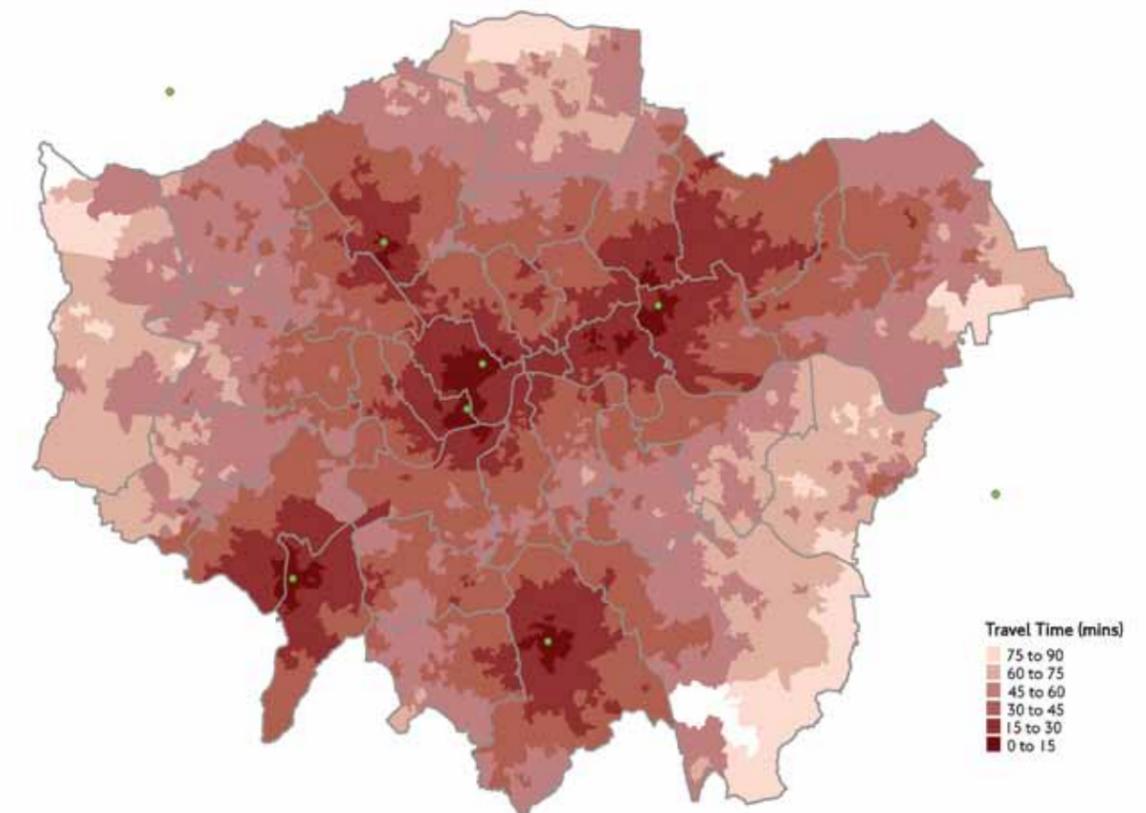
Calculating realistic travel times between locations can be difficult as they will vary owing to a wide range of conditions and issues, for instance diversions, delays and cancellations. There can be significant differences between the maximum (slowest) average time and the minimum (fastest). CAPITAL provides a consistent set of travel times across London at a detailed level, which can be used to compare a range of sites on an equal basis. How the data is used is very much up to the analyst. Typically,

it can be linked with complementary datasets including Census information or patient records to demonstrate the impact service changes could have on the target population.

3.2. Public transport CAPITAL

Public transport CAPITAL (PT-CAPITAL) calculates detailed end-to-end journey times through the public transport network for any combination of user-defined origins and destinations. This combination can be defined by the user. PT-CAPITAL achieves this by combining walk times from the user-defined origins and destinations with public transport travel times derived from TfL's strategic transport models, which are detailed representations of London's public transport network.

Figure 2: shows output data derived from TfL's PT-CAPITAL model showing travel times to a series of locations



Walk times are calculated (using a detailed walk network) from the user-defined origin/destination points (such as Census Output Areas or clinic locations) to the public transport network service access points (SAPs) as defined in the transport model. SAPs will include locations such as bus stops or station entrances and provide a link between the detailed walk times and the transportation network travel times.

The transport model is used to calculate travel times through the public transport network between the SAP points. PT-CAPITAL benefits from a highly detailed representation of public transport services in the city and across Greater London.

Each origin or destination point will have a number of possible SAPs in its vicinity, so several different routes will be possible between them. PT-CAPITAL calculates the

travel and walk time for each alternative, then selects the combined minimum journey time for each origin/destination pair. For example, there could be 10 bus stops and station entrances near the origin point and 20 near the destination point. PT-CAPITAL will calculate the 190 different options and provide the minimum travel time from this set. The nearest SAP may be a bus stop, but in reality people will be willing to walk further to a rail station if services are faster and the overall journey time is reduced.

The final origin to destination travel times will include all elements of the journey (not just the time spent on the bus or train):

- Walk time from the user-defined origin point to the transport network
- Public transport travel time, including waiting time, time spent on the bus or train, and interchange time (eg between bus stops and a Tube platform)
- Walk time from the public transport access point to the final destination

Another important feature of PT-CAPITAL is its ability to use current or future transport networks. Travel times can therefore be compared with and without new schemes such as new routes or stations. Users could, for example, compare the travel time catchments of a hospital site using the current transport network against those for a future network that included Crossrail.

When requesting PT-CAPITAL data the client can specify a number of variables:

- Any combination of origins and destinations – depending on the level of detail required
- Three time periods – morning peak, inter-peak or evening peak
- All public transport modes or bus-only modes. This may be useful when assessing travel for specific user groups that would not normally consider travel by train or Underground

3.3. Highway CAPITAL

Highway CAPITAL (HW-Capital) functions in a similar way to PT-CAPITAL providing detailed road based journey times for any combination of user-defined origins and destinations. The road networks used in HW-CAPITAL are derived from one of TfL's strategic transport models. The tool operates by combining outputs from a geographic information system (GIS) and the transport model:

- The transport model calculates road-based travel time from the modelled point closest to the selected origin to the modelled point closest to the destination
- Using more detailed GIS data of the street network, we add the time from the origin selected by the user to the nearest modelled point, and the time to the destination selected by the user from the nearest modelled point

Like PT-CAPITAL, the sum of these provides the overall minimum highway journey time for each origin and destination. Highway times only give the journey time between the origin and the destination points: parking and other factors are not included.

Times have been calculated for the morning and evening peaks, and the period in between (the inter-peak). The morning peak offers the slowest times as this is when significant traffic congestion occurs. The inter-peak is the least congested and is the closest to free-flow times. All travel times take into

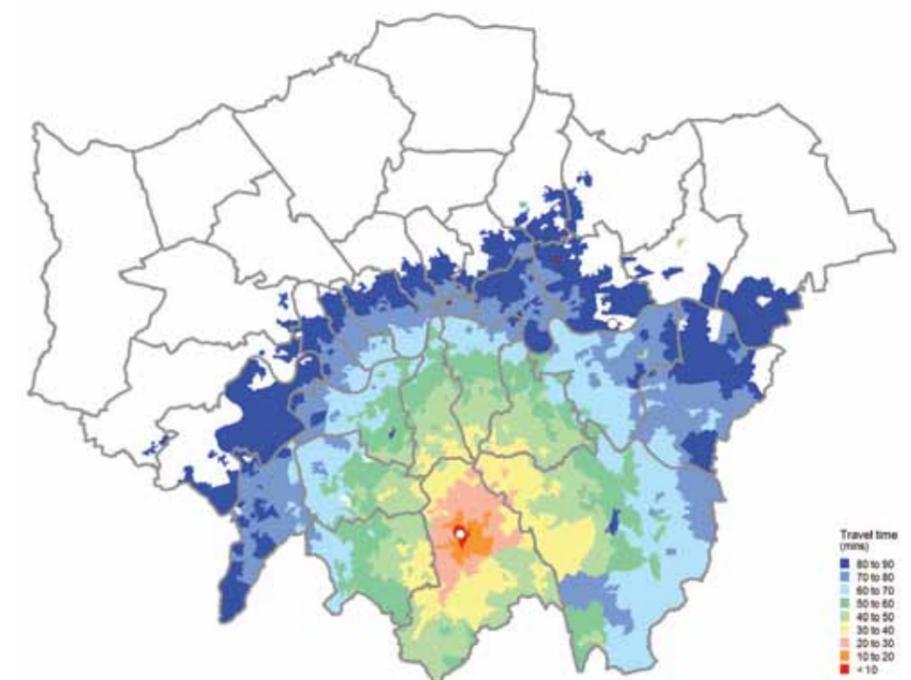
account delay factors such as junction delays and road speed restrictions.

3.4. Requesting CAPITAL outputs

To request CAPITAL data, interested parties should complete our request form. Please note that the analysis and mapping of that data will be the responsibility of the recipient organisation.

The form will request background information on the proposed project and contact details. Separate forms are provided for public transport and highway data. The requester

Figure 3: This diagram uses data derived from TfL's HW-CAPITAL model and shows morning peak road times to Croydon town centre



should provide details on the extent and characteristics of the data required. Including:

- Origins/destinations
- Mode
- Time

3.4.1. Origin/destination selection

The study area is broken down into zones. This breakdown can be done in various ways, from a very detailed set to a less detailed one. We use the term ‘zoning system’ to describe each such possible geographical breakdown.

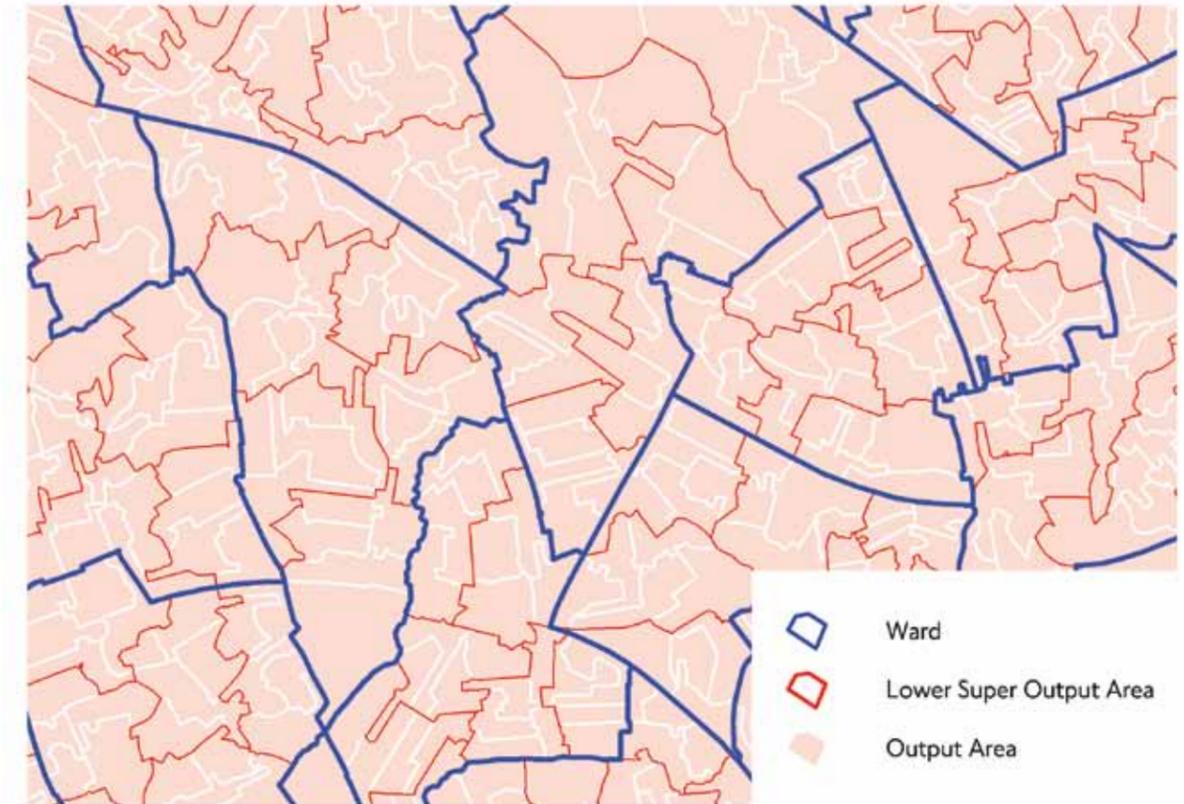
The table below highlights the standard zoning systems available. The column ‘what it can be used for’ suggests in which cases each zoning system should be used.

Zoning system	The level of geographical detail	Source of the information	What it can be used for
Grid	Flexible, based on the interval defined by the user, eg 100 metres, 250 metres	User defined	Local analysis – within a borough or defined area
Postcodes	Flexible, based on the location of patient or households, as defined by the user	User selection	Calculate travel times at individual post-code level. Possible to aggregate average results to COA or Lower Super Output Area (LSOA) to retain confidentiality
Census Output Area (COA)	25,053 zones in London. Average of 5 zones per LSOA	ONS – 2011 Census reporting. COAs align to LSOA boundaries	Local analysis – within a borough or sub-region
Lower Super Output Areas (LSOA)	4,835 zones in London. Average of 8 zones per ward	ONS – 2011 Census reporting. LSOAs align to ward boundaries	Aggregations of COAs. Suitable for London-wide analysis
Ward	649 wards in London. Average of 20 per borough	Administrative definition – wards align to borough boundaries	Most suitable for London-wide analysis. There will be considerable variation of travel times/demographics within a ward and these differences will not be identified at this level. It may be necessary to present results at ward level only when the prospective audience is familiar with the ward boundaries, eg borough councillors
Borough	33 London boroughs	Administrative definition	Suitable for displaying London-wide, borough-based statistics

Figure 4 shows how these zoning systems align to each other. In a ward there will be considerable variation of travel times which will be revealed if using the more disaggregate census areas: LSOAs or COAs.

Most NHS travel analysis work has been based on the Census Lower Super Output Areas or Output Areas as the origin locations, either on a London-wide basis or for a selection of boroughs. This way, it is possible to link the results with additional information from the Census.

Figure 4: Zone alignments within a selected area of London.



On the request form you should highlight the level of geographical detail required, based on the table on page 10. The actual point used within the zone is usually based on the population-weighted centre rather than the geographic centre, as this offers a closer approximation of where people actually live within the area.

The point representing the destination – for example a hospital or clinic – could be based on a number of criteria:

- Site entrance – for small locations such as a clinic, or where the site has only one main entrance
- Central location – one location that represents a large site
- Selection of points – where there are multiple site entrances, for instance on a larger hospital campus site

On the CAPITAL data request form you should provide the easting and northing coordinates of any individual sites you require data for. If this is not possible the site postcode should be provided.

3.4.2. Mode selection

Mode selection at the highest level refers to public transport or road-based travel times. Separate forms exist for each of these options.

For public transport modes two different options are available. Most requests will be for travel times using all modes. This includes National Rail, London Underground, Docklands Light Railway (DLR), tram and bus. Bus-only travel time data may be useful where the majority of a site's visitors would only use the bus network. Travel times will be correspondingly longer than those using all modes.

3.4.3. Time period

Public transport and highway travel times can be supplied for the following time periods:

- Morning peak
- Inter-peak
- Evening peak

For highway times the morning peak will be the most congested while the inter-peak will represent the least congested period.

3.5. Using CAPITAL outputs

3.5.1. Data outputs

These are provided in CSV format and offer the following information:

- The origin identifier, eg the LSOA code
- The destination name, eg St. George's Hospital
- Travel times for the morning peak (07:00 – 10:00), inter-peak (10:00 – 15:00) or evening peak (15:00 – 19:00)

This data can be imported into standard GIS software packages, such as Mapinfo or ArcView, for mapping and spatial analysis using the appropriate zoning system. It can also be imported into a spreadsheet or other statistical software package for further analysis.

3.5.2. Data presentation using maps

We recommend producing maps and tables to demonstrate how people's travel times will be affected by any reconfiguration of services. Where there is a considerable amount of data to capture and analyse, it should be presented in an analysis resource pack. However, these outputs will not necessarily be suitable for the target audience, which will want to know:

- How long it takes to reach the current hospital/NHS site
- How long it takes to reach the new site
- The difference between the two
- The areas most affected by the service reconfiguration

Maps will be one of the best ways to present this information in an accessible format. Not only are they visually attractive they also:

- Make it easier for people to relate data to location

- Help users to identify geographic trends in the data, in a way that would be difficult using a chart or table

The figures in this section show how travel times could be presented. Any maps should also include:

- An appropriate number of classes for the data. These examples feature fixed ranges of 10-minute intervals
- Suitable colours – they can be graduated but it can be difficult to distinguish more than four shades of one colour. Also, white is typically used to indicate areas where data is missing or unavailable so avoid using this colour to represent any part of the range of values
- Contextual information such as borough boundaries, the road network and key locations (for instance town centres and hospitals) to ensure people can locate areas of interest
- Guidance – remember that these maps may be used not only in strategic technical reports but as evidence presented to the general public, so they need to be accessible to everyone. There may be more appropriate ways to present this data or, if not, support it with guidance notes

Figures 5 and 6 show travel times to one destination. All transport modes (bus, rail, Tube or tram) are included in the map on the left, while the map on the right is based on bus-only travel time. Catchment areas can be relatively large, although the effectiveness will always be constrained by neighbouring centres, which will appear more attractive as they benefit from shorter access times.

Figure 5 – Travel times to location E by any available transport mode

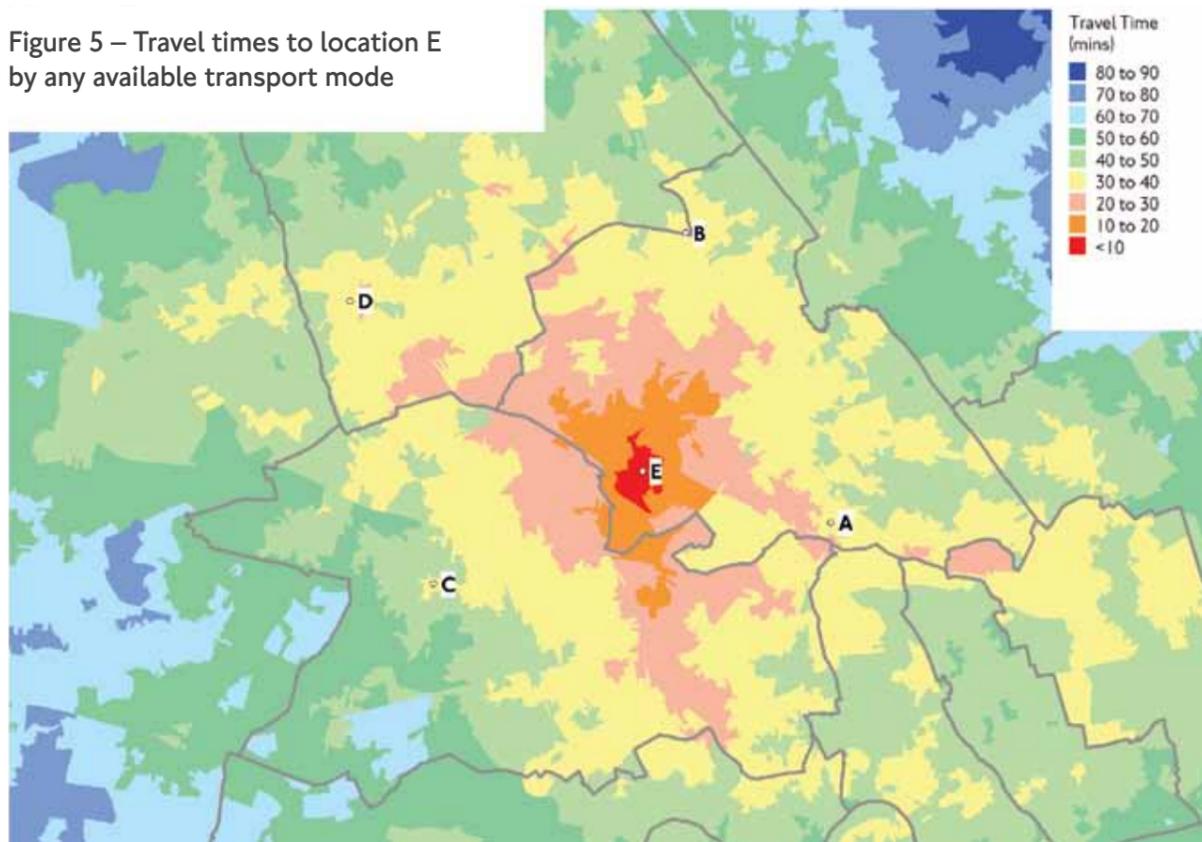


Figure 6 – Travel times to location E by bus only

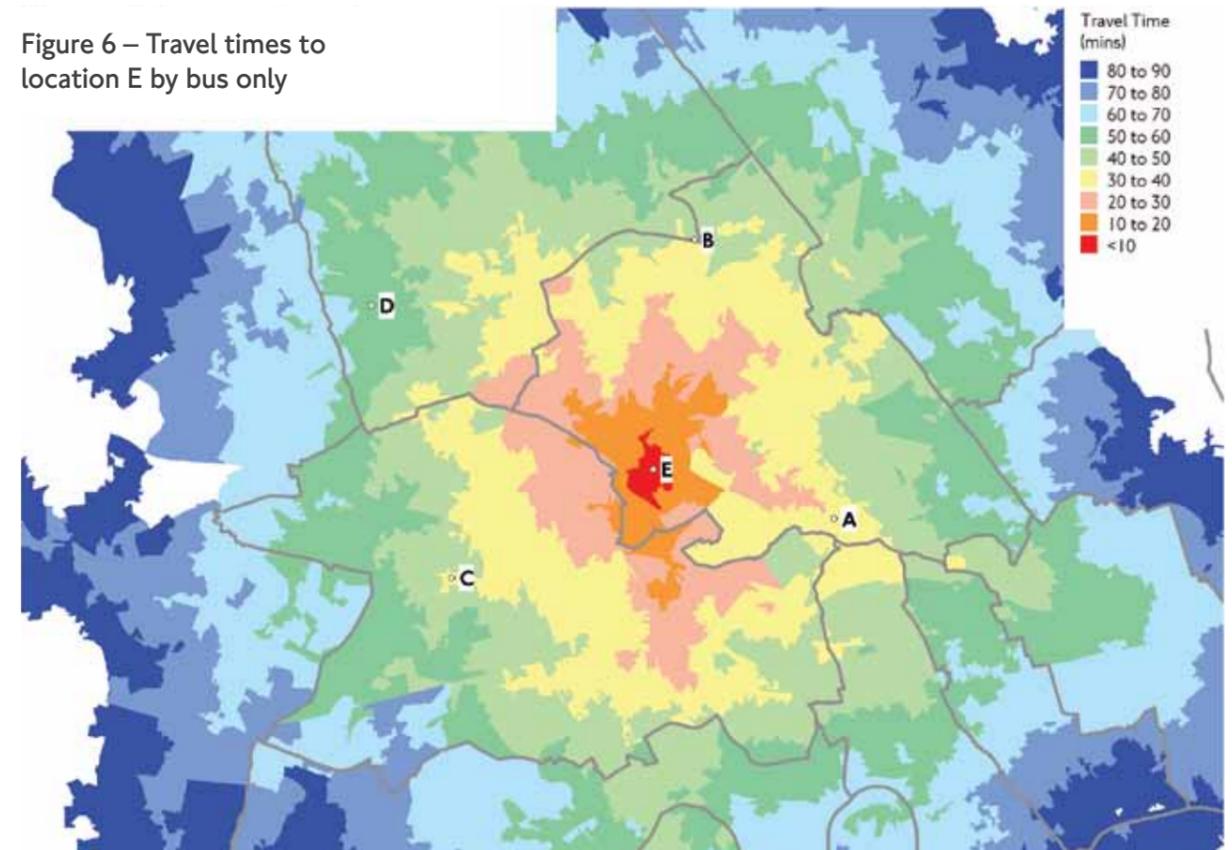


Figure 7 illustrates how travel time data can be displayed for a number of destinations. This map shows the minimum travel time for each output area zone to any location, with the underlying assumption being that people will travel to their nearest site.

Figure 7 – Travel time to the nearest service when services A to E are available

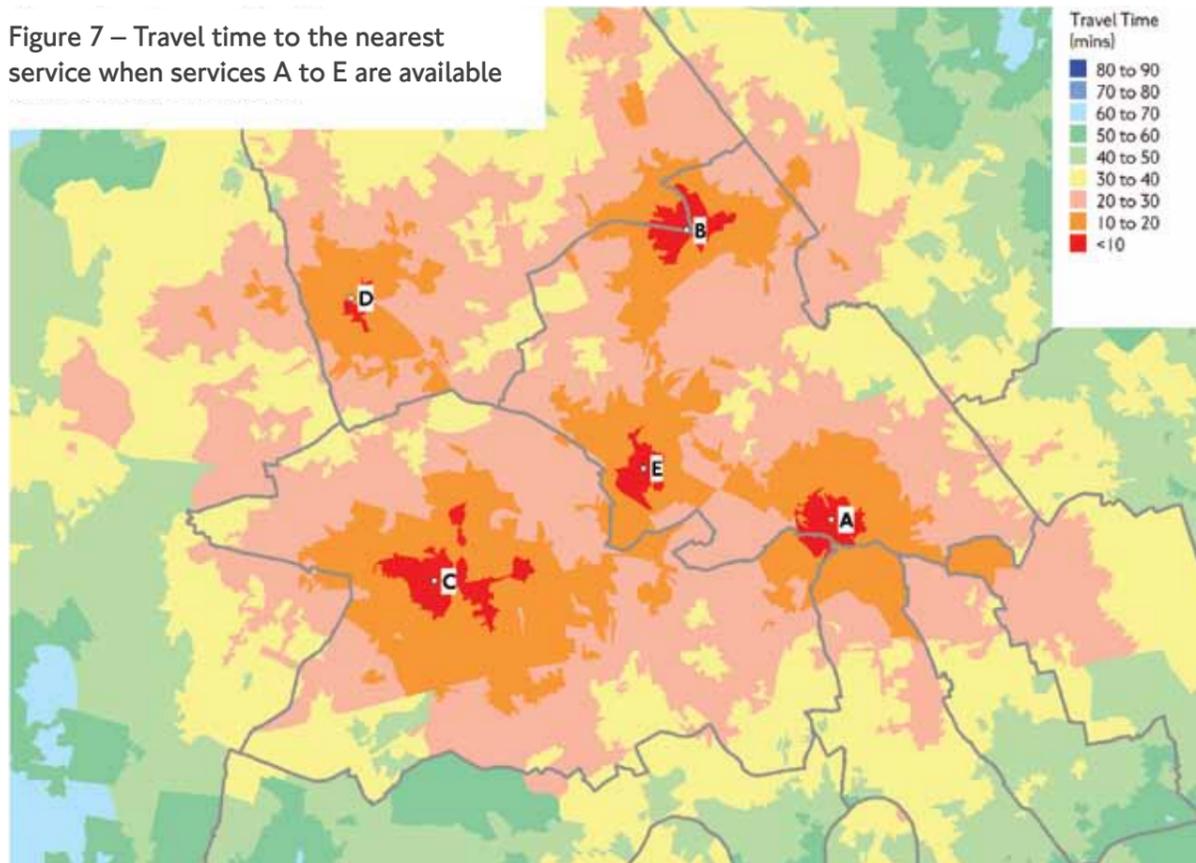


Figure 8 shows the future configuration of services and the minimum travel time for each output area zone to any location. In this case, location E is closed and travel times are based on the remaining four.

Figure 8 – Travel time to the nearest service when service E has been closed

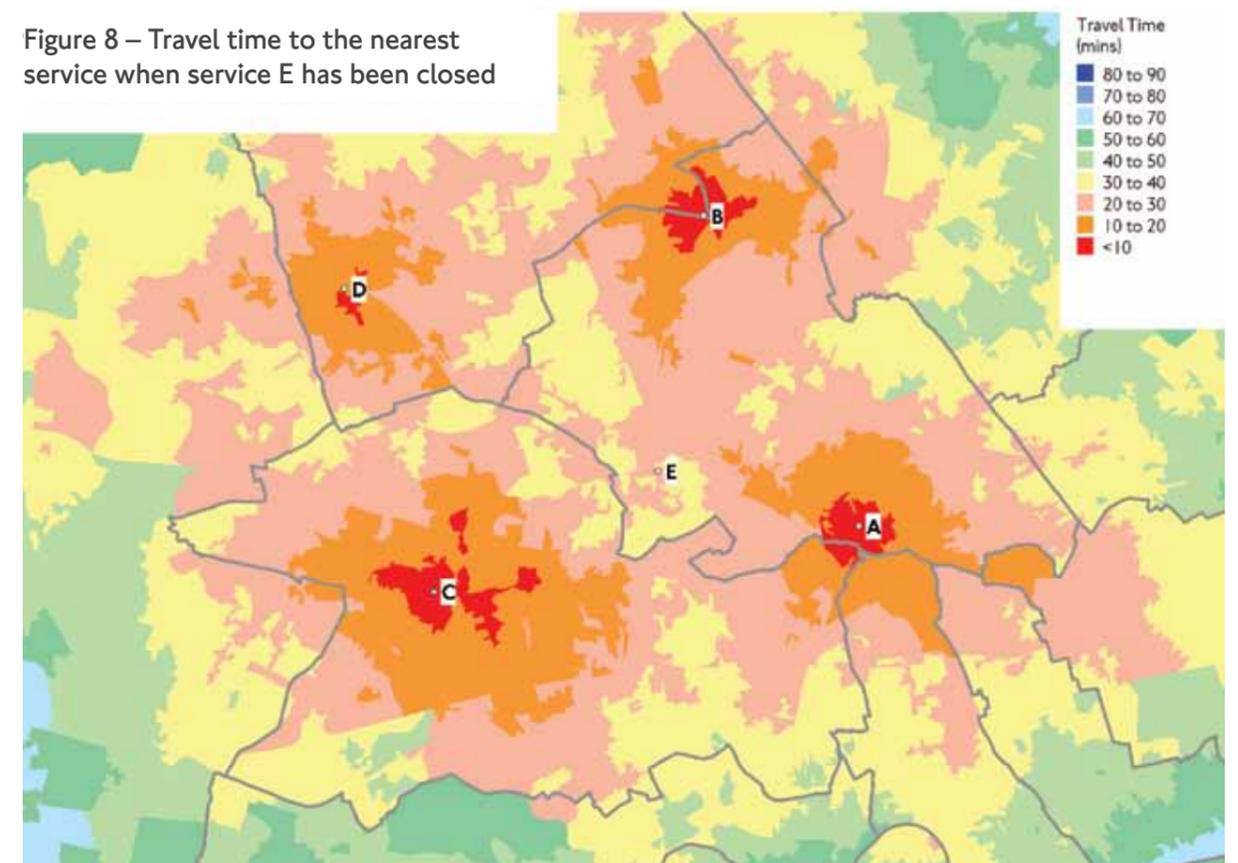
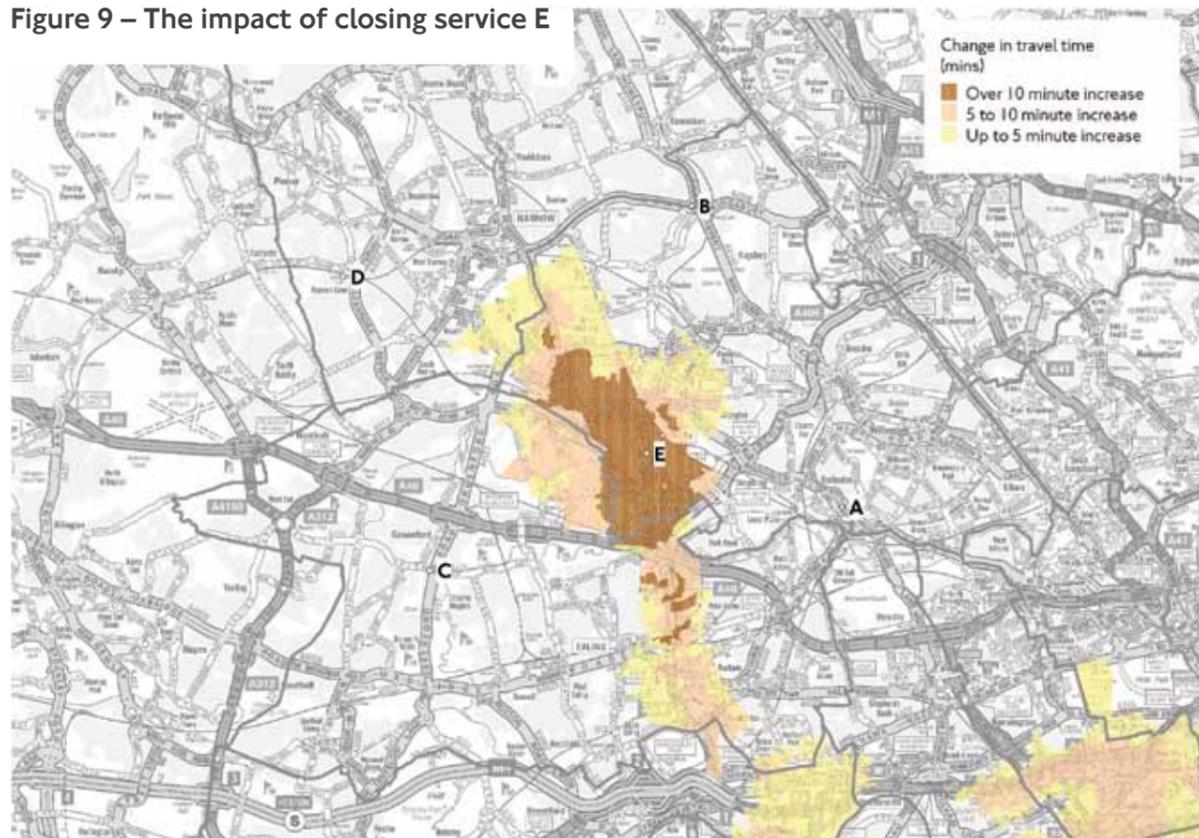


Figure 9 highlights the impact of the change in terms of increased travel times between figures 7 and 8. In most cases the nearest site (using public transport) is not site E so there is no change. The greatest change in travel time

occurs in locations nearest to the closed site (dark brown shading). These locations will be of greatest interest to residents, so may require more analysis in terms of their demographic composition.

Figure 9 – The impact of closing service E



3.5.3. Data presentation using tables

The examples given earlier are primarily for presentation purposes rather than as sources of reference material. They are excellent for showing geographical patterns but not so good for providing precise values that people can use to make their own calculations. Therefore graphical/mapping outputs should be supported by detailed, but accessible, tables highlighting the extent and location of the main travel impacts of any proposed change.

The example below, which is taken from the Health for North East London Programme travel analysis packs, uses data extracted at Census Output Area level, but is presented at ward level. In many cases the only sub-borough spatial unit known to the target audience will be the ward.

District/ Borough	Ward name	Number of Census Output Areas (COAs)	Number of COAs impacted by > 5 minutes	Current Configuration - minimum and maximum travel times to nearest A&E		If service were moved from site A - minimum and maximum travel times to the next nearest hospital		Greatest increase in travel time for a COA in the ward
				min	max	min	max	
Newham	Plaistow South	38	38	4	27	30	45	36
Newham	Boleyn	37	37	10	33	31	51	34
Newham	East Ham South	40	40	12	38	42	50	33
Newham	Custom House	38	34	12	31	41	52	30
Newham	Canning Town North	41	41	15	35	34	44	25
Tower Hamlets	East India & Lansbury	35	7	31	41	32	42	10
Newham	East Ham North	27	22	27	40	32	49	10
Barking & Dagenham	Abbey	32	4	34	47	38	47	8
Barking & Dagenham	Gascoigne	31	3	39	51	44	51	5

Section 4

Additional connectivity queries

In the course of our collaboration with the NHS, a number of common issues have arisen across various studies. This section provides guidance on these matters.

4.1. Studies outside London

Our models focus on London's public transport and road networks, including all rail services into London and bus services that cross London's boundaries. In certain NHS studies the area of interest may extend beyond the boundary and, in these cases, we recommend using other data sources. One example is Accession, which is endorsed by the Department for Transport. This model calculates travel times using public transport service data extracted from the National Public Transport Data Repository – a bank of public transport information submitted annually by all local authorities.

Where data is obtained from an alternative system such as Accession, caution should be taken when combining the results with H-STAT as they are derived using different parameters and can show significant variations in travel times. Ideally, a single consistent dataset should be used.

4.2. Difference between PT-CAPITAL and Journey Planner

PT-CAPITAL travel times differ from those generated by TfL's Journey Planner because they have two different functions. PT-CAPITAL can look at either the existing transport system in London alternative future versions of this system, once various improvements have

been built. PT-CAPITAL is derived from TfL's strategic transport models and shows travel times on a 'perfect network', where real-time delays are not considered. This approach offers a more consistent basis to compare results over time – for example by seeing how current travel times would change once Crossrail is introduced in a few years.

Travel times generated by Journey Planner take into account temporary changes on the network. This includes a large amount of additional information on day-to-day operational changes, but it does not reflect potential future improvements. Travel times can change day by day, so comparisons between locations would be more difficult. Relying on this data source would require a sample of journey times, which would ultimately be closer to the results produced by PT-CAPITAL.

4.3. Ambulance (blue-light) travel time

This refers to the time it takes for an ambulance to transport a patient from a pick-up point to hospital under emergency conditions. The majority of ambulance trips will not operate under blue-light conditions and standard road travel times will be appropriate. However, in an emergency, blue-light travel times should be faster than standard times with previous studies suggesting they are about one-third of private car travel times. For any study looking at blue-light times, we recommend that discussions are held with the London Ambulance Service.

Section 5

Additional support

We recommend that when studies to review health service provision are undertaken, the travel implications are considered as early as possible. Recent consultations on health service reconfiguration in London have shown that these issues are of great concern to the public, patients and staff.

If health services are being moved as part of a reconfiguration, the NHS needs to prepare detailed travel time analysis and supporting commentary for relevant stakeholders using the tools and techniques described earlier.

We can also help by:

- Organising an introductory meeting with our transport experts so NHS project managers can find out more about data modelling, bus planning, stakeholder engagement and travel planning information

- Providing data from our Health Service Travel Analysis Toolkit (H-STAT) so the NHS can produce effective travel time analysis to help shape any changes to its service
- Sharing best practice relating to data presentation
- Providing representatives to sit on any reconfiguration-linked travel group

If you would like further information on any of the issues above, please contact hstat@tfl.gov.uk

Section 6

Glossary

CAPITAL – (Calculator for Public Transport Accessibility in London) – a TfL tool linking GIS-based walk networks to a transport model, to provide detailed measures of travel time for any combination of origins and destinations.

Census Output Areas (COAs) – created for Census data, specifically for the output of Census estimates. The COA is the lowest geographical level at which Census estimates are provided and align to the Census zoning hierarchy. In London there are 25,053 zones. They were designed to be as similar as possible, in terms of population size (average of about 125 households), household tenure and dwelling type. We use COAs for the level of detail provided and because it is easy to relate travel time data to Census outputs.

Geographic information system (GIS) – a generic term for software (eg MapInfo, ESRI, ArcView) that allows you to map and analyse geo-referenced datasets and their associated attribute data.

Health Service Travel Analysis Toolkit (H-STAT) – an umbrella term covering TfL's PTAL, CAPITAL and other strategic accessibility models for use by the NHS and other organisations.

HW-CAPITAL – calculates travel times using the highway/road network for private car journeys.

Integrated Road Network (ITN) – a detailed geographic link and node representation of the road network in Great Britain maintained by the Ordnance Survey. TfL has also included additional links in the PT-CAPITAL walk network to represent routes and short-cuts that can be made by pedestrians.

Lower Super Output Areas (LSOAs) – aggregations of groups of COAs that are used to report Census statistics. Like COAs, they align to the Census zoning hierarchy. There are 4,835 LSOAs in London.

National Public Transport Data Repository – database containing a snapshot of every public transport journey in Great Britain for a selected week in October each year. Data is currently available for October 2004 to October 2011. The dataset is compiled from many sources, including local public transport information from each of the traveline regions, plus coach services from the national coach services database and rail information from the Association of Train Operating Companies. It is mainly used by local authorities and other organisations to produce accessibility indicators using software tools such as Accession.

Public Transport Accessibility Levels (PTALs) – a measure of access to the public transport network. For any given point in London, PTALs combine walk times to the network (stations, bus stops) with service wait time at these locations to give an overall accessibility index. This is allocated to six accessibility levels, with 1 being poor and 6 being excellent.

PT-CAPITAL – calculates travel times using the public transport network.

Population weighted centroids – refers to the central point of a zone, weighted to reflect the population distributions to show where most people live.

Service access points (SAPS) – nodes held in the transport model that represent locations where passengers can access/board the public transport system, eg bus stops and station entrances.

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