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Paper title: **Accessibility modelling: a powerful tool for appraisal**

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Abstract (200 words):

This paper will discuss transport modelling, with a focus on accessibility modelling, and how this can be used to inform scheme appraisal, using a major London transport scheme – Crossrail – as an example. The appraisal of a project of this size and complexity requires a robust framework in order to compare different route and service pattern options. The appraisal framework for the Crossrail project follows the UK government guidance, which focuses on the five overarching policy objectives of: economy, safety, environment, accessibility; and integration. The appraisal framework considers additional issues, included in the guidance, relating to distribution and equity, affordability and financial sustainability, and practicality and public acceptability. The accessibility modelling for Crossrail combined a strategic public transport model of London and a Geographical Information System (GIS) package to allow the detailed modelling of journey times to and from particular areas such as town centres, employment centres and regeneration areas. How useful these models are in appraisal depends very much on how the outputs are presented to members of the project team and also to key decision makers, and the public in the form of consultation. This paper goes on to describe some examples of the communication of model outputs and the linkages to appraisal frameworks.

Introduction

This paper presents a discussion of the use of transport planning models, and in particular accessibility models, in the appraisal process for major transport schemes in the UK. Further to this it goes into some detail about the workings and use of a specific accessibility model developed by Transport for London – CAPITAL – for use on London projects.

The examples given in this paper are based in large part on experience gained from the Crossrail project in London, and this scheme is used as a backdrop to the discussions in this paper, although any example output presented is generic and illustrative and should not be taken to be representative of the costs or benefits of the Crossrail scheme.

In order to set the scene for the discussion, this paper first gives a brief background to the Crossrail project; then outlines the appraisal framework guidance used for major multi-modal projects in the UK. For the Crossrail project an outline of the modelling framework is presented to illustrate how the accessibility modelling fits into the hierarchy. Following on from this is a discussion of the CAPITAL model and how it has been used; and finally there are some examples of how the output from this and other models within the framework can be used to feed into the overall appraisal.

A background to Crossrail

London's current Network Rail (NR) and London Underground (LU) networks experience high levels of crowding on services running into and across London in the peak periods. The Mayor of London's draft London Plan forecasts a population increase of approximately 700,000 and an employment increase of approximately 600,000 by 2016. This level of growth will not be achievable without significant development of key regeneration and brownfield sites around London, and significant investment in the transport infrastructure. Even with the currently planned increases in capacity on the NR and LU networks, the forecasts suggest that the rail system will still experience overcrowding across the network.

A joint venture company – Cross London Rail Links Limited (CLRLL) – was established in 2001, by Transport for London (TfL) and the UK's Strategic Rail Authority (SRA). This company was tasked with assessing the options for two rail schemes, the first linking up systems to the east and west of London and the second providing links running north-south across London. These schemes would provide additional capacity into and across London and relieve some of the pressure on the existing network, as well as serving the areas where the largest development is planned to achieve London's growth targets. The initial focus is on the east-west scheme, with planning on the north-south scheme running a few years behind. The east-west scheme is also linked to the viability of London's bid for the 2012 Olympics.

The east-west scheme, from now on referred to as Crossrail, is the UK's largest transport infrastructure project planned for the next decade, estimated to cost around \$25 billion. A significant consultation exercise was carried out during 2002 and early 2003, before the business case was submitted to the UK Department for Transport in July 2003. Following an independent review some areas of the business case were reassessed and resubmitted in November 2003.

Appraisal of multi-modal projects: the UK perspective

In 1998 the UK Department for Transport published a policy paper – A New Deal for Trunk Roads in England: Guidance on the New Approach to Appraisal (DETR, 1998). This paper announced a new approach to appraisal (NATA) for road-based studies. This approach involved identification of current and potential problems, assessment of these problems and proposal of possible solutions; and, of course, appraisal of the suggested solution options. NATA was further developed to provide a framework for appraisal of a series of multi-modal projects across the UK, where the effect of proposed schemes on all modes of transport was considered. In 2000 guidance was published to accompany this appraisal framework – Guidance on the Methodology for Multi-Modal Studies (GOMMMS, DETR 2000).

This new approach and guidance was wider than the traditional areas of cost benefit analysis and environmental appraisal, although these were included, and allowed for consideration of areas that have not been traditionally put into monetary terms. It also encouraged the consideration of solutions that may relate to policy areas other than transport, such as land-use and health. The approach proposed preparation of an Appraisal Summary Table (AST), setting out appraisal criteria under the Government's five overarching policy objectives:

- economy;
- safety;
- environment;
- accessibility; and
- integration.

The guidance focuses on the principles of appraisal within these five objectives, allowing the development of individual criteria to be specific to the scope and scale of the project. Outside of these five objectives the framework suggests consideration of additional issues relating to:

- distribution and equity;
- affordability and financial sustainability; and
- practicality and public acceptability.

These areas are considered separately as they can affect particular groups of stakeholders, rather than being a global consideration. For example if a proposed scheme is predicted to reduce the overall number of households exposed to a level of noise above a policy-set threshold but in doing so increases the noise for a small number of households to a much higher level than they currently experience, then this may be considered an unacceptable solution when considering the distribution of benefits and equity of the proposed scheme.

With such a large scheme, such as Crossrail, the appraisal needs to be within a rigorous framework, so the NATA and AST approach was used along with GOMMMS. The framework was large and comprehensive with a number of specific criteria identified within each of the 5 main policy objectives.

Crossrail modelling framework

The Crossrail project used a number of inter-linking transport models in the appraisal – these models are shown in Figure 1.

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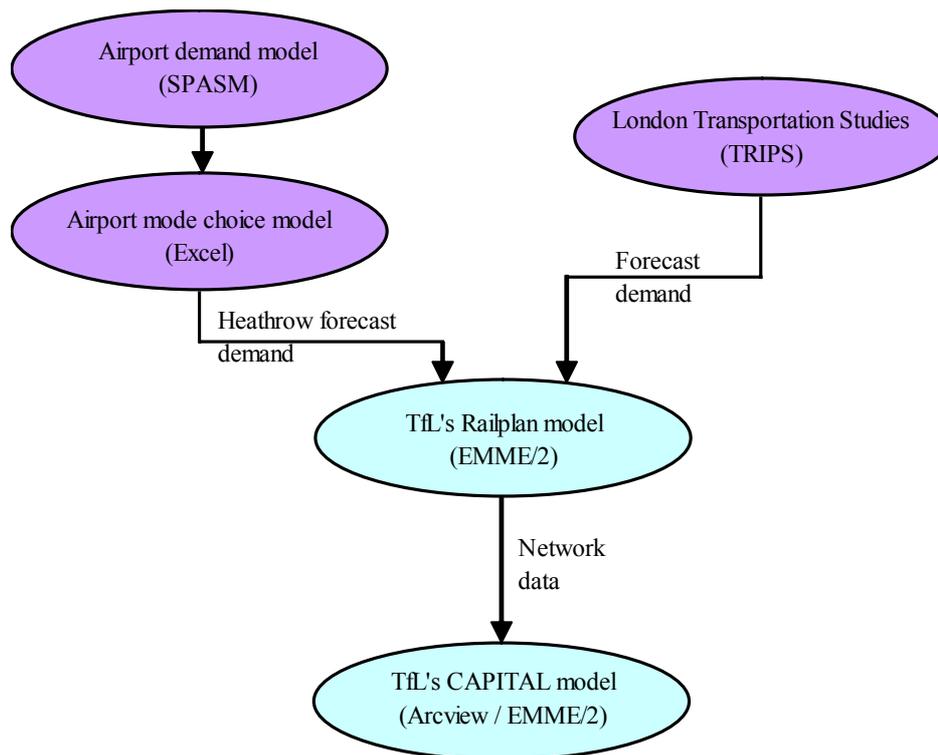


Figure 1: Crossrail model hierarchy

The LTS (London Transportation Studies) model is the four stage multi-modal model of London and the SE of England, developed by local and central Government over a period of 30 years. Data for the model comes from the London Area Travel Survey (LATS), a major survey exercise undertaken every decade to correspond with the UK census. LTS is run in a bespoke version of TRIPS.

Railplan is a more detailed public transport only assignment model developed originally by London Transport, London Underground and now Transport for London. Railplan is run in EMME/2. For the Crossrail appraisal, it was decided at an early stage to use the demand matrices from LTS. A number of highway assignment models exist for the London area, and using LTS matrices for both these and Railplan would ensure consistency across all project appraisals. It would also ensure consistent use of the planning data from the emerging London Plan.

Most Crossrail options serve London Heathrow airport; air passengers are a significant element of the appraisal, mainly because in the economic calculation of benefits they have a higher average value of time than commuters. Because LTS is a strategic model covering the whole city it has difficulty in forecasting both airport demand and surface access mode choice (especially given the wide range of surface access options available, including metro, heavy rail and premium rail services). With this in mind a more accurate representation of air passengers and their surface access mode choice was required.

SERAS (South East Regional Air Services Study) was the largest of a number of regional air transport studies undertaken in the past four years in the UK. These studies formed the basis of the 30 year UK Government White Paper on the future of air transport. Central to all of

these studies is the need to forecast the future usage of airports in the UK. SPASM (Strategic Passenger Allocation Model) is a national model allocating air passengers travelling between ground district origins and foreign or domestic destinations to UK airports on the basis of the relative generalised costs of travel by all possible routes. Generalised cost comprises combinations of surface access costs, flight frequency and interchange costs, in-flight time and fares. The SERAS Passenger Mode Choice Model (PMCM) is a hierarchical logit model developed to forecast surface access mode shares to London and SE airports. The SERAS public transport surface access model was developed from Railplan. The costs from this and a local highway surface access model, along with the passenger data from SPASM (segmented by the PMCM's 6 market segments) are used as the primary inputs to the PMCM.

An overview of CAPITAL

CAPITAL (CALculator of Public Transport Accessibility in London) is a public transport accessibility model developed by Transport for London (TfL) that allows journey time data to be identified at a high level of geographical resolution. It is the most advanced model of its type for the London and South East area in the UK, and has been used on a number of projects. The Crossrail appraisal was the first major application of the enhanced version 2 of CAPITAL, which is considerably more powerful than its predecessor.

CAPITAL combines a GIS (Arcview) front end with an EMME/2 public transport network. This allows it to take network coding for options directly from TfL's established public transport model – Railplan.

One of the main advantages is that the calculation of journey times within CAPITAL is independent of demand. This means it can identify changes in journey times as an indication of potential benefit without the requirement of making forecast assumptions, which can often be complex and contentious. It also allows the calculations to be undertaken at high levels of resolution as it is not assigning demand, only calculating the OD journey time.

An additional advantage is that the model is not constrained by zone boundaries – the level of geographical detail modelled (i.e. the zoning) is flexible and can be defined by the user. The most commonly used is Census Enumeration Districts (EDs), which are subdivisions of wards based on the number of households. Each ED contains around 200 households, and there are approximately 15,000 in Greater London, and 37,000 in the south east of England. However, CAPITAL is not even constrained to using a zone system. Should journey times be required between a number of specific points on the network, these points can be defined as the origins and / or destinations as required. For example if a study was interested in journey times to a particular town centre the origins could be defined as the EDs for Greater London and the destination as a chosen point representing the town centre.

Within CAPITAL an origin / destination trip is split into three sections:

- the walk from the origin point or centroid to an access point on the public transport network (i.e. a bus stop, tram stop or station entrance);
- the trip on the public transport network; and
- the walk from the egress point on the public transport network to the destination point or centroid.

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In order to define the walk at either end of the public transport trip, CAPITAL uses GIS to analyse the following:

- the origins / destinations as defined by the user;
- the definition of the public transport network access points (taken from the EMME/2 network);
- a defined walk network; and
- limitations on the walk distance / time set by the user.

The defined walk network for London is usually based on the Ordnance Survey Centre Alignment of Roads (OSCAR) dataset. The OSCAR network is defined to a high level of detail, and CAPITAL uses this as a way of identifying allowable routes between the origins / destinations and the access points on the public transport network, i.e. ones that follow existing roads or footpaths.

The limitations on the walk distance / time can be set by the user based on the mode being accessed, or by using the spatial definition of public transport access points. For example in central London a passenger may be prepared to walk an average of 5 minutes to catch a bus, and 10 minutes for a rail station, but further out of the city centre these times might longer, for example 10 minutes to access a bus stop and 15 minutes for a station.

Figure 2 gives an example of a potential journey in CAPITAL, going from the origin (home) to the destination (work). In this example there are 2 bus stops and one rail station within walking distance of the origin, and a further 2 bus stops and 3 rail stations within walking distance of the destination. CAPITAL will calculate the journey time for all 15 possible routes and identify which is the optimum for this OD pair.

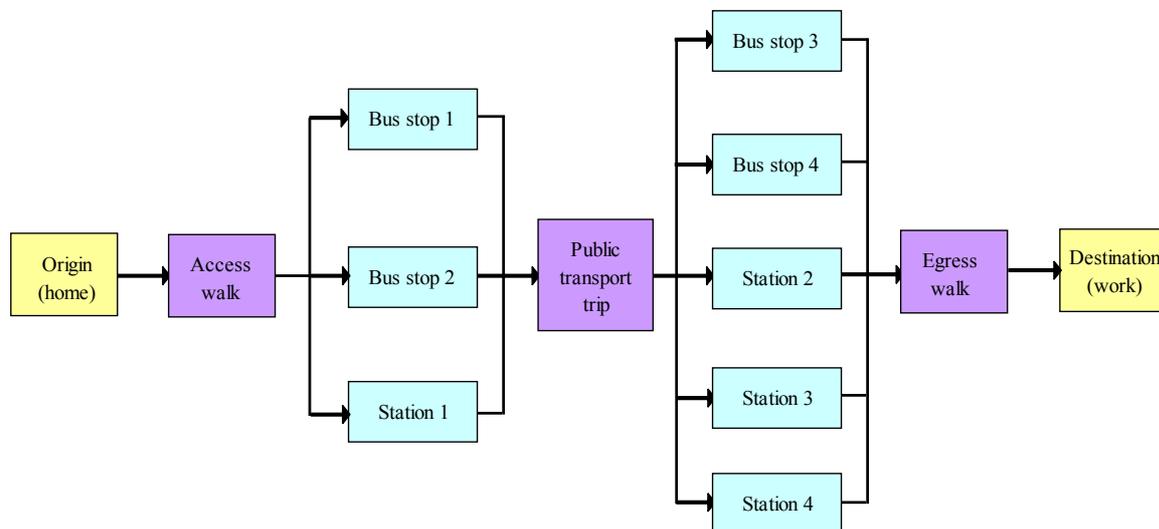


Figure 2: Example of CAPITAL journey time optimisation

Figure 3 gives an example of two of the possible fifteen routes, and in this example CAPITAL would identify the second option – accessing the public transport system at station 1 and egressing at station 4 – as the quickest option, despite both walk elements of this option being longer than the alternative.

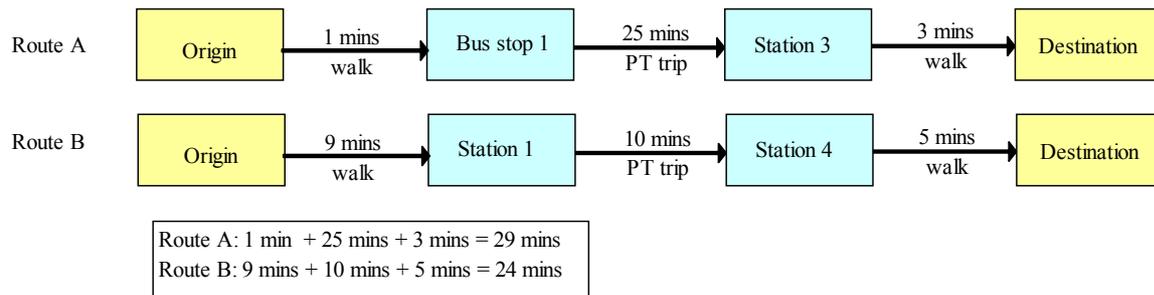


Figure 3: Comparison of two possible routes in CAPITAL

For the Crossrail appraisal, CAPITAL was used to investigate the change in journey times between 25,000 EDs in the study area and specific EDs representing areas of interest. The direction (i.e. whether the specific areas of interest are origins or destinations) is significant, as Railplan is a morning peak model and has tidal services.

Making use of the fine level of geographical data, the journey time output from CAPITAL can be combined with background GIS maps to present a readily understandable picture of the model output; an example is shown in figure 4. This example sets the CAPITAL journey time results against a background showing the National Rail and London Underground networks giving a distinct spatial element to the output. CAPITAL can also be integrated with databases of planning data held at a geographical level, for example population and employment data, to determine how transport improvements contribute to increases in access to opportunity.

Examples of appraisal criteria

From the discussion above, it can be appreciated that Crossrail is a large and complex project, which would require a detailed and robust appraisal framework. This paper does not have the scope to outline all the criteria used in the appraisal, so the following section identifies a small number of specific examples of appraisal measures, most linked to work developed using CAPITAL, but also including other outputs from the models used in the Crossrail project. These examples are described in the following four sub-sections, each identifying which of the five overarching policy objectives they cover, or how they additionally support the appraisal.

Accessibility: improving accessibility within London

One of Crossrail's objectives is to improve access to and from the regions surrounding London, and also to improve accessibility across and within the capital. In order to measure the extent to which the options achieved this objective a number of key regional centres were identified, and output from CAPITAL was used to find the change in journey times for trips into central London and other regions.

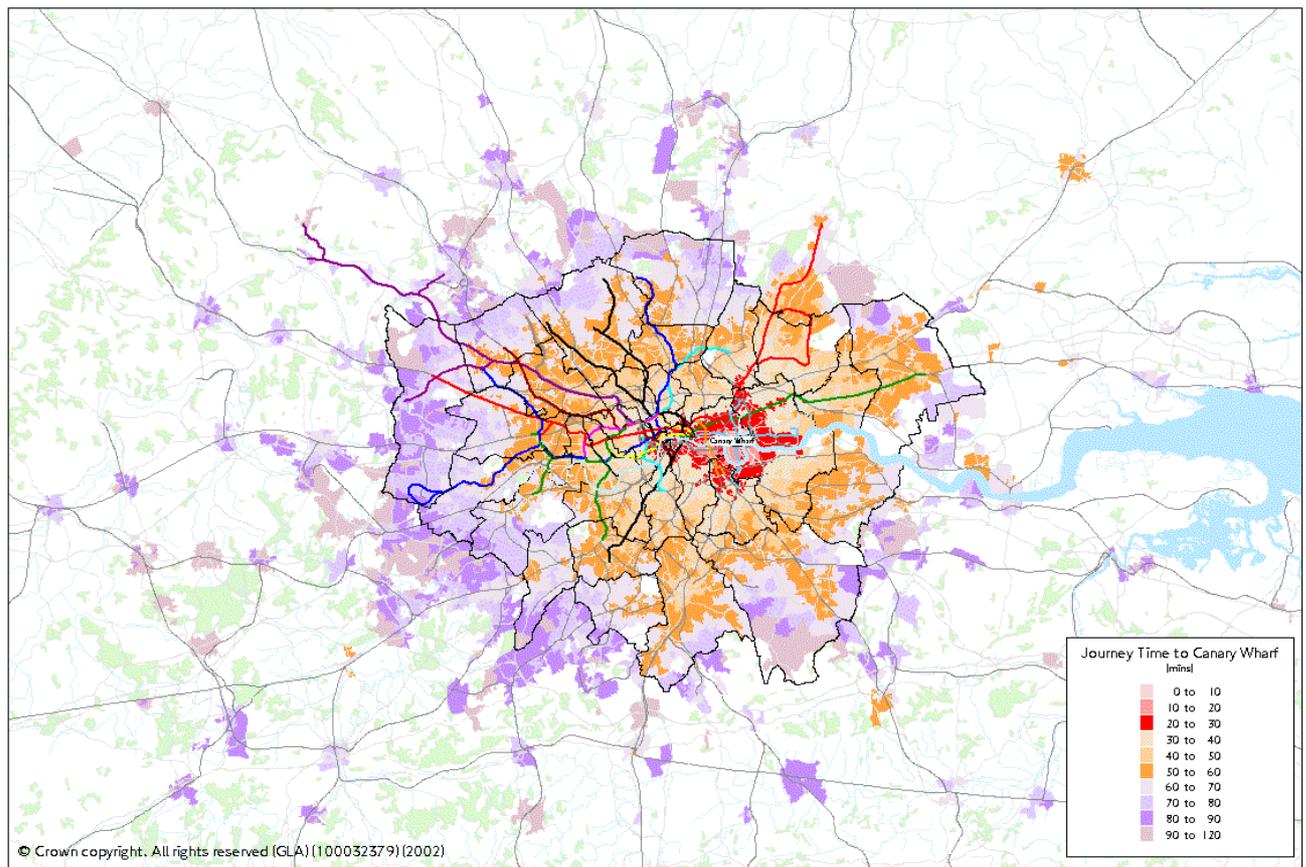


Figure 4: Example of a CAPITAL journey time plot

This is a straightforward use of the model outputs, and these results can be presented in a number of ways in order to tell the story of what the effects of a scheme are; some examples are given in figures 5 and 6. Figure 6 uses GIS to represent the journey time changes against a geographical background, including mapping this output against rail services and the road network.

This approach was also used for a number of other appraisal criteria, such as assessing the impact of the Crossrail scheme options on accessibility to London's international connections (i.e. airports and international stations) within the integration policy objective.

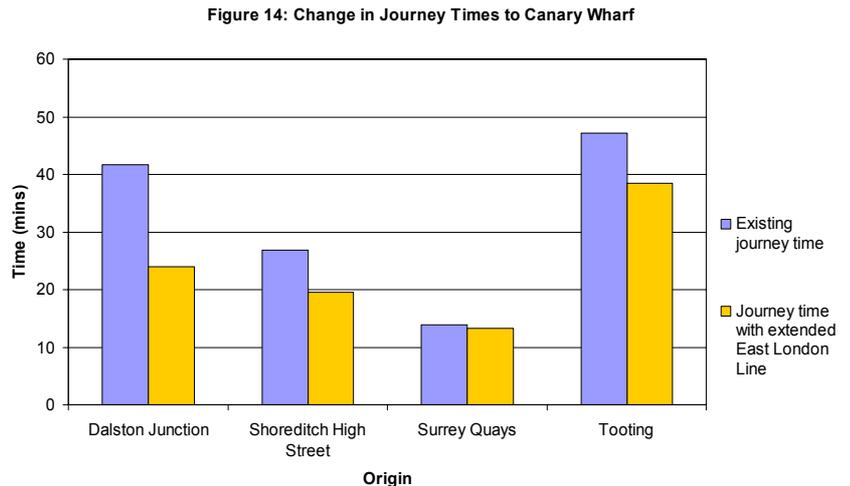
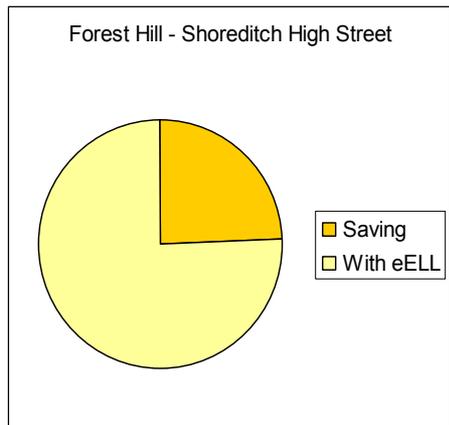


Figure 5: Two graphical ways of representing journey time changes

Economy: regeneration

One of Crossrail's primary objectives is to support the plans developed for London and the surrounding regions, and part of this is to contribute to the development of key regeneration areas. Crossrail will have significant benefits for these regeneration areas by increasing public transport accessibility to and from them. For example, Crossrail provides links to the Thames Gateway area, which is the largest area of economic redevelopment in western Europe, with a number of brownfield sites targeted for development. This is a key element of London's ability to achieve its growth targets, as there is very limited space available in the capital. This improvement in public transport accessibility would be expected to have two main effects: firstly improving the viability of commercial and residential development, leading to an increase in local jobs and homes; and secondly improving the ability of residents to access additional jobs and facilities. These are the main areas which CAPITAL modelling can contribute to measuring; however, an additional benefit of Crossrail would be in improving the image of regeneration areas through this increase in opportunities and developments and leading to greater further improvements – creating a virtuous circle of inward investment.

To inform this analysis, and the areas which might be expected to experience the greatest benefits, scheme options were mapped against defined areas of regeneration – an example of this is shown in figure 7. As the regeneration benefits come predominantly from improvements in accessibility they were measured using changes in journey times. These changes in journey times were then combined with forecast population and employment data, taken from the Mayor's Spatial Development Strategy and draft London Plan, disaggregated by ED. This allowed an estimation of the changes in catchments of people and jobs within a defined (in this case 1 hour) journey of the regeneration area, in order to provide a comparison between options to feed into the appraisal.

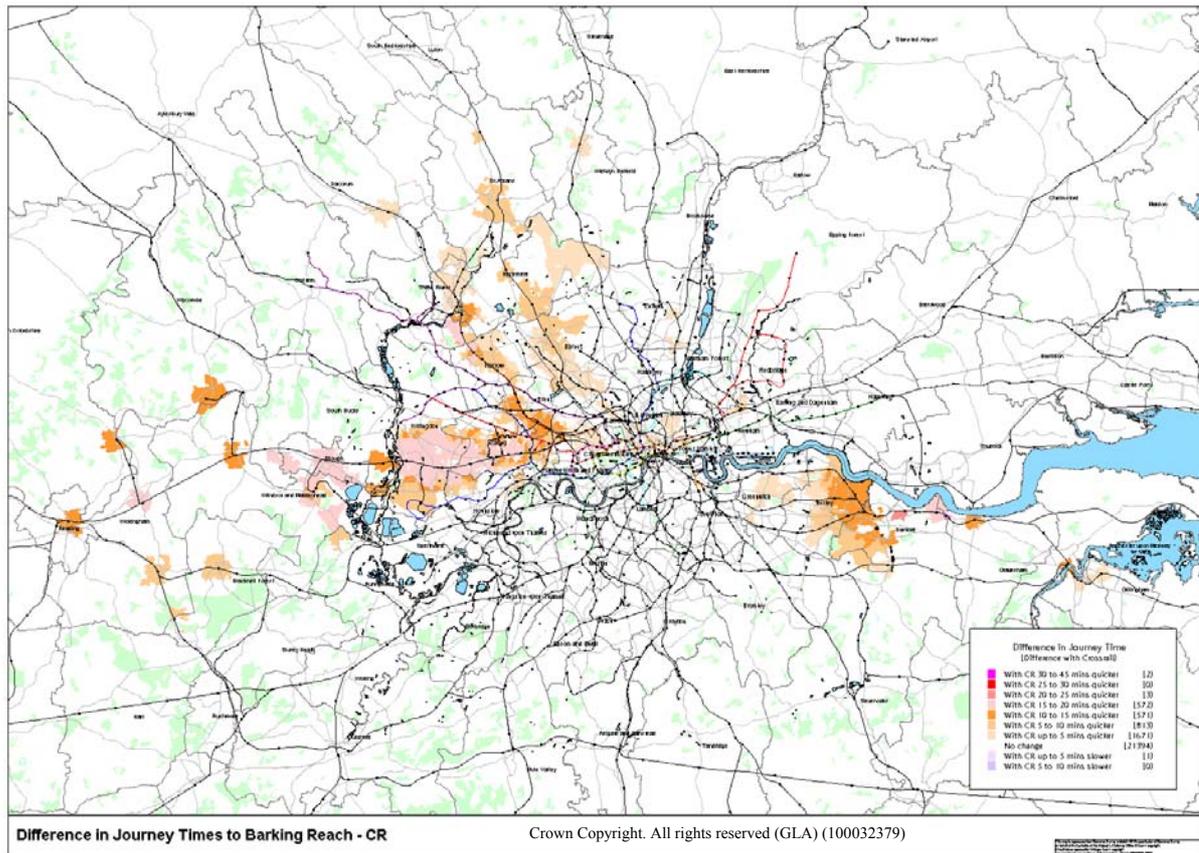


Figure 6: Example plot representing journey time changes using GIS

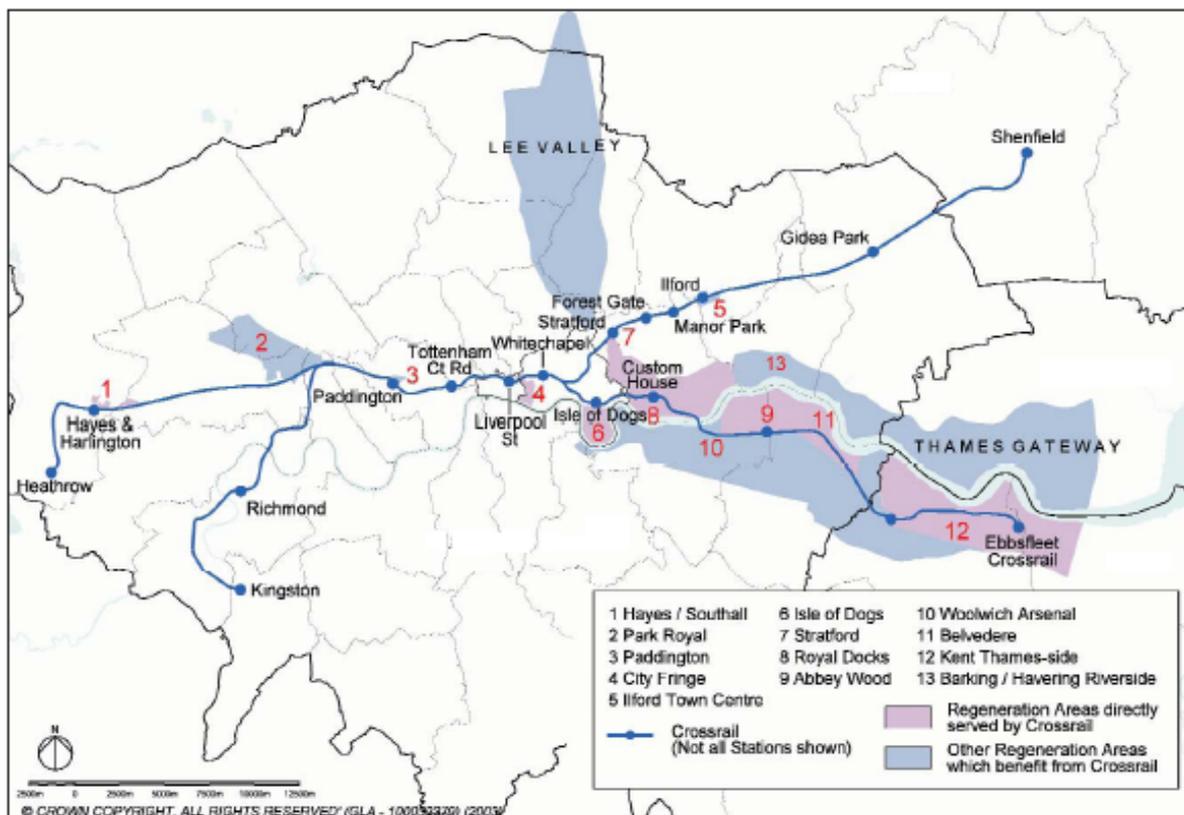


Figure 7: A Crossrail scheme option mapped against areas of regeneration

Supporting analyses: distribution and equity

This example comes from another London rail project appraisal – the East London Line extension. This is a scheme that serves some of the most deprived areas of London, so this was something that was drawn out in support of the appraisal under the five overarching policy objectives under the consideration of the distribution and equity of the benefits.

The walk element of CAPITAL was used to identify the wards that are within a 1km walk of the proposed stations. This data was combined with deprivation data across the whole of the UK and mapped to demonstrate the interaction of the scheme with some of the most deprived areas in the UK. Figure 8 shows that the presented scheme would have an influence on 3 of the 100 most deprived wards, and that the majority of the wards within 1km walk of the stations involved are in the 1000 (or 12%) most deprived wards in the UK.

Economy: wider economic impacts

Crossrail aims to support London's position as a world city and therefore the appraisal also needs to consider how it can contribute to the economy of London and the UK, above and beyond standard economic benefits such as time savings. London is one of the major centres for the finance and business services (FBS) job market in Europe. Unlike other employment sectors where increases in jobs in London would be seen as taking jobs from other parts of the UK with little net gain to the UK economy, the FBS sector can be seen, in some respects, to be internationally mobile and therefore securing employment in this area could generate net gain to the UK economy as a whole. FBS jobs are both mobile and cluster together; should capacity constraints discourage development in London then these jobs could relocate to other major European cities to the detriment of the UK economy.

Most Deprived Wards along the Route of the Extended East London Line Ranked by Level of Deprivation

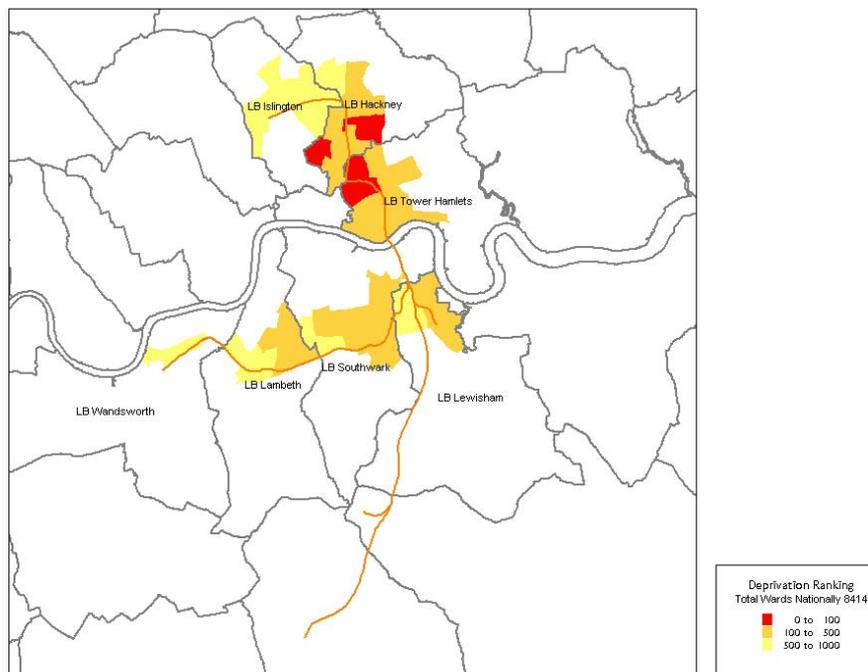


Figure 8: Combination of station access data with deprivation datasets

Crossrail serves areas of FBS markets in London, both the traditional areas (e.g. central London) and the newly emerging centres (e.g. the Isle of Dogs), and would therefore be expected to have an economic benefit by increasing transport capacity to these areas. This is not an easy benefit to identify. The appraisal of these wider economic impacts for Crossrail looked at how the capacity of transport into key economic development areas changes and compares to the demand into these areas. Simple cordon analysis, based on the Railplan model, can identify the demand and capacity of services crossing cordons into these economic development areas. This approach, however, has one major weakness, and that is the averaging effect when taking these figures across the whole of the cordon. This means that it does not identify specific problems on the most crowded links and can underestimate the problem, and therefore underestimate the benefits brought about by introducing additional capacity in the form of Crossrail.

In order to better identify the benefits of Crossrail a new approach was taken, using the Railplan model. This identified the “crowded” links on the network; there were a number of definitions of what was considered crowded ranging from operating at the planning guidance capacity up to 1.5 times the planning guidance capacity, which was defined as “extreme” crowding. In the example of extreme crowding, links in the network operating over this level of crowding were identified and select link analysis was undertaken to develop a matrix of trips that were using these links, i.e. identifying the numbers of passengers who were experiencing this extreme level of crowding and allowing the analysis to consider the crowding experienced over the whole trip not just the element that crossed the cordon.

These results were aggregated over destination zones for the model and mapped; an example of this is shown in figure 9. This clearly shows the areas of London where public transport access is affected by extreme crowding – in this example it can be seen that there are some destinations in central London (including the key FBS area – the City) where over 30% of trips are affected by extreme crowding. This information can be combined with identification of the key FBS areas so that the extent to which Crossrail alleviates capacity constraints on trips into these areas can be measured. To quantify this, for example, it could be identified that in the current situation 4% of trips into the Isle of Dogs FBS area are affected by extreme crowding. In the future year scenario this may be forecast to rise to over 11%, but when Crossrail is introduced this drops back down to 3%.

The strengths of this approach over cordon analysis are that it provides a geographic breakdown of the incidence of crowding, it identifies the number of people affected by crowding and how long they are affected, and it focuses on the key crowded links on the network. It allows a comparison between different scenarios, but the main limitation is that it does not identify the absolute constraints.

Summary

The primary purpose of transport models is to identify costs and benefits of proposed changes to the transport network. How useful these transport models are depends very much on how the outputs of the model are communicated to other members of the project group outside the transport planning team, and also the key political decision makers. The more effectively the benefits can be communicated to these decision makers and the public, through consultation, the more likely the scheme is to secure wide ranging support.

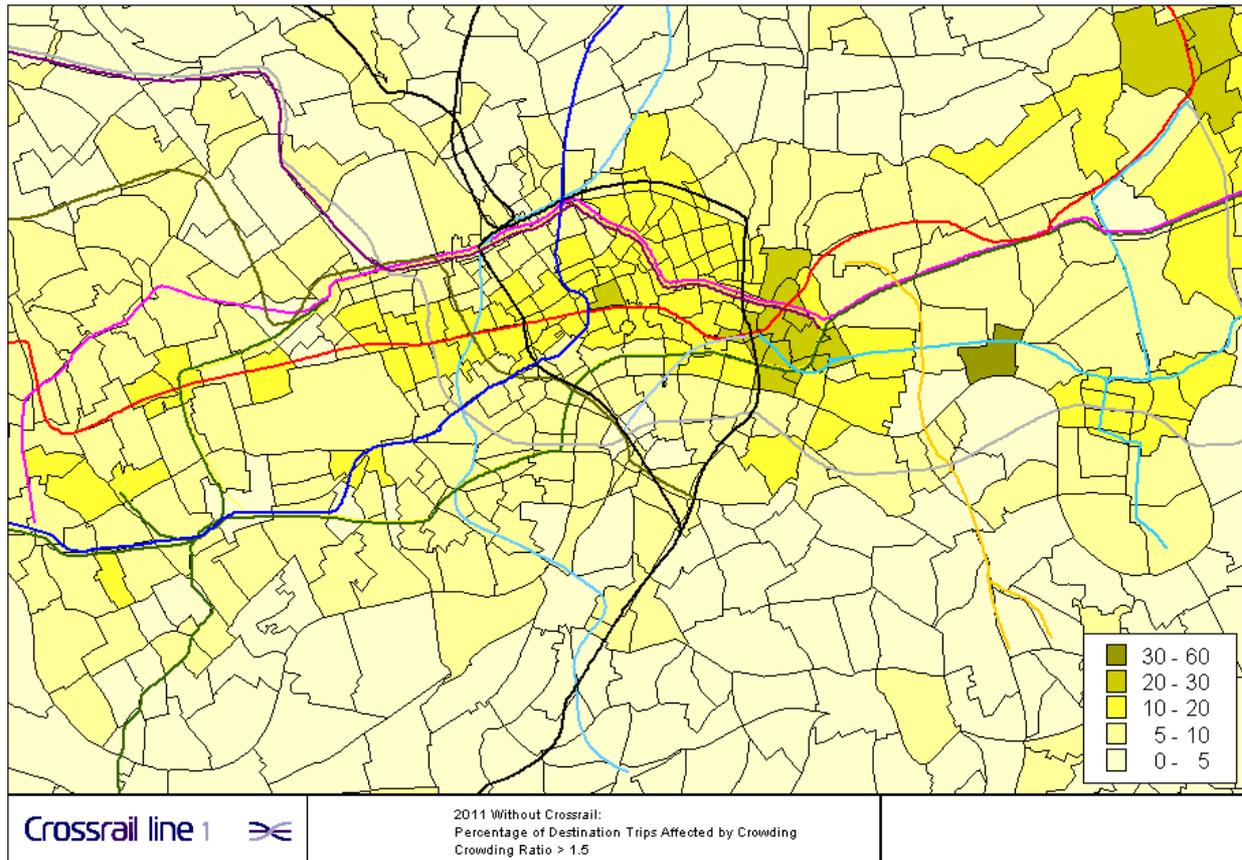


Figure 9: Example of analysis attempting to identify how capacity constraints impact on development potential

This is an area where the development of more powerful tools, such as CAPITAL, can be combined with imaginative and innovative approaches to provide a better way for transport planners to undertake this communication. This paper has given some examples of how these model outputs can be used to create inputs, both numerically and graphically, in order to contribute to coherent and robust appraisal frameworks, but there is still plenty of scope to develop this communication further.

Acknowledgements

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